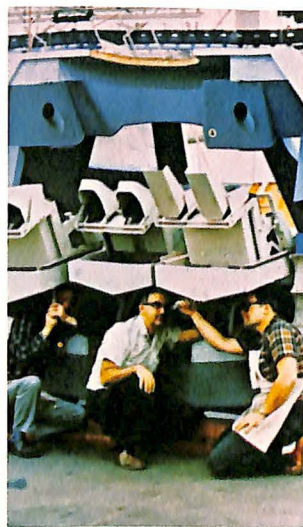
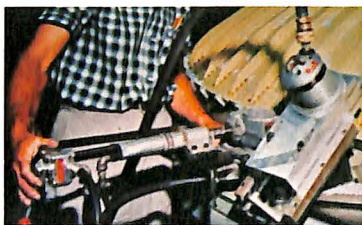
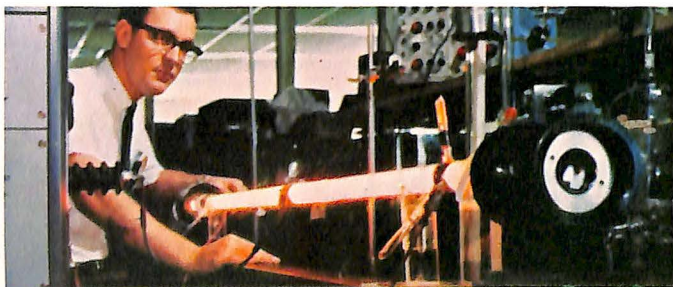
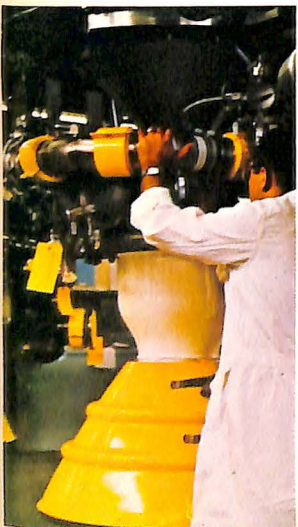


U. S. AEROSPACE

Skills Forge The Future



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The Mission Operations Control Room at Houston, Texas, is the pivot of a global tracking and communications network for all manned space flights.

Countdown

One day before the end of this decade, a three-man crew will board the space vehicle atop a Saturn V booster positioned for a launch at Cape Kennedy, Florida. After countdown, the five mighty engines of the Saturn's lower stage, producing 7,500,000 pounds of thrust, will roar into action and man will move toward his greatest adventure — a landing on the moon.

This is the goal of Project Apollo. Behind it will be nearly 3,000 hours of manned space flight in earth orbit. The near-flawless Gemini flights constituted the prelude — the proof of capability — to Project Apollo. Here is a description of a typical Gemini flight:

Inside the Mission Control room at the Manned Spacecraft Center of the National Aeronautics and Space Administration at Houston, Texas, men turn their eyes to the Greenwich Mean Time clock atop the wall of monitoring displays and listen as a voice over the loudspeaker says: “. . . *The flight crew has entered the spacecraft. Countdown is proceeding. All systems verify green. T minus 100 minutes and counting . . .*”

This announcement causes no pause in the routine at Houston, for the countdown to launch another Gemini two-man spacecraft is going smoothly.

A thousand miles to the east and another 1,350 miles to the northeast, other men have heard the same announcement. In a similar room at Goddard Space Flight Center in Greenbelt, Maryland, computer, tracking and telemetry specialists adjust their earphones. All around them, rows of electronic tape instruments, translating machines, trajectory and velocity increment plot boards whir and click off the final pre-launch checkout of the globe-spanning network and programmed flight sequence.

The focus of this attention is a launch pad at Cape Kennedy, Florida, with its launch erector standing upright and enfolding in its rust-protected steel framework a fueled, gleaming white Titan II booster rocket, 109 feet tall. Seven men, dressed in white coveralls, are busy connecting the life support and communications equipment of the two American astronauts, now strapped into the capsule atop the rocket.



A McDonnell Aircraft Corporation Gemini capsule is lifted off a pad at Cape Kennedy, Florida, by a Martin Company Titan II booster.

A final go-ahead sign is received from each astronaut and the white room is cleared.

A loudspeaker on the pad crackles again and comes alive: “. . . *T minus 35 minutes and counting . . . Start range telemetry check . . . Drift test complete . . . Sequencer checkout of launch vehicle systems begun . . .*” The monotone voice pauses briefly and starts again: “. . . *The blockhouse will be sealed in ten minutes . . . Begin lowering launch erector.*”

From a press observation point 9,000 feet away, the heat makes the Titan II booster seem to quiver. Then, the voice over the loudspeaker sounds again: “*This is Gemini control . . . We are at T minus eight minutes and counting . . . All systems checks are proceeding nicely.*”

Back in Houston, men in the Mission Control Center, tense and waiting, are seated at their consoles in three parallel rows, ready to monitor every spacecraft and human activity. Behind and on a dais above them, is a single desk-like console, watched intently by Flight Director Christopher C. Kraft. Before him, the master switchbox, which monitors the status of each separate activity of the flight, has just given him a series of instrumented decisions. The solid rows of green lights he sees tell him the instruments say “GO.” But the final decision to launch rests with him.

“T minus two minutes and counting. . . .”

There is not a sign of life at the launch pad. The area is vacated. The blockhouse, several hundred yards away, is sealed. But the slim booster has come very much to life. The rocket and its spacecraft are now functioning on internal power and the entire system is ready to go.

“T minus 30 seconds and counting. . . .”

Inside the spacecraft, a final glance at the instrument panels by the astronauts and time for a last terse communique: “Gemini Control, this is Gemini command pilot. All systems verify green. Spacecraft is GO.”

“Five . . . four . . . three . . . two . . . one . . . zero. . . .”

The Titan II's engines erupt with a cloud of dirty brown smoke and a crackling roar as the cables are released and the booster strains at its tether.



The launch facility for the Martin Company Titan III-C at Cape Kennedy, Florida, is designed for efficiency.



*“ . . . Plus one . . . plus two . . . plus three . . .
LIFTOFF”*

With the thrust chambers of its twin main stage engines consuming fuel and oxidizer at a rate of 156 gallons per second, the Titan II begins a slow, graceful climb, its engine nozzles emitting a luminescent bluish plume as it arcs up and out over the Atlantic Ocean.

This mission required the ingenuity, knowledge, experimentation and talent of 1,691 U. S. aerospace companies, employing 57,700 people.

• • •

On a Texas airstrip, the pilot of an experimental jet interceptor aircraft pushes the throttle forward for the first time and the plane speeds down the runway.

• • •

At a California airport, passengers board, for the first time, a medium-range commercial jet transport aircraft, just purchased by a major world airline.

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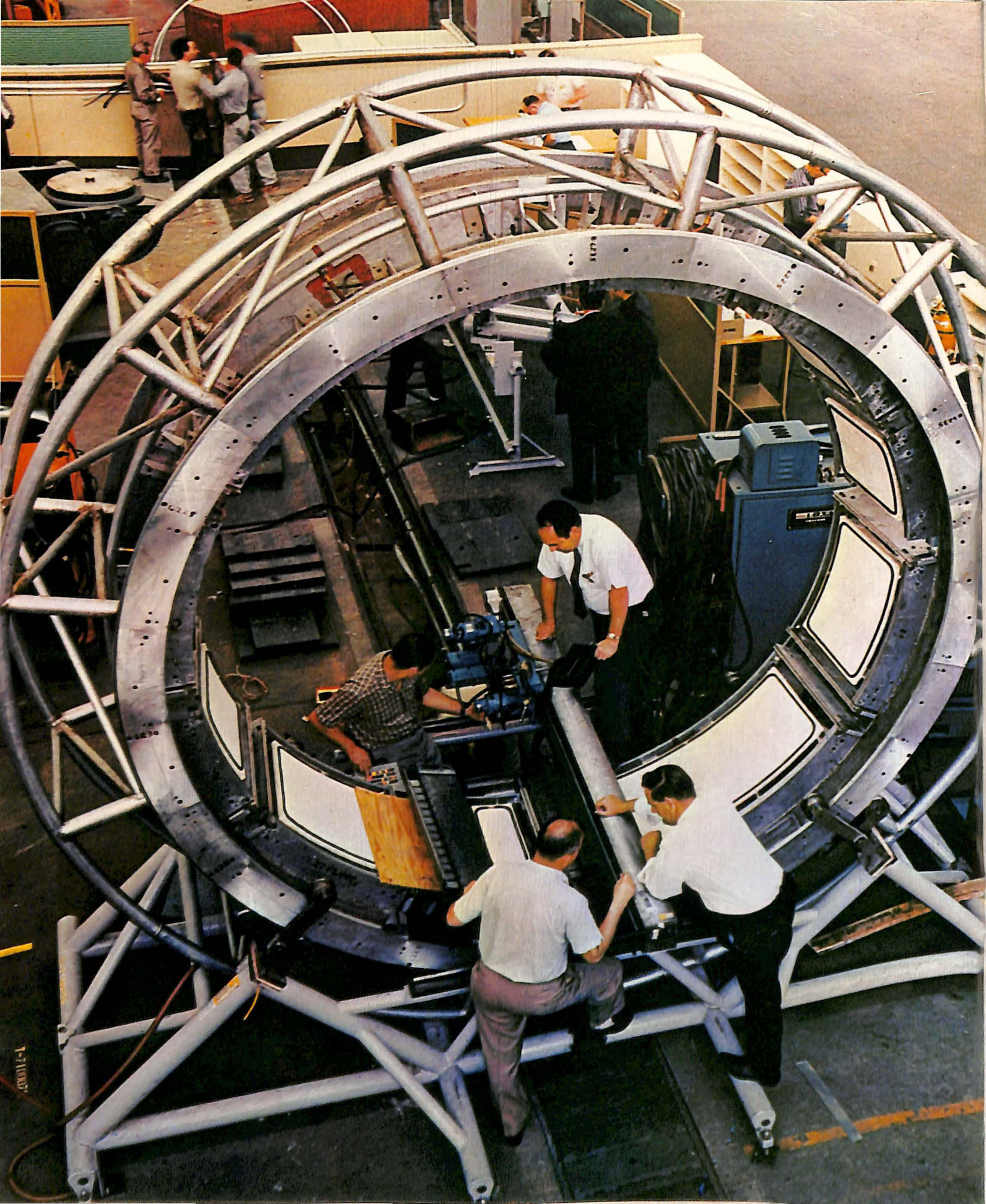
In a small town in the state of New York, a scientific computer is set in motion for a simple demonstration, and in a split-second, adds a column of seven-digit numbers stretching two miles in length, and gives the total.

• • •

In the research laboratory of a Pennsylvania firm, a ruby crystal glows white-hot and a solid beam of light leaps from a camera-like box to which it is attached, across a space of ten yards, and instantly “burns” a hole in a slab of metal one inch thick.

• • •

In these, and thousands of similar examples happening every day across America, science and technology continue at an ever-quickening pace. Behind each of these miracles are the men and women of the U. S. aerospace industry, utilizing their special skills to roll back the frontiers of science and technology.



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The Industry

Twenty years ago, American aircraft manufacturers began disassembling the world's most powerful industrial force. The wartime mass production of aircraft was a thing of the past, and they recognized that new concepts, techniques and approaches would be required to survive in a highly competitive environment in which performance and reliability would be paramount.

Leaders of the industry started then to lay the foundation for the application of new developments in science and technology. In the past two decades, they have created the most dynamic industrial force in the U. S. A.

This is the aerospace industry, and its business is innovation. Today it is America's largest manufacturing employer, with 1,100,000 workers producing a wide variety of civil, commercial and military aircraft, plus rockets, spacecraft and missiles and all related components and ground support equipment. These companies range in size from huge corporations to small firms and are spread all across the United States.

Their primary task is creativity—of concepts, designs, and, finally, of equipment made up of components conceived by advanced science and technology. They function in the American free enterprise system, yet are ever conscious of another responsibility—to produce a product and a technical proficiency that will assure America and the Free World of a pre-eminent role in the exploration of space, while providing adequate defenses for the Free World.

The deep-rooted strength of an industry of this size and diversity is its ability to respond to tough jobs and tougher timetables.

Its response has been outstanding. Twenty years ago, for example, there was even skepticism over the principle of an intercontinental ballistic missile, to say nothing of the ability of anyone to produce a workable system. Today, U. S. intercontinental ballistic missiles can reach half way around the world with accuracy. The SR-71, a strategic reconnaissance aircraft, can cruise at supersonic speeds and

attain altitudes of better than 70,000 feet. The Titan II booster system can place a 7,000-pound spacecraft with two men aboard into an orbit of the earth for a two-week trip covering several million miles.

These brief descriptions of performances do scant justice to the skills that created these miracles—to the abilities of the people who are the aerospace industry's greatest single asset. What specialized talents and skills have these people developed and perfected? What values motivate them to reach these high standards of excellence?

They come from all walks of life, all ethnic backgrounds, these Americans. Their names are Jones, Smith, Dimetrios, Foo, Kerzov, Previn, von Bunn, Brown, Zamphl, O'Toole, Rossolini, Rosenblum and many more. They are brilliant young people and experienced, mature professionals, chosen for the work they do by a single guideline: their ability, talents and skills.

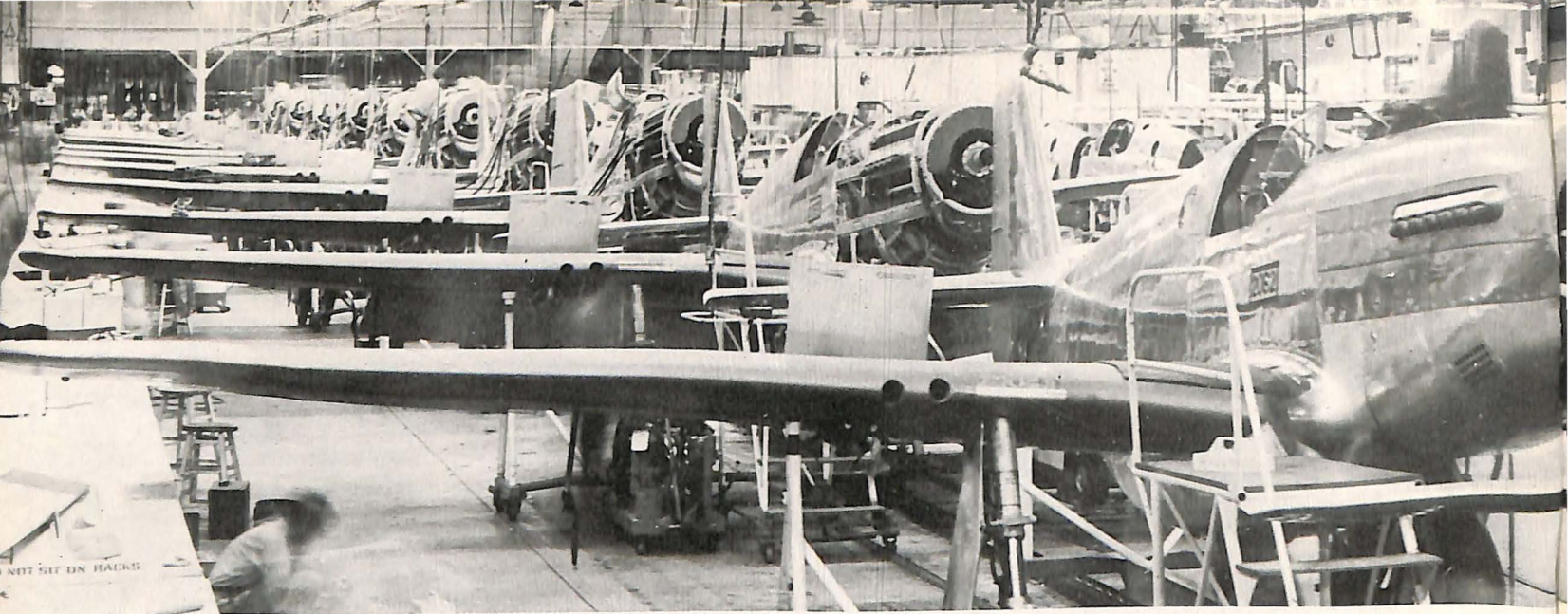
As the industrial mix of aerospace products and research has expanded and diversified over the past 20 years, so have the abilities of its employees and the variety of jobs performed by them. Today, there are as many as 4,000 distinct types of working skills required by the industry. Many of the employees are "first-generation" specialists in fields that did not exist two decades ago—fields such as rocket fuels, cryogenics, nucleonics, digital programming and computing and high temperature metallurgy.

The unique requirements upon industry to produce highly complex space flight equipment and weapon systems under great pressures of time have demanded the adoption of a new type of tool called "systems management." This concept identifies the best method of production using the most direct path from design to final product at the least cost and in the shortest time.

The systems approach, in turn, has placed major stress on the availability of the best and most productive minds of well-educated management specialists. These people are experts, schooled in finance, education, equipment reliability, quality control, and other fields.

This approach marks a radical departure from the early days of the U. S. aircraft industry. In the 1930's, the design, research and development of airplanes was, to a large degree, a "fly-it-and-try-it"

North American Aviation engineers resolve problems involved in the manufacture of very large, very precise aerospace equipment.



This line of North American Aviation P-51s is typical of U. S. production efforts in World War II.



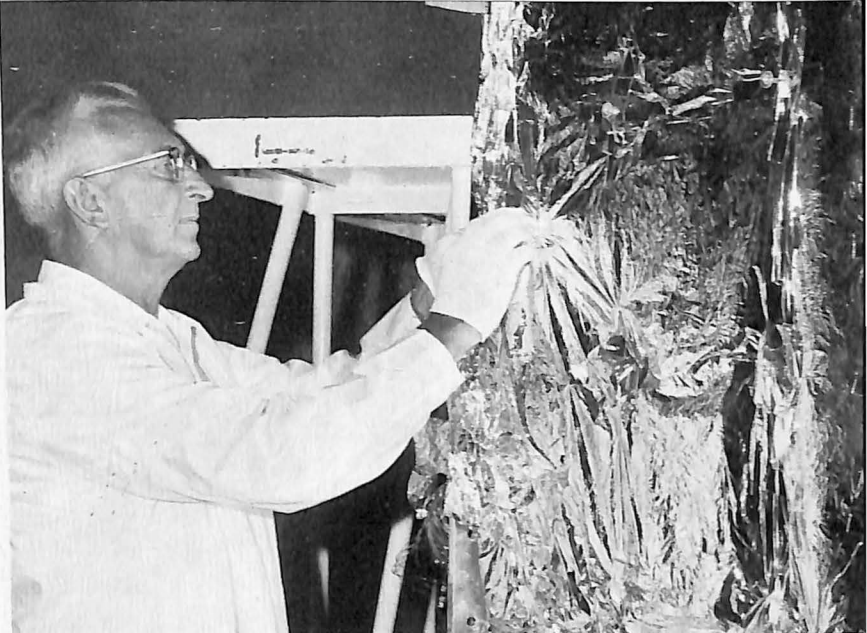
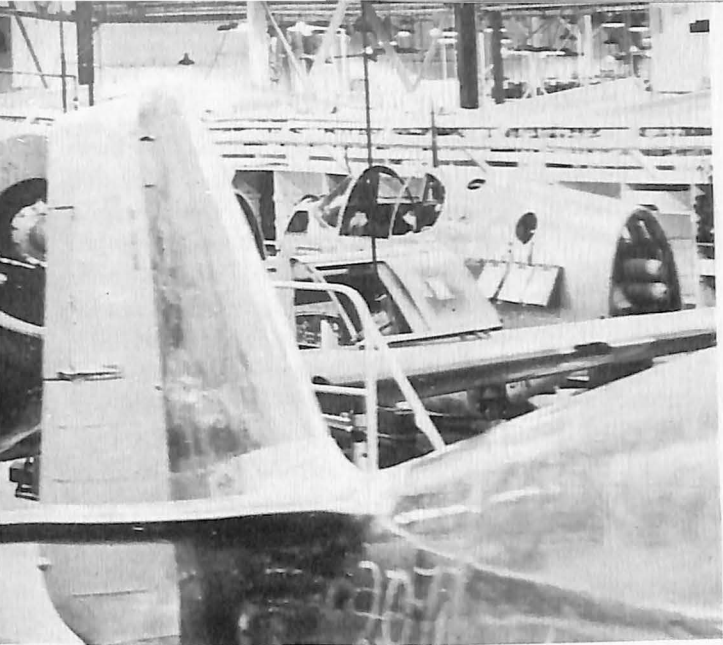
An Aerojet-General Corporation technician uses an electron beam to weld an injector for a rocket engine.

procedure. If a new design feature didn't work, designers went back to the drawing board.

To build an airplane, a company first needed a workable design. However, men who could design an airplane were scarce and not to be found on the employment rosters. Those few who could skillfully work on airplanes *were* working on airplanes. There were few schools offering training in aeronautical engineering. So the task of aircraft concept and design fell primarily to the founders and executives of the companies, the industrial pioneers such as Donald Douglas, Senior, Glenn L. Martin, Lawrence Bell, Igor Sikorsky and Glen H. Curtiss, to name a few.

The results of top executives working over drafting boards had become legendary by the end of World War II. For example, the best designer and one of the most competent engineers at North American Aviation during the mid-1940's was the late James H. "Dutch" Kindelberger, then president of that firm. When Allied air power was gathering its forces for the coming struggle with the German Luftwaffe over control of the air over Europe, it was Kindelberger with a few of his top associates, principally J. Leland Atwood, now president of the company, who worked around the clock for four months and four days conceiving and designing a single-engine fighter plane. The result was the P-51 "Mustang," one of the finest operational fighter aircraft in the war.

The mass production tool-up by the defense industry during World War II also brought into focus the skilled labors of men and women in aircraft as-



George W. Rappold, Grumman Aircraft Engineering Corporation, has developed his skills in twenty-two years with the firm, and today has a responsible job as a technician on the Lunar Excursion Module.

sembly lines across the country. The riveters, welders, electricians, mechanics, sheet metal fabricators and engine specialists formed the core of the aircraft industry's labor force—about 75 per cent of the total aircraft industry employment. The engineers, scientists and scattering of specialty occupations—such as bombsight manufacturing—made up only 10 per cent. The separate skills involved, though highly developed, remained small in number, limited in their variety by the relative simplicity of producing a flying gun platform with three basic building blocks: engine, airframe and guidance.

Today, those basic building blocks remain the same for all equipment that flies, whether in the atmosphere or in space. But the complexity of both the end product and the means by which it is achieved has increased a thousandfold or more, and with this increase there has been a complete change in the top-to-bottom make-up of aerospace industrial personnel. The emphasis on research and development and a systematic approach to proficiency call for a wide range of scientists and engineers who make up an increasing proportion of the aerospace work force. At present only half of the industry's employees are classified as production workers.

The requirement for better trained, better educated specialists runs throughout the aerospace industry from the top project manager to the production line assemblyman. The welder who plied his skill throughout the structural frame work of a B-17 bomber in 1944 has, in many cases, long ago put away his goggles and oxyacetylene torch. Today, he wears a 75-pound protective suit and uses an electron-beam

welder that requires precise judgment in its application, for the metals he welds are often as thin as paper. He must submit his work to the analysis of an X-ray machine that detects flaws in the weld the human eye cannot see. He must be able to analyze the properties of metals with which he works, knowing, for example, their resistance to corrosion and radiation, their malleability factor and thermal properties. In short, the welder of today has become a better trained, more skilled technician, schooled in his exacting art with a fundamental background in thermal engineering, metallurgy and electronics—a valued member of the aerospace production team.

The upgraded job of the welder is by no means an exception among skilled aerospace labor. The veteran machinists, metal-benders, tool and die makers, electricians and fabricators are still performing many of the same tasks, but their individual talents and knowledge have been vastly increased by the need to use new processes, techniques and materials. The aircraft and spacecraft assemblyman of today still has occasion to put to use his knowledge of electrical wiring and the uses of aluminum. But more and more, he is required to handle complex electronics gear, microminiaturized circuitry and rare metals and alloys. Through the classroom and on-the-job training, he has become a specialist in the use of the transistor, the cathode ray tube, the printed circuit board, tungsten steel, titanium, columbium, zirconium and molybdenum.

George W. Rappold, a veteran of 22 years' experience, is typical of these highly skilled aerospace workers. With very little formal education, Mr. Rap-



Mrs. Gladys Shaw, Fairchild Hiller Corporation, inspects castings and forgings.

pold began his career in the aircraft production business. Starting in the patent shop at a plant on Long Island, New York, later working in the fiberglass shop and in many other jobs along the way, he has developed and perfected a variety of material-handling talents as each new complexity arose, supplementing this training with formal education provided by the company. Today, this 59-year-old seasoned professional is a thermal technician working on the Lunar Excursion Module, the two-man vehicle that will carry the first American astronauts to the surface of the moon.

"When I began working in this business," he says, "there were only a few kinds of materials you had to deal with. You learned quickly how much bending they would take before they would break, how much pressure they would absorb before they would crack, and how to drill and cut and twist them. All that has changed now. Since I've been with this company, I've gone through about six completely new trades, each one more difficult to master than the one before it. You learn a lot by doing, in this business, but it still takes every bit of experience gained over the years plus a lot of study to get the job done right. The principles of thermal mechanics are the basis of everything I do today. Twenty years ago, those words weren't in my vocabulary."

Mrs. Gladys Shaw, a 55-year-old great-grandmother and an inspector of forgings and castings, is another example of personal initiative directed toward better capabilities. Mrs. Shaw has worked for an aircraft firm in the state of Maryland since the early 1940's and was one of the first women employed on actual shop production there. Her initial job was in the covering and sewing department—using curved needles and a baseball stitch to sew fabric on airplane fuselages.

Later, she recalls, came a period of employee retraining. "The fabric and needles were the same," she recounts, "but we had to learn a new technique called the 'rib' stitch to sew on the fabric. That sounds very simple, I know, but when you were accustomed to using the baseball stitch, you can't imagine how difficult it was to change."

Mrs. Shaw, like most of the 20-year veterans of the aircraft industry, foresaw the changes in aircraft manufacturing processes, techniques and talents, and knew that her chance to survive depended on her own initiative to keep abreast technically of these developments. "So, I went to school at night after my work shift and studied. The company paid all the expenses of this educational training."

Upper level employment requirements in the aero-

space industry have undergone many changes. One reason for this is the emergence of astronautics as a major science field. As this scientific discipline has broadened in scope, the aerospace industry has recognized a continuing need to expand the abilities of its personnel. From top management through research, to production, test and evaluation, the industry has placed strong emphasis on obtaining and keeping the educated specialist on its payroll.

Whole new fields of applied technical and scientific work associated with astronautics now demand experts in mathematics, psychology, physiology, materials, agronomy, geology, physics, solid and liquid fuels, electronics, space navigation, microminiaturization, sociology and circuitry—to name just a few.

Dr. William M. Jacobi is just such an educated specialist. At 35, Dr. Jacobi is manager of a design group developing advanced nuclear reactors in Pennsylvania. Educated at Syracuse University and the University of Delaware, Dr. Jacobi has been active in nuclear research work for 13 years. Like many others involved in concepts for applying nuclear energy, Dr. Jacobi is vitally concerned about

Dr. William M. Jacobi (standing) designs advanced nuclear reactors for Westinghouse Electric Corporation.



the potential of nuclear fuel used to power spacecraft on manned interplanetary missions.

“Here we have what is essentially a development group. We have built a prototype system that works. Now, we need the go-ahead to build a solid piece of operational hardware—something that can be flown,” he says. “What we are designing now is really an upper-stage nuclear engine with its real application perhaps 10 years away. The dollar is the big factor in deciding when or if we go with this, I think. For today, in this business, there is no direct accrual of a dollar’s worth of knowledge for every dollar spent. So, you see, it is difficult for research people to relate or equate the results of research to any given set of values. It just doesn’t work that way, and I don’t think it ever will.”

Dr. Jacobi is like all aerospace professionals—he likes to see his ideas become working realities. “You get personally wrapped up in the work you do, the product you build, the results you find. The real reward is getting a piece of equipment that works, that does what you said it would do,” he says.

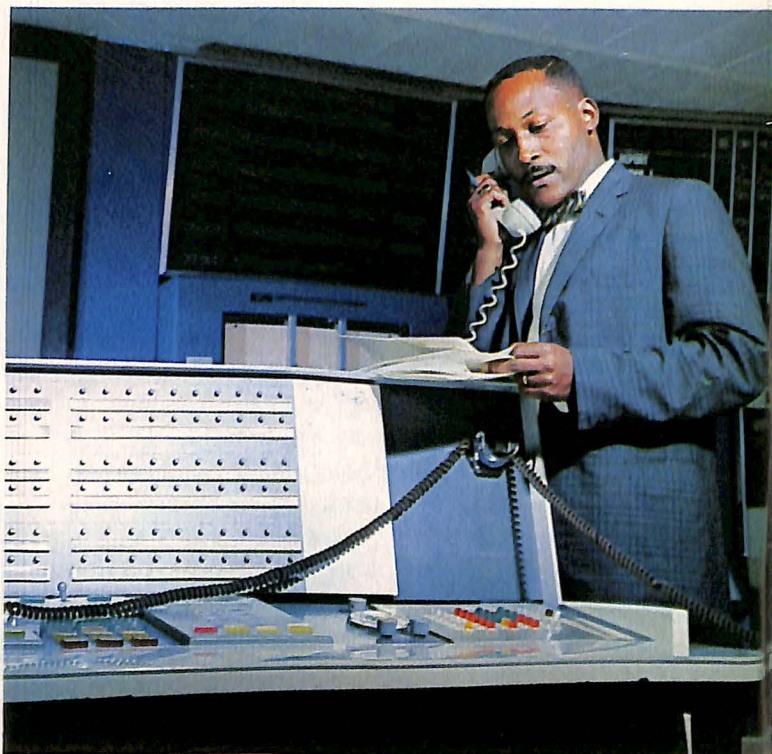
The science of astronautics has served merely as a catalyst to the explosion of aerospace industrial talents; advances in other aerospace fields have been equally demanding of the educated individual.

An engine manufacturer identifies as one of his company’s major problems the accurate measurement, analysis and solution to problems associated with vibration and stress rates on jet engines. One of the ways in which his firm has set about to solve this difficulty is through the establishment of a group of highly-skilled metallurgical specialists—nearly every one a doctor of philosophy. Confronted with the problem of what is called “brittle fracture,” or metal engine components that break under stress and wear, this group tackled the problem head-on. Recognizing that every metal is made up of a series of crystals and that breaking points occur at the rims of these crystals, the applied researchers have developed a new substance with a single, unified crystal—thus having no breaking point.

Underpinning all of these talents is an intangible yet powerful force called personal motivation. The Atlas-Mercury space flight system with 65,000 working parts is only so much cable and metal if a single switch the size of a fingernail fails to work; if a wire that activates an electric trim system on an experimental jet fighter aircraft doesn’t carry the right signal, the aircraft could crash. To reduce these failures to an absolute minimum, the aerospace industry has established high standards of production reliability and quality control. Standards of this cal-



Lou Marino is the director of airborne radar development for General Precision, Incorporated.



Lou Jones, IBM Corporation, is a senior associate programmer for computers.

"Clean room" workers at the Ryan Aeronautical Company assemble components of a lunar landing radar system for the Surveyor unmanned moon exploration spacecraft.



iber are not attained solely by textbook rules and regulations. Nor are they reached only by carefully monitoring that which has been produced; they have, rather, been achieved by the individual dedication of aerospace industry employees.

Employees in every part of aerospace industrial life have assumed a deep and conscientious sense of personal responsibility, a pride in workmanship.

To some of these employees, outstanding performance is, in a sense, like a moral obligation.

Lou Marino, a 36-year-old director of airborne radar development for an aerospace firm in New York, feels this way. "My parents and my grandparents were immigrants from Italy. None had much education, but all felt that education was important," he recalls. "So, it was natural for them to want me to be a professional man. They gave me the chance for an education. Education gave me the tools to do my job. This company gave me the opportunity and even paid for my graduate work in college. The rest is up to me."

Professional responsibility to these people means that they are not afraid to admit their mistakes. For example, there is the case of a missile engineer, assigned to the Gemini-Titan II space flight system checkout at the firm's Maryland Vertical Test Facility. A complex series of systems checks, lasting several days, had ended in a negative result. Hours of exhaustive study and review failed to find the error. While nearly positive that he was not at fault, the engineer maintained from the start that there was a possibility that he could have failed to properly reconnect an electrical umbilical cable. When no other solution could be found, the bad connection was discovered. The man had left himself open to severe criticism, placing his whole career as an aerospace engineer in a position of scrutiny. But to this engineer, the mission was more important than his future. He knew that failure to uncover the cause of the difficulty might mean setting the program back months, costing his company millions of dollars and perhaps even placing the whole project in jeopardy. His admission of guilt, while costing him a severe reprimand, kept the program on schedule.

Industry has found ways to inspire personal motivation for employees. "Zero Defects" is such a program and has been adopted by many aerospace companies. The program graphically tells each em-

ployee of the effect of his individual efforts on the overall quality control of manufactured components and systems. Plants involved in the production of manned flying systems encourage personal meetings between an astronaut or pilot and factory people who are producing the equipment he will fly.

Industrial safety programs are an important part of aerospace disciplines and an indirect motivation to employees. A large percentage of the work performed today by aerospace industrial firms involves hazardous materials, techniques and handling procedures. Nuclear research and experimentation call for strict procedures in handling radioactive isotopes, packaging and shipping them, shielding workmen from their gamma rays, and conducting tests with them. Many rocket fuels and oxidizers are lethal if touched or even breathed. A laser beam can be a killer if the human body comes in contact with it. Thus, industry has set up a carefully evaluated safety program for all hazards, governing the actions of every person working in their proximity. One company, for example, has made it mandatory that each person connected with its manned spaceflight program—including the president of the firm—attends a company-sponsored course in the safe handling procedures for nitrogen tetroxide, a highly toxic oxidizer used in the space booster, and Aerozine 50, the fuel for the system.

These are the people of aerospace.

They know that theirs is a business in which technical skills can—and often are—rendered obsolete overnight by the pace of advancing technology. Most of them accept this, knowing that their company stands ready and willing to assist in preparing them for tomorrow's need for newer, more complicated tasks.

Their response to the challenge is best summed up in the words of Lou Jones, a senior associate programmer for a Maryland firm engaged in the manned spaceflight program: "I'm not sure I can put into words the reasons why I love the work I do, but I know I love it. Maybe it's because a project becomes 'your' program and uses 'your' component in the system. Maybe it's because it demands the best in me to be both fast and precise; that a whole project may hit a snag if I'm wrong. That's why I don't worry about tomorrow or yesterday. If I'm good enough, I'll be here."

Members of a management team at the Aeronutronic Division of Philco Corporation discuss the design of an instrument to study the planet Mars.



Management

Managers and executives—the decision-makers—guide the corporate destinies of their companies.

They are businessmen, dealing in practicalities, profit-and-loss statements and project decisions involving millions of dollars, analyzing continuously the prime factors of cost, competition, reliability and quality control.

They are also realists, in spite of knowing that there is no assurance that what they design and develop today may ever become a productive, profitable venture; technology may leap over them; their plans may become obsolete overnight; global economics and politics may dictate radical national changes which might rule out a major part of a corporate effort.

These men all share a final common ground: the decisions they make and live with require imagination, initiative and courage, liberally endowed with a thorough working knowledge of every part of their company's effort and the need to make these parts function as a single unit.

Once a major decision is made, the chain of corporate command begins to forge ideas into action using the firm's most dependable tool—its skilled people.

One of the major problems facing aerospace management is to determine what talents will be needed in each segment of the industrial work force, to meet increasing technological demands—and then to find those talents.

Complex aerospace assignments for individual companies differ widely, and, as such, dictate the basic characteristics of the individual sought.

Gil Cole, an administrator of design operations for a Connecticut firm, links his need for specialized skills to the educated individual. "Experience in de-

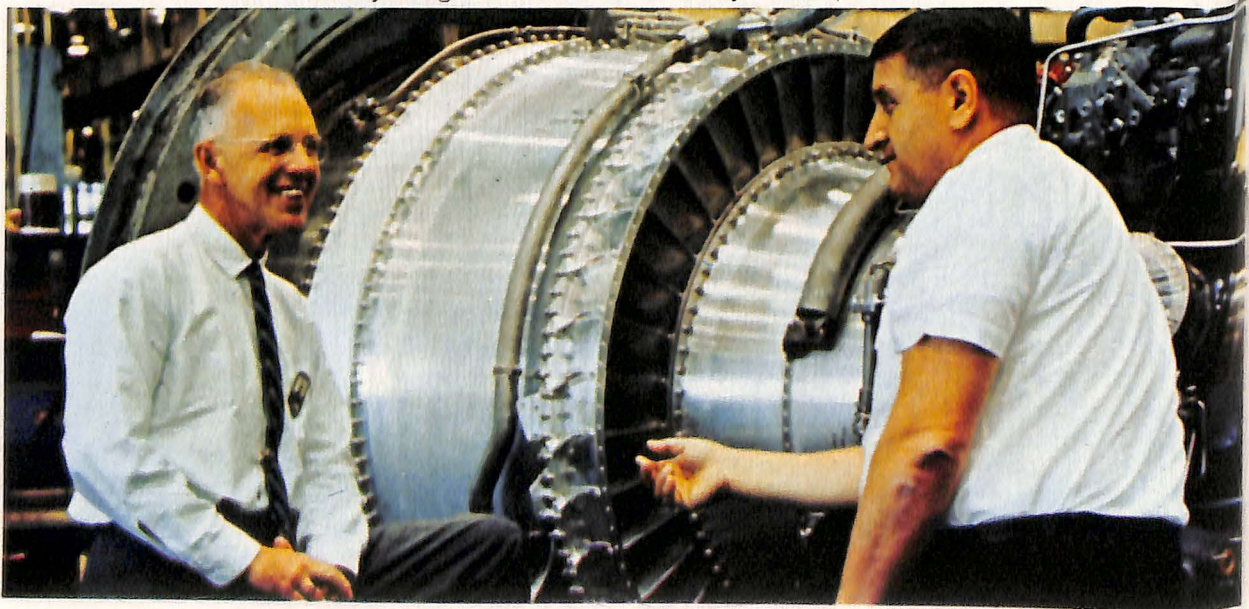
Gil Cole (left), Pratt and Whitney Aircraft, United Aircraft Corporation, is an administrator of design operations for the aerospace engine firm.





Clarence L. (Kelly) Johnson, Lockheed Aircraft Corporation, is a leading designer of very high speed aircraft.

Robert Pratt (left) and Gino De Monte are members of a management team working on turbojet engines at Pratt and Whitney Aircraft, United Aircraft Corporation.



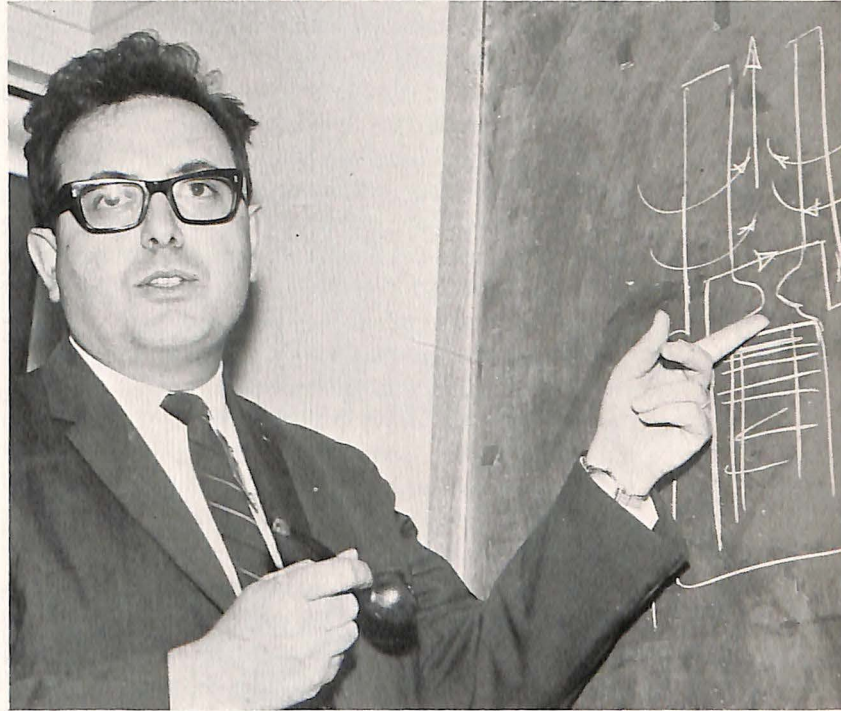
signing and working on jet engines is valuable, but it's no substitute for the analytical mind of an engineer, and a thorough educational background in thermodynamics," he says.

"We are dealing with complexities that demand the skills of a man with a doctorate degree. Today and tomorrow, management and the people closely tied to management's decisions must arrive at carefully constructed, rational approaches if we are to be able to perform and compete. The peak technical level of what we know today will be obsolete by the time we can use much of it. Of course, this means that we are all subject to re-education as the technology gains momentum."

Robert Pratt, a member of the same management team, describes the talent search this way: "In the 1940's, we thought we did pretty well if it took us six years from concept of an engine to the production of a working prototype. Today, we perform this same work cycle on an engine 100 times as complex, but we do it in 30 months. You haven't got much time to wait for skills to be developed if you're going to meet these time schedules."

George Wood, manager of a rocket support team in Maryland, seeks another kind of skilled employee characteristic—adaptability. "What I'm always looking for is the individual who can adapt to the changes that this business demands, and do it without a break in his stride. A good background is important, of course, but this business stays in a state of flux, and that takes care of most people's experience level. What do I care if an engineer with a textbook knowledge of a fuel like unsymmetrical dimethyl hydrazine comes to me for a job? I want an engineer who knows, for example, all of the vacuum pumping characteristics of whole *families* of liquid fuels, not one specific fuel. This way, I've got an expert who knows the principle, who can go in whatever direction the modifications on later rocket models require."

Mr. Wood doesn't expect the impossible of new employees. "First, we indoctrinate them in the job of this company and the specific job they are to work on. Then, we may also see to it that they learn the



Dr. Aldo LaRocca is manager of advanced propulsion systems in the Spacecraft Department of the General Electric Company.

Nancy Riddick is a programmer for the IBM Corporation at a space flight center.



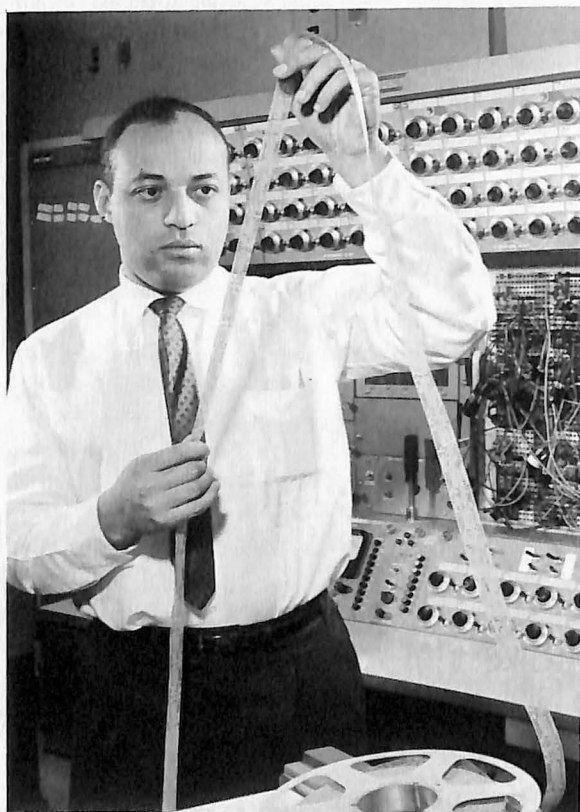
language of the computer and how it is programmed to assist them with their job. If a new development makes everything he is doing obsolete, then we may even send him back to school to upgrade his thinking.”

It is in the area of educational assistance to employees that aerospace management has matched steps with the surge of technology. Most major firms today offer a full range of study to employees throughout their ranks. These include complete university curriculums, in most instances fully paid for by the company; graduate fellowships, primarily to research specialists seeking doctorate degrees; courses in the latest methods of systems management, performance evaluation, contract negotiations and approaches and aerospace administrative procedures; and technical courses, conducted by the company for new and veteran employees seeking more responsible and better paying positions.

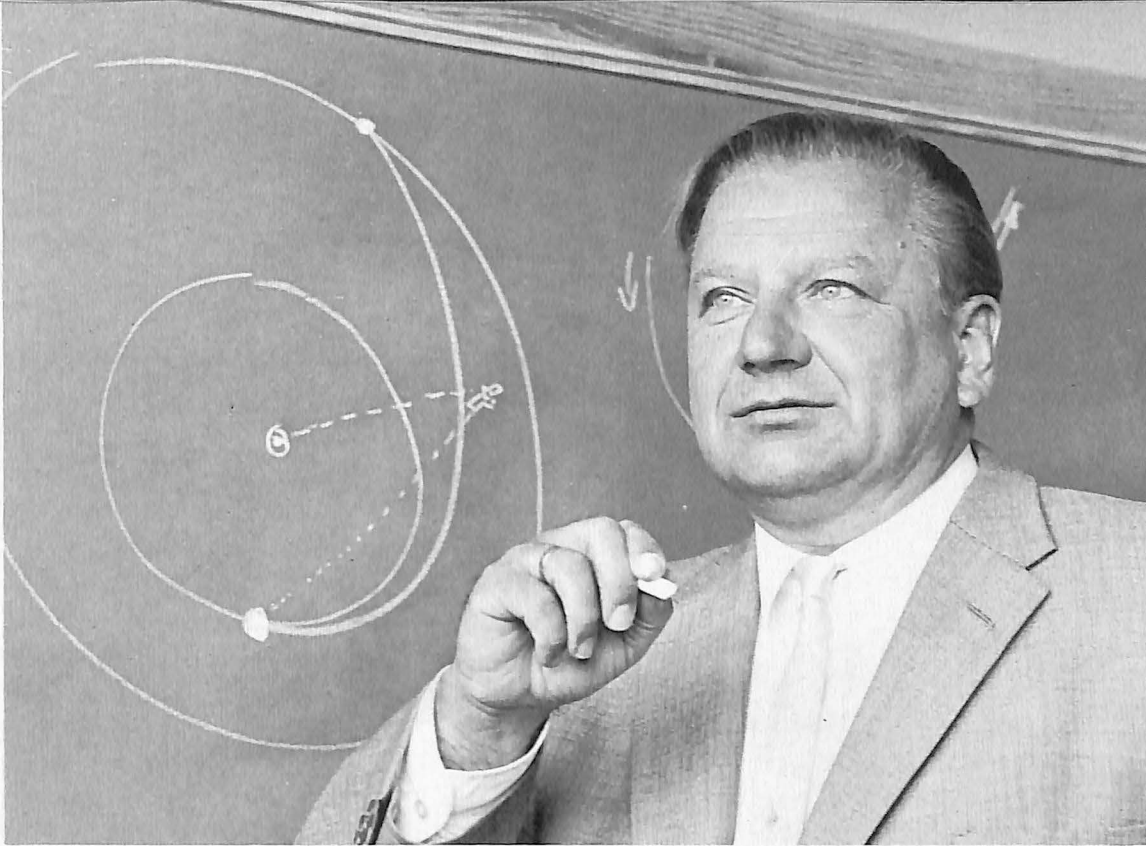
Perhaps the greatest single assist in the last 20 years to all phases of aerospace industrial capabilities has been the development of the high-speed digital and analog computers. The complexities of managing a company with dozens of study projects, major production runs and systems under analysis could not be done as efficiently without computer technology. Management is only one area of aerospace industrial life to be improved by the use of the computer. Research and development, production, and test and evaluation all depend on fast analyses and logic provided by the computer, saving weeks—even months—of tedious labor and valuable time.



Kaz Hiroshige (center), General Dynamics Corporation, discusses technical management problems with design specialists.

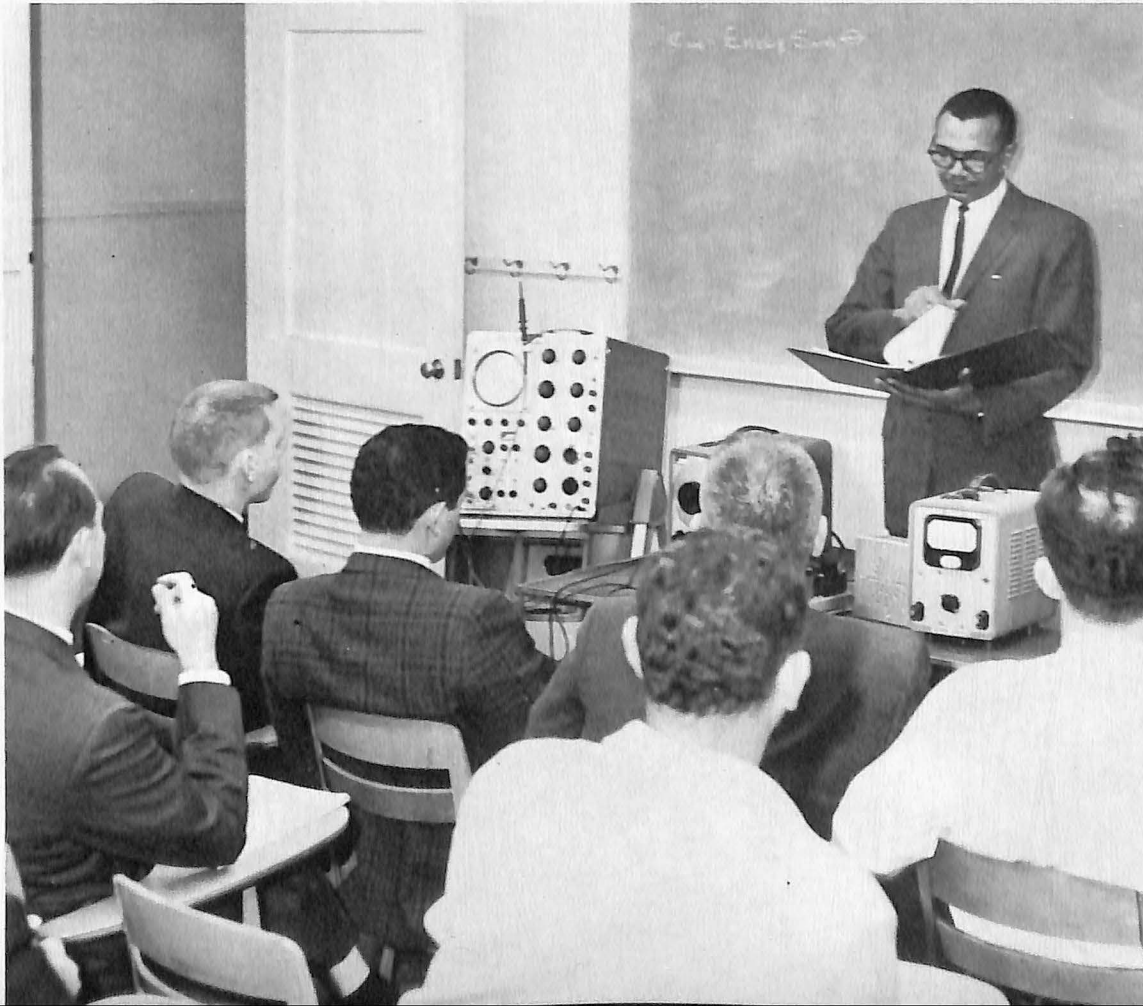


Hughes Aircraft Company engineer Leonard W. Massey helped to design one of the smallest and fastest airborne digital computers.

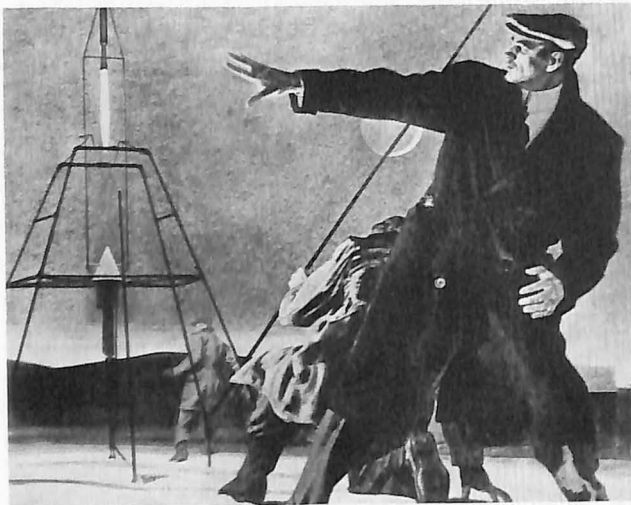


Kraft Ehrlicke, General Dynamics Corporation, is a German-born authority on manned and unmanned space flight.

Eli Corbitt instructs a class for the Lockheed Aircraft Corporation. Aerospace technology requires continuous study to keep pace with the state of the art.



Research and Development



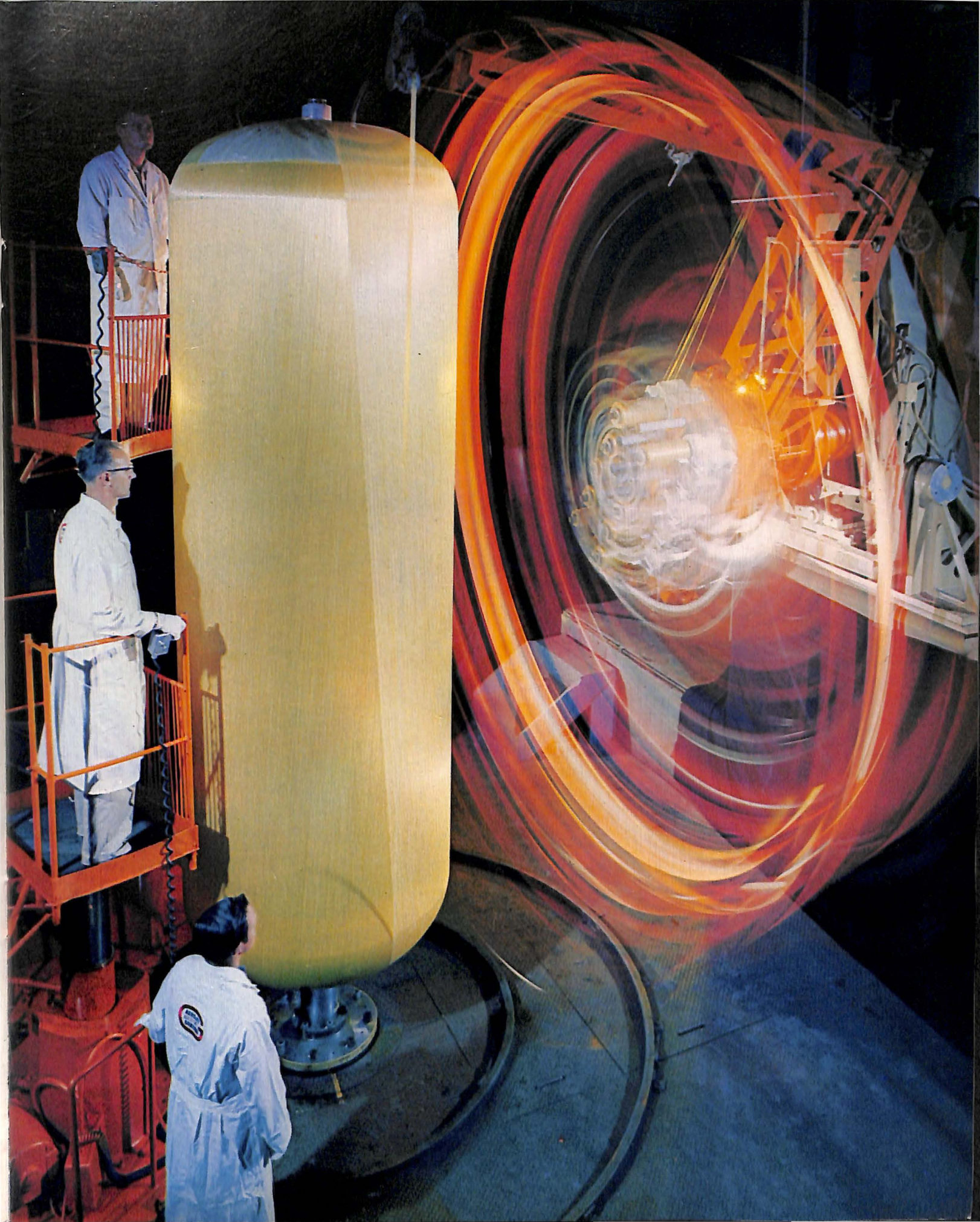
Dr. Robert H. Goddard, the pioneer of rocketry, conducted early rocket firings.

The examination of accumulated knowledge—the experimentation and analysis of basic and applied ideas—is the life blood of the aerospace industry. This endeavor—research and development—is the core in the many-sided structure of every program today and is the basis of the industry's promise to the world of tomorrow.

The value of research and development lies in the fact that it is a continuing series of additions and refinements of both fact and theory to the sum total of knowledge.

At Huntsville, Alabama, during the summer of 1965, five F-1 liquid-fueled rocket engines, held in a clustered mounting and tied to a concrete test stand, were fired simultaneously. These engines, which will form the powerplant for the first stage of the Saturn V space booster rocket, produced 7,500,000 pounds of thrust. They and the two upper stages produce enough power to send a satellite weighing 125 tons into an orbit of the earth or to send a 95,000-pound spacecraft to the surface of the moon.

The research and development needed to build the rocket engines actually began in an open field near Auburn, Massachusetts, on March 16, 1926 with the first test firing by Dr. Robert H. Goddard of a liquid-fueled rocket which travelled 41 feet into the air. Later, using Dr. Goddard's plans, German scientists at Peenemunde contributed more to the storehouse of rocketry knowledge with the V-1, and the V-2 ballistic rocket. Still later came the early



U. S. contributions—Jupiter, Redstone and Thor and more recently, the Thor-Delta, Atlas, Titan and Saturn I. With each succeeding project, new processes, techniques and materials added to the total capability.

Each development initiated expansion of better, more complete ideas which, in turn, fostered new developments with even greater potential. This is the pattern of aerospace research and development.

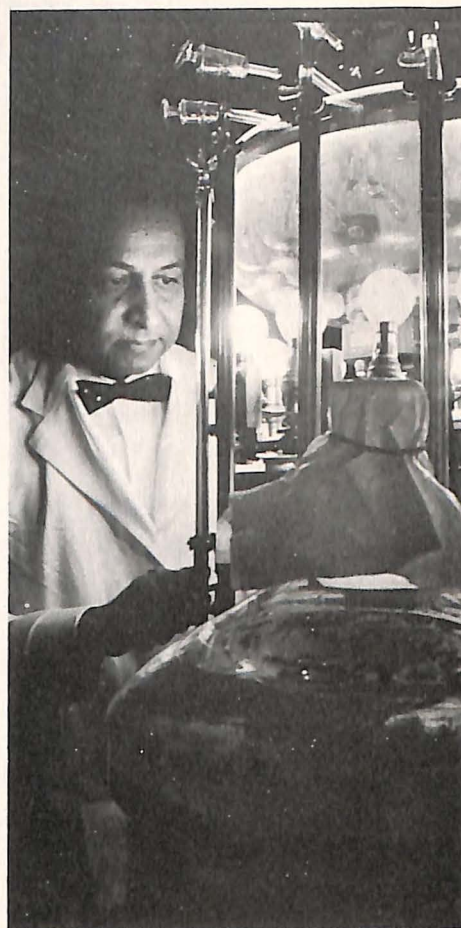
Some concepts are uncovered that have no immediate utility and are thus filed away for possible later adaptation. Other ideas have uses now or in the foreseeable future and are translated into applied development programs leading to production. These two systems of study—basic or “pure” research, and applied development—constitute the bulk of aerospace research.

Most of the basic aerospace research undertaken during the past 20 years has involved materials, techniques and design concepts. Whole new families of metal alloys, plastics, silicones and synthetic fibers have been discovered. Physical properties of substances, such as stress rates, torque—or twisting—strengths, thermal factors, and many more, have been examined and catalogued. New aerodynamic shapes have been exhaustively tested in wind tunnels to find the best designs for a variety of flight patterns.

Structural requirements present one of the most formidable problems to basic research, according to metallurgist David Goldberg, who has studied and worked with these concepts for 15 years. The 44-year-old manager of structural materials and processes with an industrial nuclear research laboratory in Pennsylvania says: “Sophistication has taken over in nuclear work. We have a new power source with lots of potential and everyone is trying to find uses for it. But there is really so much we don’t know about—things that only basic research can uncover. We don’t even know what uses will be required 15 years from now.”

Mr. Goldberg’s experience in working with rare metals goes back to World War II. Shortly after receiving his master of science degree in metallurgy from Stevens Institute of Technology, he was hired by the Battelle Institute of Technology to conduct metallurgical analysis of enemy weapons picked up from the battlefields of Europe and the Far East. By studying the metals in these weapons, Mr. Goldberg could determine not only what they were made of, but how they were put together.

“I remember toward the end of the war,” he recalls, “a situation involving a German field artillery



Dr. M. I. Hussain Aleem, a native of Pakistan, observes an experiment involving bacteria which may lead to development of improved instruments for detecting life in space. The experiment was conducted at a Martin Company facility.



AiResearch Manufacturing Company experts apply insulation around a vessel used for storing liquid oxygen and hydrogen at super-cold temperatures aboard spacecraft.



David Goldberg (right) is a metallurgist for Westinghouse Electric Corporation.



Optical techniques are used in polishing components for rocket engines.

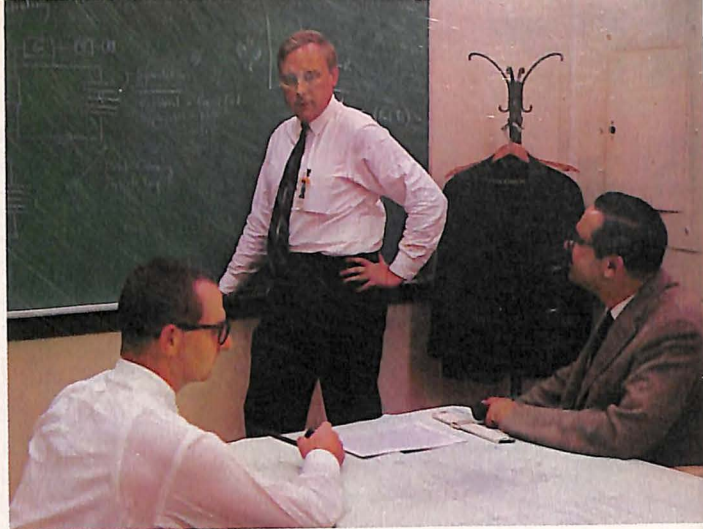
gun which came to us for analysis. We looked it over and found that it was held together with a gas-type of weld, rather than the tungsten welding process which produced a far better job on all of their earlier models. When we saw a few more of these gas weld jobs, we realized that the Germans were running short of tungsten."

Physical characteristics of metals are Mr. Goldberg's biggest difficulty today. "We know, for instance, that tungsten is brittle. But we still have needs for using it that require that it be bent to fit different shapes. So, we have been working on ways to make it malleable."

Working with Mr. Goldberg is Carroll Sinclair, a 37-year-old manager of systems development. His job is to take the results of research scientists and study their uses in the form of complete systems that can be applied to a variety of equipment. Drawing on his extensive educational background, which includes degrees in science from Yale University and the University of Pittsburgh plus a management course at Harvard University's Business School, Mr. Sinclair and his group use the systems approach to study a variety of ways in which nuclear energy can be adapted to the world of tomorrow.

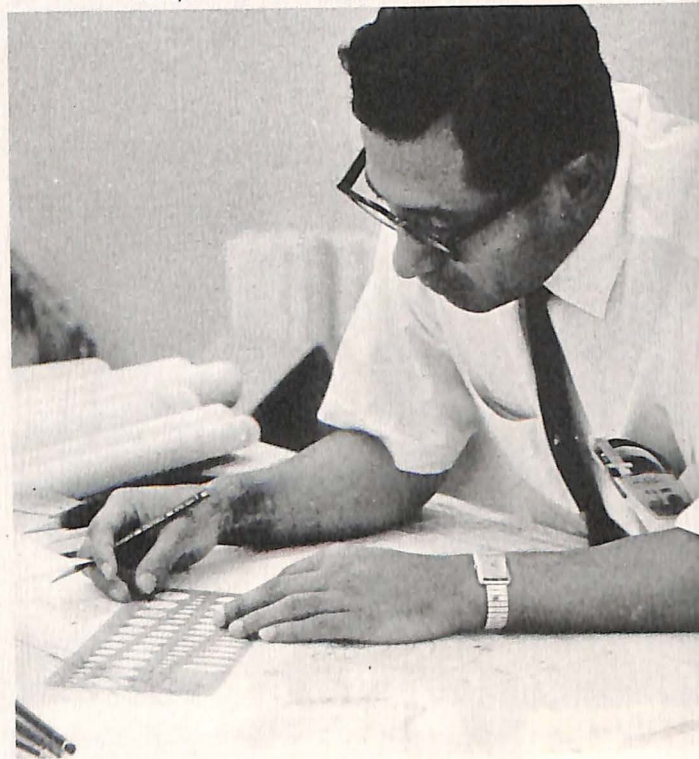
"To work out a concept using basic research findings and putting these together into a pattern with a purpose, you need to be able to analyze a lot of results, feed into these results the cost figures and then relate this to what you are ultimately trying to develop. This means, of course, that you do a lot of constructive arguing, lose a few points and win some. But in the end, you come up with a well-managed, carefully thought out project," he says.

Mr. Sinclair points out that the scope of aerospace research and development today has become so diverse in many fields that the concentrated educational base in any given field of interest may not have been advanced to the point of being applied to a project. In instances such as these, he says, the project must come first, and the research and development follows. "For example," he cites, "the federal government may have a particular problem related to a project involving the building of a piece of equipment on which no basic research knowledge is immediately available. The government will then ask industry if it has within its storehouse of know-how applicable research results. If no one has done this before, then an industrial firm is selected for the job, given a set of plans and specifications for a piece of equipment or process and told to study thoroughly everything about it, including the variety of ways it can be accomplished."



Carroll Sinclair (standing) is a manager of systems development and works with David Goldberg at a Westinghouse Electric Corporation facility.

George Cruz, an engineer-scientist for the Douglas Aircraft Company, designs a major component for a commercial transport aircraft.





Dorothy Shimasaki, a lead engineer, works on sealants for the Boeing Company.

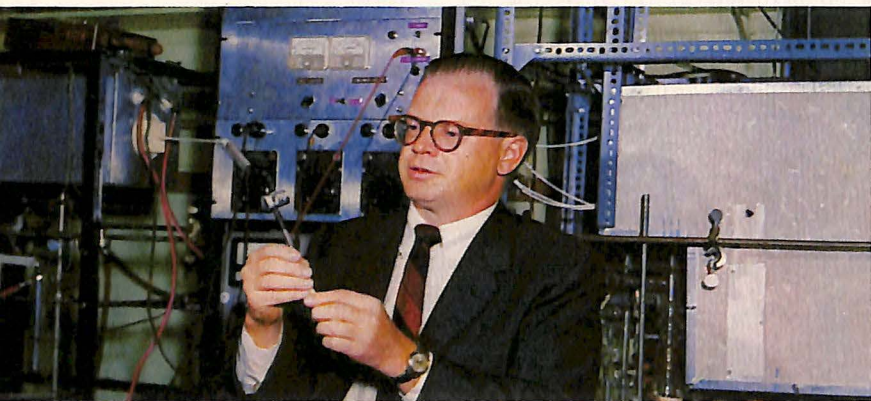
A Lockheed Aircraft Corporation technician operates equipment at the firm's electromagnetic laboratory and antenna ranges.



A close relationship is maintained by an industrial firm between its basic research people and its applied development group. "You simply have to know what they are working on in their departments," Mr. Sinclair says. "Otherwise, you may invest a lot of time, effort and money to develop a use for something, only to find that while you were doing this, the basic research people within your own plant had discovered a cheaper, better, more efficient method of doing the same job."

Cost and competition have become two of the most important factors in aerospace research. Be-

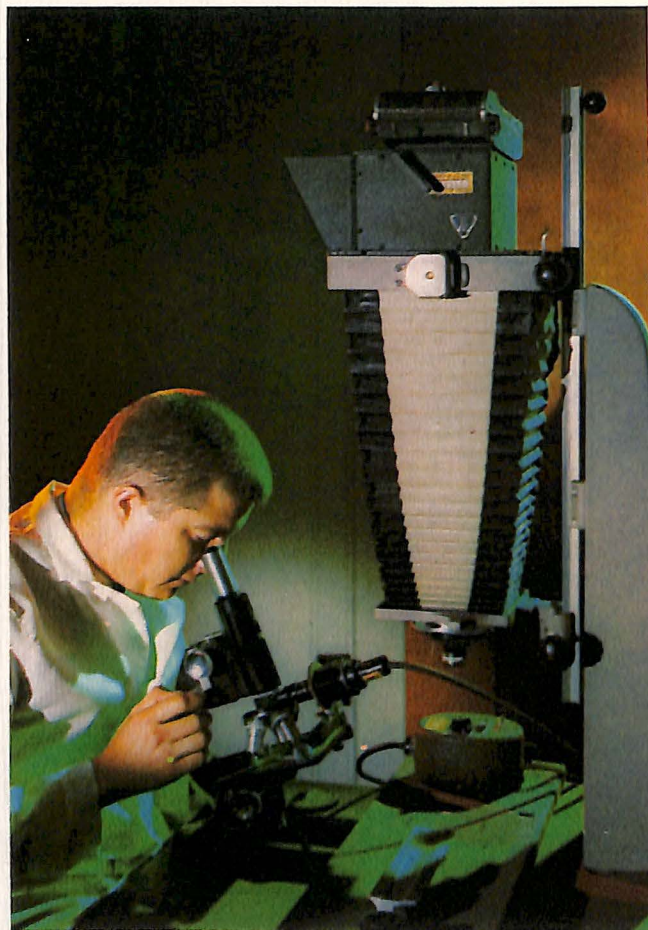
cause of the sheer volume of companies involved in research work in the United States today, it has become a critical problem for companies to keep abreast of the successes or failures of other firms working in the same technical area. Since aerospace firms finance some of the research work they perform—and these funds invariably come from a company's profits—it becomes a matter of necessary business judgment to know the point at which a research project must be discontinued for competitive reasons or accelerated if on the verge of a new discovery with profit-making potential.



Ivan Greenwood is the director of advanced development for General Precision, Incorporated.



Dr. Lakshmi Sanga, a native of India, studies actions of superheated gases at the Boeing Company's Scientific Research Laboratories.



A General Dynamics Corporation technician utilizes a precision microscope in a research project.

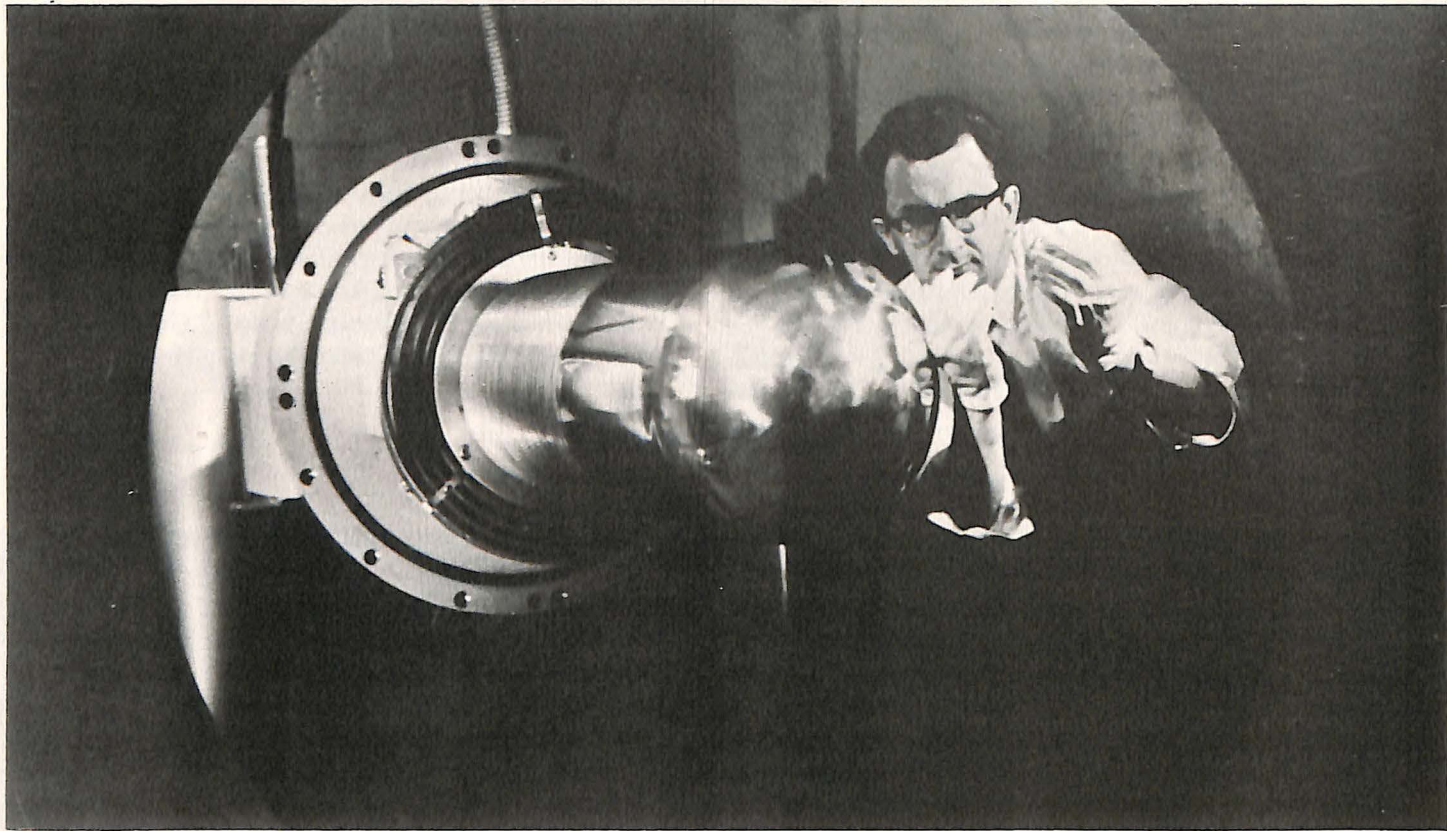
The aerospace industry has worked hard to maintain the proper environment in which research and development can accomplish its most productive results. This has meant, in some instances, almost complete physical removal from the factory and production environment to an isolated setting that makes research work easier. Such is the thought of Ivan Greenwood, director of advanced development for an instrumentation firm, whose research facilities are located on a former estate in New York. Involved in complex nuclear experimentation with guidance systems for spacecraft concepts, Mr. Green-

wood is a strong believer in the individual freedom of the research scientist.

"Here, we are trying to create both the ways and means by which new advances in man's knowledge can be accrued," he says. "There are many stumbling blocks along such a path. Among the biggest problems we face are the ways in which innovation is achieved. We know so little about what we are working on, compared to what remains to be learned." Mr. Greenwood adds: "The individual scientist, to fulfill his potential, must be free to use his mind."

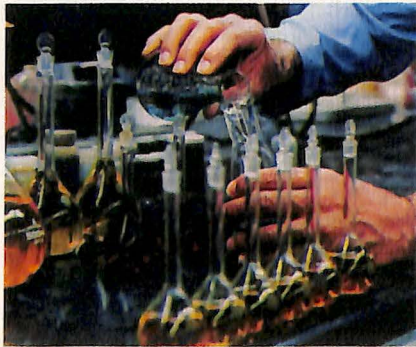


Charles Banning, United Aircraft Research Laboratories, makes a configuration change on a helicopter in a low speed wind tunnel.

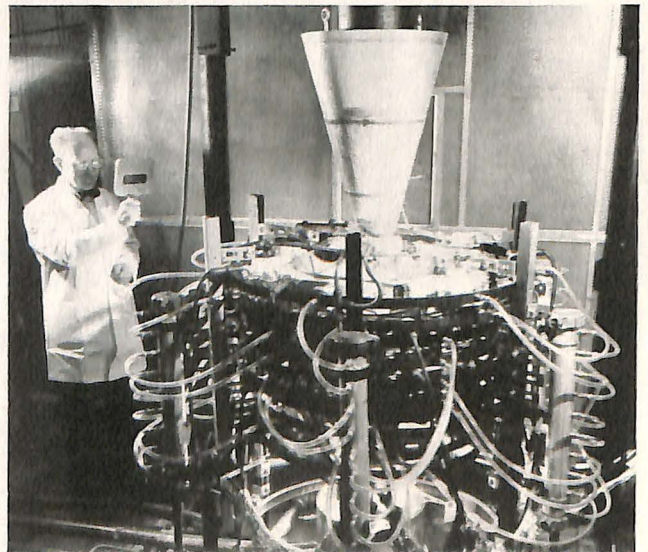


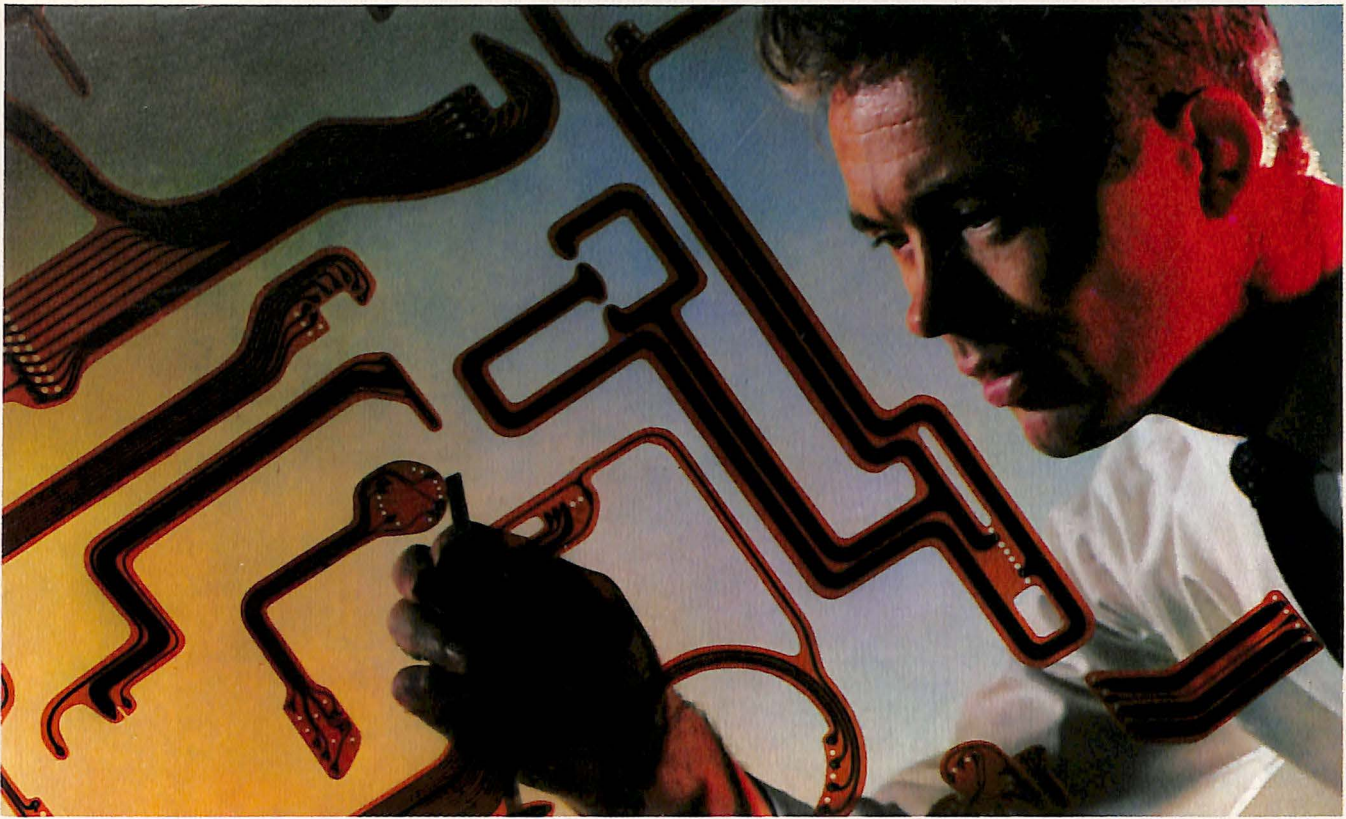
R. C. Hand, Radio Corporation of America, Defense Electronic Products, develops a 1-million-volt beam of electrons with a Van de Graaff accelerator.

Chemical processes are analyzed by a Ryan Aeronautical Company scientist. Aerospace chemists keep up to date with constantly changing requirements.

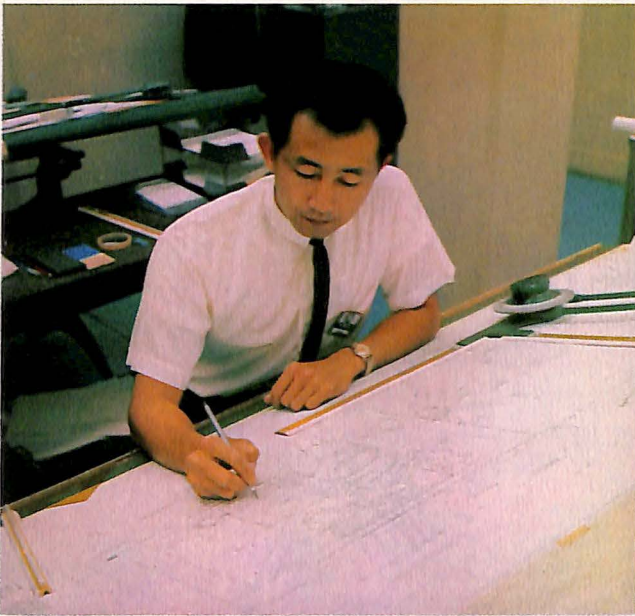


A Boeing Company research engineer uses a filter to protect his eyes while watching effects of high temperature on the model of a re-entry vehicle.

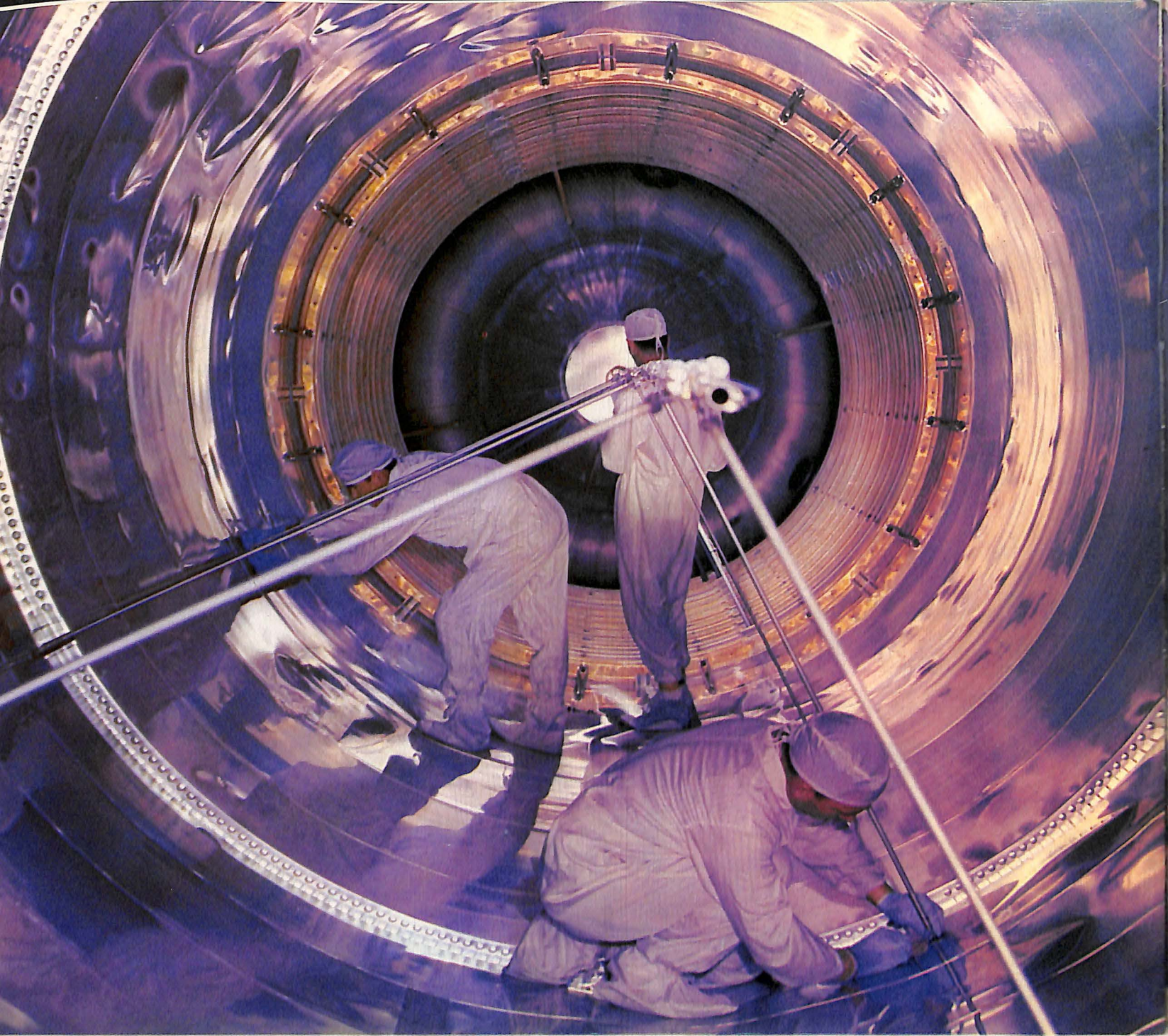




John E. Fennimore, a design engineer for the Martin Company, examines an inter-connection for an electronic system. Wiring is printed in copper on flexible plastic.



Robert Yamamoto, a designer for Pratt and Whitney Aircraft, works on components for jet engines.



General Dynamics Corporation technicians install instruments to measure the amount of liquid oxygen contained in a space launch vehicle tank.

Production

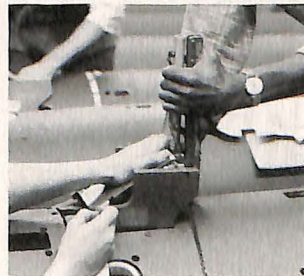
Putting together aerospace equipment today—whether it be a tiny electronic circuit, a jet transport aircraft or a spacecraft to go to the moon—requires a blend of traditional skills and new talents. These fabricating tasks are, however, being performed under a new set of production standards governing the quality and reliability of the equipment being produced.

Aircraft and missiles are assembled on a production line basis, using engines, components, systems and sub-systems, electronics, instrumentation, wheels, gears and a full range of assorted parts built by suppliers under contract to a prime contractor. The prime contractor puts together the piece of equipment from all of the parts. But making these separate components, as well as fitting them together, has become a highly refined art involving many individual employee skills.

The reliability of equipment today in every phase of aerospace manufacturing and in all product lines is only partly due to the emergence of more useful materials, processes being adopted and handling techniques being perfected. A major share of the credit must go to the industry's employees who have learned to use these materials and adopt these processes and techniques in their repertoire of talents. For aerospace equipment is only as dependable as the skill of the men and women assembling it.

These capabilities cover the widest scope of aerospace production activities from the oldest skills to the newest. The ancient art of the glassblower is still utilized. Making a variety of complex glass containers, tubing and vacuum vessels, aerospace specialist Carl Putnam uses the singular talent of "touch and feel" that has been accumulated over 40 years of his professional experience. "It is something you

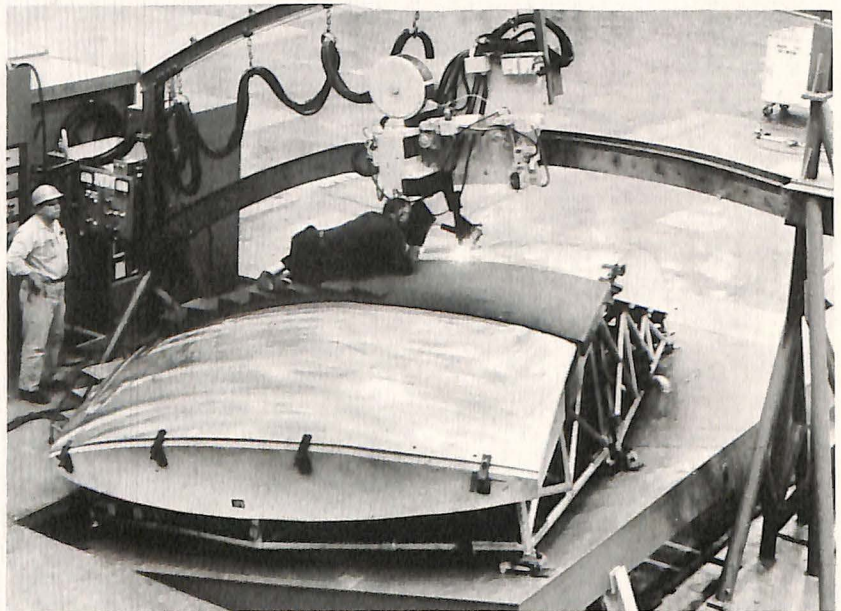
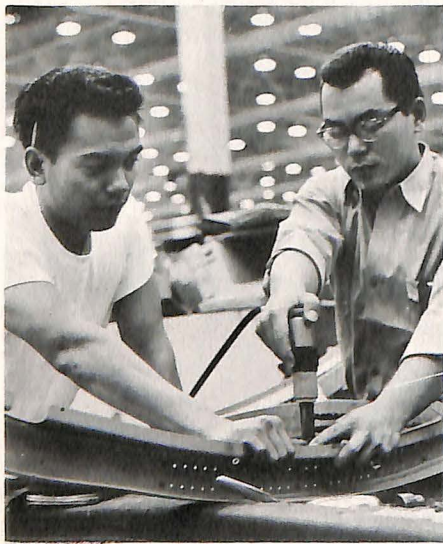
Carl Putnam, United Aircraft Research Laboratories, is a glassblower. This ancient art is still utilized in the aerospace industry.





Geraldine Croak, Piper Aircraft Corporation, has worked for twenty-five years in aircraft fabrication.

Conrad Villamor and Vern Ko rivet a door section for a Douglas Aircraft Company commercial airliner.



Boeing Company workers join sections of a tank used in a stage of the Saturn V moon rocket.

learn by doing," he says, "by trial and error, mostly error. You do a variety of work for about 10 years before you're good enough to handle anything that comes along in a glass shop." Few, if any, machines can duplicate the products of his craftsmanship.

One of the newest production skills involves the making of microminiaturized circuitry—tiny electronic parts that carry electrical impulses causing a piece of equipment to function. Some of these parts are so small they can hardly be seen. The workman who assembles them into such items as a missile guidance system does his job wearing a white smock, cap, gloves and shoes in an environment so free of impurities that it exceeds cleanliness standards of a hospital's surgery room.

While the production of spacecraft, missiles and related components utilizes the biggest share of new and exotic talents, the aircraft industry also has need of many of these talents as well as traditional skills

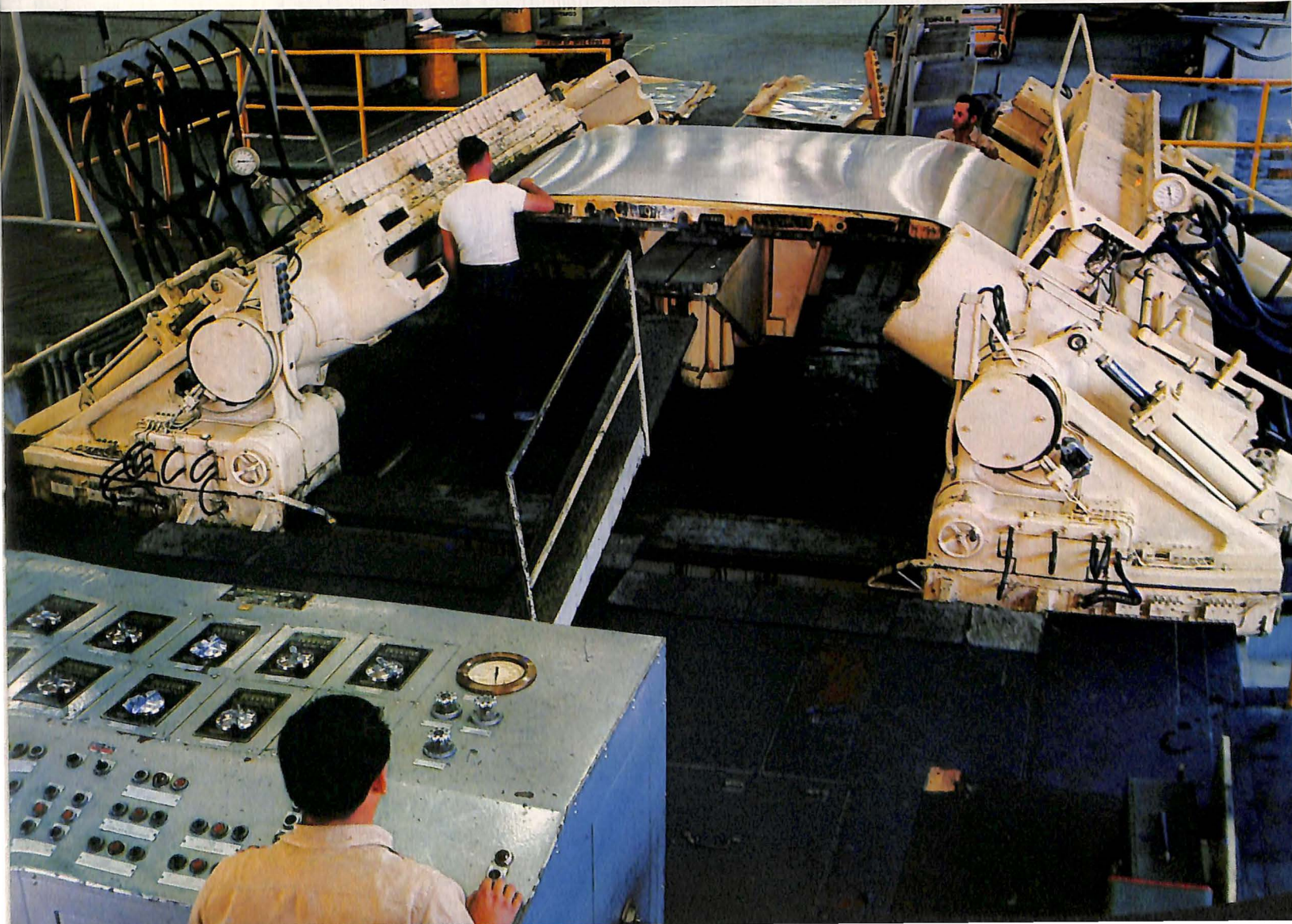
and trades, some of which date back to early days of the mid-1920's, before mass production was conceived for the aircraft industry. Miss Geraldine Croak has been gluing cotton fabric to the wings and fuselages of airplanes for 25 years at a Pennsylvania plant. She has seen the development and production of many types and models of fabric-surfaced aircraft. "But my job hasn't changed much over the years," she says. "The fabric we use now is better and easier to apply and it will last much longer than the material we used to work with. The dope or glue I use is also a better product today than it used to be. But I still stick the fabric to the frame in the same way I've always done it." Expertly applying a bolt of white cloth to the metal framework of an airplane's fuselage, hung on an overhead assembly line, Miss Croak completes four planes a day—an average of two hours per fuselage.

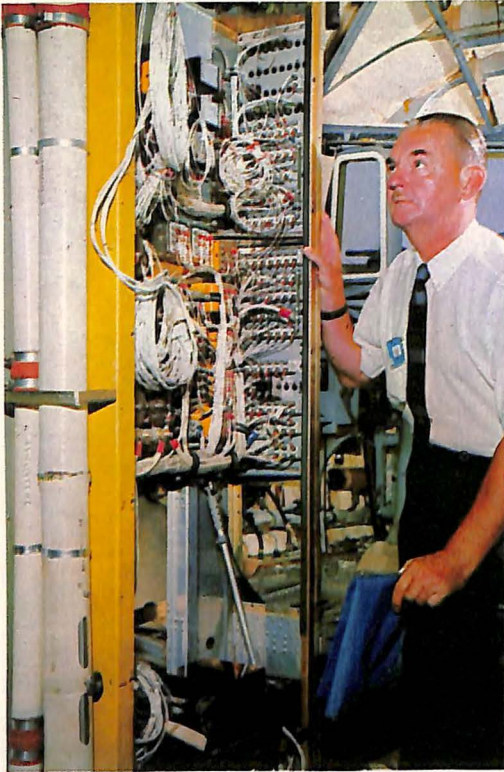
But even the third-generation skills still being per-

formed have been vastly improved by modern machinery, materials and processes. In the building adjoining the one in which Miss Croak works, veteran assemblymen, most of whom have worked their entire adult lives for this firm, are operating the drill presses, oxyacetylene torches and rivet guns they have always used. But, in this section of the plant, the whole construction technique is different. The tubular steel and fabric aircraft structure 'has been replaced by all-metal monocoque construction principles—a method of building airplanes using no braces but giving greater structural rigidity. The sheet metal worker here must now use a variety of new techniques, including pressure forming, drop hammer, stretch press and other novel means of bending and twisting aluminum for an airframe.

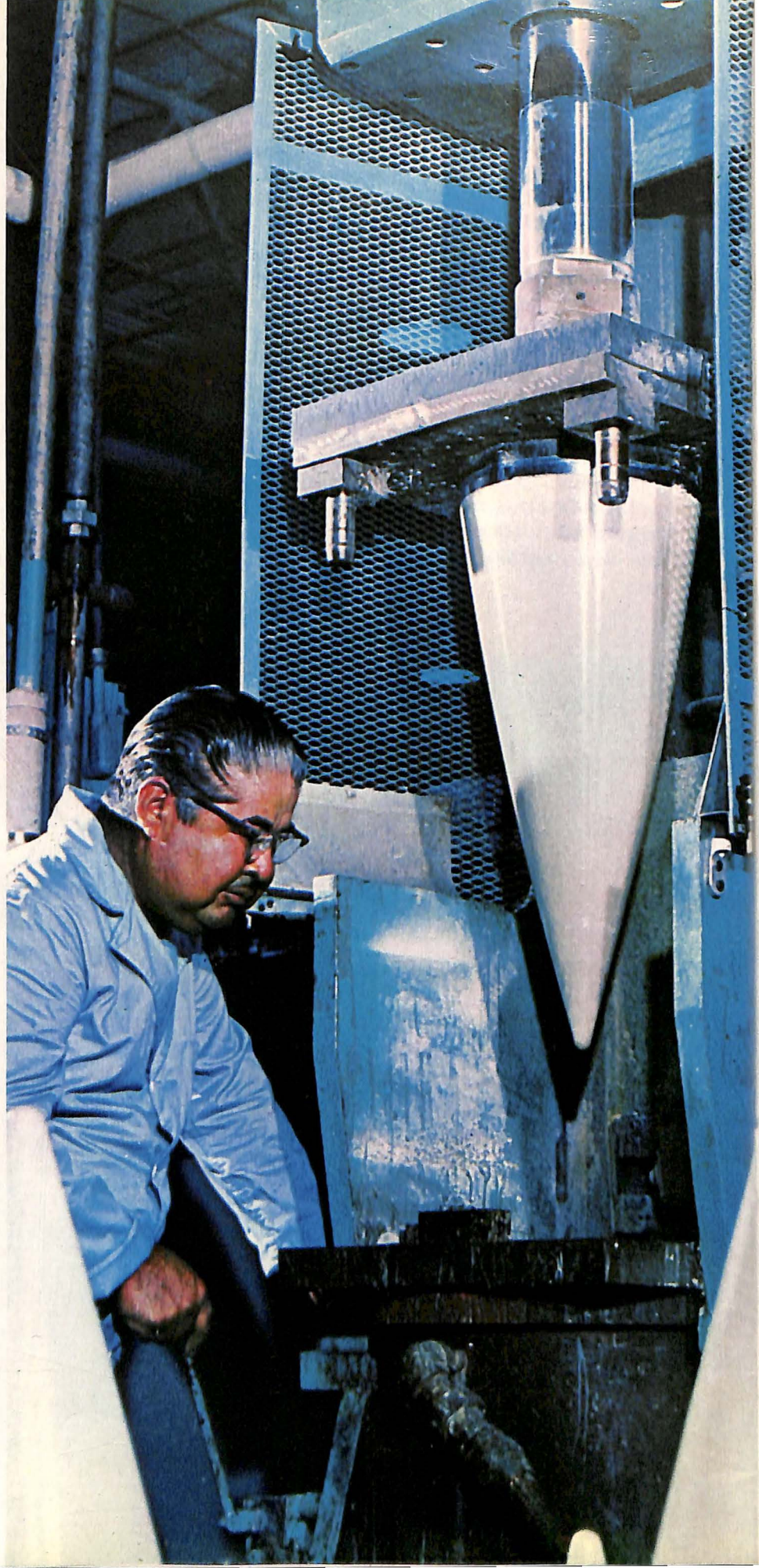
Finn Estlick, a general superintendent for an aerospace firm in Pennsylvania, sums up what these changes in aircraft manufacturing techniques mean.

A Douglas Aircraft Company stretch press, utilized in the production of space boosters and aircraft, is controlled from a console.





George Lewis, Fairchild Hiller Corporation, is manager of product quality and inspection.



“Building airplanes is about 70 per cent a custom-made, hand-made function, with each step of the way dependent on the skill of the assemblyman. As each new development has taken place over the last two decades, we have had to upgrade our own people’s talents to meet the requirements. And the next ten years will see even greater advances in manufacturing techniques—particularly in the area of more reliable materials such as fiberglass and plastics of all kinds.

“The keynote to successful aircraft manufacturing, to me, is a reliable, strong and economical product. Each succeeding generation of aircraft we build is a little stronger, more economical to operate and maintain, and a lot more reliable. In fact,” he concludes, “the past products of this business are its greatest competition. You don’t wear out an airplane.”

The production of large commercial transport aircraft requires—and gets—rigid quality control standards set by aerospace manufacturers and the federal government. George Lewis, manager of product quality and inspection for a Maryland company, has seen these rules, and the methods to attain them, expand and grow increasingly strict in the 26 years he has spent in this business. “When I started in this work, the industry was making wooden airplanes and it was a real adventure to be working on them,” he reminisces. “Production wasn’t done on an assembly line but in small one-shop plants making nearly everything that went on the airplane, including the engine. This didn’t change much with the newer all-metal structures, because the engines just were not powerful enough to push planes through the air at high speeds.

“But when aircraft engine horsepower began markedly to increase in the late 1940’s, the whole structural requirements for airplanes needed to be updated. We’ve been doing this ever since—in one way or another.” Standing in the midst of a jumble of multi-colored wires inside a passenger aircraft being readied for delivery to a commercial airline, Mr. Lewis spoke with authority as he concluded: “The precision with which this aircraft is put together would stagger the imagination. We check every part as it is installed, and inspect its fittings with the parts it joins. If it’s a moving part, we move it many, many times during production. For when a plane rolls off



Douglas Aircraft Company technicians weld a section of a Saturn booster stage.

A Bendix Corporation technician uses a special gun to bond plastic loops around electrical circuits.



◀ A Ryan Aeronautical Company technician works with heat-resistant resins to achieve metallic to non-metallic bonding.

the end of the line, everything on it is guaranteed to work. Our whole reputation is at stake."

The job of building and assembling a spacecraft is the newest and one of the most difficult of all aerospace production jobs. A satellite is a package of electronic devices, tubing, switches, instrumentation and experiments—linked into a compact, functional unit by miles of circuitry. Each of the parts that goes into it must be constructed with painstaking care, with attention given to the most minute detail.

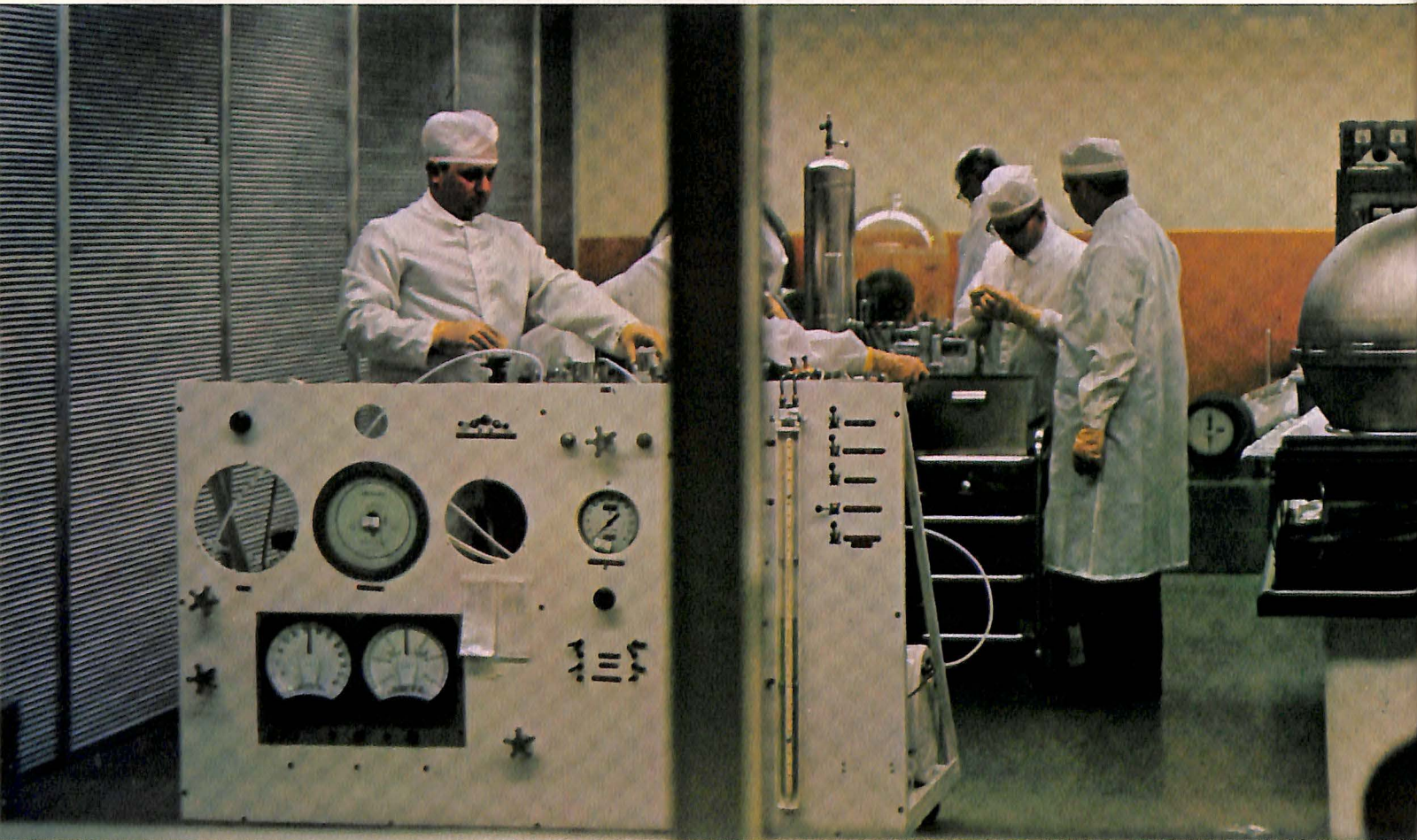
For example:

In a sterile room, a spacecraft assembly specialist delicately attaches a magnetometer to the end of a telescoping boom rig which is fastened to the body of a satellite. This special piece of equipment being

attached is no bigger than a basketball, yet contains tiny instruments capable of detecting and recording strengths of magnetic fields of particles being emitted by the sun. The fabricating task of this spacecraft assemblyman seems simple: attach a relatively lightweight instrument to the end of a spring-loaded shaft in a manner that will guarantee proper deployment of the instrument once it is in space.

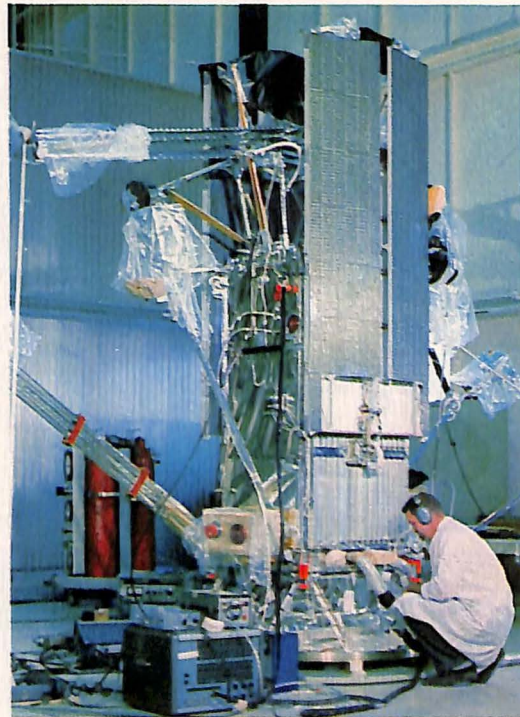
But the job is infinitely more complex. For the boom and its magnetometer, folded during launch, will deploy in an airless void. The special dry film lubricants must "grease" the concentric sections of the boom, which fit into each other with tolerances of less than one-millionth of an inch. Too much lubricant and the boom will snap out to its full length

AiResearch Manufacturing Company engineers and technicians assemble a spacecraft life support system in an atmosphere that exceeds hospital cleanliness standards.



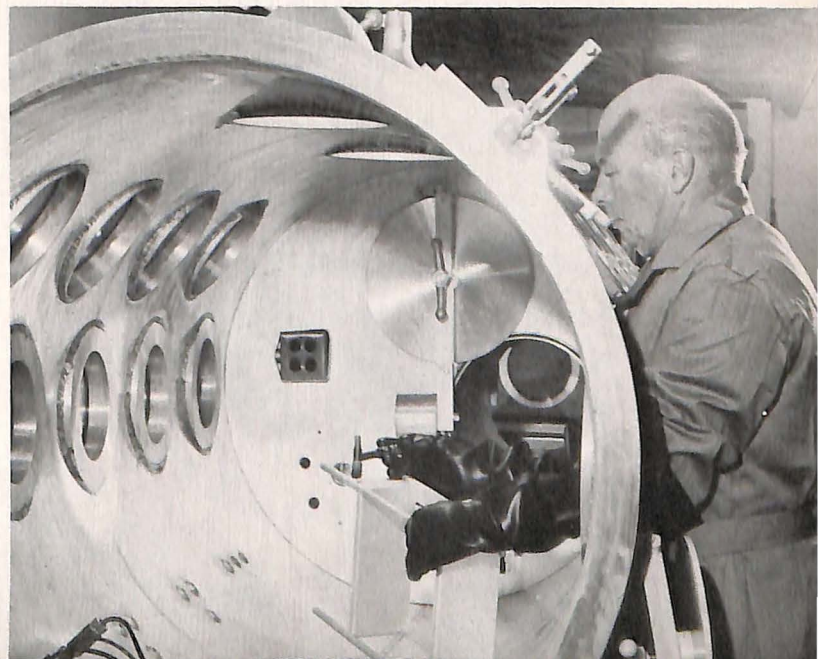
with such force that the magnetometer's direction will be upset, rendering the instrument useless; too little lubricant and the boom won't deploy. It is the job of a technician with great skill.

Industry assemblymen who work on spacecraft to be manned by astronauts have the added burden of knowing that the survival of a man may well rest on the reliability of the product they construct. But safety of a future pilot does not override the flood of technical considerations for spacecraft production. For example, weight of the spacecraft has become a governing factor in every design or production decision. Payload weight is the chief problem facing Paul Henton, structural designer of the Lunar Module at a Long Island, New York, aerospace com-



An electrical technician, TRW Incorporated, makes final adjustments to insure the capability of a spacecraft to deploy properly in space.

Lockheed Aircraft Corporation research engineer Frank Adgate demonstrates how a vacuum chamber permits automatic welding of very hard space age metals.



pany. "We have become incredibly weight-conscious in building the LM," he explains. "Every pound we can save by eliminating a strut or using a lighter material means a pound more fuel we can add for a little better safety margin for the mission."

Production of missile systems requires an equally large variety of specialists, trained in scientific doctrines such as ballistic aerodynamics, high-acceleration fuels, stress and gravity factors, and microelectronics.

Such an expert is S. S. Chin, a chief aerodynamic engineer for a firm in Florida. Born in China, Mr. Chin has spent his entire career in the rocket field. "When I began working in this area, we had very little data to work with other than captured German data picked up at Peenemunde after the war," he says. "We've come a long way in 20 years, but there is still so much we don't know, so much we can't do yet. If anything, we have a shortage, not a saturation, of talents in this business."



Paul Henton, Grumman Aircraft Engineering Corporation, is a structural designer for the Lunar Module.

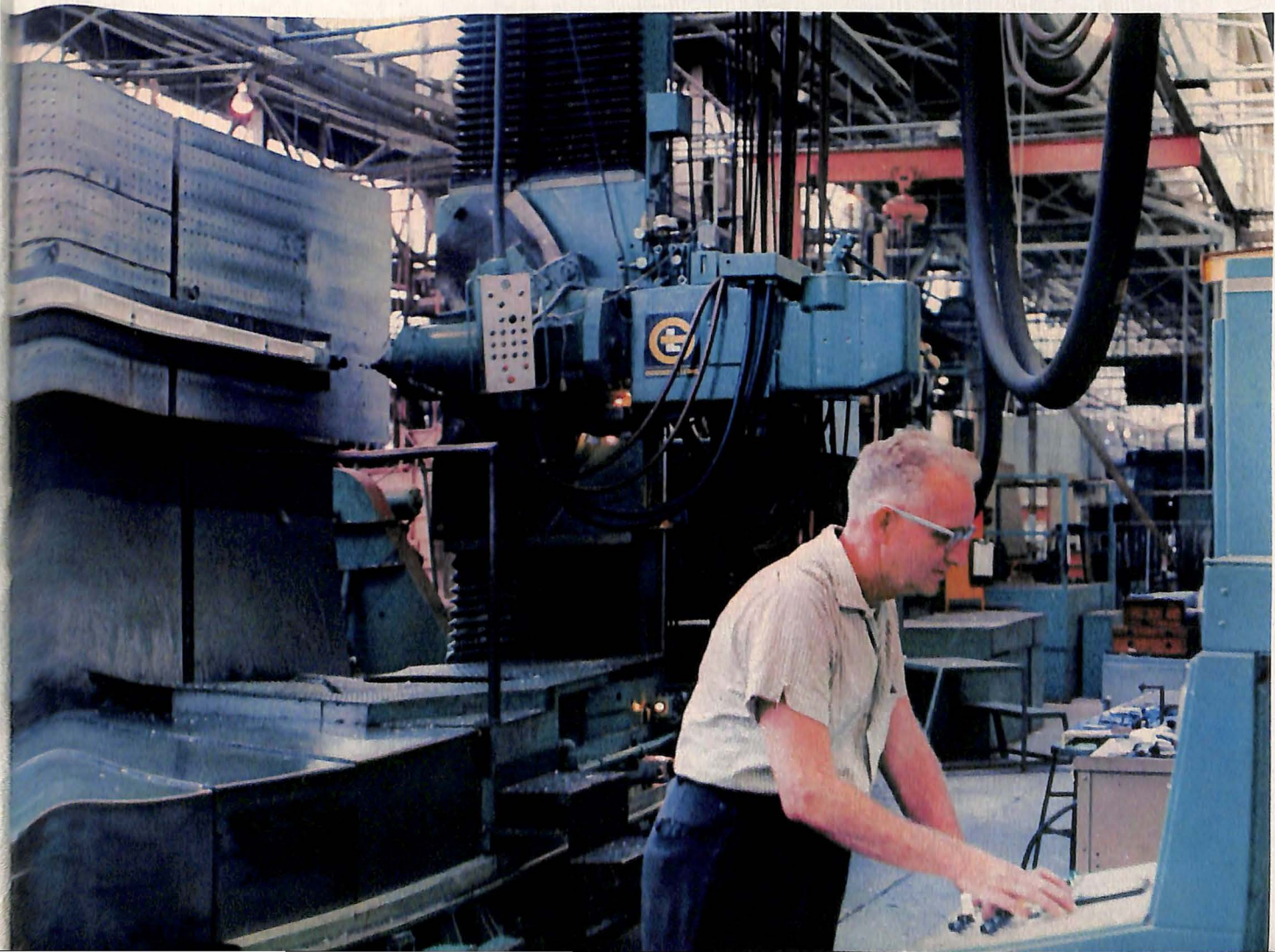


S. S. Chin, Martin Company, is a chief aerodynamicist who has spent his entire career in the rocket field.



General Dynamics Corporation draftsmen are a key part of the engineering-production team for a high performance fighter aircraft.

A Ryan Aeronautical Company craftsman starts a tape-controlled machine which makes complex parts for an advanced aircraft.



A production technician for the Sikorsky Aircraft Division of United Aircraft Corporation spot welds parts for a helicopter.





An Aluminum Company of America production worker welds forgings for a liquid rocket engine.

A descent engine for the Lunar Excursion Module is machined by a Ryan Aeronautical Company technician.



These huge Aluminum Company of America forgings form the backbone of a new long-range transport aircraft.

Test and Evaluation

A Douglas Aircraft Company engineer prepares a test in an anechoic (soundless) chamber which is used for studies on aerospace structures.

Strapped securely into the cockpit of a jet fighter aircraft, Jim Philbin carefully checks his instrument panel, notifies the tower and taxis the powerful plane into takeoff position at a Long Island base.

This is not just another airplane. This is the prototype model of an experimental jet fighter, taking off for the first time. And Jim Philbin is not just another pilot. He is an experimental test pilot, an aerodynamic specialist and a valuable employee of an aerospace company.

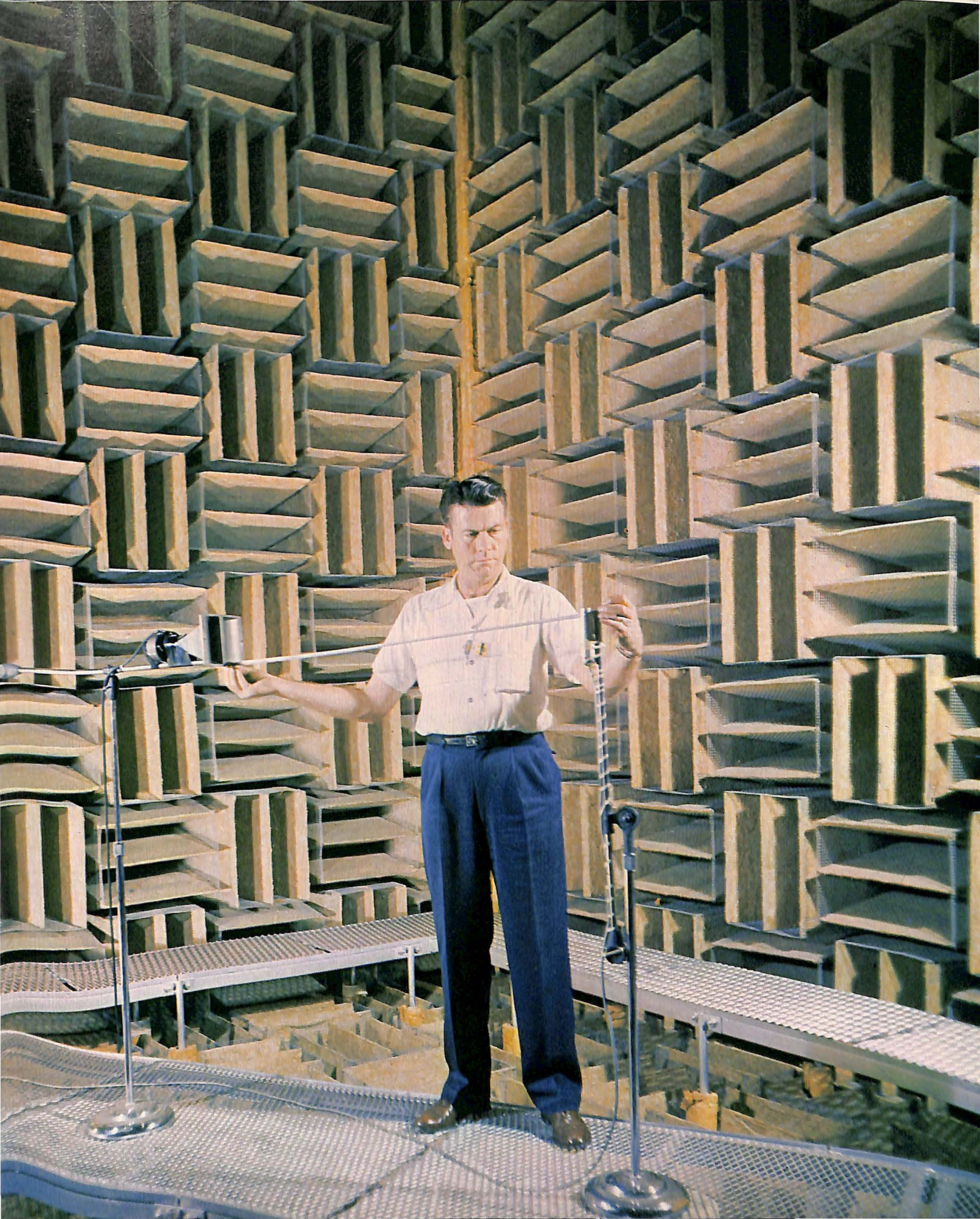
Mr. Philbin is qualified to fly every type of jet aircraft in his company's inventory. But flying is only a small part of his job. The emphasis today is on engineering and scientific analysis of every detail of the aircraft, from its inception on a drafting board throughout the entire test and evaluation flight program.

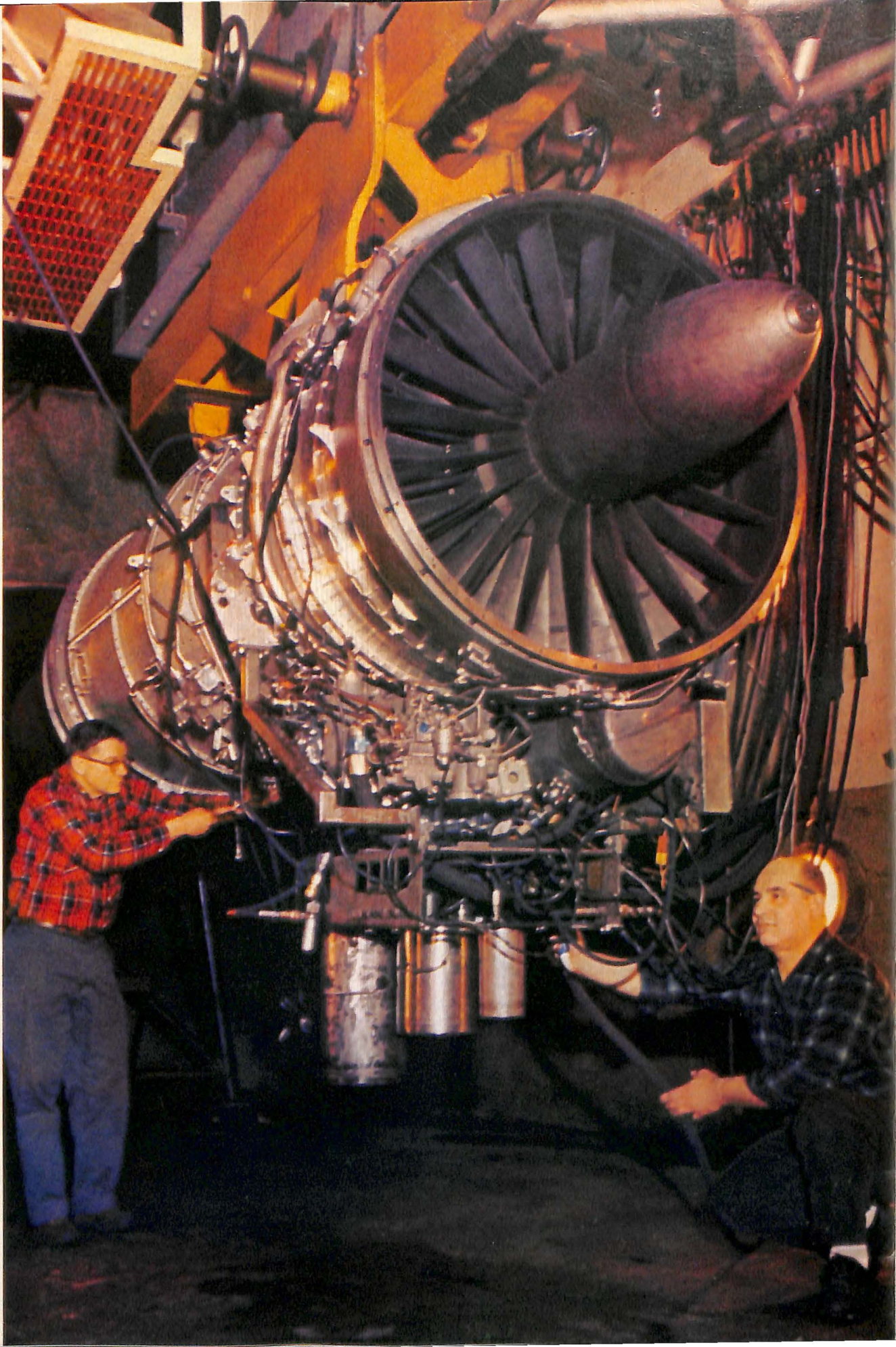
"Flying has become a business in every sense of the word," he says. "You can't evaluate problems and solve difficulties today—either in the air or on the ground—without thorough educational training. I'm not negating the value of practical experience. There's no substitute for that, particularly in flying high-speed jet aircraft. But there is so much more to



Jim Philbin, Grumman Aircraft Engineering Corporation (left), is a highly-trained test pilot as well as an aerodynamic specialist (below).







this job that demands knowledge, not manual dexterity. For example, I have to prepare reports, studies and summaries of aircraft performance, suggest ways to improve flight characteristics, analyze the structural integrity of the plane, edit manuals before the plane is turned over to a customer, train their pilots, and assist in any revisions or modifications that become necessary at a later date."

The academic approach to test pilot work with high-performance aircraft must, however, be balanced well with actual experience in operational flying. The supersonic jet fighter, equipped with complex fire control systems and a dozen weapons choices, requires an extraordinary degree of flight proficiency which, in many cases, can only be found in the seasoned professional test pilot.

Two of the aerospace industry's most noted test pilots are Herman "Fish" Salmon and Tony LeVier. Employed by the same company in California, both of these 52-year-old men have studied their specialized trade for the past three decades, and today are experts in many technical fields.

Mr. Salmon, now chief engineering test pilot, describes a test pilot's job this way: "The test pilot is called upon to evaluate everything from a human's ability to read instruments to the task mission profiles for which the aircraft was designed. He must be an expert in such fields as maintenance design, stability and control of aerodynamic structures, special stability devices for power control and response, and must even be able to design safety equipment for crash survival." This is only part of the job for Fish Salmon. He must also assist with market analysis, flight simulation studies and a wide variety of industrial tasks keyed to corporate planning.

Because of the increasing specialty roles in test flying, he sees many changes in the years ahead. "In the future, company engineering test pilots, I think, will be required to be graduates of an accredited test pilot school. They will need at least two years of military test and evaluation, and experience in many different types of aircraft. Age of the test pilot is becoming less of a factor, with experience the prime concern in the limited but expensive approaches to aircraft testing."

Mr. LeVier, who has been flying since he was 15 years old, is a "seat-of-the-pants" pilot (one of those who learned to fly by "feel" first and later by instruments), whose career includes barnstorming and charter flights. Now director of flying operations, he



A Boeing Company crew takes an experimental hydrofoil on a test run.



A Lockheed Aircraft Corporation engineer tests an aircraft structural part.

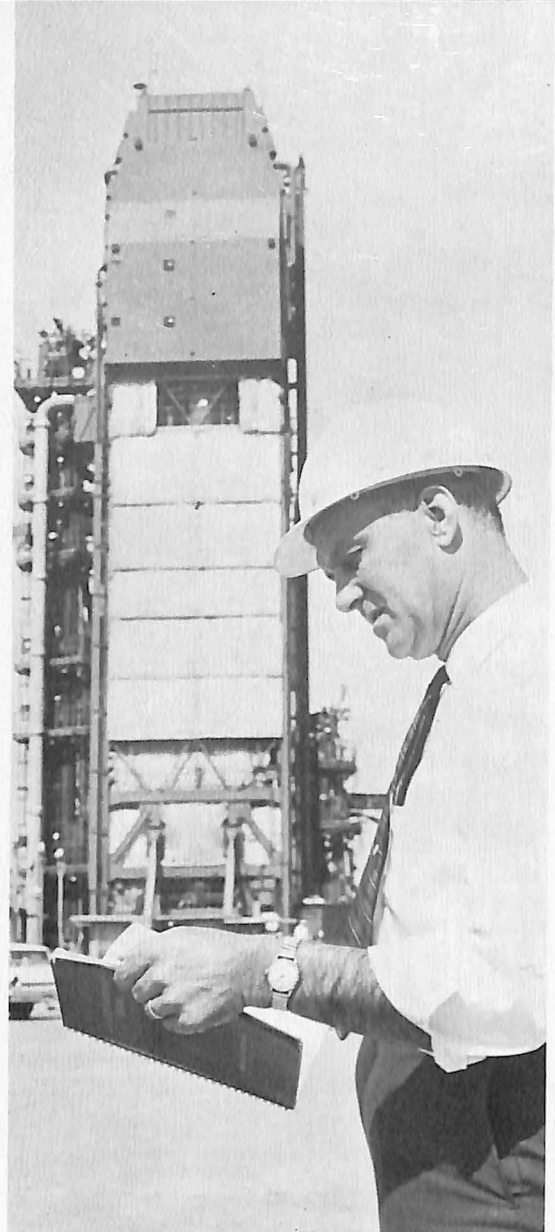
believes a test pilot must be a good pilot first and an engineer second. The work for Mr. LeVier today is more specialized than it was a decade ago, but it still stresses first a pilot's judgment. "Look at what we do today in test evaluation. There is the first flight of any new aircraft. Then comes stability and control tests, structural examination such as dives, stalls, spins and related post-stall gyrations—and all at very high speeds for maneuvers that can get very delicate sometimes. Then comes performance testing, weapons system evaluation and development, and training those who will have to fly the equipment. Of course, most pilots breaking into industrial test and evaluation have aeronautical engineering degrees, but this is balanced with experience level that you only get by flying the aircraft. There aren't any books that tell you what it feels like to put a supersonic fighter plane into a series of aerobatic maneuvers at Mach 2 (twice the speed of sound). Test pilots for tomorrow's aircraft will need to be better trained, if not better educated. The new design changes coming along all the time make it mandatory for everybody to continually keep studying. Pilots, on the whole, however, seem to adapt well to changes that come along."

Aerospace test and evaluation today is a part of disciplines beyond aircraft flight characteristics. Astronautics utilizes a variety of test and evaluation specialists in such areas as missiles, space simulation, and aerospace biomedical studies.

Norman Brady, who works as a rocket launch vehicle "chaperone" at Cape Kennedy, Florida, for an aerospace manufacturer, is responsible for the separate function of every one of 10,000 parts which make up a specific rocket produced for the manned space flight program. More than that, he must monitor the construction and complete test procedures of the whole system through to its final launching. In fact, his job doesn't end until all of the launch telemetered data have been evaluated to see if the rocket did its job as planned.

"My job is to make certain that every problem, big or small, encountered during production and testing is followed up and the proper corrective action taken," Brady says.

"If I, as the rocket's chaperone, am not satisfied with a procedure concerning a rocket, I can order the whole job repeated until I am sure it meets the rigid standards set for a rocket system that will launch a man into space. I learn to live with this project and with my special rocket. The relationship becomes very personal over the year or so it takes to build, test and launch it."

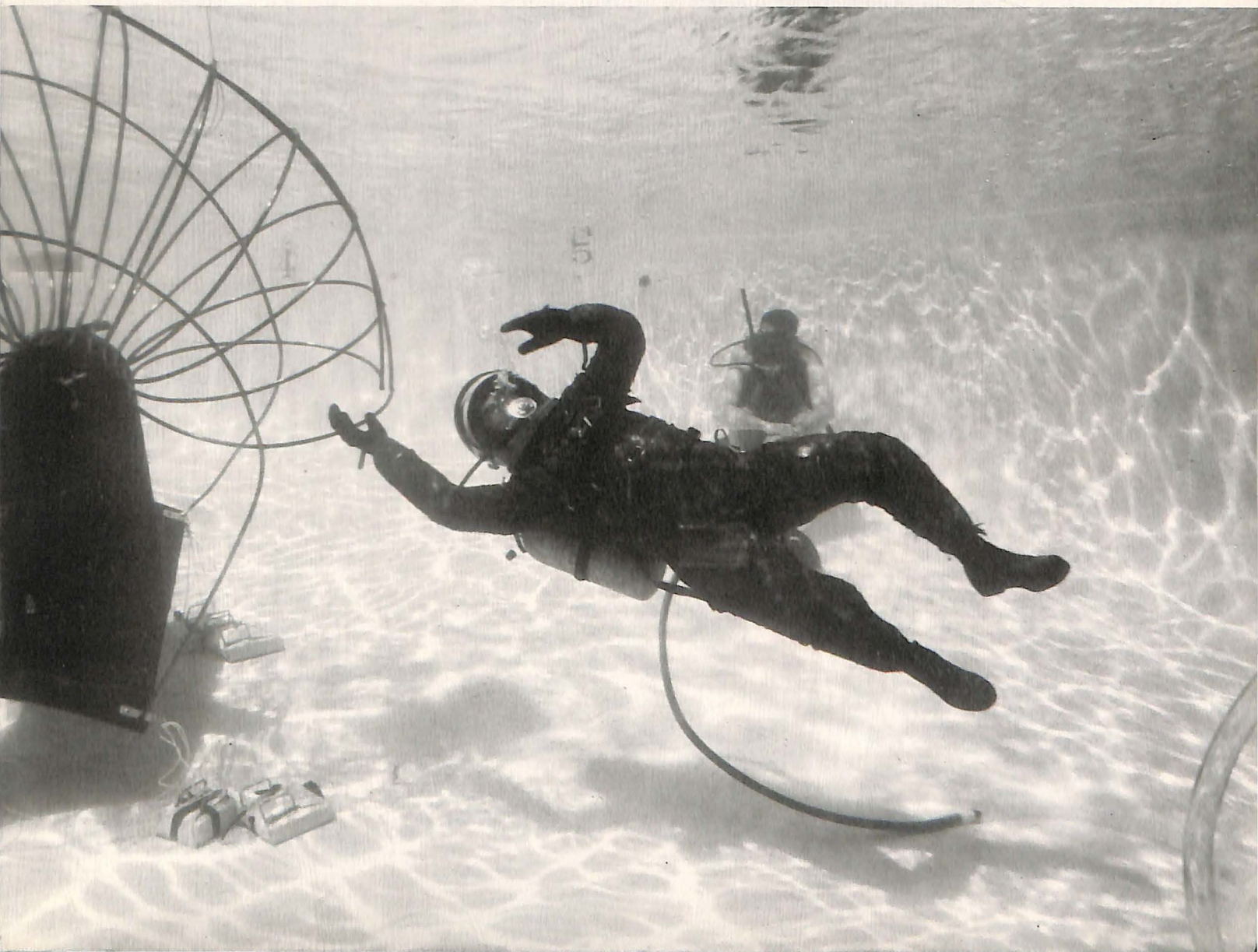


Norman Brady, Martin Company, is a rocket launch "chaperone."

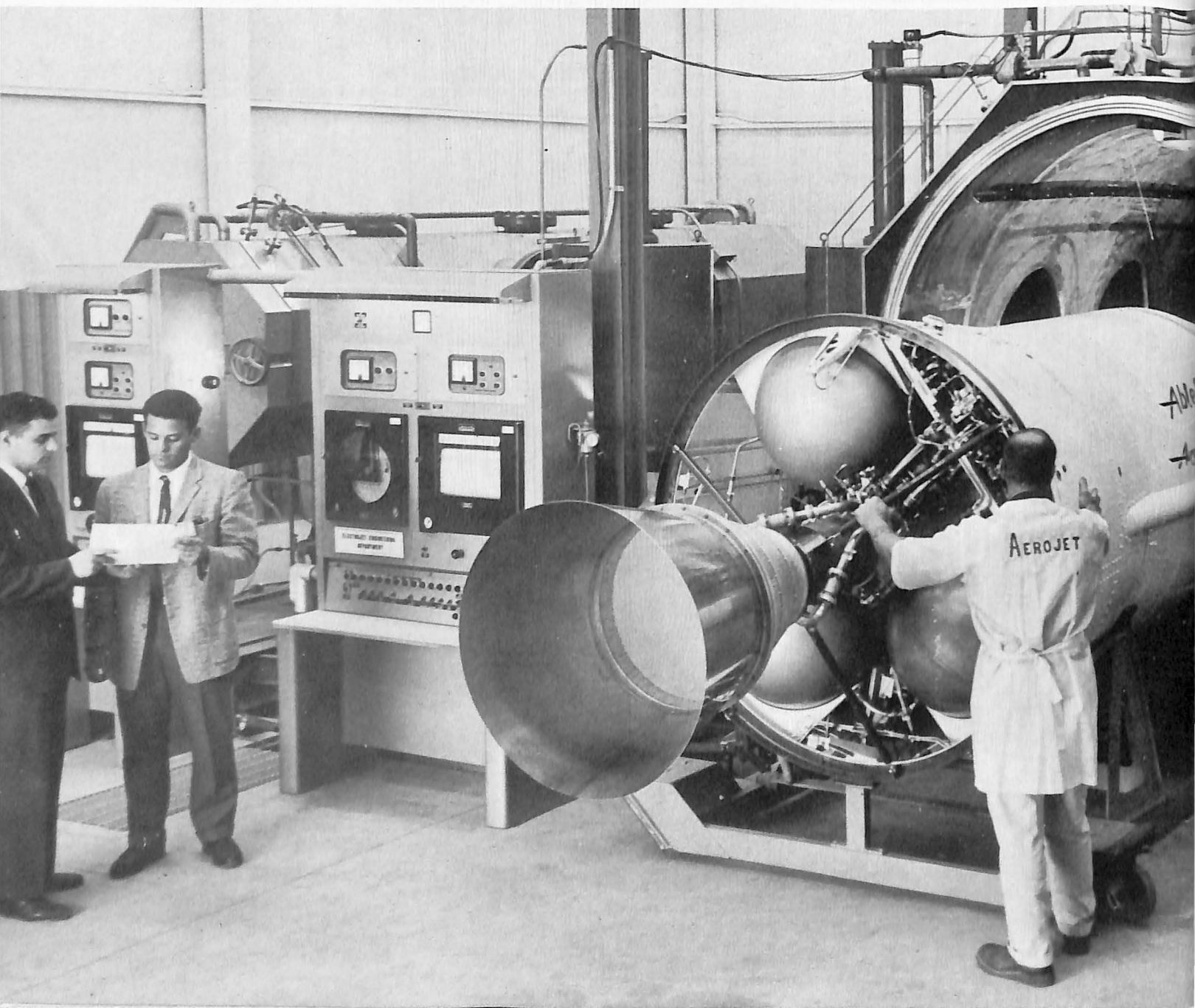


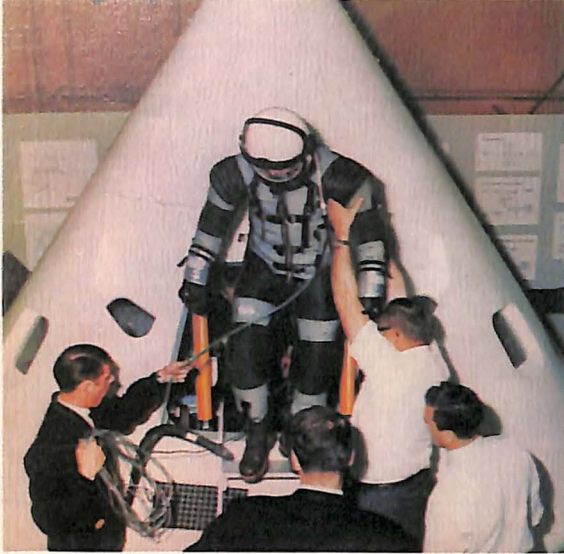
A Lockheed Aircraft Corporation technician checks gauges during a complicated test of aerospace equipment.

General Dynamics Corporation engineers test space suit mobility in an underwater experiment designed to simulate the weightlessness of space.

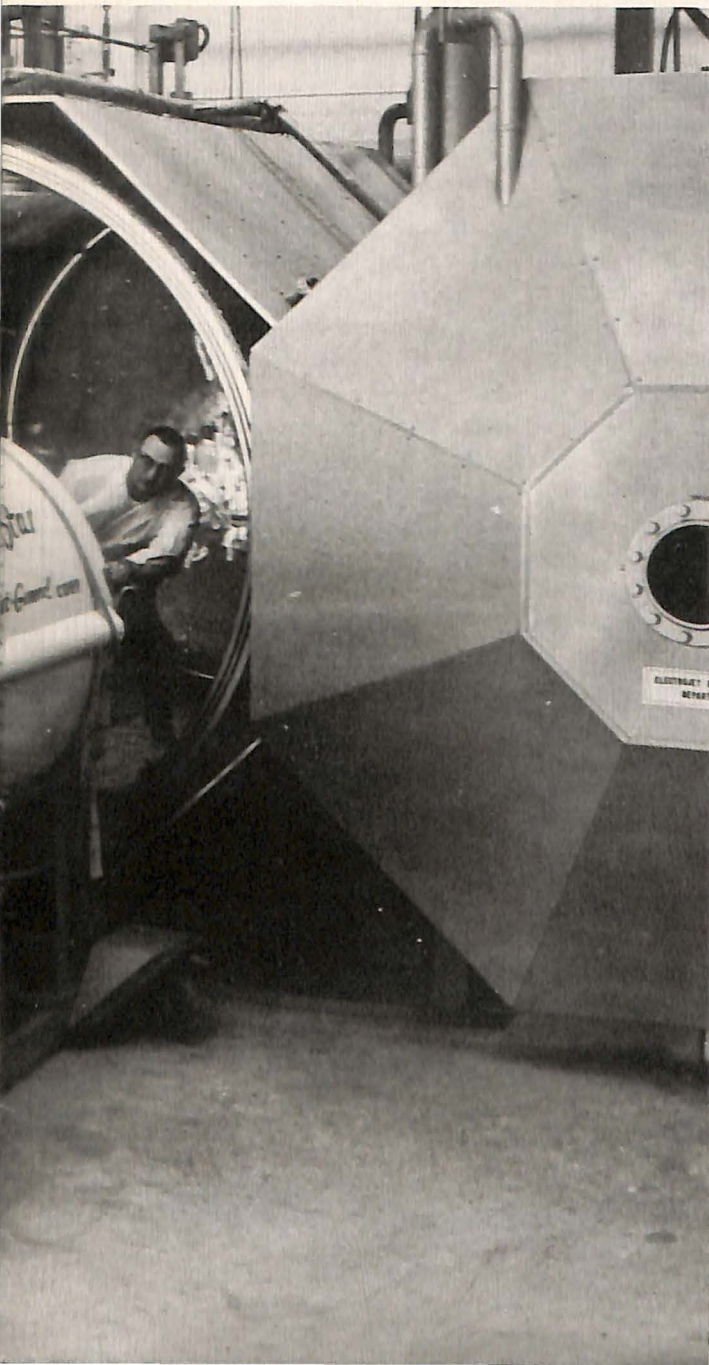


The upper stage of a satellite launching vehicle enters a space environmental chamber for a simulated flight to determine reliability.





North American Aviation engineers check an experiment for the Apollo manned space flight project.



Clayton L. Scott, chief production test pilot for the Boeing Company, prepares to fly a new commercial transport.

Summary

This has been a brief look at the skills used by the aerospace industry of the United States. Today these skilled workers are the performers of miracles, the transformers of concepts into realities. What of the future?

Employees and their companies are already expanding their goals and visions of the next 50 years, and are planning ways to meet what promises to be their greatest challenges.

Already on the drawing boards are such wonders as the supersonic transport, which will be able to carry passengers from New York to London in three hours; space exploration stations to be placed in orbit around the Earth and on the surface of the moon and planets in our solar system; and a complete inventory of space satellites with applications for advanced weather prediction and communications on a global basis.

In the field of space exploration alone, industry has begun to respond to future requirements with designs for space projects that will follow the Apollo program. The studies, while still in the early conceptual stage, envision permanent stations on the surface of the moon, capable of supporting a scientific expedition for many months; interplanetary manned space vehicles; trips to the most distant parts of our solar system, and perhaps beyond, within the lifetime of the explorers; and concepts for a global communications satellite system, able not only to link by voice and television all parts of the world, but also to transmit great quantities of data.

All of this lies in the future—much of it more than a decade or two away.

Today, technological and scientific knowledge of the U. S. aerospace industry has been expanded to begin the first chapter in the scientific exploration of a new and challenging dimension—the world's

oceans. Abilities have been demonstrated for the desalination of sea water; geological and mineralization studies have begun, as well as man's first attempt at long stays on the ocean's bottom.

Aerospace companies have found a way to apply the wealth of knowledge to concepts not related directly to science and technology. Even now, they are seeking ways to ease the congestion of increasing urban populations, searching for methods to conquer air and water pollution, planning high-speed transportation systems, developing an information flow system to combat the crime rate, studying methods to divert the world's waters to arid, barren lands.

And what kind of people will be needed as these developments begin to take shape?

Their characteristics will be like those of the individuals making up today's aerospace work force. Their standards of living may be slightly better, but their basic motivations will be the same. Within a collective unit, however, their roles will be greatly changed. For as the difficulty of the job to be done increases, so will the need for total professional competence, flawless craftsmanship and absolute reliability of production by the men of the future. They must and will accept this, for change is the essence of innovation.

But it will be more than just change. It will be progress. In the words of Dr. Abe Silverstein, director of NASA's Lewis Research Center in Ohio: "Change is the basic continuing dynamic of the universe. We are not privileged to accept or reject it. It occurs. Progress, then, is not just a growth of technological skills or material wealth. It is an advancement toward excellence in every aspect of our lives, and a striving toward a culture and civilization that will recognize both the grandeur of the universe and the dignity of man."



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