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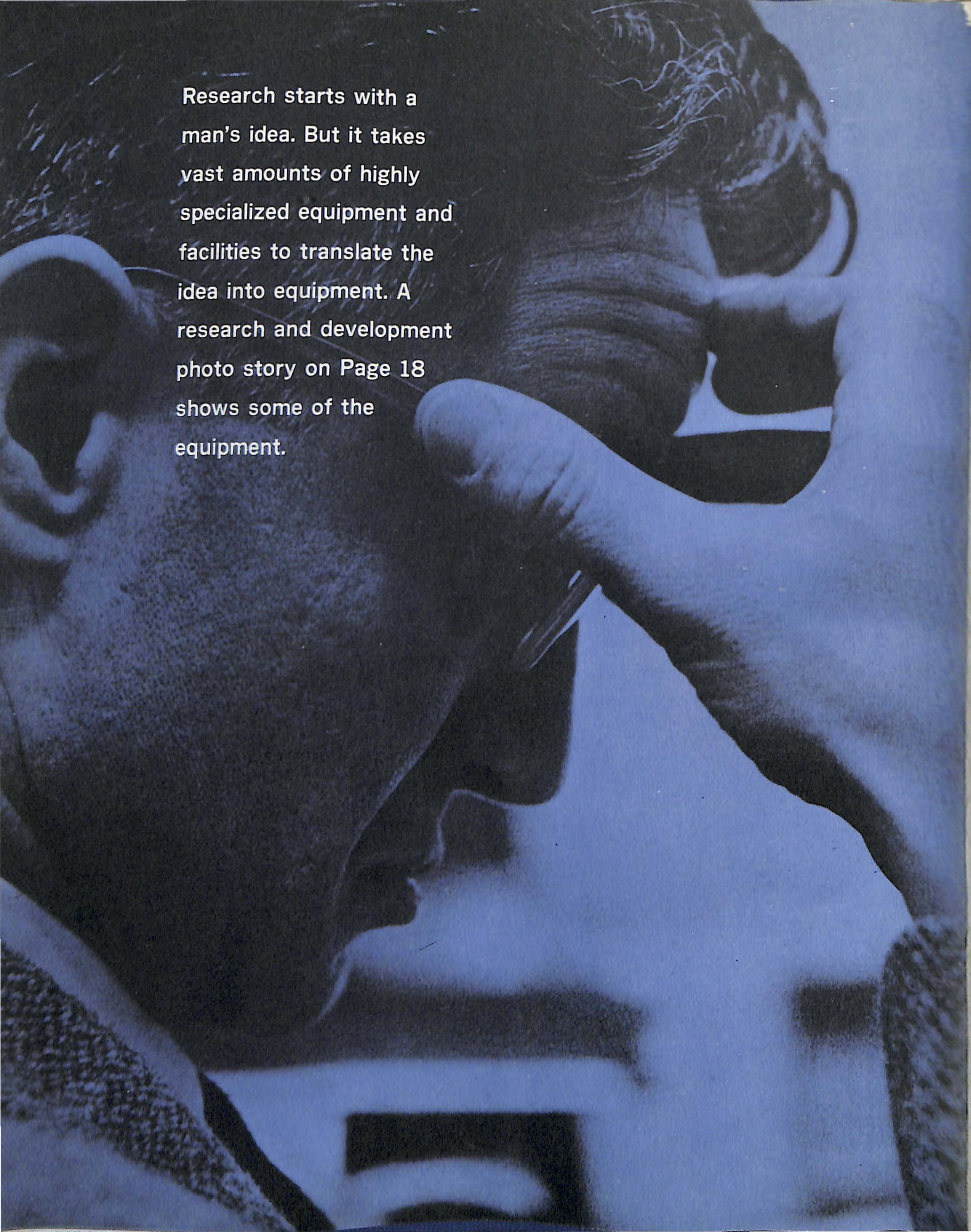

Research starts with a man's idea. But it takes vast amounts of highly specialized equipment and facilities to translate the idea into equipment. A research and development photo story on Page 18 shows some of the equipment.

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Official Publication of the
Aerospace Industries Association of America, Inc.

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FRONT COVER shows an atomic particle tracer used in the design of a space engine.

BACK COVER is an anechoic chamber used in researching the impact of sound on aerospace structures. The sound absorption exceeds 99 per cent.

AEROSPACE is an official publication of the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

Publication Office: 1725 De Sales Street, N. W., Washington 6, D. C.

New York Office: 150 East 42nd Street, New York 17, N. Y.

Los Angeles Office: 7660 Beverly Boulevard, Los Angeles 36, California.




BY JAMES E. WEBB
Administrator
National Aeronautics and Space Administration

1963: THE GREATEST YEAR IN SPACE

During 1962 the United States made great progress in its stepped-up effort toward the national goal of pre-eminence in space.

The year was one in which rapid and visible progress in manned and unmanned space flight was accompanied by equally significant, although less visible, achievement in laying the basis for more advanced missions in space.

The major accomplishments of 1962 included the three-orbital flight of America's first astronaut, and the extension in subsequent flights over longer periods of time of his experience with weightlessness and other factors in space.

In its scientific program, NASA launched the first Orbiting Solar Observatory, the Mariner II Venus probe, and the international satellites Ariel and Alouette, all of which added significantly to our knowledge of the space environment.

Substantial progress was made in the development of applications satellites. The orbiting of additional Tiros weather satellites provided further demonstrations of their value in weather forecasting, leading toward the ultimate establishment of operational satellite weather systems. Telstar and Relay demonstrated the promise of global satellite communications.

And, finally, NASA moved ahead in advanced research and technology which will be required for future developments in space exploration and aeronautics.

These were the visible demonstrations of our nation's space activity. While achieving these successes, however, NASA was also establishing the structure which will undergird the space activity of the future, and give the nation space competence for any purpose which the national interest may require.

All of the major elements of the Apollo spacecraft were placed under contract. Three successful test flights of the first stage Saturn I booster were conducted. And, of great importance, sites were selected and work undertaken to construct the massive ground engineering complexes which will be needed to assemble, test and launch the large rocket boosters required for manned exploration of the moon, and even more advanced missions in space.

As these projects move forward during 1963, we can anticipate our greatest year of achievement in space. Much of this activity will be less apparent than the more spectacular flight missions of 1962, but progress will be none the less real and important.

The current year will not be without visible accomplishment, however, even though much of what is done will be in preparation for the achievements of future years. Here are ten important milestones which we hope to pass during 1963, or early in 1964:

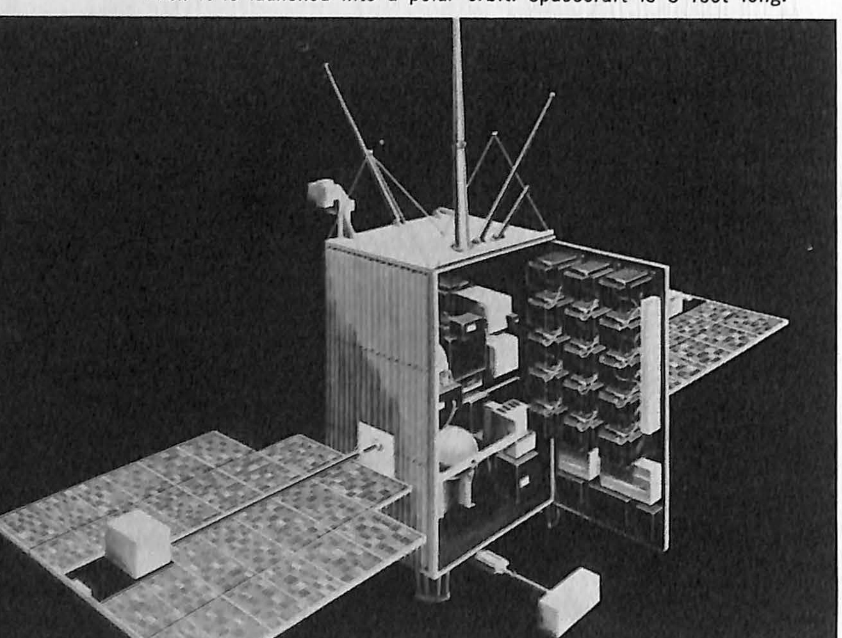
UNMANNED INVESTIGATIONS IN SPACE

A new series of Ranger shots at the moon will seek close-up photographs and other data urgently needed in planning for Project Apollo.

Our first Orbiting Geophysical Observatory will carry many experiments in a highly eccentric orbit passing through the Van Allen radiation belt. An improved version of the Orbiting Solar Observatory will also be launched in 1963, with the first Orbiting Astronomical Observatory to follow in 1964 or 1965.

Flight tests of a liquid hydrogen rocket (Centaur), which will represent a tremendous step forward in launch vehicle technology and be able to carry much heavier scientific payloads to the moon or planets than we can launch with the Atlas-Agena rocket of today.

Orbiting Geophysical Laboratory will have nineteen experiments aboard when it is launched into a polar orbit. Spacecraft is 6 feet long.



ADVANCED RESEARCH AND TECHNOLOGY

. . . The first demonstration of electric propulsion in space (Project SERT).

. . . Successful Kiwi reactor tests which will enable us to move ahead more rapidly in development of our first (and we hope the world's first) nuclear-powered rocket.

MANNED SPACE FLIGHT

. . . Culmination of the highly successful Project Mercury with Astronaut Cooper's one-day flight.

. . . First flight tests of both stages of the Saturn I booster, believed to be the world's most powerful launch vehicle. This will be another demonstration of successful use of the superior power of liquid hydrogen, upon which our plans for reaching the moon in this decade now depend.

. . . First flight (without crew) of the two-man Gemini capsule, paving the way for a series of manned orbital flights of a week or more, and development of rendezvous techniques beginning in 1964.

SPACE APPLICATIONS

. . . The first satellite in synchronous orbit, another momentous advance in space technology. Two Syncom launchings are scheduled for 1963. There will also be further tests of the familiar Telstar, Relay, and Echo balloon satellites.

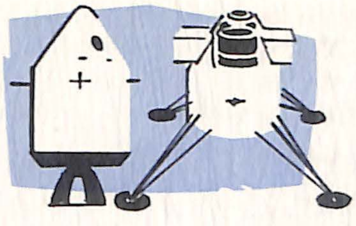
. . . Continued improvement in world weather reporting from space with launching of the first Nimbus satellite.

All of these efforts are part of a civilian space program for which $3.7 billion has been authorized for Fiscal Year 1963, and $5.7 billion requested by the President for Fiscal Year 1964.

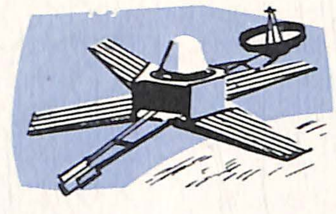
The moon has been selected as the focal point of our current space efforts because it will yield valuable scientific information which will contribute to a better understanding of the universe, and because success in achieving this goal requires essentially the same progress in science and technology needed to achieve our broader objective—that of becoming the world's leading spacefaring nation.

To achieve mastery of space requires that we add substantially to our scientific knowledge and to our utilization of technology. The NASA program is moving forward on both of these fronts. In a complex effort such as this, conducted in a new medium about which much is yet unknown, the scientist and the engineer work closely together and grow increasingly dependent upon one another.

In the exploration of space, the scientist may depend upon the engineer to design the equipment which will



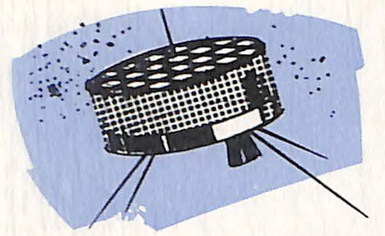
Manned Space Flight
$3,193,641,000



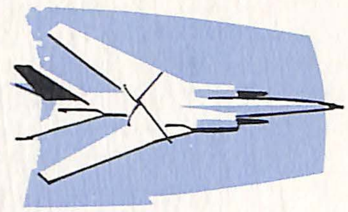
Unmanned Investigations in Space
$754,765,000

Space Research and Technology
$463,863,000

Supporting Operations
$318,046,000



Space Applications
$136,559,000



Aircraft Technology
$45,126,000

The NASA request for Fiscal Year 1964 includes $4,912,000,000 for research, development and operations. About two-thirds of all funds requested will be spent in the area of manned space flight, and are aimed directly or indirectly at realizing one of our major initial goals in space—manned exploration of the moon within this decade. **Manned Space Flight** includes $1,139,454,000 for large launch vehicles and $1,647,441,000 for spacecraft development and operations. **Unmanned Investigations in Space** includes $605,233,000 for spacecraft development and operations. **Space Research and Technology** includes $268,783,000 for propulsion and space power. **Supporting Operations** includes $261,608,000 for tracking and data acquisitions. **Space Applications** includes $73,085,000 for meteorology and $55,771,000 in satellite communications. **Aircraft Technology** funds will permit continuing and expanded activity with advanced V/STOL aircraft, helicopters and supersonic transport aircraft. In addition, the FY 1964 authorization request seeks $800,000,000 for construction of facilities.

enable him to investigate conditions and forces which exist there. But at the same time, the engineer must look to the scientist for precise knowledge which will enable him to design equipment which will operate or sustain human life in this harsh and unfamiliar environment.

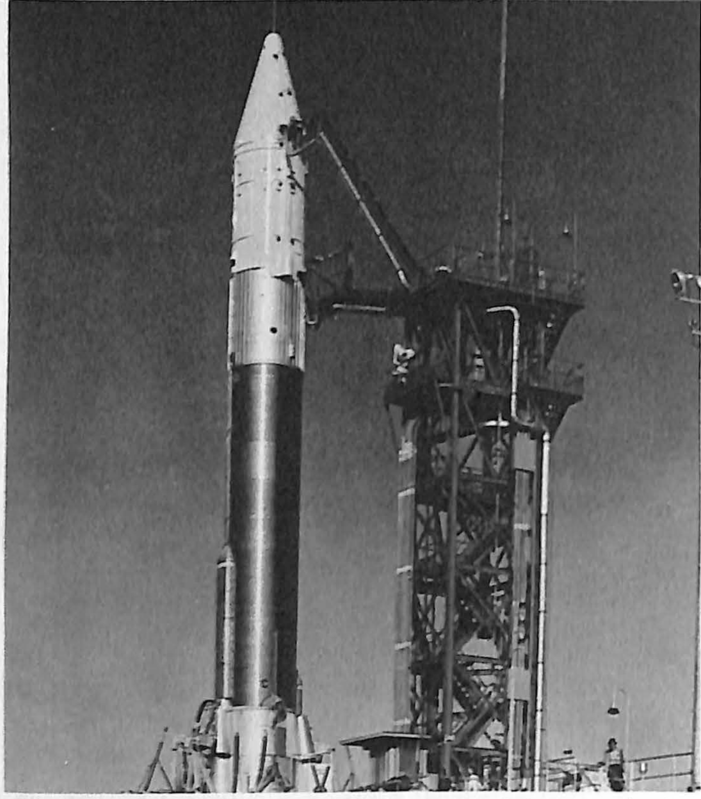
The NASA program, therefore, must expand both science and technology. We must move forward on a broad front. We cannot afford to be trapped into a narrow program—one limited, for example, to developing only the technology needed to reach the moon with state-of-the-art hardware. To do so might well be to find, some years hence, that we had won the battle and lost the war as far as ultimate and enduring superiority in space is concerned.

Basic in all NASA decisions is the concept that we will encourage wide-spread participation in the space program by American industry, to develop a broad base of competence in space technology by contracting out to industry the maximum possible amount of our work, and utilizing the competitive forces of the market place to obtain top-notch performance. More than 90 per cent of our work is now performed under contract with industry, universities, and private research organizations.

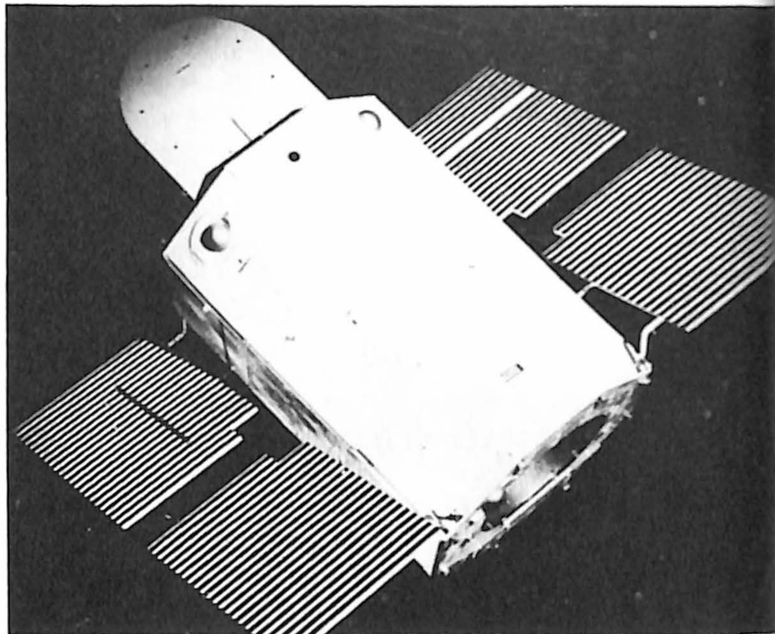
As Chairman George P. Miller, of the House Committee on Science and Astronautics, said recently:

"The American people are convinced that we must explore space and . . . look to Congress and to NASA for the assurance that our national space program, especially the manned lunar landing, will be conducted with the utmost vigor possible. And in turn, *Congress and NASA look to private industry in order to achieve in practical terms all of our objectives.*"

Congressman Miller expressed a point of view which all of us in NASA share. The effort in which we are engaged, although financed and managed by the Federal government, is dependent for success on the efforts of many American industries, large and small, throughout the 50 states. It is a truly national undertaking which will demand the best of all of us.



Substantial part of the NASA budget will be expended for the development of launch vehicles.



The Orbiting Astronomical Observatory is a key satellite in the unmanned investigations of space.

Some of the basic policies which guide NASA in its relationships with American industry may be of interest to *Aerospace* readers:

First, we have taken steps to try to make certain that contracting patterns will not become frozen; that major areas of competence will not be pre-empted or locked in by single sources. Typical of our actions under this policy was the establishment of the Michoud Plant at New Orleans, and the nearby Mississippi Test Facility, as government installations, with resources available to private contractors selected through competition.

The decision to assemble and test our multimillion-pound boosters in centrally located government facilities was made with the deliberate intention, among others, of keeping open a continuous competition within the industry for the contracts to build future stages.

Second, we have developed through the Bellcom Corporation, a systems engineering group organized by the American Telephone and Telegraph Company, a capacity to continuously examine the developing state-of-the-art in the areas essential to our success in manned space flight. This group will continuously match the results against the concepts and assumptions underlying our programs, and relate this matching to the hardware and mission profiles toward which we are working.

Through a contract with the General Electric Company, we are also endeavoring to provide a means for measuring and storing in computors performance and test data on the vital components and the finally assembled boosters and spacecraft in an effort to substantially increase reliability. These arrangements will not be used to provide crutches for NASA contractors, but rather to measure and insure competence on the part of the contractor himself.

The contracts insure that the full responsibility of the corporations, both AT&T and GE, are pledged to the success of these extremely important and difficult endeavors.

Third, we are steadily moving in the direction of insisting that prime contractors obtain components from those sources which have already developed reliable hardware. Our object here is not only to insure that NASA obtains the best available performance, but also to encourage prime contractors to seek out superior subcontract skills, among companies of proven performance, rather than risk failure or increased costs by trying to develop internal or new sources of competence to perform these tasks.

This policy is of great significance to all segments of industry and areas of the nation because it means that specialized or smaller firms can afford to invest time, effort and money in perfecting a product with the assurance that the prime contractor must listen to their evidence showing what its performance is. The prime contractor cannot reject available outside skills simply to keep the business within his own organization or pattern of suppliers.

In short, we are making a deliberate effort to use the self-policing forces of the market place to avoid building government competition with industry, and also to maintain sufficient managerial and technical capability in our own organization to make certain that our contractors are giving us the reliability we must have and the taxpayer a dollar's worth of work for every dollar we spend.

As a part of this managerial effort, we are looking to multi-disciplinary centers of competence in the universities, and to Civil Service research and development centers such as the new Electronics Research Center which we propose to establish in the Boston area. This center is not intended to compete with industry, but to give us the capability to manage a vast program in electronics similar to that which NASA developed in aeronautics.

Another basic policy which we are following in the award of research contracts, particularly those which are concerned with basic research, is to do what we can to assist the universities of the nation in the training of additional scientists and engineers, particularly those who are working toward advanced degrees.

As a nation we must look to the future requirements for highly trained scientific and engineering manpower. Much of the research work which NASA requires is the kind of work in which graduate students can participate under the direction of, and with the inspiration of, a qualified scholar or researcher.

Thus NASA can help make the university a center for developing men with eager, trained, self-starting minds and also a center of creative activity in basic research in support of broad national objectives.

NASA is also taking other steps to help strengthen the universities and assure a continuing supply of scientific and technical manpower. These include the encouragement of interdisciplinary groups within the university for research in broad areas, to be supported by contracts or grants; support of pre-doctoral training in the fields of space science and technology and, in some instances, the financing of research facilities needed for expansion.

Our objective, as I have said, in NASA is to build competence in space for the United States, and to be, in the words of President Kennedy, "in a position second to none."

In the programs of the National Aeronautics and Space Administration we seek a national competence in space which may be applied for any purpose which the national interest may require. NASA, like its predecessor NACA, is a research and development organization. It is our job to provide the basic scientific knowledge and technological skill which will enable other agencies of the government to carry out the operational responsibilities which are theirs.

Thus, we work in close cooperation and collaboration not only with the Department of Defense, but with many other agencies such as the Weather Bureau, the Communications Satellite Corporation, and the Atomic Energy Commission, in order that what we do will meet their needs.

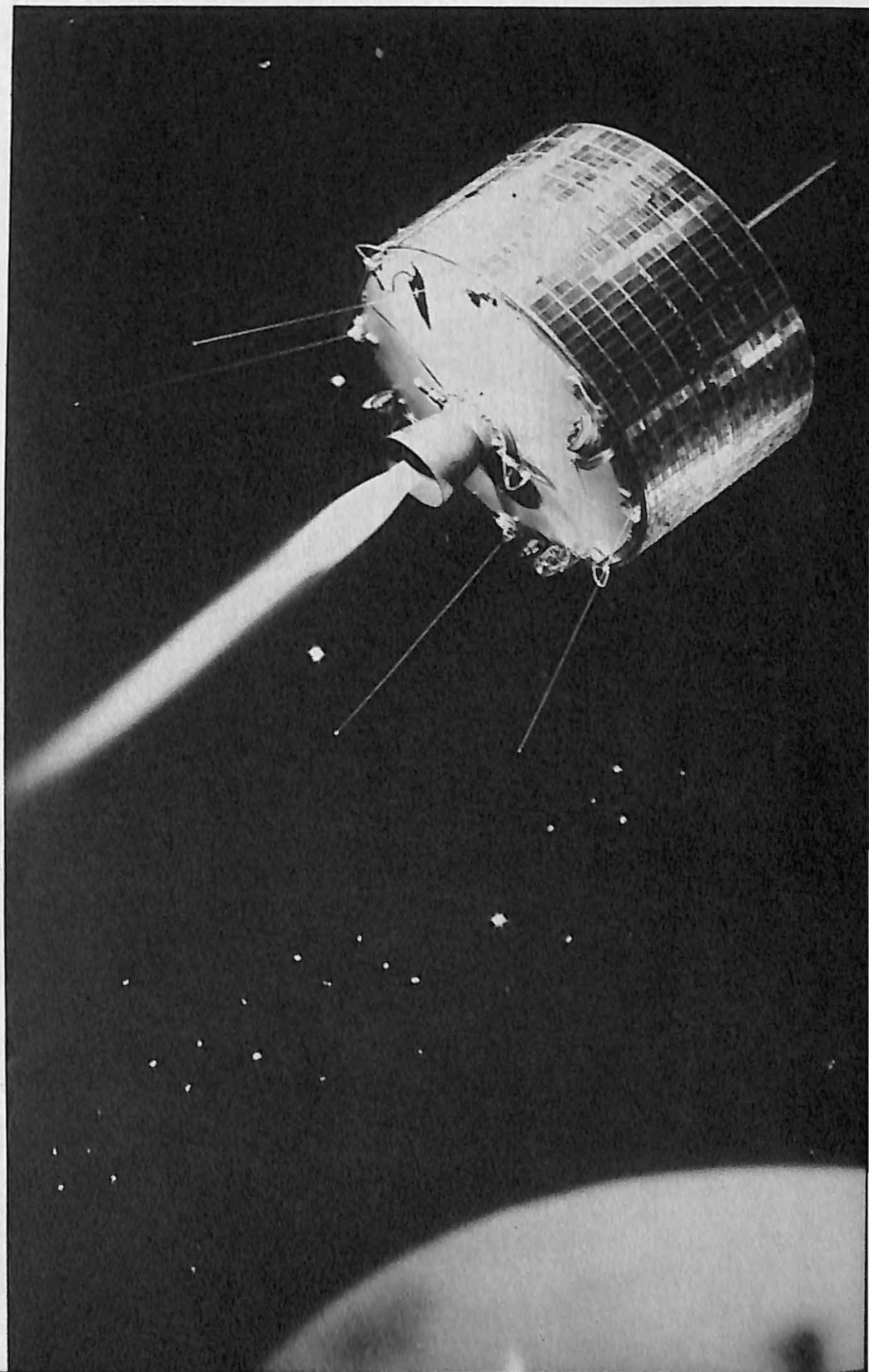
It is important that each of us, as we consider the contribution which we can make to this effort, keep constantly before us the importance and urgency of our responsibilities.

We must remember that our national security itself is heavily involved in the space competition. Not only our prestige but our capacity for constructive international leadership, our economic and military capacity for technological improvement, depend upon a superiority in science and technology that is understood and accepted.

The nations of the world, seeking a basis for their own survival, continuously pass judgment upon our ability as a nation to make decisions, to concentrate effort, to manage vast and complex technological programs in our own and not infrequently in their interest. It is not too much to say that in many ways the viability of representative government and of the free enterprise system in a period of revolutionary changes based upon science and technology is being tested in our space programs.

It falls to every citizen, in and out of government, to help prove that we are equal to the test.

Syncom is a communications satellite that goes into an orbit synchronized with the Earth. It stays in a fixed position relative to a position on Earth.



RESERVOIR OF SKILLS

NATIONAL defense and exploration of space are not the only areas to which aerospace companies are devoting progressive thinking. The same dynamic approach which is responsible for the nation's rapid strides in defense programs and space exploration is being applied with gratifying results to another important national problem—employment of handicapped persons.

Placement of the thousands of Americans who are partially incapacitated yet able—under many circumstances—to be self-supporting, is a continuing problem to public officials. Aerospace companies have lent a powerful assist to the placement program as the technological transition of the industry has uncovered a wealth of critical tasks which can be performed by handicapped persons.

The industry's leadership in the field should be described more appropriately as an attitude than a program. It is the inclination of companies to consider handicapped applicants for employment on the basis of what they can accomplish in terms of productive work, rather than on the basis of quotas or planned programs.

The companies make every effort to help the physically handicapped adjust themselves to their occupation. The adjustment is accomplished by counseling services and such mechanical aids as ramps, special parking space, and minor modifications in some facilities.

Other than this, the physically handicapped aerospace employees are not given—nor do they want—any special privileges. The same attitude is likely to prevail in opportunities for advancement, and company officials are quick to say that handicapped persons are very often among their most valued employees.

The practical reasons for this official attitude are not difficult to pinpoint. They are productiveness and safety. Intense desire born of the incapacity is apt to place the handicapped worker in the forefront in production, and because his disability has taught him caution, he is often a better safety risk than other employees.

Thus a visitor to an aerospace plant might well find a paraplegic veteran performing important work on the complex assembly of radar systems. Hundreds of physically handicapped workers like him have contributed to the production of some of the nation's leading defense weapons systems and advanced space age products.

Another case in point might be the father of five children. Although he has been blind since World War II fighting in Italy, he is a capable structural assembler and earns a good living for his family.

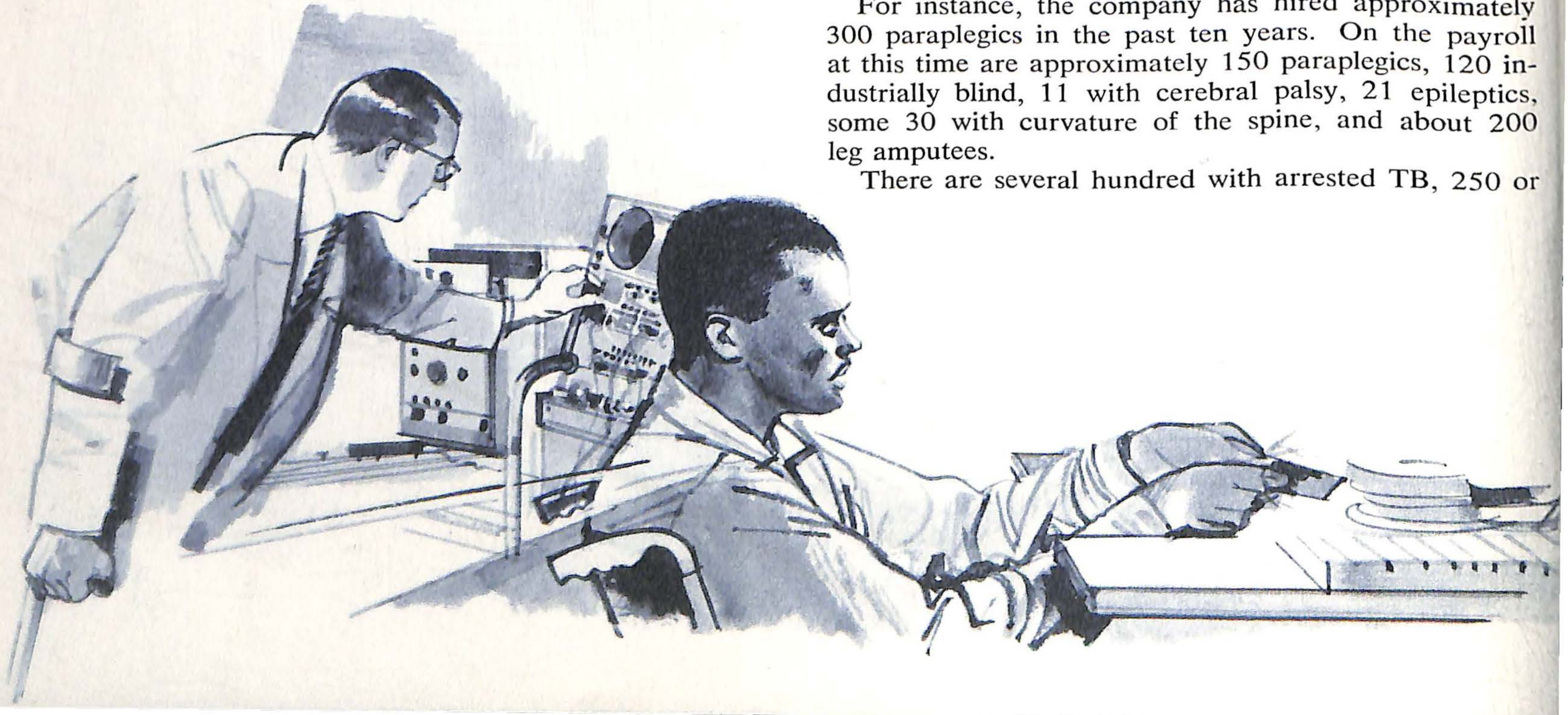
Amputees, polio paralytics, and others are finding niches in these firm which they can fill as capably as able-bodied workers, and by giving them an opportunity to compete for such jobs, the aerospace companies are not only performing a national service but enhancing their own productive capability.

One of the leaders in the field of hiring handicapped is the Hughes Aircraft Company, which has been assiduously hiring disabled workers for more than ten years.

Hughes officials say it is difficult to pinpoint the exact number of physically handicapped employees at Hughes, since employment figures fluctuate, and definitions of "physically handicapped" vary. But a conservative estimate places the number of such employees at about 20 per cent of the total 28,000 company population. These are persons who have a handicap severe enough to make routine employment in the open market difficult.

For instance, the company has hired approximately 300 paraplegics in the past ten years. On the payroll at this time are approximately 150 paraplegics, 120 industrially blind, 11 with cerebral palsy, 21 epileptics, some 30 with curvature of the spine, and about 200 leg amputees.

There are several hundred with arrested TB, 250 or



more with diabetes, 40 deaf mutes, 80 who are totally deaf, and 150 with heart conditions severe enough to be restrictive.

Lawrence A. Hyland, vice president and general manager of the firm, describes the company attitude this way:

"We have found that regarding these employees of ours, while we may have had a few humanitarian instincts in the beginning, we have forgotten all about that. The only special thing we do for them is that in very serious cases where they are almost immobilized, we provide them with a parking place close to the plant and a ramp to get into the plant. From there on, they are on their own.

"Their workmanship is judged on the same basis as anybody else's, and it is an extraordinarily productive operation for us. I believe it is good business to hire the handicapped. I would hate to have these people taken away from me because they are among our more valuable employees."

On the matter of productiveness and safety, Hughes officials are emphatic in their approval of the handicapped. They maintain there is no record of a single lost-time accident occurring to any member of the handicapped population during the past ten years.

Employment of handicapped persons is governed by the same policy which covers all job applicants at Hughes:

"The best qualified persons available are selected for position assignments without prejudice, or discrimination by reason of race, age, color, sex, religious belief, or national origin. Physically limited persons are eligible for employment consideration."

The history of the company's position on the matter began in England in 1943 when Lt. Gen. Ira Eaker, then commanding the Eighth Air Force, visited an Oklahoma Indian boy in a hospital.

The youth had been a gunner on a Flying Fortress over Germany, and because the plexiglas of his ball turret had been shattered, his legs were frozen and had to be amputated. When the General told him he would be flown home soon, he protested that he came to see the war through and that he didn't shoot with his feet.

General Eaker carried the memory of that incident with him to a Decoration Day ceremony in 1949, which he attended as a vice president of the Hughes organization. He saw dozens of American veterans in wheelchairs, and realizing that they were capable of performing any task that could be done sitting down, he offered them jobs.

This was the start of what the Hughes Company calls an "exciting experience."

The story of Hughes' efforts since then has been portrayed in a motion picture, "Employees Only," which was nominated for an Oscar by the Academy of Motion Picture Arts and Sciences as one of the best documentary short subjects of 1958. Prints of the film are still in circulation nationally and in foreign countries.

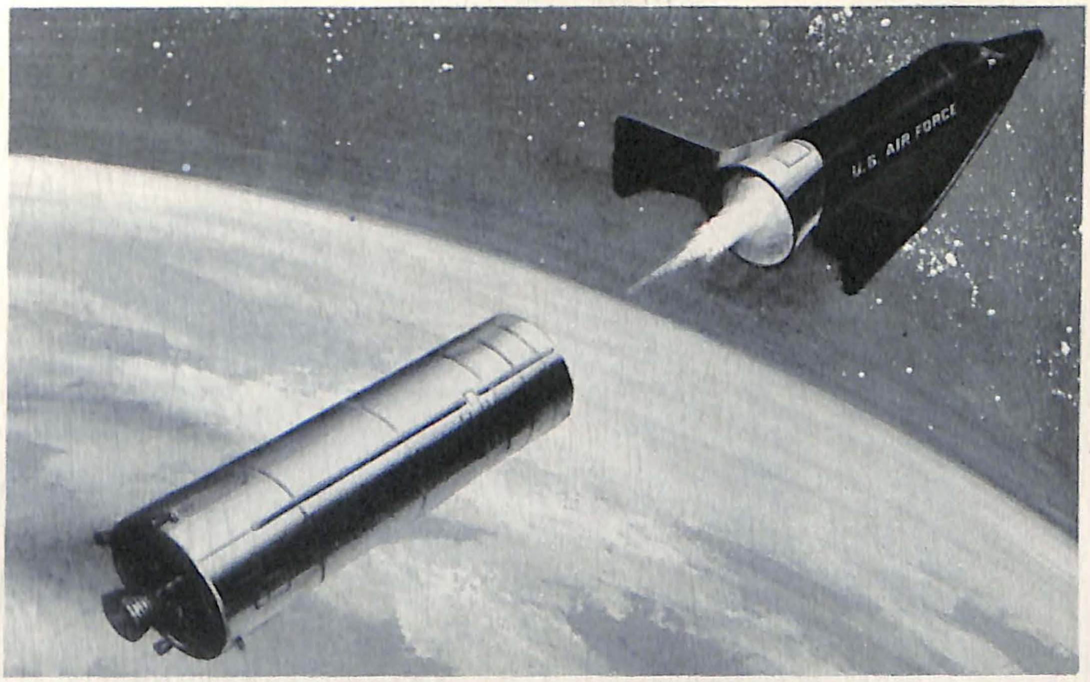
It illustrates many outstanding case histories of persons who have overcome their disabilities to take valued positions in the company, in every kind of job—production, management, scientific, maintenance, accounting and others.

Mr. Hyland says, of the company's feelings:

"The human brain is a vastly more complex computer to program than our most elaborate electronic machine. It takes at least 20 years to program the brain through schooling, the influence of the home and parents, and the experience of everyday life. It is a most valuable commodity which God has given to each of us, and He has given it in equal abundance to the physically handicapped.

"We want to preserve and apply this capability. And we want all employers to know of our experience, so they too may tap this excellent labor pool of capable, enthusiastic people."

FORCES OF THE FUTURE



The X-20 Dyna-Soar spacecraft is shown separating from the Titan III booster. A major portion of the Air Force's Advanced Development effort will be expended on the X-20 and its launch vehicle.

THERE will be continuing heavy emphasis on research and development in the Department of Defense, but there will be greater care exercised in the initiation of new weapon systems programs, more thinking and planning before the "metal bending" stage is reached and a tighter rein on costs. These, together with an outline of the projects aimed at strengthening the U. S. military forces of the future, are the main points of a statement on research and development policies and activities delivered to the Congress by Secretary of Defense Robert S. McNamara.

"We have often paid too little attention to how a proposed weapon system would be used and what it would cost, and whether the contribution the development would make to our forces would be worth the cost," Secretary McNamara said. "By a more thorough and complete study and assessment of the facets of each new development—prior to major commitments—we can reduce the number of expensive projects which might later have to be re-oriented, stretched out or terminated."

The Secretary's detailed outline of the research and development projects to be conducted in the coming fiscal year provides an excellent guideline to the type of defense systems the military services will be operating in the future. The projects are grouped into five categories: Research; Exploratory Developments; Advanced Developments; Engineering Developments; and Management and Support.

RESEARCH

The "Research" category is general in nature, consisting of basic and applied research directed toward the expansion of knowledge in such fields as the physical and environmental sciences, mathematics, psychology, sociology, biology and medical sciences, with each of the services sponsoring its own programs. Examples include the Army's research on tropical medicine, oceanographic underwater acoustic and arctic research programs conducted by the Navy, and the Air Force's studies of atmospheric density and gravity gradients.

EXPLORATORY DEVELOPMENTS

Exploratory developments are those directed toward the solution of specific military problems short of the hardware stage.

In this area, the Army's effort will include new propulsion systems for Army

The Vought-Hiller-Ryan tri-service V/STOL transport operates like a helicopter yet achieves speeds of 300 mph in level flight.

aircraft, studies for improved night viewing equipment, rocket research, improved small arms and anti-armor projectiles, better surface mobility and mine warfare and barrier research.

Among the Navy projects under this category are work on radar, anti-submarine warfare devices, data correlation techniques, navigation and communication devices for both ships and aircraft. There will also be considerable effort on non-nuclear air launch systems, missile propellants, guidance systems and countermeasures, as well as studies on advanced aircraft concepts "with emphasis on simplicity, endurance and low-speed characteristics."

A large portion of the Air Force's exploratory development program will be devoted to space research, including studies, experimentation and component development in such fields as guidance, flight control, propulsion, life sciences, surveillance and electronics techniques. There will also be emphasis on advanced tactical and strategic missiles, new production cycles for hypersonic manned systems, laminar flow control, materials and structures, and technology related to reconnaissance, communications, command and control, data processing, electromagnetic warfare and advanced weapons.

The Advanced Research Projects Agency will also be active in the field of exploratory developments. Specifically mentioned were ARPA's projects Defender and Vela. Defender is concerned with development of knowledge for application in a system of defense against ballistic missiles. Vela involves research toward an improved capability for detection of nuclear explosions underground and at high altitudes.

ADVANCED DEVELOPMENTS

This category includes those projects which have advanced to the hardware testing stage.

All three services are cooperating on development of tri-service V/STOL aircraft which will combine vertical or short-run take-off characteristics with much greater speed in level flight than that attainable by helicopters. Three major projects in this area include:

- A large prototype V/STOL of the tilt-wing variety. Five aircraft will be built for flight test and for Army/Air Force evaluation of operational problems and suitability.
- A twin-tandem ducted fan research vehicle being developed under Navy management. Two prototypes will be built.
- A twin-turbine aircraft with four tilting propellers. The Air Force will procure two for flight test.

There are other tri-service projects in the field of surveillance aircraft. The services will support further development of the P.1127 Hawker, a British-designed V/STOL being jointly funded by the U.S., the United Kingdom and Germany. The Army will also continue work on four research aircraft, two of the fan-in-wing type and two augmented jet types now under test. The Air Force will manage development of propulsion systems for advanced V/STOL aircraft. This work is aimed at development of V/STOL aircraft with speed capabilities in the high subsonic range for use as surveillance systems.

The Army and the Air Force are teaming on the development of a military communications satellite system. The initial system, consisting of a large number of small satellites in random orbits, will operate at medium altitude (about 6,000 miles). Under study for possible later development is a stabilized satellite in synchronous orbit (22,300 miles).

Other advanced developments include:

ARMY

There will be a continuation of work on a system of defense against ballistic missiles pursuing new advances in radar technology and oriented toward defense of "hard" sites, such as missile bases and command posts. Included are the advanced Nike-X system and the complementary ZMAR-Sprint Hard Point Defense, employing a high-acceleration missile which offers more time for discrimination between targets and decoys.

The Army will also investigate, through a flight test program, the feasibility and design requirements for heavy lift helicopters capable of moving Army equipment over otherwise impassable terrain.

Another Army program involves development of anti-armor weapons such as the lightweight, vehicle-mounted Shillelagh missile and TOW, an advanced anti-tank weapon.

NAVY

In addition to its participation in the V/STOL projects, the Navy will devote considerable effort to undersea warfare research and work in such areas as hydrofoils, detection by surface effects and acoustic countermeasures.

AIR FORCE

A major portion of the Air Force's Advanced Development effort will be expended on the X-20 Dyna-Soar spacecraft and the Titan III launch vehicle, designed as the work-horse military space booster for this decade.

The USAF will also continue component research on the aerospace plane, now called the "advanced hypersonic manned aircraft." This is an aircraft which can take off from existing runways and fly directly into orbit.

Research will also continue on an advanced ICBM, although McNamara's testimony cautioned that "this is not a development project but rather a program to investigate technological and operational concepts for ballistic missiles."

As part of a coordinated DOD-NASA program, the Air Force will develop large solid-fueled boosters in the 156 to 260-inch class.

ENGINEERING DEVELOPMENTS

The Secretary of Defense defined this category as "those development programs being engineered for service use, but which have not yet been approved for production and deployment."

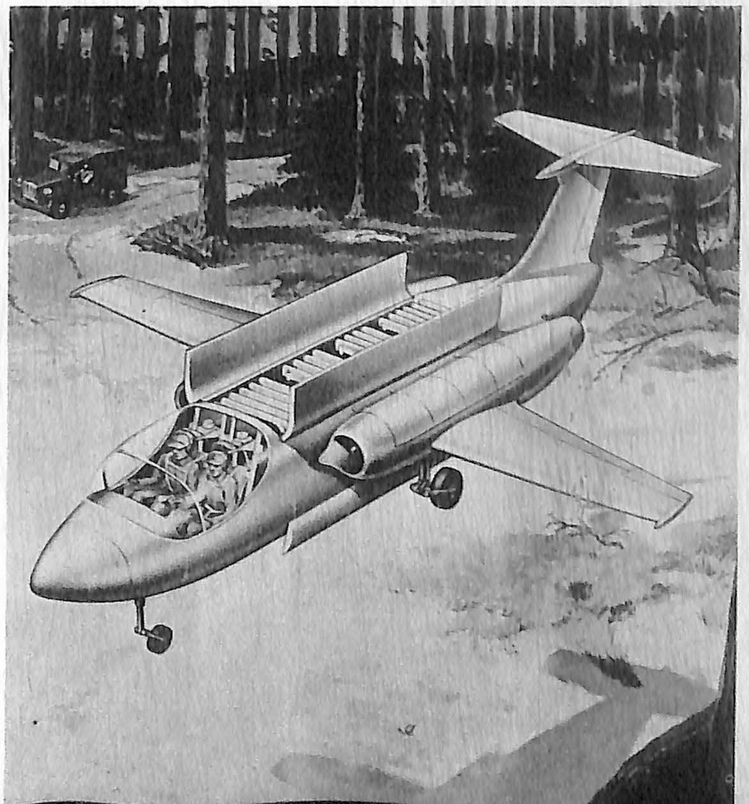
ARMY

In addition to a new battle tank and an armored reconnaissance/airborne assault vehicle, the Army is developing the new Lance missile, a lightweight air-transportable weapon designed as a replacement for Honest John and Lacrosse.

The Army will devote considerable effort to engineering development of communications and electronic equipment, including improved radios for forward area use and navigation and control systems for aircraft supporting ground forces.

Also under way are projects involving development of new artillery and infantry weapons, including special ordnance for guerrilla and counter-guerrilla warfare.

The Army will use this Lockheed "Hummingbird" aircraft in various research programs to test the jet ejector lift principle.



NAVY

The Navy is developing a regenerative turboprop engine with significantly lower specific fuel consumption, for use in ASW aircraft.

In the missile field, the Navy program provides for continued development of Typhon, a medium-range surface-to-air weapon with an improved complementary radar, and Sea Mauler, a Navy adaptation of the Army's air defense system.

In final development and nearing operational use is the Transit navigational satellite system. The operational system will consist of four satellites, four ground tracking stations, a computing station, two injection stations, and equipment aboard each ship.

The Navy's engineering development program also includes work of interest to the Marine Corps, including radar surveillance systems, weapons and vehicles.

AIR FORCE

In the aircraft field, the Air Force will complete development of three prototypes of the XB-70A Mach 3 bomber.

Under fiscal 1964 funds, the USAF will proceed with full-scale development of the MMRBM (Mobile Medium Range Ballistic Missile) to fill a gap between ICBM's and the Army's Pershing missile. Terming this a good development investment, the Secretary cautioned that no decision has been made to produce and deploy the MMRBM.

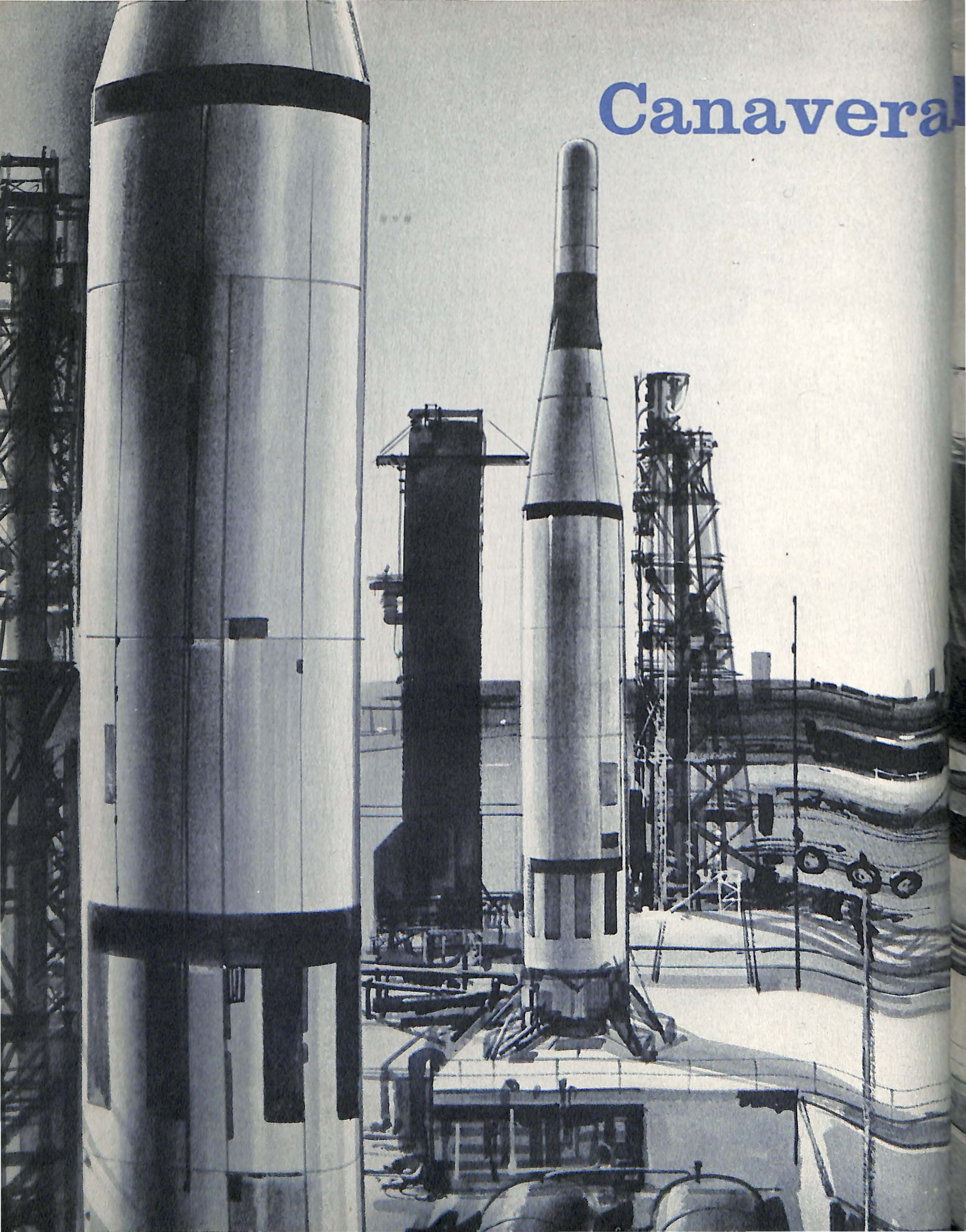
The USAF's engineering development program also involves investigations of new missile re-entry systems and penetration aids.

In space, the Air Force will continue work on the Satellite Inspector, a system designed to rendezvous with and inspect orbiting objects, "reorienting it to the latest technological developments."

MANAGEMENT AND SUPPORT

The Management and Support category includes the operation of research and development installations, such as ranges, test facilities and laboratories, and the funding for specialized technical and scientific services performed for the Air Force by outside organizations. The test ranges include the White Sands Missile Range, the Atlantic Missile Range, the Vandenberg AFB, Point Mugu and Point Arguello complexes on the Pacific Coast and the Nike-Zeus test range at Kwajalein. The Navy will operate the Atlantic Undersea Test and Evaluation Center (AUTEC) for testing anti-submarine weapons and equipment.

Canaveral



Revisited

America's private enterprise system is the big booster at Cape Canaveral

BY GEORGE CARROLL
Aviation Editor,
The Hearst Newspapers

THE mightiest lifter and heaver at Cape Canaveral is not, as generally supposed, the moon rocket Saturn. Even though Saturn weighs off the launch pad at 500 tons, much like an airborne distant cousin of the Empire State Building, the biggest booster at the Cape is industry—the American private enterprise system which got us up where we are today in defense and space exploration.

Operations at the Cape are vastly different today from the first shoot this writer covered in the summer of 1951. A Martin Matador, one of the ground-to-ground wonders of that day, was fired over the Atlantic. We can still visualize its leisurely departure, then the flipping aside of its burned-out tail section, and its flight a relatively short distance over the ocean. Today ICBM flights are measured in the thousands of miles, and the planet Venus was the goal of the recent successful Mariner II shot.

The military runs the Air Force Missile Test Center at the Cape and its 10,000-mile Atlantic Missile Range going all the way down into the Indian Ocean from the east coast of Florida.

How well they've run is proved by our well stocked arsenal of Atlases, Titans and Minutemen, the best known and most respected keepers of the peace in an era of ICBMs.

But civilians outnumber by four to one Maj. Gen. Leighton Davis's men in blue and silver tan here in this greatest shooting gallery of them all. General Davis commands the center.

The National Aeronautics and Space Administration recently took over a new, 87,000-acre launch area on Merritt Island just to the northwest of Canaveral. NASA will be shooting for the moon from Merritt. In its stewardship of the new site, nearly six times the size of the Canaveral complex, it has another mark to shoot at, too: to reach as fine a level of performance as the Air Force has at the Cape.

Like a big booster should, the Cape is composed of a host of components all dovetailing into their proper places.

The major contractors on missiles and rockets at the Cape read, as might be expected, like a blue ribbon list of aerospace firms. General Dynamics, Aerojet-General, Boeing, Douglas, Lockheed, Garrett, General Electric, McDonnell, Hughes, Westinghouse, you name them. Interlaced among them, however, you encounter names from the world of smaller businesses, names the uninitiated may never hear of, such as Soroban Engineering, Cubic Corporation and Radiation, Inc.

The big and the small, they're all mixed up in profound togetherness, all dedicated to the vital job of putting what comes out of America's missile and rocket plants over the last hurdle.

Who, for instance, operates the range itself and does all the housekeeping on the stepping stone chain of tiny island stations stretching nearly to Africa? Since 1954, this task has been accomplished by Pan American World Airways though the people who luxuriate about

the globe aboard Pan American's jet clippers might be surprised to hear their carrier is up to its wings in rocketry.

It is somewhat less surprising to hear that Radio Corporation of America, as a Pan Am subcontractor, handles all the technical instrumentation, photographic and data reduction work on the range.

An industrial directory updated to last October at General Davis's headquarters lists 57 firms "associated with the missile industry" that have opened up permanent diggings hereabouts, the best known ones in office complexes between Patrick Air Force Base and the Canaveral launch area.

In size of staffs, they range from as many as 6,000 to some of the smaller firms with a few employees.

Ten or more companies can be concerned in a very large way in the testing of a single bird or beast. That may double or triple when NASA comes to shoot for the moon with the three-man Apollo hoisted by an advanced Saturn.

The Rocketdyne Division of North American Aviation has been supplying the rocket motors for Saturn, and firms such as Pratt & Whitney, Douglas, Grumman and General Dynamics are assuming ever larger roles in the lunar program.

This writer is indebted to a veteran around the Cape, Ed Bramlitt, assistant to the area chief of Army Engineers, for a vignette of the earth turning curtain-raiser for U. S. industry at Canaveral.

Duvall Engineering & Construction Company of Jacksonville, Florida, arrived with their bulldozers in the spring of 1950 on a hurry-up assignment to build the first launch pad at Cape Canaveral, plus access roads. Basil Ellis, still in the construction business at the Cape, was in charge.

"He had 45 days to build that pad and he did it," Ed Bramlitt recalls admiringly.

"Bee Ellis put in a 100-foot pad, not much by the standards of today. An old Army tank was positioned for a control blockhouse. They laid lines for Army field phones as a communications net. Sometimes you'd get through over 'em and sometimes you wouldn't. But she functioned O. K., that Pad One."

On July 24, 1950, a captured German V-2 with a US-made WAC Corporal as its second stage thundered up from Pad One, the first Canaveral shot.

Today the number of missiles and rockets fired from Canaveral is creeping up toward the 2,000 mark. Costs have crept up, too. Duvall got $275,000 for Pad One. The first Saturn pad runs around $14,000,000 and a two-shot pad costing more than that is going into place up the beach.

The first all-American shot took place in June, 1951, with the launching of a Martin Matador. This makes the Martin Company the oldest of all the contractors in terms of continuous tenancy on the Cape. Martin produced a third of the first 1,000 missiles launched.

"This gets the thinking and the doing much closer," explains George S. Cherniak, director of the Florida Division of Space Technology Laboratories, Inc., a subsidiary of Thompson Ramo Wooldridge, who also saw the value of a divisional setup.

"The space field is changing. Field work requires a higher degree of sophistication to accomplish more with less cost than in the early days. Thinking and doing were separate then. Now, from necessity, they must be closer."

Floridians are glad the Matador came down from Baltimore that summer of 1951. Martin now has a large manufacturing facility at Orlando, and is the largest industrial employer in the entire state. The old Matador, long since replaced in NATO by its more modern sister Mace, is one of the reasons NASA could announce this year that the Sunshine State ranks fifth of all the states in space work. Matador got the ball rolling.

In one of his weekly columns this past January, Roger Babson, the economics writer, noted:

"I have watched with much interest the development of electronics and aerospace businesses. While the big boys might have been expected to hog the field, countless small producers have also done a tremendous amount of experimentation, research and actual production of complicated new items. Analysis of available figures proves most smaller concerns are getting along extremely well, not just in civilian production and trade but also in the booming aerospace and defense fields."

The job of fitting bits and pieces together into a missile that may have 1,000,000 parts from 1,000 different manufacturers and 36,000 connections alone in its "black box" brain has coined a brand new word at Canaveral—interface.

Interface is the method whereby the meticulous Merlins make everything mesh. The process of interface must not only make everything work in harmony; it must also forestall any situation where the redesign of a single faulty part could set off a chain reaction that would require the yanking out of numerous adjacent parts for reworking.

Spaceport, USA—soon to be Moonport, USA, it is hoped — has outgrown the dictionary. Still, this shouldn't be too surprising. After all, even NATO popularized a noun new to most of us, infra-structure, which may or may not mean something nailed down, we're not sure.

If we caught the contractor philosophy of interface correctly, it goes something like this:

"Let's design it, make certain it works and shoot it."

Sort of a paraphrase, you might say, of old Henry Ford's philosophical guidelines when he was making the Model T—make sure it runs under any and all conditions of farm, ranch or city street. Well, if it was good enough for Henry, why not for Spaceport, USA? Ford is here in the missile and space business along with all the others: AC Spark Plug Division of General

Motors, A.T.&T.'s Bell Telephone Laboratory, Burroughs, American Bosch Arma, Sperry Rand, Northrop, IBM, Thiokol, Hercules.

Perhaps it was providential in more ways than one that on Feb. 26, 1952, according to the files of Historian Marvin Whipple of the Test Center, members of the Aircraft (now Aerospace) Industries Association's Eastern Region Aircraft Research and Testing Committee met at Patrick AFB. The purpose:

"To coordinate problems arising at operational level with regard to design and construction of the missile range."

The contractors thus had a chance to plan for the leading role they were to play on the Cape, as well as to try to attract other segments of American free enterprise to fix them up with a place to stay and play in their off hours at Canaveral.

Mr. Whipple's history goes on to state that "eight days later the most successful Snark launching experienced so far took place." We hesitate to declare this interface constituted anything more than a happy omen.

No question, though, that business began to hum and so did the telephone wires around Cocoa Beach. Joel Harris, local manager for Southern Bell Telephone, says there were only 173 non-military phones around in all the Cocoa Beach region, at the beginning of 1952. Now there are over 8,000.

From the standpoint of safety in what could easily degenerate into one of the world's most dangerous spots, private industry has done handsomely. The Cape is Station No. 1 on the missile range and Pan Am bears the responsibility for ground safety and security and protection services within each range station clear down to Ascension Island in the South Atlantic and Pretoria, South Africa.

In nearly 2,000 launches involving some of the most volatile fuels known to man there have been just two fatalities in 13 years, not bad compared to nearly 40,000 people killed annually on the nation's streets and highways.

One man fell down the elevator shaft of a gantry and the second was killed installing an explosive "destruct box" in a rocket soon to be test fired.

When our missile and rocket engine programs were sharply cut back in the late 1940's and early 1950's, firms such as Convair and North American Aviation went right on with the work, using their own funds, confident that they would be needed. They gambled their own funds, as Boeing did with nearly $20,000,000 on a jet transport.

Thus, all operational benefits to the team effort aside, private enterprise long ago earned the right to copreside at rocket and space launchings. Men in uniform and civilian attire sit together at the blockhouse controls.

A launch expert who has served in both uniform and mufti at the Cape, Earl Wollam of Douglas, explained procedures. The top staff of a military launch would look like this:

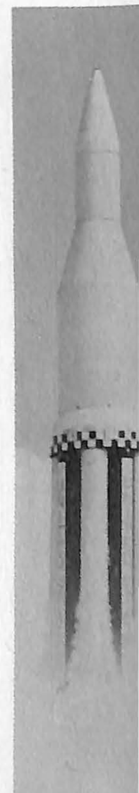
Test Director (Air Force)
Test Controller (Air Force)
Test Conductor (Contractor)

The test director waves the baton, runs the show. The test controller keeps his hands more closely on the day's operations. The test conductor sees to it the countdown is followed precisely, and can call for a "hold" if anything is out of order.

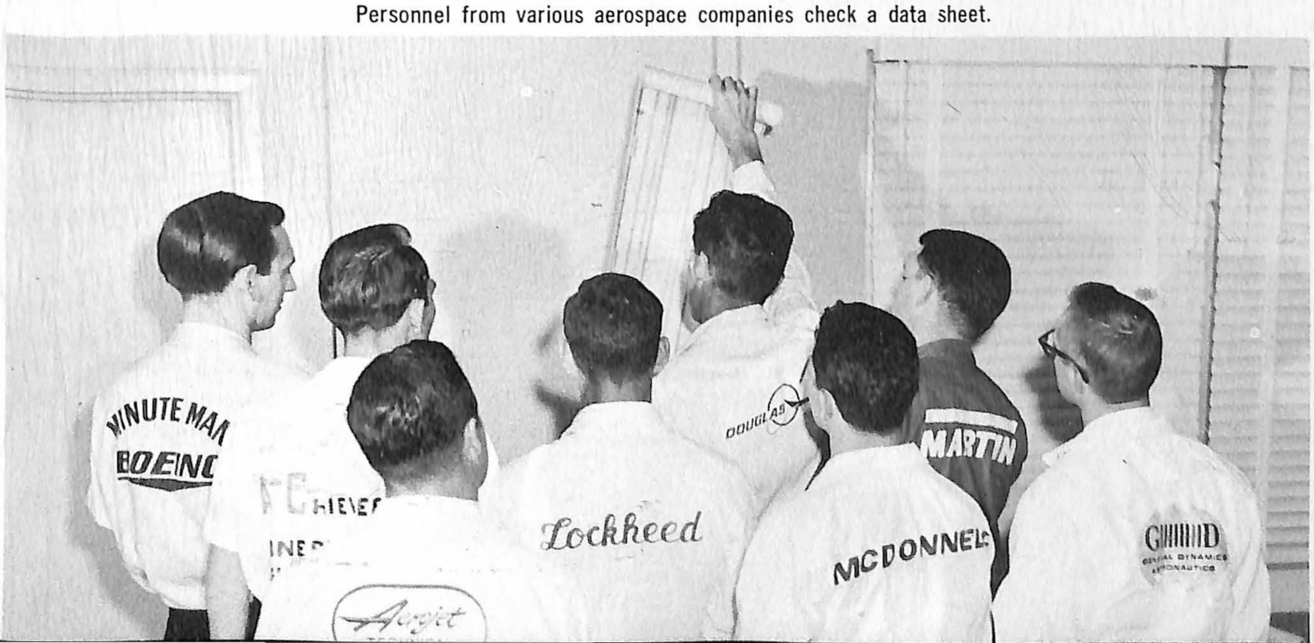
As an Air Force lieutenant, Mr. Wollam, a native Floridian, who used to wander around the Cape as a lad, launched numerous Snarks. Today he serves as supervisor of Douglas's technical operations here. He told how launches of the Delta for NASA differ from the military kind:

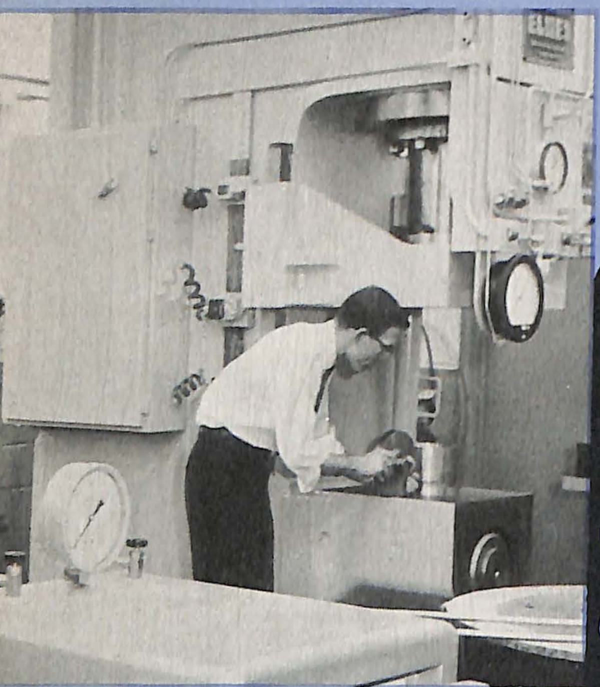
"Douglas designs, builds, manages and launches Delta. NASA brings us the payload and we put it in. NASA has a mission director and test controller on hand for the launch which will be handled by Morey Brimer, Douglas test conductor.

"You might say we furnish the driver and truck and NASA puts stuff in the truck. They tell us where to go, what 'city' to take it to. Sometimes six or seven different governmental agencies, not just NASA, may have stuff in that truck." It was Earl's truck that put up Telstar.

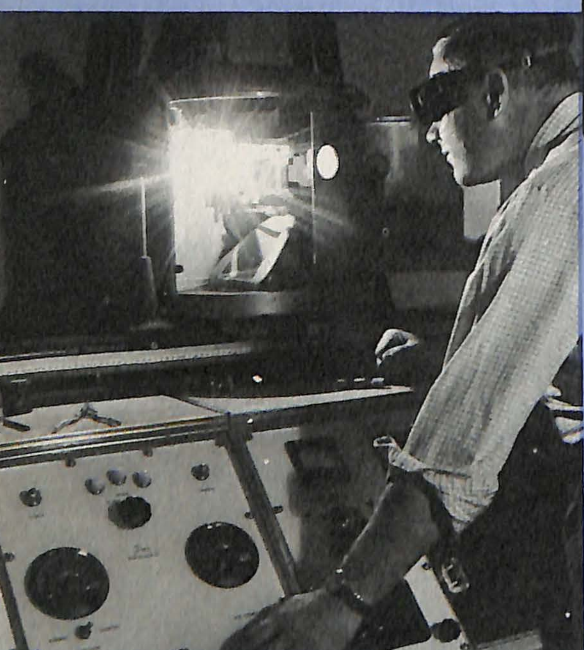


Personnel from various aerospace companies check a data sheet.

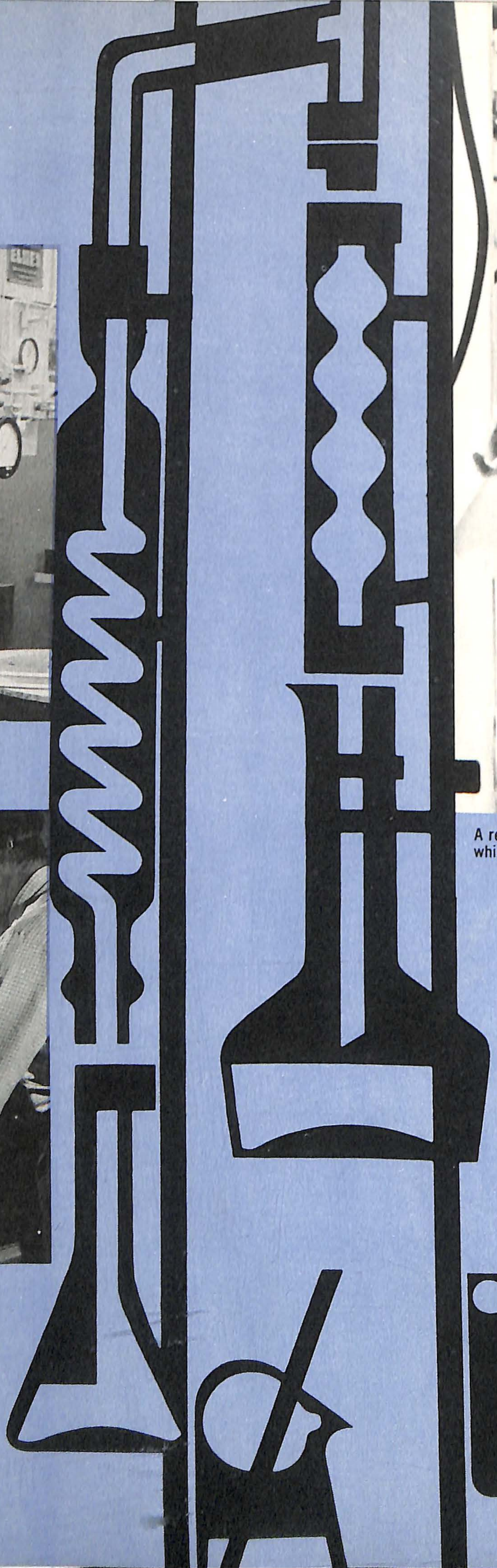


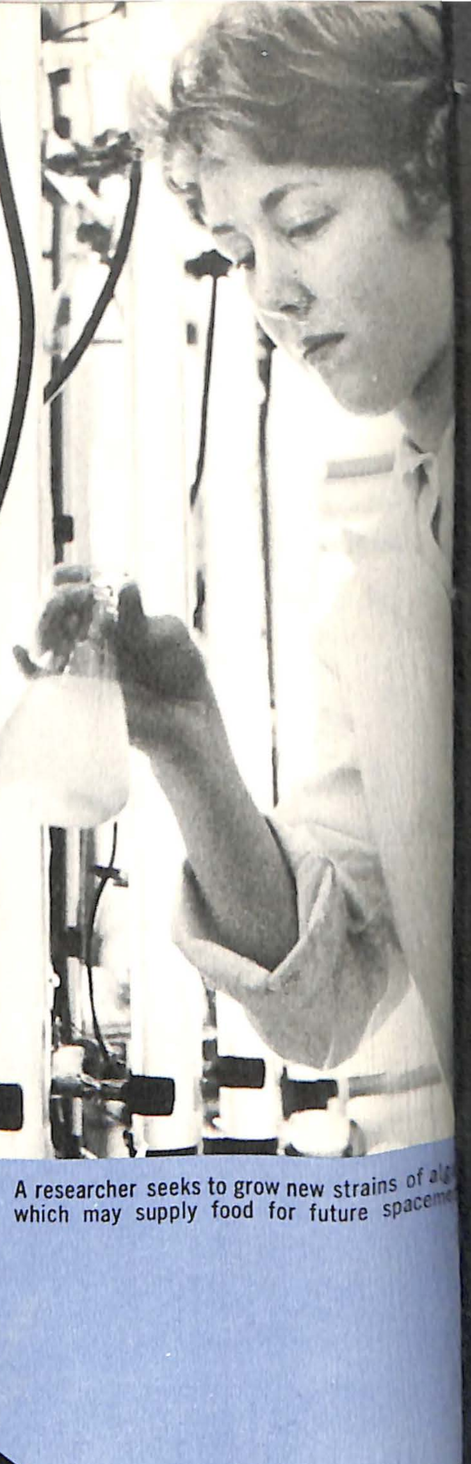


This laboratory can achieve pressures up to 70,000 atmospheres and temperatures up to 15,000 degrees Centigrade to modify materials for space applications.



An aerospace technician conducts a test with an optical emission spectrograph. A vast array of unique devices is required to meet research goals.



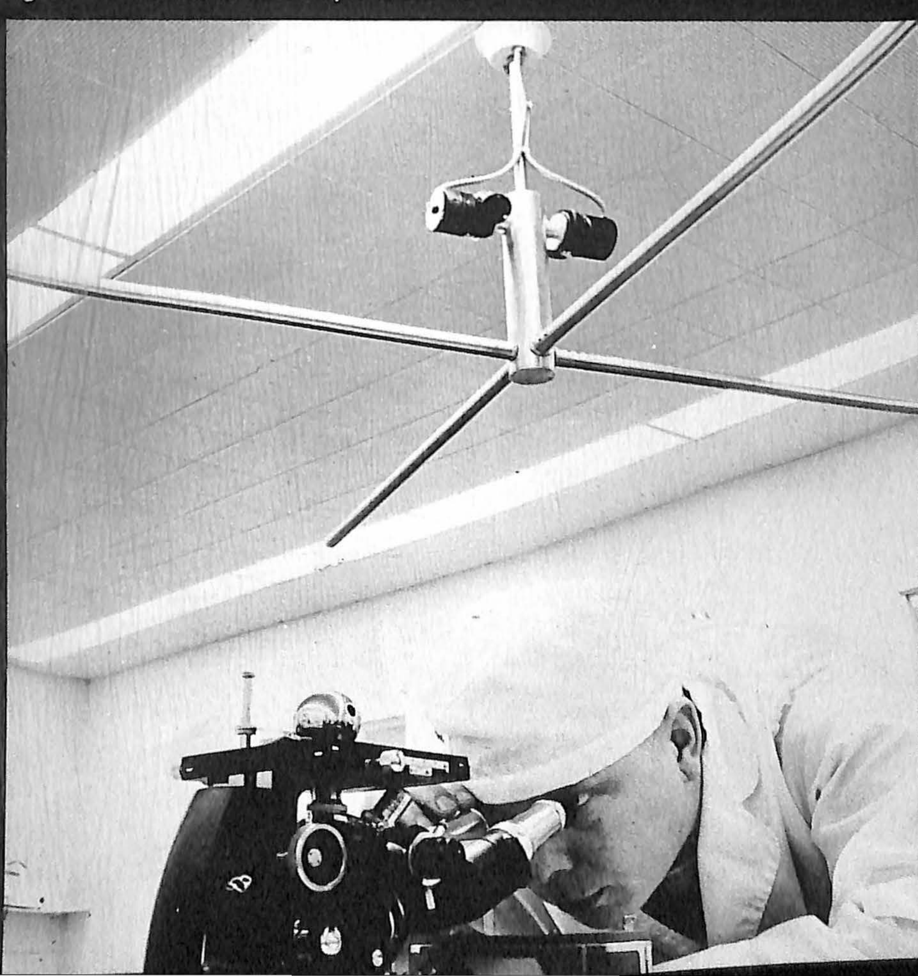


A researcher seeks to grow new strains of alg which may supply food for future spacem

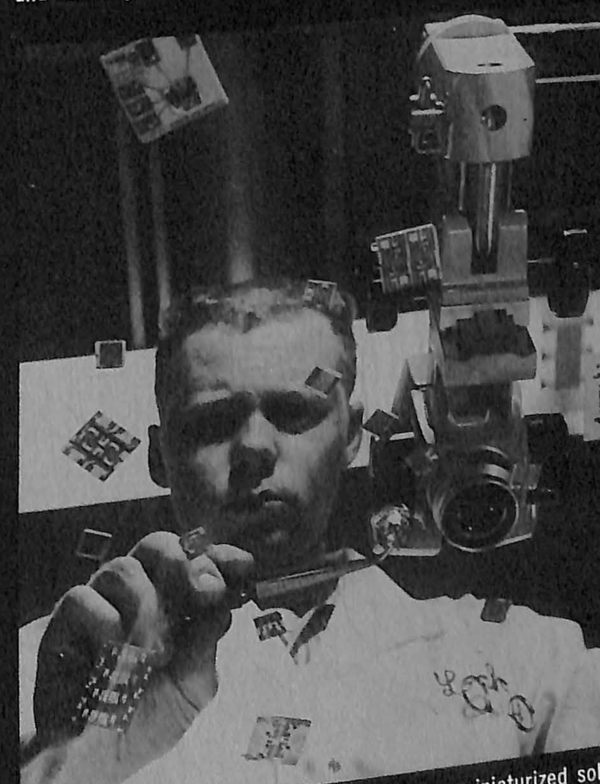
The dominating factor in the aerospace industry today is research and development. An aerospace company without a vigorous R & D program, backed by aggressive management, cannot hope to remain competitive. Ten years ago, this industry accounted for 5 per cent of company-financed R & D done by all U. S. industries. Today it accounts for about 15 per cent. Approximately 65 per cent of all scientists and engineers in the aerospace industry are assigned to R & D tasks, substantially more than any other major industry. The latest survey by the National Science Foundation shows that more than one-third of the total R & D (private and government-financed) carried out in the U. S. is accomplished by the aerospace industry. This technological capability is one of our most vital national assets.

RxESEARCH PRESCRIPTION FOR PROGRESS

A four-pronged thermostat controls room temperatures within one-tenth of one degree of the desired level. Temperature deviations of one degree can disturb precise measuring devices used in critical inspection areas.

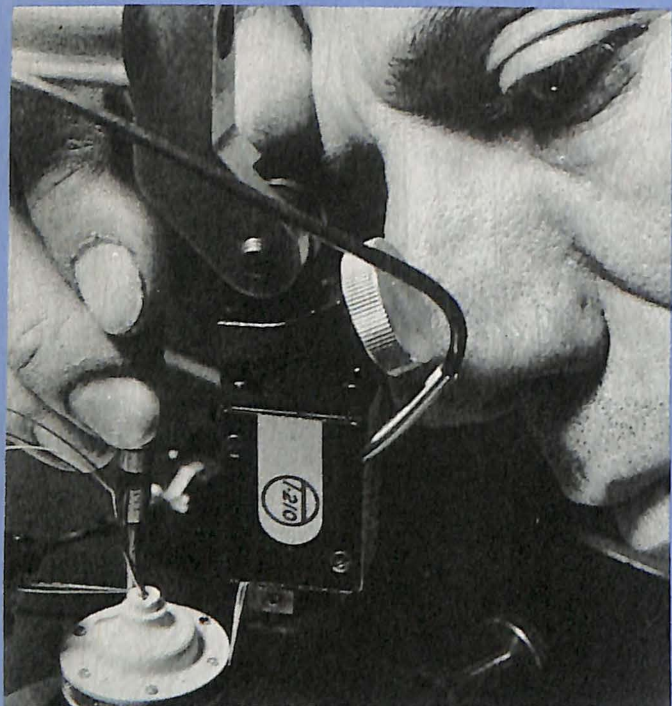


An area of bioastronautics research is concerned with the growth rate of plants under varying conditions of carbon dioxide supply and humidity.



A revolution in electronics has produced microminiaturized solid state modules (photographed through glass table). They are complete working circuits and only a fraction of the size of the first vacuum tubes.

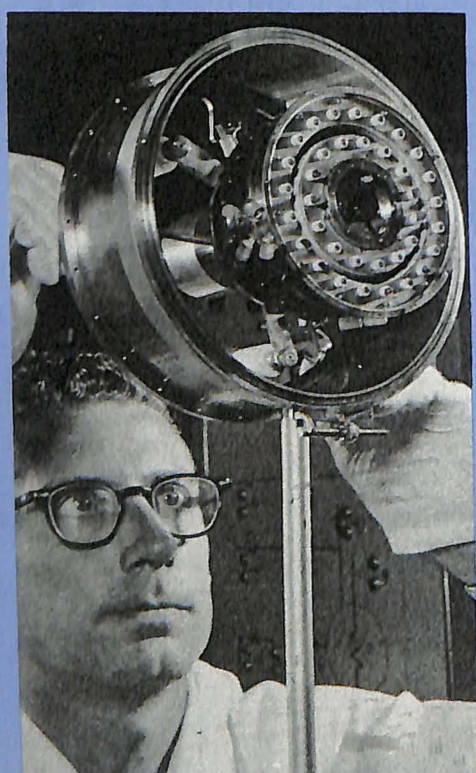
RESEARCH PRESCRIPTION FOR PROGRESS



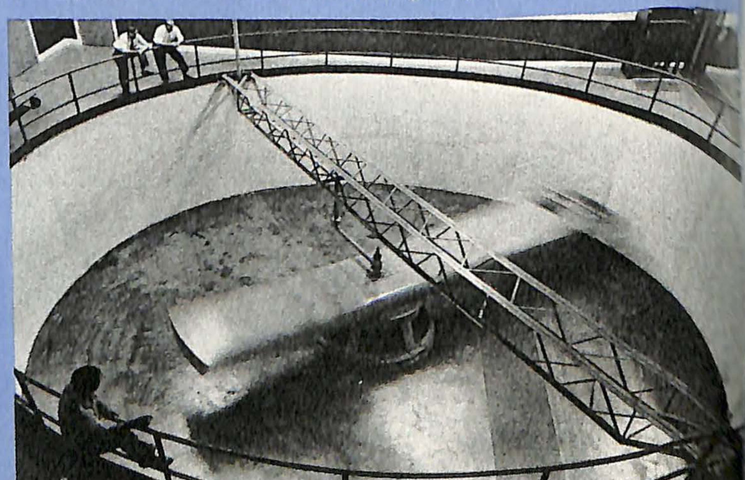
An electronic measuring device, calibrated in millionths of an inch, checks tolerances on a gyroscope's spin motor.

A compressed air device forces smoke from an oil-soaked cigar into the path of a carbon arc light reproducing the intensity of sunlight. This is part of a space mission temperature control experiment. The thick smoke makes the light pattern stand out sharply on photographs, and measurements tell if the light beams have been re-directed by an optical system to travel in parallel paths as natural sunlight does.

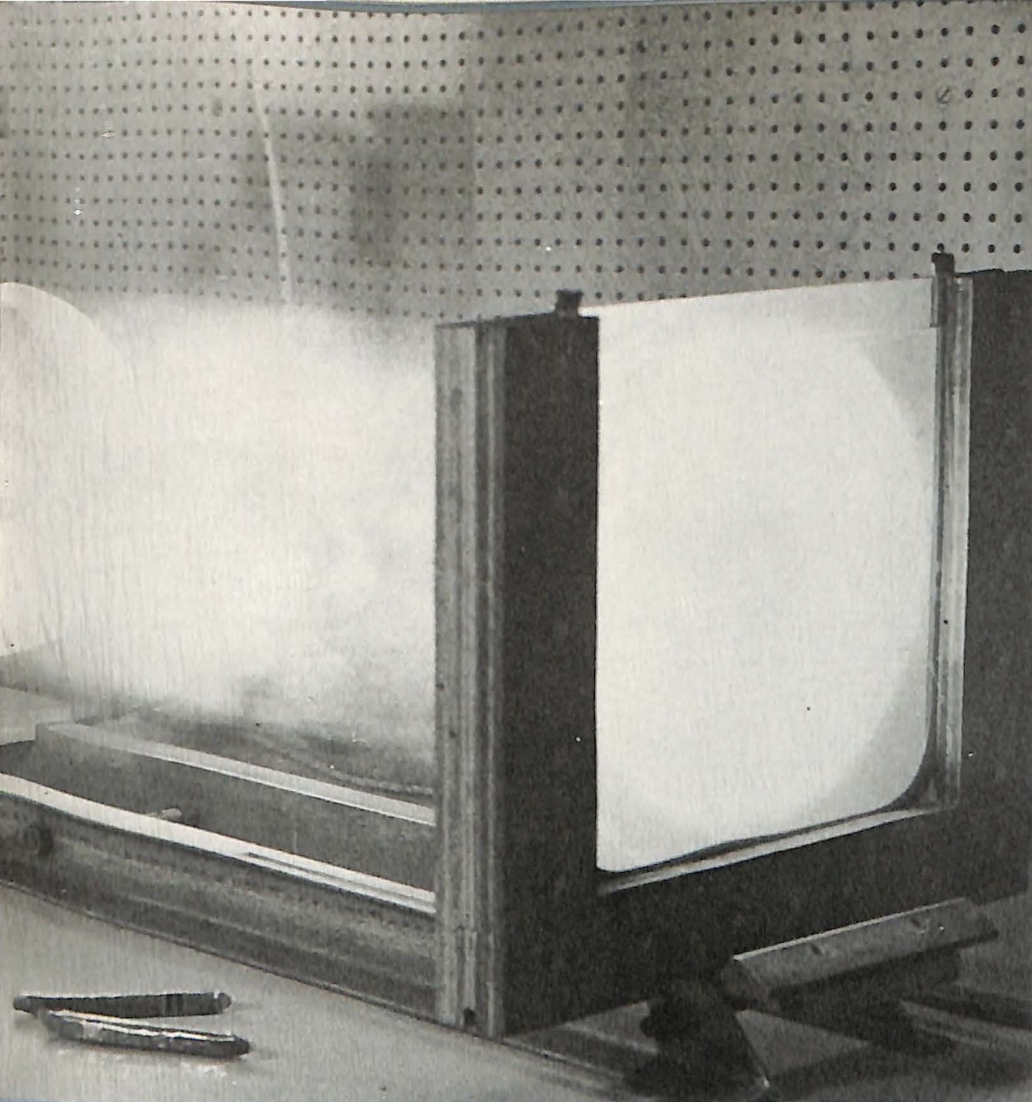
Experimental ion engine may be forerunner of a propulsion system for exploratory space flights.



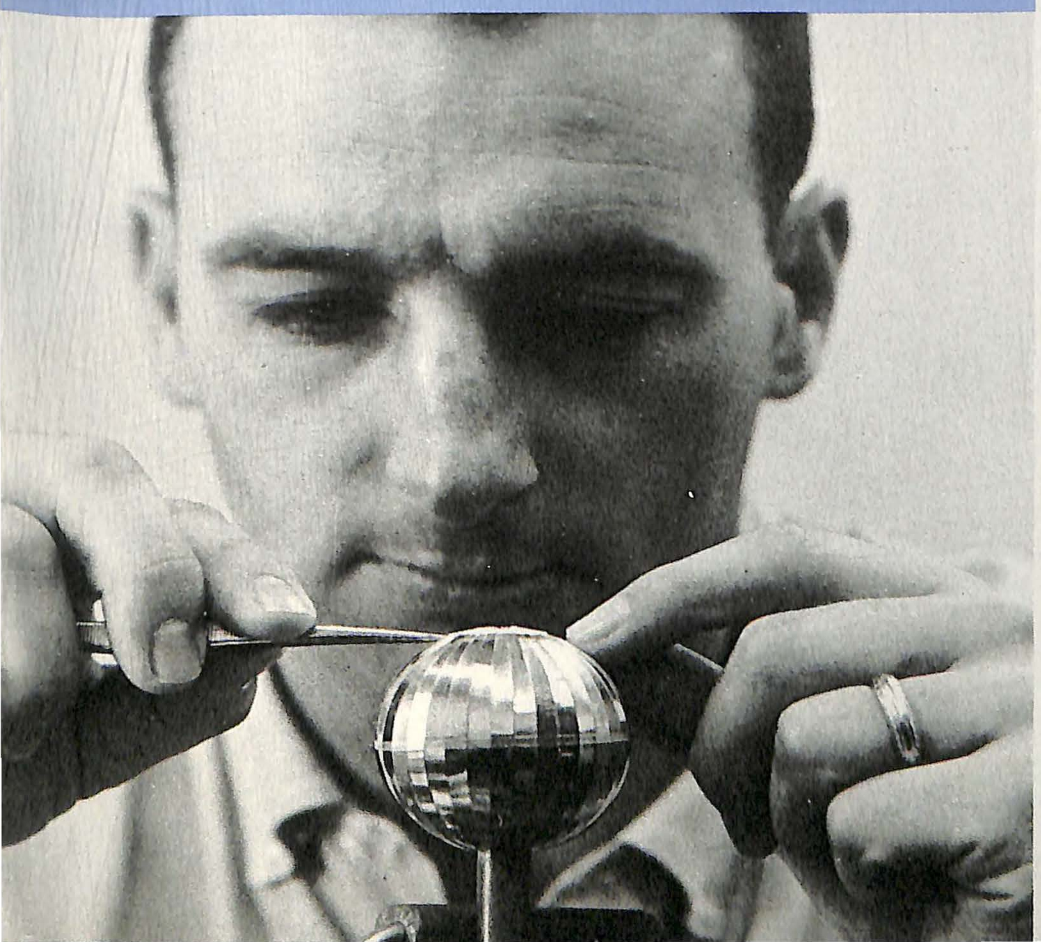
Centrifuge simulates in-flight stresses encountered by missiles, space vehicles and aircraft. Components weighing as much as 300 pounds can be subjected to 100 times the force of gravity.



Simultaneous body stresses associated with space flights are tested in this chamber.



A nuclear scientist prepares a gold sphere target which will be bombarded with sub-atomic particles. This is part of an experiment to measure interaction cross sections.



AIA MANUFACTURING MEMBERS

Aero Commander, Inc.
Aerodex, Inc.
Aerojet-General Corporation
Aeronutronic, Division of Ford Motor Company
Aluminum Company of America
American Brake Shoe Company
Avco Corporation
Beech Aircraft Corporation
Bell Aerospace Corporation
The Bendix Corporation
The Boeing Company
Cessna Aircraft Company
Chandler-Evans Corporation
Continental Motors Corporation
Cook Electric Company
Curtiss-Wright Corporation
Douglas Aircraft Company, Inc.
Fairchild Stratos Corporation
The Garrett Corporation
General Dynamics Corporation
General Electric Company
  Defense Electronics Division
  Flight Propulsion Division
General Laboratory Associates, Inc.
General Motors Corporation
  Allison Division
General Precision, Inc.
The B. F. Goodrich Company
Goodyear Aircraft Corporation
Grumman Aircraft Engineering Corp.
Gyrodyne Company of America, Inc.
Harvey Aluminum
Hiller Aircraft Corporation
Hughes Aircraft Company
IBM Corporation
  Federal Systems Division
Kaiser Aircraft & Electronics, Div. of
  Kaiser Industries Corporation
The Kaman Aircraft Corporation
Kollsman Instrument Corporation
Lear Siegler, Inc.
Ling-Temco-Vought, Inc.
Lockheed Aircraft Corporation
The Marquardt Corporation
Martin Company, the Aerospace
  Division of Martin Marietta
  Corporation
McDonnell Aircraft Corporation
Menasco Manufacturing Company
Minneapolis-Honeywell Regulator
  Company
Motorola, Inc.
North American Aviation, Inc.
Northrop Corporation
Pacific Airmotive Corporation
Piper Aircraft Corporation
PneumoDynamics Corporation
Radio Corporation of America
  Defense Electronic Products
Republic Aviation Corporation
Rohr Corporation
The Ryan Aeronautical Company
Solar Aircraft Company
Sperry Rand Corporation
  Sperry Gyroscope Company Division
  Sperry Phoenix Company Division
  Vickers, Inc.
Sundstrand Aviation, Division of
  Sundstrand Corporation
Swiss-American Aviation Corporation
Thiokol Chemical Corporation
Thompson Ramo Wooldridge, Inc.
United Aircraft Corporation
Westinghouse Electric Corporation
  Atomic, Defense and Space Group

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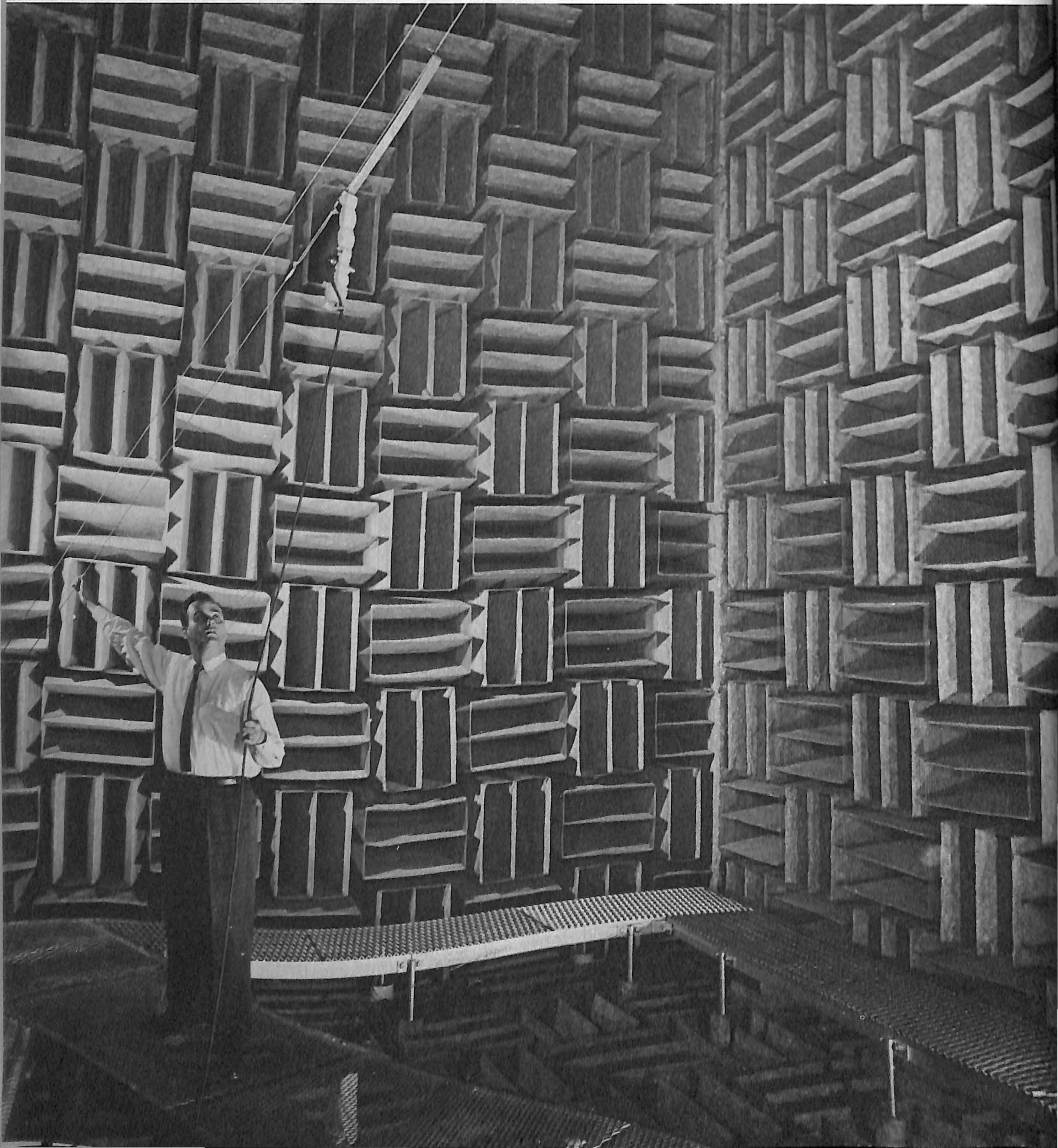
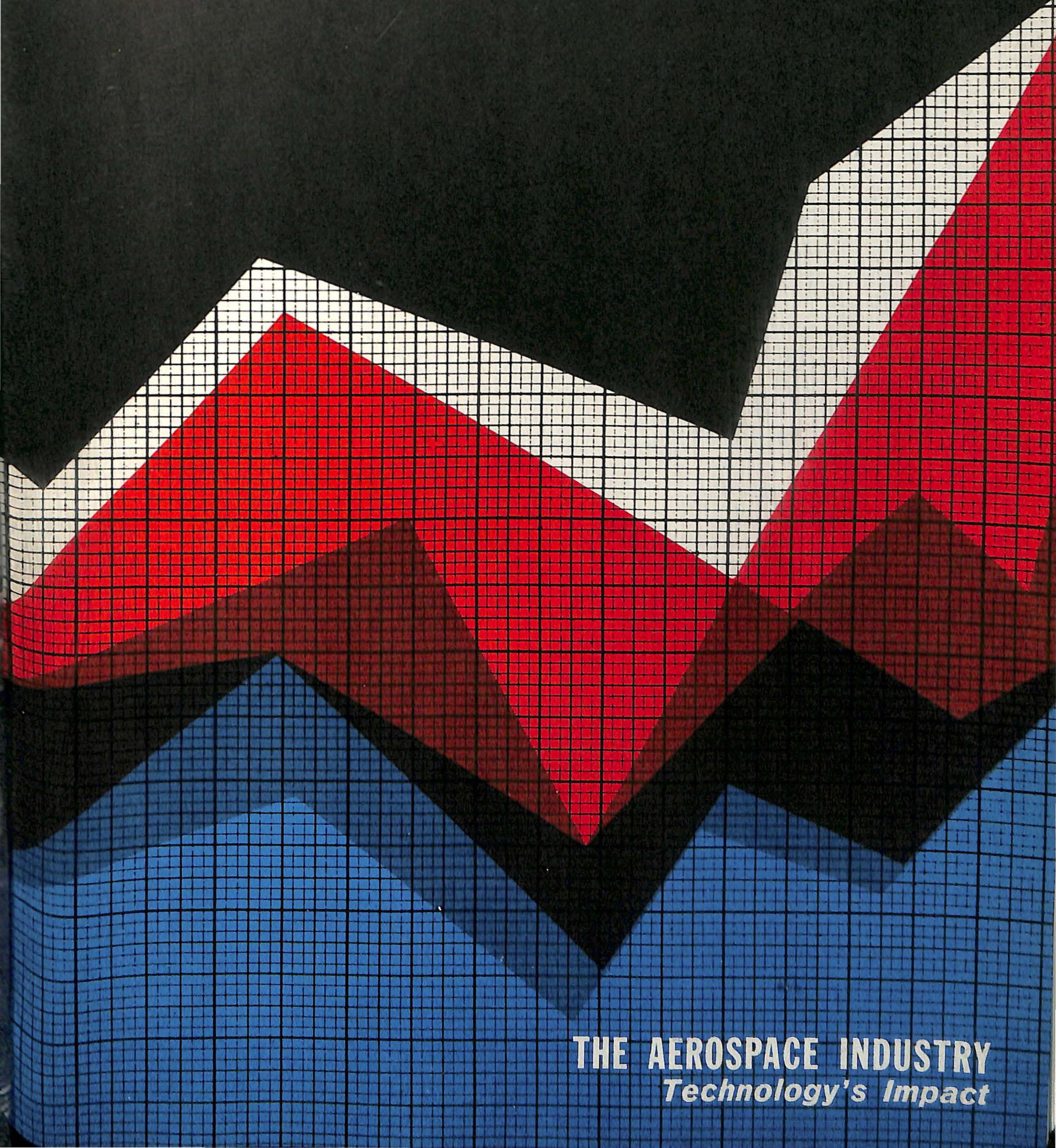


aerospace

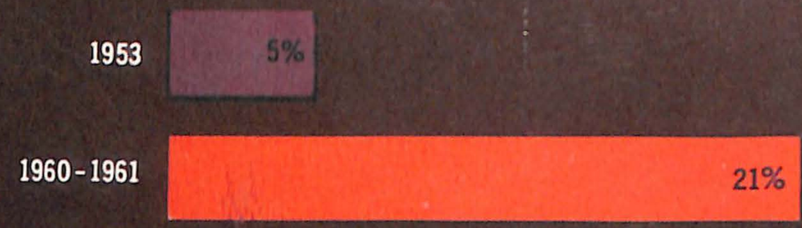
JUNE 1963



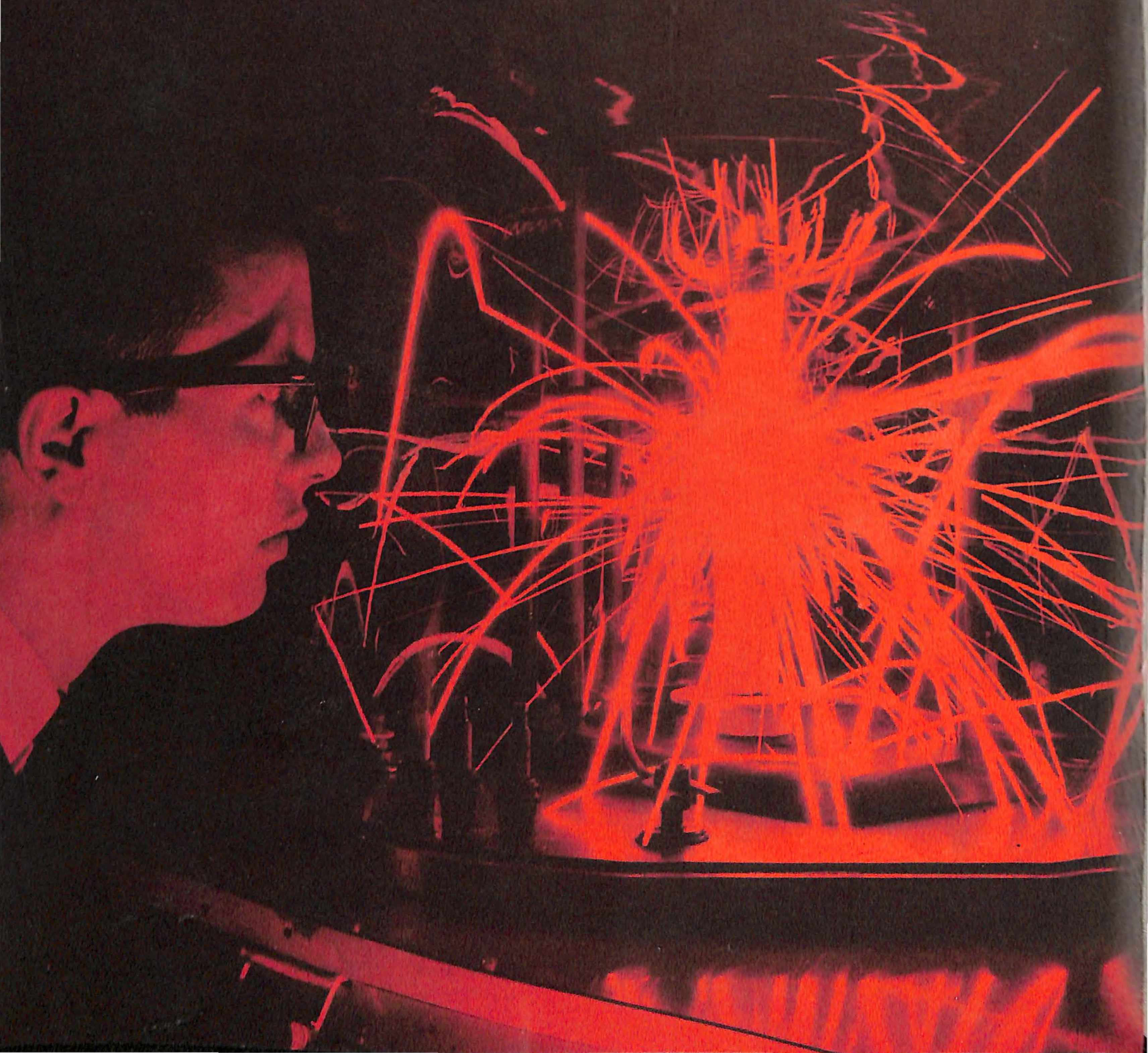
THE AEROSPACE INDUSTRY
Technology's Impact

RESEARCH AND DEVELOPMENT

(As a percentage of sales by 12 major aerospace companies)



SOURCE: STANFORD RESEARCH INSTITUTE



AIA

aerospace

Official Publication of the
Aerospace Industries Association of America, Inc.

VOL. 1, NO. 2 *JUNE, 1963*

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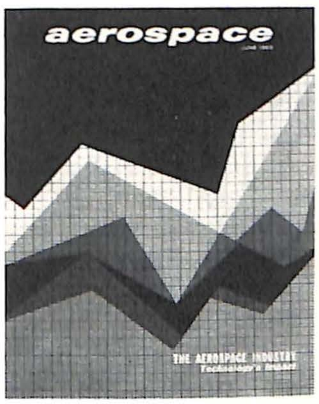
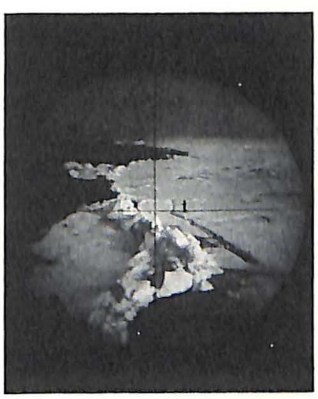


FRONT COVER: Changing industry is illustrated by Art Director Fisher



BACK COVER: Submarine's periscope frames Polar action upon emerging from depths

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems:
Foster understanding of the aerospace industry's responsibilities in the space exploration program;
Foster understanding of commercial and general aviation as prime factors in domestic and international travel and trade.

AEROSPACE is published quarterly by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

Publication Office: 1725 De Sales Street, N.W., Washington 6, D. C.
New York Office: 150 East 42nd Street, New York 17. New York.
Los Angeles Office: 7660 Beverly Boulevard, Los Angeles 36, California.

AEROSPACE ECONOMICS

"It is the practice of the United States Government to depend primarily upon private industry for the conception, the research and development and the production of defense and space systems. The achievements of industry have helped to preserve the security and the international technical reputation of the country. However, many representatives of both industry and Government believe that the industry-Government relationship is not as creative, productive or rewarding to the parties involved as it should be."

—From the preface to the Stanford Research Institute Report.

A detailed analysis of "The Industry-Government Aerospace Relationship," just completed by Stanford Research Institute (SRI), emphasizes there are "significant and difficult" problems that must be overcome if the relationship is to continue fully to meet its promise.

The Menlo Park, Calif., research organization, working under a contract from the Aerospace Industries Association, declares in its report that only a limited segment of U. S. private industry is equipped to develop the hardware needed for defense and space operations. SRI states that current requirements for facilities, talents and technology are so specialized and extensive "that there is little alternative but for the companies involved to continue to devote their principal attention to Government contracts." SRI points out that aerospace firms "must be ready to fulfill Government requirements for hardware because they are the only major source and yet be flexible enough to survive if Government demands slacken."

During the 45 years since World War I, SRI indicates, the aerospace industry can look back on four major accomplishments:

*It has successfully applied advanced technology to hardware.

*It has produced large quantities of such hardware for its principal customer, the Government.

*It has survived periods of great uncertainty and very little business.

*It has adapted itself readily to the technical challenges of the space age.

SRI says the fact that this transition was accomplished "is a tribute to the industry's management, as well as to the many far-sighted Government officials with whom the industry has worked." The industry's history is one of change, SRI adds, "with its managements' attention caught up in the rapid expansion and precipitous contraction of business as well as with dramatic advances in technology."

The report cites the "conflicts and frictions" that result from differing objectives of our economic and political systems as reflected in the industry-Govern-

Stanford Research Institute makes first comprehensive, independent study of Industry-Government relations since the advent of the space age

ment aerospace relationship and suggests that the preponderance of bargaining strength is on the Government's side. The U. S. has "strength through control of funds, definition of goals, timing and technique, encouragement of competition, participation in management, the application of political pressures and power to terminate contracts."

According to SRI, the industry's chief balancing force lies in the fact that it "retains most of the capability, initiative and creativeness to accomplish the complex tasks that appear necessary to assure the nation's survival." SRI also states, "It is industry that is supposed to be able to utilize the nation's resources of manpower, money and material in the most efficient ways. It is industry that is in a position to recognize the real cost and time delays involved in the Government's attempts to utilize defense and space contracts to achieve social and economic ends. It is industry, not Government, that could more aggressively lead the way in developing newer and more efficient means of reaching hardware goals." The Stanford study calls on the aerospace industry to recognize these responsibilities and challenges and urges that aerospace firms not dissipate their talents by defending themselves "occasionally without justification and often ineffectively" against what they consider over-regulation and over-management by the Government.

The SRI study group reports 12 trends now influence the relationship between the industry and the Government. The changing relationship is caused by:

(1) An increasing national and international pressure for spectacular technical advances.

(2) A decreasing requirement for volume production of system hardware and an increasing attention to research and development.

(3) A reduction in the number of large systems authorized and funded.

(4) A move toward making single systems fill multi-Service needs.

(5) Greater attention to system definition prior to contracting.

(6) A centralization of major procurement decisions in the Office of the Secretary of Defense.

(7) An increasing emphasis on competitive award of contracts.

(8) Increasing pressure for more general geographic distribution of contracts.

(9) Increasing use of cost-plus-incentive-fee contracts rather than cost-plus-fixed-fee contracts.

(10) Increasing pressure on industry to assume a greater share of the risks in defense-space activity.

(11) Increasing detailing of procurement regulations and closer Government supervision of contractor activities.

(12) Increasing military attention to relatively unsophisticated, conventional warfare systems.

Cited as "major problems now present in the industry-Government aerospace relationship" are:

- Industry consideration that its technical performance, costs, income and reputation are being affected adversely by over-regulation, conflicting regulations, ineffective administration of regulations, close (and not always capable) Government surveillance of its activities and burdening of the procurement process with socio-economic objectives.
- The attitude of many Government officials, based on past experience, that without close supervision or risk-carrying incentives, industry cannot always be depended upon to fulfill its contractual obligations on time or at reasonable cost.
- The general belief of industry executives that the Government's often inconsistent, loosely specified,

but increasingly stringent attitude concerning allowable costs is detrimental to the industry's well-being.

- Disagreement between industry and Government over the profit rate that constitutes and adequate return. This disagreement stems largely from varying opinions concerning the extent of risks borne by the industry and industry's cost in maintaining and advancing technical capability.
- The absence of a "free-market" environment in which the industry and Government do business, which requires special attention to the balancing of capacity with requirements. The means to accomplish this desirable objective have yet to be resolved.

In trying to explain the reasons why these problems exist, SRI researchers pinpoint:

(1) The seeming lack of complete mutual confidence and respect between industry and Government.

(2) Absence of a clear understanding and general acceptance of industry's and Government's proper roles in the relationship by all levels of the business community and by Federal employees involved.

(3) Industry's failure to appreciate fully the nature

PROPOSAL PROBLEMS

Stanford Research Institute reports from a reliable source that 18 per cent of the aerospace industry's top scientific and engineering talent is working on proposals for new business rather than concentrating on existing contracts. About 75 per cent of this effort is spent on proposals which are rejected by the Government.

Many in industry and Government consider the proposal effort worthwhile because "each unsuccessful effort is said to insure better understanding and capability for the next attempt."

SRI researchers point out that some waste is involved, particularly in smaller competitive procurements. "It is reported that often the cost of the efforts involved in the competition, both for proposal writing and for proposal reviewing, exceeds the value of the contract awarded," according to SRI.

of the often delicate interactions that must take place between Government agencies in reaching decisions of importance to the relationship. Also, industry mav not fully realize the full significance to Government officials involved or to the industry itself of the unfavorable reactions generated by contract schedule slippages and over-expenditures.

(4) The failure of Government representatives, in turn, to recognize or admit to the impact on industry's performance of conflicting, vague, voluminous and changing regulations, and their inconsistent interpretation and administration.

(5) A tendency on the part of the (military) services as buying agencies to devote too little attention to the formulation of requirements, thereby specifying needs too generally, using the need for action and flexibility as justification. Auditing of technical factors is difficult.

(6) In contrast, cost and contract audits are easily and frequently made. The result may be that Congress and the buying agencies pay too much attention to preventive legislation and regulation. In this way the transgressions or failures of some become the bases for continuing burdens and expense to all.

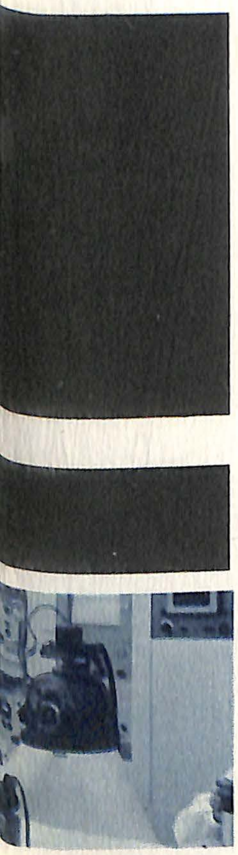
(7) Congress, in attempting to protect the public interest, has enacted legislation and established agencies whose subsequent actions, vis-a-vis industry, are not fully coordinated and are frequently conflicting.

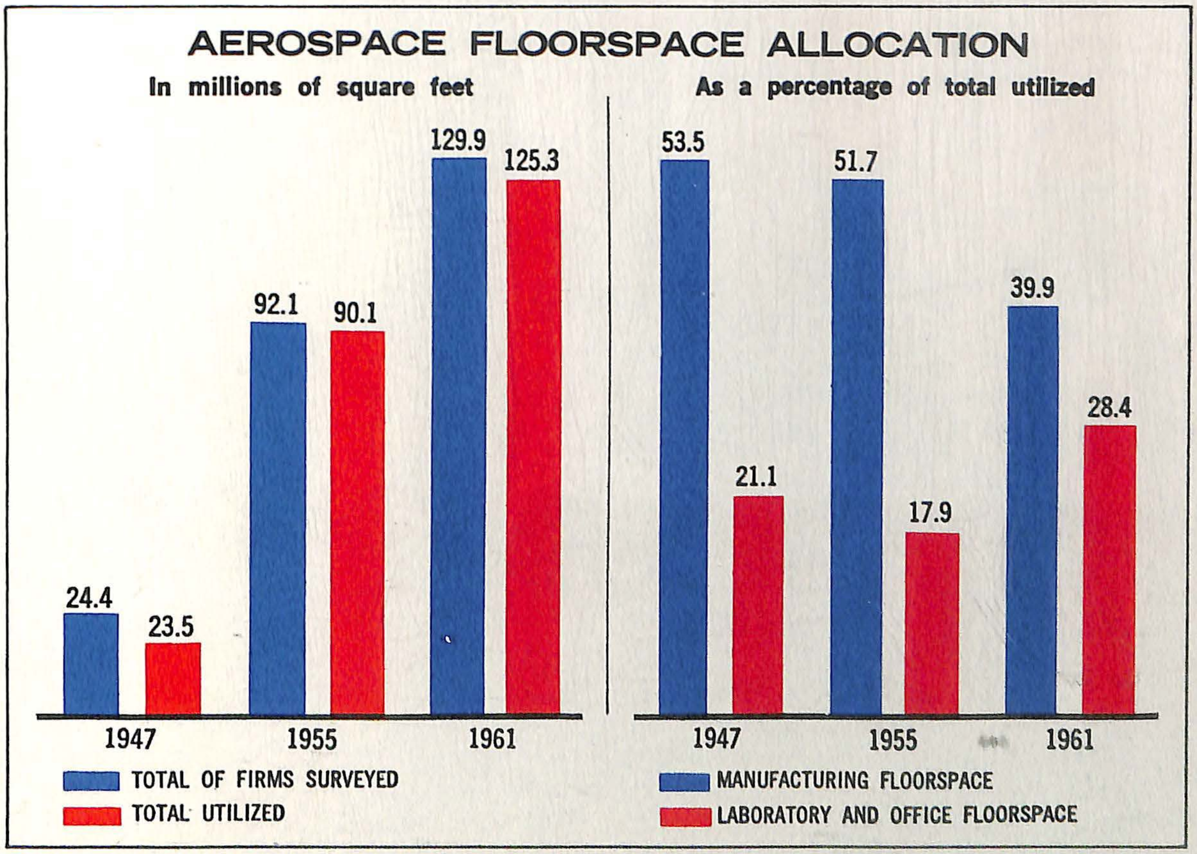
(8) The flexible CPFF contracts applied to programs involving high technological risk have led to some inefficient practices and increased costs in both industry and Government.

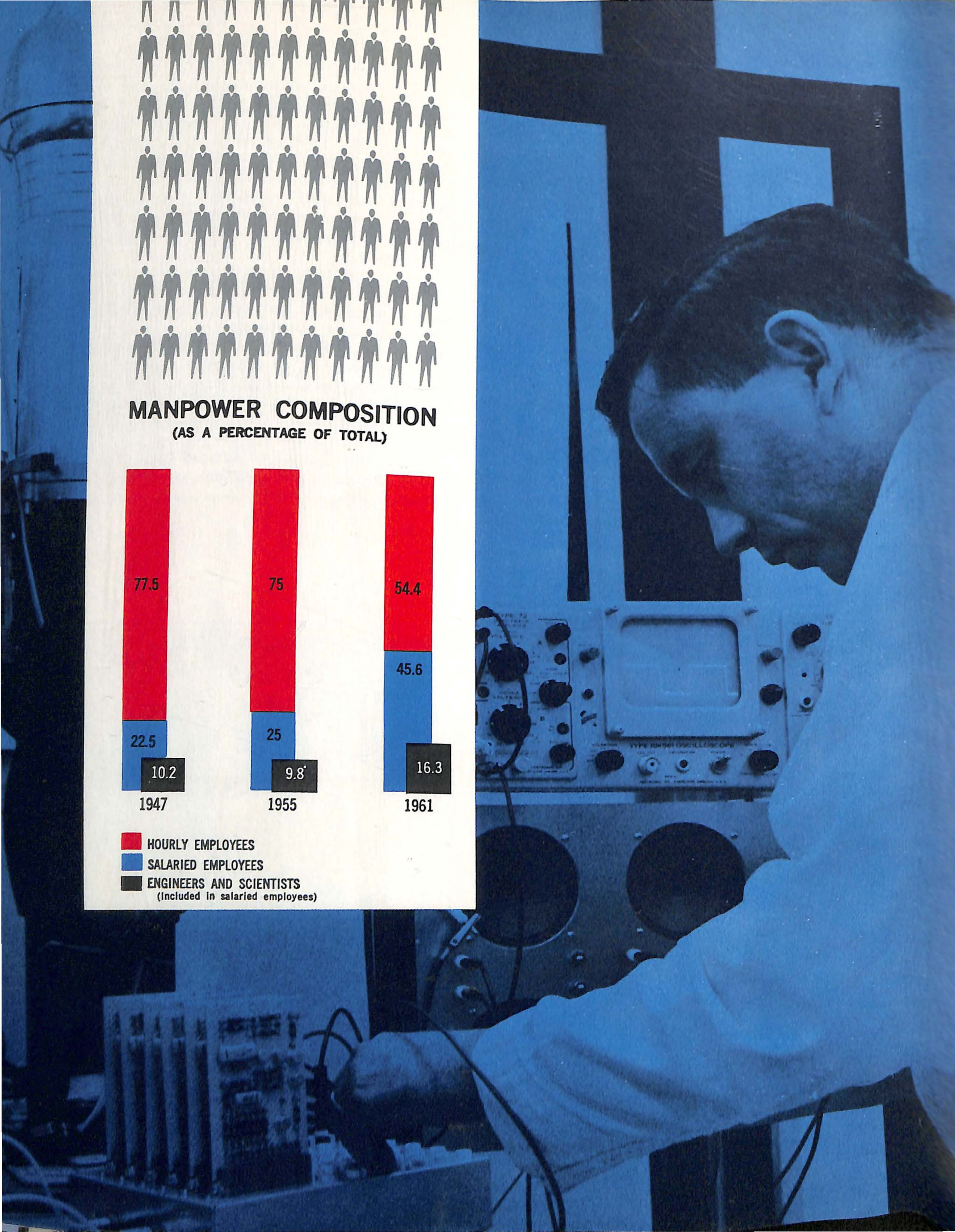
(9) The detrimental impact on delivery schedules and cost targets of program changes encouraged, by generalized specifications may not be fully appreciated by either industry or Government.

(10) Even though some key Government procurement officials admit to "over-managing" industry and express the desire to "disengage," steps to do so have been limited to the application of CPIF-type contracts and study of regulations that might be relaxed when such contracts are employed.

(11) The Government's reduction of facility funds and limitations on progress payments are shifting to







MANPOWER COMPOSITION
(AS A PERCENTAGE OF TOTAL)
77.5
22.5
10.2
1947
75
25
9.8
1955
54.4
45.6
16.3
1961
HOURLY EMPLOYEES
SALARIED EMPLOYEES
ENGINEERS AND SCIENTISTS
(included in salaried employees)

industry a greater burden in maintaining an adequate aerospace capability. The shift is well under way. However, there has not been agreement on the extent to which the risk should be shared between industry and Government or on the level of industry compensation warranted.

(12) The relationship between industry and Government until recently was of great material and economic consequence only during actual war. Major industrial activity in support of the national defense in peacetime accounted for a relatively small portion of the nation's Gross National Product (GNP). Since Korea, however, world tensions and weapons capabilities have required the maintenance of an aerospace industry capability that alone generates about three per cent of our gross national product and an even greater proportion of U. S. manufacturing volume and employment. Thus, location and relative efficiency of this industrial operation have become matters of current national interest and concern, and some political activity. This has increased the stresses and strains in the relationship.

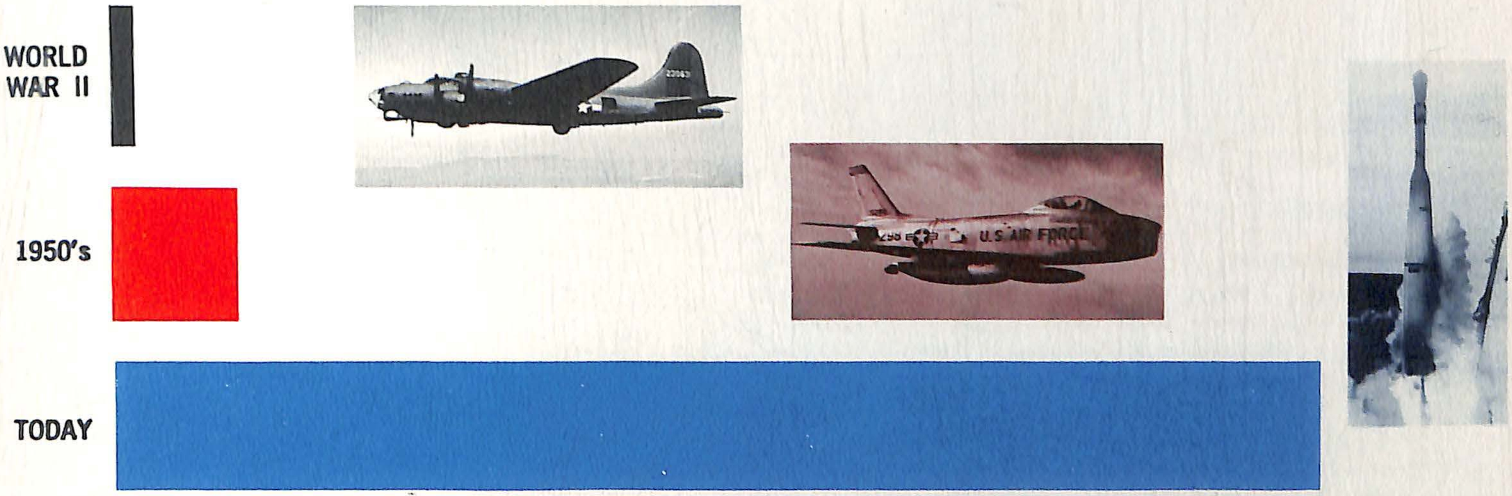
(13) However much it might wish to the contrary, a major portion of the industry is not "free enterprise" in the classic sense of the term and does not operate as such. Because of its almost complete dependence on the Government, it seldom takes firm positions in opposition to the Government's desires, however justified.

On the matter of "regulating" the aerospace industry,

NON-PROFIT ADVISORS

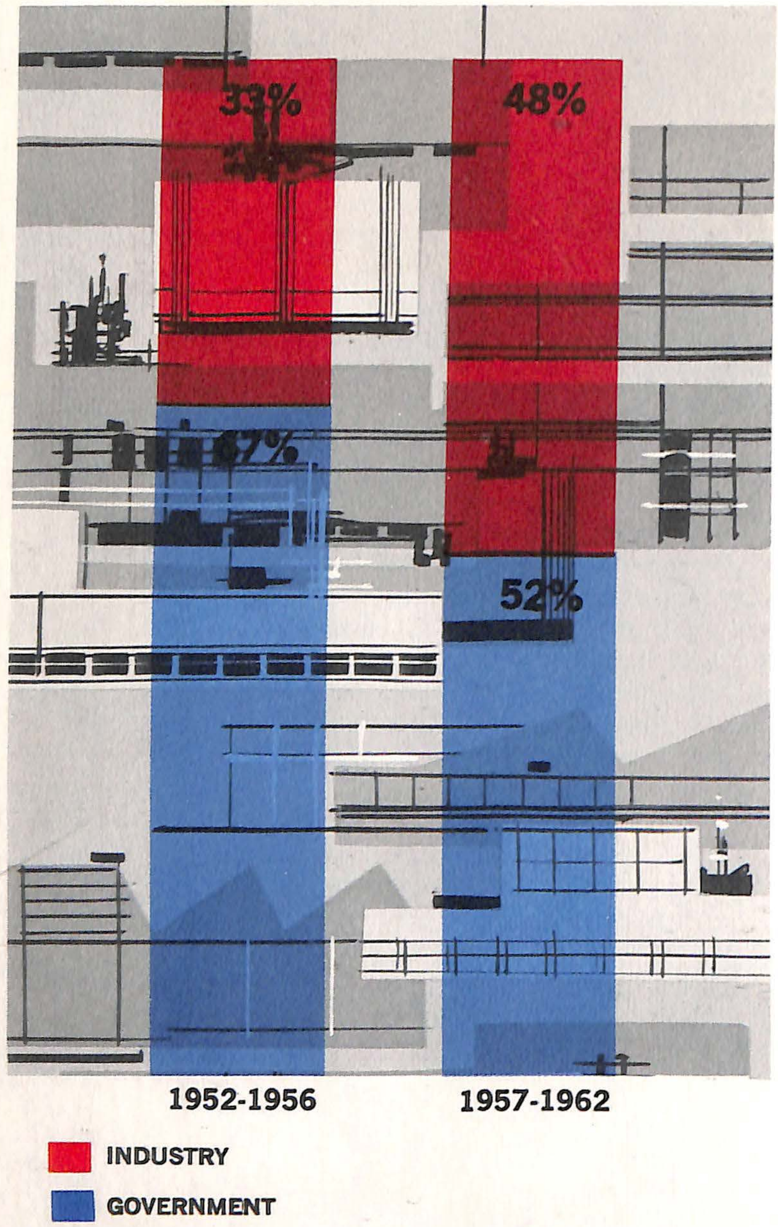
The U. S. has come to rely increasingly on the use of specially created non-profit organizations to advise and assist in advanced weapon system programs. Researchers for the Stanford Research Institute indicate that few aerospace companies quarrel with the Government's right to obtain expert opinions. "Since the expertise that the Government requires must be both impartial and objective, it follows that specialized organizations have an important part to play as technical advisors," the report states.

But, SRI's report points out, aerospace companies "are concerned about the fact that these organizations, in their role as technical advisors to the Government, appear to be taking over a portion of industry's one-time role in conceptualizing new systems and components and are becoming increasingly active in the conduct of research." SRI also reports the industry's concern about "the relatively aloof and sometimes competitive attitude of these special organizations in their consideration of ideas. This is important because the livelihood of the industry is increasingly at the research and development level where proprietary ideas are crucial. Industry must be careful not to mix "fancy" with fact in submissions, however.



Cost per pound of aerospace products has increased sharply. In World War II, a period of very high production, cost was about $10 per pound; in the 1950's cost per pound soared to $100. Today it is $1,000 per pound. Technological gains have shown an even greater increase.

FACILITIES
(GOVERNMENT AND INDUSTRY INVESTMENT)



During the 1952-56 period, Government investment in aerospace facilities amounted to 67% of the total. In the 1957-62 period, the Government portion had dropped to 52%. From 1947 to 1961, 22 aerospace firms spent $2.1 billion of their own funds for new plants and equipment. This amounted to 36% of their total net earnings during the 15-year period.

the SRI study points out that this control is not exercised by an independent commission (e.g., Civil Aeronautics Board, Interstate Commerce Commission, Federal Power Commission) before which the public and industry can present their cases. SRI reports this control is accomplished "unilaterally through procurement regulations and other provisions that may be included in Government contracts." The result of these Government actions, according to SRI, is they "to some degree transform the members of the aerospace industry into closely controlled agents of the Government for the operation of 'arsenals' for modern weaponry and space exploration." SRI suggests that the 'anomaly' is, "the aerospace firms are expected to act with the drive, efficiency and flexibility usually attributed to private enterprise."

SRI's research team suggests that industry "learn how to retain the advantages that private enterprise offers society, while serving the vital needs of the nation and selling to a customer with formidable bargaining power." The Government at the same time is urged to learn to distinguish "between those regulations that protect the public's financial interests without jeopardizing the national security and those regulations where short-run financial savings are outweighed by the loss of industrial incentive and creative ability."

The report declares that partly because of failures on the industry's part the aerospace industry currently "is overwhelmed with Government red tape and surveillance," adding that this is "a period of discomfort and disenchantment on all sides."

Noting that Government agencies and the aerospace industry work closely in research and development and weapon system procurement, and that industry is considered essential as a source for new ideas, SRI researchers nevertheless emphasize that initiative for even the first step—demonstration of feasibility—normally rests with the Government because of high costs. This single fact, the report states, "more than any other, has contributed to industry's uncertainty about its future business." SRI also points out that managements are often more concerned with getting the contract than managing it because "past performance is not necessarily a major factor in the awarding of new business" and cites the current lack "in the Defense Department, at least, of a reasonable and generally applied method of contractor performance evaluation."

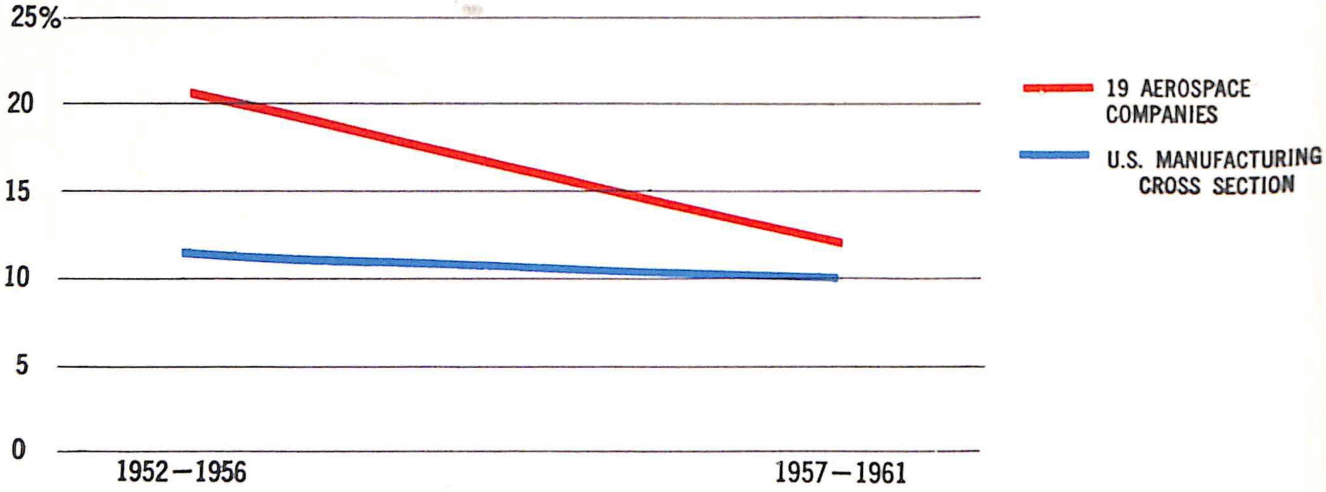
The SRI report indicates that the industry's future cannot be predicted with any degree of certainty. Relations with other nations and space progress will be determining factors. Governmental efforts to centralize control of procurement, limit the number of weapon systems, increase competition, supervise work in process and make greater use of incentive-type contracts will also be influential. SRI's report concludes: "Whether or not, in the face of these moves, the industry can maintain its initiative and unique abilities remains to be seen."

FINANCIAL PROFILE

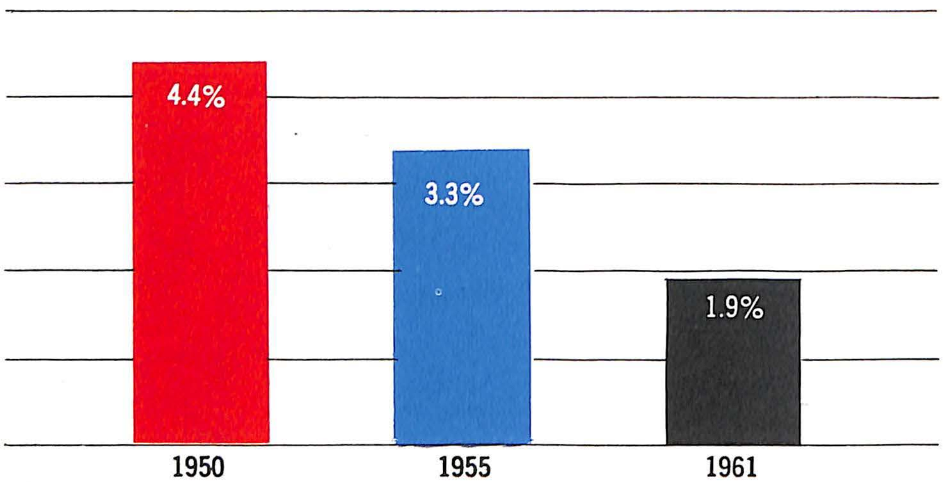
The Stanford Research Institute study group compiled much new data on the aerospace industry. The following paragraphs summarize the highlights:

- Sales of 16 leading companies varied widely over three consecutive five-year periods. Between 1947 and 1951, total sales for the 16 firms amounted to $7.8 billion. Between 1952 and 1956, aggregate sales came to $32.5 billion. And between 1957 and 1961, the total sales reached $50 billion. Over the 15 years, the 16 firms sold $81.5 billion (or 89 per cent of the total) to the U. S.
- Between 1948 and 1961, a representative group of companies farmed out 45 per cent of their total work and retained 55 per cent in-house. Usually, firms which did 90 per cent or more of their business with the U. S. subcontracted more of their work (48 per cent) than firms with lesser reliance on Government orders (43 per cent).
- Research and development spending by 11 companies soared from $100 million in 1947 to more than $2.1 billion in 1961. About 84 per cent of this R & D was Government-sponsored, another 10 per cent was company-sponsored but recoverable through indirect charges on other U. S. contracts and about 6 per cent was completely industry-financed. R & D spending was equivalent to 17.5 per cent of sales, including 1 per cent of sales financed out of earnings. But the 1 per cent was a substantial investment for firms with a traditionally low profit margin on sales.
- Unrecoverable costs are mounting steadily. Interest payments to finance expansion—just one disallowable item in U. S. contracts—rose from $1 million in 1950 to $4 million in 1955 and $26 million in 1961 for 12 reporting companies. Other disallowable items (advertising costs, selling costs, company-financed R & D) are also climbing.
- Sales of complete aircraft, aircraft engines, propellers, and parts reached a postwar peak in 1957 ($11.75 billion) and has since leveled off. By 1960, decline in sales of complete aircraft, engines, propellers and parts amounted to nearly $3 billion. During the same period, the drop was counterbalanced by increases of more than $2 billion in the sale of other products and services, including missiles.
- Industry sales (for a larger group of companies than those cited above) amounted to nearly $15 billion in 1961, including $11.5 billion in sales to the Government. The $15 billion equalled 3 per cent of the GNP in 1961; the $11.5 billion amounted to more than 23 per cent of U. S. spending on defense.
- Employment by aircraft and parts firms totaled 338,000 in December 1950; 769,000 in December 1955 and 646,000 in December 1961. An additional 140,000 employees in 1961 were on the payroll of missile producers not classified as part of the aerospace industry.
- Payrolls met by aircraft and parts manufacturers rose from $1 billion in 1950 to nearly $4 billion in 1955 and $4.5 billion in 1961. About $1 billion more was paid out in 1961 to missile workers employed by non-aircraft companies.
- Military spending for aircraft and parts dropped from the $9.1 billion postwar high recorded in 1954 to less than $6 billion in 1961. But sales of aircraft and parts to other customers (commercial airlines, etc.) during the same period jumped from $800 million to $2 billion.
- Exports of aeronautical equipment edged upward from $1 billion in 1957 to $1.3 billion in 1960, slid back slightly to $1.2 billion in 1961 and reached $1.4 billion in 1962. Aeronautical imports simultaneously tripled from $53 million in 1957 to $152 million in 1961.

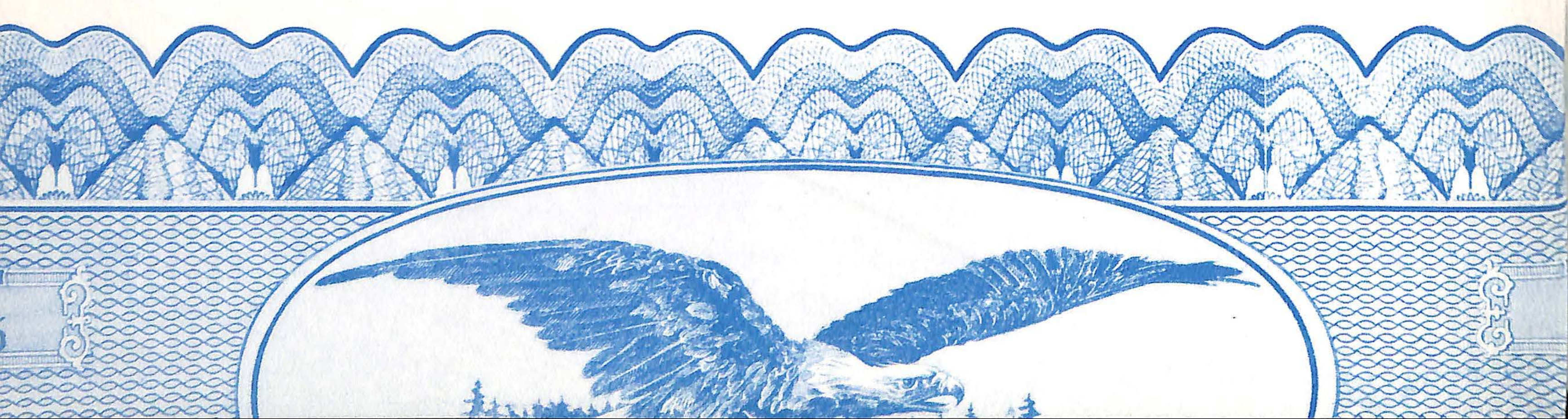
PERCENTAGE RETURN ON NET WORTH



PERCENTAGE RETURN ON SALES



After tax earnings for 12 major aerospace companies declined from 4.4% of sales in 1950 to 3.3% in 1955 to 1.9% in 1961. During the 1947-1961 period, 20 leading aerospace firms paid out 55% of their net earnings to stockholders as dividends.



SRI Recommended Actions:

TO BE INITIATED BY INDUSTRY:

- Encourage government's "disengagement" from its position of overmanaging industry, by developing and suggesting simpler, more effective, and less costly surveillance techniques.
- Assist in crystallizing and adopting a uniform and fair performance evaluation technique, a study of which is currently under way.
- Take steps to consolidate and present industry's points of view on critical issues, while also giving sufficient recognition to the merits contained in divergent views.
- Proceed with studies to determine industry's risk and relate it to required rates of return, investment requirements, and similar measures of the adequacy of the industry's over-all performance.
- Encourage the adoption, on an individual contractor basis, of principles for guidance in government relationships.
- Encourage additional meetings between industry and government to discuss common problems. Be prepared to offer factual evidence of needs for change.

TO BE INITIATED BY GOVERNMENT:

- Intensify efforts to determine requirements and define programs before initiating development contracts.
- Through contractor performance evaluation, depend increasingly on end performance rather than detailed in-process review in the monitoring of contractor activities.
- Policy level offices of the Department of Defense, NASA, and AEC should initiate whatever steps may be necessary to assure implementation of policy at all working levels.
- Initiate efforts to simplify the organizational structure and reduce the costs of contract surveillance.
- Conduct and encourage further study of contracting and its implications for public policy.

TO BE INITIATED JOINTLY BY INDUSTRY AND GOVERNMENT:

- Undertake to simplify regulations and eliminate conflicts and confusion.
- Organize and conduct a series of top-level industry-government-wide policy discussions on the nature of mutual problems, toward agreement on solutions.
- Organize and conduct a series of educational seminars for industry and government working-level liaison personnel to improve understanding and application of policies and procedures.

OCEAN FRONT

Triangular-shaped sonar reflectors provide a bearing f
submarines in an underwater acoustic range experimen

Three times in the second half of the 20th Century tremendous new markets have opened up for which the broad talents and capabilities of the aerospace industry are especially well suited.

The first was the advent of the guided missile, which though markedly different in design and employment from the previous prime weapon system, the aircraft, had a number of commonalities with its forerunner which made the aerospace industry its logical producer. The second was the space exploration vehicle, made possible by missile technology.

The third is the now-developing exploration and exploitation of the world ocean—that vast little-known realm consisting of more than 300 million cubic miles of seawater and covering 70.8 per cent of the earth's surface. In its depths are not only great military potential, but also the answer to the world's mounting hunger for greater resources of raw materials, for the restless enterprise of business, for the insatiable quest of man for new worlds to explore and for an adequate diet for the planet's ill-fed millions.

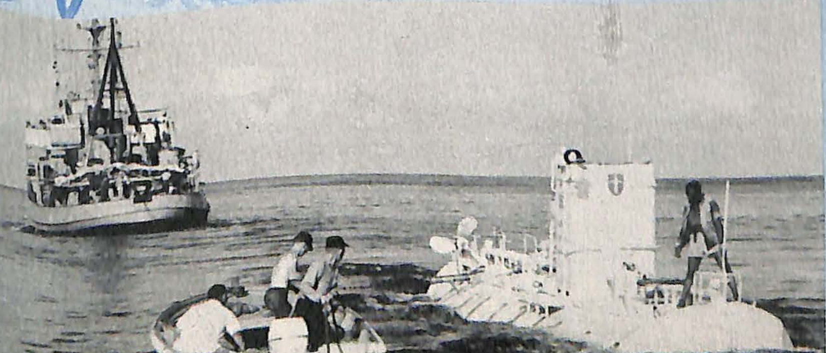
In terms of dollars, the U.S. will spend over $2 billion on ASW (anti-submarine warfare) in fiscal year 1964—money for all classes of ships, planes, submarines, ocean-floor listening stations, sonar, magnetic detection gear, rocket-boosted torpedoes, and nuclear depth bombs.

The Polaris Fleet Ballistic Missile program will be another $2 billion. By 1965 this program will have put 41 boats to sea armed with a total of 656 nuclear warheaded missiles, each with a range of 2,500 nautical miles.

Federal spending for oceanography, exploration and research in the sea, has increased an average of 50 per cent a year for the last three years; it will top $155 million in FY-'64, covering everything from acoustical studies and the geology of the ocean floor to the migrations of fish, and efforts to forecast deep sea "weather" conditions.

ERS

By SEABROOK HULL
and E. H. MARTIN
Ocean Science News



Private industry is spending over $5 million a year on oceanographic research, and additional tens of millions of dollars in the search for undersea minerals and in other "profit-potential" aspects of ocean research and exploration.

Dramatic evidence of the changing technology of undersea operations is provided by the fact that there is hardly an aerospace company that does not have its ASW, oceanic, oceanographic, hydrospace, or ocean operations division or department. This is true of aircraft, missile and spacecraft companies, of the major electronics companies, and of many firms concerned primarily with high-performance structures and materials. All told there are probably over 200 companies with a major interest in the underocean field. These, in turn, are backed up by tens of thousands of subcontractors and suppliers.

The ocean, like space, is an environment, the conquest of which makes demands on all technologies without exception. You need only examine the challenge and the potential in relation to the environment to see why.

According to recent testimony by Secretary of Defense Robert S. McNamara, nuclear-tipped Polaris missiles on patrol in the ocean's depth share with land-based ICBM's the assignment as a main deterrent to Soviet aggression in the Sixties. This heavy reliance came about because of the enormous difficulties of defending against the submarine-launched ballistic missile.

Conversely, it is the reason for our urgent concern with ASW. The Soviets have developed a comparable capability. Chief of Naval Operations George W. Anderson testified recently that the U.S. now has "a very small numerical advantage" over Russia in nuclear submarines. At the same time the Red fleet of conventionally-powered U-boats tops 400 craft and constitutes a far greater threat to the West's survival than the much smaller fleets with which Germany and Japan started World War II.

Commercially, the ocean is already turning a nice profit for some of those who have ventured into its depths. Off the coast of South West Africa one company is taking 700 carats a day of gemstone diamonds from the ocean's floor. A second is preparing to follow suit. A pilot plant operation is extracting over 30,000 tons a month of commercial grade iron ore from the ocean's depths around Japan. Claims have been staked for gold mining rights in the seaward sands of Norton Sound, Alaska, the beaches of which caused the gold rush of '98. Nodules containing manganese, chrome, copper, phosphorite and other minerals *grow* on vast areas of the ocean floor, assuring endless supplies.

The U.S. Bureau of Commercial Fisheries is already experimenting with the use of electrical fields for herding fish into commercial fishermen's nets. One U.S. city stores its municipal water beneath its harbor, while power companies are considering underwater storage of

◀ Navy's bathyscape TRIESTE has been down to depths of 18,000 feet. Vessel gathers scientific data.

fuel supplies to free costly dry-land real estate for more profitable and esthetic uses. A major oil company is planning completely submerged oil fields in 1,000 feet or more of water and is already completing wells at depths of 250 feet with the aid of underwater robots manipulated from the surface.

Medical scientists anticipate new families of drugs and antibiotics derived from the sea. The cheapest and by far the most abundant source of protein food is the creatures of the sea. Man today eats only a few of the sea's many edible species and catches but a fraction of what he could if he harvested instead of hunted.

Colorful word pictures of "things to come" flow like wine at a wedding. And though these may inspire enthusiasm, the hard accomplishments of real progress are won in the laboratories and on the drawing boards and assembly lines of industry.

The ocean is an environment as different from the one to which we are accustomed as though it were on another planet. It is hostile and strange to man and his machines. Like space its conquest depends upon learning its most intimate secrets and upon the highest order of man's scientific and technological capabilities. Whatever we seek to do and the difficulties with which we are presented are in large measure the same in inner and outer space. The environments are different in detail but many of the problems are startlingly similar—as are the solutions.

Space is a hard vacuum. The ocean is a high pressure environment. Both require pressurized vehicles. Missiles and spacecraft are plagued with payload weight limitations and must keep booster deadweight to a minimum. Deep sea vehicles are caught between the rising dead weight of pressure hulls and the need to have some natural buoyancy left over for operational systems, for human crews, and the ability to at least barely float. The problems of building deep sea pressure hulls are comparable to those of designing and fabricating high-strength-to-weight ratio solid rocket motor cases. This is why aerospace companies are competing in the underseas market. The structural difference is compression vs. tension—inside vs. outside pressure—but the factors are comparable, and solutions appear to be taking similar courses. The pressures, incidentally, of the deep ocean environment exceed those of a rocket's combustion chamber by orders of magnitude, peaking at 20,000 pounds per square inch seven miles down.

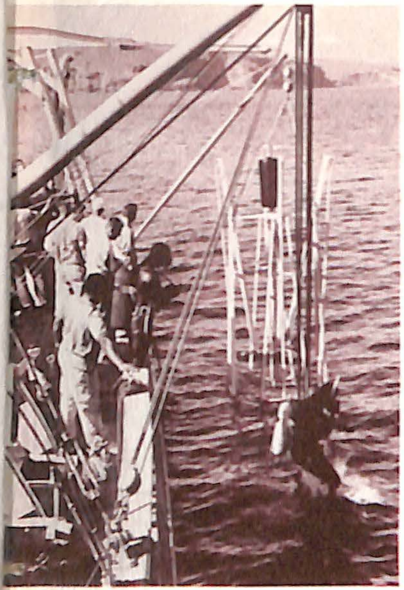
Both the ocean and space, each in its own way, are highly destructive of materials. The ocean is just plain corrosive. Add the further hazard of biological attack—the simple case of fouling that every small boat owner dreads and the fact that many structural materials are on the approved diet of many marine animals. Both space and the oceans require careful selection of materials and close quality control in production.

Both the ocean and space pose unique navigation, search, detection, localization, identification and communications problems. The ocean prohibits the use of RF energy (radio, radar), and light, except over very short distances. You "see" through the ocean with your ears. Yet whether it is acoustics or radar, the same technology in electronics that differentiates a flock of birds or a meteor from a hostile warhead also discriminates the distant echo of an enemy submarine from a reflection off a whale or from the incessant clack, whistle and chatter of sea creatures.

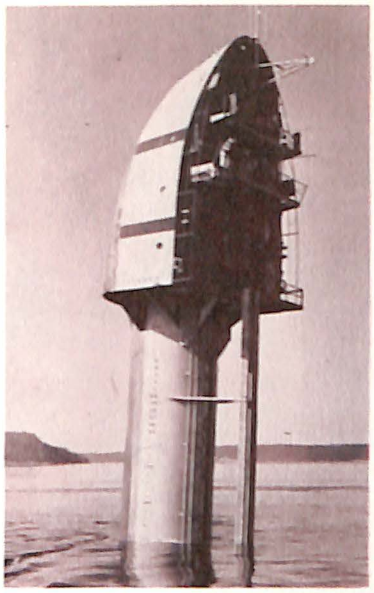
Often the problems of oceanography and space converge into a single identity. For example, spacecraft payloads are weight-limited despite the requirement for ultra-high performance under severe operational conditions. The same problem confronts tomorrow's deep diving submarines. Today's nuclear craft float low in the water not from choice, but because that's all the

Rugged USS SARGO penetrates 48 inches of ice in surfacing operation. Navy conducts many experiments in Polar regions.

DASH (Drone Anti-Submarine Helicopter) hovers in free flight with homing torpedo. Aircraft play a major role in anti-sub work.



In a deep-sea acoustic experiment, diver releases pin from array and arms extend to tracking position.



FLIP (Floating Instrument Platform) ship is readied for ocean tests. Note men on bow with ship at the vertical.

positive buoyancy left after floating the pressure hull, reactor, radiation shielding, steam turbines, heat exchangers, coolant, ship's controls, navigation gear, ordnance, fire control, ship's stores, life support systems and crew. To achieve sharp increase in operational depth capability, hull material strengths will have to approach those of rocket motor cases, electronics, and other support systems will have reduced size and weight, approaching specifications laid down for spacecraft. Even the number of crewmen will be less as more and more automation and systems integration is realized. Only the bulk and weight of individual man is irreducible.

Already submarines use airplane-type controls. The high-speed nuclear submarine is "flown" with a yoke that controls dives, climb and turn. Speeds are such that hydrodynamics is in large measure a translation of high-speed aerodynamics into the fluid environment—such things as boundary layer control, turbulence and boundary layer separation.

Undersea warfare is more than just submarines and their on-board ordnance and systems. Nudging the depths where light no longer penetrates, a submarine is about as hard to find as an intelligent guppy in a millpond. The efforts of ASW involve all kinds of platforms—submarines, surface ships, the sea floor itself, aircraft, helicopters, and eventually satellites. Submarines can hide behind temperature barriers, settle among the crags and rocks of the sea floor, hang motionless like a whale, or simply be somewhere else.

The days of a sonarman listening to a single hydrophone and partly relying on instinct are gone forever. The Thresher class submarines carry over 1200 hydrophones. Aircraft and ships carry a variety of sonar devices including sonobuoys, dunking sonar, and variable depth sonar. For close-in detection aircraft carry MAD gear (Magnetic Anomoly Detection). Other efforts have included "sniffer" devices to trace down diesel fumes from snorkling subs; "snooper" systems to home in on radiation; airborne infrared sensors to detect the peculiar change in the surface ocean's temperature pattern due to the wake of submarine passing deep below; and even hypersensitive turbulence meters designed to identify disturbances in ambient flow patterns induced by distant passing subs.

These are some of the problems of the hardware of the sea, problems that are not unique to defense alone, but which are also generated by man's efforts to ferret out a living or just to relax in the undersea realm. The technologies that serve the one will also serve the others.

But the best hardware in the world will be of but little avail without a far greater knowledge of the sea than we now have. We know less of the ocean as a three-dimensional environment than we do of cislunar space. Some $24 million of the current "national oceanographic budget" is being spent for survey work—the job of just measuring and mapping the many ocean parameters, such as sea-floor topography and geology, temperature patterns, ocean currents, salinity, dissolved gases, the interchange of energy and moisture between the atmosphere and the ocean, and the density and variety of sea life. Yet we are barely scratching the surface—or the bottom. The prospect of manned ships doing the entire job is staggering. Instead, efforts are being made to arrive at a proper balance between manned ships, unmanned buoys, and, perhaps, aircraft. In support of this effort, the National Aeronautics and Space Administration has begun a user requirement study of a data-gathering satellite which would "milk" the buoys of their stored data. Concurrently, efforts are being made to perfect HF (high frequency) over-the-horizon radio telemetry.

Once the ocean has been mapped and measured it will have to be monitored, for it is far from static. It is constantly changing, and already the Navy seeks reliable six-hour forecasts of future underocean conditions as essential to its submarine operations. So, the future requires oceanographic "weather stations" on continuous duty—remote unmanned devices performing a modern technological task in a rigorous, unfriendly environment over long periods of time and with a high degree of reliability.

The task of exploring and exploiting the ocean is as big and complex as man cares to or is forced to make it. But already his ventures under the sea have carried him out of the age of just shipyard and able-bodied seaman and into the age of advanced technology—the age of nuclear reactors instead of oil-fired boilers, of computers and stable reference platforms instead of sextants, of fathometer arrays instead of the lead line, of the true undersea craft instead of the surface ship with the ability to borrow a few moments beneath the waves. In the ocean, as in outer space, it is a different age by far, and in the ocean, as in outer space, it is an age in which the aerospace industries will play the leading role.

AIRCRAFT

By **JAMES J. HAGGERTY, JR.**
Associate Editor, Aerospace

Is the manned airplane moribund?

Every now and then, the suggestion that piloted aircraft are dead or dying crops up in the press.

The suggestion has no basis in fact; the corpse is very lively.

How it all got started is a matter of conjecture, but it's a good guess that the false notion was born in the controversy over the XB-70A/RS-70 (either terminology is correct, depending on whether you're talking about the flying prototype or the advanced concept). Pronouncements by top Government officials made clear their feeling that the type of aircraft which looses gravity bombs has little future. Apparently, in the minds of hasty readers, this brewed the idea that all manned aircraft were through.

However, the facts argue otherwise.

Item: Production of manned aircraft today constitutes the largest single element of the aerospace industry's workload.

Item: Excluding helicopters, there are 27 types of military aircraft in production status. Eleven of them are combat type aircraft (as opposed to trainers, transports, observation craft, etc.) and six of them are gravity bombers of the attack and fighter-bomber variety. Additionally, there are 11 military helicopter types in production.

Item: There are other military aircraft which are no longer in production but which are undergoing conversion or modification programs to fit them for extra years of service life.

Item: There are 45 separate types of civil aircraft now in production. Most of these, to be sure, are light and executive aircraft used by that ever-growing segment of the air world grouped under the heading "general aviation," or all aviation which is neither military nor airline. Some 6,700 aircraft of this type were built in 1962, bringing the total general aviation fleet to more than 80,000 planes. However, industry is also turning out heavy commercial turbine-powered equipment at the rate of about 200 planes a year, and although some of the earlier jetliners are being phased out of production, new types (short and medium range passenger craft and convertible cargo-passenger planes) will fill the production gap.

The fact that manned aircraft production is the industry's prime effort is based on dollar volume data from a survey of 66 top aerospace manufacturers. In this survey, net sales of the companies for the calendar year 1962 are broken down into five major activities: production of aircraft, including engines and parts; missiles, including propulsion units and parts; space systems, including propulsion; "other activities," which embraces modification and conversion programs on aircraft, missile site activations, and other aerospace products, such as drones and target vehicles; and "all other products and services," which includes manufacture of non-aerospace items and all basic research. Receipts for applied research and development are included in the totals for the various categories.

FORECAST—clear weather ahead

Total sales for 1962 were $15,848,000,000. Of this total, $5,899,000,000 was for work on aircraft (airframe and engine production, parts manufacture, research and development, etc.). In terms of percentages, aircraft accounted for 37.2% of the sales volume. With sales of $4,644,000,000, missile work was in second place at 29.4%. The "other activities" category generated 16% of the sales with a dollar value of $2,540,000,000. In fourth place ($1,446,000,000 and 9.1%) was the "other products and services" subdivision, while space systems ($1,319,000,000 and 8.3%) placed fifth.

Last year was by no means an isolated example. In 1961 and in the preceding years of the missile/space era the order of ranking was the same and the percentages comparable.

What about the future?

First, let us take the immediate, or predictable, future, the period through the calendar year 1965. There may be a slight decline in sales of heavy commercial aircraft in 1963, but the advent of new jet types should bring sales back to the 1962 level in 1964/65. General aviation, which has grown every year since World War II, is expected to continue its growth with a resulting high level of light and executive aircraft sales. There is also an upward trend in commercial helicopter usage.

Most of the military aircraft now being built will continue in production through 1963, some of them through 1964 and 1965. The fiscal 1964 budget now before Congress provides a good guideline as to the relation between aircraft and missile activity in the industry over the next few years. The budget request calls for an increase in missile procurement funds—an $83,000,000 boost to a total of $4.1 billion. *Yet there is an even greater increase in aircraft procurement money—$158,000,000 to a total of $6.4 billion.*

Aside from procurement, the major defense budget item affecting the industry workload is the category known as "Research, Development, Test and Evaluation." For several years, because of the necessity for developing whole new families of automated weapons, expenditures in this category for missile work have far outstripped those for aircraft, and this is still true of the fiscal 1964 budget estimate.

However, a comparison of the last three budgets (FY 1962-64) shows an interesting trend. Obligations for research, development, test and evaluation of missiles and related equipment have declined from $2.75 billion in FY 1962 to $2.44 billion in FY 1963 and to $2.23 billion in the pending budget. On the other hand, obligations for aircraft and related equipment have gone up over the same period: from $615,000,000 to $689,000,000 to $753,000,000.

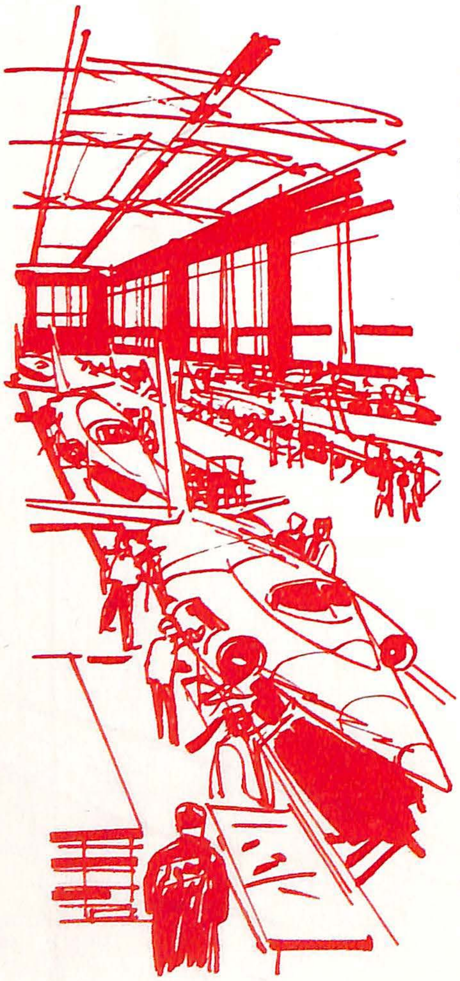
Weighing these guidelines, and adding anticipated commercial sales to the aircraft segment of the industry effort, it appears obvious that manned aircraft production and development will retain the No. 1 spot in the activity breakdown through 1965, with missilery continuing in second place. Fabrication of space equip-

MILITARY HELICOPTERS IN PRODUCTION

Designation	Name	Type	Service	Manufacturer
UH-1B/D (HU-1B/D)	Iroquois	Utility	Army	Bell
UH-1E (HU-1E)	Iroquois	Utility	Navy	Bell
UH-2A (HU2K-1)	Seasprite	Utility	Navy	Kaman
CH-3B/C (HX-2)	....	Cargo	Air Force	Sikorsky
SH-3A (HSS-2)	Sea King	Antisubmarine	Navy	Sikorsky
OH-13/23 (H-13/23)	Sioux/Raven	Observation	Army	Bell/Hiller
UH-34D (HUS-1)	Seahorse	Utility	Navy	Sikorsky
HH-43A/B (H-43A/B)	Huskie	Search & Rescue	Air Force	Kaman
CH-46A (HRB-1)	Sea Knight	Cargo	Navy	Vertol-Boeing
CH-47A (HC-1B)	Chinook	Cargo	Army	Vertol-Boeing
CH-53A (HH-X)	....	Cargo	Navy	Sikorsky

MILITARY AIRCRAFT IN PRODUCTION

(Fixed Wing)



Designation	Name	Type	Service	Manufacturer
U-8 (L-23)	Seminole	Utility	Army	Beech
U-8F (L-23F)	Queenaire	Trainer	Navy	Beech
RC-135A/B	Stratolifter	Cargo	USAF	Boeing
KC-135A/B	Stratotanker	Tanker	USAF	Boeing
T-37B	....	Trainer	USAF	Cessna
F-8E (F8U-2NE)	Crusader	Fighter	Navy	Chance Vought
A-4C (A4D-2N)	Skyhawk	Attack	Navy	Douglas
A-4E (A4D-5)	Skyhawk	Attack	Navy	Douglas
A/EA-6A (A2F-1,1H)	Intruder	Attack	Navy	Grumman
S-2E (S2F-38)	Tracker	Antisubmarine	Navy	Grumman
E-2A (W2F-1)	Hawkeye	Attack Warning	Navy	Grumman
OV-1 (AO-1)	Mohawk	Surveillance & Observation	Army	Grumman
HC-130E	Hercules	Cargo	USAF	Lockheed
C-140	Jet Star	Cargo	USAF	Lockheed
C-130E (GV-2U)	Hercules	Cargo	Navy	Lockheed
P-3A (P3V-1)	Orion	Patrol	Navy	Lockheed
F/RF-4B (F4H-1,1P)	Phantom II	Fighter	Navy	McDonnell
F/RF-4B/C (F110,RF110A)	....	Fighter	USAF	McDonnell
A-5A/B/D (A3J-1,2,3)	Vigilante	Attack	Navy	North American
T-39A,B	Saberliner	Trainer	USAF	North American
T-39D (T3J-1)	Saberliner	Trainer	Navy	North American
T-2B (T2J-2)	Buckeye	Trainer	Navy	North American
T-38A	Talon	Trainer	USAF	Northrop
F-105D/F	Thunderchief	Fighter	USAF	Republic
CV-2B (AC-1A)	Caribou	Cargo	Army	DeHavilland
U-10A/B (L-28)	Helio Courier	Light Support	USAF	Helio
C/TC-4B (G-159)	Gulfstream	Cargo	Navy	Grumman

ment will become a greater portion of the total workload. Assuming continuing Congressional approval of the national manned lunar landing program at its currently scheduled pace and further increases in funding for military astronautics, space work should climb to third place in the industry activity rankings.

Looking farther down the road, to the period beyond 1965, the picture becomes less clear as regards the workload relativity between aircraft, missiles and spacecraft. It will hinge on currently unpredictable levels of military spending, on what form the peaceful space program will take in the post lunar landing period, and on how many of the myriad concepts for future aircraft, missiles and spacecraft reach hardware status.

This much is clear, however: Missiles have by no means taken over *all* the jobs once handled by aircraft and there still exist a wide variety of requirements for manned aircraft in military operations.

There are a number of aircraft types already programmed for production beyond 1965 and for operational use well into the decade of the seventies. There is, for instance, the Air Force/Navy high-performance tactical fighter, the F-111, better known as the TFX. There are also plans for a new, ship-based attack aircraft. In the military transport category, there is the C-141A turbofan cargo plane, scheduled to make its first test flight at the end of this year and planned for later production.

Now a subject of considerable interest is the Department of Defense research program on V/STOL (Vertical Short Take-Off and Landing) aircraft, those which combine the vertical lift characteristics of the helicopter with high performance in forward flight. The military services are experimenting with several types of American-built V/STOL's, and in addition are actively participating in British, French and German programs in this area. Planes of this type can reduce dependence on large airfields and permit operations in remote areas. Successful development of V/STOL's may bring an entire new generation of production aircraft, such as vertical-rising fighters, reconnaissance/strike planes and airborne assault craft.

Another area of development which could extend the service life of manned aircraft is the COIN project, aimed at producing a light counter-insurgency aircraft for a great many missions in conventional warfare ranging from tactical strikes to helicopter escort.

Still another research area of promising potential is the Air Force's X-21 Laminar Flow Control Aircraft Program, in which the flow of air over the wings is smoothed by suction through slots in the wings. This smooth airflow provides a significant reduction in airplane drag and offers greatly increased range, payload or endurance for aircraft of the future. These attractive performance gains may open up new missions for military aircraft.

There are also requirements (or potential requirements) for new aircraft in specialized Army operations, in antisubmarine warfare, and in air defense.

And although in the public view the manned bomber seems to have been relegated to Limbo, the burial may have been premature. In recent Congressional testimony, Air Force Chief of Staff Gen. Curtis E. LeMay said the USAF is investigating—so far on a study basis—new types of manned bombers. He mentioned three types: 1) a long-endurance subsonic plane which could serve as an electronic countermeasures vehicle, as an airborne command and control post, or as a missile launcher; 2) a low altitude-penetration bomber; and, 3) a high altitude bomber of the B-70 type which would incorporate advanced technology not available at the start of the B-70 project.

On the future of the manned military airplane, Gen. B. A. Schriever, Commander of the Air Force Systems Command, had this to say in a speech delivered earlier this year:

"In spite of the great potential that exists in ballistic missile and space technology, we have no intention of neglecting the possible developments in aerodynamic flight. In terms of technical feasibility, the military aircraft definitely has a future. During the next 10 years it will be possible to provide significant improvements in aircraft range, speed and versatility. The development and use of boundary layer control, improved engine inlet designs and advanced combustion technology are all feasible in this time period.

"A great variety of advanced aircraft types, including conventional design, V/STOL, variable geometry and paraglider configurations could afford many new mission capabilities. The fact that such aircraft may be feasible does not guarantee their actual development, but at least there seem to be no technical barriers in the way. These advanced aircraft can be developed if they are needed to meet military requirements."

The future of commercial aircraft seems equally assured. There will be a continuing need to move people and products from one place to another and the era of the ballistic rocket transport is definitely not around the corner. There will be new and improved types of subsonic aircraft to meet the transport requirement and to re-equip the vast and growing general aviation fleet. Successful VTOL development could bring another transportation revolution. And as inevitable as tomorrow—regardless of who builds it—is the supersonic transport. As soon as the SST is in service there will probably come a demand for a hypersonic transport, because in a world which accepts the fantastic as commonplace, the user will insist on the maximum convenience that technology can provide.

So, if you've mentally buried the manned airplane, exhume it. It appears quite likely that, on the centennial of Orville and Wilbur Wright's first flight, in the distant year 2003, there will still be some type of winged, aerodynamic vehicle plying the airways.

BIG LIFT FOR AIR CARGO

BY DAVID HOFFMAN
Aviation Editor
New York Herald-Tribune

UNTIL very recently, men who move cargo by air have been especially fond of two cliches.

The first: "Air cargo is a chicken and egg proposition."

The second: "A really big breakthrough is just around the corner."

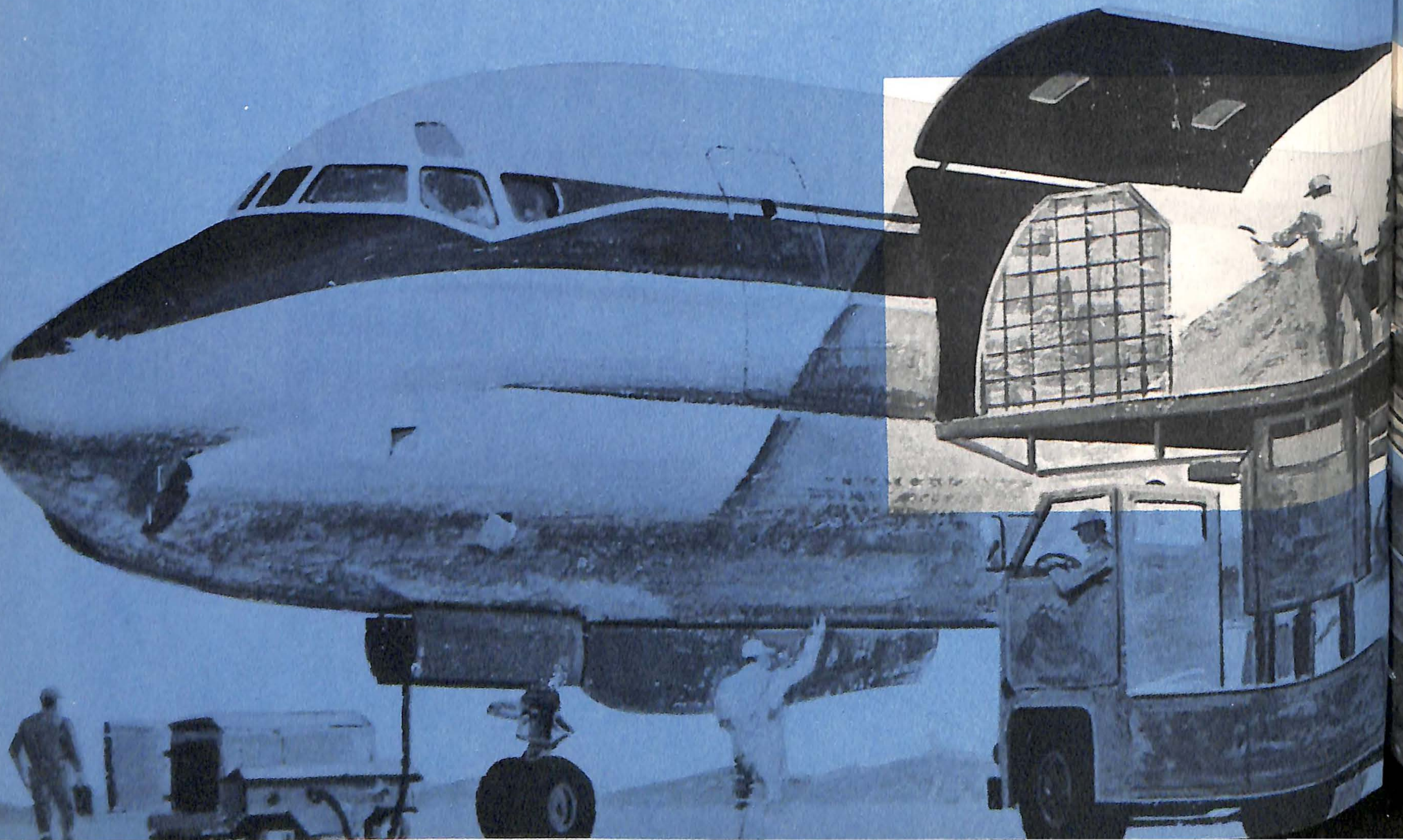
No longer does either find a place in the jargon of insiders. For the air cargo industry is fast maturing into a sophisticated, highly technical business. The specialists who run it have lost patience with cliches; they want to make money and they're willing to acquire knowledge, to invest capital, and to take risks.

"Chicken and egg" thinking holds that air cargo's growth will remain stunted until freight rates come down. Rates will not come down until the airlines can buy more efficient freighters. But the airlines cannot buy more efficient freighters until the volume of air cargo swells, which it will not do until rates come down, etc. Stagnation was trapped inside the closed circle.

Surprisingly, many of the leading chicken and egg men were also "big breakthrough" men. Despite the dilemma of which comes first, they argued that the industry, as if propelled by a giant spring, would leap to prosperity. Experts vied to predict air cargo's leap year, then watched their predictions fall apart under the weight of statistics. No leap came.

Instead, the volume of cargo carried in scheduled service by U.S. airlines began climbing at a very respectable, if not quite a breakthrough, pace.

In 1962, U.S. airlines placed their first firm orders for



the big, pure-jet freighters designed by Douglas and Boeing. Although the Douglas DC-8F "Jet Trader" and the Boeing 707-320C "C-Jet" resemble their passenger counterparts, the new ships boast cavernous holds that can carry up to 10 times more cargo. The fleet of four *windowless* 320Cs ordered by American Airlines last fall could, within a year, haul every ounce of freight moved by the scheduled U.S. carriers during all of 1961. And American executives are confident, after prolonged study of the market, that the 90,000-lb. capacity of each jet won't be wasted.

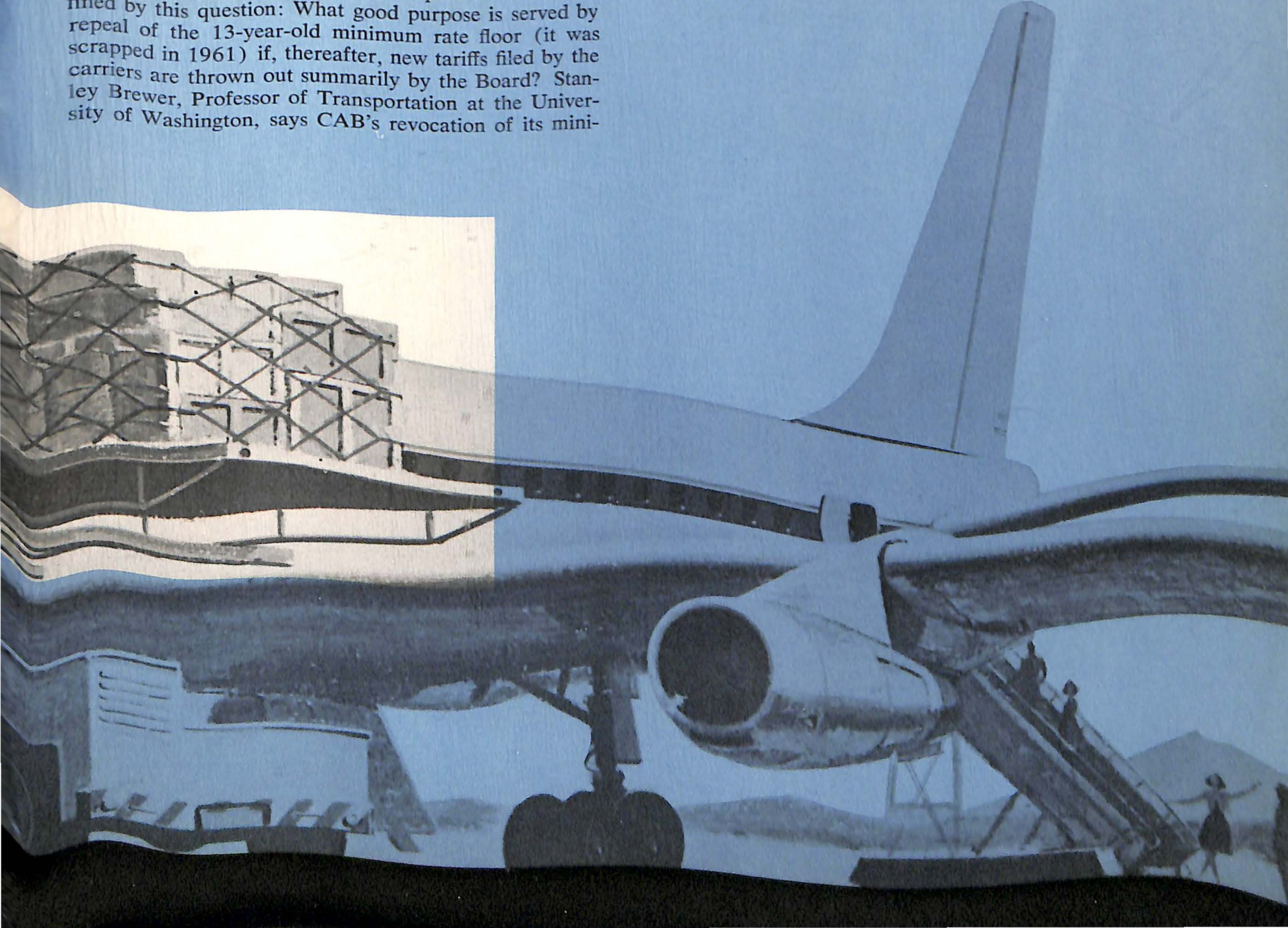
In 1962, as ATA President Stuart Tipton puts it, there was "an unprecedented surge in sales promotion: more cargo salesmen on the street, more cargo advertisements in the trade journals and national newspapers, and more merchandising activity than ever before" to assist those who would use air to penetrate new markets. Last year alone, Pan Am's World-Wide Marketing Service, which global traders don't pay for, was queried by 15,000 firms. The service, Pan Am says, has persuaded 3,000 U.S. companies to buy and sell on the international market for the first time.

In 1962, the Civil Aeronautics Board faced up to a problem many think it created. The problem is best defined by this question: What good purpose is served by repeal of the 13-year-old minimum rate floor (it was scrapped in 1961) if, thereafter, new tariffs filed by the carriers are thrown out summarily by the Board? Stanley Brewer, Professor of Transportation at the University of Washington, says CAB's revocation of its minimum rate order "compounded confusion with chaos in the domestic air freight rate structure." Carriers complained and CAB reacted. Board Chairman Alan Boyd now is forming a separate "Rates Division" within CAB. Its purpose: to streamline tariff filing procedures, to make rate experimentation a less costly, less time-consuming task for freight-oriented airlines.

Perhaps the future for air cargo can be foretold from the past. Perhaps by glancing backward we can see the end product of hard-nosed marketing and 500 mph. jet freight service. Perhaps jet freight service and the truck's coming of age have much in common.

Museums compete for old carriages and you've almost got to find a farm to find a horse. But 50 years ago, we still called it a horseless carriage. The automobile, and its offspring the truck, swiftly forced Americans to build a new transportation system. Horse-trails became roadways that tied the tiniest hamlet to the largest city. When truck freight rates became competitive, some companies chose to exploit this network; they found new markets and slashed distribution costs. Others clung to the horse and quietly disappeared.

New jet transports are now on hand: convertible, car-



go jets that will erase the five hour time lag between New York and the major European gateways for freight; jets that for the first time will bring "next morning delivery" to shippers on each end of a single transatlantic flight; jets that can lop 30% from current freight rates; jets that promise to set in motion changes as sweeping as those brought by the truck, for the jet freighter will offer many shippers the same advantages offered by the first trucks and the first railroads—extra speed, access to new markets and the competitive edge that goes hand-in-hand with improved service.

What the automobile was to the horse and carriage, the jet freighter's cargo hold is to the old warehouse and the outmoded distribution system it represents—a far more efficient replacement.

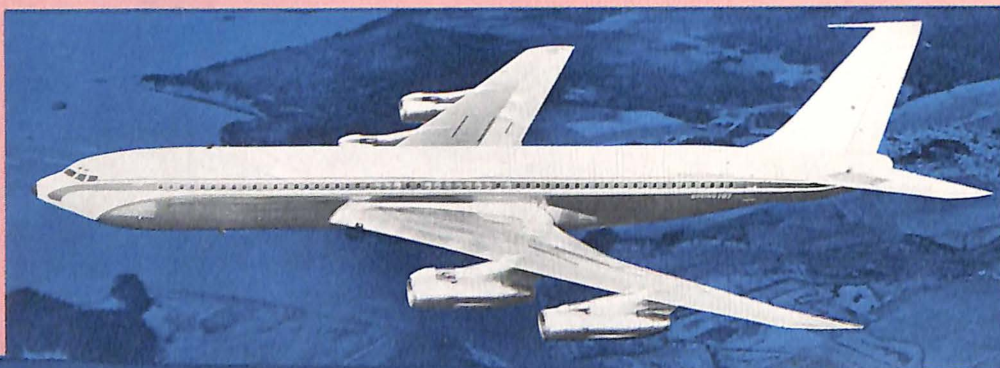
Warehouses, essentially, are wasteful. True, they smooth the flow of commodities between factory and consumer and thus render a service. But they also tie up capital, expose goods to pilferage, hike insurance costs, complicate paperwork, increase labor costs and lull surface shippers into false feelings of leisure. Each drawback, moreover, applies to the long, surface pipelines that feed the warehouses.

A survey published in 1961 at a convention of U.S. marketing men said that in the decade 1951-61 handling costs associated with storing goods in a warehouse jumped 110%. Public warehousing costs went up 28%. During that 10-year span, the average cost of moving freight by rail, truck and water climbed 41%, 45% and 33% respectively. Only in the air cargo business can rates be expected to drop, the marketing men were told.

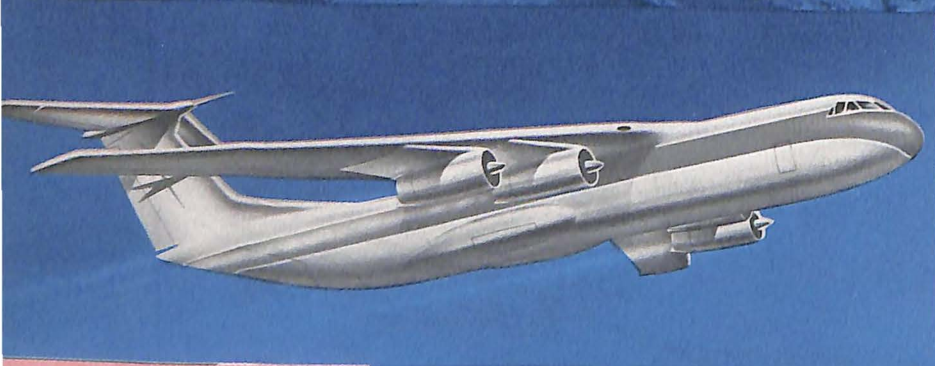
Total distribution by air of so-called "air-eligible" commodities is the concept airlines are trying to sell. Their sales arguments bristle with examples that prove it pays off. To illustrate:

Last year, Southern California Edison Co. wanted to move a 35,000-lb. turbine rotor from Newark to its new $52-million generating plant at Oxnard, Calif. The massive part was picked up by a Flying Tiger Line CL-44 and flown across the country. Had the shipper elected to use a surface carrier, delivery would have been delayed by at least five days. Flying Tiger was paid $5,200 for making the move. But during those five days, the new plant generated $12,500 worth of bonus electricity. Saving: $7,300.

The Hupp Corp. selected air to move 51 refrigerators and 72 kitchen ranges from Ohio to Kingston, Jamaica. Why? Because it knew air would prove the cheapest way to get them there, cheaper in fact by $1,500. To create the bulky items for ocean transport would have added 3,000 pounds to their weight and cost $900. Higher duties and insurance fees, plus wharfage charges at Kingston, would have cost another $600. Said ATA Vice President Jack Slichter after the airlift ended:

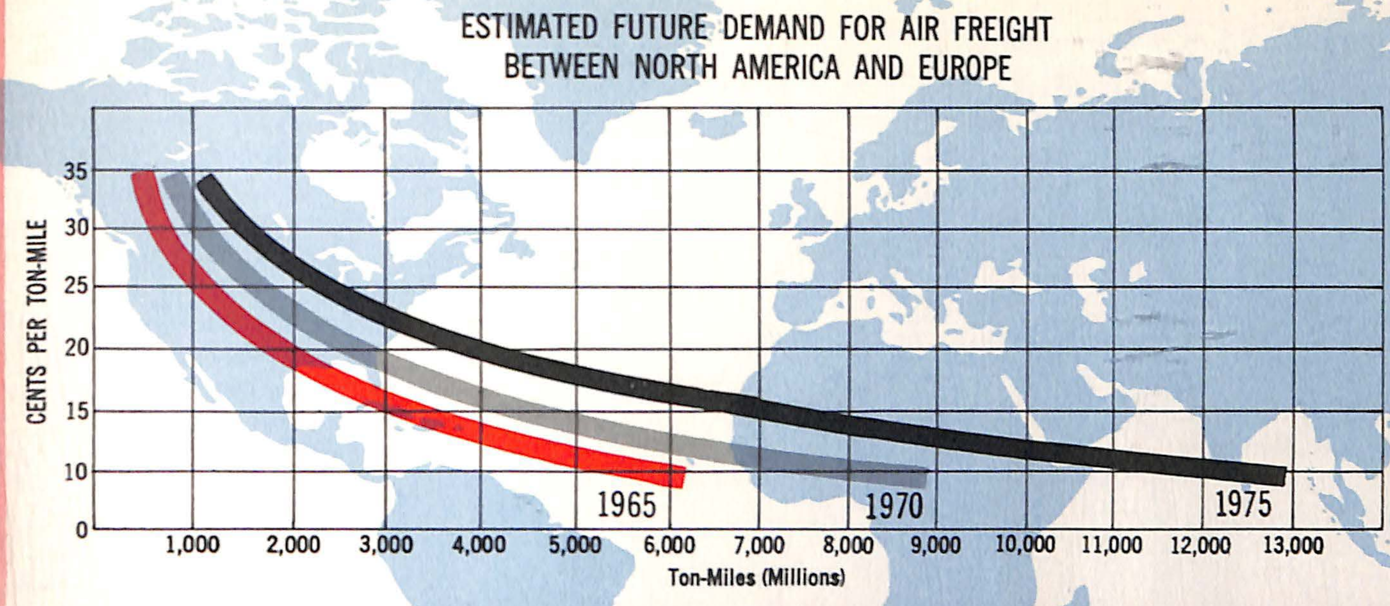


BOEING 707-320C



LOCKHEED L-300

DOUGLAS DC-



"What excites us in the airline business is that this demonstrates how the airlines are able to beat surface transportation on such heavy, non-emergency cargo as refrigerators and ranges—despite the fact that air rates run higher."

A Baltimore manufacturer who wanted to break into the Puerto Rican clothing market was faced with a problem: How to get his suits into a San Juan haberdashery with sharp creases and no wrinkles. An airline freight salesman produced a plastic-shrouded garment hangar that was lighter than conventional shipping cartons. Overhead telescopic rods were installed in trucks owned by the local air freight cartage operator and in the belly of a Boeing 707. Freshly ironed suits were deposited in San Juan by this flying clothes closet.

Distribution—that vastly complex system through which raw material finds its way to a factory, then back to a consumer—has been called "the last frontier of industrial waste and inefficiency." It is, in fact, the third largest cost incurred doing business. Each year, $100 billion, or double the net profit of all U.S. corporations, is eaten up by distribution expenses.

"The only area left to American business to make major changes in our competitive cost position is within the framework of the distribution process," says Pan Am cargo expert Harold Graham.

The cost of distribution, however, is probably the most elusive of all industrial costs to pin down. Clarence D. Martin, Jr., Under Secretary of Commerce, says it's about 50% of a manufacturer's net sales (he also says air freight would cut it in half). But percentages vary widely from company to company; few know precisely what distribution costs are.

If a shipper doesn't know what he spends, grumble the air freight salesmen, how can we show him how much he could be saving?

Selling the concept of marketing by air, standardizing equipment, writing precise tariffs and lowering freight rates are probably the most pressing problems that confront the air cargo industry today.

"Our big challenge in 1963," says ATA's Stuart Tipton, "is to make the managers aware they can save if they ship by air. Salesmen can't knock on every corporate door with a hand-tailored plan; the company must first show interest." This means simply that air cargo, which Tipton calls the "bright rising star of the airline industry" is due to receive more attention this year than last.

Through their "Air/Truck" program, the scheduled airlines will try to offer 24-hour freight service to many more communities. Last year, 9,500 were served by local truckers acting in concert with the airlines. The project's ultimate goal is to serve 20,000. At the same time, industry will work toward making a wider variety of products air-eligible—to lure more bulky, less precious and less perishable commodities into the holds of its new turbine freighter fleet.

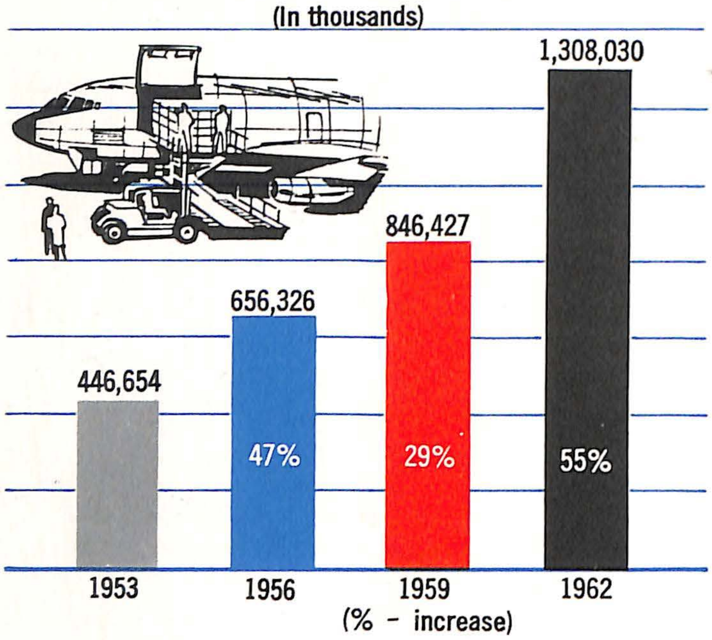
The semi-science of containerization also will benefit from 1963 research. Last year, an airline advertisement pictured eight separate cartons (including a portable horse stall and an insulated tropical fish pack) that customers could order. This year the emphasis will be on standardization and cheap, multi-purpose wrappers.

Subject of 1963's most intensive sales drive will be the biggest customer of them all—the U.S. Post Office. In terms of tonnage, about 11% of all U.S. inter-city first class mail now travels by air. But next door in Canada, almost 100% is airlifted. The Post Office, airlines say, could save $1 million annually if it sent 40 to 50% of its first class mail by air. The number of mail-carrying passenger trains has decreased by one third during the past decade, a universal rate has been set by CAB, aircraft are ready and waiting, and the Post Office needs help.

The case for standardization was phrased concisely by Robert F. Stoessel, Chief Marketing Development Engineer for Lockheed-Georgia Co., where the C-141 is taking shape. Speaking at an air cargo forum in Atlanta, Stoessel said: "We are today at approximately the same point as the railroads of the U.S. were toward the end of the last century, just prior to standardization of track

AIR CARGO—SCHEDULED AIRLINES

Revenue Ton-Miles
(Includes air mail, other mail, express and freight)



gauge. We too must standardize and do so soon, or we'll have missed an irretrievable opportunity."

In other words, a load of air freight must be shaped, packaged and handled so that it can be sped from any airplane, through any terminal and into any truck. But that sentence is deceptively simple. The average air freight shipment weighs only 165 lb. It has a random shape and must be combined with other parcels of random shape, then placed on a pallet. The pile must pass through aircraft cargo loading doors of varying width and height. The truck waiting for the aircraft . . . well how many kinds of truck are there?

Nevertheless, Boeing, Douglas, Lockheed, Canadair and the airlines are encouraged by the limited progress to date. For example, a standard-size pallet of 108 by 88 inches has been approved by the American Standards Assn. and, tentatively, by most airlines. The spacious forward cargo doors of the DC-8F and 707-320C are almost identical in size (91 by 134 inches for Boeing and 85 by 140 inches for Douglas). Both can carry 13 pallets, both are compatible with the military's 463-L cargo handling system, both can use the same types of ground support equipment used by the CL-44.

What kind of freight tariff attracts freight and enhances the profit potential built into a jet freighter? To that question there are almost as many answers as there are airlines. Each, in attempting to write an effective tariff, must wrestle with idiosyncrasies of the business.

As a rule of thumb, freight will not move by air unless it's worth more than $2 per pound. The jet freighters will drive this figure downward and thus capture some of the high-volume, low-value cargo that now goes via surface carrier. But the principle still stands: Finished products, not raw material, are the prime candidates for air shipment. Because of this rule, air cargo flows most freely between industrial countries, and from industrial countries to undeveloped mining and farm lands. And that creates the return load problem which directional rates, thus far, have failed to solve.

In about two hours, however, the Jet Trader and the C-Jet can be converted from an all-freight to an all-passenger configuration, or to any mixture of the two. On one-way freight routes, then, passengers will occupy the space vacated by cargo so that the return trip still turns a profit.

Perhaps the most encouraging development on the international air freight scene is the burgeoning economy of Europe. Within 10 years, the level of personal consumption in Western Europe is expected to jump 65%. The rising standard of living there could well spark a consumer's market explosion felt round the world. The consumer uses high-priced products, not raw materials.

In a recent study, the more-often-right-than-wrong Professor Brewer made these predictions:

- Trade across the North Atlantic will increase 5% per year for the next 15 years. But trade in the commodities most commonly air shipped will increase 7% per year during the same period.
- Air cargo traffic across the North Atlantic will grow at an average annual rate of 25 to 36% in 1963, '64, and '65, then taper off slightly. Annual growth rates above 20% will be experienced during the next 15 years.

Two types of cost figure in moving a piece of freight from A to B: the direct cost of operating an airplane and indirect cost of packaging, handling, loading and unloading the cargo it carries. Historically, direct costs and indirect costs have been equal. But they won't be much longer.

Direct costs will be slashed in half, and then some, by the new jet freighters. Whereas it now costs 8 to 10 cents per ton-mile to fly a Douglas DC-7F or a Lockheed 1049H, it *will* cost only 4 to 5 cents per ton-mile to operate a Jet Trader, a 707-320C or a Lockheed L-300 when they enter service. Once learning curve problems are behind, direct cost of these jets may be shaved to 3.5 cents per ton-mile or less.

Halving direct cost only reduces total cost by 25%. Before rates can come down 50%, indirect costs must be similarly cut. Can they be? The answer lies hidden in freight terminals.

At some terminals, terminals staffed round-the-clock, dock crews work less than 20% of their day on duty. At many airports, several freight terminals have been built, and all operate well below capacity. Some, surprisingly, are a couple miles from the spot where freight is unloaded. Utilization of costly equipment is far too low.

Sending the Queen Mary on its maiden voyage before docks had been built on either side of the Atlantic would be roughly comparable to the terminal situation that prevails now, at the dawn of the jet cargo age.

Secretary of the Treasury Douglas Dillon presents Thomas V. Jones with a replica of the Liberty Bell.

THE aerospace industry is matching its technological achievements in national defense and space exploration with a solid contribution to the nation's economic well-being.

Treasury Department reports that the aerospace industry leads all other major industries in the systematic purchase of U. S. Savings Bonds with 62 per cent of approximately 750,000 employees participating.

Thomas V. Jones, president of the Northrop Corp., is the national chairman of the aerospace-aircraft industry bond drive. He is one of 28 key executives from such industries as automotive, petroleum, railroads, rubber and steel.

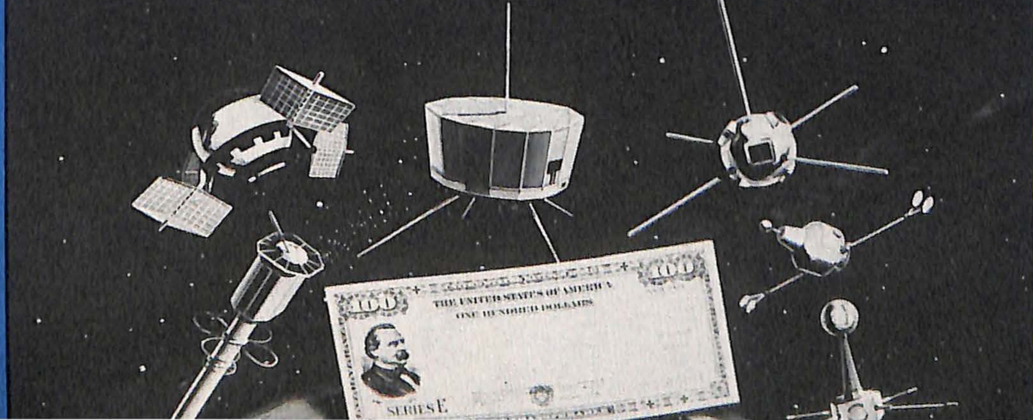
Mr. Jones has met with other executives of the aerospace industry on the east and west coasts to formulate plans to progress from this "high ground" of achievement to a higher performance level.

Karl G. Harr, Jr., president of the Aerospace Industries Association, recently stated to the AIA membership: "In view of the high level of national spending for defense and space products, it is considered both appropriate and significant that this industry should lead in the percentage of employees who regularly purchase savings bonds. Such participation reflects, perhaps more strongly than anything else, the sense of responsibility of your employees as well as their faith in the integrity of this industry and its ability to develop and produce promptly materiel necessary to our national defense and space posture."

Treasury officials point out that 21 per cent of the publicly-held portion of the public debt is in the hands of individual citizens in the form of savings bonds. "This is a way the nation can shore up its financial front in one sector through sale of savings bonds as a means of resisting the erosion of inflation," an official said. Today the sales of savings bonds amounts to about $5 billion annually with a total of $46 billion currently held from past sales.

Treasury Secretary Dillon told the 28 business leaders that the payroll savings plan for buying bonds marks the difference between saving systematically and not saving at all. "Each of you," he said, "by your leadership in one of America's leading industries is making a substantial contribution to the growth and strength of our economy. You are adding considerably to that contribution by your initiative, your guidance and your enthusiasm in helping further the progress of the payroll savings plan."

BONDS OF FREEDOM



AIA MANUFACTURING MEMBERS

Aero Commander, Inc.
Aerodex, Inc.
Aerojet-General Corporation
Aeronutronic, Division of Ford Motor Company
Aluminum Company of America
American Brake Shoe Company
Avco Corporation
Beech Aircraft Corporation
Bell Aerospace Corporation
The Bendix Corporation
The Boeing Company
Cessna Aircraft Company
Chandler-Evans Corporation
Continental Motors Corporation
Cook Electric Company
Curtiss-Wright Corporation
Douglas Aircraft Company, Inc.
Fairchild Stratos Corporation
The Garrett Corporation
General Dynamics Corporation
General Electric Company
  Defense Electronics Division
  Flight Propulsion Division
General Laboratory Associates, Inc.
General Motors Corporation
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General Precision, Inc.
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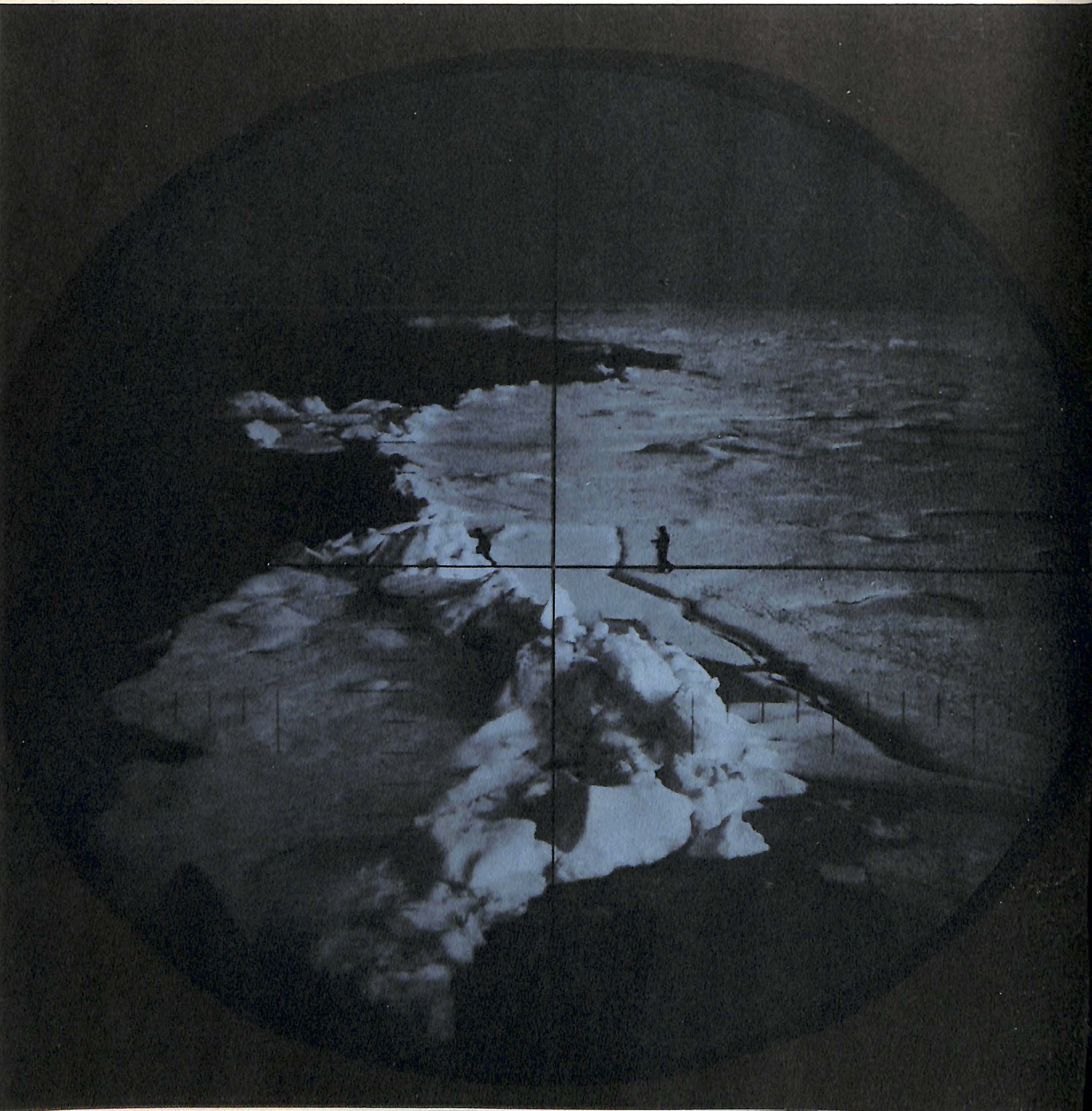

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SEPTEMBER-OCTOBER 1963

SPACE EXPLORATION

NASA

TODAY AND TOMORROW

AIA

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Official Publication of the
Aerospace Industries Association of America, Inc.

VOL. 1, NO. 3 *SEPTEMBER-OCTOBER, 1963*

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CONTENTS

The purpose of AEROSPACE is to:

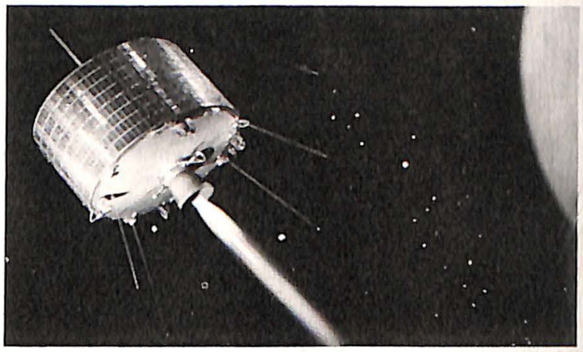
Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems:
Foster understanding of the aerospace industry's responsibilities in the space exploration program;
Foster understanding of commercial and general aviation as prime factors in domestic and international travel and trade.

AEROSPACE is published quarterly by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

Publication Office: 1725 De Sales Street, N.W., Washington 6, D. C.
New York Office: 150 East 42nd Street, New York 17, New York.
Los Angeles Office: 7660 Beverly Boulevard, Los Angeles 36, California.

NASA
THE FIRST FIVE YEARS

By **KARL G. HARR, JR.**
President,
Aerospace Industries Association

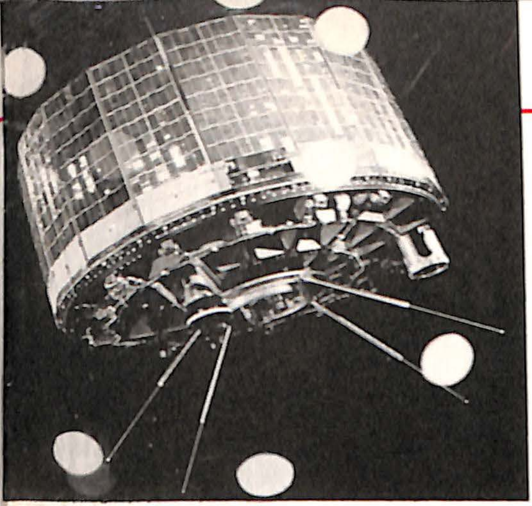


SYNCOM

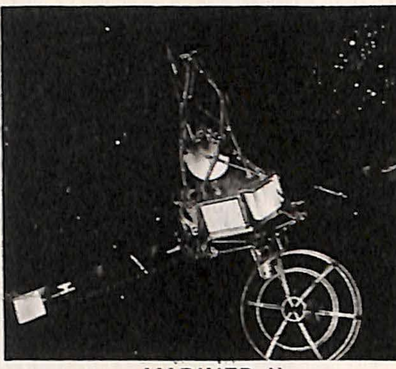
FIVE YEARS AGO the National Aeronautics and Space Administration was established for the purpose of achieving the toughest technological task this nation has ever attempted: the successful exploration of space.

Whatever 20/20 hindsight may prove in the years ahead, NASA's incredible successes in its brief existence, in terms of solving scientific, technological and managerial problems, earn a front-rank position in 20th Century accomplishments. There is no need here to ponder whether space exploration is worth the price. Our purpose is merely to pause to note the miracles that have been created, starting from scratch, in a mere five years. The huge sums of tax dollars involved, measured against obtained and predicted results, are and will continue to be a proper subject of national concern and debate. Vice President Lyndon B. Johnson, in another article in this issue of AEROSPACE, makes a lucid and forceful case for man's voyage to the moon.

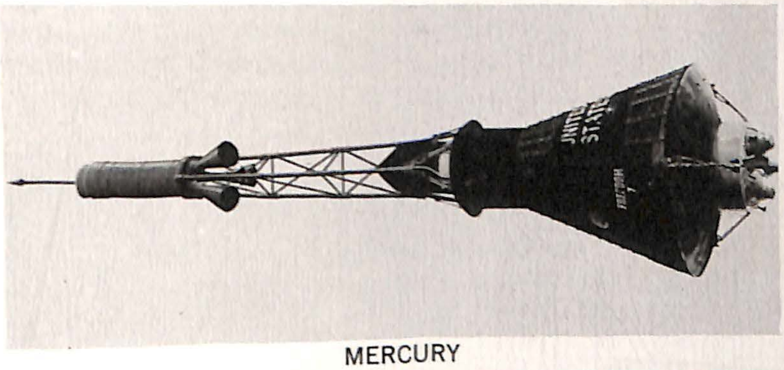
A description that fully conveys the scope of NASA's accomplishments is indeed difficult. In simplest terms, man has discovered more about the universe around him during the half decade of the space agency's existence than in all previous recorded history. The manned Mercury flights proved conclusively that humans can operate in space and can re-enter the earth's atmosphere safely. The various Pioneers, Explorers and Vanguards provided data about radiation belts and other space phenomena sometimes millions of miles from the earth's surface. Ranger successfully impacted on the moon. Mariner II has provided totally new information about the planet Venus. Echo, Telstar, Relay and Syncom have already demonstrated new possibilities in transoceanic telecommunications. Various Tiros satellites have supplied international weather information totally unobtainable by conventional meteorology techniques. Cooperative launchings with Great Britain and Canada (Ariel and Alouette) have been successfully carried out and similar shots



TIROS



MARINER II



MERCURY

SATURN V

using the payloads of other nations are definitely programmed. In addition, test firings of Centaur and Saturn launch vehicles — the larger boosters required for the space shots of the middle 1960's and beyond — have already been made.

This quick countdown of our successful achievements only hints at the dramatic efforts involved. The men and money involved provide another clue.

In the five years since NASA emerged from the old National Advisory Committee for Aeronautics, it has increased its manpower from NACA's 8,000 to a current payroll of 29,000. Its budget has climbed steadily from NACA's $100 million annually to more than $5 billion for Fiscal Year 1964.

The job of organizing and managing any multi-billion dollar program is enormous. When that size is coupled with vast and unprecedented technological complexities the problems are doubled and redoubled. Initially, far reaching quantitative and qualitative policy decisions on approaches to space exploration had to be made — and made quickly. Then major contracts had to be placed for hardware that had never before been produced and that, in turn, required techniques and often materials still to be developed. Even viewed as early as today, the results produced under these extreme circumstances represent a remarkable technological and managerial *tour de force*.

The scope of our nation's space effort is also astounding. NASA's current research and development projects cut across a multitude of traditional scientific disciplines and encompass technological areas barely identified when the agency was created. Research techniques range from those necessary to speed development of a tiny ion engine generating a barely measurable thrust to those producing a huge booster like Saturn V with its 7.5 million pounds of thrust.

Moreover, the management procedures and shortcuts evolved for the NASA program can readily be adapted to such other technological challenges as water desalinization, effective civil use of atomic energy, even increasing the world's food supply.

NASA formally came into being October 1, 1958, with responsibility for three of the four major national objectives in space. Except for applying space science and technology to military purposes for national defense and security — the job of the Department of Defense — NASA was charged with fulfilling the nation's role in space. Specifically, this included the assignments to:

> Conduct the scientific exploration of space for the United States.
> Begin the exploration of space and the solar system by man himself.
> Apply space science and technology to the development of earth satellites for peaceful purposes to promote human welfare.

Even with respect to that part of our national space effort reserved to the Department of Defense, i.e. space research for national security purposes, NASA experiments have been and will be of great benefit.

Under the National Launch Vehicle Program, for example, 11 large boosters varying in size and performance are being evolved by DOD and NASA for use by whichever agency has a requirement for a specific booster.

Similarly, the cooperative agreement between the Air Force and NASA on the two-man Project Gemini program will enable the USAF to obtain data on rendezvous operations at the same time as NASA. Since the Air Force feels a rendezvous capability will be necessary for inspection, interception and possible destruction of unidentified satellites, the Gemini findings should prove extremely helpful to the military.

MAJOR NASA MILESTONES

PROGRAMS	LAUNCHES TO DATE	OBJECTIVES
Manned		
Mercury Series	6 (Two Suborbital)	Man in orbit
Scientific		
Pioneer Series	7	Lunar & Interplanetary Studies
Explorer Series	13	Near Space Studies
Vanguard Series	3	Near Space Studies
Beacon Series	2	Near Space Studies
OSO Series	1	Solar Observatory
Ranger Series	5	Lunar Probes & Landing
Mariner Series	2	Venus Probes
Applied		
Tiros Series (Meteorological)	7	Weather Data
Echo Series (Communications)	4	Balloon Reflector
Telstar Series (Communications)	2	Int'l Telecommunications
Relay Series (Communications)	1	Int'l Telecommunications
Syncom (Communications)	1	Fixed Position Satellite for Int'l Telecommunications
International		
Ariel Scientific	1	Joint with Great Britain
Alouette Scientific	1	Joint with Canada
Launch Vehicles		
Scout	3	Small Payload Booster
Centaur	1	Intermediate Payload Booster
Saturn	3	Heavy Payload Booster

NASA's forthcoming new facilities at the Merritt Island Launch Area north of Cape Canaveral will be made available to any of the services expressing a need. This will be a form of reciprocation because the space agency has utilized the Air Force's Cape Canaveral site, the Navy's Pacific Missile Range and the Army's White Sands range in New Mexico for various tests during its five-year history.

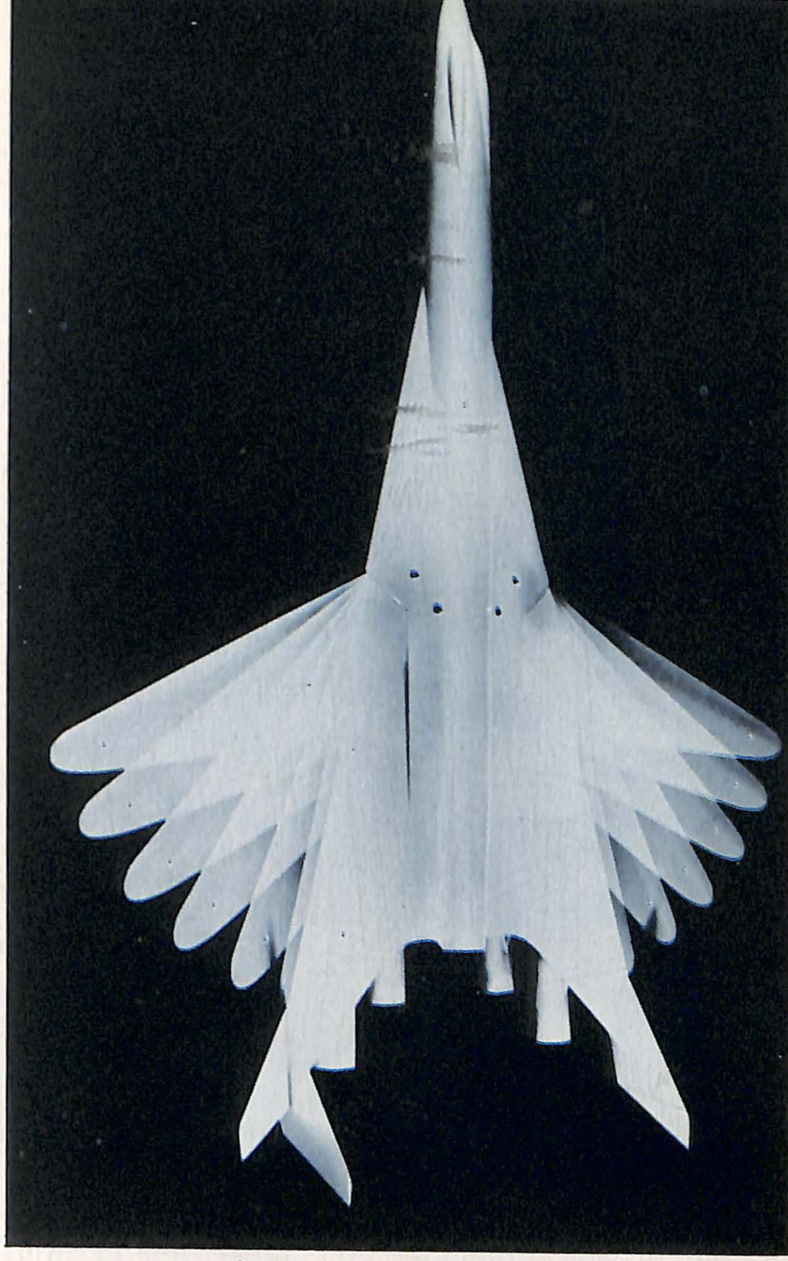
Other examples of NASA programs which will have both short- and long-range impacts on military space programs are the space agency's work in nuclear rocket engines, small power plants (ions, photons, nuclear) for space propulsion, meteorological satellites, communications satellites, bioscience and the findings in the Gemini and Apollo projects as to how effectively man can perform in space. Various supersonic and hypersonic wind tunnels at NASA research centers will continue to be available for military research requirements.

Although the bulk of NASA's budget is devoted to space projects, the agency has not neglected its original charter for aeronautical research. In the period before NASA came into existence, the NACA's budget approximated $100 million a year, with half of it devoted to research on aeronautics. Last year, NASA allocated approximately $45 million specifically for aeronautics studies plus additional sums for more fundamental research applicable to both space and aeronautics.

Two forthcoming aircraft, one civil and one military, serve to point up the importance of the space agency's aeronautical studies. NASA's work on variable sweep wings made an important contribution to development of the F-111 (TFX) tactical fighter to be used by the Navy and Air Force. The Agency's work on Mach 3 aircraft (including studies it sponsored with aerospace companies) is a major reason why the Federal Aviation Agency feels it can ask the industry for proposals on a supersonic transport for airline use in the 1970 decade. Other examples of NASA research in the aeronautical field include testing of new concepts for vertical and short take-off and landing aircraft, studies which hopefully will result in better aviation fuels and efforts to lessen the noise made by jet-powered aircraft.

There is no question that NASA's half decade has been filled with progress and promise. NASA Administrator James E. Webb, and his predecessor, Dr. T. Keith Glennan, and deputy to both of them, Dr. Hugh L. Dryden, have shaped the agency into a mature organization capable of managing the efforts of a huge complex of aerospace companies, research centers, scientists, technicians, engineers, non-profit concerns, colleges and universities.

On this, its fifth birthday, NASA, as well as the nation, can look back on the passage of many historic milestones since the U. S. started its space effort in 1958. Other, even more far reaching markers, especially Apollo, still lie ahead. But judging from its performance over the first and therefore the most difficult five years, we all feel great confidence that these goals also will be successfully gained.

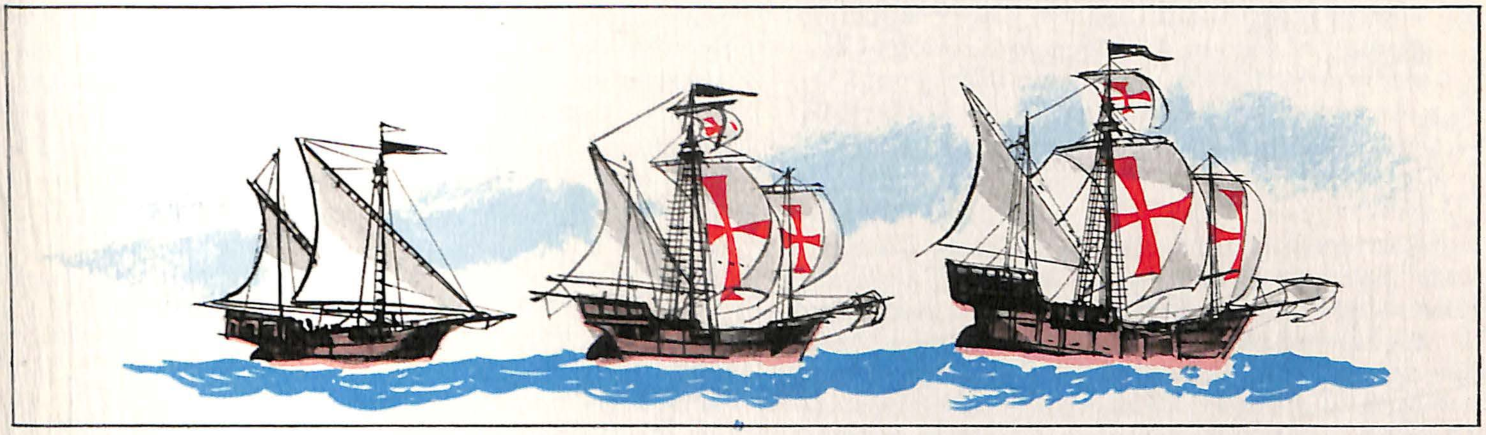


Supersonic transport model shows variable sweep wing in six positions

Ion engine ready for test run

WHY GO TO THE MOON?

By VICE PRESIDENT LYNDON B. JOHNSON



Seldom in its lifetime is a country fortunate enough to be confronted with such a challenge as that of the National Space Program. It enables our people to devote their skills, their courage, their initiative, and their resources to a continuing series of projects which dwarf their imagination while enriching their country.

A CHALLENGE

The space program — and particularly the manned flight portion of that program — has been likened to Columbus' voyage to the New World. And, there are grounds for such comparison. Both include exploration of the unknown and uncharted regions of the universe; both involve risks and skills and investment of resources; both contribute to broadening of man's knowledge and breaking down narrow barriers of thought. Yet, with all due regard to Columbus' venture, there are many features of the space program which raise it above the level of that historic feat of the fifteenth century.

One cannot measure the relative amounts of courage required by Columbus and his small crews, as compared with our astronauts. Suffice to say that both were great. No, the differences lie in other respects. The space venture stems from a decision by the elected representatives of the people, is financed by the people as a whole, is participated in by hundreds of thousands of individuals, pushes the state of the art and technology to new horizons, contributes to new industries, new products, and new knowledge. Moreover, it furnishes a vehicle for improved international relations and increases the possibility of world peace.

AN INVESTMENT

The space program is a test, in a sense, of our way of life — a test of our confidence in our country. It is a situation where peoples of a country — generally well fed, well clothed, well housed, and even fairly well endowed with leisure and luxury — are willing to undertake, not ordered to undertake, a difficult challenge and are willing to meet that challenge with their material and intellectual resources.

There are those who decry the expenditures involved — those who by a curious line of reasoning conclude that it is not "fiscally sound" to go to the moon. In this free country, they are, of course, entitled to hold and to express such views, mistaken as they seem to me to be. It is worth pointing out that fiscal soundness does not mean that an individual or a nation should refrain from spending. Rather, it calls for spending for those objectives which promise the most assured and most constructive returns. The parable of the talents from the Bible comes to mind. The Lord's wrath was bestowed upon him who buried his money and the Lord's blessing was bestowed on those who spent or invested it wisely.

The space program is a wise investment. If the returns from the space program will be worth many times the cost — and I believe they will — then it would be fiscal irresponsibility to refrain from the investment.

A NATIONAL DECISION

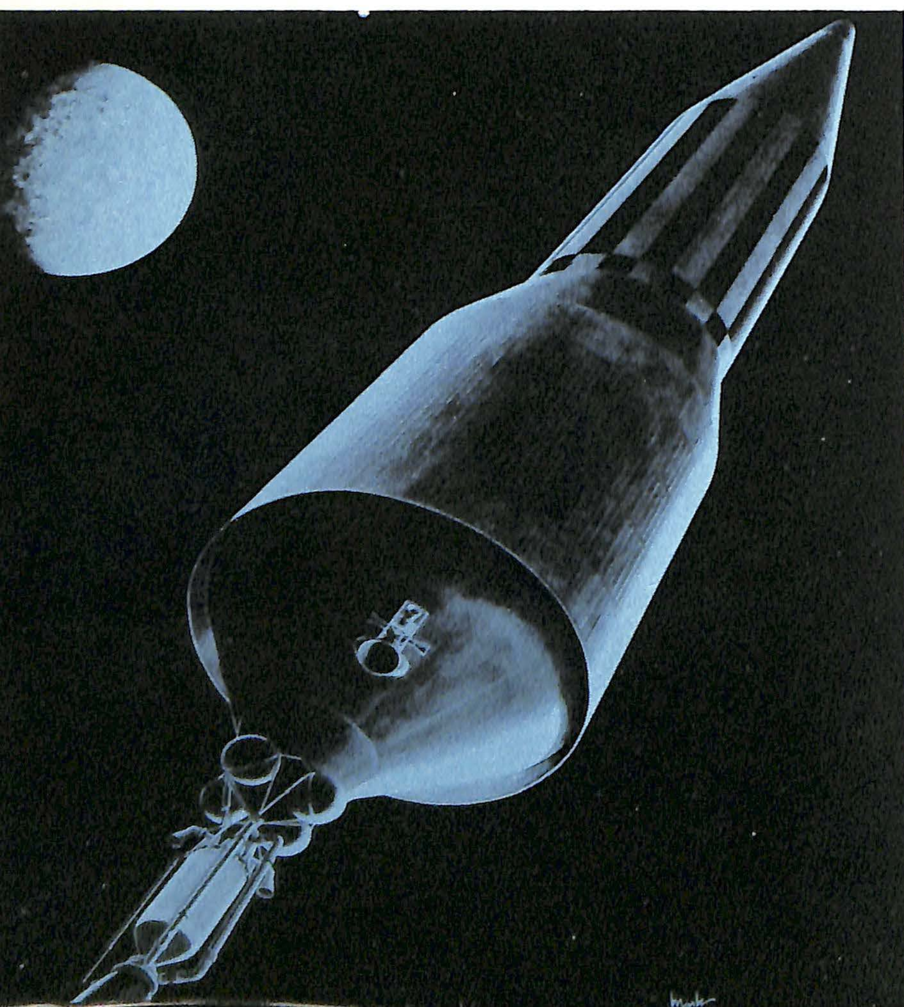
On May 25, 1961, President Kennedy went before the Congress to talk about what our country should do to meet the "extraordinary challenge" before it. On that occasion, he said:

> *"Now it is time to take larger strides — time for a great new American enterprise — time for this nation to take a clearly leading role in space achievement, which in many ways may hold the key to our future on earth."*
>
> * * * *
>
> *"I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth. No single space project in this period will be more impressive to mankind, or more important for the long-range exploration of space —"*

The country is stronger because the President made this decision and took it before the Congress. I am proud to have recommended this action to him.

The record should be clear, however. The President was also declaring a policy and a program for a well-rounded and balanced national space program, of which the moon project was an important part but only a part nevertheless. In that same message, and backed up by subsequent budget requests, he referred to the need to develop large liquid and solid fuel rockets, as well as acceleration of the construction of nuclear rockets. He referred to unmanned as well as manned exploration of space. He urged action in the fields of space communication and meteorology.

NUCLEAR-POWERED (RIFT) SPACE VEHICLE



Moreover, as the subsequent budgets reveal, the President has asked for significant funds for military development in space. For example, the defense space budget for FY 1964 is larger than the total spent for all space activities in FY 1961 — the last year of the previous Administration. (FY 1964-requested for Defense is $1667.6 millions; FY 1961-spent for all programs was $1468.3 millions.)

While it is my intention in this article to give major attention to the moon project, I want to emphasize that the National Space Program includes many space projects. Moreover, it will continue indefinitely to be a program of building broad space competence so that the new dimension of space will become as much a part of our way of life as the land, the sea, and the air.

A LUNAR PROJECT

Why have we chosen the moon? Why undertake such a difficult and expensive project? What advantage does a round-trip to the moon have, which other less ambitious space projects would not also have?

Let's look at some of the reasons for the moon trip:

(1) A CLEAR OBJECTIVE. Impetus, order, and efficiency stem from having a clear-cut target in any enterprise. The moon is such a target. To get there requires organization and planning, specifically fitted and suited to accomplishing a definite goal. To bring forth the best effort the goal has to be difficult and challenge the very best brains — in management, engineering, and science. There are other space targets which meet these criteria, some more remote in time, but surely the moon trip meets these well.

(2) LOCATION OF THE MOON. Compared with other targets in space, the moon — only 240,000 miles away — is relatively near. Certainly it is the logical place in space where we can test the equipment and the men for future and more distant space travel. It is an area which we can photograph and examine by instrumentation prior to manned exploration. Little as we know about the moon, it is the area in space concerning which we now know and can most easily learn the most.

(3) SPACE COMPETENCE. Various space projects, such as weather satellites or communication satellites, require varied competence and sophisticated equipment. They are difficult to develop and they are important. But no project, currently within our capability, brings into focus as wide a range of developmental capabilities as the lunar task. Powerful rocket engines, complex spacecraft, precise guidance, trained astronauts, elaborate tracking facilities, and protective measures against the multiple hazards of space, are just some of the competences which must be wrapped together for a successful moon shot. These competences, once developed for this project, all have value as a solid foundation for a great variety of other

space endeavors.

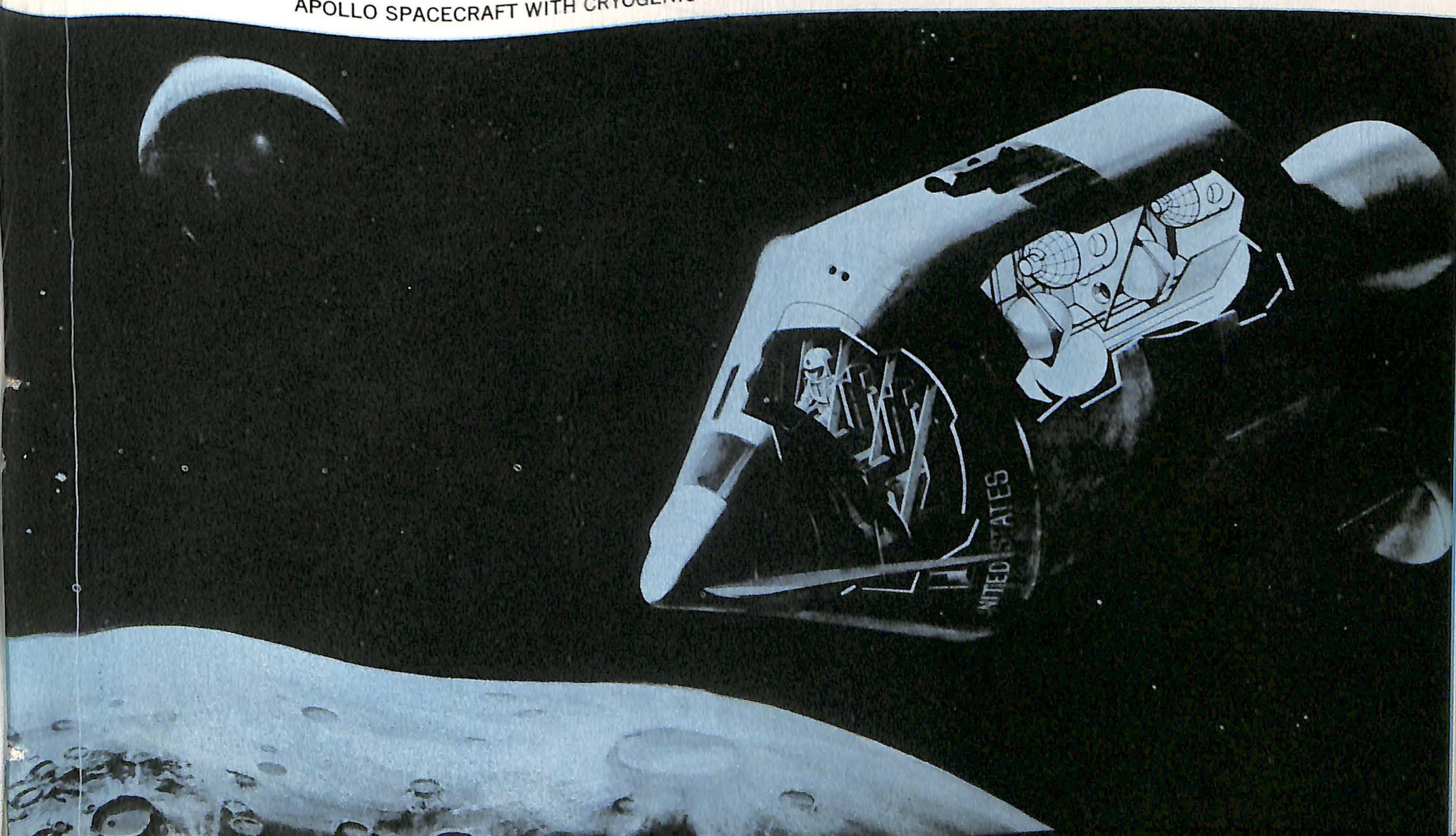
(4) PRESTIGE. No country should undertake as complex, expensive, and hazardous a venture as the moon trip, for prestige reasons alone. But, it is a significant reason nonetheless. People in other countries are impressed with our abundant economy and our high standard of living. They are even more impressed with our over-all strength and our scientific and engineering accomplishments. There is little question that the USSR, with its Sputnik I and its subsequent space successes, has achieved a prestige position which does much to influence other nations. Surely the country which combines the ability, the resources, and the courage to go to the moon will sit high at international negotiating tables. If such a country is one which protects freedom, a strong blow is made for a world of peace instead of a world of subjugation.

(5) RELATED BENEFITS. There are those who fail to see the manifold benefits which flow from the lunar project — either because they cannot measure the benefits precisely or because they do not want to recognize their existence. Yet, the benefits from our space program are many and the lunar project leads the list as a contributor. One can cite improvements in metals, alloys, and ceramics; in electronics; in steelmaking and temperature control of buildings; in medical equipment for hospitals; in instruments for measuring degrees of radiation; and many more. Likewise, benefits flow from improved education, greater employment of manpower, and a wide range of new and better consumer goods.

(6) SCIENTIFIC KNOWLEDGE. In addition to the expansion of knowledge in the process of building the equipment, testing man's reaction to the hostile environment of space, and analyzing the mathematical complexities of rendezvousing with the moon, the lunar trip will add importantly to man's meager understanding of the origin of the solar system and of life itself. The impetus to science, both directly in the project itself and in the classrooms of our universities, cannot be overestimated.

(7) DEFENSE CONTRIBUTIONS. While many accept other convincing arguments for the moon trip, they tend to overlook the significance of this project to our national defense. It is reasonable to conclude that the moon is of doubtful value as a weapons base for military activity on earth. At least, current technology leads one to conclude that there are much more effective and less time-consuming ways in which to meet attack from hostile powers. However, the defense contribution flows from a different source. The lunar project has forced us to develop many competences which have military as well as non-military significance. These are competences which we would have been slow to develop were it not for this national moon objective. For example, rendezvous technique so basic to our moon project is essential to detecting and examining other spacecraft which may be hostile. Life protective measures are essential to

APOLLO SPACECRAFT WITH CRYOGENIC STORAGE SYSTEM SHOWN IN CUTAWAY



WHY GO TO THE MOON?

a useful police force in space for maintaining the peace. Powerful rockets, reliability of space equipment, development of control and guidance systems, experience with manned spacecraft, etc. are all spin-offs from the lunar project, which help build our defense capability.

Each of the cited reasons for going to the moon could by itself be expanded into a persuasive argument. Taken all together, they form a sound, unemotional, pragmatic justification.

It is perhaps pertinent to comment briefly on a few of the counter arguments, not so much because they merit attention but because they receive attention anyway.

A MANPOWER DEMAND

For example, the charge is made that the lunar program is a waste of trained manpower. It seems to me absurd to identify as waste the use of skills, even though scarce ones, on anything as challenging and constructive as the space program. Moreover, those who use this argument of waste are vague as to where these skills are being diverted from. Are they being taken from equally important projects and, if so, what are they? Or, are they being shifted from research and development on improved soap chips or more elaborate styling for automobiles? I doubt that those questions can be answered in any useful generalization, although I am confident that the net result is a more effective use of manpower. Those skilled scientists and engineers, who move into the expanding space arena, do so because of the challenge and the opportunity to put their skills to a real test. They will be better technologists for the effort, and the country will gain from the added knowledge and the demanding experience obtained.

It is interesting also to look at the statistics on this manpower shift. Currently, NASA is using for all of its space efforts, primarily through its private contractors, about 3% of the total supply of physical scientists and engineers. This percentage may rise to 6 or 7% within a few years but that is hardly a serious drain on the total number available, although it may strain the supply of some specialized individuals. Well over 90% of the country's total supply will still be devoted to other endeavors.

In addition to that statistical point, the fact is that the space program is stimulating more young people to go into the disciplines which space requires. It should also be noted that NASA, through fellowships and facilities grants to universities and other private organizations, is taking positive action to increase both the quality and the quantity of the supply for the future.

AN ESSENTIAL PROGRAM

The argument is sometimes made that there are more worthwhile things on earth for which manpower and funds should be spent.

Granted that we need to do more in education, slum clearance, medical research, and crime prevention. But, when one looks at the billions spent annually for non-essentials in this country, it is clear that funds do exist for handling both the space program and all other essentials, if we as a people just decide to spend our income that way. Moreover, curtailment of spending in space — abandonment of the moon project, for example — would not automatically mean expansion of spending for slum clearance or any of the other serious needs. In fact, it is more likely that the funds released thereby will go to the race tracks or for larger yachts, or for fancier country clubs. Do not be misled by the argument that space is taking from other essentials. Incidentally, most of those who make that argument would also oppose using the funds to meet the other essential requirements of our burgeoning society.

A RISK

There are also those who say that the moon trip is dangerous — that the project could be crowned with disaster instead of success. If the first attempt fails, we would probably try again, with all the safety provisions we can devise and with the increased knowledge obtained from our first attempt. But, assuredly, the United States does not avoid risky ventures when the benefits from success promise so much. Even if the moon flight turned out to be a failure, which is possible but unlikely, there will have been tremendous gains from the competences developed in the process.

AN ORDERLY PROGRAM

With all the sense of urgency which the moon venture engenders, it is still not a "crash" program. It is erroneously compared with the Manhattan Project, which was properly labeled as a "crash" effort. In that case we used all the resources we could obtain in order to develop the atomic bomb in the shortest period of time, regardless of cost. We maintained duplicating operations over a three-year period in the hope that one would work. Apollo is no such project. If it were, we would not have had the controversy over whether we should choose earth-orbital rendezvous or lunar-orbital rendezvous, or direct launch to the moon itself. A crash program would have gone into operational stages of all three alternatives. No, the lunar project is given a high priority, but it is being conducted in an orderly manner and with due regard for cost efficiencies and unnecessary expenditures.

A STEP TOWARD PEACE

In conclusion, I like to think that our space program, with all of its challenges and all of its material costs, is a constructive step toward world peace. In this effort, there is opportunity to cooperate with other nations, without stepping on the nationalism of other territories or the embedded barriers of tradition. There is room in space activity for nations to grow closer together through exchange of information and through sharing of experience. There is also some possibility that an international peace force in space could deter the drive of aggression which might break loose from lesser restraints.

It is my hope and my expectation that the Space Age will be an age of maturity in man's relationship — an age of exploration, not exploitation.

SPACE BOUNTY

"One hundred years from now the knowledge attained in space research will surely have paid untold, unforeseen, and unexpected dividends. Already the dawning of the space age has impelled Americans to seek to improve their schools. That alone may be worth the cost of all of our space rockets."

— LEE A. DuBRIDGE,
President, California Institute of Technology

The benefits of space exploration probably will never be accurately assessed. Measurements simply are not available to count even the economic advantages that accrue from the acquisition of new knowledge.

However, already visible are many commercial benefits ranging from simple product improvement to revoluntionary management and manufacturing techniques. The National Aeronautics and Space Administration is moving aggressively to make the results of its vast research and development efforts available to industry. The agency has established an Office of Technological Utilization to do the job. After much study, a system has been developed to locate and record, analyze and disseminate useful results of NASA R & D projects.

There have been over-optimistic statements regarding the immediate impact of NASA research on consumer products with predictions that there would be an avalanche of new products.

Most of the experience to date indicates that industry is, at the present time, principally interested in improved materials and processes rather than new product lines. The response to one booklet, Selected Welding Techniques, prepared by NASA's George C.

Marshall Space Flight Center, drew 6,000 requests from industry. As an example, the single pass welding technique was utilized by a manufacturer of furnace and air conditioning equipment. The welding process secured a better weld, reduced costs, but it was not a new product.

A major area of civil benefits is in the applied satellite program — principally communications and weather. The communications program, with the Telstar Relay and Syncom satellites, has been outstanding. The Relay I operated successfully for more than 200 days and performed every one of the 500 experiments for which it was designed. The Syncom satellite has been placed in a synchronous (fixed) orbit 22,300 miles above the earth, and as few as three of these satellites, properly located, will provide worldwide TV and other communications coverage.

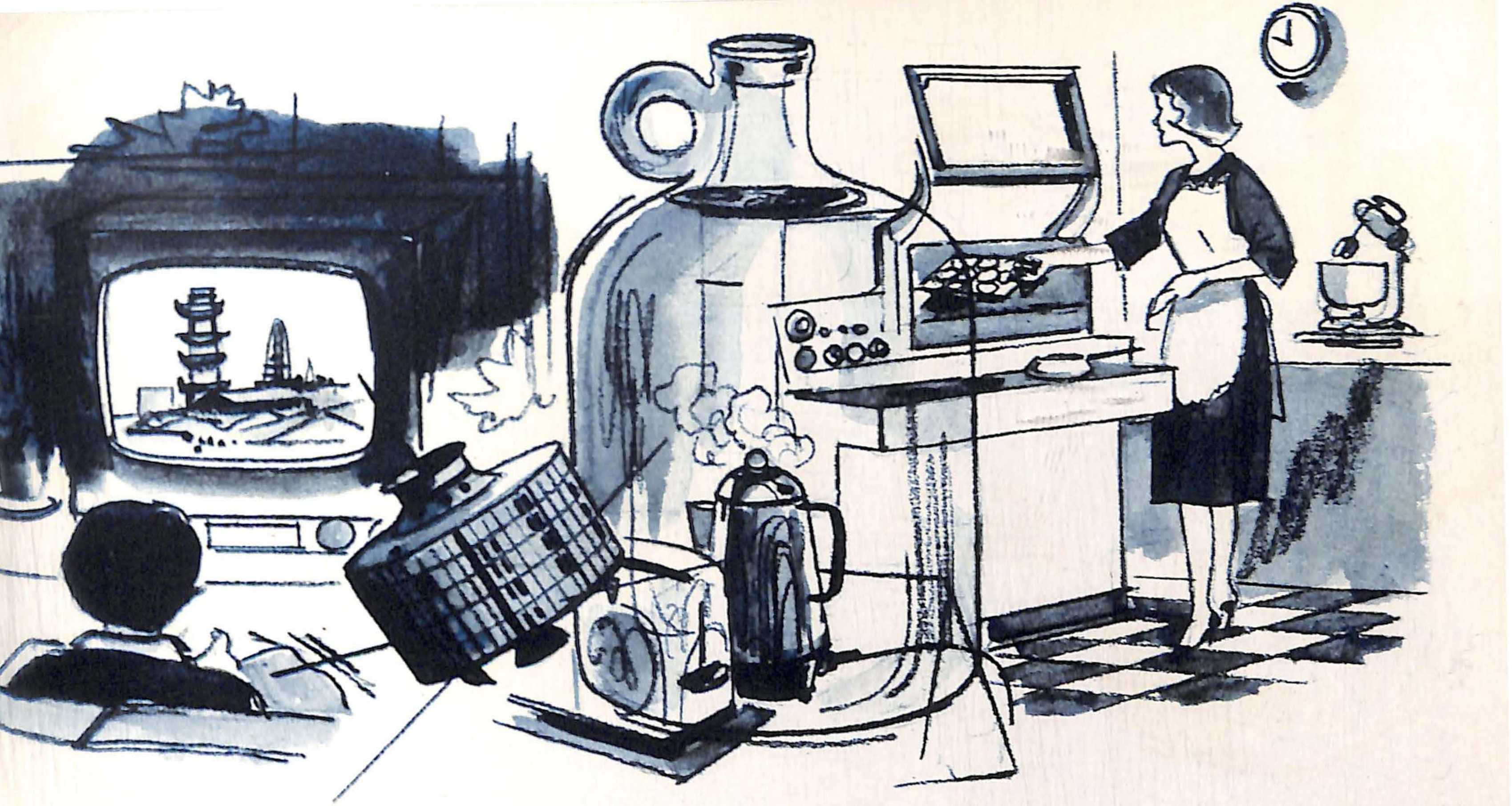
The Tiros weather satellite has been an outstanding success. Seven Tiros satellites have been launched without a single failure. They promise truly global weather coverage. There is the promising potential for not only averting disaster, but also as an invaluable aid to agriculture, predicting run-off from snow cover and even spotting schools of fish for commercial fishing vessels.

NASA Administrator James E. Webb points out that the cost of Tiros is not unreasonable when the area covered is considered. "A weather ship in the North Pacific," he states, "can observe an area with a maximum radius of about 30 miles and costs $1 million to maintain and operate annually. A weather satellite can observe an area of approximately 640,000 square miles in each picture it takes, and can photograph many areas of the earth each day. Its cost is about $4,500,000, including the launch. This is only 4½ times the cost of operating one ship, and is economical considering the vastly greater coverage which is obtained."

The cost savings from accurate weather predictions, only five days in advance, is remarkable. Senator Clinton Anderson, Chairman of the Senate Space Committee, recently cited some estimates of savings. They included $2.5 billion a year to agriculture, $45 million to the lumber industry, $100 million to surface transportation, $75 million to retail marketing, and $4 billion in water resources management.

In the industrial applications field, here are some of the space age developments:

- Air bearings. These are devices which lubricate bearing surfaces with thin films of air or inert gas. They are used in the space program for high-speed gyroscopes, and inertial guidance and stable platforms which are vibrationless. In industry, air bearings can carry heavy loads to facilitate material handling. One man can easily move heavy factory loads.
- Aluminized mylar film. The Echo I satellite was made of a very thin plastic material only ½ thousandth of an inch thick and coated with aluminum. It has widespread application in industry as insulation for extremely low temperature use. The aluminized film can be used for such diverse purposes as packaging of freeze-dehydrated foods, and to minimize boil-off of liquid oxygen used by metal companies in blast furnaces.
- Energy absorption systems. A frangible tube



was developed to absorb the impact of the landing of the Apollo capsule. This can be used as an elevator safety device or as a safety measure to minimize damage to automobiles in collisions.

- An advanced pump and pressure-time control for rockets is capable of adaptation and development for an artificial heart mechanism.

This is only the barest sampling of the results now ready for industry.

The future is boundless. An aerospace company executive recently asked scientists on his staff to do some day-dreaming, to take a long look forward. Here are a few of the results.

One research assignment involved the creation of temperatures encountered in re-entering the atmosphere after space flight. This research is leading to an understanding of the construction of matter, a long-sought scientific goal. This means more knowledge that will produce new materials, alloys and synthetic chemicals. Materials could be custom-made. Wear-out proof clothing could be made or walls made of materials that permit controlled frequency emissions, a glowing lumination, that would eliminate today's lighting fixtures.

In bio-astronautics, work is being directed toward finding solutions needed in the growth of higher plant life capable of surviving the environments to be created on Mars and Venus. These studies could well create the ability to grow "perfect" crops on earth; and it may originate a strain of inexpensive foods to supplement farming in one-crop countries.

Already developed is an information center, which utilizes computer techniques, to provide instructions to mechanics and technicians when repairs are needed to a machine. This could be adapted to aid physicians in the treatment of rare or unusual diseases. A physician confronted with a bewildering combination of symptoms could dial the center and, within seconds, receive a televised description of a possible diagnosis and recommended tests and procedures.

For many years scientists have studied the influence of a magnetic field on the acceleration of gas particles. The knowledge of behavior of ionized gas has already been used in the design of an experimental power generator. One of these devices may prove capable of supplying electricity from sea water. It is estimated that the deuterium in one gallon of sea water can be converted into 10,000 kilowatt hours of electricity, a supply sufficient for a family of five for one year.

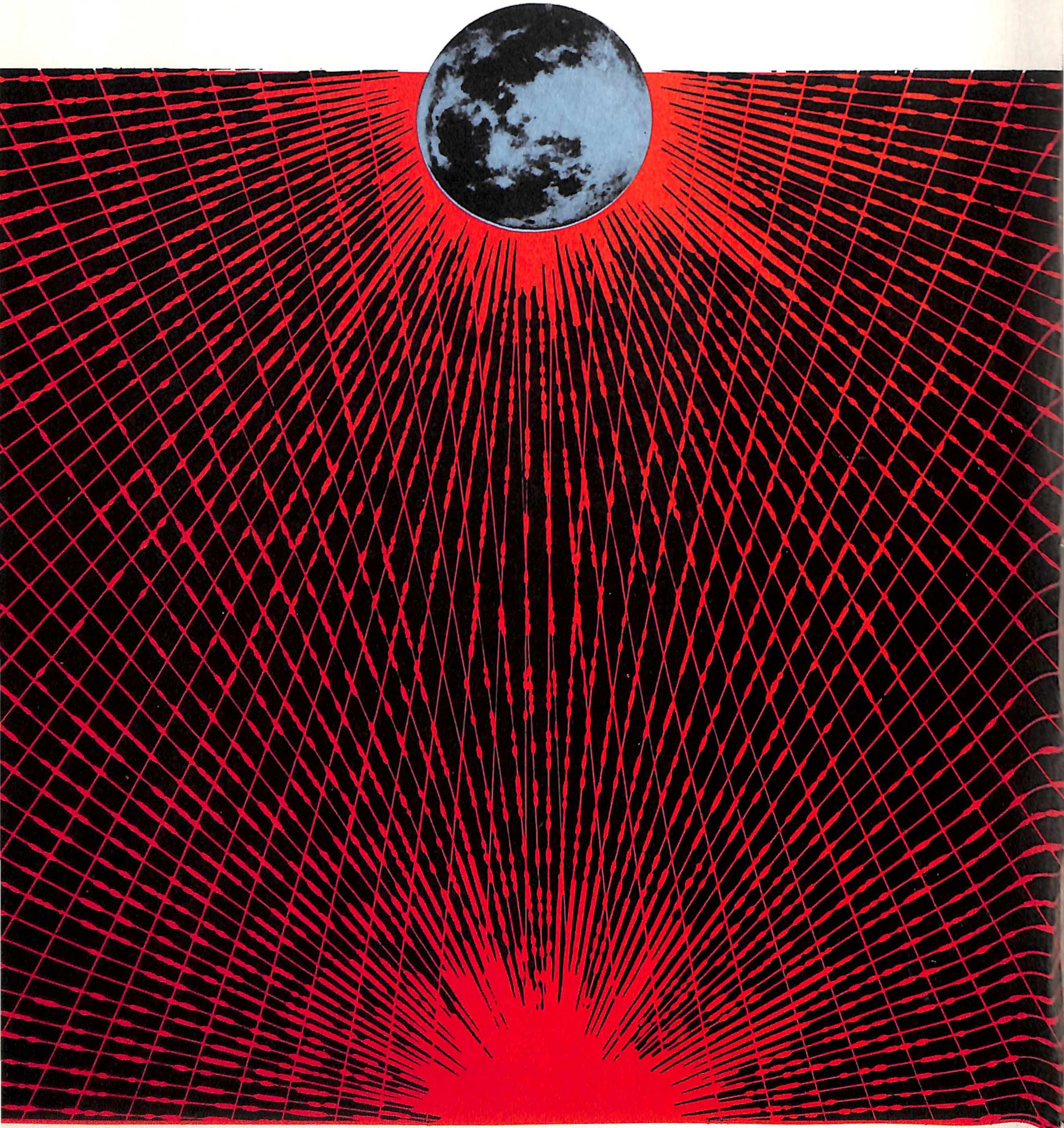
There is practically no end to the theoretical gains. Many may prove utterly impracticable. But one payoff could be revolutionary.

Lt. Gen. James M. Gavin, returning from his assignment as U. S. ambassador to France, put forward this thought on the U. S. space program. He called it "one of the most remarkable things that has occurred since the founding of the Republic."

He predicted that a marriage of the space-age economy of the U. S., with the prosperous and dynamic economy of Europe would set an extraordinary example of economic cooperation and provide a tremendous boon to the economic prospects of the non-Communist world.

Whatever the benefits — a better medicine or a better balance of trade — any major explorative effort by man has always exceeded his predictions and often his hopes.

THE MOON AND



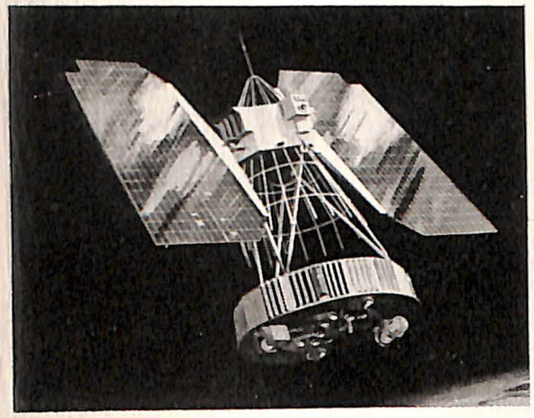
BEYOND

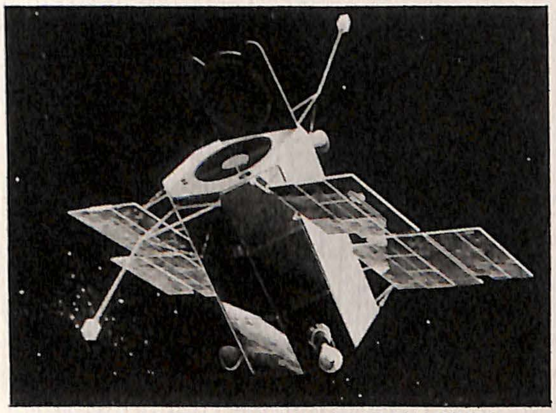
By JAMES J. HAGGERTY, JR.
Associate Editor, Aerospace

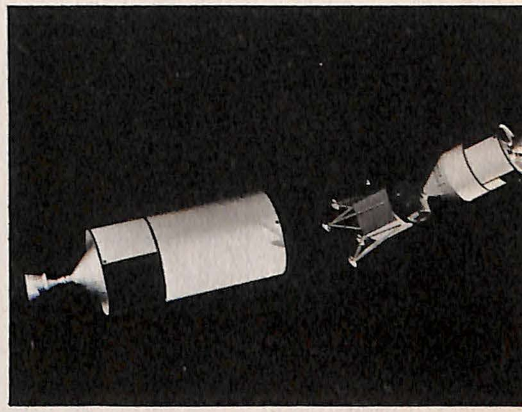
Space progress during the brief span of NASA's history has been truly remarkable, but it pales in comparison with the achievements which can logically be expected in the remainder of this decade.

The accomplishments of the first five years were important from both the prestigial and scientific standpoints, but perhaps their greatest importance lies in the base they provided for the bigger things to come. The half-decade was a learning period; projects like Mercury, Mariner, the applied and scientific satellites generated an across-the-board technological capability which will increase the rate of progress in future years.

"With the availability of more powerful launch vehicles like the Saturn series," says one NASA official, "we will have a really vast capability. In fact, the capability will exceed our ability to exploit it. We do not have the resources to do everything which is now, or will soon become, possible to do. So we must pick and choose carefully, selecting those programs which will provide maximum benefit within the available resources."


NIMBUS


ORBITING ASTRONOMICAL OBSERVATORY


APOLLO

The programs for the remaining years of this decade are reasonably firm, although they may be altered in detail because of technical advances, expanded or cut back because of budgetary considerations. In general, they consist of manned flights of increasing duration and at greater distances from earth, culminating in the lunar landing; more advanced applied satellites; intensified research in the area between earth and stationary orbit altitude (22,300 miles), between the earth and the moon, and between earth and the sun; unmanned lunar exploration; additional unmanned interplanetary probes to Mars and Venus, and possibly Mercury.

Looking farther down the road to post-Apollo space research, the picture is not so clear. NASA is already conducting a great many studies toward establishing the direction of the space program of the Seventies. Project possibilities include a more ambitious study of the moon than will be possible with the Apollo spacecraft, a manned lunar base; a large earth-orbiting manned space station or laboratory, together with logistics spacecraft for ferrying men and supplies between earth and the space base; unmanned probes to the more distant planets; and, what may become the focal point of space research beyond the moon, a manned expedition to Mars.

Budgetary factors aside, such projects involve tremendous technological advances over a wide range of systems, most importantly the launch vehicle. Even the huge Saturn V, with 7,500,000 pounds of thrust in its basic stage, is inadequate for these missions; NASA researchers envision a booster with at least three times Saturn V's payload capability. This booster, tentatively called Nova, is the subject of a great deal of study within NASA and industry. It may be chemically-propelled by either solid or liquid fuels, it may have a nuclear power plant, or it may have a combination propulsion system. NASA officials feel they have another two years or more before it is necessary to decide on Nova's composition, and the key factor will be the rate of progress in nuclear rocket development.

While the "way-out" researchers are laying the ground work for the programs of the next decade (none of which will be initiated until Apollo spending has passed its peak), NASA will concentrate on successful completion of these major projects of the Sixties:

APPLIED SATELLITES

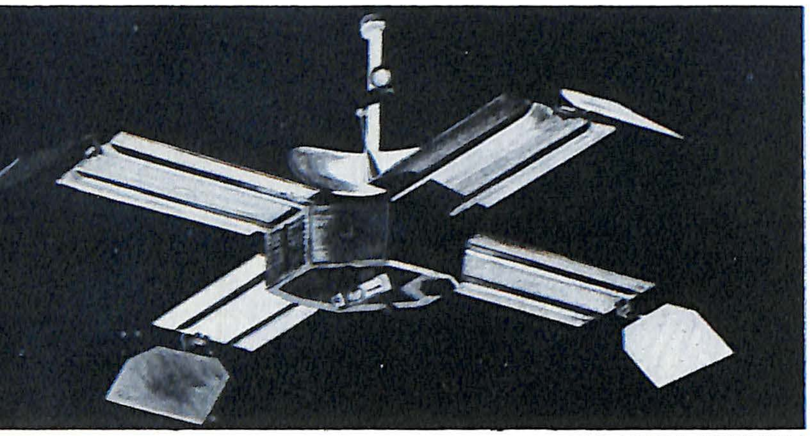
Although NASA will explore other spacecraft applications, the bulk of the research in this area will be devoted to perfection of meteorological and communications satellites.

There will be approximately six more launches of the Tiros weather satellite under a joint NASA/Weather Bureau program. Tiros, with seven successes in seven launches, has been an extraordinarily effective project. It does, however, have limitations: its cameras "look straight down" on earth only through a small portion of the orbit and it provides only 10 to 25 per cent of the global cloud cover daily.

In development, and scheduled for first flight either late in 1963 or early in 1964, is the more advanced weather satellite Nimbus. Nimbus will have a stabilization system which will permit its cameras to view the earth vertically at all times. Nimbus will also have a longer operating lifetime—six months to a year, compared with about three months for Tiros.

Both Tiros and Nimbus operate at relatively low altitudes. Under study is a synchronous orbit meteorological satellite tentatively named Aeros which would remain in a fixed position relative to earth and permit continuous weather observations over a selected segment of earth's surface.

Despite the successes of communications satellites such as Echo, Telstar, Relay and Syncom, considerable development work remains and it will be NASA's role to help the Communications Satellite Corp. by carrying out the experimental effort directed toward future systems.



MARINER FOR MARS MISSION

There will be additional research on the passive, or signal bouncing, communications technique with a 1963 launch of Echo II, a 135-foot diameter rigid balloon satellite. Work on the active repeater type of comsat will continue with at least one more launch of Syncom. In study status, and slated for full development, is a comsat similar in principle to Syncom, but with a greater communications capability. It is known as the Advanced Synchronous Orbit Communications Satellite.

Another area of applications research is the navigational satellite Transit, wherein NASA will explore the use of the Navy spacecraft as a navigational aid for nonmilitary ships and aircraft.

Under study is the Data Collection Satellite, which would collect information from ground stations around the world and report it to a central agency. This type of satellite could collect meteorological, oceanographic, magnetic and cosmic ray data and might also be applicable to tracking icebergs or wildlife, relaying tidal wave warnings or locating persons in distress.

SCIENTIFIC SPACECRAFT

Scientific spacecraft may be broken down into two general categories: earth satellites and lunar/planetary probes.

There will be several types of small satellites designed to gather scientific data on the near-space surrounding earth, in particular data on energetic particles, atmospheric structure and the ionosphere. This group will include the Explorer series, which operate close to earth, and a number of "monitors," which orbit from intermediate to near-lunar distances from earth. There will be additional international programs, including the polar ionosphere Beacon satellite, in which 20 countries will cooperate.

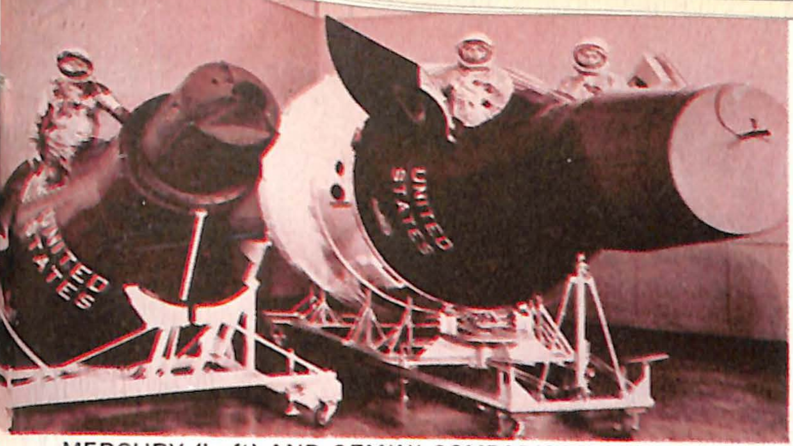
Of major interest are the large unmanned observatories, the first of which, the Orbiting Solar Observatory, was launched in 1962. OSO I provided a great deal of new solar information of vital importance to the manned space flight program, particularly the matter of solar flares which generate intense radiation. Future OSO's will have improved pointing accuracy and greater data storage capability for more precise solar measurements. NASA has scheduled 12 more OSO's for launch during 1963-67.

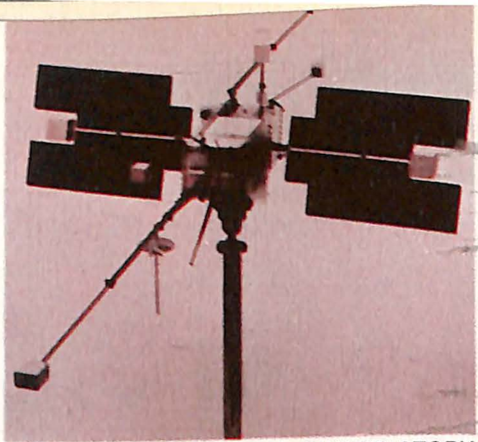
The Orbiting Geophysical Observatory is a 1,000-pound satellite containing instrumentation for about 20 experiments embracing a large number of geophysical and solar phenomena. OGO, designed to provide a better understanding of earth-sun relationships, will operate in a highly elliptical orbit, reaching altitudes of more than 50,000 miles. NASA plans to keep two OGO's with different orbits in space through a complete solar cycle of 11 years. First launch is scheduled for late 1963, with a total of 12 OGO's planned through 1967.

To study the stars and interstellar gases from orbits above the earth's distorting layer of atmosphere, NASA will launch a series of Orbiting Astronomical Observatories. OAO is a 3,600-pound earth satellite, which will operate in a 500-mile altitude circular orbit. Its experiments will include four 12-inch telescopes to map the sky in ultraviolet; one 16-inch and four eight-inch telescopes to study selected bright stars and nebulae; a three-foot telescope for detailed studies of about 5,000 stars and nebulae; and a 32-inch telescope for studies of interstellar matter. First launch will take place early in 1965, and NASA plans five launches through 1967.

For lunar research, NASA will continue the Ranger series of spacecraft, five of which have already been launched with one impacting the moon. NASA hopes to launch another Ranger this year and six a year in 1964-66. Equipped with television cameras and an instrumented landing capsule, Ranger will provide detailed photos of the lunar surface, conduct initial reconnaissance of possible lunar landing areas for manned spacecraft, and explore lunar topography, surface texture and seismological data.

For more advanced lunar research, NASA will launch a series of Surveyor soft-landing spacecraft. Surveyor will check out soft-landing technology, study various landing areas on the moon, and, with a wide


MERCURY (Left) AND GEMINI COMPARISON


ORBITING GEOPHYSICAL OBSERVATORY

variety of instruments, measure the physical and chemical properties of the lunar surface and sub-surface. The first of approximately a score of Surveyors will be launched in 1964 and tests will continue through 1967. In addition to the lunar landing Surveyors, NASA also plans a series of five moon-orbiting satellites, which will make detailed photographs of the lunar surface from as close as 22 miles, a prelude to selection of the manned lunar landing area.

Following up on the highly successful launch of Mariner II to Venus, NASA has programmed a series of Mariner flights for more intensive study of Mars and Venus, the first to come in late 1964 when Mars will be in a favorable position. This next Mariner mission will be a "fly-by." The spacecraft will be equipped with a television camera for photography of the planet and instruments for experiments in infrared spectroscopy to determine the possibility of life on Mars. A more advanced version of the Mariner will contain a landing capsule for detailed measurements of the surfaces and atmospheric composition of Mars and Venus. NASA plans call for 16 launches of the Mariner series through 1967. In addition, there is in study status the Voyager project, involving a much larger and heavier Mars/Venus spacecraft capable of orbiting the planets and landing a sizeable instrument payload.

In other interplanetary research, NASA will launch 11 Pioneer deep space probes during 1964-67.

MANNED SPACE FLIGHT

As a bridge in the technical gap between Projects Mercury and Apollo, NASA will conduct a series of manned flights with the Gemini spacecraft, similar in configuration to the Mercury capsule, but about 30% larger and weighing 7,000 pounds. With the two-place Gemini, NASA will initially investigate the physiological aspects of long-duration (up to two weeks) orbital flight. Later, Gemini will be used for rendezvous missions at about 185-miles altitude, docking with an Agena vehicle. With Gemini, astronauts will learn how to perform most of the maneuvers needed for a lunar landing mission. The project will also include experiments in spacecraft control during re-entry and descent, employing reaction controls and a "paraglider" recovery wing.

After Gemini comes the all-important Apollo project. The 80-foot tall Apollo spacecraft, which will accommodate three men, consists of three modules: a command module, which houses the crew and serves as control center; the service module, which contains the life support systems as well as a propulsion unit for mid-course corrections and injection into and out of lunar orbit; and the excursion module, in which two men will descend to the lunar surface.

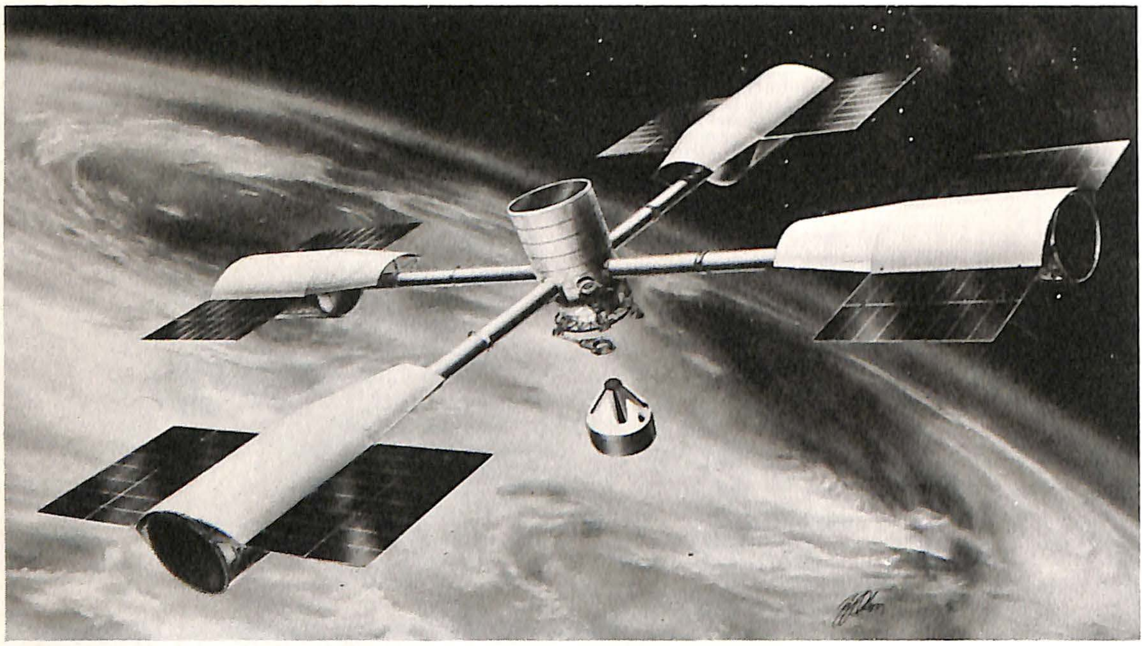
Apollo missions will get under way in 1964, with the launch of an unmanned "boilerplate" spacecraft by the Saturn I vehicle. The first manned flights will come in 1965, using the command and service modules as a spacecraft for earth orbital maneuvers. With the availability of the more powerful Saturn IB, NASA will launch the three-module spacecraft into earth orbit to develop operational techniques for rendezvous and docking. Later, with the Saturn V launch vehicle, the Apollo project will progress to a circumlunar reconnaissance mission, finally to the manned lunar landing.

In the planning stage are further manned space missions. The most probable next major project is the manned space station, now under intensive study. Proposals for this project cover a wide range of possibilities, from a modified Apollo with a 100-day lifetime to a large 20-man rotating spacecraft with artificial gravity provisions, capable of remaining in orbit for indefinite periods. Also under study are transport and supply shuttle vehicles for ferry to and from the station. Advanced studies include the manned lunar base and manned planetary missions, the first of which would be an expedition to Mars, considered technically feasible during the 1970's.

The foregoing represent only the highlights of NASA's future activity. The space agency will also be active in a great many other areas including development of a series of launch vehicles and engines; the launching of a large number of sounding rockets with specific research assignments; participation in scientific programs as contributions to the International Year of the Quiet Sun; bioscience experiments, to be carried aboard balloons, unmanned satellites and interplanetary spacecraft; advanced nuclear, chemical and electric propulsion research; electronics and communications research; space power generation, involving experiments in solar, chemical and nuclear sources for on-board spacecraft power needs; and improved tracking, telemetry and other data acquisition equipment. Finally, there will be considerable effort devoted to the frequently overlooked but not neglected area of NASA's responsibilities, aeronautical research, in which the agency will concentrate on supersonic transport, hypersonic aircraft and V/STOL research.

IDEAS – STEPS TO SPACE

It is the assignment of the National Aeronautics and Space Administration to draw up the detailed requirements for a specific space project and to select those projects from which will accrue the maximum scientific benefit to the nation. There are several steps, however, before "approved program" status is reached, and the first step is the basic idea. The idea is studied for basic feasibility, modified and expanded into a proposal. In addition to the NASA centers and laboratories, new concepts originate in a number of sources within the nation's scientific and engineering community, and one of the most fertile points of origin is the aerospace industry. Using private funds, industry devotes a good portion of its research effort to studies aimed at development of new space systems. Shown here are the different approaches of various contractor study groups to future major national space projects such as manned space vehicles.



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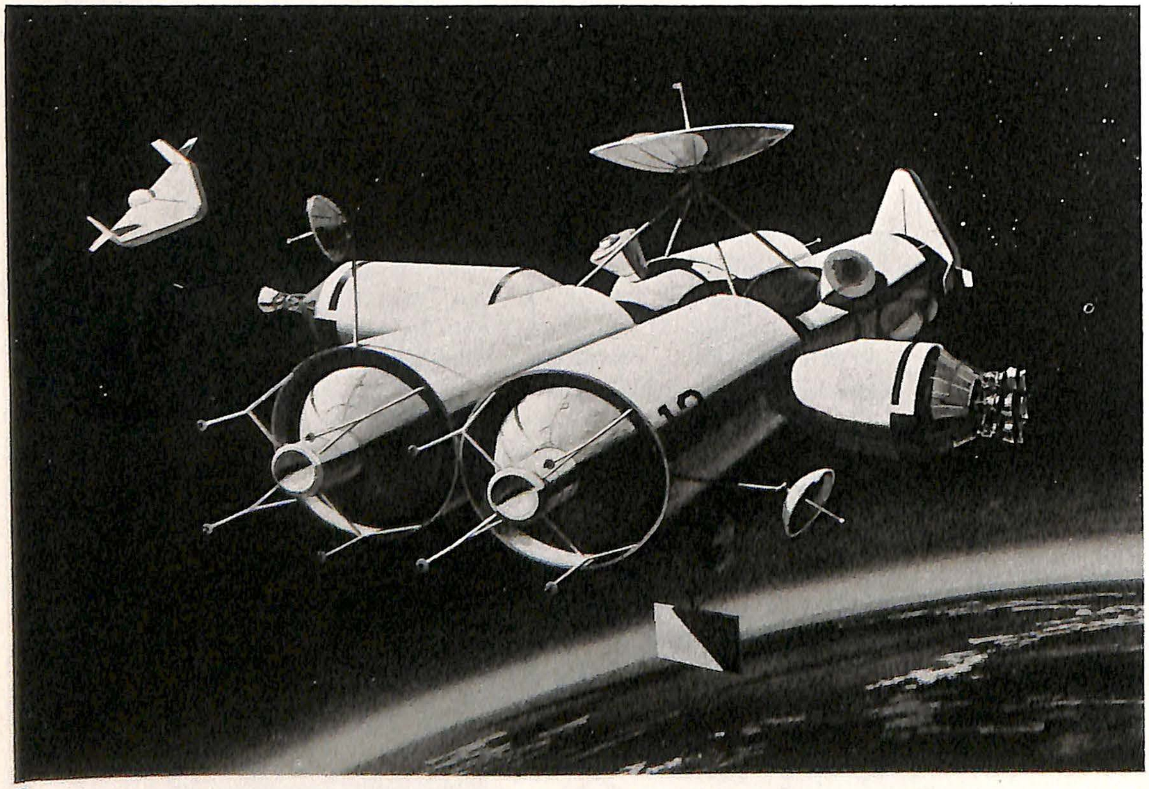

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1. Space station orbits the earth over west coast of Africa. This station would provide "garages" for manned Apollo spacecraft at the end of each spoke of the spinning satellite. Access to modules and hub is provided through hollow tube spokes. Apollo spacecraft is shown as it approaches the hub at elbowed docking point.

2. A multi-purpose space base could be established as a rendezvous and launch point for lunar shuttle vehicles, reusable vehicles and homeward bound planetary spacecraft. This base could also be utilized for assembling interplanetary vehicles. Technology for this base is available.

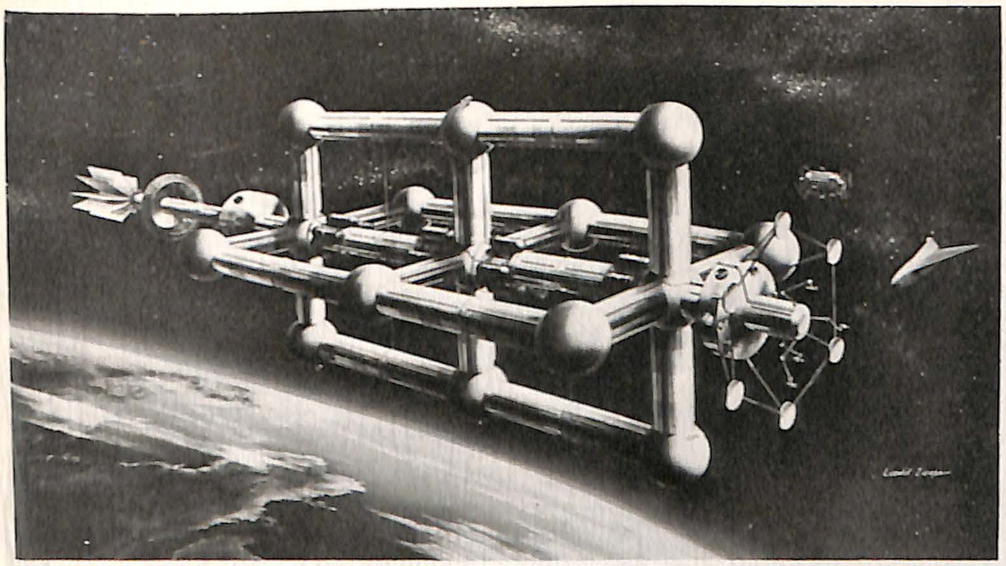
3. A design patent has been awarded to an aerospace company for this space station. The concept originated from 4,500 hours of study by 25 scientists and engineers. Base is multi-purpose.

4. Laboratories on earth can approach the space environment, but cannot accurately and simultaneously duplicate the vacuum, meteoroid flux or the quality and quantity of a solar storm. This base could be used for testing equipment, structures and operating techniques for prolonged periods of time.

5. Excursion craft could be detached from a convoy of vehicles in orbit around Mars to land men on the planet for brief periods. Convoy concept would provide flexibility to space missions.

6. A global communications network might use atomic-powered satellites such as the one shown here. Power would last 20 years.

7. Large chemical rocket would use a 1.5 million pound thrust engine and two 40,000 pound thrust engines as the first stage. Nose section contains conical life support system for crew.



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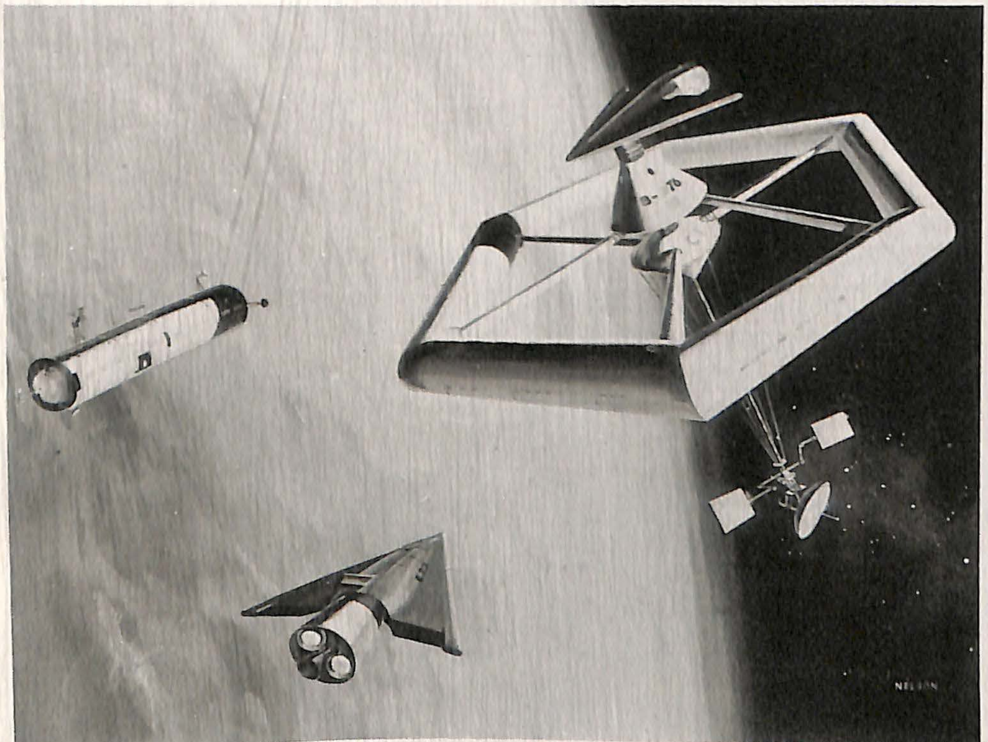

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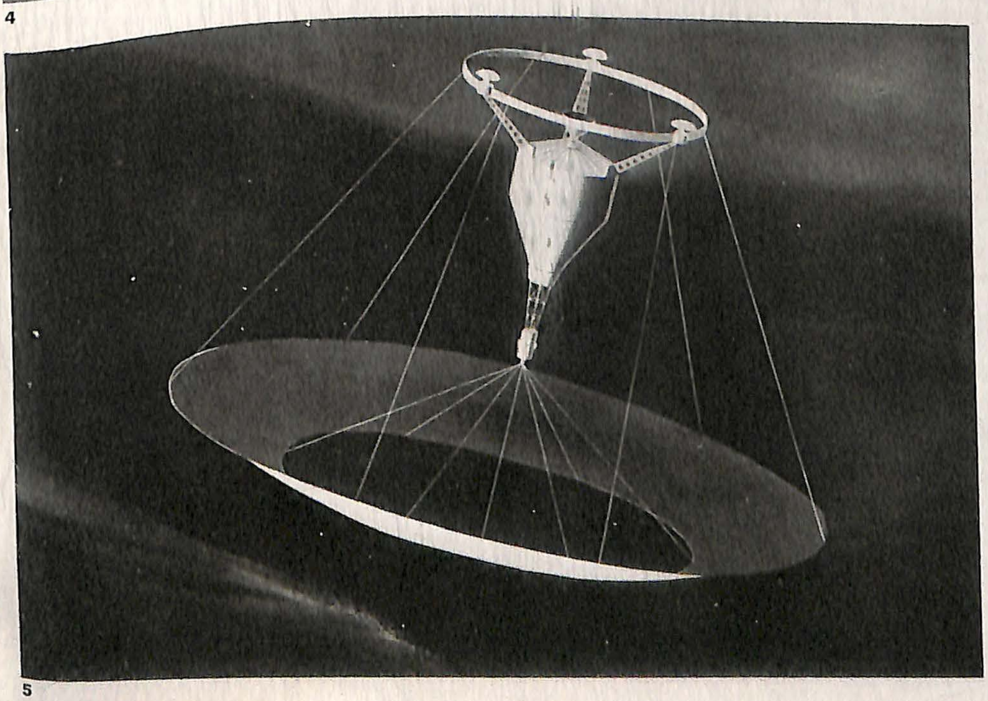

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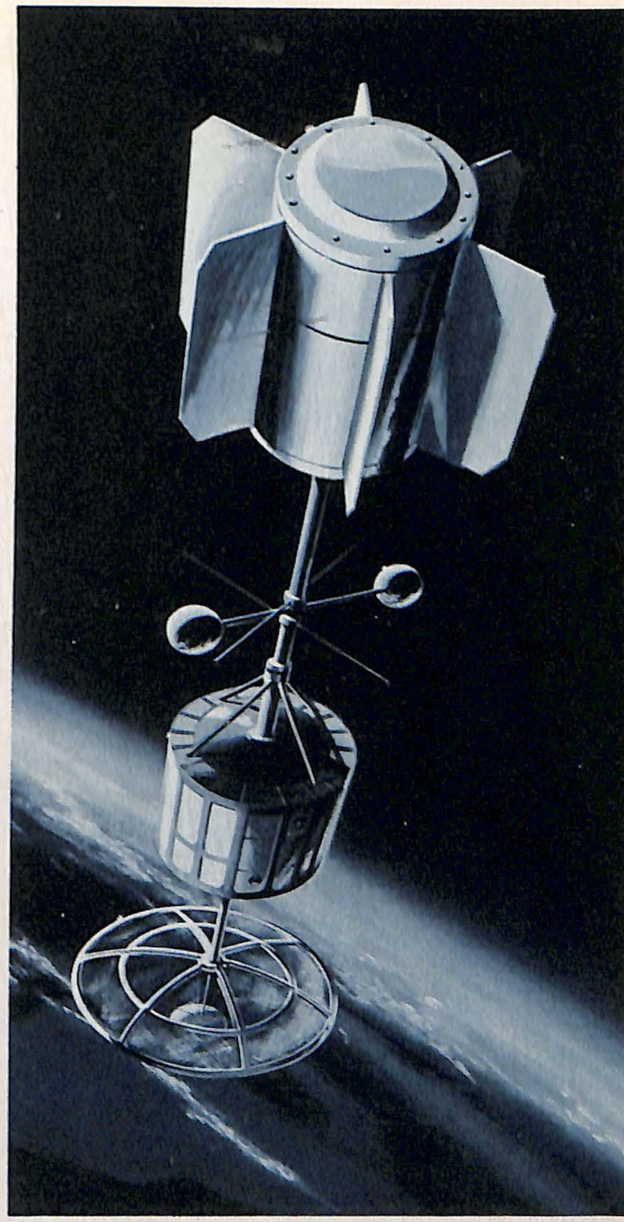

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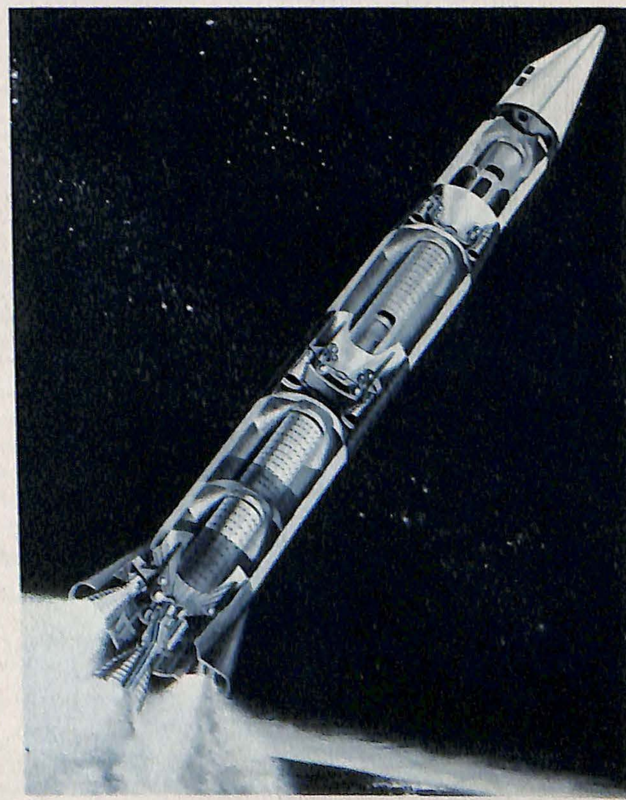

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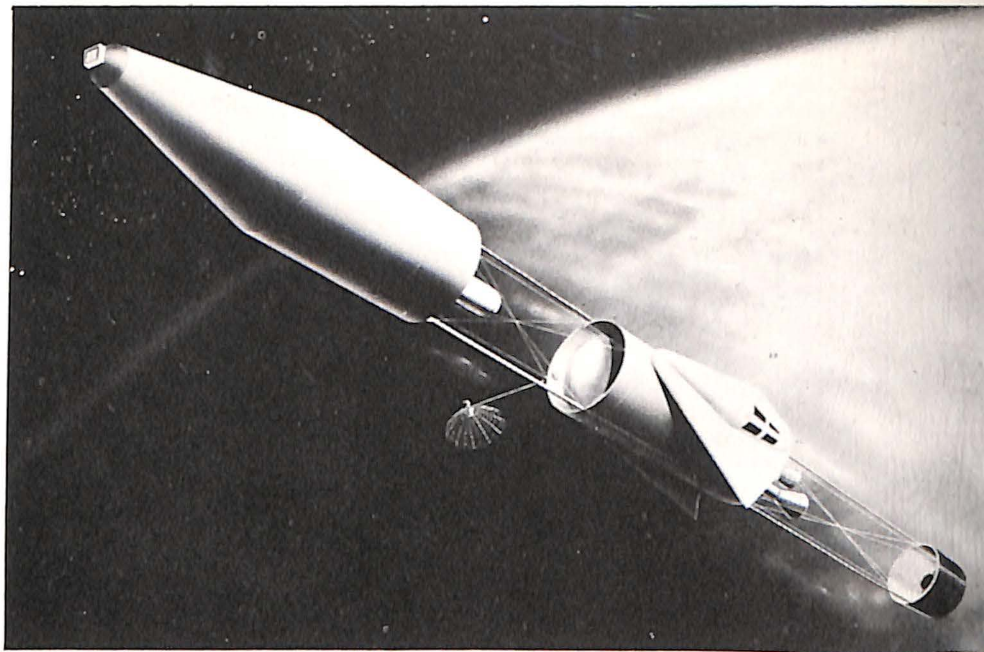
IDEAS-STEPS TO SPACE



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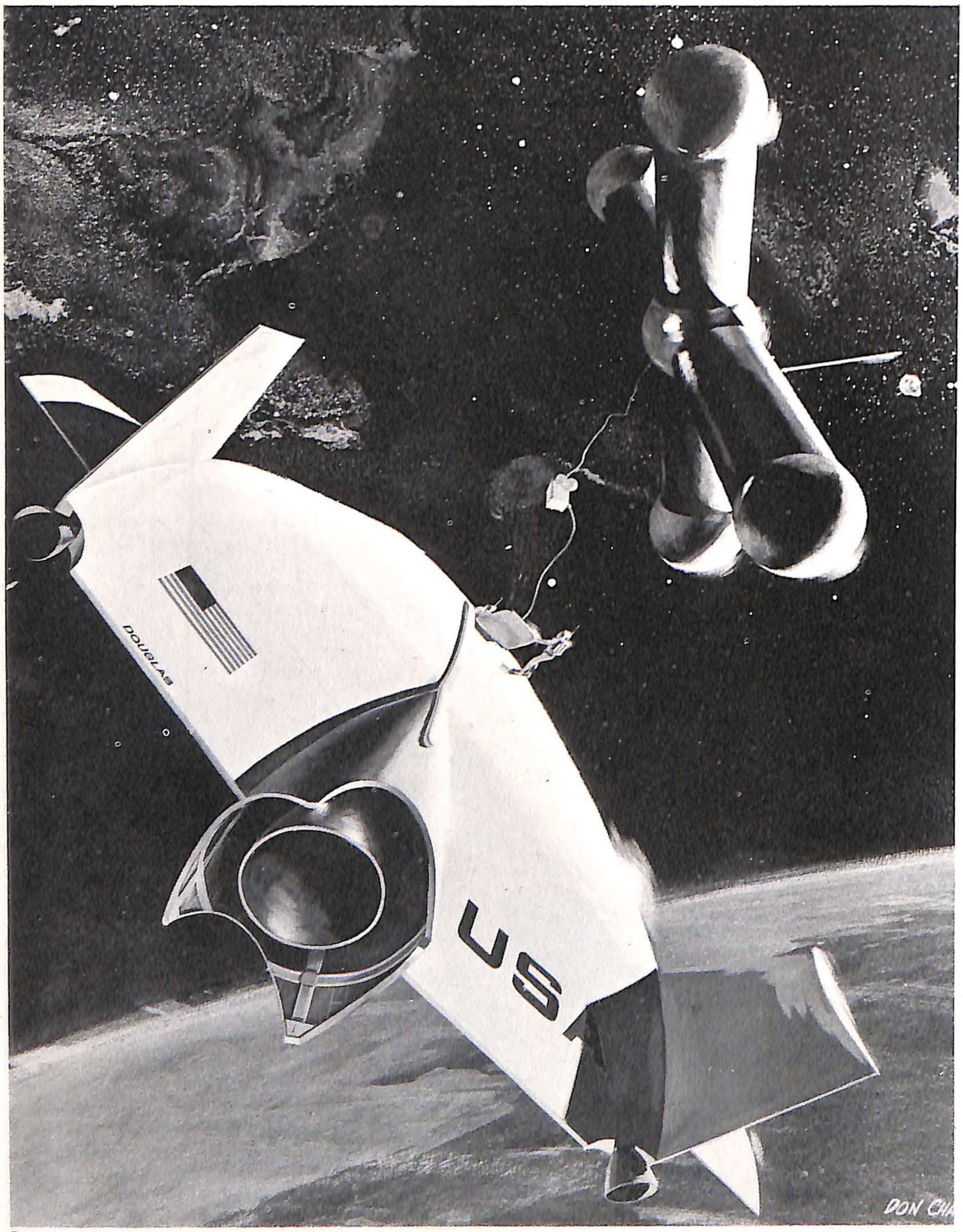


8. Delta-winged vehicle would combine aircraft and rocketry concepts into a versatile manned space system for ferrying personnel and supplies to space stations, and to maintain and repair them. First stage booster and spacecraft is capable of returning to earth and landing at airports.

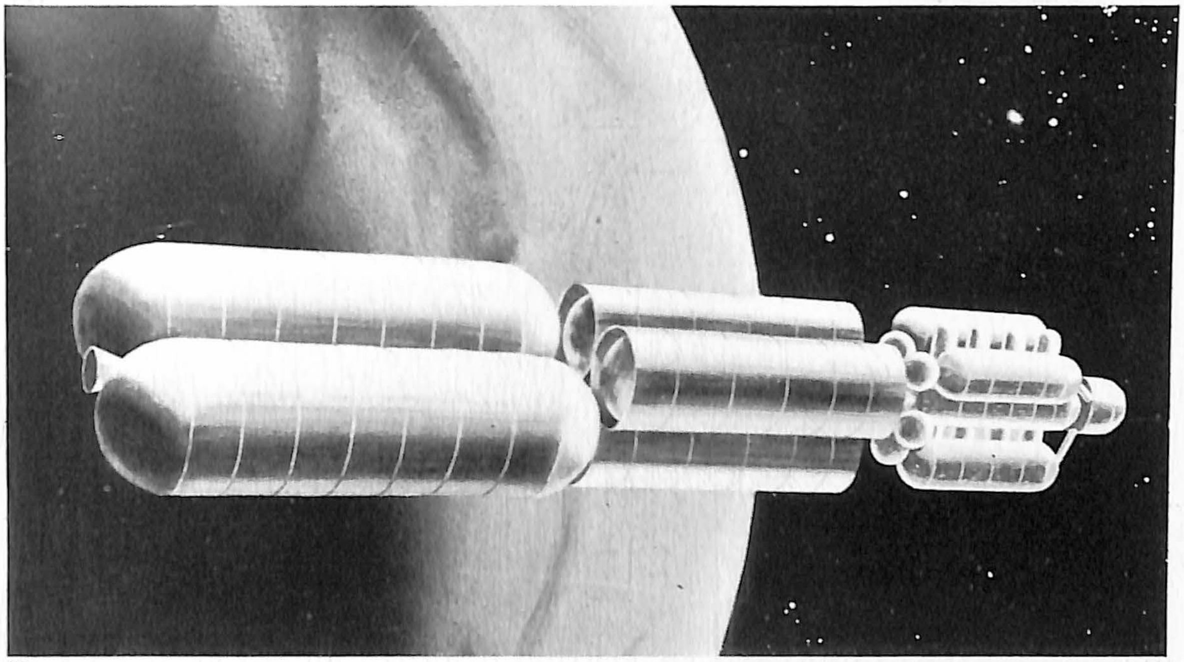
9. This space laboratory would have quarters for a four-man crew and an atomic reactor. Compartments in crew quarters (left) would provide sanitary facilities, recreation area, sleeping quarters and a control room. Reactor would provide power. Centaur (middle) is second stage booster.

10. Concept of a manned planetary ship, made up of individual units, is shown in orbit around Mars. This is a possible solution to flight between the planets in our solar system.

11. A solar-powered spacecraft may take man through space. Sunlight captured by the large plastic sphere is used to heat liquid oxygen. Half of the sphere facing the sun is transparent. Other half is coated to form a mirror-like surface which collects solar radiation. Crew gondola is at the opposite end. The ships would be constructed and also launched from a satellite in orbit.

12. An earth-orbiting manned space station would be used for research. Men would be shuttled from earth.

13. Manned weather stations in space could provide a long step toward actual control of weather. The benefits are obvious and abundant. Such a satellite, incorporating man's intelligence and on-the-spot control over such forces as hurricanes, would be invaluable. Drawing shows a weather control satellite.



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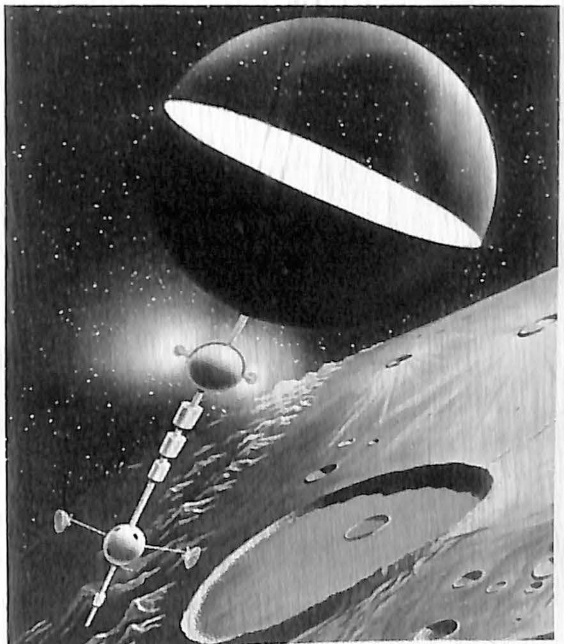

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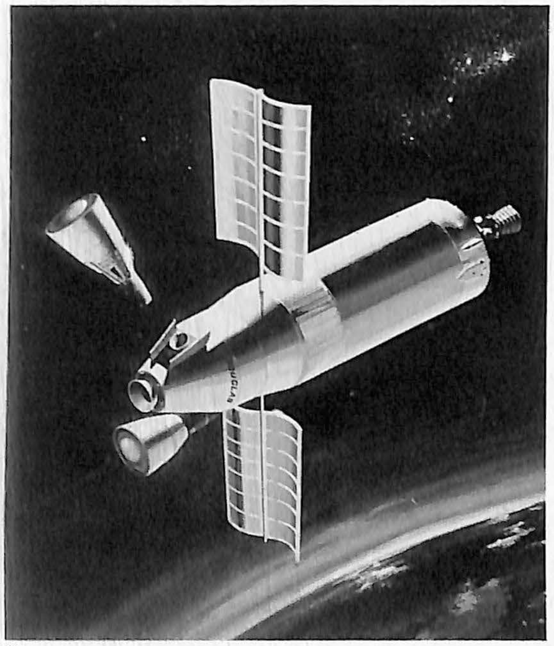

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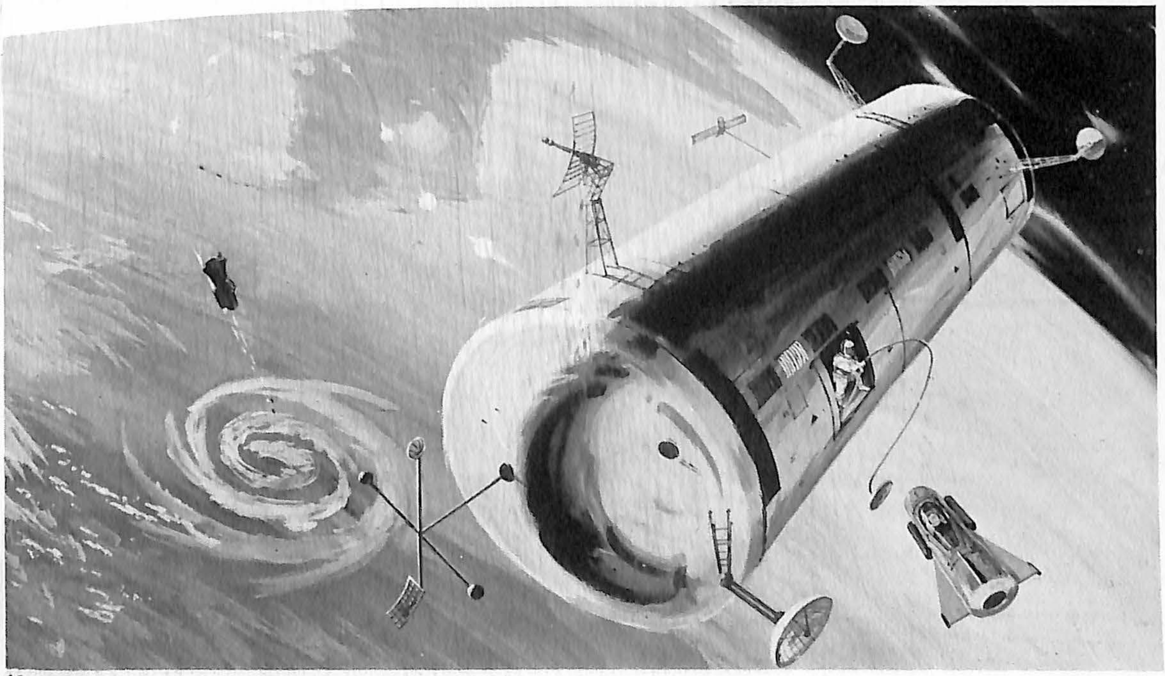

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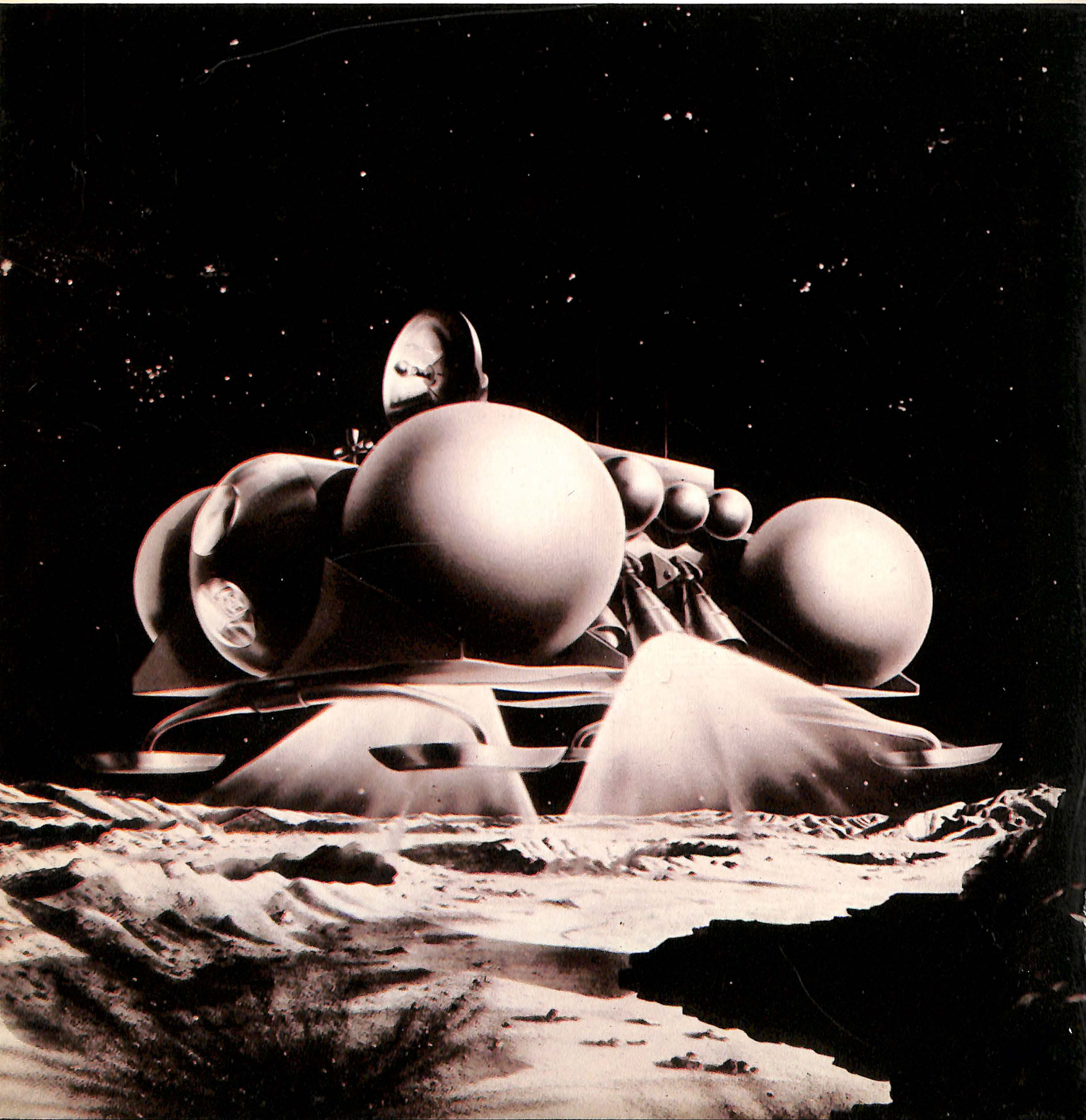

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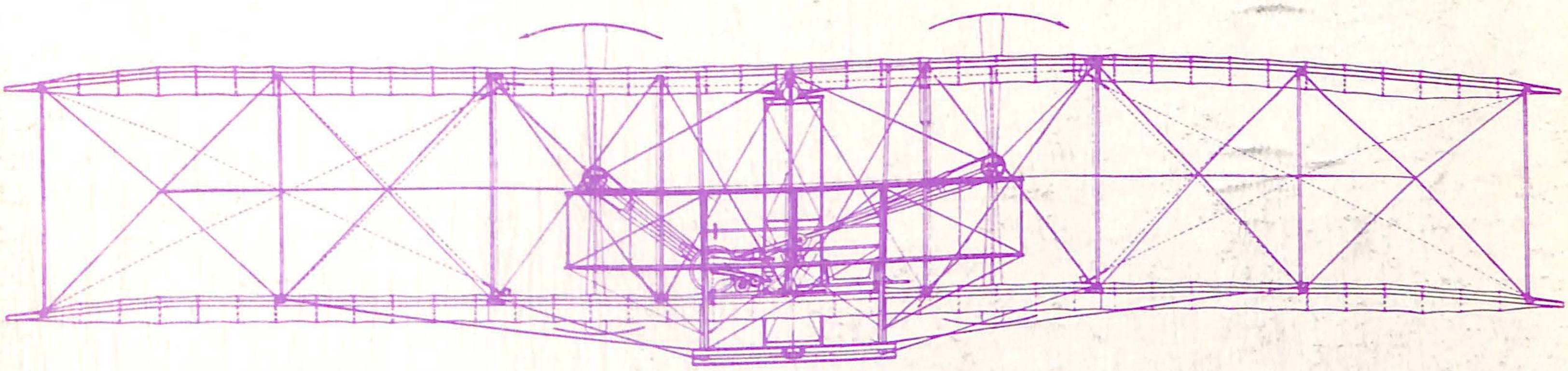
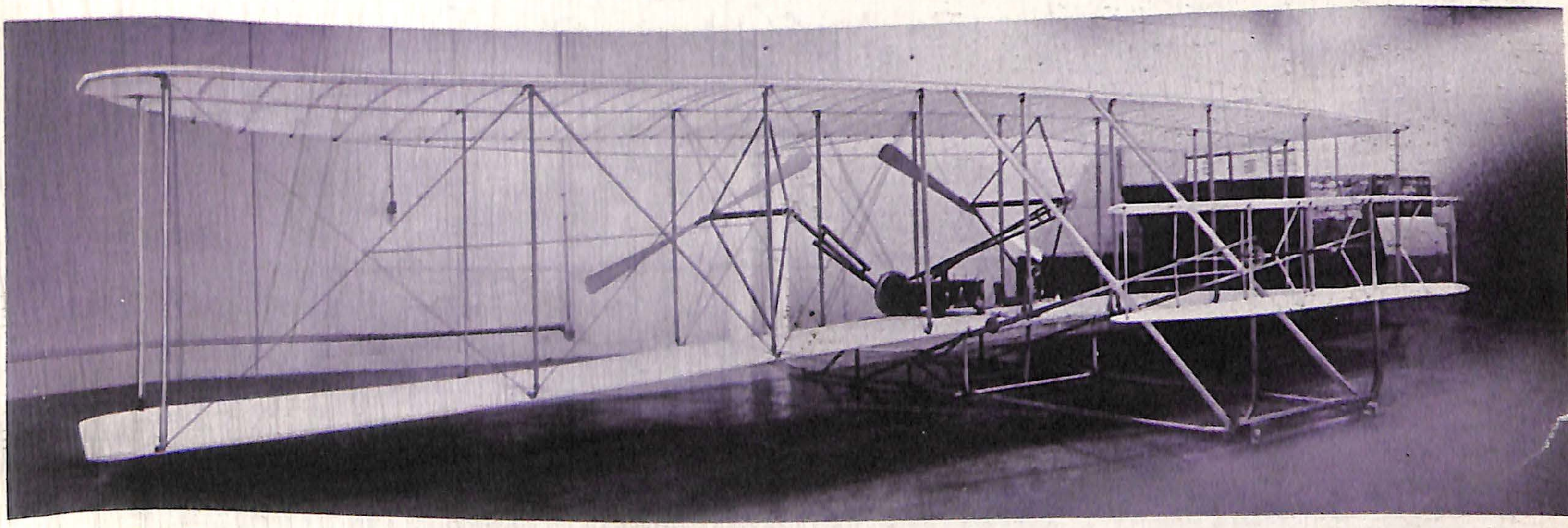
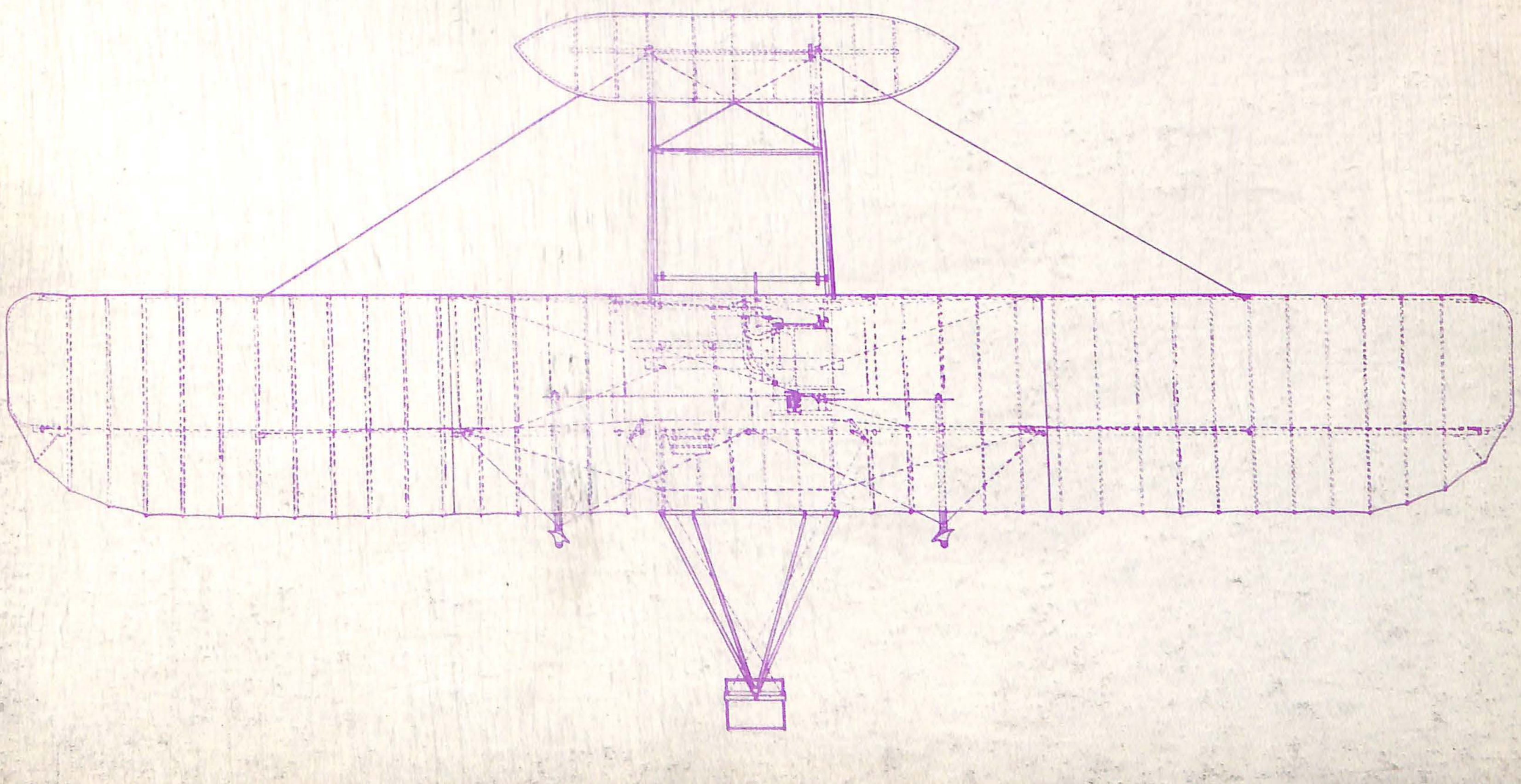
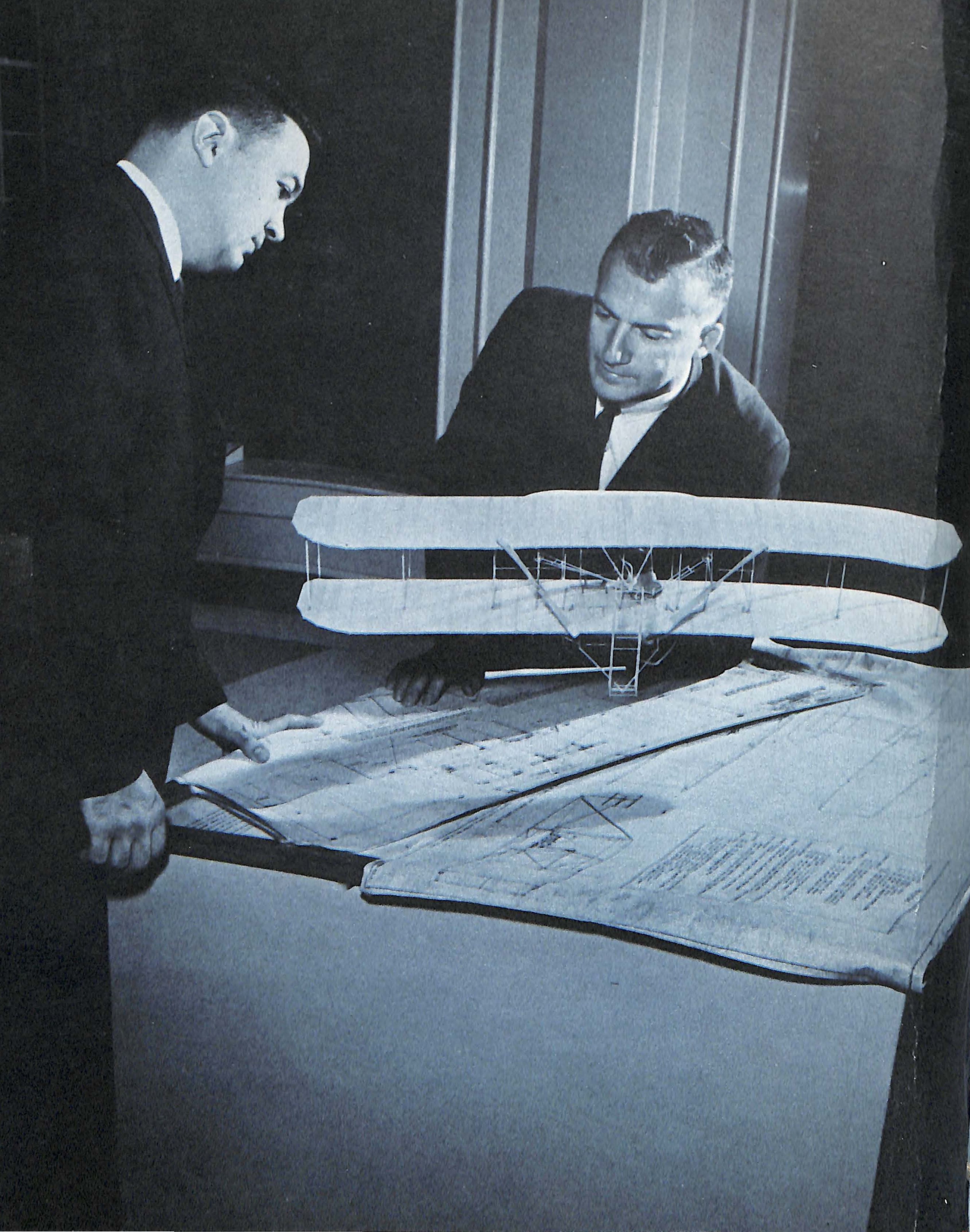




1903 WRIGHT FLYER 1963





Thomas D. McAvoy, who photographed the reconstruction of the Wright Flyer for **Aerospace,** is the first photographer employed by **Life Magazine.** He has worked 26 years as a Time-Life photographer, and has covered innumerable photo stories. They range from the first candid photos of the late President Roosevelt in the Presidential office to covering revolts in Tunisia, Morocco and Algiers. His interest in aviation extends back to a below-age enlistment in the Maryland National Guard where he photographed the Curtiss Jennies. During World War II, he did a photo essay on the operations of the longest aerial supply line in history — the Air Transport Command's supply of the China-Burma-India theater. He flew 27,697 miles in the same cargo aircraft in 10 days. Crews were changed 14 times; Photographer McAvoy stayed with the plane and the story. His brother, William H. McAvoy, recently retired as a chief test pilot for the National Advisory Committee for Aeronautics, now the National Aeronautics and Space Administration. "It was a great pleasure to cover the reconstruction of the Wright Flyer," McAvoy said. "All photographers like a chance to re-shoot history. I may even qualify as the Matthew Brady of the Aerospace Age."

AIA

aerospace

Official Publication of the
Aerospace Industries Association of America, Inc.

VOL. 1, NO. 4 *DECEMBER, 1963*

CONTENTS

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems:
Foster understanding of the aerospace industry's responsibilities in the space exploration program;
Foster understanding of commercial and general aviation as prime factors in domestic and international travel and trade.

AEROSPACE is published quarterly by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

Publication Office: 1725 De Sales Street, N.W., Washington, D. C. 20036

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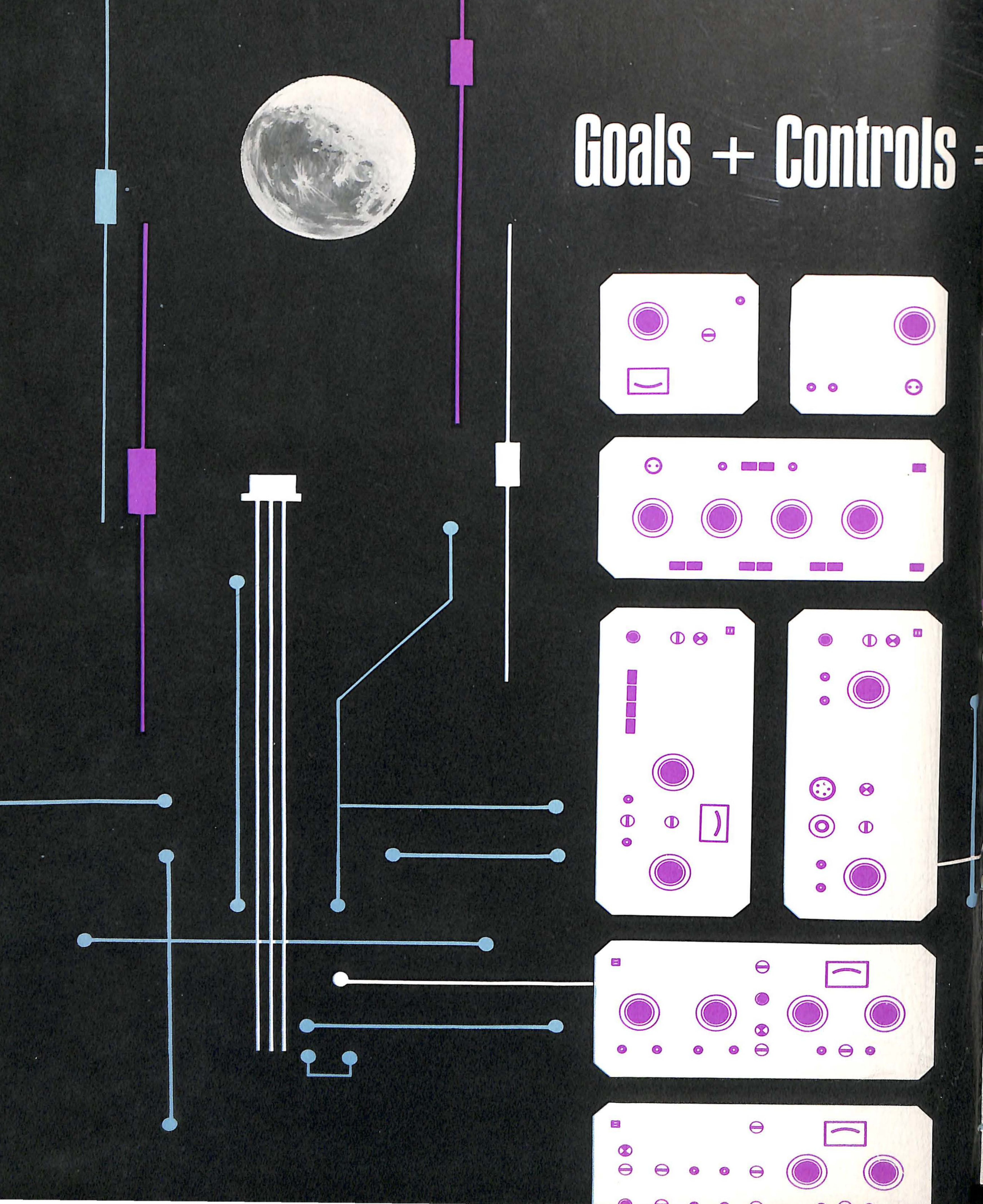
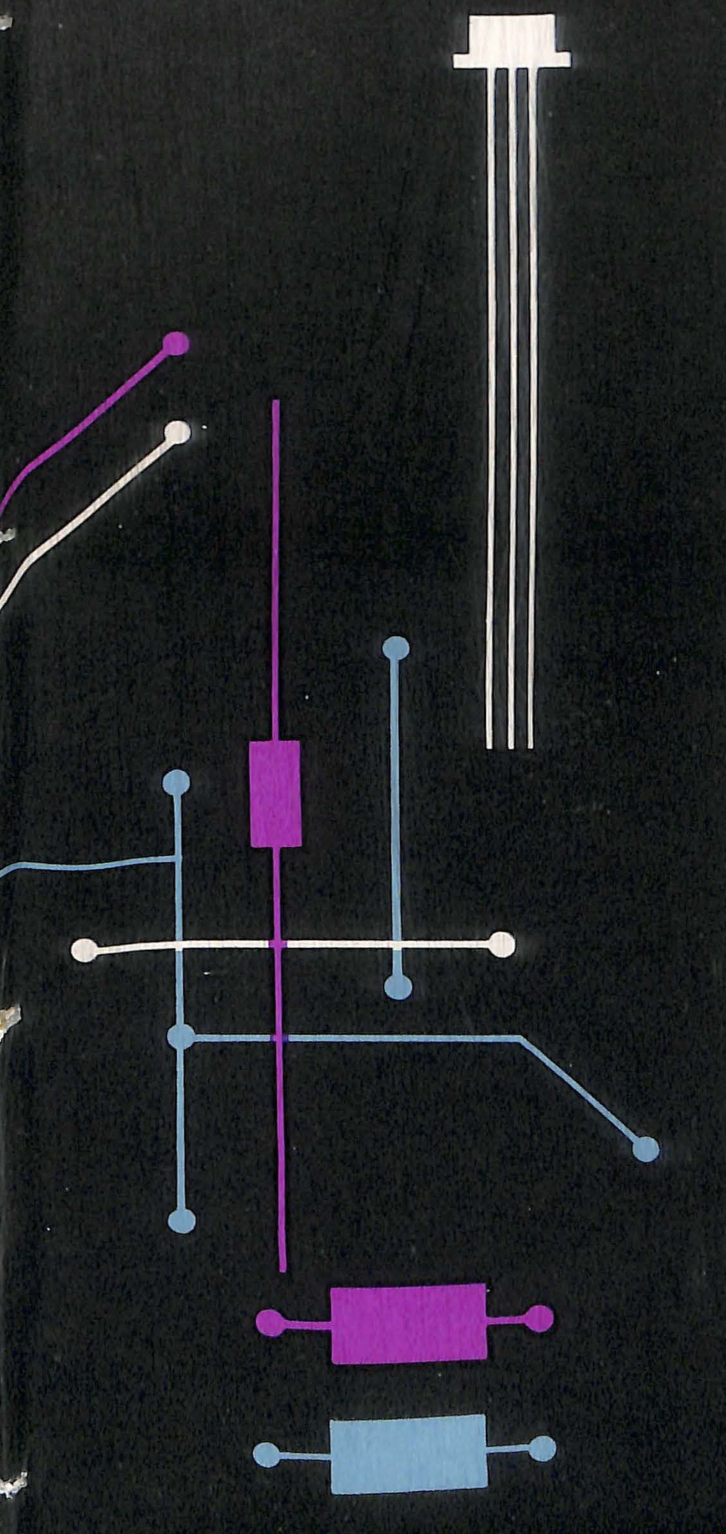


Quality Assurance

By JAMES J. HAGGERTY, JR.
Associate Editor, Aerospace



"Quality assurance" is a formal term which means, in simple language, making sure your product works the way the customer wants it to work.

And that, in the aerospace world, is not easy. The manufacture of today's extremely complex, high performance systems for defense and space exploration demands a degree of workmanship unparalleled in the annals of product fabrication.

Despite the complexity and high performance requirements, however, the aerospace industry today boasts a quality effort better than that of any other industry because of its highly refined procedures for assuring product excellence. Perfection — 100 per cent reliability — is almost impossible to achieve because of the extraordinary performance demands, yet despite the complexity, specified reliability goals of 95 to 99 per cent are constantly being met.

Although quality has always been a by-word in the industry, it has become increasingly important in this era of advanced technology, not only from the standpoint of customer satisfaction (which is vital, since the prime customer is the government) but also because quality assurance has a bearing on low cost production and on-time scheduling, the other two major factors which influence a company's competitive standing.

The importance of quality assurance in the industry is growing daily, and the "quality man" in an aerospace company has graduated from the inspector level to a top management position (an Aerospace Industries Association survey shows that in almost 90 per cent of the companies studied, the quality assurance manager reports directly to executive management rather than to a manufacturing or engineering head, one indication of the importance industry places on this vital facet of its operations). And product quality comes high — the industry spends hundreds of millions annually on salaries for personnel engaged in quality assurance work and a like sum on highly specialized assurance equipment.

The terms "quality assurance," "quality control," and "reliability control" are often used interchangeably, but one definition draws shades of distinction between them. Quality assurance is the overall control of all the factors which influence the excellence of the final product. Quality control and reliability control are measures designed to obtain the overall assurance. The former involves procedures to insure that all of the buyer's specifications are met and that the product is acceptable. The latter concerns efforts to guarantee that the product will perform as required *after* its acceptance by the buyer and throughout its lifetime.

In the manufacture of aerospace products, quality assurance techniques begin while the product is still just a set of figures on paper. The first responsibility toward insuring quality falls not to the maker but to the customer, who, in nine cases out of ten, is a government buyer. By preparing proper specifications, the buyer can contribute to the quality of the product. R. F. Hurt, president of Lockheed Propulsion Co., puts it this way:

"The necessity for good specification cannot be overemphasized. A performance specification properly prepared will state the desired results and the conditions under which the results are wanted. Each influencing factor will be assessed and proper allowances made. If each pertinent factor is known and included in the specification, the producer will be able to provide a product of the desired degree of reliability at reasonable cost."

From the manufacturer's standpoint, quality assurance starts in the proposal stage. Armed with statistical data on possible failure causes in every step of manufacture, quality control and reliability control engineers work with designers in an effort to come up with a blueprint for the product which has inherent reliability. They also take into consideration the operational use and maintenance of the end product, and attempt to build easier "maintainability" into the design.

Quality assurance personnel keep elaborate records of the performance of their thousands of subcontractors, suppliers and vendors, and they contribute to built-in quality and reliability by recommending only those who have demonstrated ability to produce an acceptable item.

Aerospace testing equipment is more complicated than the hardware it checks. Such equipment must be developed simultaneously with the product.

In aerospace manufacture, a primary aim is prevention of failures rather than costly and time-consuming correction of them and a basic method of prevention is the process of stimulating the individual employe to try harder and rewarding him for better work. Many aerospace firms have adopted such programs.

Typical of them is Martin Co.'s "Zero Defects," wherein the company tries to instill in the employe greater pride of workmanship and overcome the basic belief that mistakes are unavoidable. By direct contact of supervisors, by bulletins, posters and billboards, Martin Co. runs a constant campaign to drum home the idea that "Mistakes must be prevented before they happen."

The results have been amazing. Martin's files are full of outstanding individual efforts stemming from the program. For instance, a solderer on the Bullpup missile line hand-soldered, during a six month period, 4,200 printed circuit boards with more than 336,000 soldered joints, without a single defect. In the first year of its operation at one of the company's plants, the Zero Defects program reduced the overall plant reject rate by 39 per cent and the scrap cost rate by 40 per cent.

But, although it is demonstrably possible to reduce the possibility of human error, certain jobs in the aerospace manufacturing process are more conducive to error than others, so, as another quality control measure, the industry has turned to automation. Automatic tools are employed for certain operations; automatic test equipment, in some cases more complex than the product being tested, is used to check out equipment performance all along the line; and automatic data processing equipment computes the results of the tests.

Throughout the manufacturing process, inspection and test are constantly under way in the concerted effort to assure quality. Raw materials coming into an aerospace plant are given close inspection. Parts and sub-systems delivered by thousands of vendors and subcontractors are checked carefully. When a defect is discovered, the vendor is asked for corrective action; if he is unable to correct the deficiency, a quality assurance team from the prime contractor's plant provides the necessary technical assistance. There are further inspections and tests as the systems and sub-systems are integrated, and, finally, a rigorous inspection and test of the completed product before delivery to the customer.

In today's complex aerospace equipment, accuracy of measurement is a vital factor in quality assurance and one that poses a great many problems for industry firms. Machined part tolerances measured in millionths of an inch are no longer uncommon and the industry must make similar minuscule measurements in degrees, pounds, volts, decibels, frequencies, etc. This involves, first of all, a very precise system of modern standards, being provided by the National Bureau of Standards. To make their measurements, industry personnel use a wide variety of tools, such as micrometers, voltmeters, thermocouples, scales and ring gauges. Each of these instruments must be periodically calibrated, so aerospace firms must operate calibration laboratories to check these measuring devices against the standards supplied by NBS. Typical of this type of facility is The Boeing Co.'s Primary Standards Metrology Laboratory, a $2,500,000 investment in product quality and reliability. Bound to rock by 4,500 yards of concrete, it is immune to vibration; it is shielded in copper against stray electricity; controlled in temperature and humidity, it is guarded against the error that might be induced by heat, cold or dust particles.

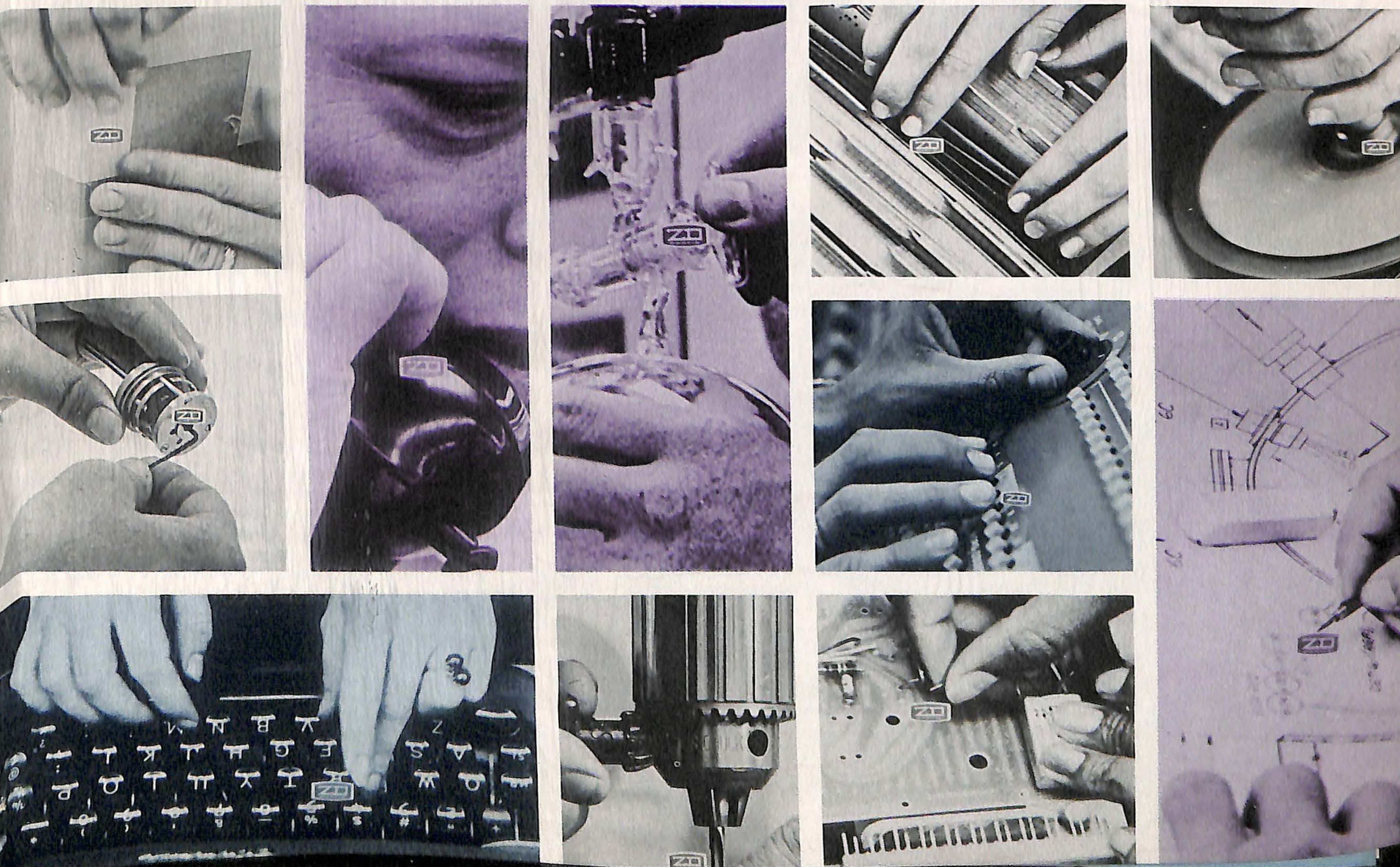
The work of this type of facility is all-important, since accuracy is a prime requirement in quality and reliability. A single degree of error in the guidance system of an ICBM can cause a 1,000-mile miss; a moon probe would miss its target by a wide margin if there were an error in the bore-hole of its gyro of only one millionth of an inch.

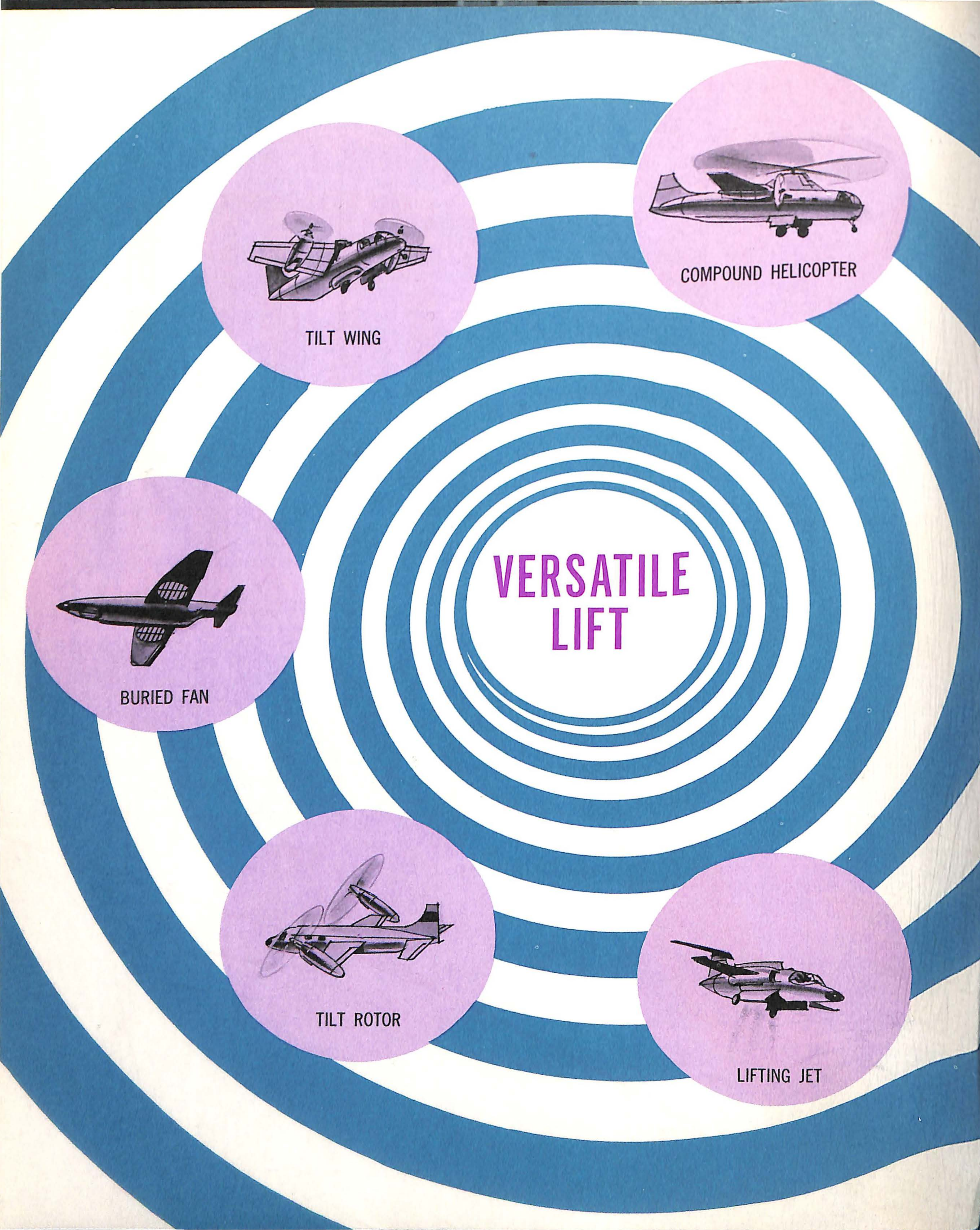
There are but a few of the great many painstaking measures taken by the aerospace industry to assure the quality of its products. The assurance of quality is expensive, running at least a billion dollars a year, and it is likely to become more so. The expense, however, is relative, for effective quality assurance measures pay for themselves. Built-in quality assurance reduces costly work stoppages for corrective measures; it increases on-time deliveries and cuts over-all production costs, which under the government incentive-type contract results in an added fee to the contractor; it reduces warrantee claims by the customer for equipment which might get by an acceptance test but breaks down under the rigors of field use; and top quality brings a contractor increased business because of his performance rating.

"There is probably no management responsibility that is as vital to the survival of a company as upholding the quality and reliability of the company's products," says Frank McGinnis, Director of Reliability and Quality for Sperry Gyroscope Co. "This becomes more true as competition for space age projects grows. The yardstick of company reputation is quality and reliability if the product be a zipper, an automobile or a moon probe."

Even more important that the company's status, as far as the aerospace industry is concerned is the requirement to supply the customer with the best possible equipment, because the customer is the government. A defective zipper is something less than a national calamity, but failure of a spacecraft under the spotlight of world publicity is a severe blow to national prestige. A grounded airplane or an ineffective missile detracts from our national defense capability. Our defense and space programs are only as good as the equipment supplied to their directors, and the aerospace industry, keenly aware of its responsibilities as the hardware-producing member of the industry/government aerospace team, is working hard to achieve the seemingly impossible goal of absolute quality and complete reliability.

Zero Defects program applies to all aerospace elements — technical, administrative and manufacturing.

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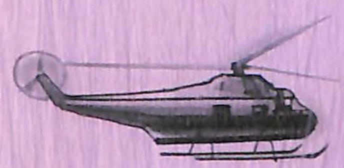


HELICOPTER

TILT DUCT

VTOL

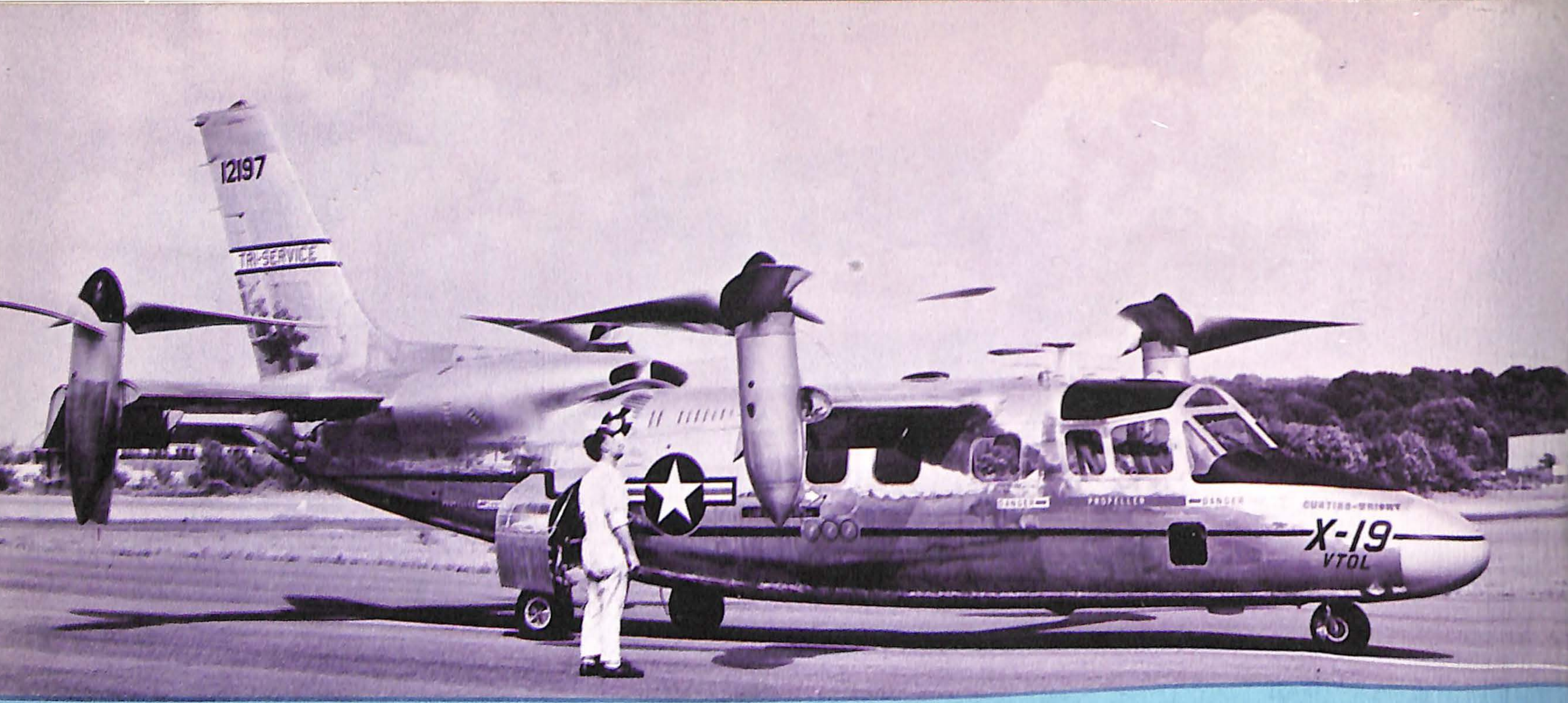
By J. S. BUTZ, JR.

One of aviation's longest sought and most elusive technical goals is being successfully achieved.

This goal is the design of VTOL (vertical take-off and landing) aircraft which combine the high speed and load-carrying capacity of the conventional fixed wing airplane with the helicopter's ability to hover, land and take-off vertically. It is no longer just a mere vision or a novel idea.

Less than fifteen years ago this dream, which is as old as manned flight, was still primarily in the theoretical stage. Few concrete answers had been found for the many difficult problems of building VTOL aircraft. Despite elation over the November 1954 flight of the first true VTOL airplane — the Convair XFY-1 which sat on its tail to take-off and land — engineers in this field knew that many years of hard work lay ahead before truly useful VTOL's would be available. Lighter and more powerful engines were needed to give these aircraft acceptable range and pay-load carrying capacity. Much more research and test flying was necessary before these unorthodox machines would have adequate stability and handling qualities, and could be flown by anyone but the most experienced test pilots.

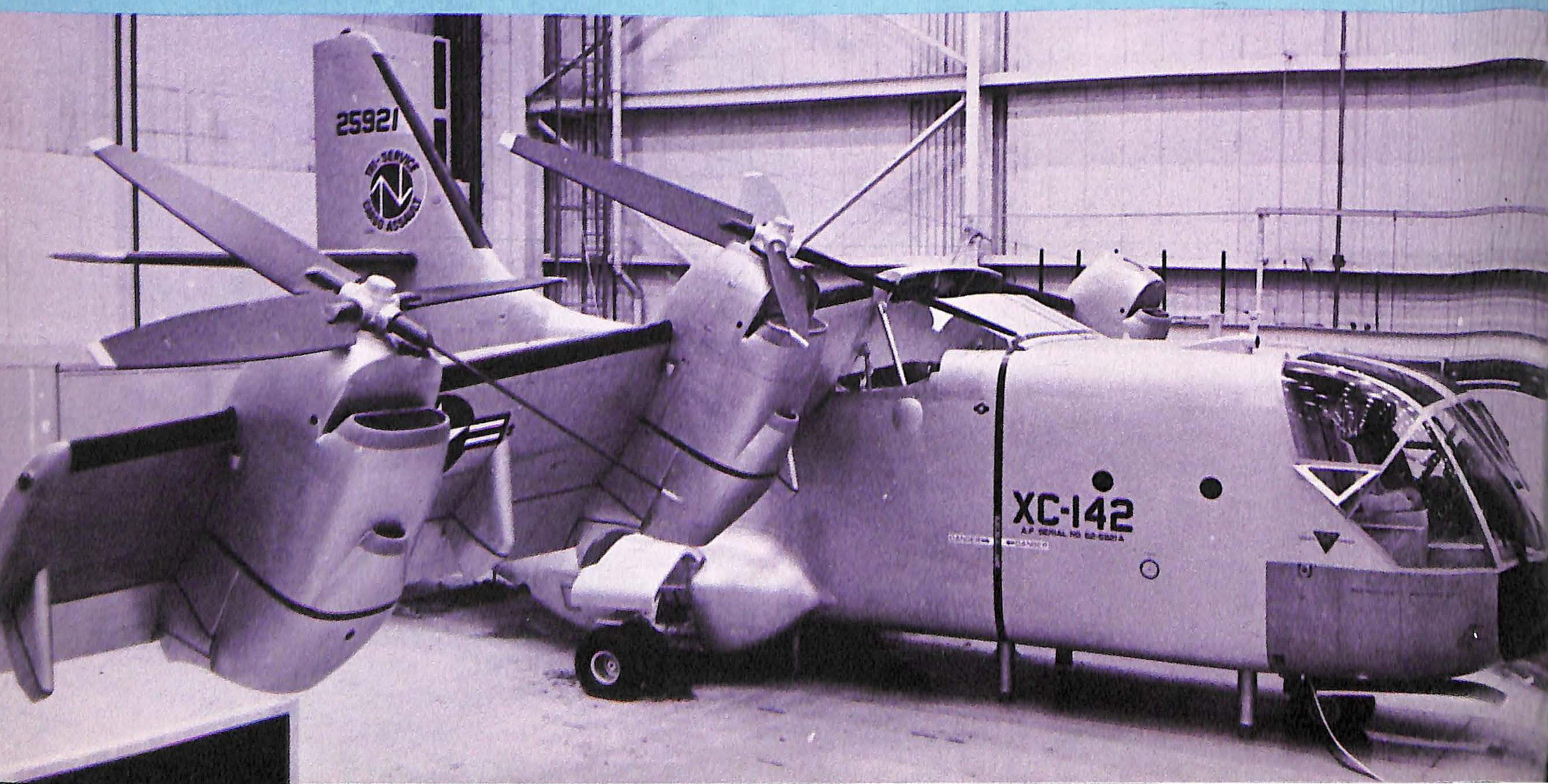
Even though these technical realities were well understood in aviation, a premature wave of public optimism



Curtiss-Wright X-19 has four propellers in tandem which can be rotated through 90 degrees to produce forward thrust when cruising. First prototype was rolled out this summer.

Lockheed XV-4A is an Army-sponsored VTOL aircraft that has no moving parts in the vertical lift system. This is provided by jet pumps. The XV-4A has flown both vertically and horizontally.

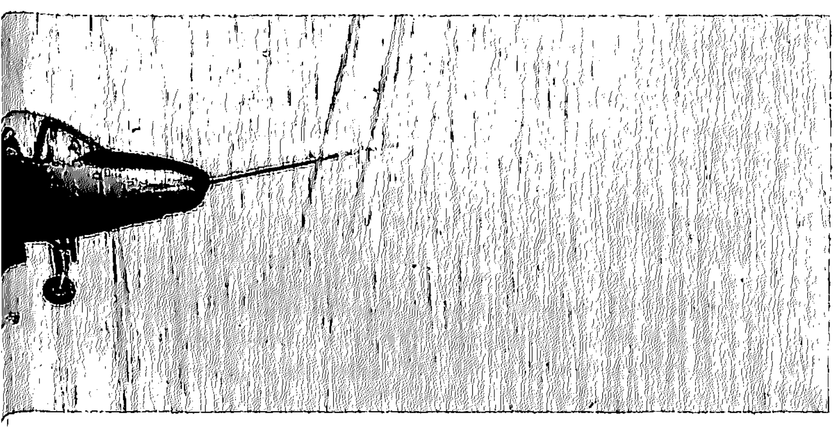
Vought-Hiller-Ryan XC-142 transport is a tilt-wing turboprop-powered VTOL plane. This aircraft has a gross weight of 35,000 pounds and will cruise at about 300 mph when loaded.



was generated by the remarkable flights of the XFY-1 and the Lockheed XFV-1, a similar tail-sitter aircraft that flew in the same period. The flights gained wide publicity. They concentrated heavily on the obvious door-to-door potential of such vehicles and at least implied that a transportation miracle was on the horizon with a VTOL in "every garage."

Such predictions still have no basis in fact and tend to obscure the truly remarkable technical achievements of the entire vertical lift industry during the past decade. Progress with helicopters, the first vertical lift machines, as well as the new VTOL airplanes has been extremely rapid and far-reaching. There have been almost steady complaints that the nation was not taking full advantage of the VTOL's potential, but in retrospect it is clear that very few technical experts were bold enough in 1953 to predict all of the accomplishments of the past decade, or the bright threshold of possibilities that would exist in 1963.

Very broadly, the major technical achievements and



possibilities for the near future can be classified into three categories.

These are:

Helicopter-type VTOL — The only operational vertical take-off and landing aircraft, the helicopter, has become firmly entrenched in civil and military aviation. More than 5,000 helicopters are in service with the armed forces and more than 1,000 are operated commercially. Some manufacturers are in the process of developing their fourth generation of helicopters. While the first successful helicopters twenty years ago could barely lift their pilot and a very small load of gas, the new generation will carry useful loads equal to or exceeding their empty weight over ranges of more than three hundred miles.

Steady improvements have been made in the handling qualities of helicopters. Mechanical advances in the rotor systems have greatly eased the pilot's job and reduced fatigue. A number of reliable, well-proven electronic stabilization systems are available which make possible "hands-off" flight. Military helicopters routinely hover under instrument flight conditions and fly when most fixed wing aircraft are grounded. There is no limitation on the operation of these automatic stabilization systems; they function at all flight speeds and at all angles of descent, up to and including the vertical.

Old complaints against helicopters — difficult maintenance and short life for many critical parts — seem to be a thing of the past. The ever-mounting backlog of operational experience has been instrumental in allowing problems to be accurately identified and corrected. All manufacturers report major successes in simplifying mechanical design and improving the maintainability of the next generation of helicopters.

These technical advances and broading operational usefulness appear to be leading to a sharp increase in helicopter sales in the near future. For instance, the Army is discussing plans to buy 3,000 or more of a *single* type, the LOH — Light Observation Helicopter. This is to be an off-the-shelf purchase of an aircraft designed primarily to civil regulations so that it will be immediately available for the commercial market. Large volume sales to the military inevitably will lower the price per aircraft for both the armed services and commercial customers.

VTOL — During its ten years of existence the fixed wing-type VTOL has been transformed from an aeronautical curiosity and concept into a reality with great potential capabilities for the future. Industry has progressed well beyond the phase of flying VTOL research aircraft with small range-payload capability. Five types of "developmental" prototypes are under construction or test in the United States and they all appear to have substantial operational potential.

Largest of these new aircraft is a 35,000-pound gross weight, tilt-wing, turboprop-powered transport being built by an industrial team of Ling-Temco-Vought, Ryan Aeronautical Company and Hiller Aircraft Corp. Most impressive feature of this transport, the XC-142, is that it is the first VTOL to come close to being an economical cargo-passenger carrier. The new VTOL transport will cruise in the neighborhood of 300 mph when loaded and has a big ramp at the rear of its very large fuselage for rapid loading and unloading.

The capabilities of the XC-142 cannot be determined exactly prior to flight testing, scheduled to begin next year. For many military and civil transport missions in which vertical take-off and landing is a necessity, the economic penalty will not be excessive and this aircraft can expect a significant operational career.

A tri-service fund of about $125 million, to which the Army, Navy and Air Force are contributing equally, is being used for the development of the XC-142 and two other prototype VTOL transports about half its size. From $60 to $100 million will be spent on the XC-142 for development, construction of five prototype aircraft, and flight testing.

About $20 to $25 million will be used for a "four-duct tandem" airplane under construction by Bell Aerosystems. One of its main advantages is compactness, of special value to the Navy and Marine Corps for use aboard carriers. The wide placement of its ducted propellers also provides excellent pitch control during hovering and slow speed flight.

The third transport in the program is a "four propeller tandem" being developed by Curtiss-Wright — the X-19. It has primarily the same advantages and disadvantages of the "four duct tandem" except that the propellers are not shrouded and they are tilted to produce upward lift, and rotated through 90 degrees to produce forward thrust during cruise. Maximum speed of the X-19 will be 400 knots with a 350-knot cruising capability and a payload of six passengers or 1200 pounds of cargo. This aircraft has been built largely with company funds — less than $10 million of military support is planned. Two prototypes are planned — the first reached the roll out stage on July 23 and currently is being groomed for initial flight.

Other "developmental" VTOL's in the U. S. inventory are being sponsored unilaterally by the Army. They are both jet-powered and are designed to carry two men at 450 knots or better. Both are intended for high-speed surveillance, ground support and rescue missions.

The first is Lockheed's XV-4A, designed for a 7200-pound gross weight with a relatively simple and unique advantage — no moving parts in the vertical lift system. The system consists of a series of jet pumps in the fuselage. These pumps augment by approximately 1.4 times the thrust of the aircraft's two Pratt & Whitney JT12-A3 turbojets, each developing 3300 pounds of thrust, to achieve vertical flight. This aircraft flew in the horizontal mode in 1962 and hovered free for the first time in early 1963.

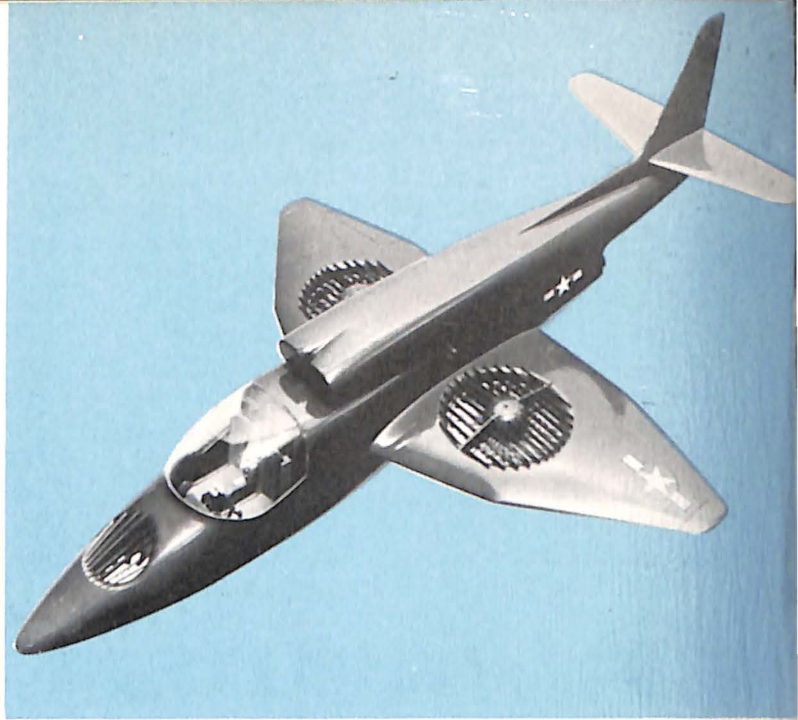
General Electric lift-fans driven by the exhaust from two J85 turbojets, provide vertical flight capability for the second of these aircraft, the XV-5A. The lift-fans multiply the 5300 pounds of thrust produced by the turbojets to more than 15,000 pounds for vertical flight. The main advantage of lift-fan system is that it delivers the proper thrust for each type of flight, while the J85 turbojets are operating at maximum efficiency with relatively low fuel consumption. This means the system delivers more pounds of thrust than the weight of the airplane for vertical flight, and thrust equal to one-third of the airplane's weight during cruise. This aircraft, with a Ryan-built airframe, will have a gross weight of 11,000 pounds. Two prototypes of both the XV-4A and the XV-5A have been ordered by the Army.

Turbine Engines — Non-helicopter VTOL airplanes did not become feasible until the advent of the gas turbine engine. The gas turbine is superior to the conventional piston engine for vertical rising aircraft because it is lighter and produces more power for each pound of engine weight.

Today, the key to improving VTOL performance is to build lighter, more powerful engines. Consequently, much of the current optimism in the VTOL industry is related to the very optimistic predictions regarding developmental programs currently under way to boost gas turbine performance.

All manufacturers indicate that the jump in performance from today's engines to the next generation of gas turbines will be by far the biggest yet achieved. The jump is expected to be much greater than the one from the piston engine to the gas turbine.

For comparison the best piston engine delivered about one horsepower per pound of engine weight, while the Allison YT40-A-14, which powered the Convair XFY-1 tail-sitter, in 1954 produced around 1.95 horsepower per pound of engine. Today the T64 turboprop in the XC-142 is providing substantially better



General Electric and the Ryan Aeronautical Company are building a VTOL design around a lift-fan system.

performance at 2.51 horsepower per pound. In the next generation it apparently will be possible to boost this figure up to better than 3.5 horsepower per pound.

The most impressive predictions, however, concern simple turbojet engines that do not drive propellers or rotors and deliver their power entirely through an exhaust stream of hot gas. The first of the U. S. turbojets, the General Electric I-A produced only 1.6 pounds of thrust per pound of engine. During the twenty years since the I-A first flew, truly amazing progress has been made, for the best operational jet engines today have a thrust-to-weight ratio of 6 to 8 pounds of thrust for each pound of engine. It is believed by the vast majority of engine specialists that this thrust-to-weight ratio can be doubled to the range of 12 to 1 on the next generation of long life, "cruise-type" turbojets.

Much better performance is expected from a new class of very lightweight, short-life, "lifting" turbojets which operate only during take-off and landing of VTOL aircraft to supplement the power of the cruising engines. Many experts believe that such engines can be built in the near future with a thrust-to-weight ratio of nearly 20 to 1.

Most of the boost in engine performance will be obtained by raising the turbine wheel operating temperature. Current applied research indicates that the compressor and combustion sections of jet engines can be improved substantially but the major point is that all the manufacturers have made great strides in raising turbine inlet temperature. It appears possible to raise the temperature of the gas entering the turbines of present engines by more than 1,000 deg. F, to the 3,000 and possibly 3,500 deg. F mark. Pushing this maximum engine temperature up 1,000 deg. F means that the thrust output of an engine of any given size (air flow) will be increased more than two and one-half times. It also is predicted that this thrust improvement will result in only a modest rise in engine weight, so that the all-important thrust-to-weight ratio will be doubled.

The key technical feature of the new turbine wheels involves cooling techniques to keep blade temperatures down around 1,700 deg. F, about the maximum that current metal alloys can stand under the heavy whirling loads, even though the gas stream is much hotter. Several cooling techniques are being investigated. They borrow heavily from rocket engine technology and they have been carried well beyond the paper planning stage. All major manufacturers have been running cooled turbine wheels in their applied research programs for some time.

During the past decade the engineering feasibility of virtually every possible type of VTOL airplane has been demonstrated conclusively through flight test. It has been shown that vertically rising aircraft can use tilting rotors, tilting wings, tilting engines, tilting propellers, deflected propeller slip streams, deflected jet engine exhausts, and so on.

One of the most important benefits of this past decade of research has been to verify the theoretical predictions concerning an "orderly spectrum" of VTOL aircraft. The most important point is that there is a trade-off between cruise speed and efficient hover time. Any VTOL which cruises as fast as conventional aircraft must pay for it in low hover time.

It has not been possible to improve on the helicopter rotor for hovering. The large diameter rotor develops lift by moving a large quantity of air at slow speeds. If a VTOL aircraft mission calls for hovering or very slow flight for 30 to 40 minutes or about 15 per cent of the total mission time, then the helicopter is the best available as far as its ability to carry payload over a prescribed distance.

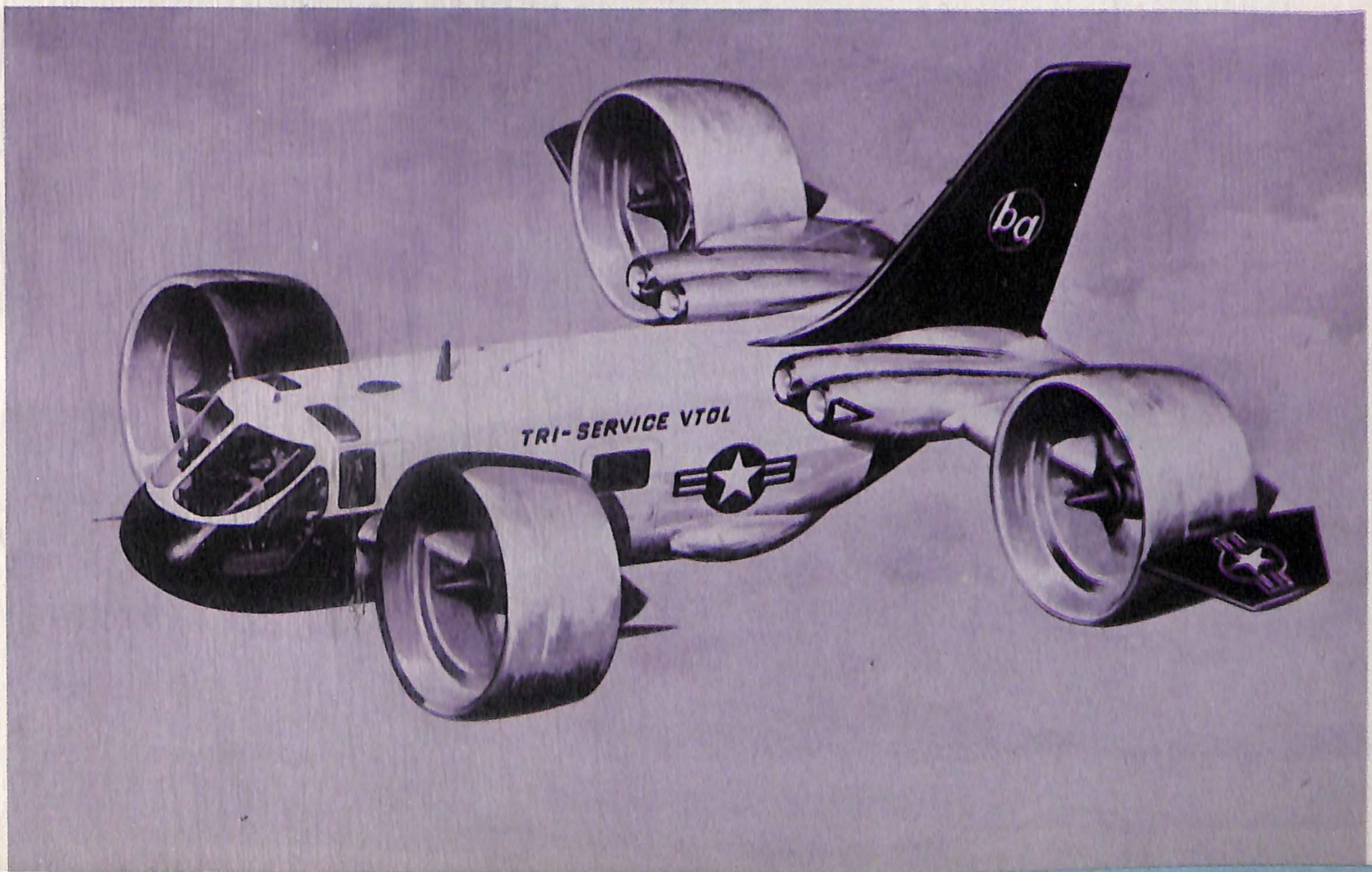
However, if a mission calls for less hover time, other types of VTOL become attractive. For example, if only about ten minutes of hover is required, the tilt-wing, turboprop seems the best. Even though it consumes fuel about four times faster than a helicopter with the same payload, this VTOL's propulsion weight plus fuel for a ten-minute hover is about the same as the helicopter's, so their "hovering efficiencies" are comparable for that length of time. Since the turboprop aircraft is not burdened by rotor drag, it can cruise at speeds from 350 to 400 mph compared to less than 175 mph for most helicopters. The tilt-wing transport can fly farther and faster with a given payload so its productivity in carrying payload is much higher than a helicopter's, providing only ten minutes of hover is required.

Still further payload productivity can be achieved if only about five minutes of hover are called for. The "hovering efficiency" of the turbojet powered VTOL transport is no lower than the helicopter's or turboprop VTOL's for this short period. This aircraft can benefit from all of the benefits of jet powered flight, flying at speeds of more than 500 mph over great ranges.

The most laudable aspect of the current program is that civil as well as military problems will be investigated. The Federal Aviation Agency is participating in the operational evaluation of the XC-142 and every effort is being made to satisfy civil as well as military requirements.

As government and industry move ahead to take advantage of the current technical opportunities, such as the new gas turbine engine technology, great efforts are being made to broaden civil-military cooperation. It is regarded generally as the best means of improving overall performance and widening the usefulness of all types of VTOL aircraft.

Bell Aerosystems is constructing a four-duct tamdem VTOL. One feature is the compactness of design.



SPACE

POWER

By **ROBERT M. LOEBELSON**
Associate Editor, Aerospace

One of the most important challenges American scientists face in space exploration is the evolution of revolutionary new power plants. These engines, now under development for the National Aeronautics and Space Administration and the Department of Defense by America's aerospace industry, range in size and power from tiny units producing miniscule amounts of power measurable only by special instrumentation all the way up to giant rocket engines which will deliver 20 to 30 million pounds of thrust or more.

The basic booster now being evolved for earth take-off is the F-1, which has a thrust of 1.5 million pounds. Five of these will be clustered to make up the advanced Saturn, which will be used to fire the Apollo moon vehicle into a lunar orbit. NASA and aerospace industry officials believe the next step in booster thrust will be a rocket producing about 24 million pounds of thrust. But before a power plant of that size can be built, substantial research will have to be conducted on better pumps and turbines to produce high propellant pressures, on flow components and systems to handle high pressure fluids, on ways to ignite and burn the propellants stably at high pressures and ways to keep the engine cool under the higher heat loads.

Industry, NASA and the Air Force also are studying the potentials of large solid rockets and hybrid solid-liquid types for earth take-off.

Booster upper stages range from engines with a few thousand pounds of thrust to the 200,000-pound-thrust J-2 scheduled for the advance Saturn. But the M-1, a hydrogen-oxygen engine now being developed, will have a thrust of more than one million pounds. Most upper stage engines now conceived will use hydrogen and oxygen, but industry and Government researchers concerned with space power systems are seeking propellant combinations which provide higher specific impulses than oxygen and hydrogen and thereby produce more thrust for the same amount of propellant. Among those being considered are hydrogen-fluorine and propellants containing light metals.

Spacecraft engines must contend with a hostile space environment, sometimes riding dormant or coasting for extended periods and often confronted with a requirement for variable thrust and multiple starts. These conditions necessitate the development of high-energy propellants which can be stored in the space environment and which have high propellant density. One of the most promising of the propellants with these requirements is oxygen difluoride-diborane, but industry's fuel specialists know that more answers are needed, especially in the area of shielding propellant tanks against penetration by micrometeoroids which might be encountered in space.

And once a vehicle gets into orbit or is fired toward the moon or one of the other planets, smaller space engines are needed to handle altitude control and mid-course maneuvering. These compact and versatile space engines must normally perform several functions at intermittent periods spread over an extended flight. Among the problems designers have discovered in trying to develop these smaller space engines is the requirement that the small power plant should preferably use the same porpellant as the main engine (to simplify fuel storage), and the difficulties encountered in cooling and getting good performance from smaller engines.

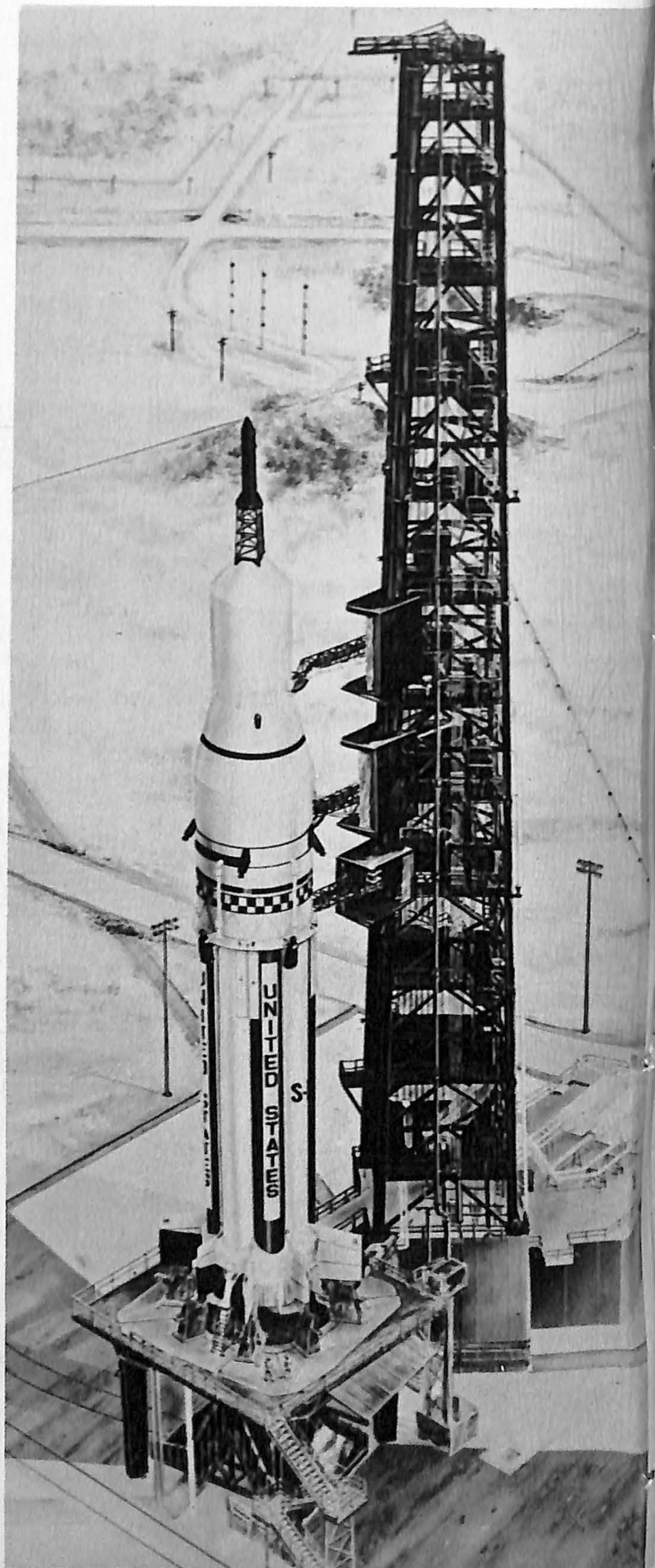
But the greatest single problem thus far encountered in rocket engine development is something called "combustion oscillation." These oscillations are pressure fluctuations in the combustion chamber of the rocket engine which tend to increase heat transfer and can destroy the combustion chamber if they continue for any length of time. Rocket industry researchers are attacking this "combustion oscillation" problem on two fronts — by doing basic studies on why these phenomena occur and by developing techniques to control or eliminate the pressure fluctuations.

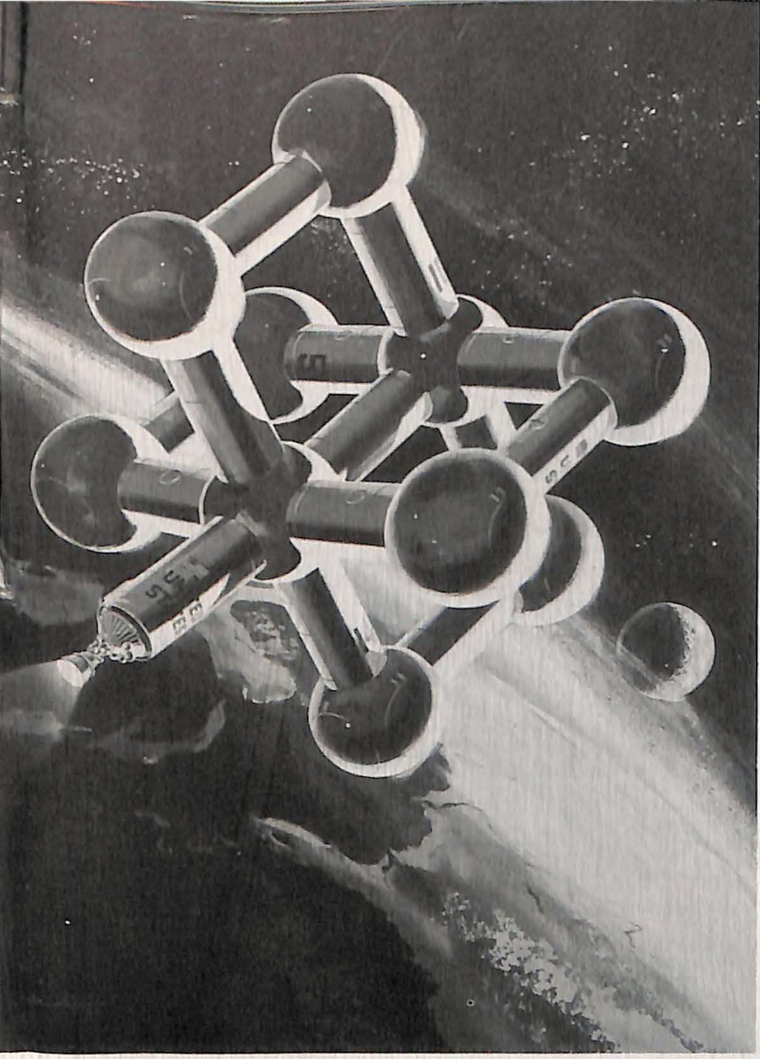
NASA, the military services and the aerospace industry know that a vehicle moving in space will be much more efficient if it contains a system to self-generate required power. Among the space power generation systems now being studied are:

- Solar cells
- Thermionics
- Thermoelectric systems
- Magnetohydrodynamics
- Solar heat engines
- Batteries
- Fuel cells
- Engines using chemical reactants
- Power conditioning and control equipment

This future space station, a "tinker-toy" type Spaceball, could be lofted into orbit by the advanced Saturn vehicle. This is one of many novel space vehicle ideas.

Saturn assembly is shown in artist's conception ready for countdown. Eight clustered engines provide 1.5 million pounds of thrust in first stage.





- Solar concentrators
- Thermal energy storage

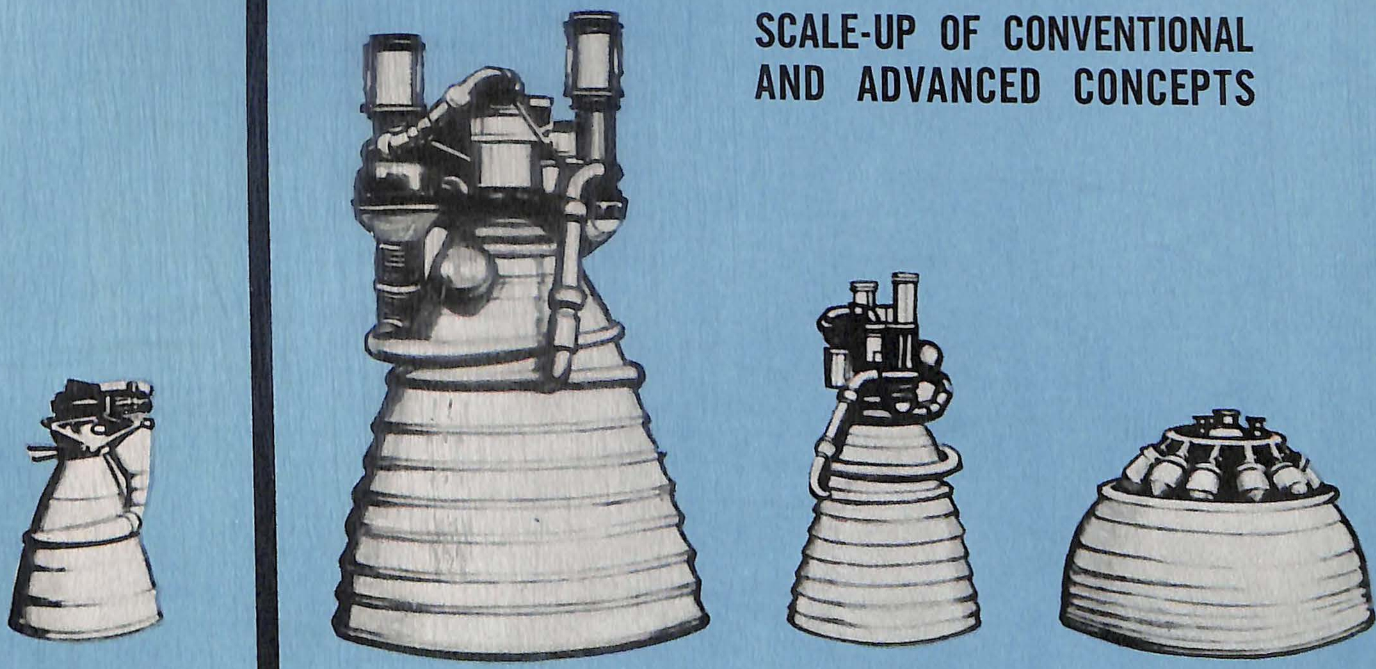
In *solar cells,* the industry-NASA effort is to increase their efficiency over a wide temperature range, improve their resistance to radiation and decrease the cost and weight. One major effort in this area is a solar cell that can be made as a thin film. These thin film photovoltaics, however, have very low efficiency and work is progressing to use them in systems requiring multi-kilowatt levels. Large thin film solar cells could be carried in a compact package for unfolding in space or on the surface of the moon.

Thermionic systems convert heat directly into electrical energy and do not have the radiation problems encountered with solar cells. Basic elements of a thermionic power converter are a solar collector, an array of thermionic diodes and associated energy storage and power conditioning equipment. One system now being developed is designed to deliver 135 watts on Mars, weigh only 30 pounds for the collector-conversion unit and be trouble-free for one year.

A multi-kilowatt *solar power system* using turbo-alternators is also under development. This device involves a solar concentrator, a boiler and heat storage unit, a turbogenerator and associated components, pumps and radiators. With mercury vapor as the working fluid, the present system will deliver three kilowatts of power. But scientists believe this type of system will be usable for 30 or more kilowatts.

Today's primary method of storing energy for power

SCALE-UP OF CONVENTIONAL AND ADVANCED CONCEPTS



F-1

F-1 TECHNOLOGY

INCREASED CHAMBER PRESSURE

INCREASED PRESSURE AND MULTI-CHAMBER

1.5 MILLION LBS. THRUST

24 MILLION POUNDS THRUST

generation is the *battery*. Current batteries are alkaline electrolyte cells using electrode combinations like nickel-cadmium, silver-cadmium and silver-zinc. Research on advanced systems indicates theoretical energies 25 times as great as nickel-cadmium can be obtained, and industry and NASA scientists are exploring these possibilities.

Fuel cells, which are compact and have few or no moving parts, have high energy-conversion efficiencies — 70 per cent or higher. Although the Gemini and Apollo spacecraft will employ fuel cells containing hydrogen and oxygen as the reactants, studies are under way on advanced models. For low temperature fuel cells, liquid or solid membrane electrolyte is considered satisfactory. Molten caustic is being planned for intermediate temperatures and molten salts and solid oxides are considered ideal for high temperatures. Other fuel cell research being conducted involves pulsed operation to reduce the weight of the system and extend its operating life, and studies of biochemical fuel cells which utilize human waste for energy.

Chemical engines can be used to generate space power on missions lasting a few hours or a few days and for intermittent use over longer periods. Several different types, both piston and turbine, are usable. Current studies involve chemical engines which use the same reactants as those employed for propulsion of the spacecraft, and a major effort is being conducted on a chemical power plant using nitrogen tetraoxide and a hydrazine mix.

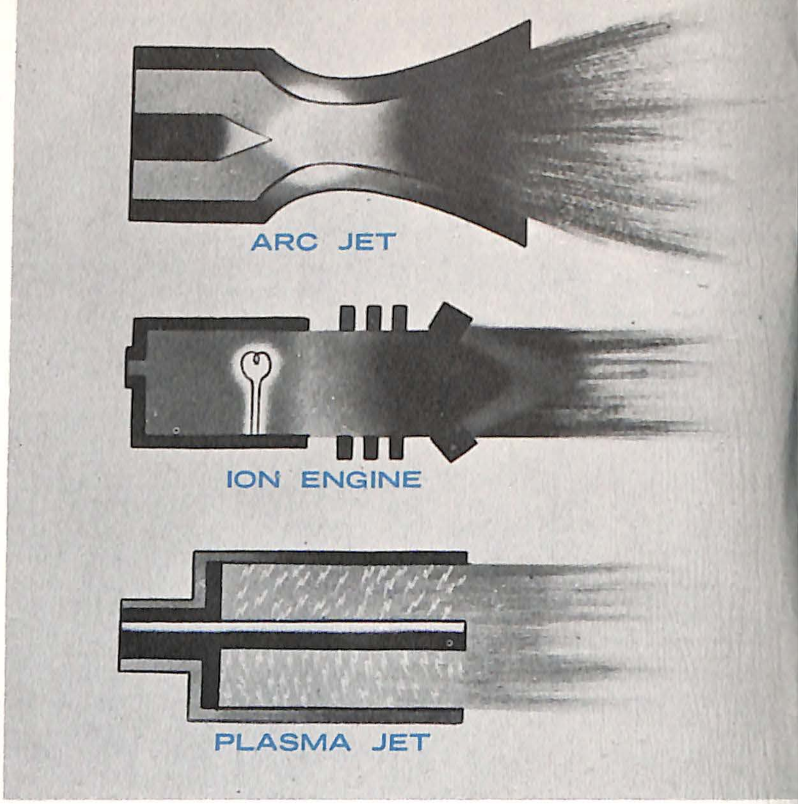
In addition to the "conventional" rocket boosters and space power systems, NASA, the aerospace industry and the Atomic Energy Commission are deeply involved in efforts to use nuclear power in the nation's space program. Basically, the goals are to develop: a) nuclear rocket systems and b) nuclear electric power and propulsion systems.

The *nuclear rocket* will emerge from a development program involving KIWI (ground-based research reactors), NERVA (Nuclear Energy Research Vehicle) and RIFT (Reactor in Flight Test). The reactor technology being obtained from KIWI will be used in the NERVA flight propulsion system and NERVA will be flight tested in the RIFT stage. The RIFT stage will be designed to fit the Saturn V launch vehicle.

Nuclear energy for electric power and electric propulsion will be needed in the space program in ranges of hundreds of kilowatts to many megawatts. Among the projects which will require these power levels are orbiting manned space platforms, manned interplanetary spacecraft, communications satellites and unmanned planetary probes. On-board power requirements involve communications, life support systems, data acquisition (some 30 to 60 kilowatts) and additional power will be needed to propel the spacecraft. The SNAP-8 Electrical Generating System now being developed by industry, NASA and AEC will handle the on-board power requirements of a 200,000-pound space platform with no difficulty while using only two per cent of the total weight.

A manned interplanetary spacecraft of the future, however, might weigh more than a million pounds, might require orbital assembly and would need a large electric rocket propulsion system calling for 20 to 30

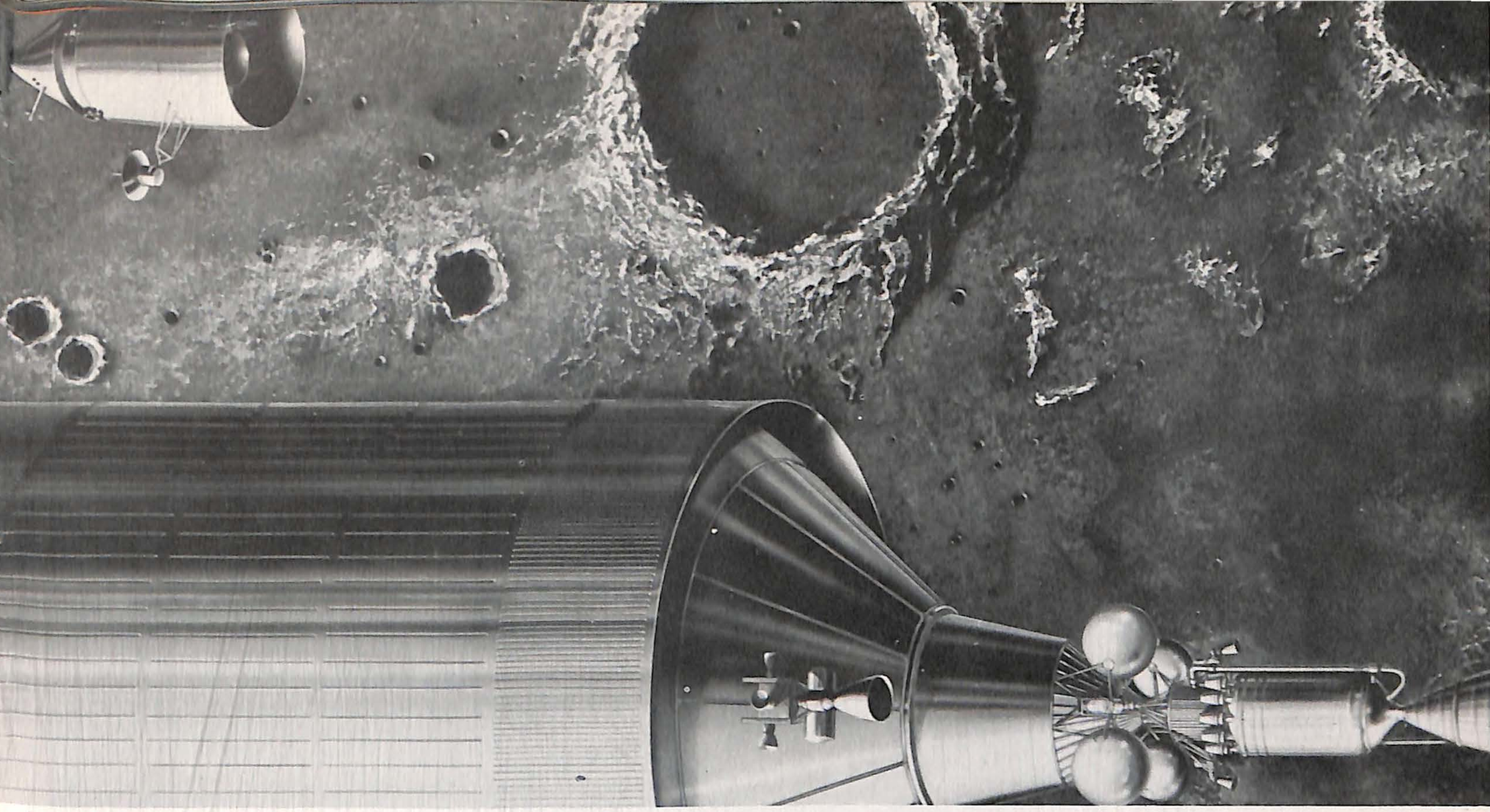
ELECTRIC THRUST CHAMBER PROGRAM



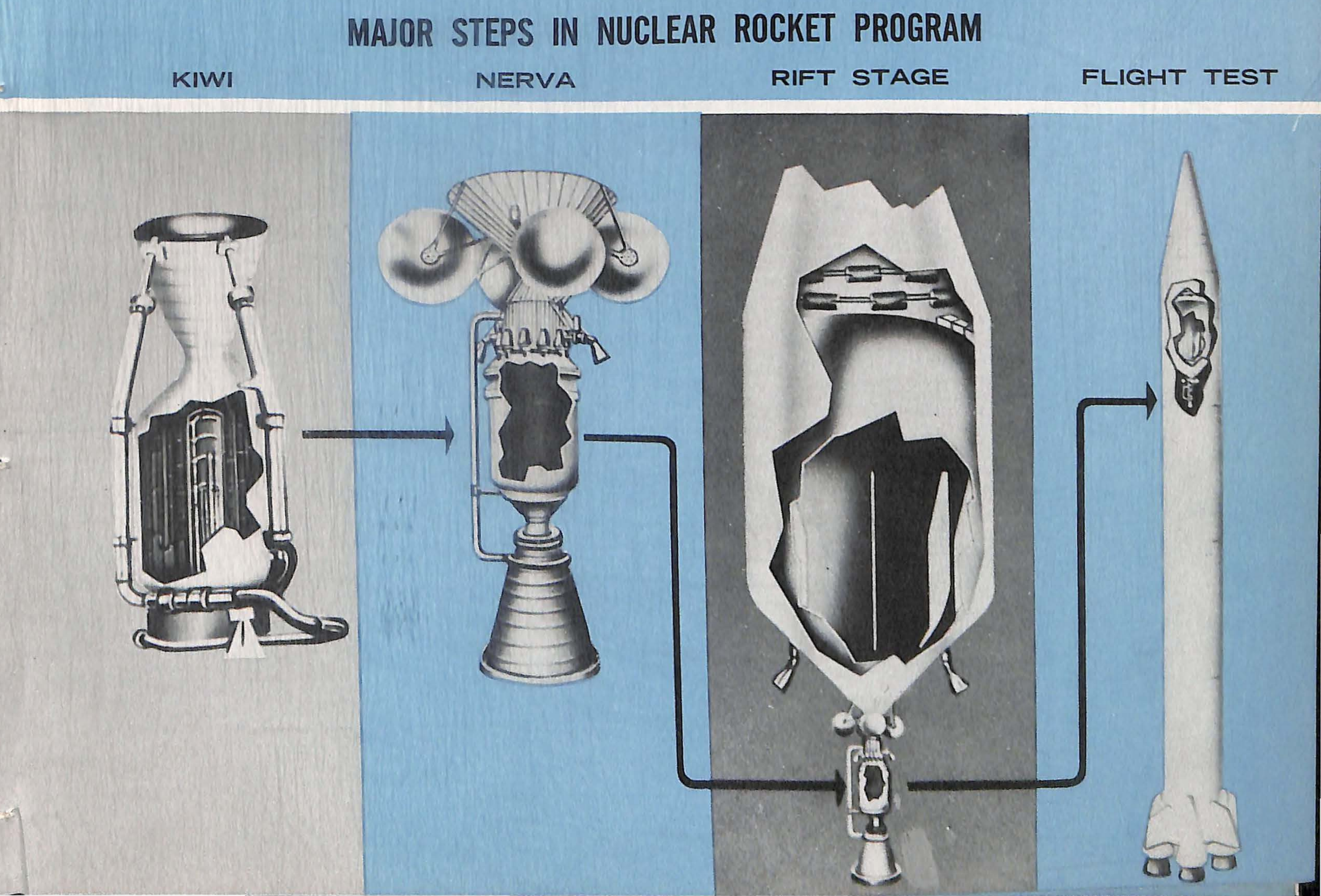
megawatts of electrical power. Since the usefulness of an electrically propelled spacecraft depends directly on the weight of the nuclear power electrical generation system for the electric rockets, space engine scientists feel they must develop a power generation system of 10 pounds per kilowatt or less including shielding. If this can be attained, a spacecraft weight competitive with a nuclear rocket would result for a manned mission to Mars. But some degree of the difficulties involved is apparent in a comparison with SNAP-8, a low power system which weighs about 100 pounds per kilowatt.

To propel spacecraft electrically, scientists and engineers are studying three main types of electric rocket engines. The *arc jet* develops thrust by heating a working fluid (hydrogen, ammonia, etc.) and expanding it through a nozzle. The *ion engine* involves the use of electrostatic forces and reactions to accelerate a working fluid (cesium, mercury, etc.) to develop thrust. The *plasma engine* uses electromagnetic forces to accelerate plasmas to develop thrust. Although the arc jet is the electric engine considered closest to attainment, all three types require extensive development and testing before they will be ready for use in space. A test program is already planned by NASA and AEC as Project SERT (Space Electric Rocket Test).

The cooperative endeavor of thousands of space propulsion scientists working for the aerospace industry and several Government agencies will result in an expanding U. S. space program to provide ever-new information about the universe. But the problem areas are so varied that the advancement will come only after a step-by-step learning process covering all types of engines usable in space.

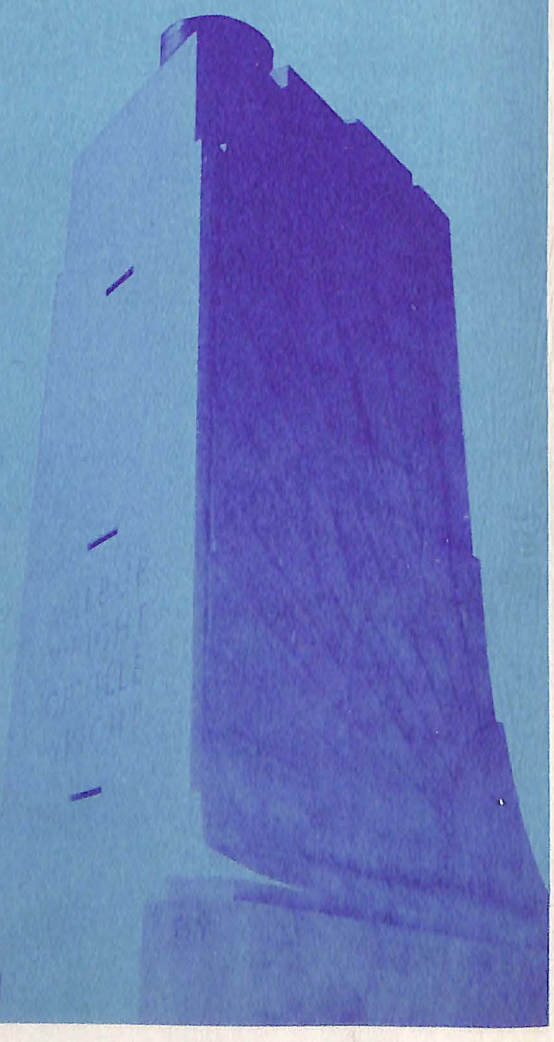


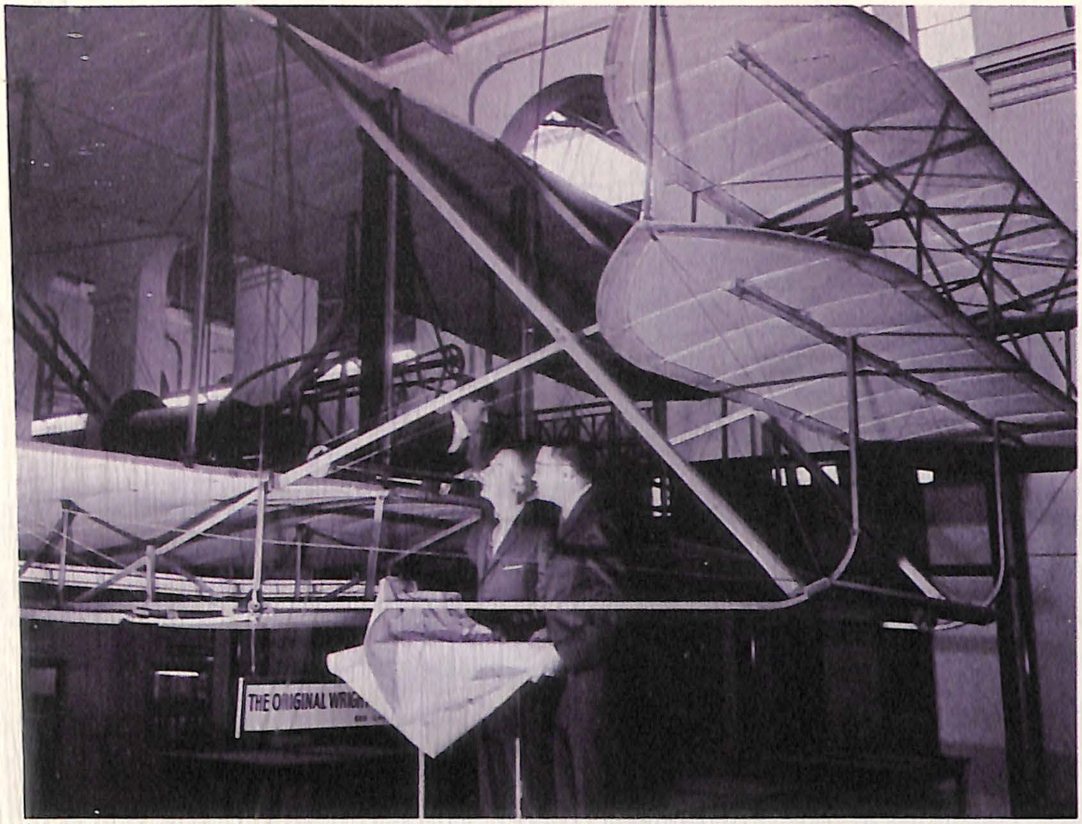
A nuclear-propelled vehicle in a moon-landing mission is shown in this artist's conception.



The construction of an exact reproduction of the Wright Flyer was a stiff challenge in "reverse" technology for the National Capital Section of the American Institute of Aeronautics and Astronautics, the aerospace technical and professional society. The program, **Project 60** — marking the 60th Anniversary of man's first powered flight by the Wright Brothers — was accomplished by about 50 volunteers from the AIAA section membership, with assistance from aerospace companies. Most of the engineers and scientists are engaged in daily jobs involving missiles, spacecraft and supersonic aircraft. Maj. Gen. Marvin C. Demler (USAF), chairman of the National Capital Section, sums it up: "It was more difficult to build the Wright plane today than it was 60 years ago. The project demanded the acquisition of new talents from our space age experts. The materials and techniques available to Orville and Wilbur Wright have, in most cases, been replaced or forgotten. Stepping back 60 years to construct the plane as it was proved a highly challenging task." The first step was to locate and purchase materials. Spruce and ash woods of the desired quality were found in a Baltimore, Md., lumber yard; special brass fittings came from Long Island; muslin wing covering was donated by a New York City fabric house. The Pratt & Whitney Division of United Aircraft Corp. built the engine — a precise machine that would run if pistons and connecting rods were added; the skid assembly was constructed by the PneumoDynamics Corp., and the chain gear propeller drives by Western Gear Co. Most of the work on such parts as forward surface assemblies, propellers, shafts and aft rudders were done in home workshops. A group of engineers at the Patuxent Naval Air Test Station built the wings in the base hobby shop on off-hours. Final assembly of all the components was done at a hangar in Arlington, Va. The Wright Flyer reproduction was presented to the Wright Memorial Museum at Kill Devil Hills, N. C., site of the historic flight made on Dec. 17, 1903. The original Wright plane is displayed at the Smithsonian Institution in Washington, and another authentic full-scale model, built by the Los Angeles Section of AIAA, is exhibited at the organization's building in Los Angeles. The British Science Museum in London displays another reproduction which replaced the original Wright Flyer when it was returned to the United States in 1948.

1903
WRIGHT FLYER
1963





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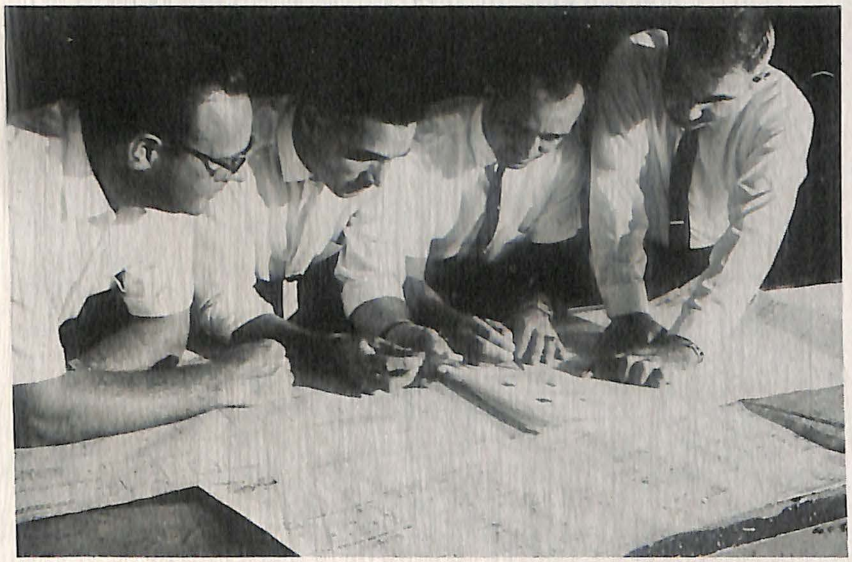
1. John S. Attinello (left) and Hal Andrews, co-chairmen of Project 60, check blueprints against the original Wright Flyer which is displayed in the Smithsonian Institution in Washington.

2. Patuxent Naval Air Test Station engineers study wing drawings. Left to right are: Harry Down, John Paradis, Joe Jennings and Gene Rooney.

3. Ben Poindexter checks wing rib fit.

4. James Trent places a wing rib in position between the wing spars. The ribs and spars were made of spruce, the same wood the Wright Brothers used in the original.

5. Nathan Frank carefully reads the blueprints of the Wright Flyer before proceeding with the next step of reconstruction. Engineers found some discrepancies between the blueprints and the Wright model in the Smithsonian.



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1903
WRIGHT FLYER
1963

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6. Poindexter places a wing rib along the curve of a plywood template. Precision of AIAA members engaged in the wing construction was proven during final assembly.

7. Down holds a fitting in place while Nathan solders a joint.

8. Lt. Cmdr. Tom Kastner, USN (center), goes over a fine point of wing construction with Trent and Poindexter. Each step of construction was meticuously planned. Wing assembly was one of the most difficult assignments in the reconstruction of the Flyer.

9. Spacers in the ribs required delicate handling to assure that the exact curvature was obtained.

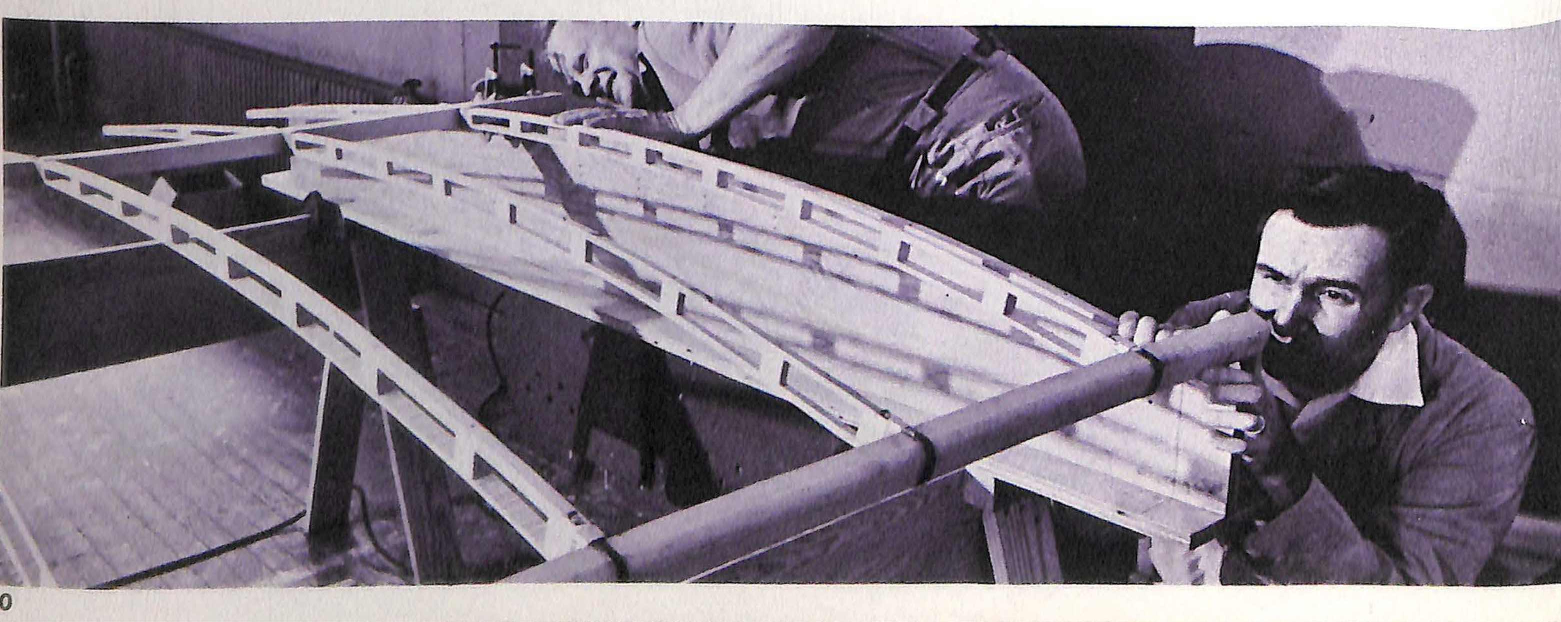
10. Volunteers from the Navy's Patuxent station check the alignment of the wing spars. The Patuxent group used the facilities of their base hobby shop to assemble the wings.

11. Wing assemblies were laid out on saw horses. Metal clips were used to attach the ribs to spars.

12. Wing covering was supplied by a New York fabric manufacturer. Fabric was laid across the wing on the bias to eliminate slack.

13. A wire was run completely around the wing to secure the covering. Wing covering was taut after final assembly.

14. Wing sections are shown in final assembly stage. Wright Brothers used a technique of wing warping for lateral (banking) control of their aircraft. Ailerons are used in modern aircraft for this purpose.

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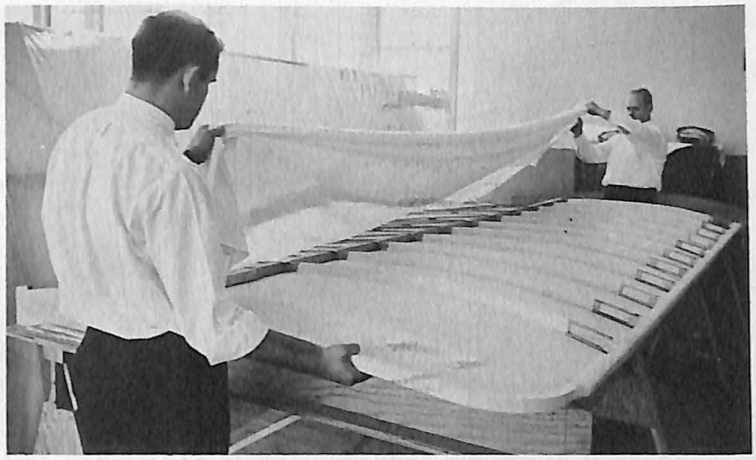
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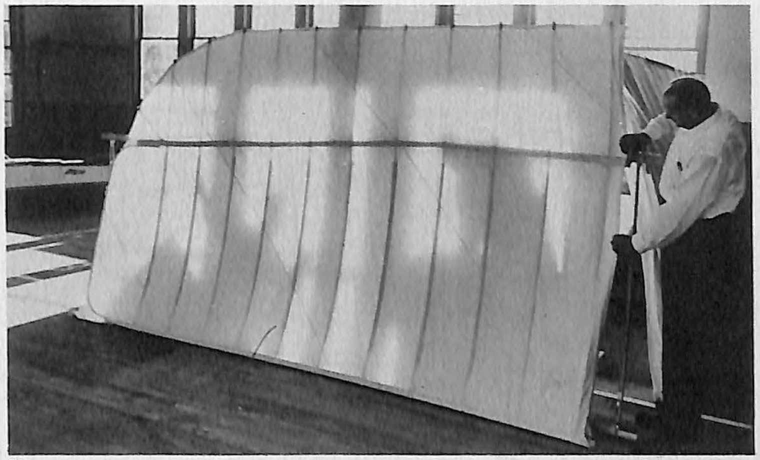
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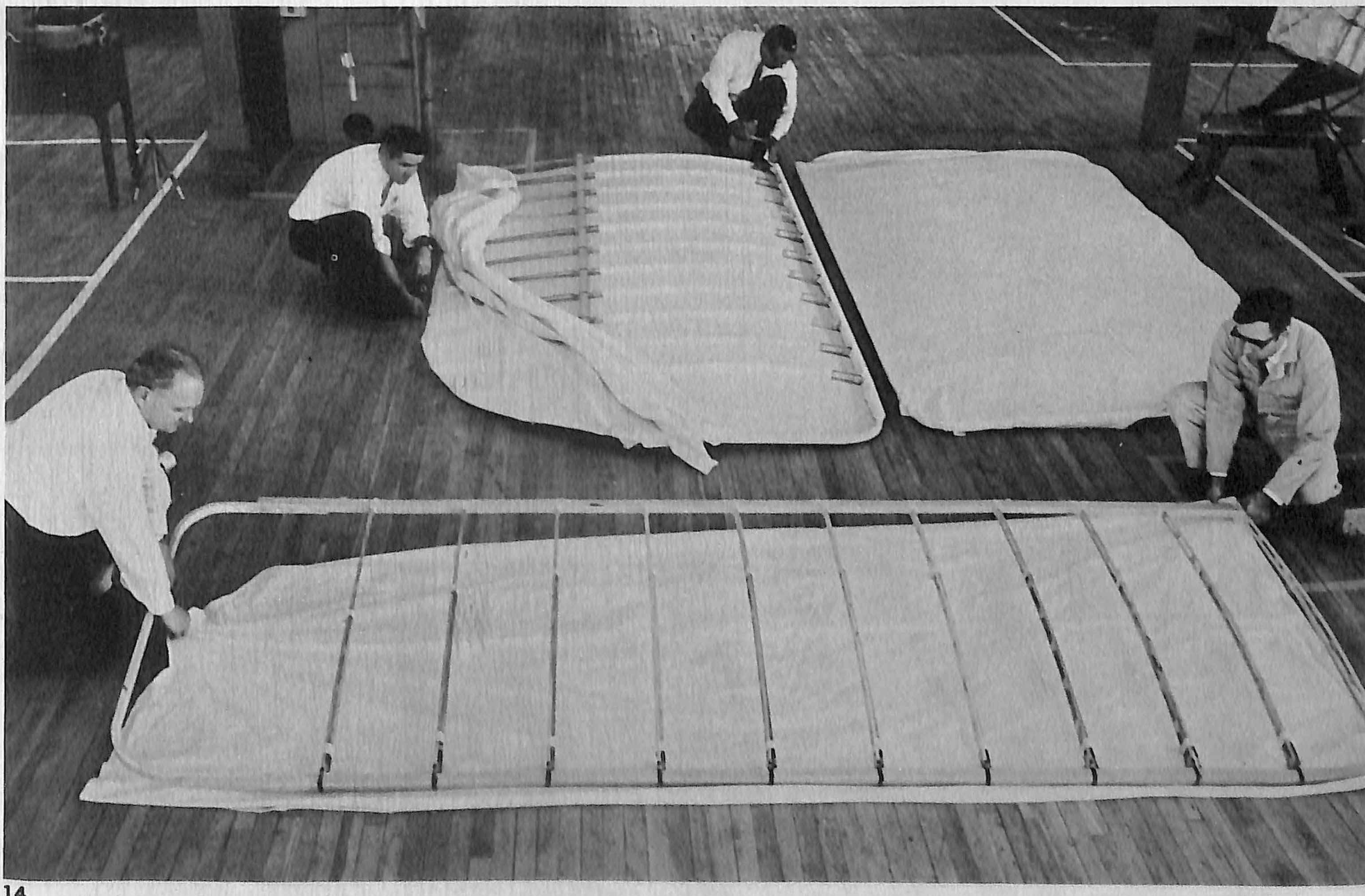
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1903
WRIGHT FLYER
1963

15. Walter Sheen, retired RAF Air Vice Marshal uses a micrometer in final check of a propeller shaft made in his home workshop. The chain drive sprocket wheels in foreground were contributed by industry.

16. Marshal Sheen begins machining of propeller shaft.

17. Richard Hartley checks blade twist during painstaking process of carving propeller from laminated spruce blank.

18. Rudder frame is aligned by volunteers Richard Murphy (left) and J. R. Kirby.

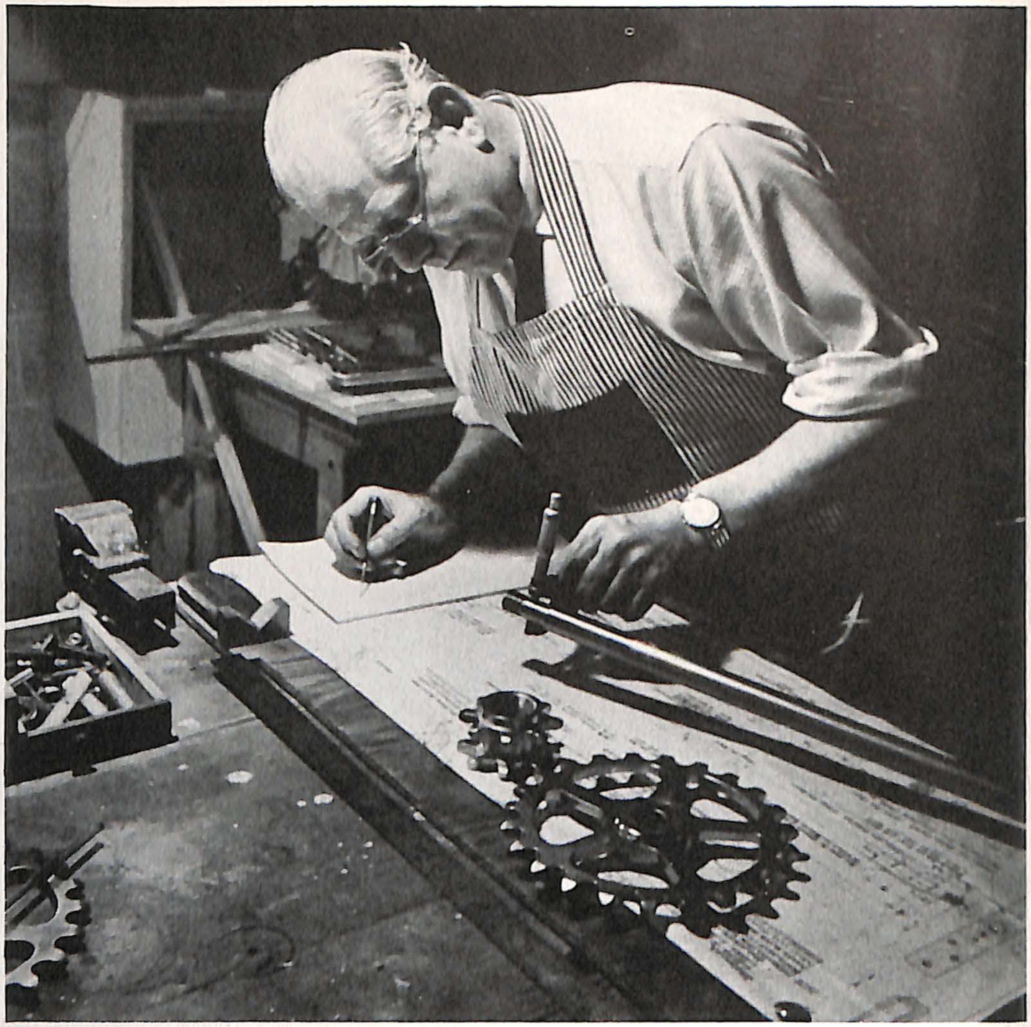
19. Forward surfaces and outrigger assembly are being mated in a jig by Murphy, Kirby and Capt. P. G. Holt, USN.

20. Technicians refer to complete set of Wright blueprints tacked to wall of British Aircraft Corp. hangar during final assembly operations.

21. William Harvey checks tension on one of a host of rigging wires — the first "built-in headwind."

22. Volunteers begin first steps in lengthy sewing job required in joining wing sections.

23. Wing dihedral angle and general rigging alignment were checked constantly during final assembly.



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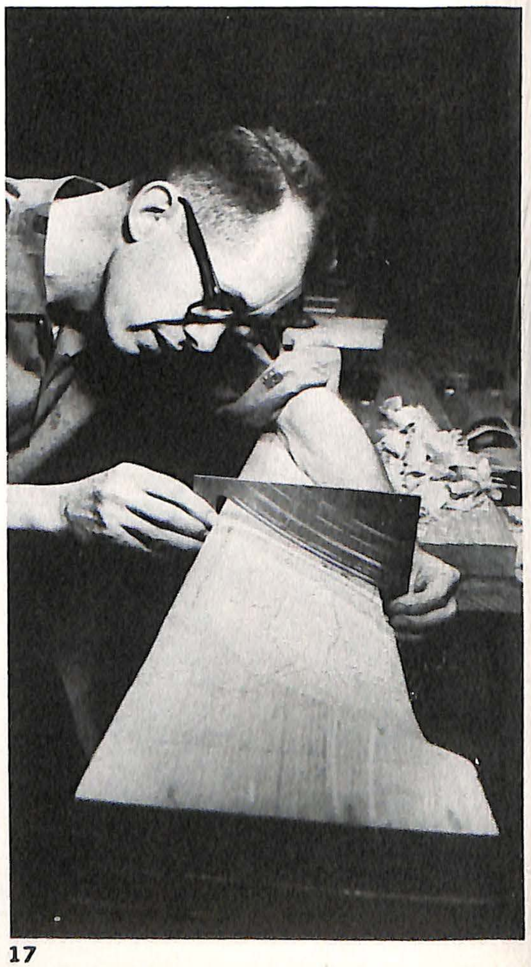

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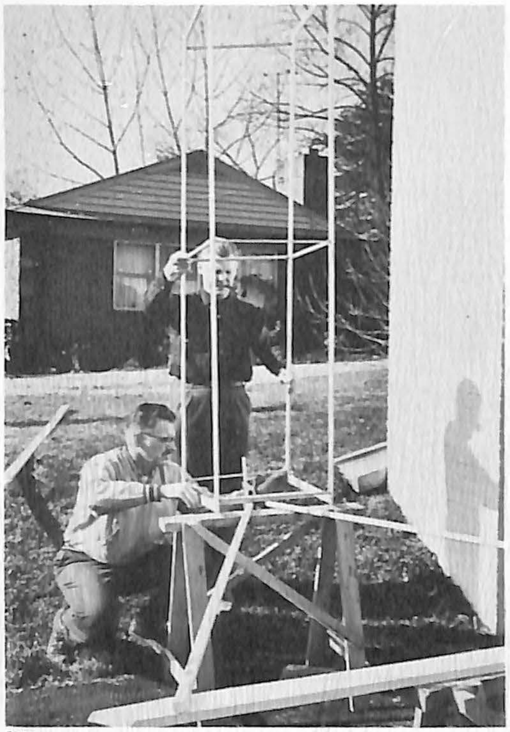
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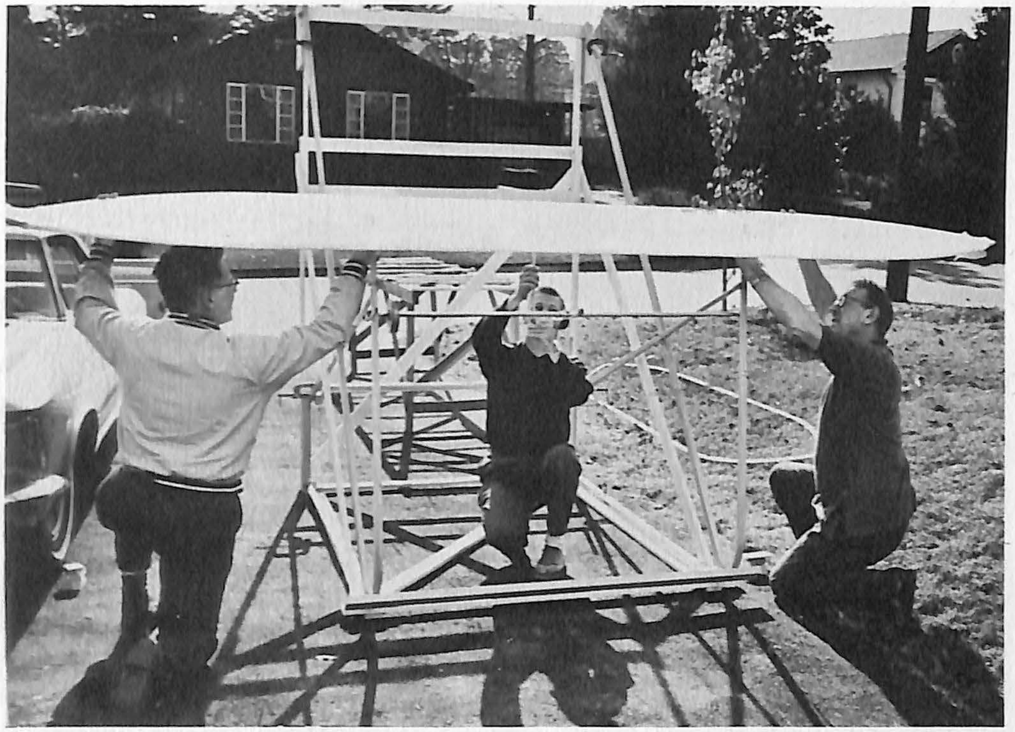
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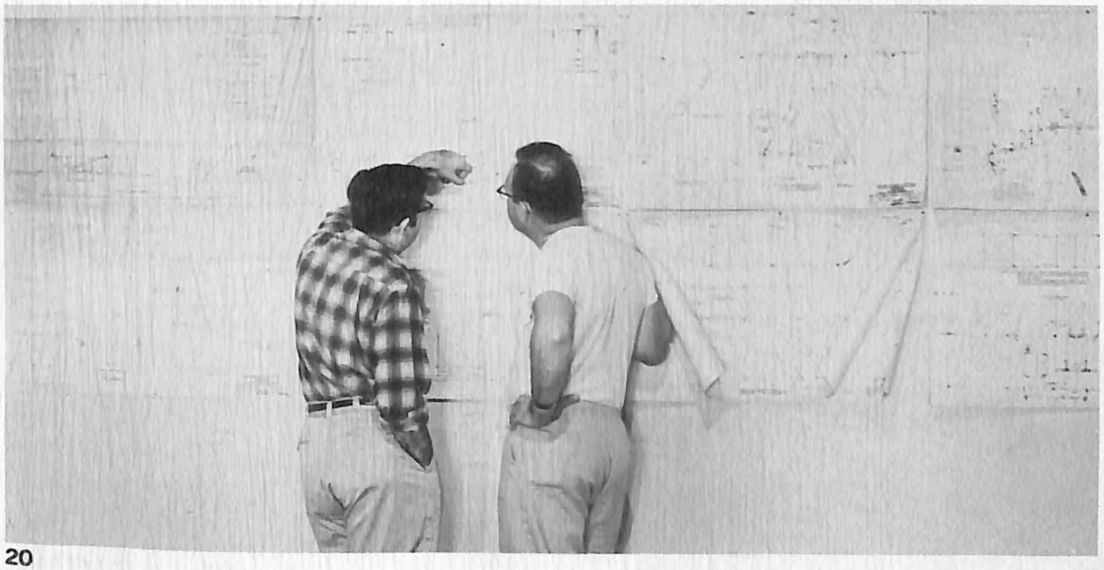
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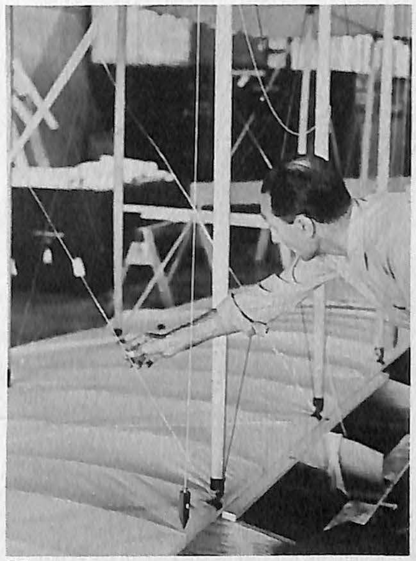
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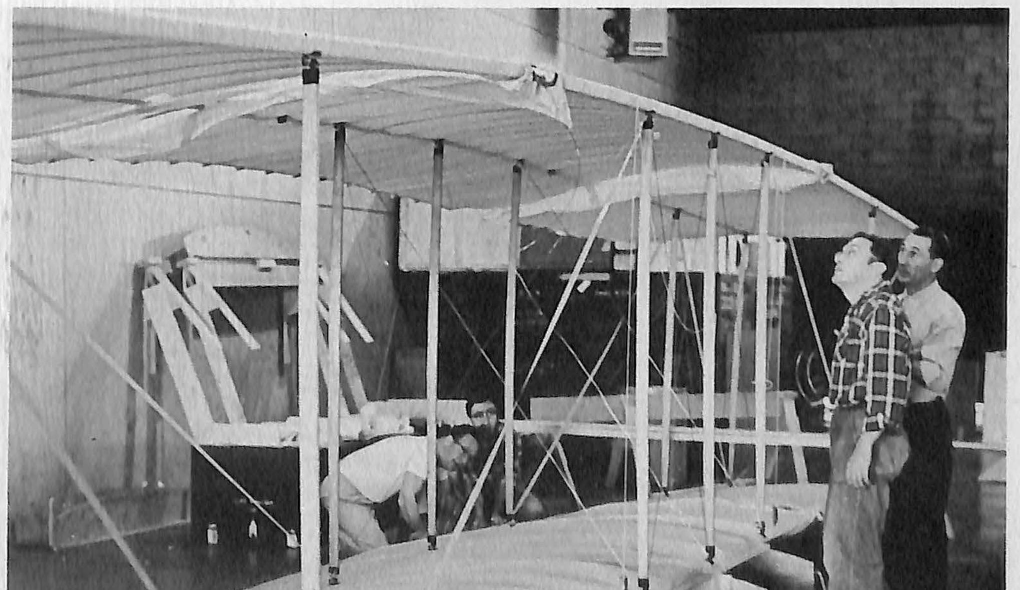
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1903
WRIGHT FLYER
1963

24. Sprocket wheel is placed on the drive shaft. Major parts made in various home workshops and industry plants were invariably exact fits.

25. Maj. Gen. Demler (left) and Marshal Sheen watch engine being mounted by Lt. Cmdr. Kastner. Gen. Demler is head of the Research and Technology Division of the Air Force Systems Command.

26. Part of the force of volunteer workers pose before the aircraft just prior to completion. The time from the idea of reconstruction through planning, work assignment, fabrication and assembly was about two years.

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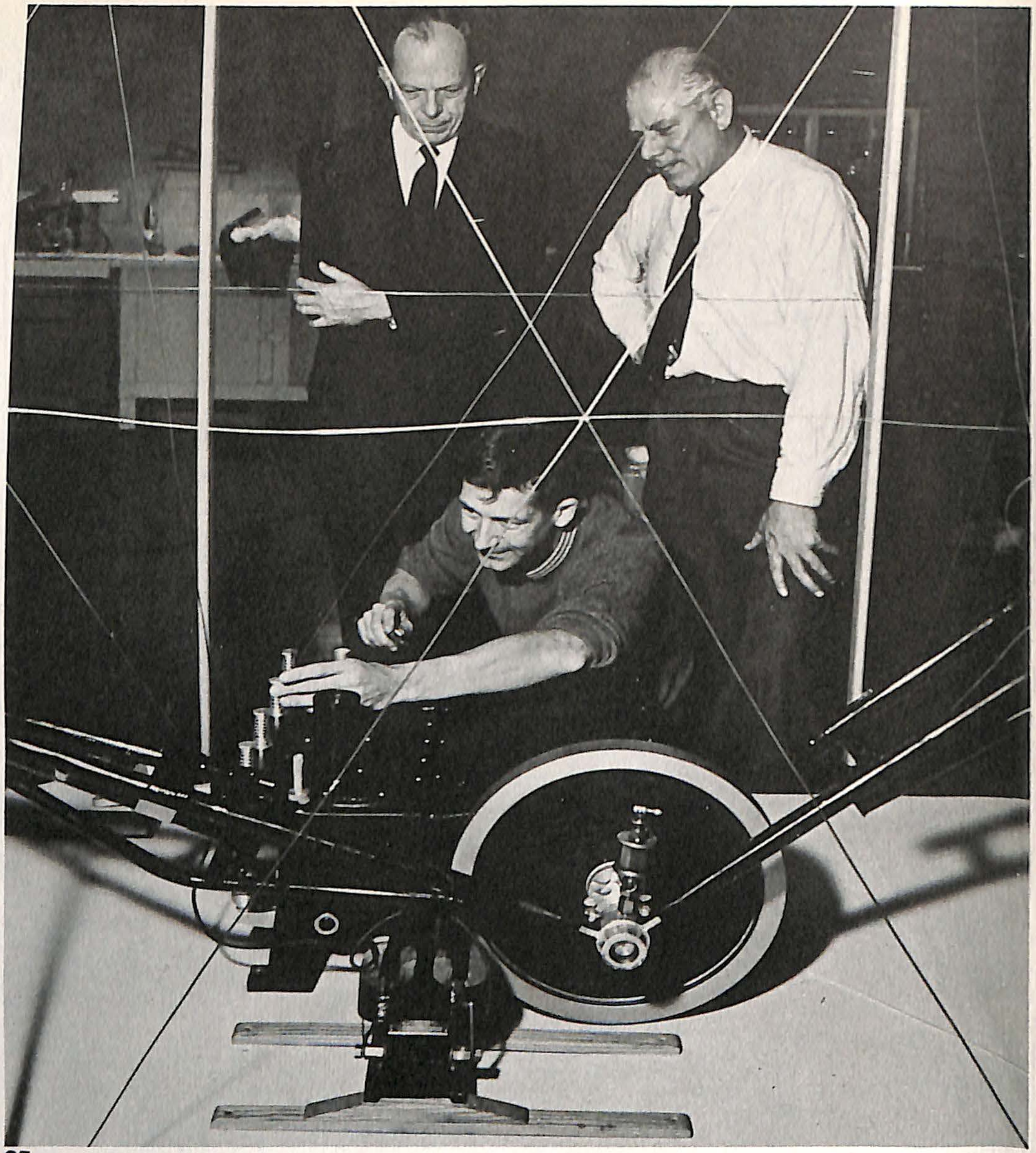

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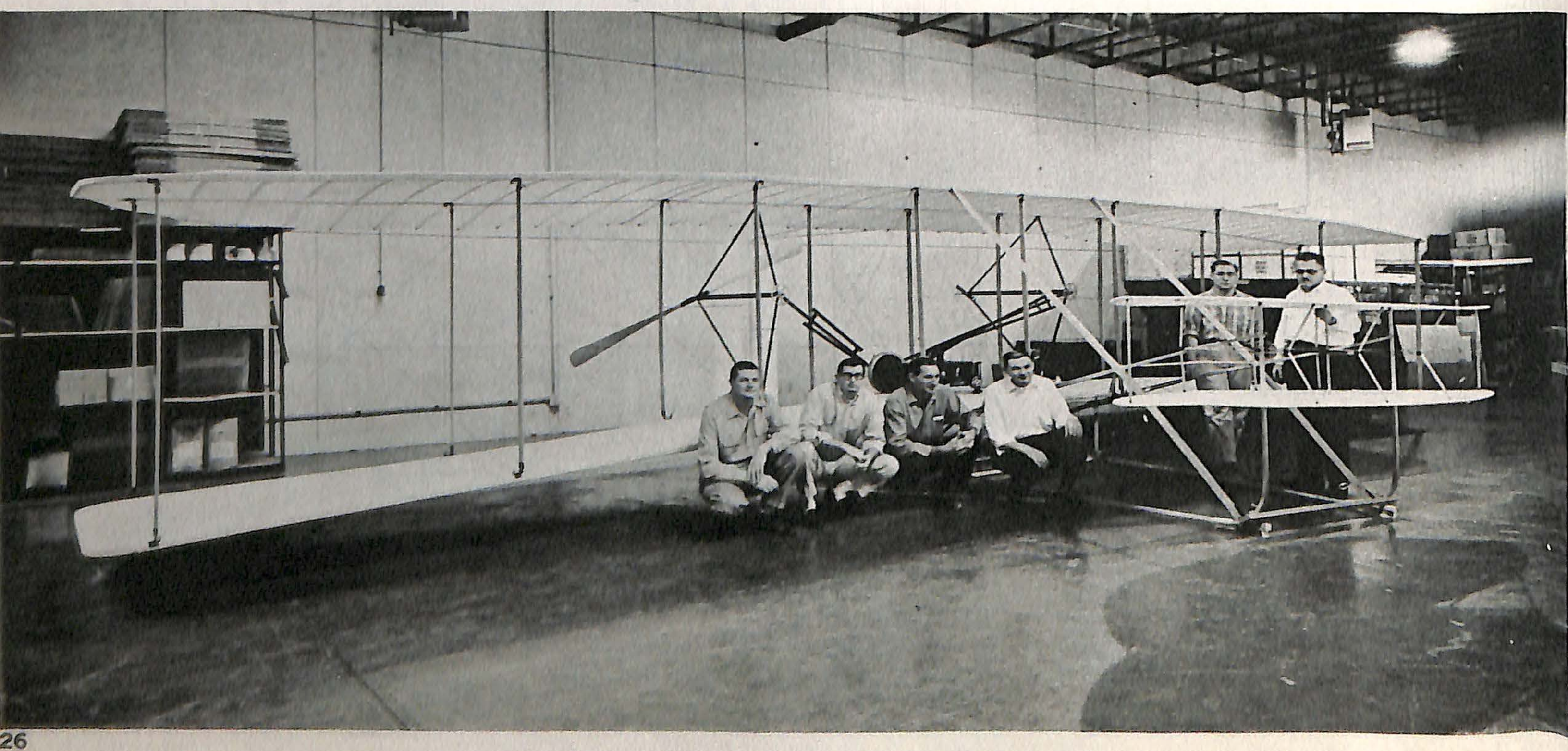

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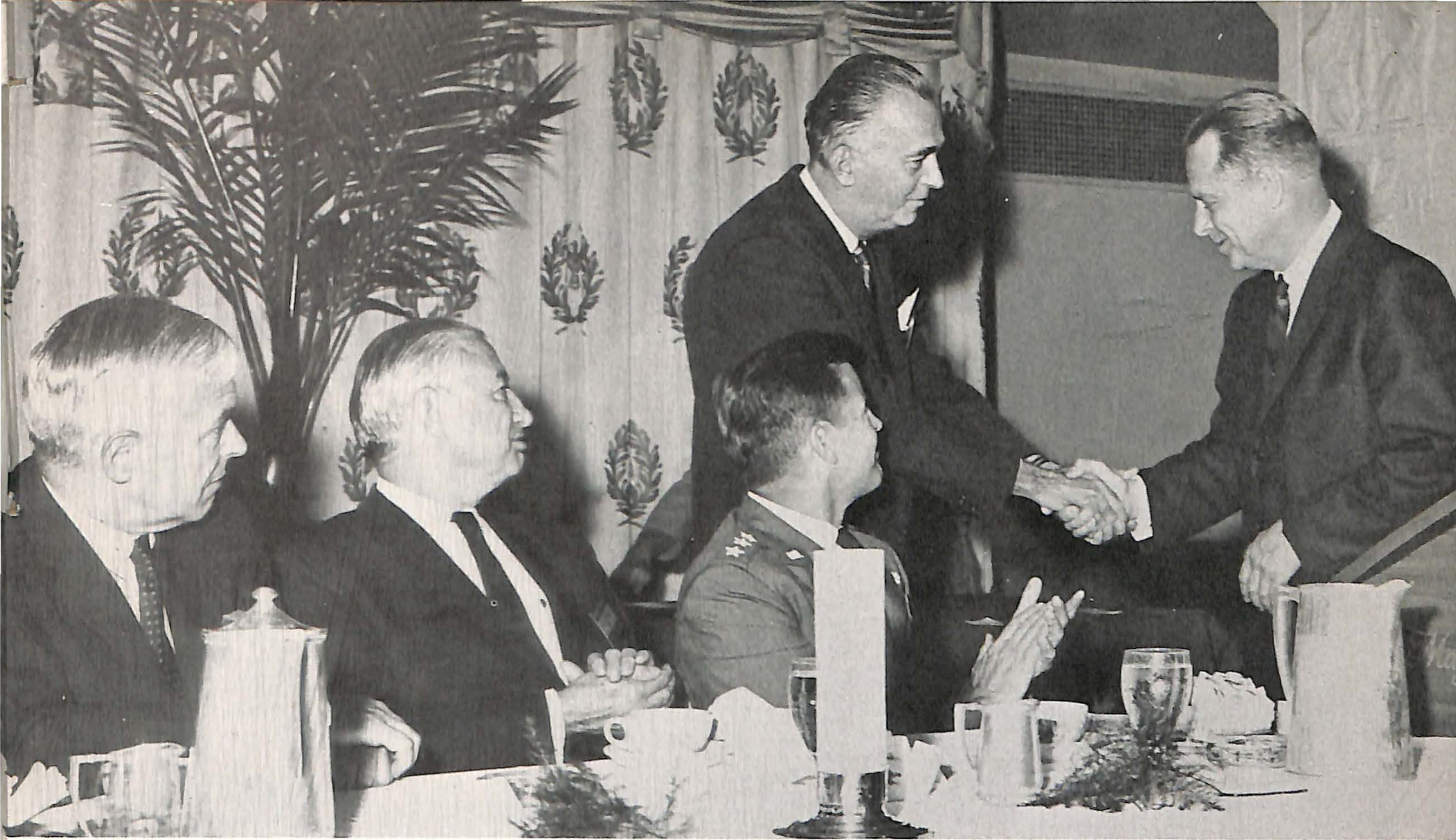

Air Force Association Citation of Honor was awarded to George F. Hannaum, retired vice president of the Aerospace Industries Association, at AFA's convention in Washington. The longtime AIA executive was chosen for his years of effort toward "furthering military-industry teamwork." In photo above, from left to right are Paul Nitze, now Secretary of the Navy; Dr. W. Randolph Lovelace II, new AFA president; Lt. Gen. Thomas P. Gerrity, USAF, Deputy Chief of Staff/Systems and Logistics, and standing Mr. Hannaum and J. B. Montgomery, then AFA president. James H. Straubel, executive director of AFA, pointed out that this was the first in its seventeen years of honoring civilians and military for distinguished service to aerospace power, that AFA has bestowed a citation on an executive of a trade association.

AIA MANUFACTURING MEMBERS

Aero Commander, Inc.
Aerodex, Inc.
Aerojet-General Corporation
Aeronutronic Division, Philco Corporation
Aluminum Company of America
American Brake Shoe Company
Avco Corporation
Beech Aircraft Corporation
Bell Aerospace Corporation
The Bendix Corporation
The Boeing Company
Cessna-Aircraft Company
Chandler Evans Corporation
Continental Motors Corporation
Cook Electric Company
Curtiss-Wright Corporation
Douglas Aircraft Company, Inc.
Fairchild Stratos Corporation
The Garrett Corporation
General Dynamics Corporation
General Electric Company
 Defense Electronics Division
 Flight Propulsion Division
General Laboratory Associates, Inc.
General Motors Corporation
 Allison Division
General Precision, Inc.
The B. F. Goodrich Company
Goodyear Aerospace Corporation
Grumman Aircraft Engineering Corp.
Gyrodyne Company of America, Inc.
Harvey Aluminum, Inc.
Hiller Aircraft Corporation
Hughes Aircraft Company
IBM Corporation
 Federal Systems Division
Kaiser Aerospace & Electronics, Div. of
 Kaiser Industries Corporation
Kaman Aircraft Corporation
Kollsman Instrument Corporation
Lear Jet Corporation
Lear Siegler, Inc.
Ling-Temco-Vought, Inc.
Lockheed Aircraft Corporation
The Marquardt Corporation
Martin Company, the Aerospace
 Division of Martin Marietta
 Corporation
McDonnell Aircraft Corporation
Menasco Manufacturing Company
Minneapolis-Honeywell Regulator
 Company
North American Aviation, Inc.
Northrop Corporation
Pacific Airmotive Corporation
Piper Aircraft Corporation
PneumoDynamics Corporation
Radio Corporation of America
 Defense Electronic Products
Republic Aviation Corporation
Rohr Corporation
The Ryan Aeronautical Company
Solar
Sperry Rand Corporation
 Sperry Gyroscope Company Division
 Sperry Phoenix Company Division
 Sperry Utah Company
 Vickers, Inc.
Sundstrand Aviation, Division of
 Sundstrand Corporation
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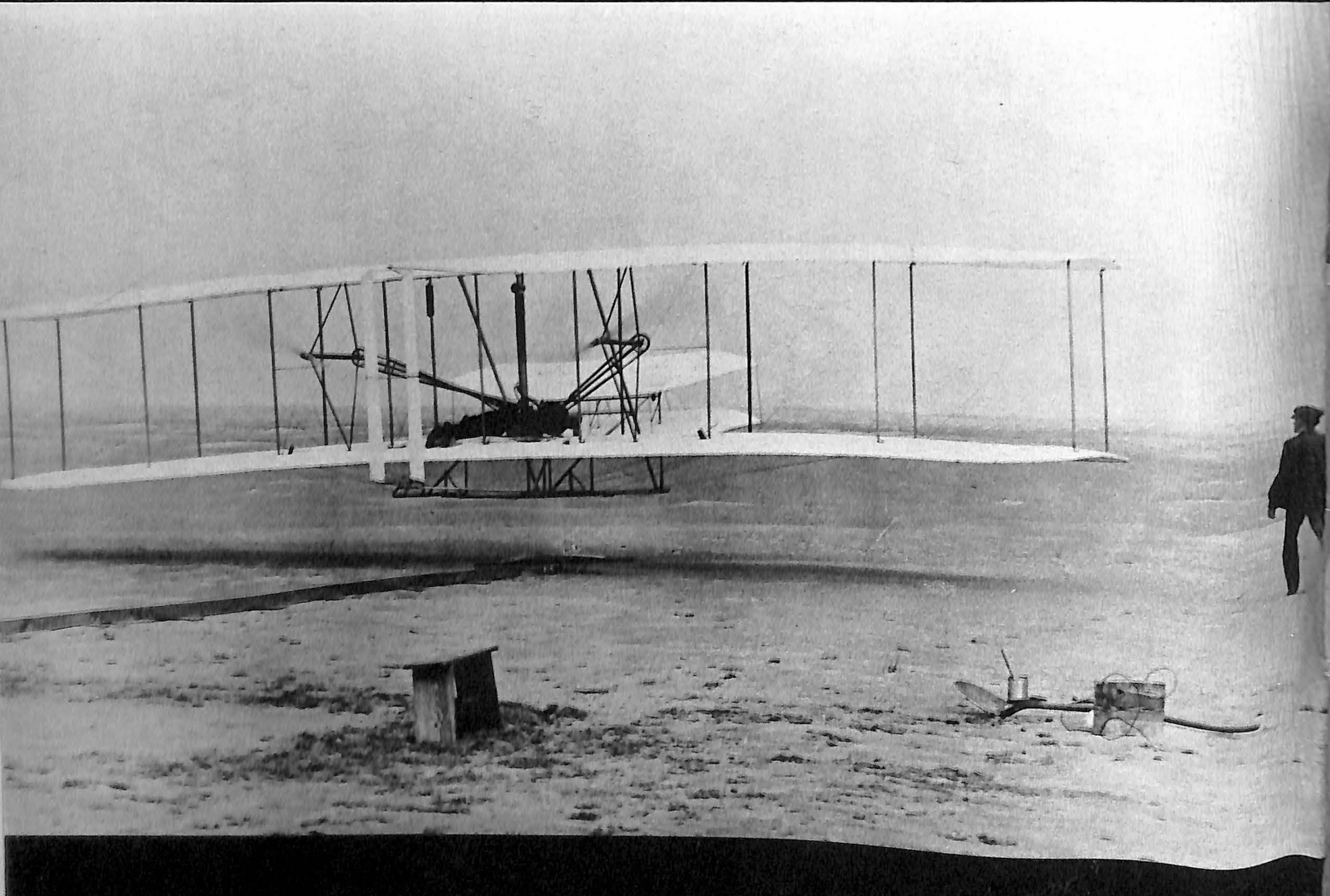
Permit No. 736



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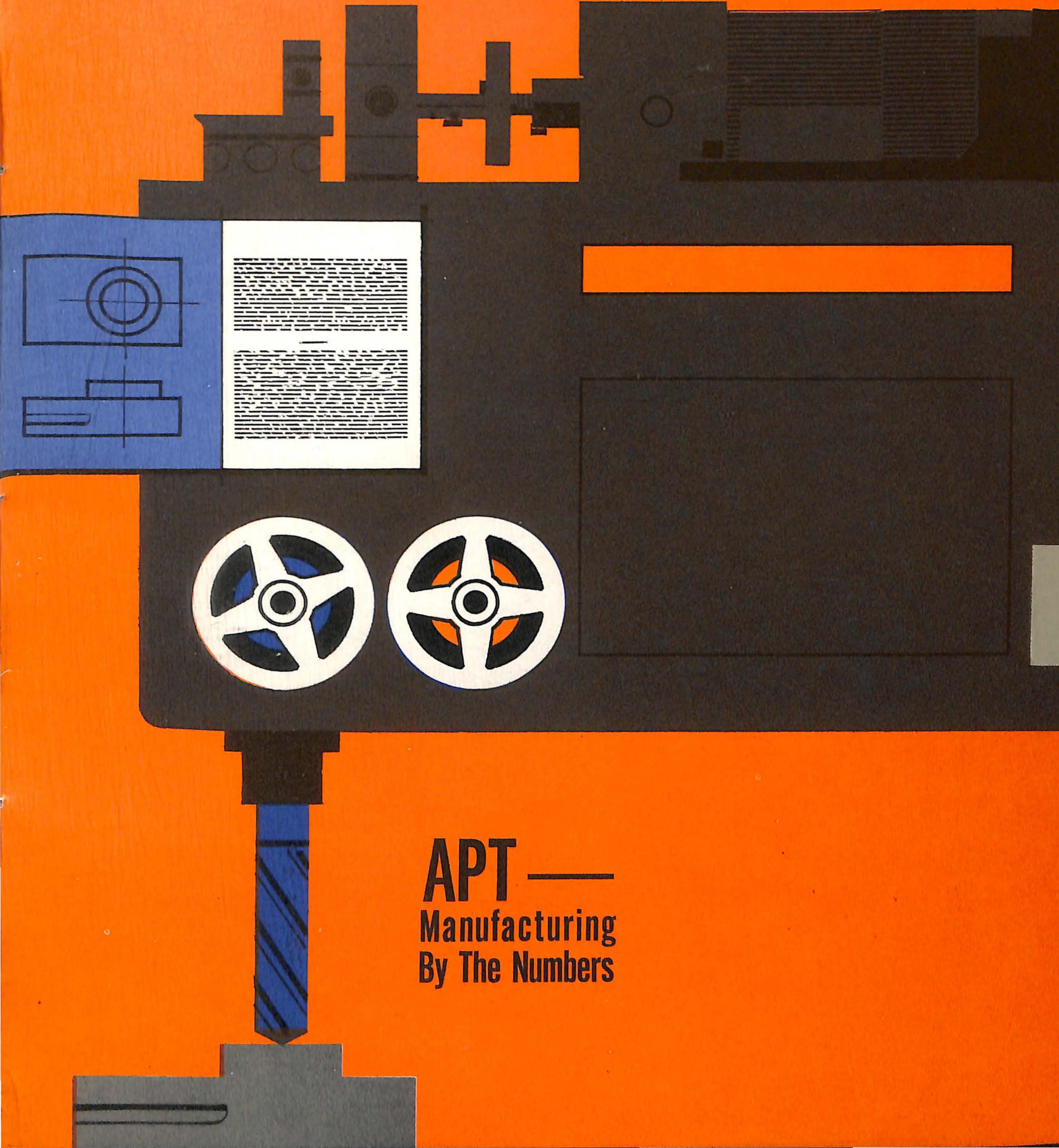

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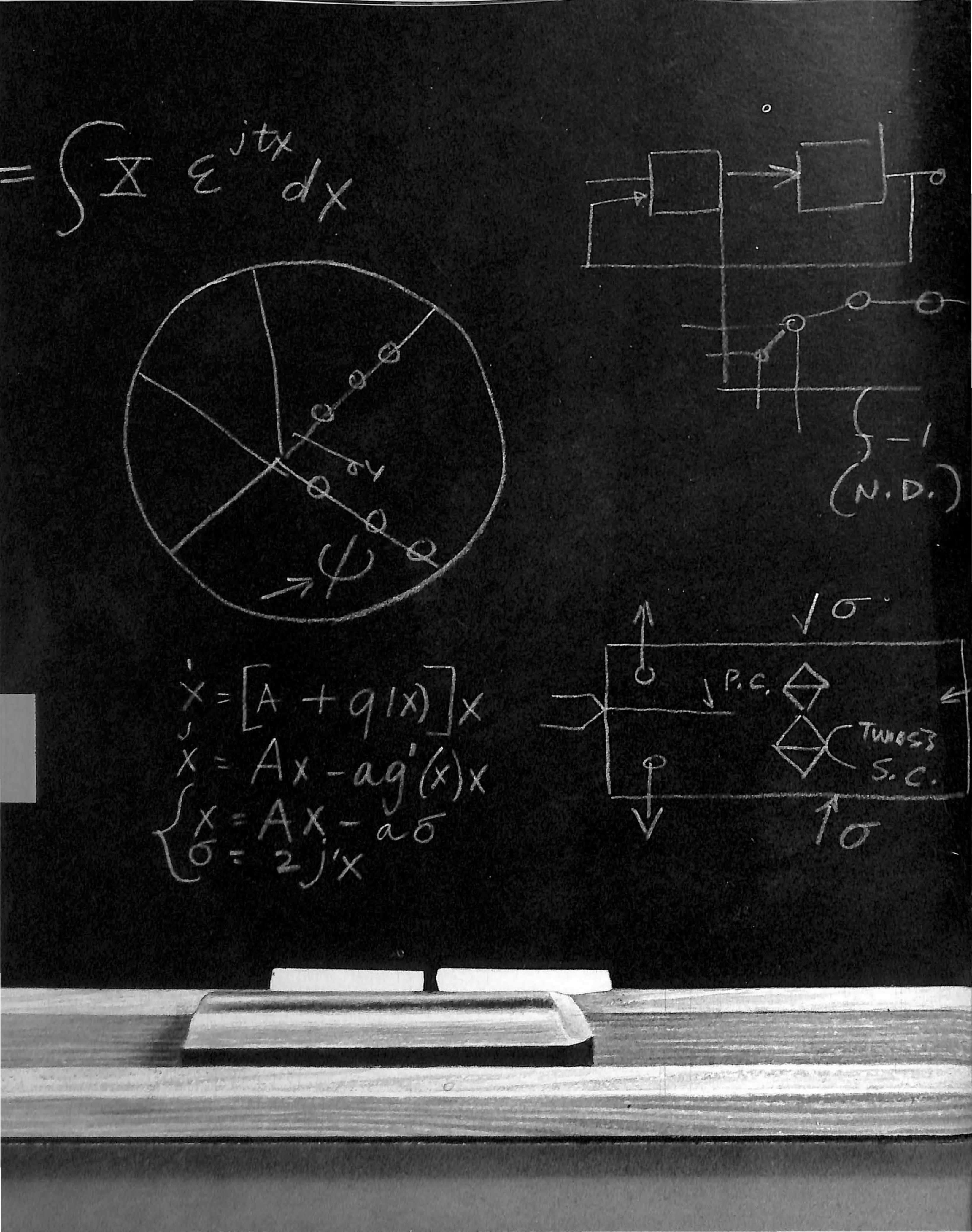
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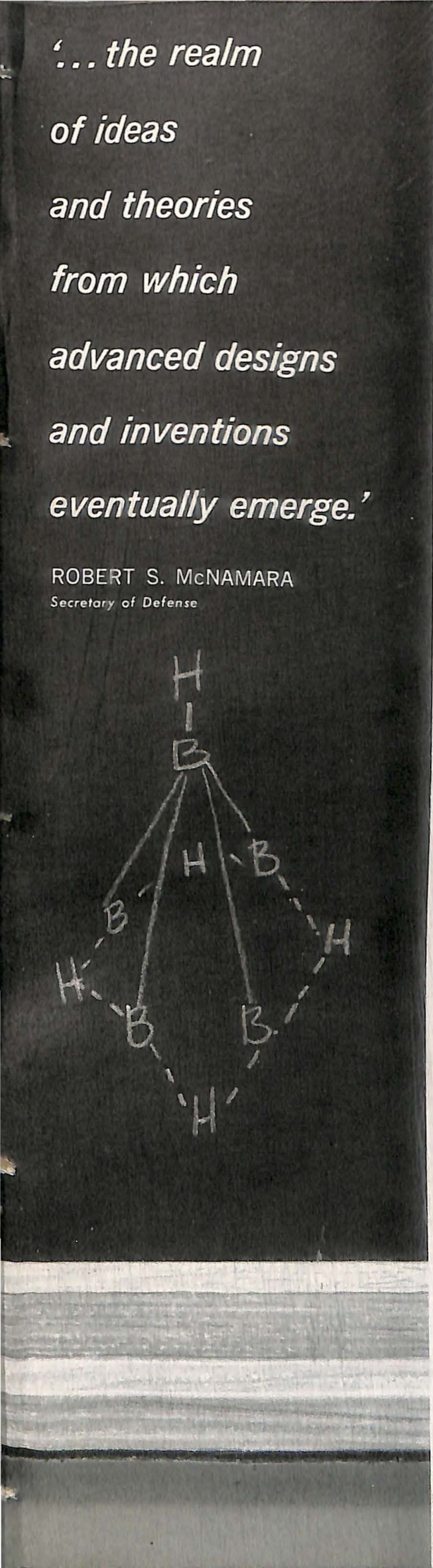

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Official Publication of the
Aerospace Industries Association of America, Inc.

VOL. 2 NO. 1 *MARCH, 1964*

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The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems:
Foster understanding of the aerospace industry's responsibilities in the space exploration program;
Foster understanding of commercial and general aviation as prime factors in domestic and international travel and trade.

AEROSPACE is published quarterly by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

Publication Office: 1725 De Sales Street, N.W., Washington, D. C. 20036

Los Angeles Office: 7660 Beverly Boulevard, Los Angeles 36, California.

PLANNING TOMORROW'S DEFENSES

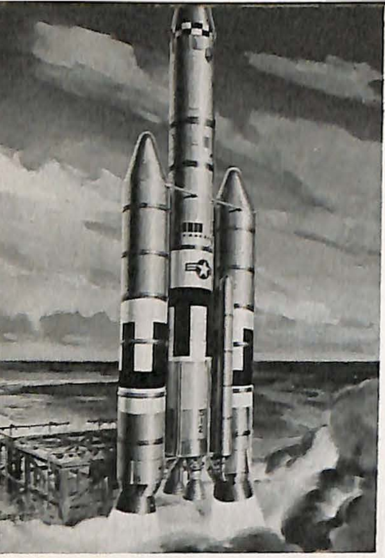
By **JAMES J. HAGGERTY, JR.**
Associate Editor, Aerospace

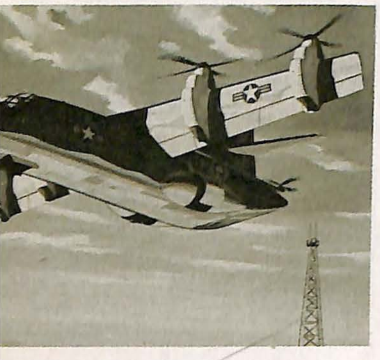
A sharper focus on military space requirements, increasing accent on defense against enemy ICBM's, efforts to improve the performance and effectiveness of our retaliatory missiles, and development of a variety of new aircraft types — these are the major goals of a broad research and development program to be carried out by the Department of Defense in Fiscal Year 1965.

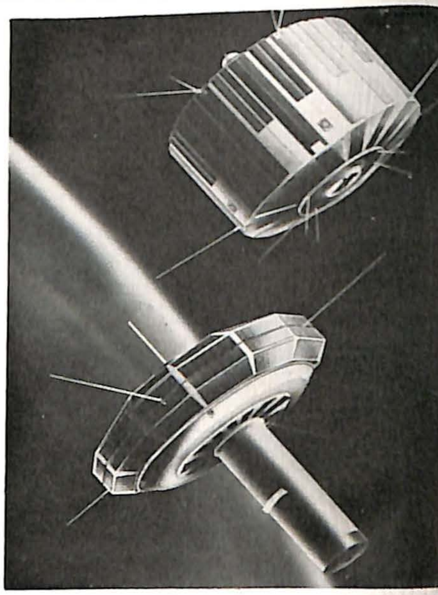
The program, outlined by Defense Secretary Robert S. McNamara in his annual posture statement to the Congress, provides an excellent guideline to the type of defense systems the military services will be operating in the future. Despite a funding reduction of about a quarter of a billion dollars from the current year's level, the program remains, the Secretary said, "a well-balanced and vigorous research and development effort, an effort which is sufficiently comprehensive and challenging to retain the interest and support of the most capable technical talent available."

The Defense appropriation requested for Research, Development, Test and Evaluation in FY 1965 is $6.722 billion, the three per cent reduction from FY 1964 stemming largely from termination or reorientation of a number of R&D projects.

In his statement, Secretary McNamara paid par-







ticular attention to space R&D projects, funding for which will total $1.474 billion or slightly more than 20 per cent of the RDT&E appropriation.

The major new space project is the Air Force's Manned Orbiting Laboratory, which will consist of a pressurized cylinder, or laboratory, topped by a Gemini B launch/re-entry command capsule. Two astronauts will occupy the capsule during launch (booster is the Titan III-C vehicle), then move into the laboratory, which will be large enough to accommodate "a considerable amount" of military equipment. For the return to earth (after up to two weeks of experimentation), the astronauts will go back to the Gemini B, fire the retrorockets and "de-orbit", leaving the laboratory in space.

Other space projects mentioned, in addition to Titan III, include Air Force participation in the National Aeronautics and Space Administration's Gemini program, continuing work on the nuclear test detection satellite (Vela) and the Navigational Satellite System (Transit), additional study of the Satellite Inspector, and advanced rocket engine development in both liquid and solid propellant systems. In the latter category funds are requested for ground testing of a space maneuvering propulsion unit.

Although there is a clear requirement for a military satellite communications system, said the Secretary, DOD is exploring the possibility that the Communications Satellite Corp. may be able to provide this capability.

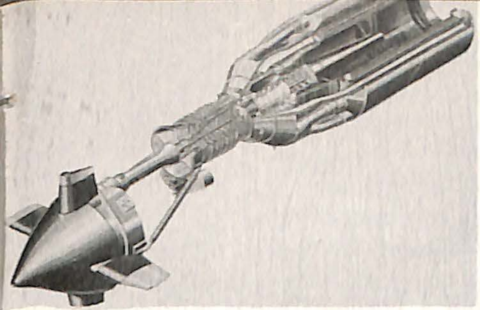
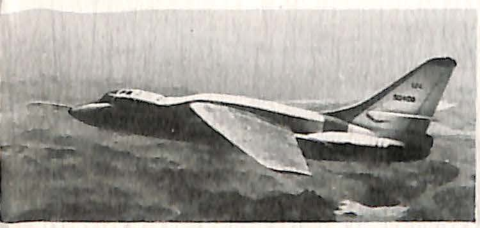
Considerable developmental effort will be devoted to improvement of the strategic retaliatory and air/missile defense forces. In the strategic area, the Secretary disclosed plans for a revision of the Minuteman ICBM force. A large number of Minuteman I silos will be "retrofitted" with Minuteman II, which will have longer range, improved accuracy, greater flexibility in choice of targets, better survivability and the capability of being triggered into action by a radio impulse from an airborne command station.

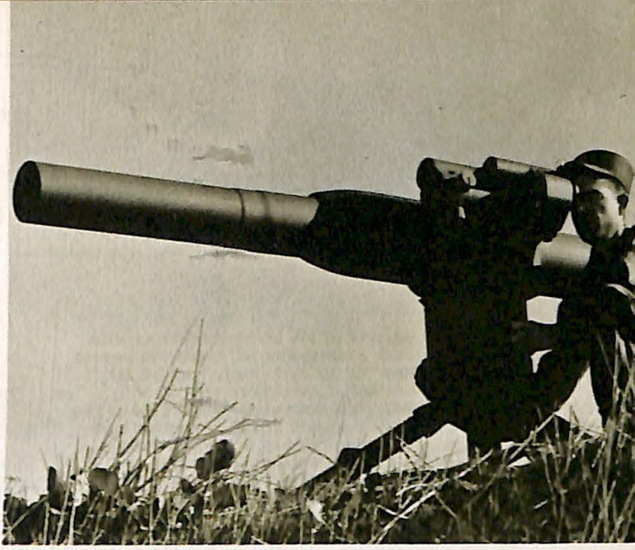
Work will continue on development of the Medium Range Ballistic Missile "for possible use in a European sea-borne force or elsewhere in the world." New systems under study include an improved version of the Polaris missile, beyond the 2,500-mile range A-3 model, and advanced strategic aircraft which could serve as airborne missile platforms.

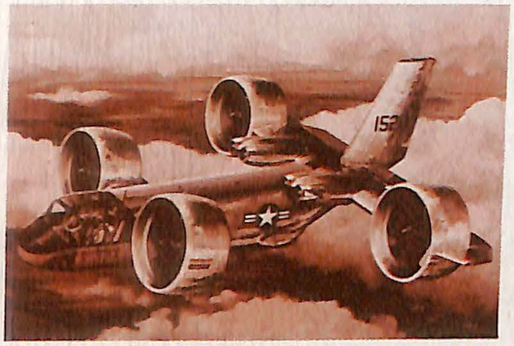
In the defense category, the major R&D program is the anti-ICBM missile, involving additional development of the Nike-Zeus and Sprint missiles and the Multi-function Array Radar (MAR), "which would have the capability to acquire and track a large number of objects simultaneously, thus reducing the probability that the system's rate of fire could be limited by saturating the radar."

Development will also continue on an advanced bomb alarm system called NUDETS, for Nuclear Detonation Detection and Reporting System, which detects A-bomb bursts and automatically reports them to command centers. The Secretary mentioned that a nationwide NUDETS network is "a future possibility," depending on 1965 tests of the first complex.

Other defensive development measures include continuing studies, toward selection of an improved manned interceptor for defense against manned bomb-






ers and new methods of defense against sub-launched missiles, such as better sonar equipment (Project Artemis) and aircraft-monitored sonobuoys for sub detection. The Nike-X battery would provide the "kill" element in submarine/missile defense.

Secretary McNamara broke down the RDT&E program into five categories: Research; Exploratory Development; Advanced Development; Engineering Development; and Management and Support. No detailed breakdown was provided for the sixth category: Operational Systems Development. Here is the outline of the projects DOD will conduct during FY 1965:

RESEARCH

Described as the "realm of ideas and theories from which advanced devices and inventions eventually emerge," this category covers basic and some applied research in the physical and environmental sciences, mathematics, psychology, sociology, biology and medical sciences. The budget request calls for $376,000,000, a $39,000,000 increase over FY 1964, allowing a slight increase in the level of research effort for each of the services and the Advanced Research Projects Agency.

EXPLORATORY DEVELOPMENTS

Under this heading are activities directed toward solution of specific military problems, "the pool of technical knowledge from which future weapon systems will be devised and designed." The funding request is for $1.126 billion, approximately the same as FY 1964. By service, it includes:

Army New and improved propulsion systems for aircraft, studies of new night-viewing equipment, rocket propellant research, and "armor defeating projectiles."

Navy New surveillance and detection devices for both ships and aircraft, research on missile propellants, guidance systems and countermeasures, and advanced aircraft concepts with emphasis on simplicity, endurance and low-speed characteristics. More than $100,000,000 will be expended on problems related to antisubmarine warfare.

Air Force About one-fourth of the USAF Exploratory development total of $308,000,000 will be devoted to space-related subjects, such as guidance, flight control, propulsion, life sciences and electromagnetic techniques. In other areas, the USAF will investigate new propulsion cycles for hypersonic manned aircraft, laminar flow control in supersonic flight and improvements in reconnaissance, communications, command and control and intelligence techniques.

ARPA The Advanced Research Projects Agency's $238,000,000 allocation will be spent largely on three major programs: Project Defender, development of systems for defense against ballistic missiles; Project Vela, research on detection of nuclear explosions, both underground and at high altitude; and Project Agile, designed to provide R&D support "for remote area conflict" problems.

ADVANCED DEVELOPMENTS

This category includes projects which have advanced to the point where experimental hardware is required for test purposes. It includes:

Army Continuing development of heavy lift or "flying crane" helicopters, the Shillelagh antitank weapon system, and a field army air defense system to replace the Nike Hercules and Hawk missiles.

Navy An expansion of hardware development for ASW missions, development of a new special warfare or counterinsurgency aircraft, and a feasibility program on the use of Air Cushion Ships for certain special applications.

Air Force Continuing investigation of concepts for an Advanced ICBM, the X-15 project, and a TAC Fighter Avionics program designed to improve night and all-weather weapons delivery of such new aircraft as the F-111A (TFX).

In addition to the foregoing, the three services will cooperate jointly on two advanced development programs. One involves continuing development of V/STOL aircraft, including the tilt-wing XC-142, the tilting ducted fan X-22A, and the tilting propeller X-19A. The other tri-service project is development of a new surveillance aircraft, a "less vulnerable, more versatile" successor to the Army's Mohawk, and new propulsion systems for this type aircraft.

ENGINEERING DEVELOPMENTS

Projects in this category are those being engineered for service use but not yet approved for production. They include:

Army An extensive effort on the Nike-X AICBM system ($334,000,000), plus an additional $40,000,000 for continuing Nike-Zeus development. Missile programs are: Mauler, a mobile general purpose weapon; Lance, a self-propelled, air-transportable field weapon system; and TOW, a wire-guided heavy anti-tank weapon. A $23,000,000 allocation will continue support of the Light Observation Helicopter. An unspecified amount is provided for the aircraft suppressive fire program, which is concerned with the adaptation of machine guns, rockets and anti-tank missiles to Army aircraft.

Navy Continuing development of the regenerative turboprop engine and the air-to-surface free-fall weapon, Walleye. Engineering development will be initiated on an unidentified medium range air-to-surface weapon which would enable aircraft to attack heavily defended targets. Another new project is a quick-reaction ASW weapon for use aboard the Sea Hawk Destroyer Escort System.

Air Force An additional $92,000,000 is authorized for engineering development of the B-70 bomber, which will finance all but $25,000,000 of the $1.5 billion program; the remaining funds are programmed for FY 1966. Included in this category is funding for the MRBM and the airborne missile platform, the latter a $5,000,000 item. Also included is $7,000,000 for work on a new Heavy Logistic Support Aircraft (CX), capable of lifting outsize items of military equipment such as ICBM's, radars, communications vans, aircraft wings, etc.

MANAGEMENT AND SUPPORT

The M&S category involves funding for research and development installations such as ranges, test facilities and laboratories, and specialized technical services provided under contract by non-government organizations.

Army Funding of $93,000,000 is requested for the operation of the White Sands Missile Range and $168,000,000 is required for general support of Army research laboratories, test facilities and proving grounds.

Navy A sum of $208,000,000 is allocated for support of Navy laboratories, test centers and other RDT&E field activities. The operation of the Pacific Missile Range, including the Pt. Arguello and Pt. Pillar facilities, requires $159,000,000. An unspecified amount will go for operation of AUTEC (Atlantic Undersea Test and Evaluation Center), a test facility for ASW and other undersea equipment.

Air Force Support of the Air Force Systems Command and its complex of installations, construction of new facilities and other AF support programs will require funding of $666,000,000. This includes approximately $100,000,000 for contract services by independent organizations. A separate allocation of $231,000,000 is provided for operation of the Atlantic Missile Range and support of NASA space efforts.

Beginning in FY 1965, the USAF will assume responsibility for operation of the Navy's Pt. Arguello and Pt. Pillar facilities, and M&S funds allocated to the Navy will be transferred.

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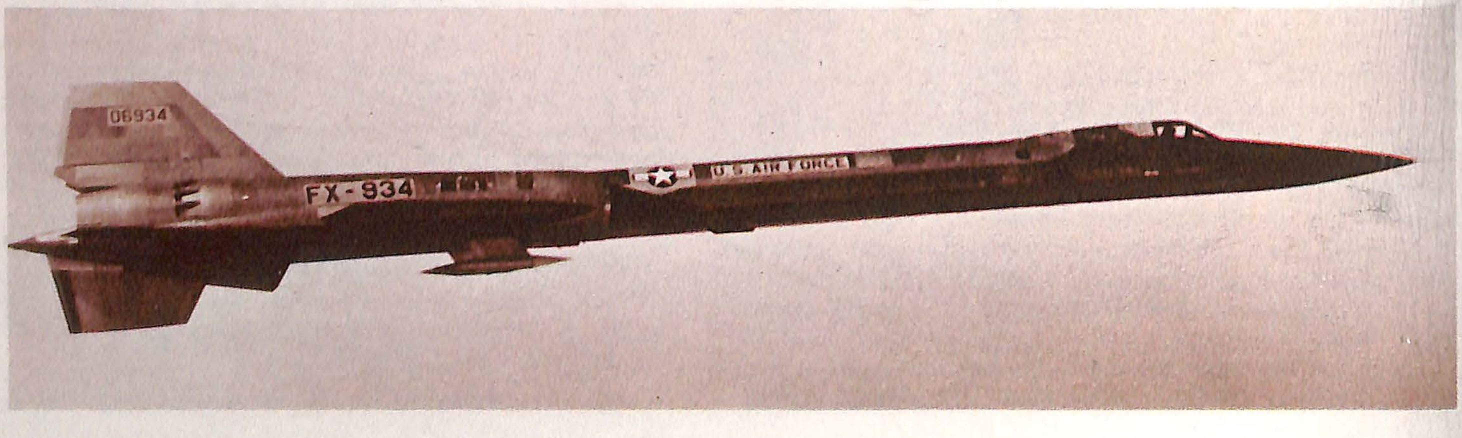


Aerospace Exports

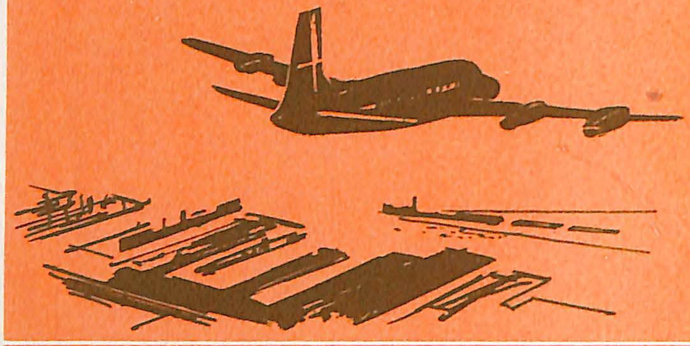
GLOBAL MARKETPLACE

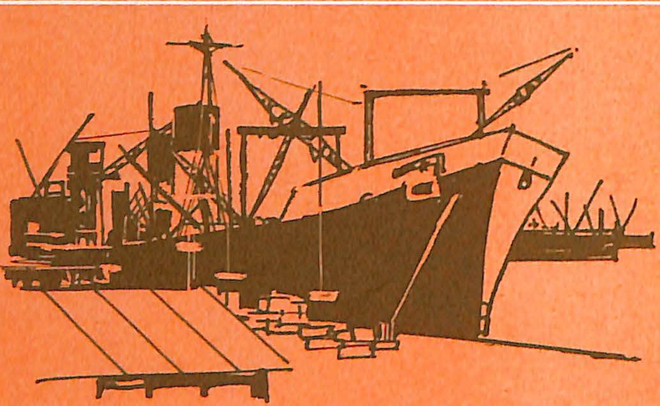
The current transAtlantic competition over the supersonic transport (SST) once again focuses attention on the importance of American aerospace exports and the balance of payments problem.

As the Federal Aviation Agency and airlines of the world study the design proposals of three airframe and three engine producers to build an American airliner capable of flying at speeds up to 2000 miles per hour, they know the British and French are well along on a competitive aircraft with a speed potential of 1400 miles an hour.

To a large extent, the success or failure of the American SST will determine whether foreign airlines pour hundreds of millions of dollars into the U. S. over the next decade to buy the airplane or whether U. S. carriers spend comparable sums abroad to import the Concorde.

U. S. aerospace firms concerned with exports have always been challenged by foreign producers whose sales efforts invariably had the endorsement and support of their own governments. Although the American





COMPARISONS OF AERONAUTIC AND TOTAL U. S. EXPORTS
1946-1963
(In Millions of Dollars)

Year	Total U. S. Merchandise Exported	Total Aeronautic Products Exported	Per Cent of Total
1946	$ 9,500.2	$ 115.3	1.2
1952	15,025.7	603.2	4.0
1956	18,839.7	1,059.3	5.6
1957	20,850.3	1,028.0	4.9
1958	17,892.7	971.5	5.4
1959	17,566.2	769.5	4.4
1960	20,549.7	1,329.5	6.5
1961	20,962.1	1,208.8	5.8
1962	20,945.0	1,435.5	6.9
1963*	22,288.0	1,280.0	5.7

* Estimated

companies have traditionally lacked the same measure of U. S. Government support — and this applies even on the SST sales effort — they nevertheless feel extremely optimistic about the near future.

The year 1963 marked the fourth consecutive year that U. S. aerospace exports exceeded the billion dollar level. During the six years ending with 1963, American aerospace exports reduced the outflow of gold by more than $6.4 billion (see chart). Despite this high level of export sales, some industry experts believe a $2 billion annual level "is not totally unrealistic for 1970 and beyond."

Exports of aircraft materiel, not counting equipment furnished America's allies under Mutual Aid and Military Assistance Programs, have accounted for a growing percentage of the industry's total sales in recent years.

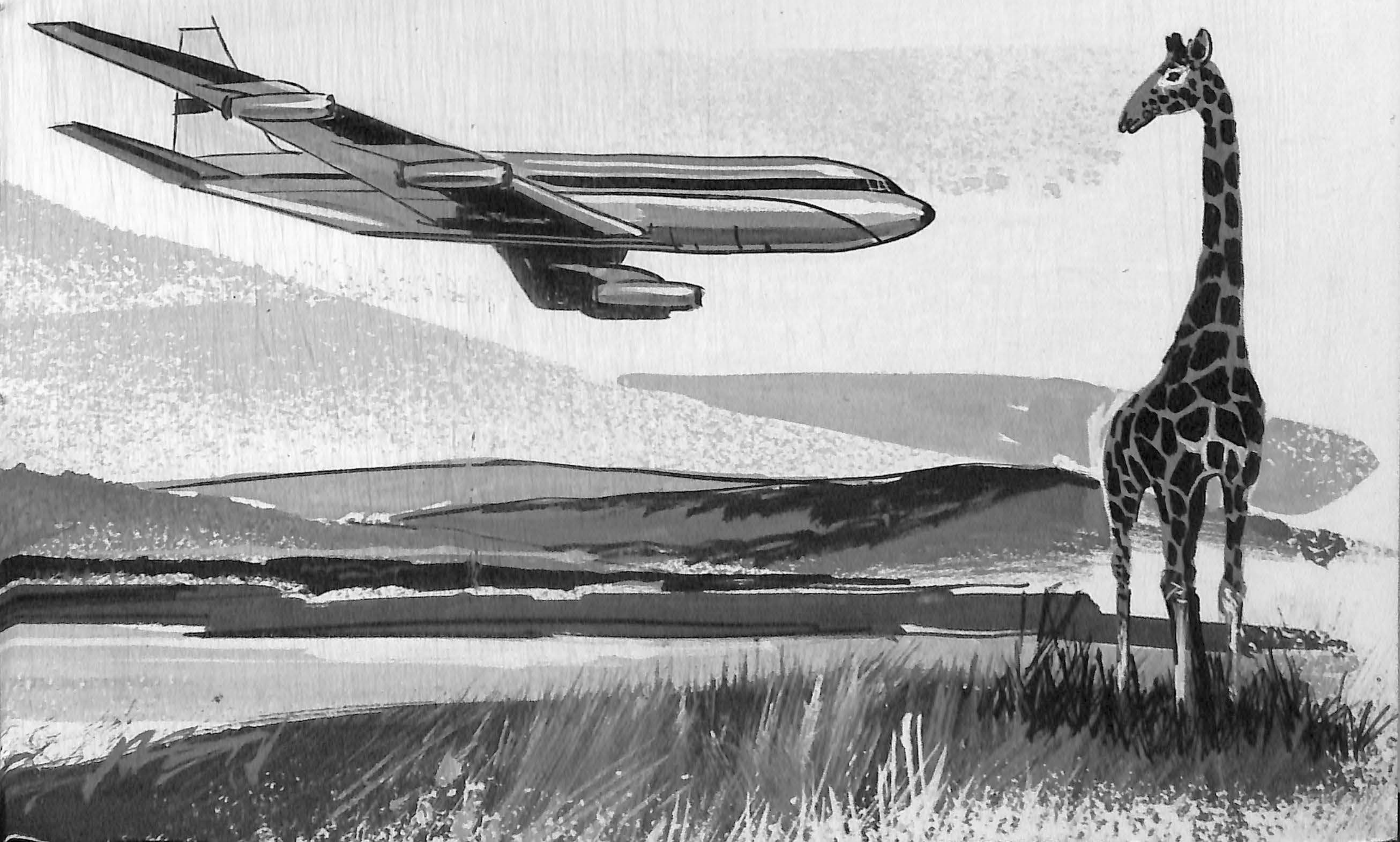
Between 1958 and 1962, 16.7 per cent of the total sales of aircraft, aircraft engines and parts went abroad. In 1963, this segment of the aerospace industry produced total sales of $5.5 billion, of which $1.3 billion — or 23.1 per cent — was delivered to foreign customers. The importance of exports to the overall industry is increasingly evident because overall sales of aircraft, engines and parts declined from $8.7 billion in 1958 to $5.5 billion in 1963.

But exports are not limited to manned aircraft or even to planes and missiles. Dr. Hugh L. Dryden, Deputy Administrator of the National Aeronautics and Space Administration, reports that over the past three years, "foreign nations have spent over $16 million in this country on procurement of sounding rockets, payloads, electronic equipment, communications ground terminals, test and other facilities, solar cells, power, and telemetry packs, and other space hardware." It seems logical that as other nations expand their own space activities, they will procure much of the needed equipment from U. S. producers.

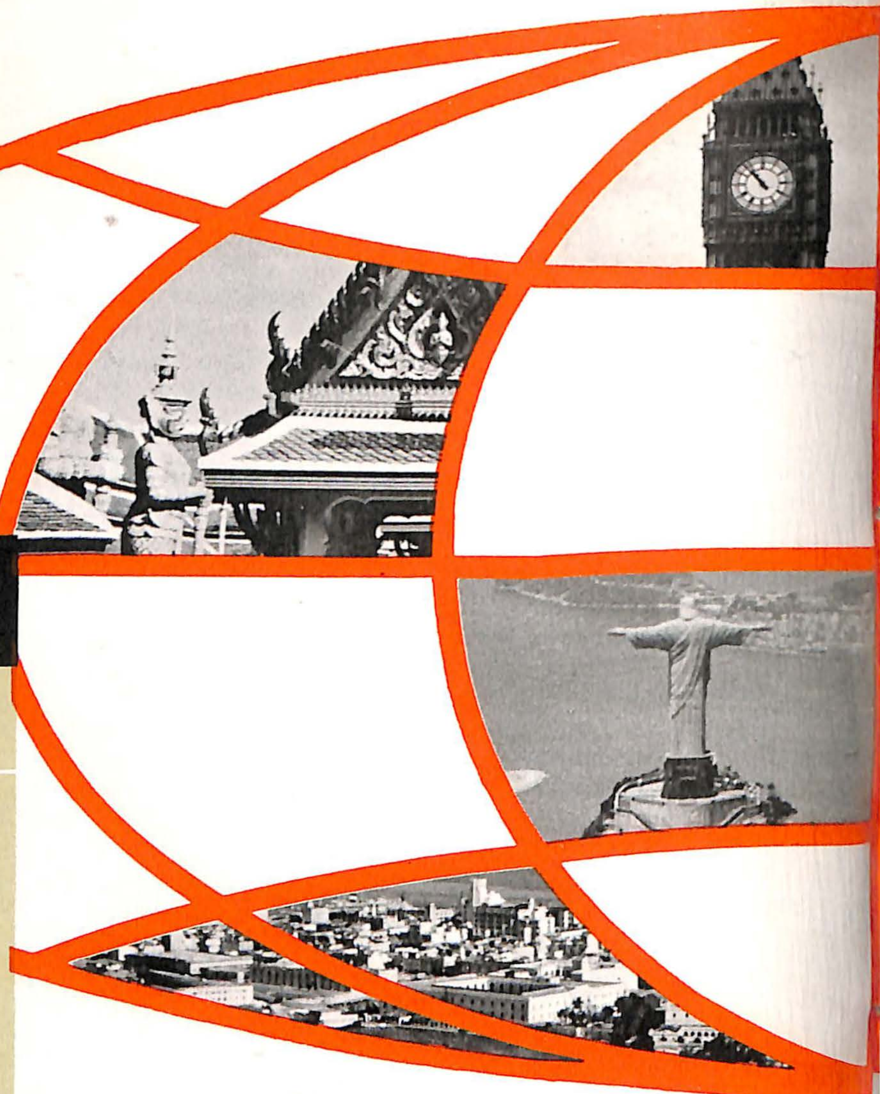
Until now, however, the aeronautical rather than the astronautical segment of the aerospace industry has accounted for the major effort to reduce America's outflow of cash. Aircraft, aircraft parts and equipment have been substantial dollar earners over the years, to a point where they represented almost 6 per cent of all the merchandise sold to foreign nations in 1963 (see chart).

One of the most important reasons why the American aerospace industry has been successful over the years in selling its aeronautical products abroad is the technological and economic superiority of U. S.-built aircraft and parts.

Foreign aircraft manufacturers have had and will continue to have a distinct advantage in the cost of labor. For example, in 1961, the average hourly wage of all U. S. production workers, including fringe benefits, was $2.71. In France, the average hourly wage,



UTILITY AIRCRAFT EXPORTS 1958-1963		
Year	Units	Value (in millions)
1958	871	$12.350
1959	956	14.494
1960	1,484	27.335
1961	1,581	29.531
1962	1,468	31.299
1963	1,578	35.173



including fringes, was 70 cents. In Italy it was 68 cents. In the United Kingdom it was $1.06 (for men). By contrast, American plants building aircraft, aircraft engines and parts in 1961 paid average hourly wages of $2.93, plus extensive fringe benefits.

Foreign aircraft companies have other advantages. They often obtain direct support from the governments for manufacturing operations. They can and do participate in inter-governmental manufacturing combines.

But the most significant sales impediment, as far as U. S. aerospace producers are concerned, lies in the fact that most of the foreign airlines which are potential customers for transport planes are partial or complete instrumentalities of their governments. Of the 109 foreign carriers, about 65 of the largest are either completely or better than 51 per cent owned by their governments.

Sales of other civil aircraft to foreign customers have also been climbing. Utility aircraft exports reported by four major general aviation producers (Aero Commander, Beech, Cessna and Piper) have increased nearly three-fold in six years (see chart).

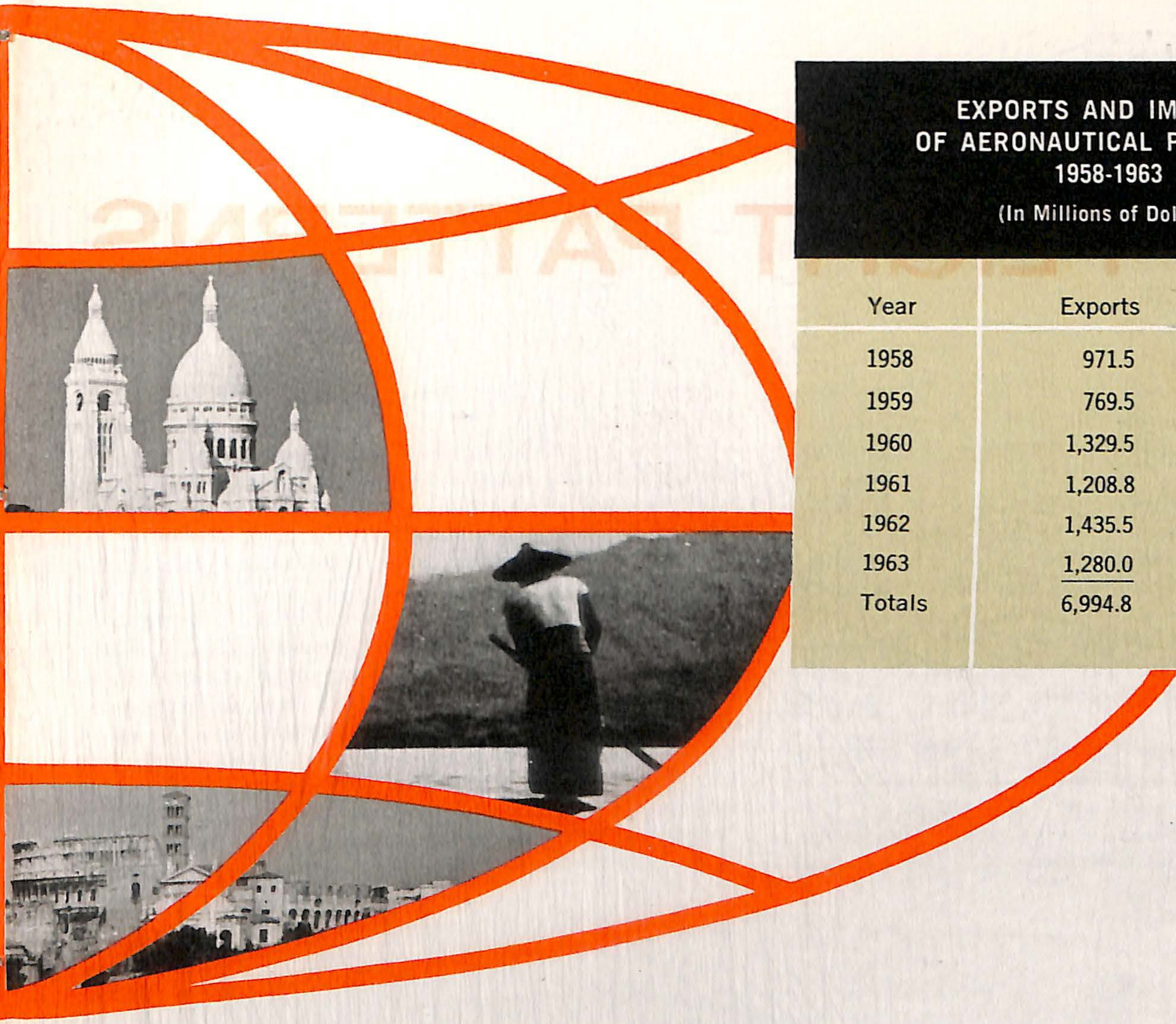
Past successes with aerospace exports are not necessarily indicative of future progress in the export field. Although leading Government officials, including President Johnson, Commerce Secretary Hodges and others, have stressed the need for an upsurge in the sale of American goods abroad, the regulations which might lead to increased aerospace exports are archaic.

The sale of military aerospace equipment is a case in point. American producers are convinced that State Department and Department of Defense procedures required before U. S. salesmen and their products are "cleared" to approach foreign governments hamper sales. All too frequently, by the time a representative of a U. S. aerospace company has obtained the needed authorizations, a competitive aircraft or missile has already been sold by a British or French company because their salesman arrived on the scene first.

Obviously, a key to greater sales of U. S. military aerospace products abroad is international financing. The U. S. Export-Import Bank, while not specifically prohibited from financing military aerospace products, tends to shy away unless there are overwhelming reasons why it would be in the national interest to do so.

Paul H. Nitze, now the Secretary of the Navy, spoke as the Assistant Secretary of Defense for International Security Affairs when he recently told an AIA export meeting at Colorado Springs:

"Government and commercial financial mechanisms must find a way to provide some $3 billion or more in



EXPORTS AND IMPORTS OF AERONAUTICAL PRODUCTS 1958-1963

(In Millions of Dollars)

Year	Exports	Imports
1958	971.5	78.6
1959	769.5	68.1
1960	1,329.5	60.9
1961	1,208.8	151.7
1962	1,435.5	128.2
1963	1,280.0	95.0
Totals	6,994.8	582.5

credit assistance over the next decade; and we need better Executive Branch coordination, procedures and resources to cooperate with and support industry's capabilities and initiative."

Secretary Nitze added that, "We need some American ingenuity from the commercial banking and insurance communities as to the best ways to make available export credits of up to $3 billion on the military equipment account over the next 10 years.

Just how big is the sales potential for military aerospace exports? Mr. Nitze estimates that between 1963 and 1971, European and Far Eastern nations economically capable of acquiring defense materiel will spend $55 to $65 billion. These nations account for 80 per cent of U. S. military exports, while Latin America, the Near East and Southeast Asia buy the rest.

Over the next three years, according to Mr. Nitze, there is a sales potential of more than $5 billion, including $3.5 billion in Europe and $750 million in the Far East. This estimate, made in a study conducted in consultation with overseas representatives, the State Department and industry, assumes that 75 per cent of the expenditures by these countries would be spent in Europe or Japan. The remaining 25 per cent of friendly nations' spending might go to the U. S. through direct sales, licensing and cooperative production arrangements.

The Nitze estimate is that military products can account for exports ranging from $1 to $1.5 billion each year through 1971, including 40 per cent for ground forces, 35 per cent to air forces and 25 per cent for naval forces. The aerospace industry should be able to participate "significantly" in the potential military export market, Mr. Nitze believes.

AIA and industry officials most concerned with exports are convinced the full potential can be achieved if:

(1) The Treasury, State, Defense, Export-Import Bank and Foreign Credit Insurance Association agencies make certain that credit and political risk guarantees are issued to commercial banks to finance military exports.

(2) The Treasury, State and Defense Departments work to expand Export-Import Bank policies to include the financing of aerospace exports.

(3) The Defense Department establishes a rotating fund to finance aerospace exports directly.

(4) Tax policies are modified to provide incentives for export expansion.

NEW FLIGHT PATTERNS

General aviation, which includes all flying with the exception of the military and commercial air carriers, today is preparing for its period of greatest growth.

Although general aviation has continued to grow at a steady rate to become a prominent factor in air transportation, it has served primarily only those people who want to fly. Now it is serving those who *need to travel.* True, those who want to fly have found profit and productivity as well as pleasure. But until recent years the need to travel extensively, to travel rapidly, and to travel to diverse locations was not extensive.

Twenty years ago only one out of ten new industrial plants was constructed in non-metropolitan centers. By 1961 this was reversed and eight out of ten new plants are built in non-metropolitan areas. This decentralization creates complex business travel patterns, and causes the need for increased usage of the general aviation airplane.

Where formerly only a crosstown drive was needed for family visits, today increasing numbers find the trip stretching across the state or across the country. Where business travel was concentrated in a few large commercial and industrial cities, it now reaches into towns and villages.

While this churning has been going on, creating the need to travel, the means has been becoming more difficult. The tremendous advances made in the design of commercial airliners have resulted in long-range airplanes carrying more people greater distances. Accustomed to the swiftness and dependability of scheduled air transportation from one metropolitan center to another, increasing numbers of individuals now are turning to general aviation for the same swift, dependable transportation from one non-metropolitan center

to another non-metropolitan center and from small towns to hub commercial and industrial cities.

As more individuals begin to use the private airplane for personal travel, they are finding thoroughly proven, advanced vehicles. Probably no other instrument of public convenience had been so far advanced by the time it was accepted in large numbers by the public. Certainly the automobile was still in the crank-starting, isinglass curtain stage when there were millions more autos than there now are airplanes.

With the physical equipment advanced to the stage of readiness for the "traveler" as well as the "flyer", manufacturers now are turning increased attention to the surrounding conditions which can provide orderly growth.

The three broad areas which will directly affect the inevitable growth of general aviation are airports, airspace, and air pilots.

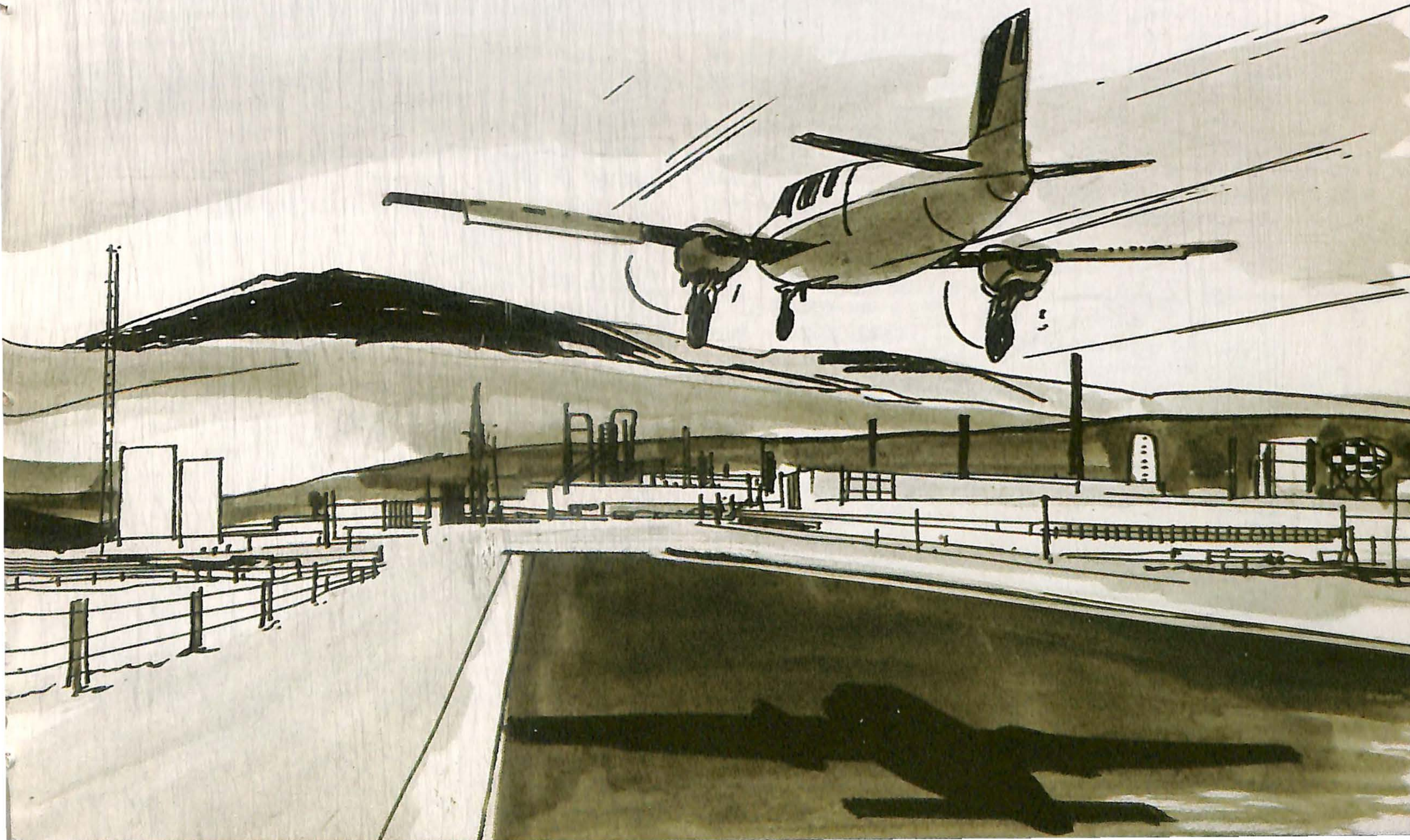
There must be adequate ground facilities at either end of the route an airplane travels. The airspace in which the airplane moves must be managed properly. The pilots must be adequately trained and licensed for the individuals' needs to fly in today's aircraft and environment.

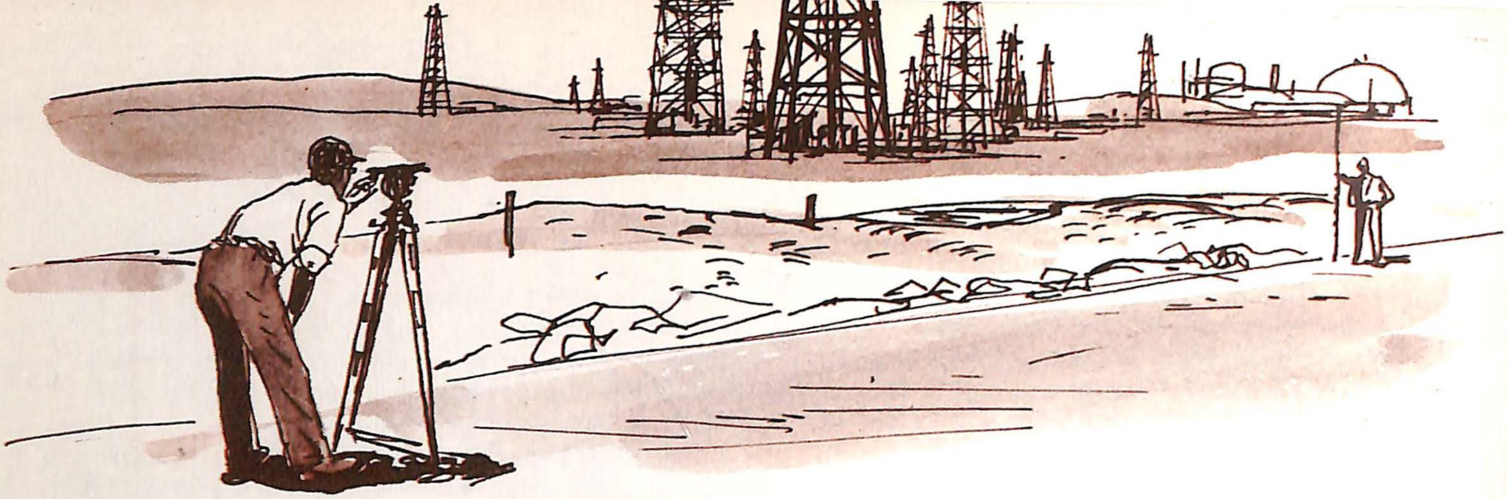
Early in 1963 the manufacturers of general aviation aircraft and engines set up committees within the Utility Airplane Council of the Aerospace Industries Association to investigate the problems of these areas and to develop specific action.

The subcommittee on airport development is attacking one of the basic retardants to general aviation — inadequate and unavailable airports. While there are more than 8,000 airports into which most of general aviation airplanes operate, these ground facilities are disappearing at an alarming rate in and near large cities. In addition, many small and medium size cities do not have even the minimum needs for air accessibility.

Critical areas are developing, such as Southern California, where airports are fast reaching capacity, both from the amount of traffic handled and the land area available for airplane parking. Thousands of medium and small towns either do not accept the airport as a community asset or do accept it but tax it on a high rate basis.

Aware that the lack of understanding of the airport's overall importance to a community underlies the apathy toward airports, the UAC Airport Development Com-





mittee is researching the economic impact which general aviation has on entire communities. Scores of examples are developing.

A small Southern community which did not have an airport invested $150,000 to construct landing facilities for a single airplane and the local citizens recognize it as the best investment the town ever made. The airport was built because a corporation, which wanted to locate a new plant in the city, operates its own airplane as a business tool and considers it essential to productive, economic business management.

With construction of the airport, the plant site was agreed upon and an operation employing 300 persons was started. Retail sales in the community have increased more than $1,000,000 a year, benefiting every individual in the area.

At the other extreme, a metropolitan complex like greater New York can trace specific community-wide benefits from general aviation facilities. In the past five years, the Long Island community of Islip calculates that 160 new retail establishments have come into being to support the people working at jobs which the proximity of MacArthur Airport brought to the area.

Across the Hudson, a New Jersey community questioned firms employing 86 per cent of all industrial workers in the county. The objective was to determine whether the local airport should be expanded or closed. Approximately one-third of the firms responded that development of a modern airport facility would be an inducement to remain and to expand. Only 24 per cent of the companies operate their own aircraft but 62.6 per cent of the firms commented on the advantage of a good airport for their customer and supplier convenience.

With this type of concrete documentation of general aviation's economic importance, the UAC Airport Development Committee will aim education programs at all levels of community life.

"Until the public recognizes that the airport is as vital to a community's economic bloodstream as is its streets, highways, docks, or tracks," says J. W. Miller, Director of Marketing, Piper Aircraft Corporation and Chairman of the Airport Development Committee, "until this happens it will be overtaxed, under supported, and sought after by every real estate developer in sight."

The project of the Committee is to develop data and to disseminate it so that communities will be aware that every time they plow up a runway, part of the economic future is plowed under with it.

Coinciding with the need for a place to land and a place to take off, is the need for practical mobility in the airspace. This is another area of great interest of Utility Airplane Council members.

"It is an area which needs much study before specific recommendations and actions can be taken," states John Ferris, Vice President of Marketing, Lycoming Division of Avco, who is now Chairman of the Education Committee and of the Airspace Usage Sub-Committee.

Although the UAC still is studying ways to reach the solution, the problem and objective are clear: regulations which permit the greatest utilization of all airspace for the greatest number with maximum safety.

The partnership which is developing between scheduled airlines and general aviation points up the need for joint use of all facilities on an equitable basis.

One example of this partnership was shown when airline operations moved out of Midway Airport at Chicago. With airline traffic transferred to O'Hare, Midway became basically a general aviation airport, yet general aviation flights into Midway dropped 46 per cent. Obviously much of general aviation's traffic was geared to making passenger connections with long-range airliners.

Last year the Federal Aviation Agency estimated general aviation operations outnumber the airlines by some 3½ million movements at the 274 airports where there are control towers. Within four years this is expected to nearly double to more than six million.

Facing this pattern of growth the manufacturing companies through joint efforts are seeking rules of the air which recognize this important position general aviation plays in the total transportation complex.

Adequate airports and practical procedures of the air can be only so useful as the men and women who pilot airplanes make them. A third committee of the Utility Airplane Council is delving into the rules and regulations currently surrounding the licensing privileges and the needs and methods of training.

Today's airplane is vastly different from those built several years ago, and today's flying needs differ from those of ten and twenty years ago. But most of the requirements for receiving the privilege of operating an airplane have developed through evolution over the years.

Individual needs differ, too. A rancher who uses his airplane from the level strip in back of his barn and flies only over his ranch or to a neighboring strip has knowledge and skill requirements vastly different from the salesman who operates his own airplane into and out of large hub-city airports.

Yet today each of these pilots is required to demonstrate the same level of skill, the same depth of knowledge, in order to receive his license. Greater flexibility is needed.

Rather than force pilots to conform to a rigid licensing structure, the Pilot Rating Requirements Committee is seeking to develop a structure which would permit qualifying for operating privileges more realistically tied to the needs of the pilot, the equipment he is flying and the degree of competency he has acquired.

Frank Martin, Vice President - Marketing, Cessna Aircraft Corporation, who is Chairman of this Committee, is seeking to determine what is required to be a thoretically perfect pilot in today's state of the art and then work backwards through the multitude of progressive stages to the student pilot.

While these three committees are dealing with the basic problems of the environment in which general aviation is to serve the needs of the many, another group is developing a program of public information to create a more favorable attitude of acceptance for this service.

Much confusion exists today as to what aviation really is. In the minds of most people it is joy rides, jets, and Jupiter and Mars. Through a committee headed by R. M. Tinney, Midwestern Sales Manager, Continental Motors, definite directions of public education are taking shape aimed at projecting a more accurate picture. This, like the other sub-committees, is drawing on the experience and talents of individuals outside the immediate companies associated with the Council.

As examples, the Pilot Rating Requirements Committee has representation from the National Safety Council, state aeronautics officials, university educators and observers from the Federal Aviation Agency. This cross section is sought both to benefit from the special skills and knowledge of the participants and to assure an objective approach to the solutions.

More than a dozen meetings have been held by the collective committees since their formation last summer. Although working independently, their activities are coordinated by the AIA Utilitity Airplane Council Manager. Activities are meshing, but not overlapping.

When the committees were formed, C. J. Reese, President of Continental Motors and the then Chairman of the Council, stated their objectives in this way: "We will strive to provide leadership in the study, the preparation of tools and the dissemination of information which may be used by all segments of aviation so that the value of general aviation can be fully understood, thus enabling it to be of even greater benefit to individuals, business, communities, and the nation."

The benefits will be multiple. A need has been generated and an industry is geared to fulfill that need. William T. Piper, Jr., Executive Vice President of Piper Aircraft and the current Chairman of the Utility Airplane Council, sums up general aviation's accelerated growth potential in seven reasons:

1. Modern industry, with diversified plants, needs the fast, flexible transportation of the privately owned airplane.
2. Scheduled air transportation is being concentrated more and more between larger cities.
3. Available rail transportation is dwindling.
4. Airport facilities — more than 8,000 available — let the private and business pilot go by air to almost any point he may wish on his own schedule.
5. Pleasure flying is increasing rapidly as Americans find they have more time and money for recreation.
6. Technological improvement in the aircraft, instruments, navigation and communication equipment has greatly increased the utility of the private airplane.
7. Ground facilities, navigation aids and services have been greatly improved and expanded.

Indicative of the need for the Council's current programs for developing growth guidelines is the potential which will be realized. There are 9,790 incorporated and unincorporated communities in the United States with a population of 1,000 or more. Last year a strong and growing general aviation industry produced 7,569 airplanes — less than one airplane for each community.

The growth potential is there, and general aviation is moving aggressively.

APT

Manufacturing By the Numbers

APT PART PROGRAM SYMBOLIC DATA

PART NO. 1763-5A PROGRAMMER C. DRAXTON DATE 7/10/62 PAGE 1 OF 7 JOB NO. 103732

SYMBOL		INSTRUCTIONS	SEQ. NO.
PARTNØ		-1763-5A MØUNTING BRACKET	1763-010
		MACHIN/BENDIX, 1	1763-020
		TMARK/1	1763-030
		CUTTER/.750, .125 $$ USE 3/4 E.M. -1/8 CØRNER RADIUS	1763-040
PTX	=	PØINT/0, 1, .1	1763-050
C1	=	CIRCLE/CENTER, PTX, RADIUS, (1.373/2)	1763-060
SP	=	PØINT/-3, 5, 0	1763-070
L1	=	LINE/(P1 = PØINT/3, 7), LEFT, TANTØ, C1	1763-080
		FRØM/SP	1763-090
		INDIRV/1, 0, 0	1763-100
		GØ/L1	1763-110
		TLRGT, GØRGT/L1, TANTØ, C1	1763-120
L2	=	LINE/PTX, PERPTØ, L1	1763-130
		TLØN, GØLFT, /L2, ØN, C1	1763-140

Metalworking manufacturing, changed drastically by use of numerically controlled machine tools, has been given new and versatile opportunities for efficiency through the lead of aerospace companies in their development of Automatically Programmed Tools (APT).

APT has made possible full exploitation of these tools in practice. The solid base provided by APT will be built upon for years to come as this revolution in manufacturing is realized.

APT is a means for efficient and accurate communication between humans and numerically controlled machine tools. A general-purpose digital computer translates simple English language statements describing a part to be cut into punched tape instructions for the machine tool. This technique saves money, shortens lead time from design to production, and introduces new standards of flexibility, reliability, and growth potential.

Interest in APT in Western Europe is considerable since the mature state of computer and machine tool technology is such that its need has become evident. With the approval of U. S. participants, and the U. S. Government, IIT Research Institute this year is offering participation internationally to companies and government agencies in friendly foreign countries.

The significance of this move cannot be overstated. It could establish a single world-wide standard. There would be none of the conflict, for example, that exists between the metric and the English systems of measures and weights.

The main advantage provided by APT in the evolution of machine tool control is that it supplants numerical control with symbolic control. The APT language contains over 250 word-symbols through which instructions are given to a computer. Since the APT system uses a language rather than signals, the programmer can communicate with his machine tool much in the same way he communicates with his fellow workers.

The computer serves as a translator, changing the word-symbols given to it by the programmer into numerical signal commands. Each word-symbol causes the computer to punch into the tape as many numerical signal commands as are required to carry out the action

APT *VS* MANUAL PROGRAMMING					
Item	Part Programming		Computer Time	Net Savings	Lead Time Savings
	APT	Manual			
	Actual Hours	Estimated Hours			
Large Fuselage Bulkhead Contour Milling	838	3500	2 hrs. 40 mins.	$22,811	6.6 weeks
Solid Rocket AFT-Head Contour Turning	36	148	3.3 mins.	$1,209	14 days
Hoglund Contour Wheel Dressing Cam	12	2400	2.8 mins.	$9,500	435 days
AFT Dome of Rocket Fuel Tank Contour Milling	12	2400	90 mins.	$5,953	13 weeks
Stabilizer Rib Contour Milling	300	1200	30 mins.	$7,200	60 days
Ramp — Forward Duct Drilling	10 (4 versions)	240 (4 versions)	12 mins.	$1,300	35 days
Missile Panel — Special Case 5-Axis Contour Milling	2.8	44	2 mins.	40 hrs.	5 days

described by the programmer. Then the punched tape is fed into the controller of the tool.

The most significant advantages of APT use become evident when the processes leading to preparation of a tape for an automatic tool are considered. With manual programming, a plan of calculation must be made and then executed using a desk calculator prior to having the tape punched. With APT, the plan becomes essentially the part program and great power of the digital computer for calculation is drawn upon for execution.

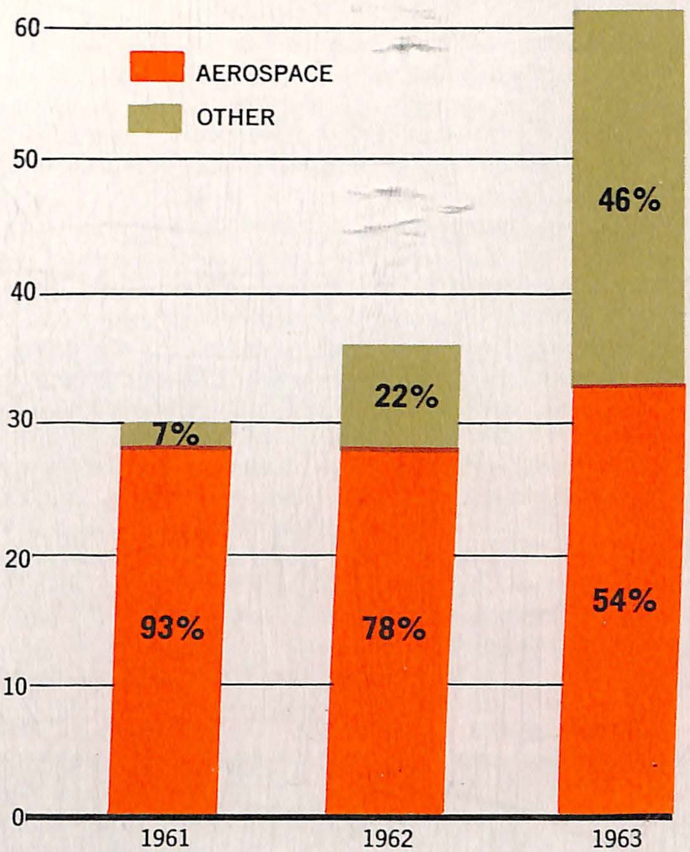
Preparation of the part program can often become very difficult, especially when complex geometries are used to achieve optimum designs. The important advantage of the APT system is the aid given to the part programmer in preparing the plan. The flexibility inherent in the generality of APT expressions to describe similarities among series of shapes or various parts makes possible elimination of much of the redundant detail of manual part programming. Even simple parts can be programmed cheaper and faster in APT. Consideration of complex parts completely rules out manual programming and necessitates APT use.

Not only does APT save money and cut lead time on individual parts, but the net effect is a snowballing one when APT is use as a standard in a plant. The total savings in time and money are often remarkable.

To make APT benefits available to all industry, IIT Research Institute has expanded participation in the program for each of the years the APT program has been conducted. The number of participating organizations was 36 in 1962, 61 in 1963, and over 80 are expected for 1964. In addition, industries other than aerospace have participated thus giving the spread to non-aerospace applications desired by the AIA in setting up the program. Of the 61 installations served in 1963, the breakdown by industry was:

33 Aerospace installations
10 Machine tool and control builders
6 Atomic energy installations
3 Automotive manufacturers
2 Computer manufacturers
2 Computer service bureaus
5 Miscellaneous manufacturing facilities

APT PARTICIPANTS
Installations Served



The APT system reliability has been greatly improved since 1962 and today it is a regular production system in many plants. It is, however, still being expanded to meet future requirements, and services are being broadened under the program to meet the wide range of interests of new and experienced participants. Benefits of participation include training, consulting, basic documents and updating service, special reports on development and research tasks, and system tapes and cards.

There are two levels of participation in the APT Long Range Program: full and associate. Both plans provide a set of services and materials for current operations as well as an opportunity to invest in the future growth and increased usefulness of the APT system. The associate plan is predicated on the assumption that smaller companies have needs which can be fulfilled with less than the full APT capability. Accordingly, the cost of associate participation is less and the services and materials are more limited.

Numerical control was designed for use with machine tools, and the APT system is presently programmed for the same use. These tools are generally used for metal cutting or removal. However, a number of devices have been developed to operate under numerical control to which APT methods can be applied — material application (filament winding); material transfer or positioning (assembly); and material forming (tube bending) are possibilities.

Numerically controlled drafting machines which will produce accurate engineering drawings from an APT tape now make it possible for a designer of machine parts to describe a new design mathematically, communicate this description through APT's symbolic language to a computer, and end up with a prototype of the part, although it has never been blueprinted. This is a great saving of time and money and reduction of human error.

In many designs, only a certain portion of the design is critical or new, while the remainder is routine and often passed along to be worked out and blueprinted. Under future symbolic control, the designer might specify only the newly conceived portion of the design; the routine part would be completed by computer.

Symbolic control finally makes it practical to fully exploit the so-called universal machine or machining center — one which may have multiple axes of motion as well as multiple functions — such as milling, drilling, boring, tool changing, and pallet changing. The versatility, cost-cutting, a greater proportion of actual metal cutting time, and the saving of floor space possible through these machines now in use are only possible in the long run by APT methods.

Future APT applications to engineering and design will steadly increase and begin to narrow the gap between design concept and finished product. The power of expression which enables abstract relationships to be precisely defined gives a designer new tools by which he can cut across the traditional bottlenecks. Today's results only point to this, but many experienced APT users feel that the real payoff will come as APT (in advanced versions) become commonplace in engineering and design.

It is also germane when looking at the future to consider that APT today represents the single most important computer application in manufacturing. The future of APT will be inseparably woven with computer means for more automatic production. Today's system calculates approximate machining time when a part program is processed, but it is not much of a step forward to allow batching of a set of part programs and to schedule a set of machines automatically. Production management of this sort must be computer-based in order to arrive at optimum allocation of facilities and materials. APT provides a framework for much future development toward automatic production.

The current advanced state of APT development has been due in large measure to the continuing team effort of the APT Long Range Program as conceived by the Aerospace Industries Association three years ago and directed by IIT Research Institute. Much work and planning contributed to this successful state and it is noteworthy to review the various developments which led to the present.

In 1952, at MIT's Electronic Systems Laboratory, the first numerically controlled milling machine was demonstrated after several years of Air Force sponsored research and development. To enhance use of such a machine, MIT embarked on computer program developments which led in 1955 to a prototype APT system for the Whirlwind computer. This rudimentary version required the part programmer to specify end points of each straight line cut to be performed by the tool. Under further Air Force sponsorship, MIT continued APT system development which included a completed APT I system in 1956 and a design for a more advanced APT II system in 1957.

AIA member companies in 1957 started installing numerically controlled machines, and these companies selected the MIT designed APT II as the basis for development of a computer program for the IBM 704 — then the standard computer for engineering and scientific calculations in the aerospace industry. Released for field testing in 1958, the APT II system relieved the programmer of the responsibility of computing successive cutter locations and enabled him to describe the curve in a language resembling common English. This was the beginning of the APT language as we know it today.

Coordinated use of the APT II system was assured by an industry committee appointed by the AIA as the system was tested and improved through use.

By 1960, it was apparent to AIA companies using APT II that a completely new system was necessary if future expansion of APT capability was to be efficiently carried out. To compress development time on this new system, APT III, into as short a time as possible, in January 1961, AIA established an APT central project at San Diego, Calif., in which twenty aerospace companies supplied outstanding technical talent to program APT III for the IBM 7090 computer. This program was completed on schedule in December 1961 and represented a significant achievement of technical cooperation of AIA members toward a common goal which benefited all.

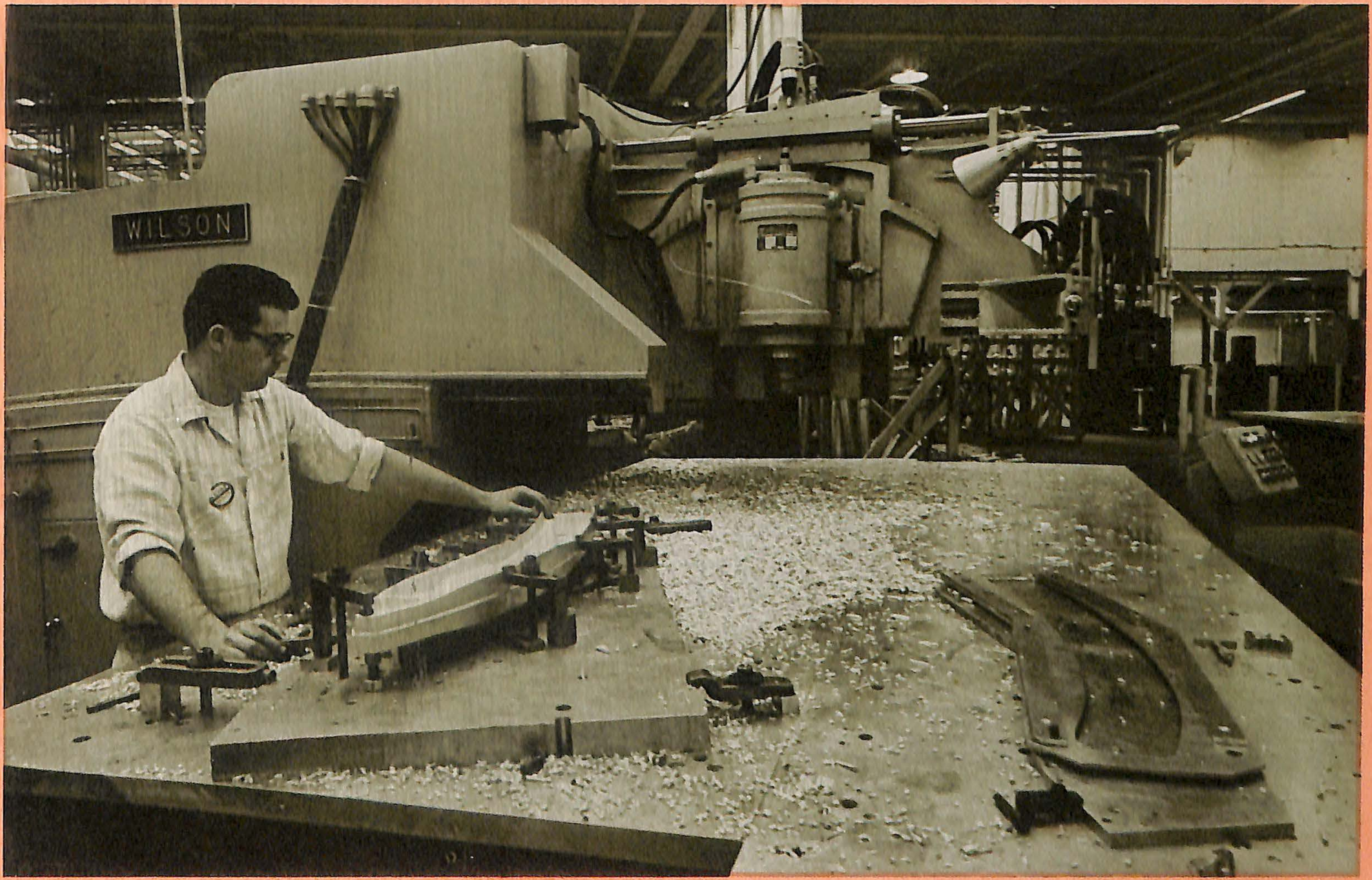
Early in 1961, AIA had realized that on completion of the programming of APT III, the work of maintaining and expanding the system would only begin. The importance of APT methods to aerospace manufacturing and to U. S. industry generally was such that AIA decided to select, on a competitive basis, an independent organization to be responsible for the future development of APT after completion of the central project. IIT Research Institute (then called Armour Research Foundation) was selected to conduct, manage, and maintain the APT Long Range Program which commenced on January 1, 1962.

Corporations and government agencies have, since that date, participated in the APT Long Range Program by paying an annual fee to IIT Research Institute in return for the various services and developments provided under the program.

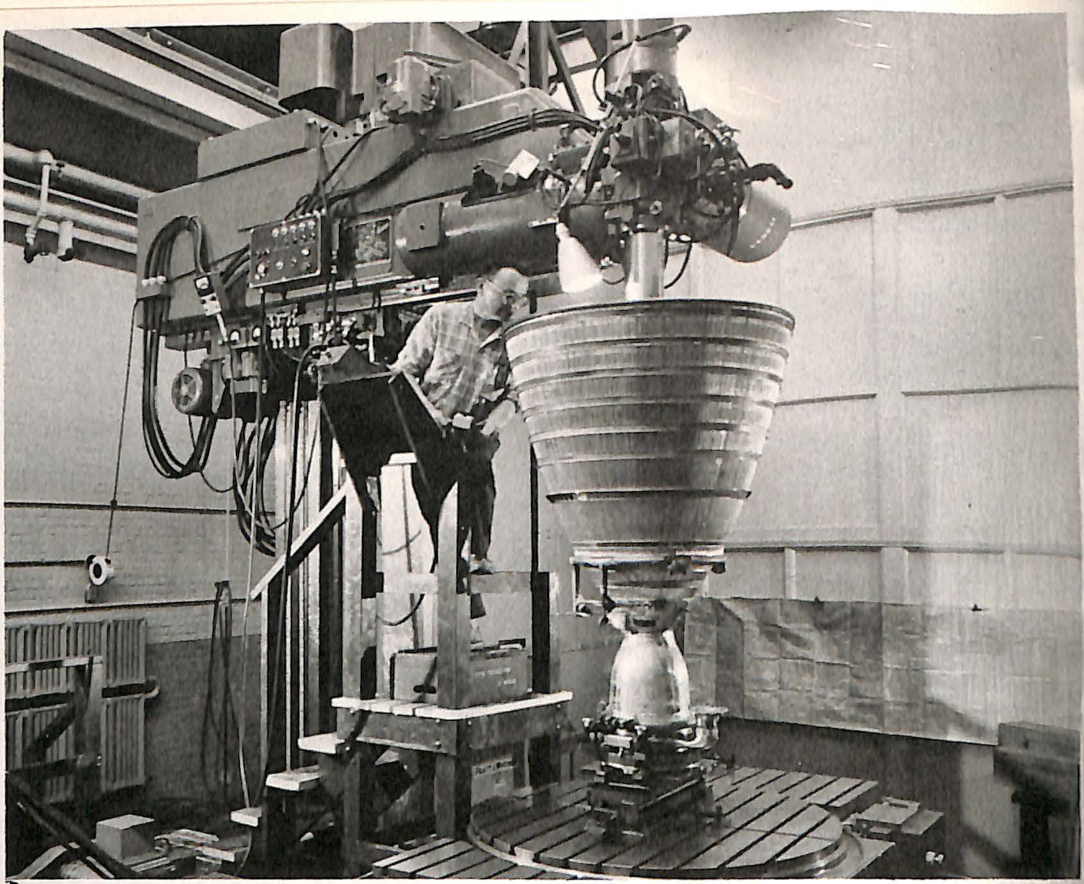
Many companies are now using APT and many are beginning to use it. As the most powerful system for programming numerically controlled tools, it will be put to more demanding uses in many new areas of application, but it is not a static system — it will be continually extended to handle new applications under the APT Long Range Program. This revolutionary technology will have a significant impact on changing our manufacturing and engineering methods to achieve more efficient and cheaper products.

Science and Manufacturing-Tools Bridge the Gap

Manufacturing techniques of the aerospace industry today are promptly taking advantage of the torrent of progress from scientific laboratories. A discovery may be promising or significant, but if it cannot be translated into a useful object its potential is unrealized. One area of meaningful accomplishment in the aerospace industry is largely unknown. This is tooling — techniques as well as machines — that produces the miraculous systems for national defense and space exploration. Equipment today can understand and execute commands. An article on Page 16 on Automatically Programmed Tools explains this process. APT is a remarkable achievement. Some parts for a rocket engine, for example, could not have been manufactured without the numerical control technique. This photo story cannot adequately convey the tremendous efforts in such fields as explosive forming, chemical milling, electron beam welding and magnetic forming. These are being used today or are in development stage. But they still retain, in some cases, the outward appearance of the punch press and the manually operated router. They lack the exotic configuration of the product which they build — the ICBM, the supersonic fighter, the satellite. But it is through these manufacturing techniques that the gap is closed between the advances made in aerospace scientific laboratories and industrial technology.



Science and Manufacturing—Tools Bridge the Gap



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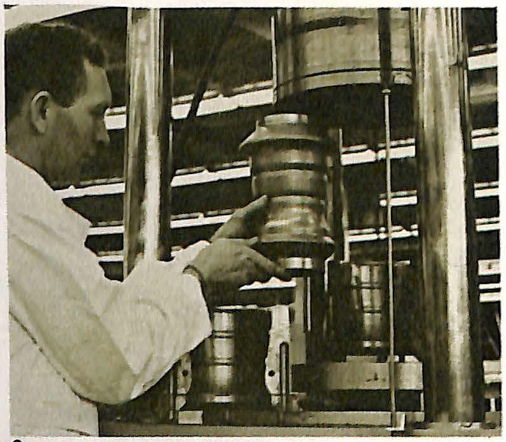

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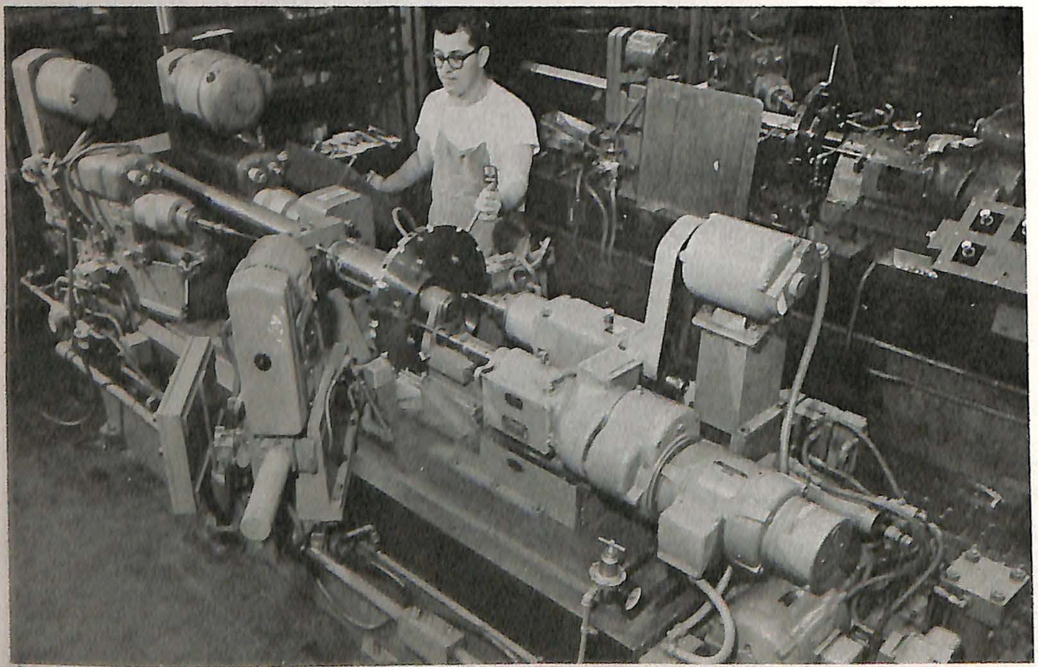
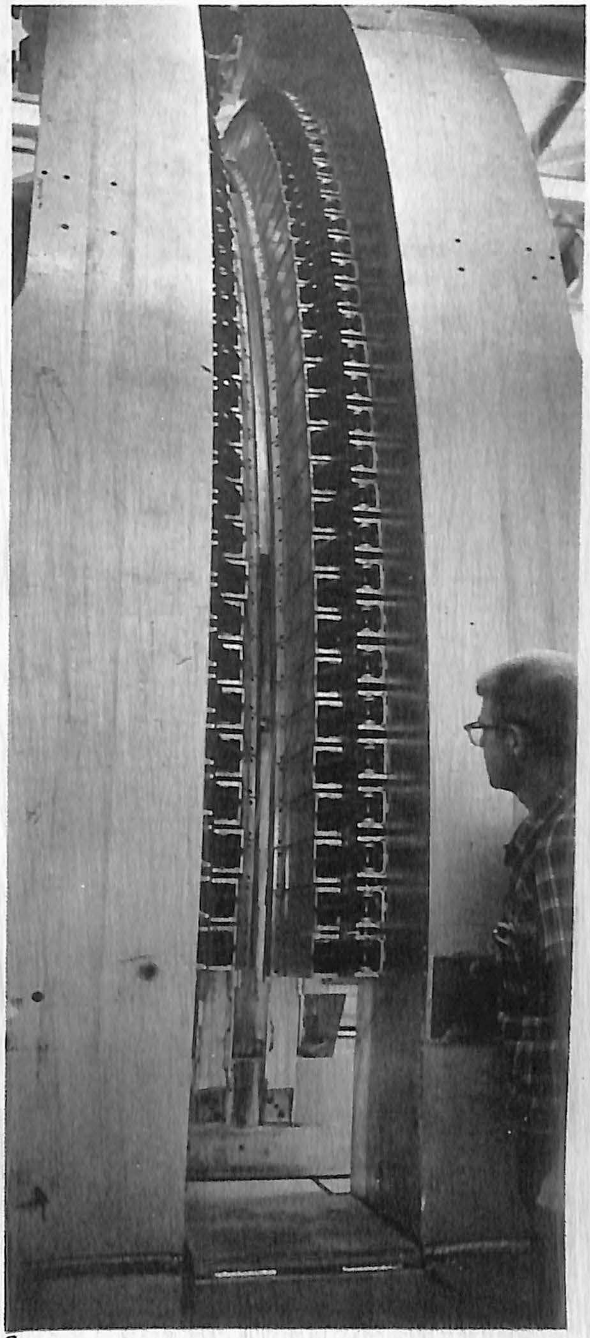


4

1. Explosive forming has proven a valuable technique for producing unique shapes. The controlled chemical explosions provide very high energy. Another feature is minimum cost.
2. Numerically-controlled jig borer has been converted to an inspection tool for a rocket thrust chamber. The machine accurately measures the inner contours of the chamber which are recorded for comparison with the master print.
3. Axial-load bulge forming is used to produce parts for a turbine engine. Machine forces extra metal into the die which prevents stretching or weakening at the deepest contours.
4. This machine is capable of drilling, reaming and boring 44 holes for a jet engine shaft with great precision.
5. This rugged fixture is required to hold the bulkhead segments of the huge Saturn rocket in position for meridian welding.
6. Mockups are shown of the enormous sections required for the Saturn rocket.
7. This die (note size in comparison with men standing in background) is used in bulge-forming of Saturn segments. Some of the metal sheets used measure nearly 200 square feet.
8. A spool of tape controls this gigantic machine. Each of the seven cutting heads shown is automatically positioned to perform in turn its operation.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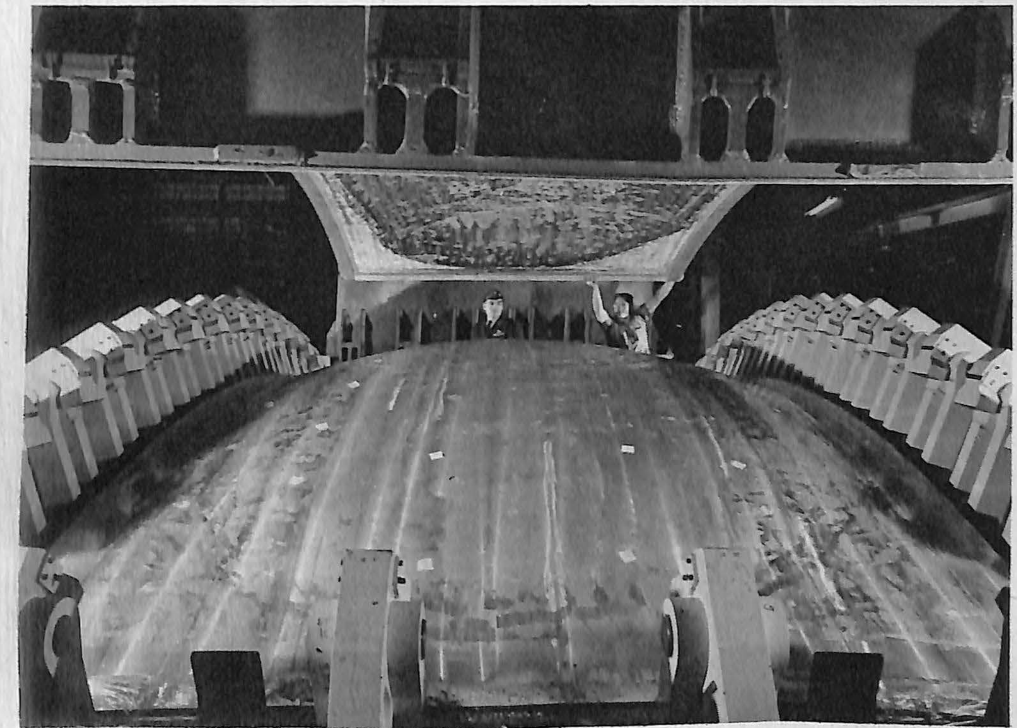
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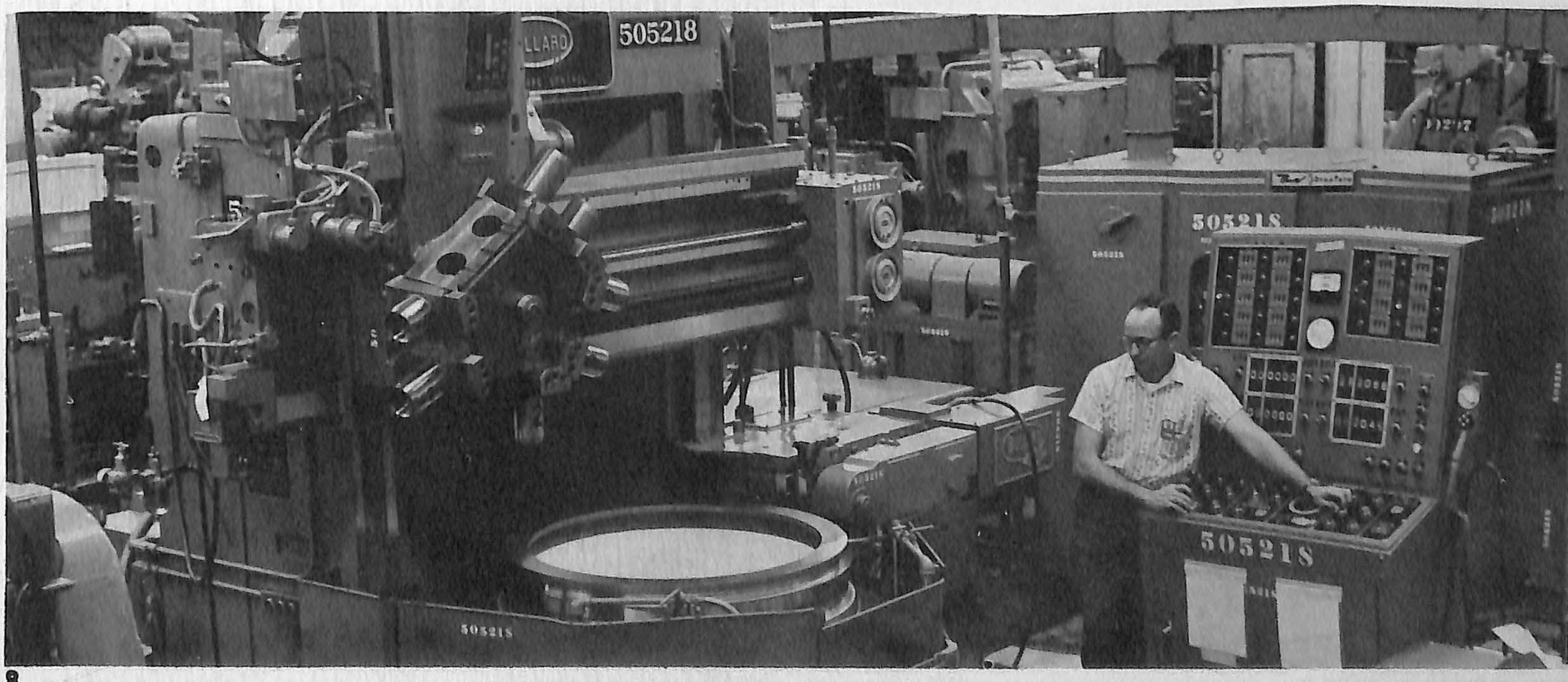

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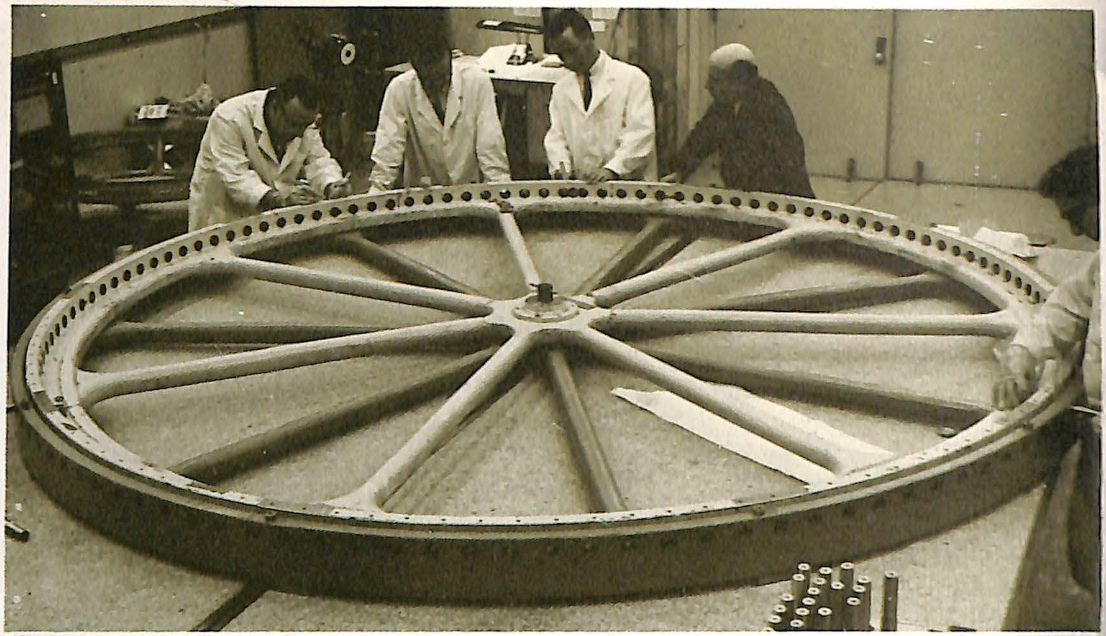
Science and Manufacturing— Tools Bridge the Gap



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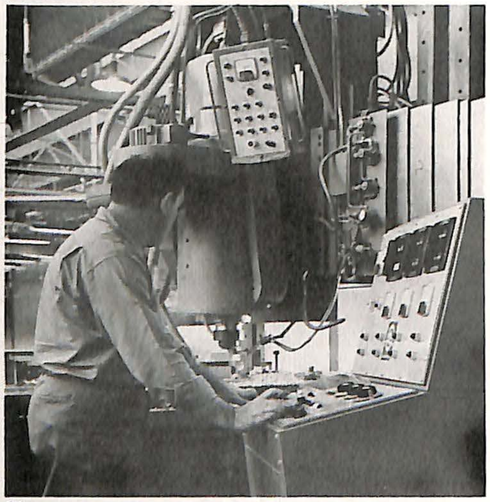

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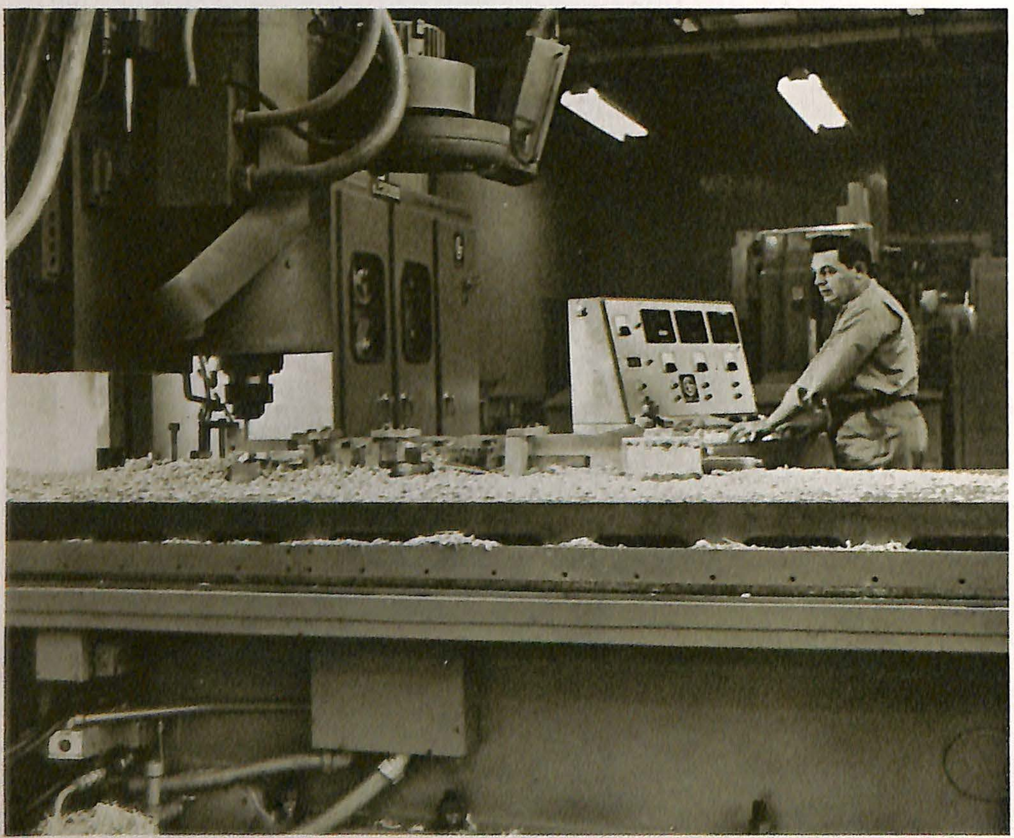
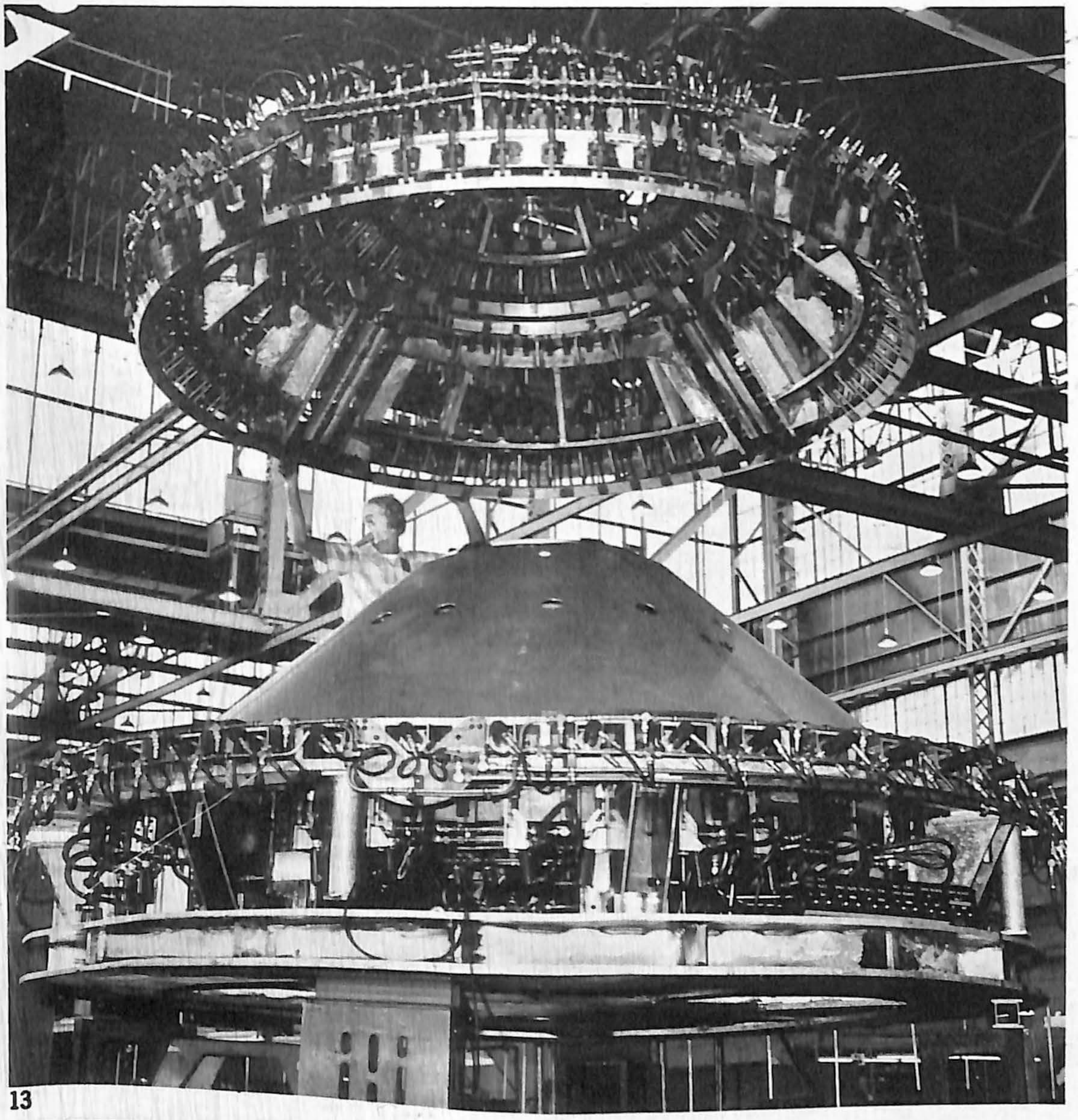


9. Hoist is used in chemical milling to lower a waffle-grid aluminum part into an etch bath. This method is used for taper-edging parts. Chemical milling is one of the advanced techniques used by the aerospace industry.
10. Master check pin, with a .99975-inch diameter, is inserted through a true 1.0000-inch hole to check the fit for Titan III rocket engine segments. The entire fabrication took place in a controlled environment area on a 10-ft. x 12-ft. granite surface plate which was situated on seismic mass. Laboratory conditions are used in much of the industry's operations.
11. Operator checks console of a point-to-point numerically-controlled profiler.
12. Entire machine used for profiling operation is shown here (see photo No. 11). Part being manufactured is a stringer fitting for the horizontal stabilizer of a new USAF transport.
13. Technicians guide i.,to place a specially designed fixture for welding an ICBM fuel tank. The tool — a cone weld fixture — makes possible rapid assembly, trimming and welding of the tank section. It is designed to trim four heavy gauge metal sheets and weld them to a hoop-frame on the bottom and a pre-formed assembly at the top. The welding fixture assures uniformity of the cone-shaped assembly throughout the entire welding and trimming operation.
14. A logging truck tie-down reduces manufacturing costs for jet airliner fuselage panels. The panels are shaped by stretch- presses pulling sheets of aluminum over convex dies. In order to prevent wrinkling on the dies, the sheets previously were held tightly against the dies with yokes made of metal and fiberglass. In this scene, yoke rubber belts are substituted. They are pulled tightly against the dies with chain tie-downs of the type used to secure logs.

12



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AIA MANUFACTURING MEMBERS

Aero Commander, Div.,
  Rockwell-Standard Corp.
Aerodex, Inc.
Aerojet-General Corporation
Aeronutronic Division, Philco Corporation
Aluminum Company of America
American Brake Shoe Company
Avco Corporation
Beech Aircraft Corporation
Bell Aerospace Corporation
The Bendix Corporation
The Boeing Company
Cessna Aircraft Company
Chandler Evans Corporation
Continental Motors Corporation
Cook Electric Company
Curtiss-Wright Corporation
Douglas Aircraft Company, Inc.
Fairchild Stratos Corporation
The Garrett Corporation
General Dynamics Corporation
General Electric Company
  Defense Electronics Division
  Flight Propulsion Division
General Laboratory Associates, Inc.
General Motors Corporation
  Allison Division
General Precision, Inc.
The B. F. Goodrich Company
Goodyear Aerospace Corporation
Grumman Aircraft Engineering Corp.
Gyrodyne Company of America, Inc.
Harvey Aluminum, Inc.
Hercules Powder Co.
Hiller Aircraft Co., Div. of ELTRA Corp.
Hughes Aircraft Co.
IBM Corporation
  Federal Systems Division
Kaiser Aerospace & Electronics
  Corporation
Kaman Aircraft Corporation
Kollsman Instrument Corporation
Lear Jet Corporation
Lear Siegler, Inc.
Ling-Temco-Vought, Inc.
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Martin Company
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  Company
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PneumoDynamics Corporation
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  Defense Electronic Products
Republic Aviation Corporation
Rohr Corporation
The Ryan Aeronautical Company
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  International Harvester Co.
Sperry Rand Corporation
  Sperry Gyroscope Company Division
  Sperry Phoenix Company Division
  Sperry Utah Company
  Vickers, Inc.
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  Sundstrand Corporation
Thiokol Chemical Corporation
Thompson Ramo Wooldridge Inc.
United Aircraft Corporation
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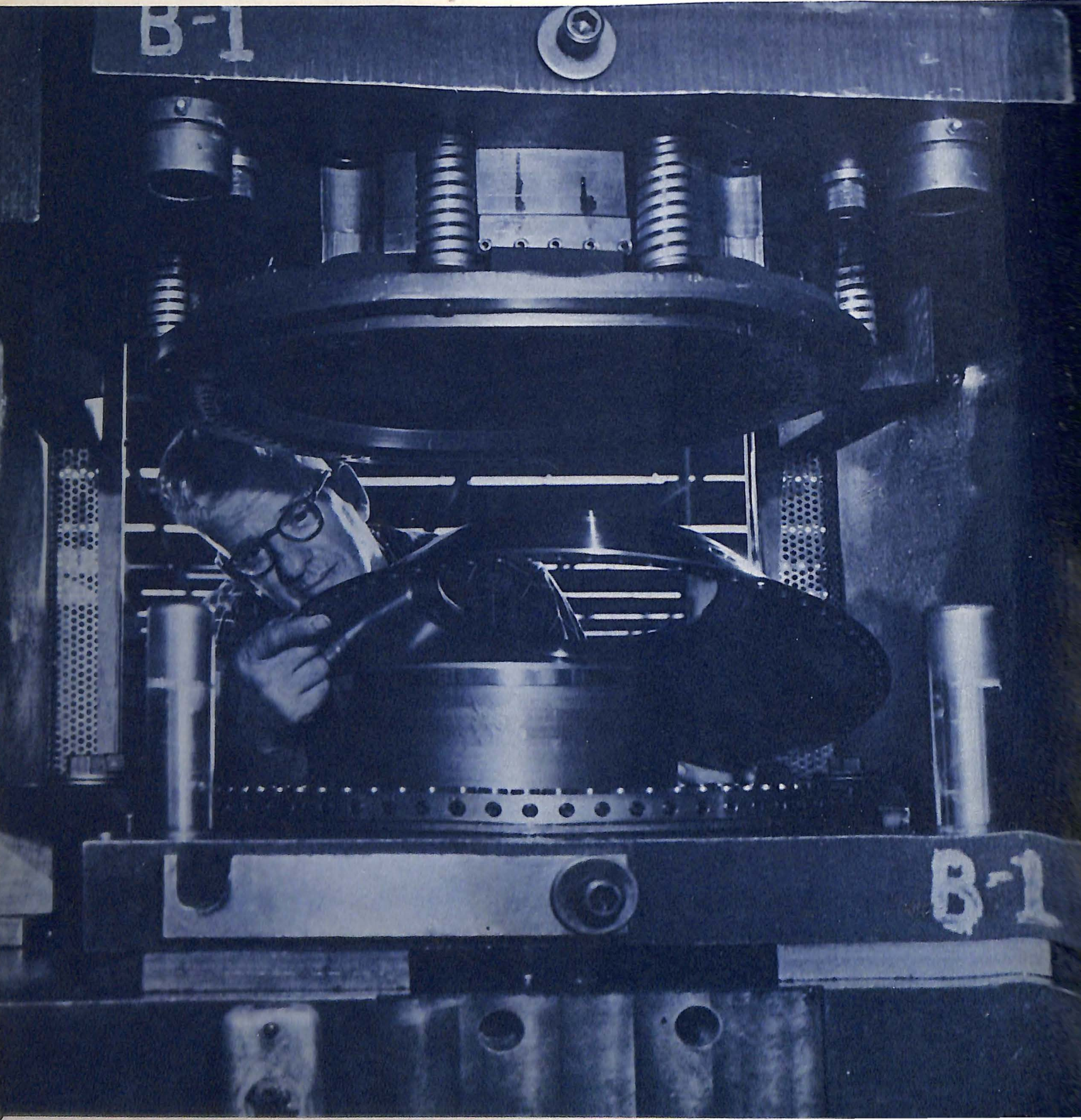

aerospace

SUMMER 1964

25 GIANT STEPS TO THE MOON

AIA

aerospace

Official Publication of the
Aerospace Industries Association of America, Inc.

VOL. 2 NO. 2 *SUMMER 1964*

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CONTENTS

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems;
Foster understanding of the aerospace industry's responsibilities in the space exploration program;
Foster understanding of commercial and general aviation as prime factors in domestic and international travel and trade.

AEROSPACE is published quarterly by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

Publication Office: 1725 De Sales Street, N.W., Washington, D. C. 20036

Los Angeles Office: 7660 Beverly Boulevard, Los Angeles 36, California.

Gemini/Apollo Management

By KARL G. HARR, JR.
President, Aerospace Industries Association

MR. HARR

The national goal of placing a man on the moon presents a management challenge certainly equalling and perhaps even exceeding the technological challenge. When the Gemini/Apollo program was announced by the National Aeronautics and Space Administration, relatively few doubts were raised that it could be done. Such a ready acceptance of the aerospace industry's technological capability to achieve the man-on-the-moon goal was impressive testimony to the past performance of this industry. It also made the decision to go ahead with the Gemini/Apollo program possible. The separate progressive steps of this program are recounted in an article, *25 Giant Steps To The Moon,* by James J. Haggerty, Jr., in this issue of *Aerospace*.

However, the major breakthrough had to be in management. The size and complexity of the Apollo management task almost defies description. The total program will involve 300,000 persons whose efforts must be directed, fully coordinated and welded to an extremely tight time schedule.

Thousands of events must occur at the right time in thousands of places, and many of such events involve research and development assignments for answers still to be found. A minor bottleneck in any one of these can halt progress in major segments of the program. Conversely, an unexpected advance in any one area of technology can cause an impact and require adjustments throughout hundreds of management interfaces.

NASA and its contractors together have developed and adopted management techniques which are at once efficient and flexible. The most important of these has been the development of the capability to identify rapidly problems at any level before they mushroom into situations that could seriously hinder over-all progress.

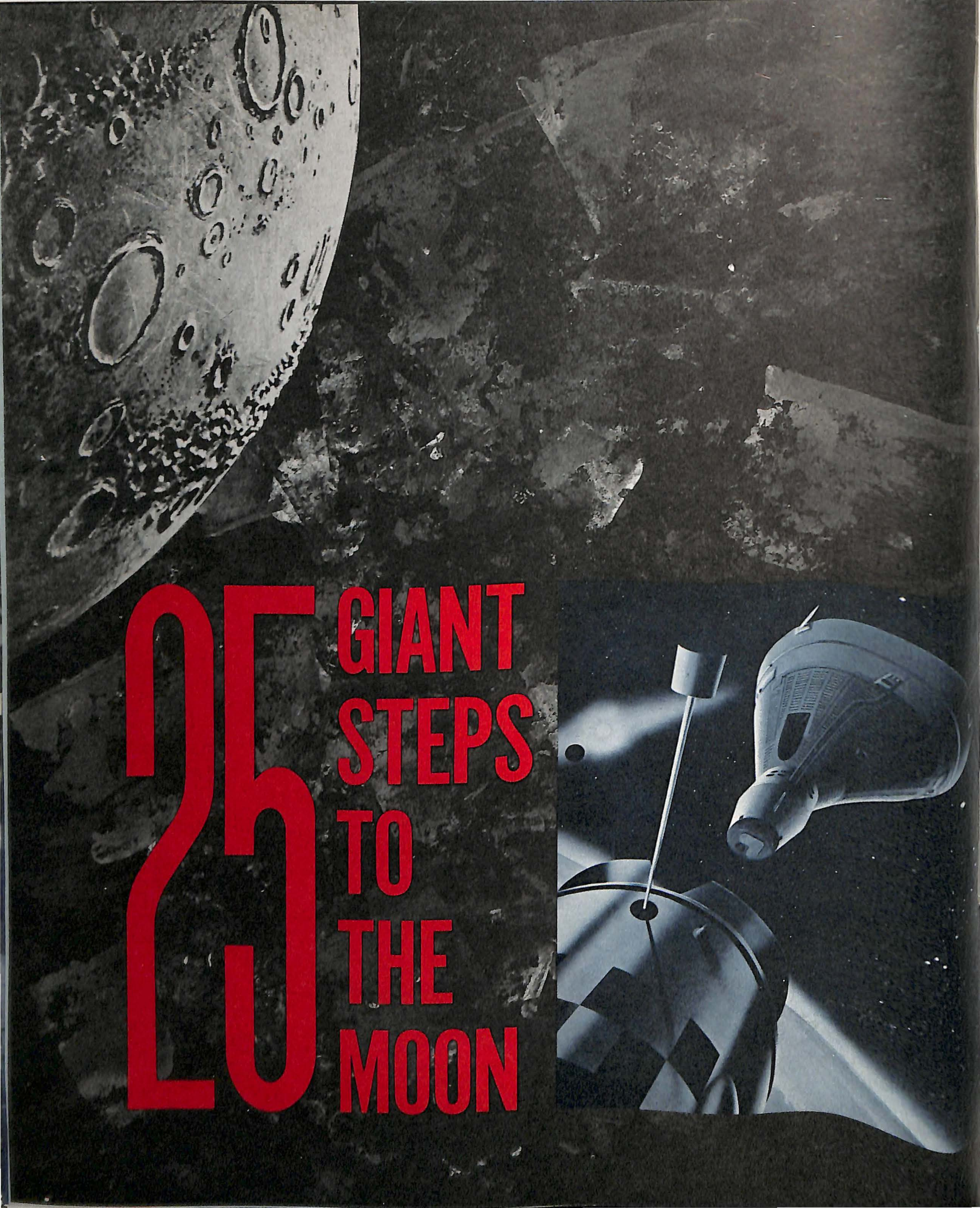
These techniques are applied through the basic management structure consisting of the Office of Manned Space Flight at NASA headquarters in Washington and the three Centers primarily concerned with Gemini/Apollo: the Manned Spacecraft Center (Houston, Texas); the Marshall Space Flight Center (Huntsville, Alabama); and the John F. Kennedy Space Center (Cape Kennedy, Florida).

Below this basic organization is the management structure of the contractors and subcontractors. Scheduling and review procedures within this framework are kept uniform and fully integrated. Scheduling depends upon technical progress, funding and manpower. The Centers and the contractors directly responsible to the Office of Manned Space Flight prepare their schedules by means of the analysis of reports from other contractors and subcontractors. The information thus obtained is then centralized for evaluation and decision in the Office of Manned Space Flight.

However, the scheduling procedures also provide current information on the status of hardware development and production at all levels for the use of management at any level. The complete system also is broken down organizationally into subsystems and the management at each subsystem level also has available current detailed knowledge of its subsystem's status.

Coordination of the direction of this mammoth and complex organization — comprised of both Government and industry — undoubtedly presents the most monumental managerial challenge ever faced by the Government-industry team. Geared solely to ensuring success when man is launched on his most ambitious voyage, it will stand as one of the true miracles of the conquest of space.

25 GIANT STEPS TO THE MOON



BY JAMES J. HAGGERTY, JR.
Associate Editor, Aerospace

Some time in the last part of this year, from Complex 19 at Cape Kennedy, a Titan II booster will hurl two astronauts into space in a single capsule. This will mark resumption of U. S. manned space flights after a hiatus of approximately 18 months.

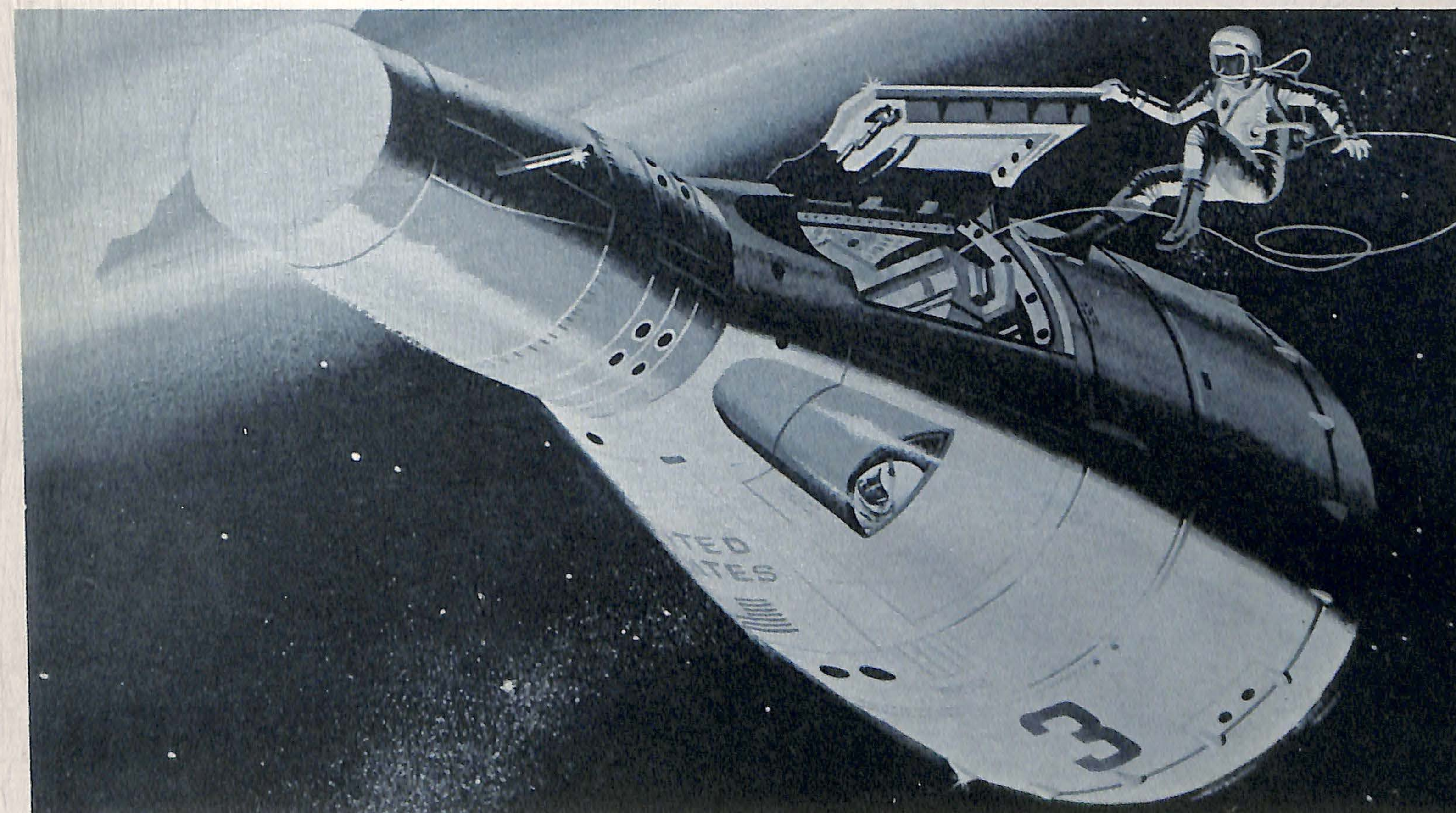
The two-man spacecraft is Gemini, bell-shaped like its Mercury predecessor but 20 per cent larger dimensionally and 50 per cent greater in volume. The Gemini project, covering 12 flights over a three-year period, is designed primarily to develop techniques for space rendezvous and long-duration manned flight experience.

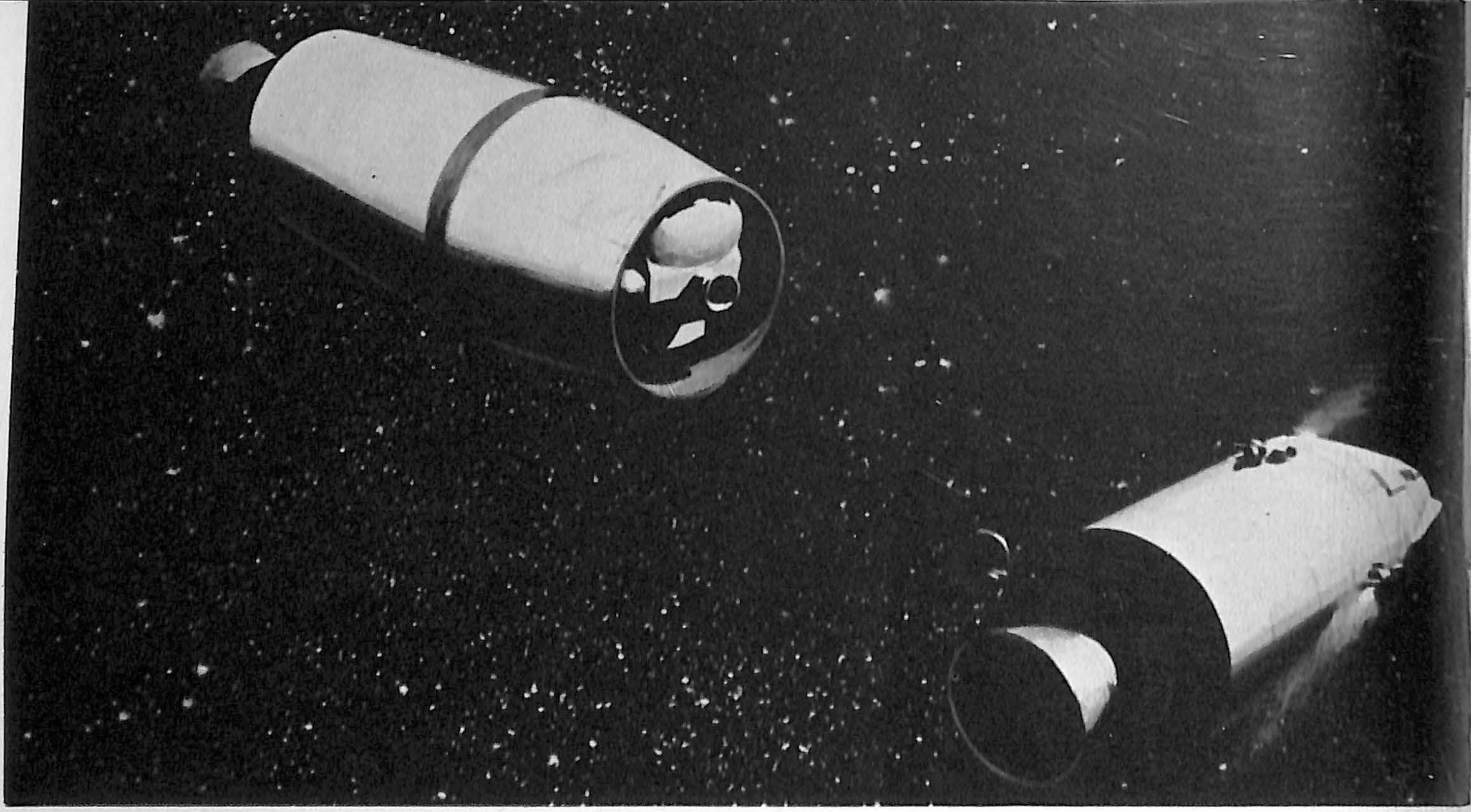
Gemini-Titan 3, as the initial two-man mission is known, will be the first of 25 major steps toward landing American astronauts on the moon. The *major* steps are the manned missions planned for the Gemini and Apollo programs. There will be a great many other steps: unmanned tests of both types of spacecraft and their launch vehicles; flights of the Ranger, Surveyor and Lunar Orbiter moon research craft to pave the way for man-landings; missions involving a number of other unmanned spacecraft which will provide scientific data of importance to the manned spacecraft projects. And, on the ground, there will be literally millions of "steps" — tests of individual parts, of subsystems formed by an assemblage of a number of parts, systems made up of several subsystems, and of the complete space vehicles in the most rigorous and comprehensive test program ever undertaken by the aerospace industry.

Under the overall supervision of the National Aeronautics and Space Administration, some 300,000 industrial personnel in more than 5,000 firms are engaged in work on the manned space flight program. Prime contractor for Gemini is McDonnell Aircraft Corp.; for Apollo, North American Aviation's Space and Information Systems Division.

The 25 steps are divided into three phases. The first phase is the Gemini program of 10 flights. The

Two-man Gemini spacecraft makes rendezvous with Agena vehicle (left). Astronaut leaves Gemini in order to carry out "extravehicular activity."





Apollo command and service modules start maneuver to dock nose-to-nose with lunar excursion module and S-IVB.

second phase is a series of eight earth-orbital flights of the Apollo spacecraft launched by the Saturn IB booster. In the third phase, Apollo will be mated with the Saturn V launch vehicle for six "dress rehearsals" of the lunar mission, and the seventh Saturn V launch will be the first lunar landing. Each of the three manned phases will be preceded by two unmanned tests of the launch vehicle/spacecraft combination.

Gemini has already completed the first of its two unmanned tests. On April 10, 1964, Titan II successfully orbited the spacecraft in a demonstration of launch vehicle performance, the compatibility of the launch vehicle with the spacecraft, and the efficiency of the tracking network.

Within the next three months, NASA will launch the second unmanned Gemini mission. This will be a suborbital flight, with parachute recovery of the capsule. It is designed as a complete check of all Gemini systems, with particular emphasis on the operation of the re-entry heat shield.

After that, at the rate of one mission every quarter-year, come the manned Gemini "steps."

The first manned Gemini flight will be a three-orbit mission. It will consist of medical experiments (which will be conducted on all flights), human control of the spacecraft in orbit, and controlled re-entry.

The next flight, Gemini-Titan 4, will be a long duration mission of up to four days in orbit at an altitude of 160 nautical miles. Primary purpose of this mission is an investigation of the effects on astronauts of extended periods of weightlessness, research which will also continue throughout the program.

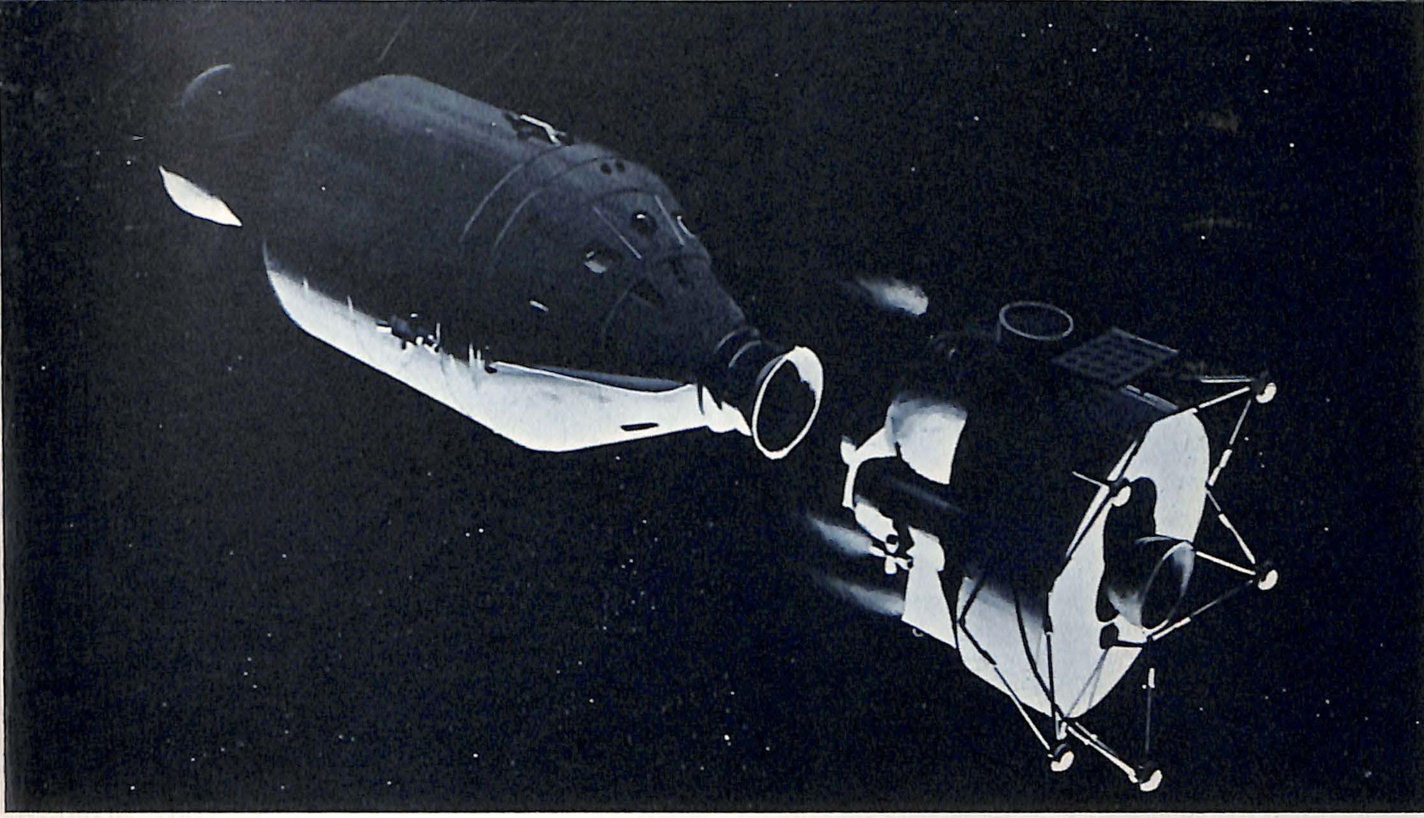
GT-5, which will take place about a year from now, will be another long duration mission, this one involving a full week in orbit. On this flight, it is tentatively planned to conduct the first experiment in "extravehicular activity," in which man will leave the spacecraft in a specially designed spacesuit. At a point in orbit, the astronaut will open his hatch, shove himself gently into space and float alongside the capsule, attached to it by a tether line. With no apparent motion although he is moving at close to 18,000 miles per hour, he will conduct simple experiments such as simulating spacecraft repair. This investigation will provide an initial assessment of man's ability to function independently of the protection afforded by the spacecraft, a requirement for exploration of the lunar surface.

On GT-6, NASA will attempt the first rendezvous mission. The ability to mate two spacecraft in orbit is essential not only to the lunar landing mission but to many foreseeable aspects of future space exploration, such as the resupply of a space station.

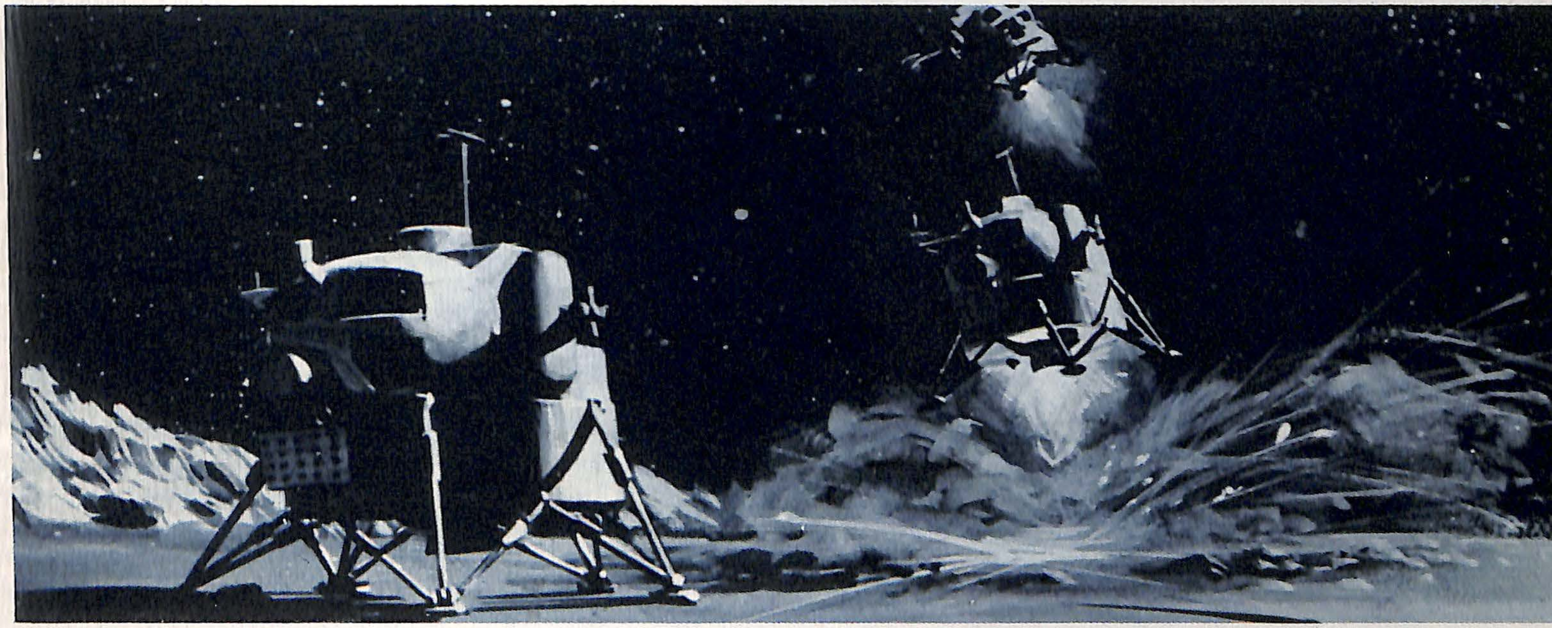
In the Gemini rendezvous mission, NASA will employ a "target vehicle," the Lockheed-built Agena D. A 25-foot-long craft normally used as an upper stage, Agena D has a 16,000-pound thrust re-startable rocket engine built by Bell Aerosystems Co.

Launched by an Atlas booster, Agena D will be sent into a circular orbit at an altitude of about 150 miles. Twenty-four hours later, Gemini will be launched into the same orbital plane, but into an elliptical orbit with a shorter "period," the time it takes to make one circuit of the earth. Thus, through a number of orbits, Gemini will gradually "catch up" with its target.

As the two spacecraft close to within 250 miles, Gemini will be guided to the target by a combination



After two astronauts climb into the lunar excursion module from the command module, the two modules detach in a lunar orbit.

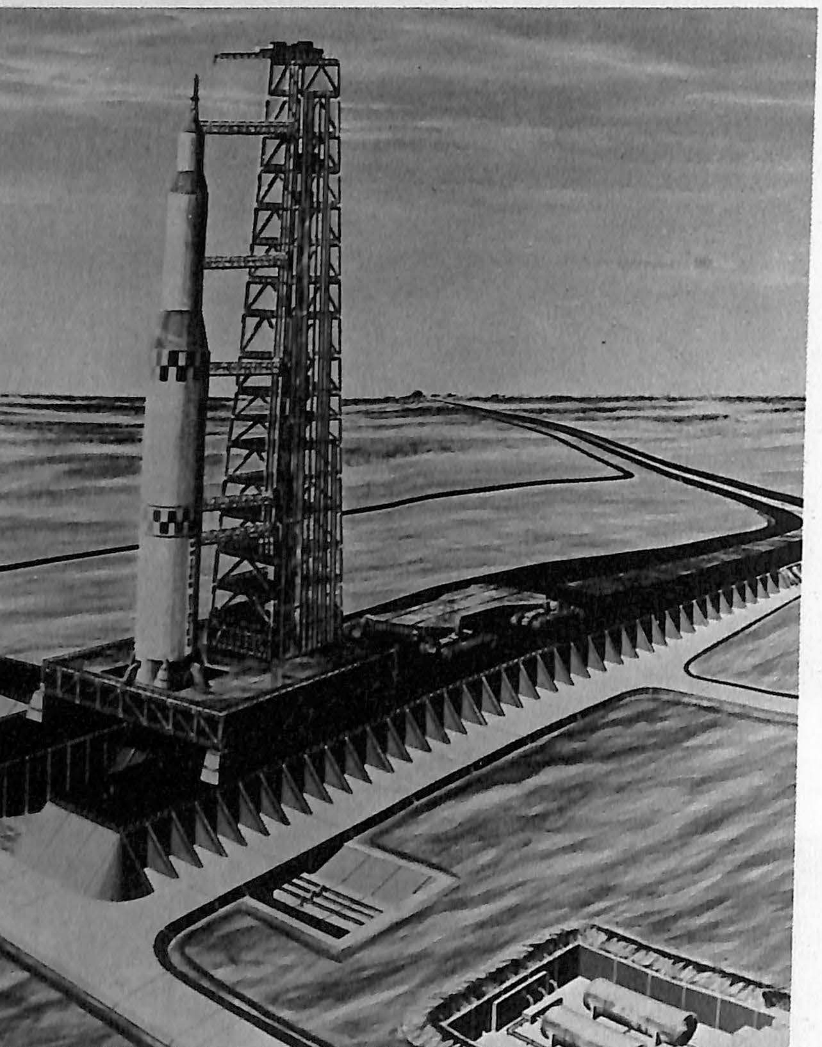


Sequence of lunar excursion module landing includes careful throttling of rockets to permit landing at about 7 miles per hour.

of ground-based and on-board radars and computers. At 20 miles distance, the Gemini astronauts will be able to see a high intensity flashing beacon on Agena D. Using Gemini's propulsion system, they will maneuver their capsule to a docking with the target.

With the two vehicles locked together, the astronauts can re-start the Agena D rocket engine and use it as an energy source for making a series of maneuvers, such as adjusting the orbit or changing to a different orbit. This rendezvous-docking-maneuvering mission will last about two days; then the astronauts will unlock the target vehicle and return to earth in the Gemini capsule.

For the remainder of the missions in the Gemini program, NASA will repeat the foregoing experiments, gaining experience in rendezvous, maneuvering and extravehicular tests and acquiring extensive biomedical data. GT-7 will provide a great deal of information in the latter area, when the spacecraft remains in orbit for its full design period of 14 days. GT-8 through



Artist's conception shows Saturn launch complex at Cape Kennedy, Fla.

GT-12 will be additional rendezvous-maneuvering missions of two days duration.

The first manned flights of Apollo aboard the Saturn IB booster in 1967 will dovetail with the end of the Gemini program. Apollo is a three-module spacecraft consisting of a command module which houses the astronauts; a 13-foot-long service module which contains the propulsion system for course corrections and various support systems; and the 19-foot-tall Lunar Excursion Module (built by Grumman Aircraft Engineering Corp.) in which the astronauts descend to the moon.

Fully fueled for the lunar mission, the whole Apollo spacecraft weighs close to 90,000 pounds. For preliminary missions in earth orbit, however, it will carry a reduced fuel load, so that it can be orbited by Saturn IB while the more powerful Saturn V goes through its final development tests.

The first manned Apollo flight will be preceded, in 1966, by two unmanned Saturn IB launches, the first being a suborbital or "lob" shot to test the launch vehicle and the re-entry capabilities of the command module. This will be followed by a one-to-three orbit unmanned flight of the Apollo spacecraft, a final check on all systems.

There will then be eight manned flights at the rate of one every three months. The first portion of the Saturn IB phase will be devoted to long duration flights of 10 to 14 days. The latter portion will consist of a series of flights in which the astronauts will practice the "turnaround" maneuver required for the lunar mission.

As the spacecraft is launched from earth, the topmost segment is the escape tower which blasts the command module free of the booster in case of an "abort." Immediately below the tower is the command module, then the service module, next the LEM, and then the S-IVB stage which accompanies the spacecraft into orbit and powers it into lunar trajectory.

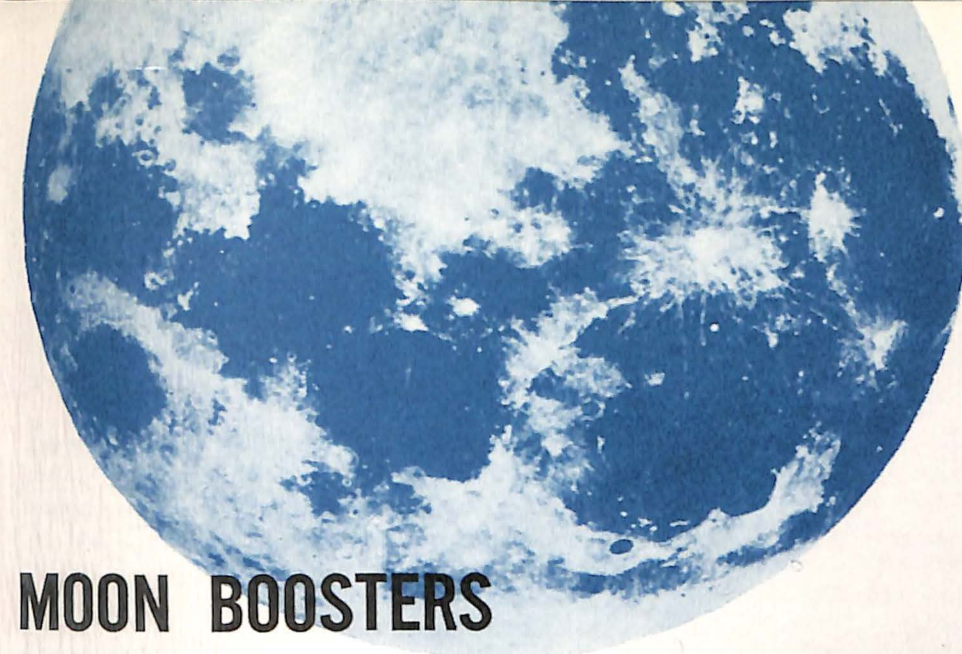
This configuration, required for safety in an emergency, must be changed for the lunar landing so that the hatches in the command and lunar excursion modules are "nose to nose," permitting the astronauts to move from one to the other. This "turnaround" will be accomplished shortly after S-IVB blasts the spacecraft into lunar trajectory. The multi-segment vehicle will be split (by small separation rockets) into two halves, one half being the command and service modules, the other LEM and S-IVB. The astronauts will then apply thrust to turn the command/service module segment around and dock nose-to-nose with the LEM. This maneuver completed, the S-IVB stage separates and the three-module spacecraft continues to the moon.

The Saturn IB phase will provide the initial experience in this maneuver and it will be perfected in the Saturn V phase.

The first two Saturn V/Apollo missions will again be unmanned. These flights will test the command module re-entry heat shield at the speed at which it will return to earth's atmosphere after a lunar mission, about 24,500 miles per hour. This will be accomplished by placing the spacecraft in an elliptical earth orbit and using the service module engine as a secondary power plant to gain the required velocity.

On the third flight of the Saturn V phase will come the first manned mission at full lunar payload, although this and the following five missions will be confined to earth orbit (still undecided is the question of whether a manned circumlunar reconnaissance mission will be required as a prelude to the lunar landing). On Saturn V flights three through eight, the astronauts will conduct dress rehearsals of the lunar mission, simulating all aspects as closely as possible from launch to re-entry.

After the initial checkout flights, the launch tempo will accelerate, and Saturn V/Apollo flights will be conducted at the rate of one every 60 days. If all goes well on the preceding steps, the seventh manned Saturn V launch will be the lunar landing mission. The first 24 steps will give the United States a cumulative total of more than 2,000 hours manned space flight experience. In 1969, on the current schedule, will come man's greatest adventure — Step 25.



MOON BOOSTERS

Imagine an aerospace vehicle that:

- **towers** higher than the Statue of Liberty;
- **weighs** more than 6,000,000 pounds at launch;
- **requires,** for assembly, the world's largest building, a structure so huge that its cubic volume is almost equivalent to the combined volume of Washington's Pentagon and Chicago's Merchandise Mart;
- **produces,** in its first stage alone, 160,000,000 horsepower;
- **generates** the thrust equivalent of 110,000,000 kilowatts of electric power, roughly 68 times the maximum generating capacity of the utility company which supplies power for Washington, D. C.

The vehicle is Saturn V, the mighty booster that will send the Apollo spacecraft to the moon. It is not a paper study. Already, at a great many aerospace plants, manufacturers are producing "hardware" for the mammoth launcher and initial assembly work is under way.

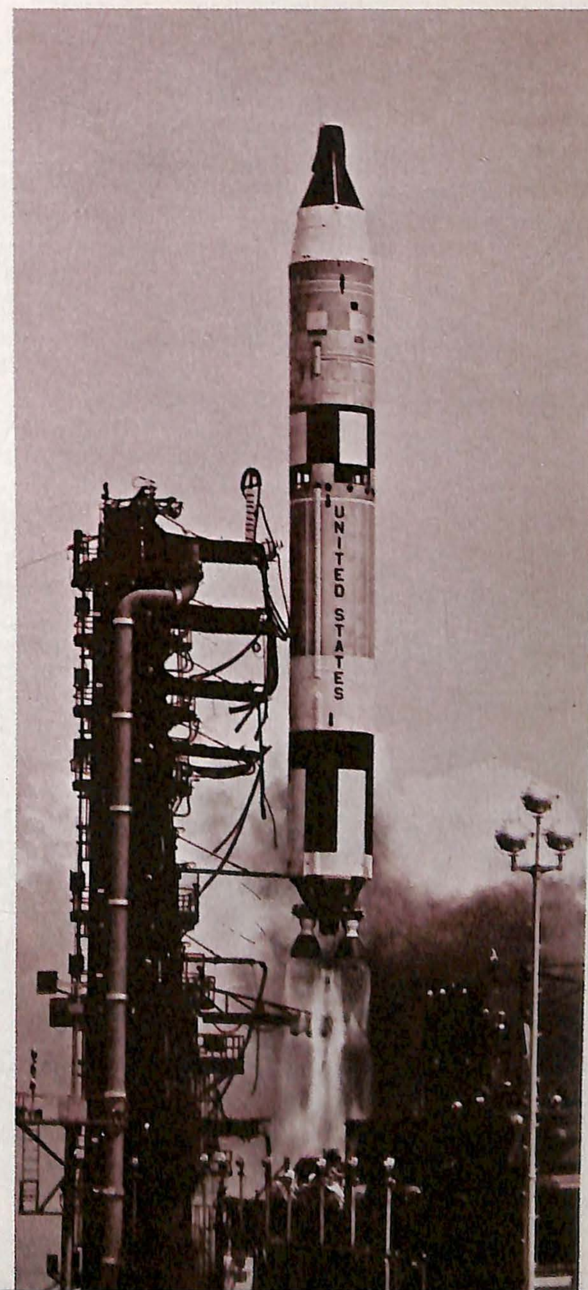
Saturn V is one of the three launch vehicles which will provide the "push" for NASA's manned space flights; the others are Saturn IB and Titan II. These boosters are the keystone elements of the Gemini/Apollo programs and of space exploration in the immediate post-lunar landing period.

With more than 100,000 persons engaged in fabrication of these vehicles, the combined projects constitute a considerable portion of the aerospace industry's workload. They are also bringing about a significant expansion of the industry's technological capability, requiring, as they do, a whole new range of tools, equipment and facilities and testing and fabrication techniques.

In chronological order, Titan II is the first of the three man-rated launch vehicles. An outgrowth of the ICBM of the same name, it is built by Martin Company under contract to the Space Systems Division of the Air Force Systems Command.

Titan II is a two-stage vehicle, 90 feet tall. Its

TITAN II



70-foot first stage, powered by two Aerojet-General LR-87 engines, produces 430,000 pounds thrust. The upper stage has a single Aerojet LR-91 engine of 100,000 pounds thrust.

Titan II uses a combination of propellants unique in American launch vehicles. The fuel is a blend of hydrazine and UDMH (an abbreviation of the tongue-twisting unsymmetrical dimethyl hydrazine) and the oxidizer is nitrogen tetroxide. These propellants can be stored within the vehicle for long periods, and they are also "hypergolic" — they ignite on contact and need no ignition system. This permits a significant reduction in countdown time and makes Titan II particularly adaptable to the Gemini rendezvous mission, where precise launch timing is essential. The thrust in the two stages gives Titan II a "weight-lifting" capacity sufficient to inject a 7,000-pound payload into an orbit of 100 nautical miles.

Under NASA supervision, five major contractors are directing the Saturn IB/V programs: The Boeing Company; Chrysler Corporation's Space Division; Douglas Aircraft Company's Missile and Space Systems Division; and North American Aviation, Inc., whose Rocketdyne and Space and Information Systems Divisions are both working on the boosters.

There are seven major "building blocks" which, in different combinations, make up the Saturn IB/V launch vehicles. These blocks are three different types of rocket engines and four "stages," a stage being the power plant, its propellant tanks, the airframe enclosing them and a number of associated systems.

The three engines, all built by Rocketdyne, are:

The H-1B. Burning a combination of liquid oxygen (LOX) and kerosene, the H-1B is an advanced version of the engine which powers the Saturn I now in test status. An outgrowth of earlier missile engines, the basic system has demonstrated a high degree of reliability with six successful launches of Saturn I in as many attempts. H-1B develops 200,000 pounds thrust. The basic system has been in test status since 1959.

The J-2. An upper stage engine, J-2 burns liquid hydrogen and LOX, the high energy hydrogen providing more energy per pound of propellant consumed than earlier kerosene-type fuels. J-2, rated at 200,000 pounds of thrust, has been fired on test stands for a total of about 30,000 seconds, including several runs of the full 500-second duration.

The F-1. The largest and most powerful flight engine ever built in the United States, the F-1 develops 1,500,000 pounds of thrust in a single chamber. Ready for flight, it stands 18 feet tall and is 12 feet in diameter at the nozzle exit. A 60,000 horsepower turbopump delivers LOX-kerosene propellants to the combustion chamber at the rate of three tons a second. In development since 1959, the F-1 has accumulated some 25,000 seconds of test stand operation, including more than 60 runs for the full 150-second programmed duration.

These engines provide the "push" for the four stages which make up the launch vehicles. The stages include:

The S-IB (Chrysler), powered by eight H-1B engines. The stage is more than 80 feet tall and 21½ feet in diameter. Most of its interior volume is taken up by the propellant tanks, a 105-inch diameter central LOX tank surrounded by four additional LOX tanks of 70 inches diameter and four kerosene tanks of the same size. These tanks carry almost 1,000,000 pounds of propellants.

The S-IVB (Douglas), power source for which is a single J-2 engine. S-IVB is 60 feet tall and, at mid-section, 22 feet in diameter. S-IVB is used on both the Saturn IB and Saturn V, and the two versions are slightly different, due to the fact that on the lunar mission S-IVB must be capable of re-starting as many as 50 times.

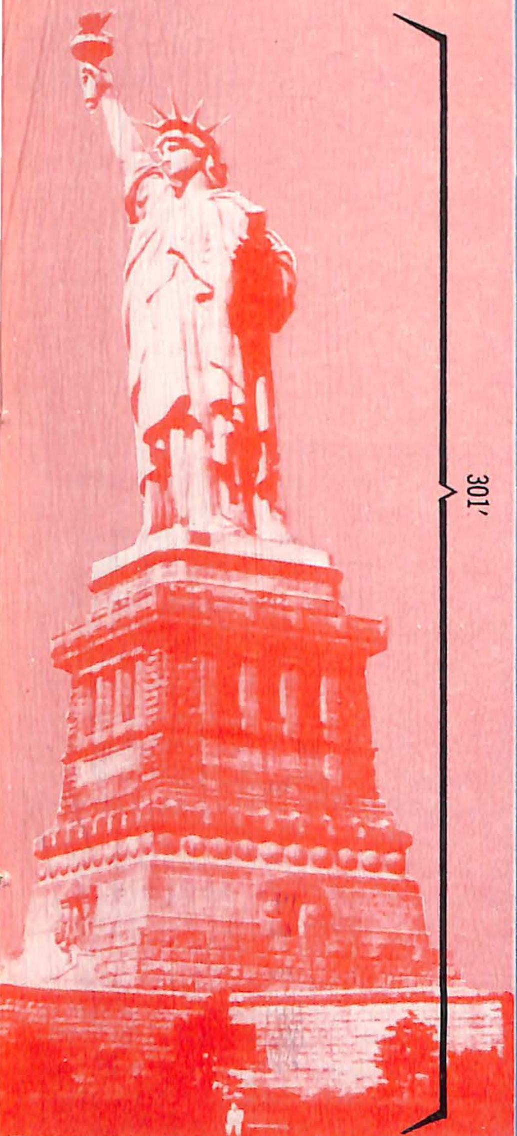
The S-II (North American), which employs five J-2 engines for a total thrust of 1,000,000 pounds. The stage is 81½ feet tall and 33 feet in diameter. It weighs only 80,000 pounds empty but more than 1,000,000 pounds fueled.

The S-IC (Boeing), the largest of the building blocks. Its five F-1 engines develop 7,500,000 pounds thrust. The massive stage is 138 feet tall and 33 feet in diameter. Two enormous tanks hold the equivalent of 59 railroad tank cars of LOX and kerosene, gobbled by the five engines at the rate of 30,000 pounds per second. Fully loaded, the S-IC stage weighs 4,687,000 pounds.

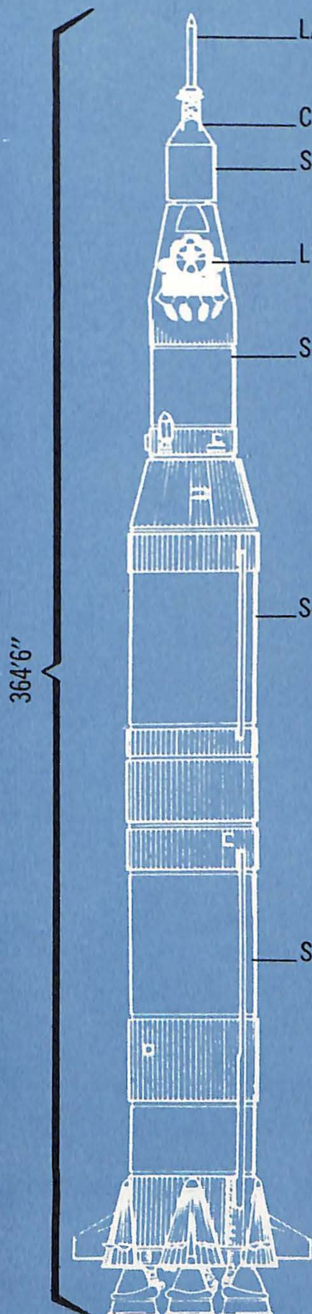
The Saturn IB launch vehicle consists of the S-IB, with 1,600,000 pounds thrust, as the lower stage and the 200,000-pound thrust S-IVB as the upper stage. This combination can send a payload of 35,000 pounds into low earth orbit. The payload capacity is sufficient for orbital tests of the three-module Apollo spacecraft without its full lunar mission fuel load.

The mammoth Saturn V, which, with its Apollo payload, stands 364 feet tall and weighs more than 6,000,000 pounds, is a three-stage vehicle. The 7,500,000-pound thrust S-IC serves as the basic stage; S-II, with 1,000,000 pounds of thrust, is the second stage; and the re-startable S-IVB (200,000 pounds thrust) is the topmost stage. Saturn V can launch 240,000 pounds into earth orbit or send 90,000 pounds to the moon.

NASA has contracted for 12 Saturn IB launch vehicles, with first flight scheduled for early 1966. Saturn V will go aloft for the first time about a year later; 15 vehicles are programmed.



APOLLO / SATURN



	THRUST LBS	WEIGHT LBS
LAUNCH ESCAPE SYSTEM	150,000	6,600
COMMAND MODULE (ASTRONAUTS)	NONE	10,000
SERVICE MODULE	22,000	46,000
LUNAR EXCURSION MODULE	13,000	30,000
S-IVB	200,000	251,900 21,900 (DRY)
S-II	1,000,000	1,005,000 75,000 (DRY)
S-IC	7,500,000	4,687,000 287,000 (DRY)