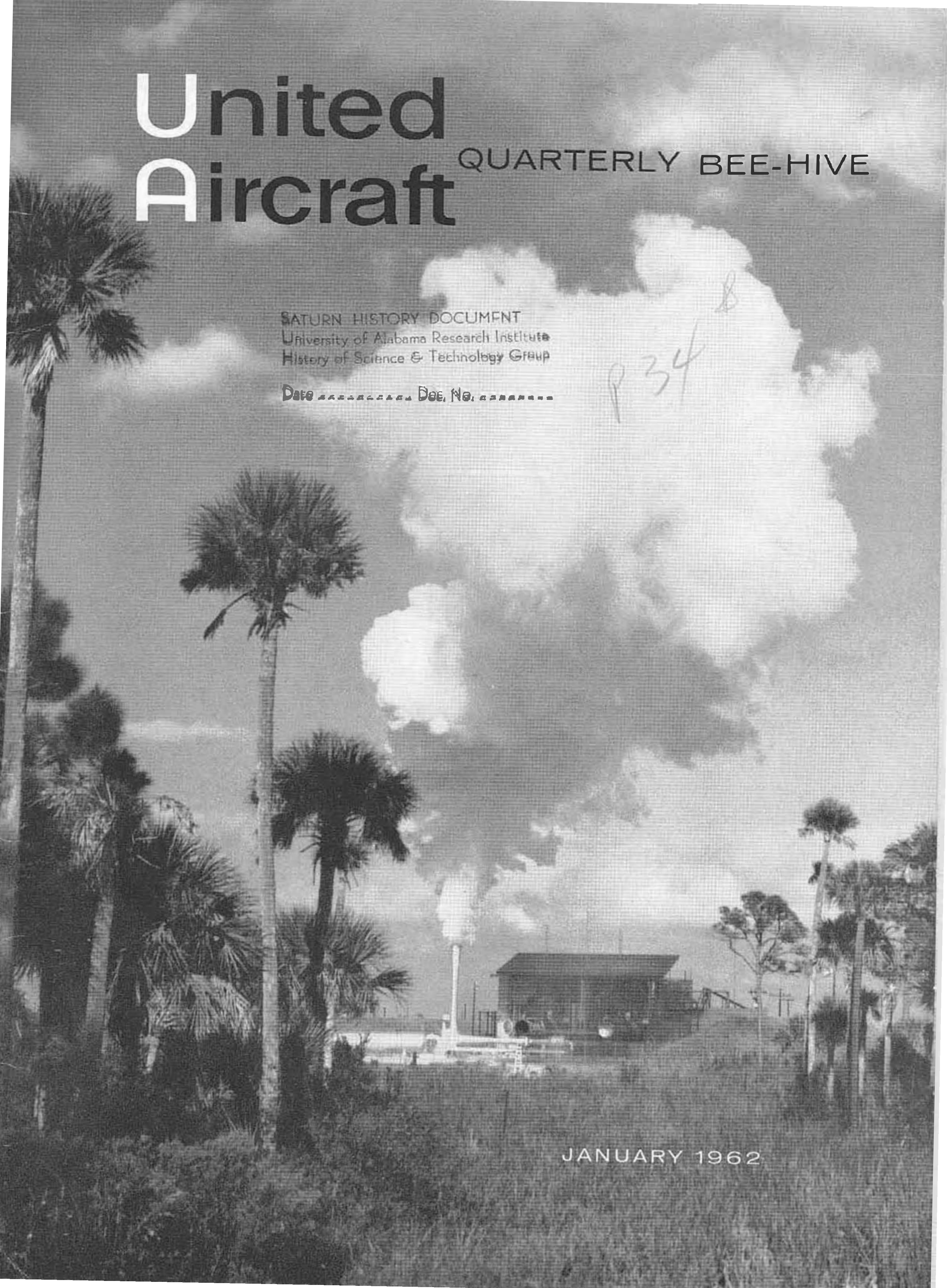
United Aircraft QUARTERLY BEE-HIVE



JANUARY 1962

MISSILE PLATFORM BOMBER

An Air Force Boeing B-52H displays beauty and grace as it eases into a gentle turn high over Edwards Air Force Base in California. Eight Pratt & Whitney Aircraft TF-33 turbofan engines, each developing 17,000 pounds of thrust, provide the bomber with markedly increased general performance over the predecessor B-52 models. Earlier this month, a B-52H flew 12,519 miles without stopping or refueling to establish 11 new world records for non-stop distance and course speed. The B-52H will be equipped with Pratt & Whitney Aircraft-powered North American Hound Dog air-to-surface missiles until the hypersonic Douglas Skybolt missile becomes operational.

United Aircraft

QUARTERLY BEE-HIVE

JANUARY 1962

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THE COVER—Deep in the Florida Everglades, final static tests prior to actual flight of Pratt & Whitney Aircraft's RL-10 liquid hydrogen rocket engine are conducted at the company's Florida Research and Development Center. Designed for deep space missions, the RL-10 — the free world's first liquid hydrogen engine — powers the Centaur space craft and upper stages of the Saturn vehicle.

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WHAT'S UP THERE?

By Fred Brewer

THE solar system is made up of one star — the sun; nine planets, only one of which is known to be inhabitable; 31 moons; a host of assorted rocks; and innumerable dust particles. It seems a sprawling, untidy neighborhood which no one in his right mind would want to prowl. But man shifts nervously on his doorstep, looking out. True, the space neighborhood shows few, if any, welcoming lights. True, the distances are vast and untraveled. Yet man moves to step forth. What will he find?

Earth's moon is now almost certain to be visited by man within this generation, possibly before 1970. Before moon voyages can become ordinary experiences for astronauts, however, much must be done. The problem is not simply to send a man to the moon; the problem is to get him there and get him home — alive. Scientists also need to know much about the nature of the moon's surface before rockets, with human crews, touch down on that lonely shore.

Sometime this year an American rocket is scheduled to thrust a payload of exploratory equipment at the moon. Retro-rockets, on signal from Earth, will bring the payload gently to the lunar surface. Then a battery of sensitive devices will sample the lunar soil, measure any tremors in the globe, detect ground radioactivity, and record temperature, transmitting the data to Earth in electronic shorthand.

Meantime, scientists can only speculate as to what really is there.

Man Knows Little About The Moon's Floor

Although we can, telescopically, bring the moon within a few miles, detecting objects less than a half-mile across, astronomers know very little about the lunar floor. Only as recently as the mid-1850s, many Europeans believed the moon to be populated with winged men who dined on yellow fruit and who worshipped in temples of polished sapphire and gold. In all fairness, it must be pointed out that the Europeans got these notions from the United States. In August and September, 1835, Americans were the prey of an imaginative journalist and his newspaper.

The paper was The New York Sun. It printed a series of lunar reports said to have first appeared in an Edinburgh Journal of Science supplement. Actually, the "reports" stemmed from the pen of one Richard Adams Locke, a facile reporter with a flair for technical language. The Sun's readers, however, believed that what they read was taken from the logbooks of England's Sir John Herschel, the most famous astronomer of the time who only a few months before had set up a large telescope in South Africa.

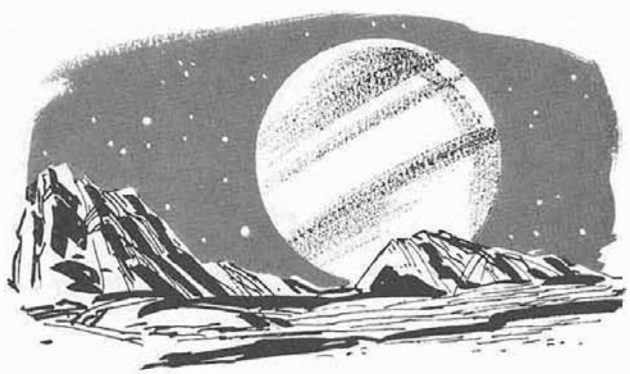
Crowds besieged the Sun's offices to buy editions as they came off the press. Rival newspapers glumly agreed that the Sun had pulled off the age's major scoop by obtaining the rights to Herschel's moon observations. But no rival appeared to doubt the truth of what appeared in the Sun's columns. Commented The New York Times: "The account of the wonderful discoveries in the moon are all probable and plausible, and have an air of intense verisimilitude."

But like many hoaxsters, Locke overplayed his hand. He began crediting Herschel's telescope with too much seeing power. Locke described in detail the eyes of his lunar animals, even the scratches on his lunar rocks. The hoax suddenly collapsed. Yet reprints of Locke's stories crossed the Atlantic, where many Europeans accepted them as factual.

Today there is as wide a choice of what the moon's surface is as there are astronomers to make predictions. In December, 1961, a team of Russian scientists agreed that the moon's surface could resemble tightly packed steel wool. On the other hand, many astronomers believe a thick dust layer exists. If so, is the dust volcanic ash, pulverized stone, or splintered fragments of stony and metallic chunks that have plunged from space to smash onto the moon? No one knows.

The moon's pockmarked appearance, however, is at once apparent to anyone who turns a small telescope upon its silvery face. Yet there is disagreement among astronomers as to what brought about the lunar mountain ranges and numerous crater holes. Volcanic activity? Or, in the remote past, was the moon the target of large rocks hurtling through space? Some scientists think Earth's gravitational pull caused the pockmarked landscape.

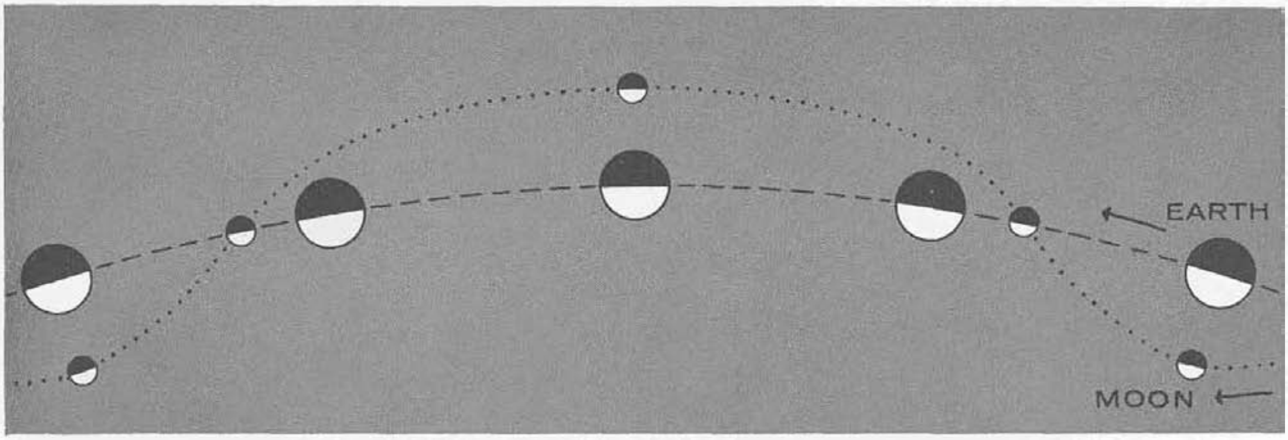
But one thing is certain. The moon is not as rugged as has been believed. Through a telescope, we see an awesome panorama of jagged craters and saw-toothed mountains. In 1960, however, British, French, and American astronomers concluded a giant photographic survey of the moon's topography. Almost 15,000 time-lapse photographs were taken of shadows cast by lunar prominences. The shadow lengths were then measured, triangulation being used to determine heights. Result: the moon is no more rugged than Earth. In fact, moon travelers will find the moon relatively flat. This is because the moon, only 2,160 miles in diameter, has



a sharper global curvature than Earth, causing the horizons to be closer. Only the nearer, higher lunar prominences will be visible to spacemen. A 9,000-foot peak 60 miles away will be below the observer's horizon.

The lack of major landmarks will make it difficult for lunar visitors to set their bearings. Especial care will have to be taken so exploration parties will not become lost. The moon appears to have no appreciable magnetic field, so compasses will be useless. Radio communication between space ship and spaceman will be possible only as long as the two are above the same horizon. There is no atmosphere to bounce radio signals around the moon. Men on the moon may communicate with one another by setting off small surface explosions. The explosions will not be heard since there is no air to transmit sound waves. But vibrations set up in the moon's crust will carry for a considerable distance. Portable seismographic instruments will detect the signals.

The moon's temperatures are cruel. When the sun stands directly overhead, the surface temperature is above that of boiling water. But in the deep shadows



While it orbits the Earth, moon at the same time follows Earth in its path around sun, weaving in and out of Earth's orbit.

and in the lunar night, the temperature hovers around 250 degrees below zero Fahrenheit. Defining "life" by our criterion of a chemistry based upon carbon, the only life forms able to survive such temperatures are a few strains of the one-celled plants we call bacteria.

Astronomers regularly observe slight color changes in some lunar regions. These changes may be caused by soil reaction to strong sunlight. There is also speculation that the changes indicate vegetation kept alive by seepage of carbon dioxide from slumbering volcanoes. Most plants require carbon dioxide. The existence of vegetation, however, is doubtful. Spectroscopic examination of the moon has yet to reveal the presence of any gas.

The moon's rotation period on its axis nearly equals its revolution period round Earth. Thus, the moon keeps the same side turned towards us. Forty-one per cent of the moon is always visible.

The Moon Shakes As It Moves Around Earth

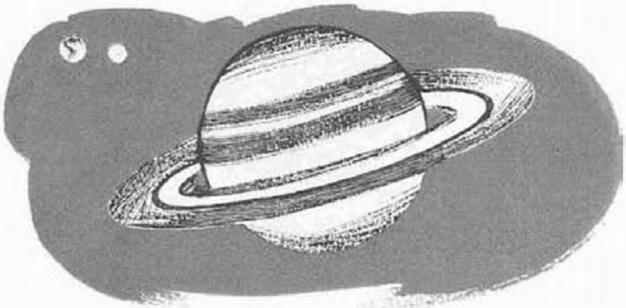
As the moon orbits Earth, it seems to shake and nod. Called libration, this movement is caused by two things. One, the moon's equator is tilted to its orbital plane; so sometimes we see more of the northern regions, sometimes more of the southern. Two, the moon travels an elliptical path. When it is closest to us, it moves faster than when it is farthest. Because of this, its axial spin and its orbital position regularly get out of step. Thus we see, alternately, a slight way round its west limb, then round its east limb. Libration enables us to see 18 per cent more of the moon now and then.

A portion of the moon's hidden side was photographed in 1959 by a Russian artificial satellite. Although the photographs, relayed to Earth by radio, were not well-defined, it appears that the moon's far side is similar to — and just as dead — as the side we view.

Zdenek Kopal, professor of astronomy at England's University of Manchester, probably best sums up what the moon will mean to man when he does arrive there: "Not a very exciting place for a holiday-maker perhaps, but for the scientist — what an Aladdin's cave!"

The first planet encountered outward from the sun is a strange, tiny world — Mercury. Mercury darts round the sun in 88 days. In this time, it turns only once on its axis. So, similar to the moon-Earth system, Mercury keeps the same side turned towards the sun. Only its central region — the zone of libration — has sunrise and sunset. The planet's backside is eternally dark.

On the sunlit side, the sky is blinding, for the sun lies, on the average, only 36,000,000 miles away. Mercury possesses no atmosphere to absorb any of the sun's cosmic ray or infra-red and ultra-violet emissions. Under this silent but relentless bombardment, the surface probably is lethally radioactive. By placing a sensitive heat-detecting instrument called a thermocouple at the eye end of a telescope, astronomers know within a few degrees what temperatures spacemen will encounter on Mercury's sunny side — a temperature hot enough to melt lead.



In the libration zone, alternate sunny and dark periods mean alternate hot and cold periods. The change from very hot to very cold may be sudden — one moment, agitated molecular activity caused by the scorching heat; the next moment, no activity at all. The temperature has dropped to a shattering absolute zero, the point where all molecular activity stops.

The dark side, perpetually cold, is an underworld of raven blackness. There are no shadows. No twilight grays steal across the horizons, for atmosphere is needed to bend sunlight around a planet's surface.

Mercury's temperature extremes possibly have molded its surface into the solar system's most weird landscape. The sunlit side may be wasteland, strewn with splintered rock and criss-crossed by yawning cracks caused by the endless heat. The libration zone may be deep piles of gritty dust, the result of alternate heating and cooling. Bald, jagged peaks, stabbing up from deeply notched valleys partly filled with space rubble, may comprise most of the planet's dark region.

The actual landscape we will discover on Mercury is, of course, unknown. Our largest telescopes show Mercury as a small, pinkish disc marked with gray patches that are at the limit of visibility. But it is certain travelers to its strange horizons will stride a half-brilliant, half-dark world of silent terror, where all is lifeless.

Venus, the second planet met in traveling outwards from the sun, is a mystery. It is entirely wrapped in a curdled mantle of thick, yellowish clouds. The surface cannot be seen. Mainly, the clouds seem to be billowing thunderheads of carbon dioxide.

What lies beneath the cloud cover?

In 1955, American astronomers Fred L. Whipple and Donald H. Menzel offered a theory that Venus' surface is covered with water. Their theory, evolved from the abundance of carbon dioxide, speculates that at one time the planet was studded with hundreds of active volcanoes spewing their products, carbon dioxide and carbon monoxide, into the Venusian air. Then water swirled forth to drown the land surfaces, extinguishing the volcanic fires. Since water does not absorb carbon dioxide, the gas literally had no place to go. It could not escape into space because Venus' gravity held it back. And any oxygen originally in the atmosphere was fused, under high heat, with the carbon monoxide to become even more carbon dioxide.

Theories Vary On What Exists Below The Clouds

Numerous other ideas have been expressed about what exists on the hidden surface — an ocean of oil, a vast desert continually shifting as cyclonic winds rip round the planet, even a land of murky light where crab-like creatures feed on a steady rain of small organisms that breed and die in the clouds. A favorite theory is that when we do penetrate the clouds we will find a prehistoric world where dinosaurs clump through steaming marshes with ferns as high as trees.

The very presence of the clouds has an adverse effect on any theory suggesting life on Venus. Like the windows of a greenhouse, the clouds trap the sun's intense radiation, making the surface unbearably hot. Recently, a radio telescope analysis of Venus showed that its surface temperature is about 800 degrees Fahrenheit — too hot for life.

Earth is the third planet from the sun. Beyond Earth, at an average distance of 142,000,000 miles from the sun, moves the planet most like Earth, except that it is smaller and has two moons. The planet is Mars, whose ruddy glow caused early Greeks and Romans to name it after their war gods. Unfortunately, the name Mars (after the Roman god; the Greeks called it Ares) has moved many writers to populate it with sinister beings, bent on destroying everything in the solar system. Actually, Mars is a relatively innocent place, even though conditions there probably are unfriendly for man.

Mars also has suffered because of an inaccurate translation of a word. In 1877, Giovanni Schiaparelli of Italy trained a small telescope on the red planet. He saw some features that puzzled him. In 1879 and again in 1881, when Mars was favorably placed for observation, Schiaparelli detected the same features. He called them "canali," Italian for "channels." The Italian observer was convinced that these canali, which looked like fine lines, were natural surface features. But canali, in English translation, unhappily became "canals"; and, as anyone knows, canals are man-made.

Excitement swept Britain and the United States. Some persons urged that messages in giant letters be traced out on the Sahara, assuming Martians could read the messages with their telescopes. Others proposed that a huge mirror be erected. Then, with controlled sun flashes, the mirror could send messages in Morse code to the distant civilization. No one suggested, however, what the messages were to be; and few persons seemed to question that Martians might be unfamiliar with the Earthman's alphabet and dot-dash code.

In the United States, a businessman-turned-astronomer, Percival Lowell, built a well equipped observatory in Arizona to study the planets. Lowell quickly turned his large telescope on Mars. Soon he was seeing

hundreds of canals. Many were double. Lowell was not alone; a few French and English astronomers also saw the multiple canal network. Schiaparelli himself observed that one night a line would appear single, only to appear double the following evening. But the observations of Schiaparelli and other astronomers were quickly swept aside by Lowell's enthusiasm. He became convinced that intelligent beings were on Mars.

The Martian civilization, as Lowell pictured it, was a dying one, faced with drought. Only the small polar caps provided water for the thirsting planet, hence the elaborate canal system. Most Martians dwelled in cities, but there were oases to visit — where the canals intersected. Lowell contended the canal pipes themselves were not visible; what was seen were 40-mile-wide garden strips along the canals.

Lowell's image of life on Mars moved some persons to demand that aid be sent, although no one could

think of a way to transport that aid — kegs of water — across the intervening space. There were second thoughts, also. What if the Martians were truly war-lords? Would it not be unwise to let them know we existed and that Earth had an ample water supply?

The canal controversy still goes on, although most of today's skilled planetary observers have never caught a glimpse of the canals. Most scientists believe the canals are caused either by contrast between abutting areas of different shades or by separate points optically merging into lines because of the distance across which Mars is seen. Evidence against intelligent life on Mars is now overwhelming.

There is no doubt, however, about the existence of Mars' polar caps. They can be observed through a small telescope. The caps regularly spread out, then shrink as Mars moves through its seasons. What the caps are remains in doubt. They may be hoarfrost. They may be chemical salts reacting to the waxing and waning of sunlight. Whatever they are, they appear to be no more than a few inches thick.

Mars has a cold, dry climate and a thin atmosphere made up almost wholly of nitrogen. Photographs taken through color filters reveal clouds, mist banks, and giant puffs of dust. There obviously are large rust-colored deserts to give Mars its ruddy cast; there are equally large areas, much darker, that undergo regular changes both in size and color. These changes are most often attributed to the seasonal growth and retardation of vegetation. Some scientists maintain the changes are purely chemical in nature.

For the last few years, Pamir — the high altitude region of central Asia — has served as a laboratory to biologists. Conditions there are most like those believed to exist in Mars' central latitudes. Called by natives Ban-i-Dunya, which means "Roof of the World," Pamir has a daily ground temperature range of as much as 140 degrees Fahrenheit. The annual range is about 212 degrees Fahrenheit. In Pamir's glacial valleys, the mean annual temperature is below freezing. The valley air is also very dry; each afternoon, the relative humidity drops to about zero. Yet the biologists have found more than 200 different plants thriving in Pamir.

Evidence Points To Presence Of Plant Life

Further evidence that plant life is possible on Mars lies in the Martian atmosphere, almost 99 per cent nitrogen. Plants use nitrogen. Plants give off oxygen, too, which they also breathe in. Although oxygen so far has not been detected in Mars' atmosphere, it is known that certain plants — aquatic ones — store up oxygen in their cells.

The dark patches on Mars' surface change seasonally from blue to blue-green. Chlorophyll gives our vegetation its green color. But it has been found that certain species of trees growing in cold climes do not absorb chlorophyll when the temperature drops below freezing. Plants also take in only that part of the sun's rays that they can use. The hotter the climate, the more solar radiation the plants reflect. For example: if plants do exist on Venus, they will be yellow-leafed because they will reject most radiation. Yellow is the visible part of the rejected rays which man's eyes can most easily detect. But on Mars, plants would absorb nearly all the solar radiation, for the sun's rays are more feeble than those that strike Venus — and the Martian plants would appear violet or blue. A few years ago at the Mount Palomar observatory in southern California, spectrographs of Mars taken with the mammoth 200-inch telescope revealed that cellulose may be present on the planet. Cellulose is the chief component of cell-walls of plants.

So, does life exist on Mars? Plant life seems possible. But man will have to travel to the red planet to be sure. Undoubtedly, he will.

Beyond Mars wheel a number of small hunks of stone and metal called asteroids. There are so many of them that astronomers have given up charting the orbits of all save the larger ones. Most asteroids are a mile or less across. The largest, named Ceres, is only about 400 miles in diameter. Asteroids are too small to hold anything loose on their cold surfaces. Suggestions that they be used as stop-over places for space ships traveling past Mars probably will never be taken up. How to anchor onto these minute worlds is a problem that now seems useless to solve.

The solar system's four largest planets — Jupiter, Saturn, Uranus, and Neptune — lie beyond the asteroid belt. Man probably will never land on them, for their covering mantles are made up of sluggish liquefied gases. Even if a spaceman could risk sinking into the liquid surfaces, he would find the giant planets' gravitational pulls so powerful that tons of precious rocket fuel would have to be expended before his craft reached escape velocities. The nearest man may approach these planetary behemoths will be to land on one of their moons, and for this, he will have a wide selection. Jupiter, Saturn, Uranus, and Neptune have 28 known moons among them.

The atmospheres of the four giant worlds may contain methane — marsh gas. On Earth, methane is a product of decaying plants. It can be detected bubbling to the surface of stagnant pools. The presence of methane on the four planets may mean bacteria exists.

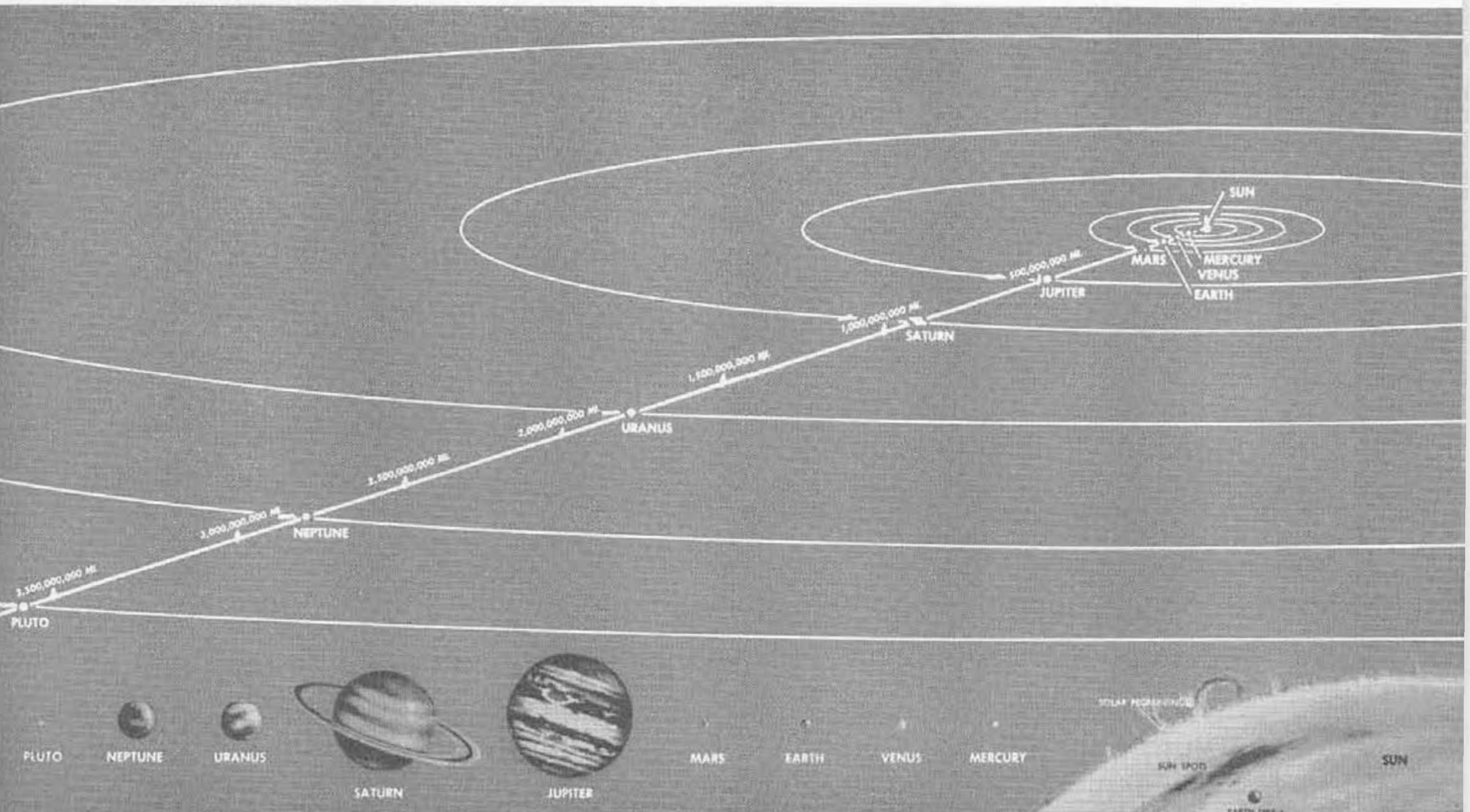
The sun's last planet is tiny Pluto, discovered in 1930. Almost nothing is known about this outpost of the solar system save that it takes 248 years to complete one orbit round the sun and it receives only 1/1600th as much solar heat and light as Earth does. By all reckonings, Pluto is the loneliest place in the solar system.

Will man ignore Pluto when, at last, he possesses the craft to reach this farthest corner of the solar neighborhood? Probably not. But assuming it will be found safe to land on Pluto, why visit it? Indeed, why visit any body beyond Earth?

In our century, almost immeasurable depths have been added to the universe. Galaxies have been found to exist in profusion throughout observable space. And when man jumps into space, there is every reason to believe he will find billions more that are beyond the range of earth-based astronomical instruments.

Lunar travel is hardly reckless adventure. The moon, for example, probably has suffered little erosion, for there is neither wind nor water. It will be a geological wonderland of keys to turn the many locks on the secrets of Earth's origin. Each step beyond the moon certainly will contribute fresh information. Perhaps, finally, we will solve the greatest mystery — ourselves. Why are we here? Where did we come from? Are we unique?

Although the universe's horizons lie at incomprehensible distances, there is a reason for the universe's plan. And here is a thought to hinge imagination on: astronomers predict that at least a trillion stars in our galaxy are orbited by planets bearing life. So the universe may not be a lonely place after all. Somewhere else, other races of men may live. And through their telescopes, they may this very moment observe our yellowish sun — and wonder.



COMPARATIVE SIZE OF SUN AND PLANETS

FUEL CELL

By John H. Martin

Model of a fuel cell for use in space vehicles is displayed by Paul Adams of P&WA.

ONE of the more exciting and potentially important new powerplants under development by Pratt & Whitney Aircraft is the fuel cell. This device, which looks something like a battery connected to fuel tanks, produces electrical power directly from fuel by a chemical reaction — without smoke, noxious fumes, noise, or vibration.

"There is an understandable worldwide fascination for the fuel cell," said Walter Doll, chief engineer for advanced power systems. "Nations new and old are demanding more and more power every year, while natural fuel resources are diminishing at an increasing rate. Here is a powerplant with a higher efficiency than any other we are familiar with. It just *has* to be important for the future.

"The fuel cell is 150 to 300 per cent more efficient than the power systems which have made our present high standard of living possible. Although the versatile, low-cost fuel cell for industrial and consumer application is still some years away, types now under development will most certainly be used soon to provide electrical power for manned space vehicles. The experience gained under severe environmental conditions in the space vehicle programs should certainly accelerate the development and use of fuel cells in a potentially large number of military, industrial, and commercial applications."

Like any new powerplant, this 160-year-old concept is not without its problems — both technical and economic. Useful power systems already have been built and run successfully, but generally not with the combined features of size, weight, cost, durability, low-cost fuels, and operating flexibility which will be required for widespread application and usefulness.

The chemists and engineers who have been working on the fuel cell are enthusiastic about the progress made to date and envisage eventual use in a variety of roles — in satellite, lunar, and interplanetary space missions; as motive power for submarines, shop trucks, and heavy construction equipment; for portable welding equipment and in the electrochemical industries; as a power package for various "remote site" areas; and, perhaps some day, for commercial power generation, home power units, and the silent electric bus and motor car which will not pollute the air.

In today's mechanized and electrified world, man obtains most of his manufactured energy from the chemical energy stored in coal, petroleum, and natural gas, the so-called hydrocarbon fuels. He does this through a heat engine medium — gasoline and diesel piston engines and steam and gas turbines. Fuel and air are burned in these powerplants, and the chemical energy available in the fuel molecules is released as heat energy. This energy is converted by various means into electricity and mechanical work.

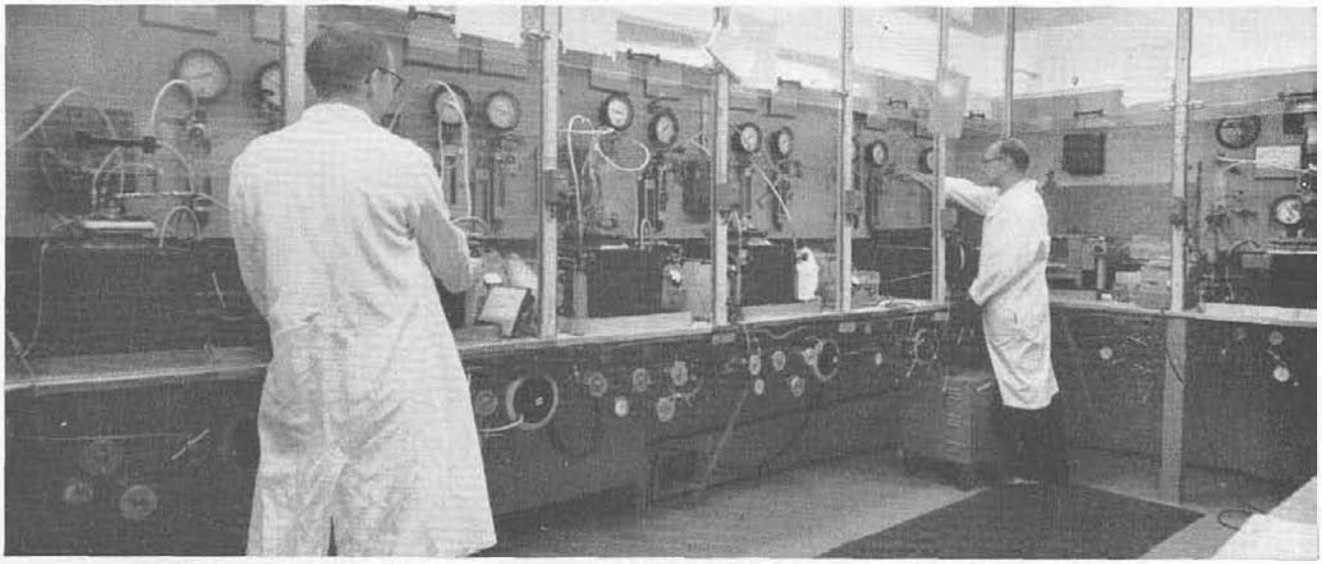
In this process, however, 50 to 90 per cent of the original chemical energy is lost forever in wasted heat, depending on the over-all efficiency of the power system used. This loss is inherent and unavoidable in power systems which first convert chemical energy to heat and then to mechanical or electrical power. Still more energy is dissipated in the friction of moving parts in a conventional engine. Thus, the most efficient modern central power stations, in their heat-steam-electricity cycle, attain an efficiency of only 35 to 40 per cent. Further efficiency is lost in transmitting the electricity to the consumer. Most internal combustion engines in motor cars operate at less than 20 per cent efficiency.

The fuel cell, in contrast, provides electricity directly from the reaction of a fuel and an oxidant, omitting the wasteful heat cycle. Theoretically, the fuel cell may approach 100 per cent efficiency at zero power output, with slowly decreasing efficiency at higher power levels. Feasible, at least, is an energy source more than twice as economical as that of the average steam power station.

Pratt & Whitney Aircraft has been vigorously investigating fuel cells as powerplants for more than two years. In a company-financed program, it entered the fuel cell field on a substantial basis late in 1959. Several months ago, the company contracted with the National Aeronautics and Space Administration (NASA) to develop a prototype of a space powerplant utilizing hydrogen fuel and oxygen.

"Our program," said Doll, "is to study all types of fuel cells, conduct essential research and engineering programs, select suitable applications, and build entire powerplant systems around them. The fuel cell systems will tend to find a home in needy places on a gradual scale. Their first significant application probably will be in space vehicles. When man goes into space he must carry everything he needs with him. Even with our largest projected launching rockets there are definite limitations to how much can be carried, particularly expendables such as fuel. Therefore, the amounts of power needed and long-trip time require power-generating systems which are both light and efficient. Here, fuel cells appear to have the advantage over anything else."

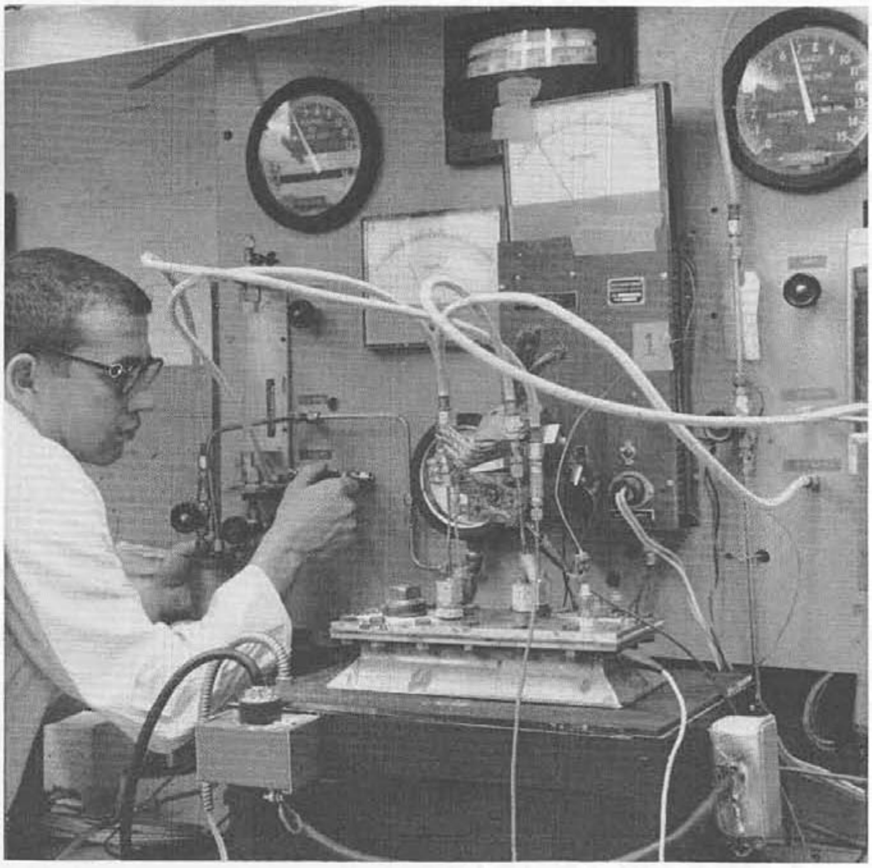
Engineers don't like to think of the fuel cell as a form of battery, although to the layman there appear to be similarities. The dry cell in a flashlight is a primary battery. It wears *out* as its chemical ingredients are used up in producing electrical current. In secondary batteries such as those used in motor cars the chemical substances can be regenerated for a time by "charging" the battery with electrical energy. But in a fuel cell the chemicals are fed from an external source to generate a continuous electrical current as long as the fuel is supplied.



Stations in experimental test laboratory contain electrodes which are checked by Frederick Loramie, left, and Andrew Dugan.

The idea behind fuel cells dates back to 1801 when the English chemist Sir Humphry Davy built a cell using zinc and oxygen and obtained electrical energy. Sir William Grove, another English investigator generally regarded as the father of the fuel cell, demonstrated in 1839 a chemical battery in which the familiar water-forming reaction of hydrogen and oxygen produced an electrical current. He used expensive platinum catalyst-electrodes in his experiments. A half-century later, German-born Ludwig Mond and Carl Langer, also in England, developed another device called a fuel cell. Technical limitations, plus the excitement stirred by the steam engine and internal combustion engine, discouraged the scientists from any extensive development of the cell.

After World War II, Francis T. Bacon of the University of Cambridge, who had begun his experiments in 1932, produced a hydrogen-oxygen fuel cell strong enough to power a fork lift truck with a two-ton load, cut a chunk of mahogany with a circular saw, and operate a welding assembly. Dr. H. H. Chambers, also of England, experimented with a fuel cell using low-cost petroleum base fuels instead of hydrogen, and air instead of pure oxygen.



Frederick Laramie adjusts test station to study performance of a pair of electrodes.

New Techniques Applied

To increase the pace and scope of its work in powerplant development, Pratt & Whitney Aircraft two years ago obtained the patent rights to the Bacon-Chambers preliminary work which many engineers considered the most productive of postwar experiments. The agreement was reached with the Leesona Corporation of Rhode Island, which had previously obtained the patent rights through an arrangement with the National Research and Development Council (NRDC) of Great Britain. Thus the research talents of those two organizations were joined to the manufacturing skills and extensive research and development facilities of Pratt & Whitney Aircraft.

Since its entry into the field, Pratt & Whitney Aircraft has introduced modern manufacturing techniques, refined and improved powerplant systems, tested long-life electrodes and made them reproducible, and made use of its vast experience in handling hydrogen as a fuel. The company has accumulated many thousands of hours of fuel cell endurance testing. A hydrogen-oxygen cell now has reached the development stage and is ready for application.

Doll said anyone can be in the "fuel cell business" with a beaker, a few square inches of electrode material, and some fuel bottles. Such units are now available to high school students for a few dollars. It is quite another matter to develop complete fuel cell powerplants which meet all the exacting performance, size, reliability, and economic requirements of commercial and military customers. To provide the fuel cell power systems which will meet such requirements, the company has organized a strong team of engineers and chemists and built new research and development facilities, including a physical-chemistry laboratory, under the direction of Dr. Johann Tschinkel, devoted to fuel cell research. The materials development laboratory in East Hartford, directed by Vernon Cooke; the new advanced materials research and development laboratory at North Haven, directed by Dr. Maurice Shank; and other parts of the engineering department, such as the physics group under Dr. John Rockett, all are contributing significantly to the over-all program.

The Pratt & Whitney Aircraft fuel cell team is split into three groups reporting to Doll. Basic research is under Dr. Tschinkel. Dr. Tschinkel, a graduate of Charles University in Prague with his doctorate in chemistry, has had extensive experience in chemical research and combustion systems. The Leesona Corporation also contributes a substantial team to basic electrochemical research. John M. Lee and Geno J. Andreini, both of the advanced projects engineering staff in East Hartford, direct the engineering and preliminary development group and the project development group, respectively.

"The problems are both chemical and engineering in nature," explained Doll, "and the chemical technology is quite complicated. It includes complex reaction processes of a wide variety of fuels, oxidants, electrolytes, catalysts, and electrode materials and constructions. Light weight and high reliability must be obtained using caustic or acid electrolytes which have an undesirable tendency to eat up many normally convenient construction materials."

A typical hydrogen-oxygen fuel cell consists of two porous nickel electrodes separated by an electrolyte — a concentrated solution of potassium hydroxide. The terminals are linked to an external circuit.

When the cell is operating, the gases and electrolyte react to produce a flow of electrons or electrical current. The electrically charged particles combine within the electrolyte to form water and complete the electrical circuit.

Efficient structural design and durability were problems in early fuel cells; there still is much experimentation on various configurations. In one Pratt & Whitney Aircraft design, multiple cells were bolted together like a stack of thin metal pancakes; in another they were arrayed in rectangular modules. Special controls were devised to keep the oxygen and hydrogen under equal pressure; otherwise the electrodes would be distorted.

Water Exhaust Is Potable

Designers also devised their own way of removing the extremely pure water produced at the hydrogen electrode. In one demonstration before NASA officials, William H. Podolny of the advanced projects engineering staff, who was responsible for the inception of the company's fuel cell work, drank water from the hydrogen-oxygen fuel cell's exhaust to show that the water was potable. Space men of the future may well obtain drinking water this way.

One way of improving the hydrogen-oxygen cell's performance is to operate it at high pressure and at high temperature to hasten the electrochemical reactions. An early Bacon cell of this type was operated at temperatures up to 450 degrees Fahrenheit, with gas pressures up to 800 pounds per square inch. Current P&WA fuel cells can produce equivalent performance at atmospheric pressure, thus greatly simplifying the control and structural design.

Since the Pratt & Whitney Aircraft program got under way, electrode development has been given heavy emphasis. The goal has been to improve both the level and the reproducibility of unit cell performance and durability. Marked progress has been made in achieving quality control of the nickel powder used in the difficult work of making the porous nickel electrodes.

Another aim has been to develop catalysts which will support reactions at varying temperatures and pressures. Catalysis still is something of a "black art," just now approaching the character of a science, and a search for effective materials becomes a methodical trial of many possible substances. The function of the catalysts in the electrodes is to lower the energy barriers, thereby stimulating the chemical reaction and decreasing the amount of useful energy that is converted to heat.

United's Research Laboratories contribute to fuel cell program through development of components by such researchers as Herman Urbach, foreground, and Maureen Neary.

The company work on hydrogen-oxygen fuel cells has led to systems of high performance and durability. At the moment, this type of fuel cell is suitable for space vehicles and military applications. For instance, it would be feasible for a fuel cell powerplant system to power submerged submarines for longer periods and more quietly than a nuclear propulsion system.

While strict quality control is vital in the production of fuel cell hardware, the key to widespread application is the production of electricity at a reasonable weight and cost. The really exciting commercial potential of the fuel cell, wherein cheap hydrocarbon fuel is substituted for hydrogen, suggests obtaining electricity directly from coal or fuel oil and natural gas without high temperatures or moving parts.

Industrial Uses Foreseen

Although commercial uses of the fuel cell may be slow in coming, one of the first forecast uses for it is in industry. For instance, electric power is a raw material in producing aluminum, which needs large quantities of direct current at low voltage. A cell using natural gas as a fuel has possibilities in this industry. A high-output cell using an inexpensive liquid fuel also would find application in trucks and locomotives.

Hydrogen-oxygen fuel cells also may aid in bringing down the cost of nuclear powerplants whose high capital cost requires that they function at near-peak loads if they are to produce cheap electricity. Nuclear power generated during daily or seasonal periods of low demand might be used to convert water into hydrogen and oxygen. This stored energy then could be used through auxiliary fuel cell installations at peak-demand periods.

"The development problems are many and varied," said Doll, "but they do not differ in scope from the problems Pratt & Whitney Aircraft faced previously in the development of aircraft engines. Materials, mechanical design, control systems, corrosion resistance and so forth are major areas of attack, and reliability, endurance, and cost are the major theme."

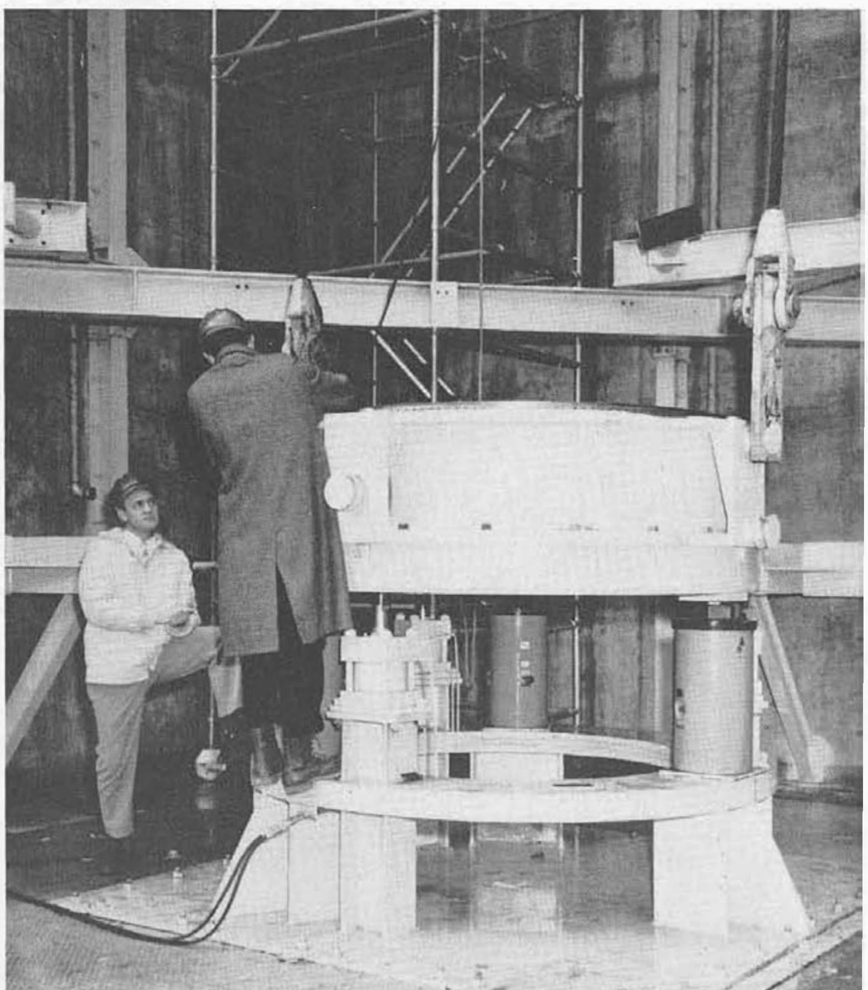
BUILDING BLOCKS FOR SOLID BOOSTERS

At 11 o'clock in the morning of December 9, 1961, a towering pillar of fire and smoke blasted from a pocket high in the mountains above the town of Morgan Hill, California. A short time later, it dropped from sight, leaving a mushroom-shaped cloud over the area.

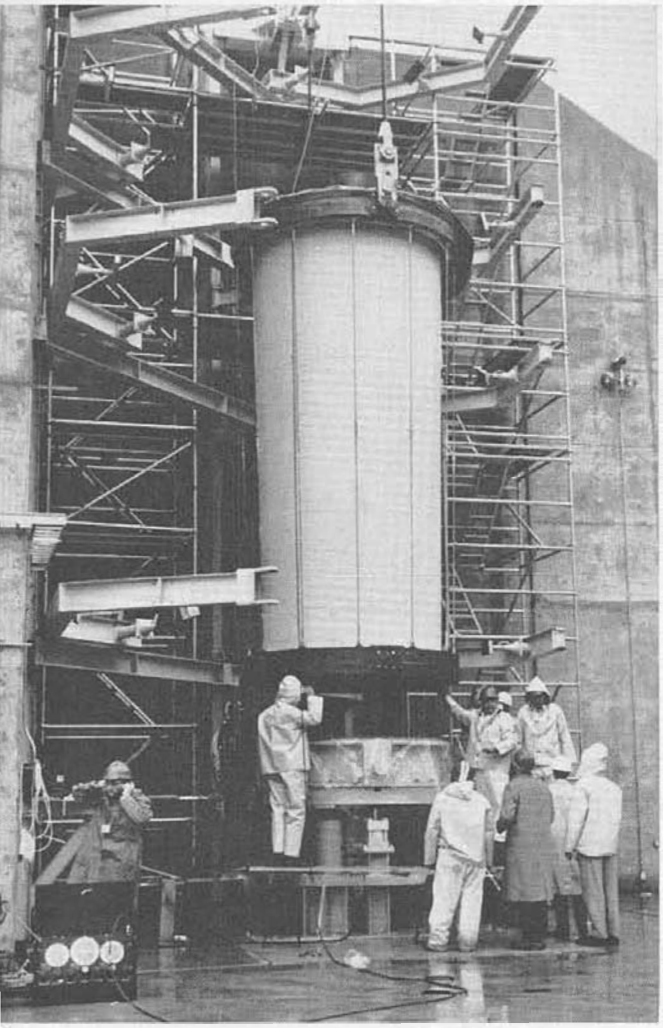
The plume of flame and smoke marked the successful test-firing of an Air Force booster-size, solid propellant rocket motor — a four-segment powerplant weighing 70 tons and standing over 40 feet high. United Technology Corporation designed and built the giant rocket motor and conducted the static test for the Air Force. Fired nose down, the motor developed nearly 500,000 pounds of thrust and its extended burning time achieved the minimum for an efficient and practical space booster.

Cases for the big motor, measuring over eight feet in diameter, were fabricated by Pratt & Whitney Aircraft and were of the precise weight necessary for actual flight. Composed of two large center segments and two end closure segments, the motor was fitted together swiftly and easily without the use of tools. The propellant charge in the sections had a thickness of over two feet and was of the actual configuration required for flight.

The test followed the successful firing by United Technology earlier in the year of a three-segment motor which developed 220,000 pounds of thrust. The two tests provided another significant advance toward the production of single, solid propellant rockets in the multi-million-pound thrust class.



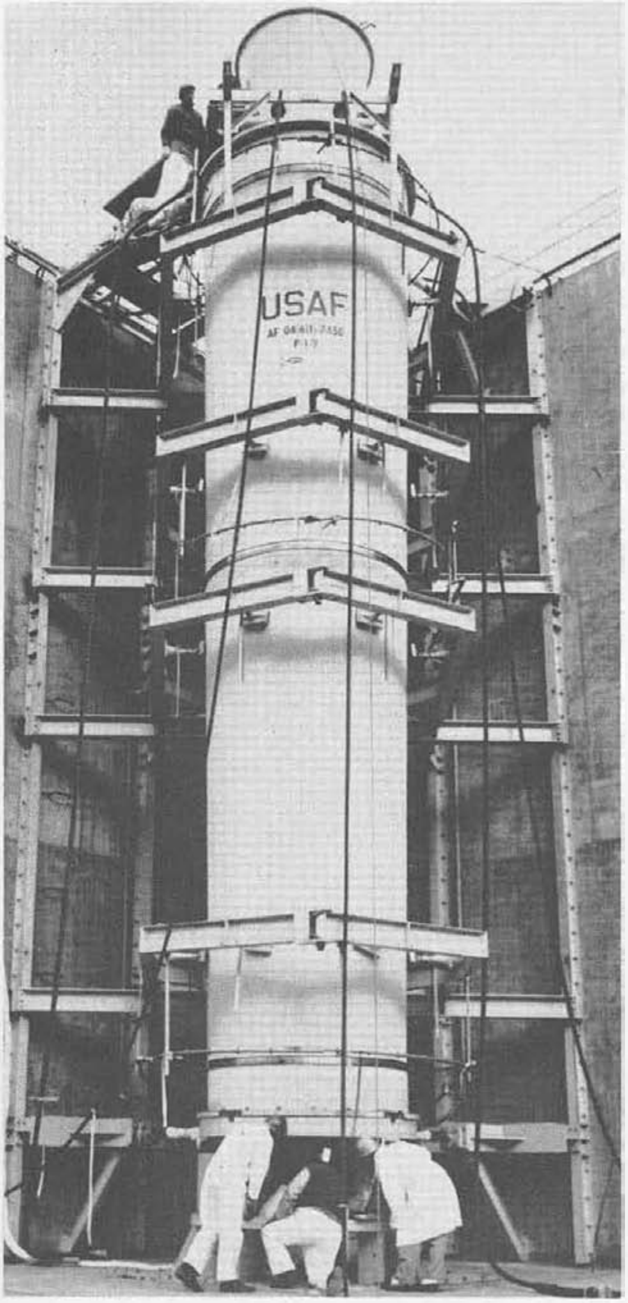
First step in the assembly of United Technology Corporation's big, solid booster is the mounting of the fore-closure segment in the concrete test stand.



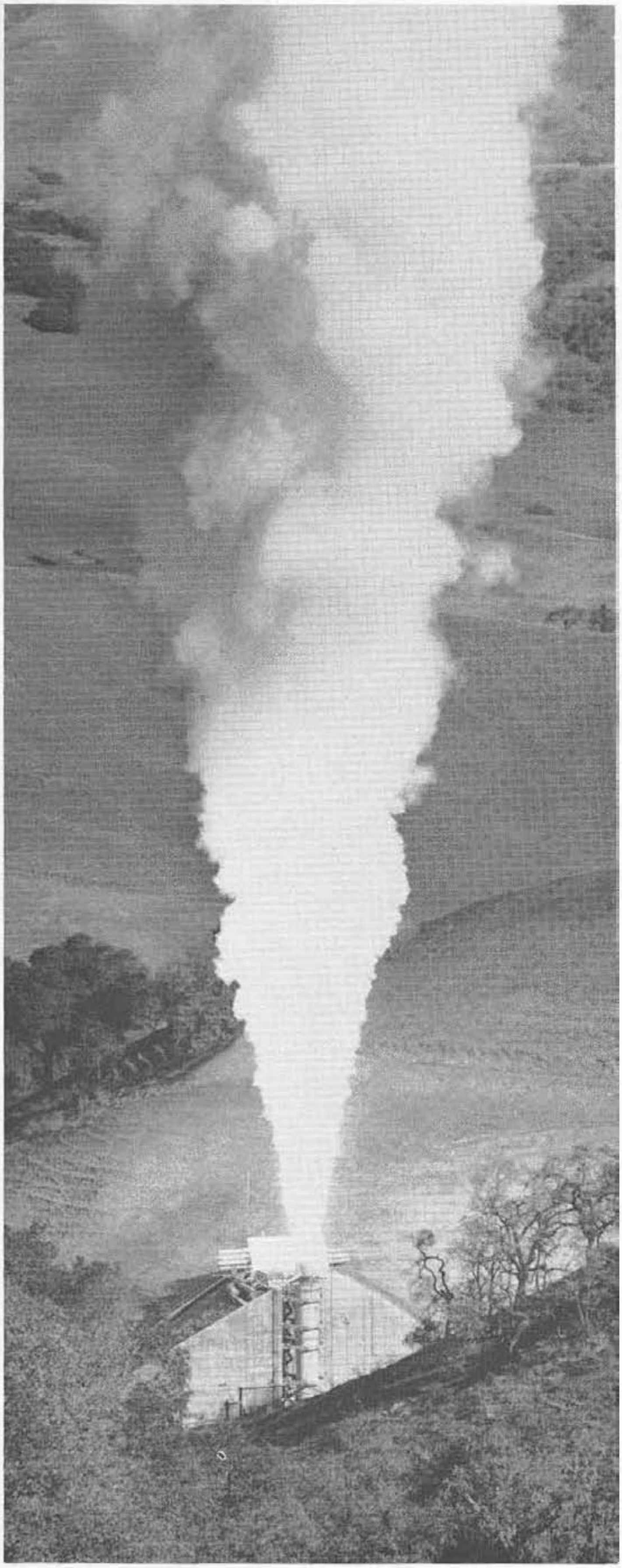
Rainy weather at the test site did not affect assembly operation. Here the first main segment is lowered into position atop the fore-closure section.

Huge crane, upper right, swings second main section into test bay as workmen on scaffolding prepare to secure it to other segment with clevis-type joints.

With the aft-closure section already secured to the motor, workmen carefully guide nozzle into position as final step in assembly of the booster.



Technicians and engineers make final checks at top and bottom of fully-assembled booster which stands over 40 feet tall and weighs 70 tons.



Towering pillar of fire and smoke issues from rocket motor during successful test. Booster developed nearly 500,000 pounds of thrust.

CAT

By Norman Sklarewitz

OFFICIALS of Civil Air Transport met not long ago in their headquarters at Taipei, Taiwan, and readily dispensed with a number of high-level matters. They approved an increase in frequency of service on CAT routes in Northeast and Southeast Asia. They heard a report on operations of the company's new jetliner. Then they came to a topic on the agenda that immediately touched off spirited debate. At issue was how much leg should be revealed by the side slit in the jet stewardesses' uniform.

The Young Lions around the table called for six inches above the knee; the Old Guard argued that two inches of thigh was quite enough. Rules of the International Air Transport Association had nothing to say on the subject, and so it was debated on the basis of Chinese tradition, American styles, sales appeal, and decorum.

Civil Air Transport, established just after World War II with a handful of surplus transports flown by American ex-GIs, has survived lean times and Communist gunfire to emerge as a busy air carrier providing luxury service in the Far East. Here is a report on the Republic of China's designated flag carrier.

Finally a compromise was offered and accepted: make the slits eight inches deep but design the skirt so that only four inches would be above the knee.

Such a debate could take place only at CAT, an airline that mixes jasmine tea romanticism with high-octane flight operations. Unlikely as the brew might seem to Westerners, CAT today is a busy carrier that flew close to two million revenue miles in the last fiscal year and carried 107,818 revenue passengers over 6,687 unduplicated route miles.

No one maintains, of course, that success in the international airline business is based on bevies of beautifully exotic girls, but they certainly do make surroundings more pleasant. And CAT manages to recruit stewardesses with more than just looks; they score high in intelligence, too. Not only are the girls completely at home with English, but most speak the King's English as a result of having been educated in either the British Crown Colony of Hong Kong or, prior to the Communist takeover of the mainland, in top-grade continental schools in Shanghai.

Civil Air Transport is the Republic of China's designated international flag carrier, a line owned and controlled by private Chinese interests, but utilizing American technical assistance in its operations. It is still sensitively proud of its American origin. To reach its present affluence, with its luxury passenger service and queenly Oriental stewardesses, CAT has had to travel a long, bumpy road. There were lean times; there were times when the airline wavered on the edge of collapse. It has been in the thick of three wars, and its planes have tasted the steel of the foe's flak.

The Dream Of General Chennault

The story of CAT is one of vision and courage and of men who possessed them in abundance. One man in particular had a dream — Major General Claire Chennault, the leathery-faced hero of the Flying Tigers who flew against the Japanese for the Chinese Air Force during the late 1930s and right up to Pearl Harbor. When World War II broke out, the Flying Tigers had been integrated into the 14th U. S. Air Force. Chennault had been recalled to active duty as a colonel and had gone on to become a two-star general, commanding the powerful air striking force.

Now, in 1946, the fighting was over but Chennault had little taste for retiring to fish in a Louisiana river. He was an old China hand. China was his life and he was staying on. He gambled that there would be other men around who thought as he did, and who, after sampling the excitement and the challenges of the Orient, weren't quite ready to become salesmen in Los Angeles or clerks in Chicago.

Chennault's plan was simple: buy a dozen or so war surplus transport planes and build them into an efficient airline to serve China. Ten years of war had virtually destroyed the country's transportation facilities which, at best, were never good. Canal and river shipping was all but wiped out; roads were primitive, and railroads virtually non-existent.

Now, with the end of fighting, the country faced the twin terrors of famine and plague. Foodstuffs and medicine were desperately needed in widely separated areas. The United Nations Relief and Rehabilitation Administration was ready to make supplies available. The only way to get them into the remote areas where they were needed most was by air.

With the crusty general and his partner, Whiting Wilauer, one afternoon in the Cathay Mansions Apartment Hotel building in downtown Shanghai were six ex-GI fliers, pilot candidates. Each had heard about the dream for a China airline and wanted to be part of it. They were Var Green and Lew Burridge, ex-Marines; Dick Rossie, one of Chennault's original Flying Tigers; Bill Hobbs and Weldon Bigony, both Navy fliers; and Felix Smith, an Air Corps instructor who had been paying his YMCA rent in Shanghai by flying missionaries out to the provinces while waiting for Chennault's plans to jell.

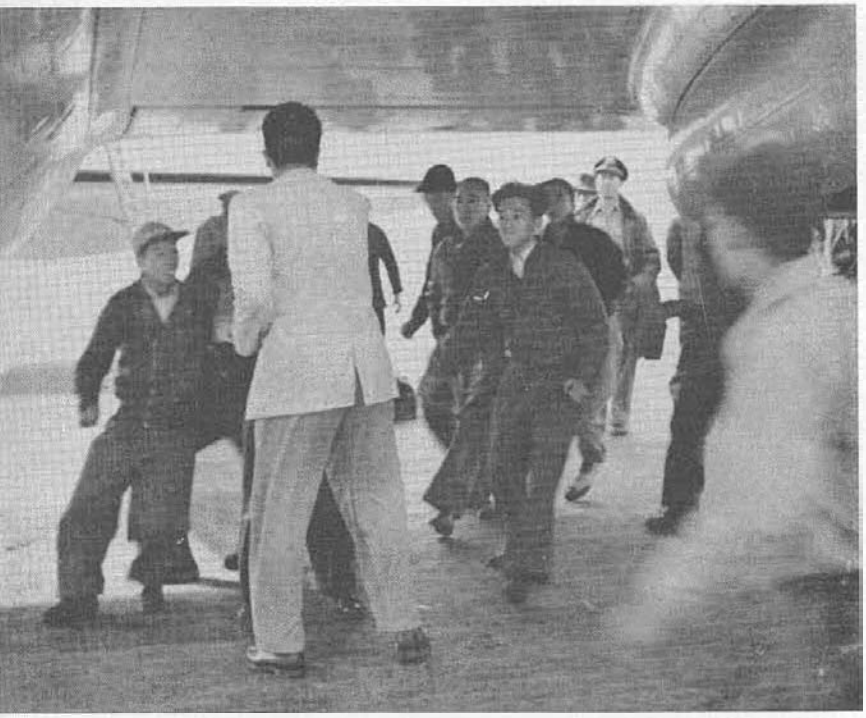
The general was, as always, completely frank with the men. He made no big promises. He wasn't interested in hiring anyone who had an eye on making a fat bankroll and then heading back home. What he wanted were men who could take care of themselves and do a job in some of the roughest flying country in the world.

All six asked to be counted in and a dozen more ex-GIs around Shanghai and Peking applied for jobs on the same basis. All were in their early 20s, with no references except logbooks that showed thousands of hours of flying from the Hump to tiny atolls in the Pacific.

Before he won the right to operate, Chennault had to buck the two airlines already operating in China, each backed by politically powerful interests. Finally, Chennault sat down with the director general of the Chinese National Relief and Rehabilitation Administration and signed his first contract on October 25, 1946.

He needed planes and these he purchased through the U. S. War As-

In airline's early days, maintenance stands for its surplus aircraft were fashioned by lashing together bamboo poles.



Captain Bob Rousselot stands off gang of Communists who tried to block takeoff from Hong Kong in 1950.

sets Administration with an UNRRA loan of about $1 million. Fifteen Curtiss C-46s were picked up in Honolulu by one group of fliers hired from the West Coast, while eight other crewmen headed to Clark Air Field, near Manila, to get four Douglas C-47s.

Bill Hobbs, as leader of the group, went to the Philippines with $500 to cover living expenses, labor, and parts. His instructions were only to get the ships into the air and back to China. Still wearing their military uniforms, the men hitchhiked to the Philippines, expecting to gas up the ships and hop right back. They got a real jolt. The planes were there all right, but months of disuse had taken their toll in wear and tear. There was even a hornet's nest in the cockpit of one of them.

It took weeks of back-breaking work to put the ships in flying shape, but finally the reliable Pratt & Whitney Aircraft engines were revving up as good as new. By then, there was just enough cash left to pay for gas to get the planes to Hong Kong. From there, credit took them to Tien Ho Airport, Canton, the main operations base for CAT.

On January 31, 1947, Captains Frank Hughes and Douglas Smith took off from Hungjao Airport, Shanghai, with the first load of UNRRA supplies — and CAT was officially in business.

The first half of the year was spent flying aid material, medicine, and foodstuffs to hospitals, missions, and relief centers throughout southwest China. On the return runs, the C-46s and C-47s brought out inland products — hog bristles, hides, tobacco, wolfram, and tin which could earn desperately needed foreign credits for China and support struggling local industry. In the months that followed, the CAT crews got to know Luchow, Chengtu, and Chungking as well as they once knew San Antonio and Corpus Christi.

Just when China was beginning to struggle to her feet after years of bitter war and internal strife, a new menace rose. Communist armies gathered in the north country. Sporadic clashes between Nationalist troops and the Reds grew more and more frequent and in late summer, 180,000 men strong, the Communists swept out of the northernmost reaches of Asia.

It was all-out civil war. China had a small air force composed mostly of American-made fighters and a handful of transports. The two scheduled domestic carriers had others. But more and more frequently, commanders of Chinese Nationalist armies in the field called on CAT for air support, and soon the C-46s and C-47s became the air transport arm of the battle against Communism.

The rolling prairies of north China permitted the Communist war machine in 1947 to move ahead ponderously, virtually unopposed except at the cities where government forces would throw up stubborn resistance. When this happened, the Communists would encircle the city, block off all routes of supply, and dig in to beat the defenders into submission. The Communist battle strategy was thwarted by one factor — CAT.

Day after day, the heavily loaded planes droned westward to resupply the beleaguered towns. At one point the airlift helped keep the city of Weihsien from collapsing under siege. For a full month, CAT flew in and out each day, bringing medical supplies, high priority emergency cargo, and food to the city of two million people.

Crewmen Added To Black List

It didn't take the Communists long to figure out that CAT's air support was snarling their timetable of conquest. Moving to wipe out the Americans, they publicly added the name of each CAT crewman to their black list — the Reds' roster of individuals to be executed upon capture as enemies of the People's Republic. Soon the Americans were flying as a matter of routine into tiny dirt airstrips under heavy ground fire, if taking an unarmed ship deep over enemy territory and down to a tiny pocket of resistance can be called routine.

The enemy churned ahead, taking city after city. CAT began to lose its fixed operational bases, and the first of what was to be a two-year succession of retreats began in the winter of 1947 in Honan Province, south of the Yellow River.

Evacuations were generally just a short step ahead of the advancing Reds, since the enemy often laid siege to a city for months without moving in for the kill. When it came, it was a lightning thrust. And some CAT people didn't make it to safety. On the morning of January 16, 1950, Captain Bob Buol, chief of operations, flew into Mengtze Airfield, about 160 miles southeast of Kunming, to plan the reactivation of a tin ore bar airlift for the government. Without warning, the Communists attacked, and Bob and eight of his Chinese employees were taken prisoner.

For five years, Buol remained a prisoner of the Chinese. In 1955, he was released, a sick and broken man, old far beyond his years. Six months later he died of a heart attack.

At about the same time, the Reds got Captain James B. McGovern. He was more than a crackerjack pilot. He was a living legend, a huge, hulking man with a sense of humor and a feeling for mankind as big as his celebrated appetite.

On December 14, he took a flight from Kai Tek Airport, Hong Kong, to Junming in Yunnan Province. Encountering trouble with his radio compass, he radioed another CAT aircraft that he was down to 40 gallons of gas and was going to try for a crash landing. That was the last word from McGovern — for the time being.

Fifteen days later, Captain Dutch Brongersma and Captain Bob Snoddy spotted a plane down on a sand bar about 23 miles southeast of Yulin in Kwangsi Province. Coming in low, they identified the craft by number and insignia. It was McGovern's.

Six months later, a huge bearded man stomped into Pop Gingles' restaurant in Hong Kong, pounded on the bar, and demanded service. McGovern was much thinner now than the 250-pounder who went down, but just as loud as ever. He said the Commies couldn't afford to feed him, so they turned him loose. The beard won Jim the nickname "Earthquake McGoon," after the Al Capp comic strip character, and his legend grew around the Orient.

'Earthquake McGoon' McGovern, left, and Bob Buol chat with friend at China airfield before Red takeover.

Courage wasn't enough to fight the Communists. First Shanghai fell; then Hankow, Nanchang, and more. There was no stopping the Reds now. Mainland China was virtually theirs. When only the seacoast cities were left, the airline bought an old LST from UNRRA and put all its heavy maintenance gear aboard, wisely figuring that the airline would operate from a floating base if it were pushed to the sea.

Renamed the Chung 118, the LST sailed from Shanghai with Captain Felix Smith as navigator. He took time out from his flying chores to put his old third mate marine license into use. From the mainland, the landing craft sailed to Hainan Island and, when that fell, CAT made its last pull-out and headed for Taiwan, the island stronghold of the Nationalist Government of Chiang Kai-shek.

He Wasn't Ready To Quit

CAT faced the prospect of going out of business. Chennault called a meeting of 50 of his key men. The old general wasn't ready to quit, but he knew difficult times faced them. He asked his men to take a 25 per cent cut in salaries; those not needed to handle the few flights still operating were given leave and asked to stand by. Anyone wanting out could go.

The room was quiet. In four years, the fliers had done a lot together. They wanted to keep CAT going as long as they could. Only six asked to be released; the rest voted to stay on.

Although CAT was originally conceived as a cargo-carrying line, a couple of runs were set up about this time to handle passengers between Taipei, the capital of Taiwan, and Hong Kong. Two C-46s were refurbished to accommodate passengers who couldn't be expected to share flight facilities with goats, sheep, and other usual CAT cargo. Overnight, CAT became a scheduled airline, its three round trips a week between the two cities sowing the seeds of its present international service.

The capabilities that CAT had built up on the mainland of China were widely recognized by the time the North Korean Communists swept across the 38th parallel on June 25, 1950, setting off the Korean war. CAT's resources and experience were quickly put to work giving air support to United Nations' troops in Korea.

Planes were taken out of mothballs and men recalled from leave, and in the desperate weeks that followed, they moved an impressive volume of the military air cargo bound for the front lines. Troops and munitions were airlifted from Ashiya and Itazuke air bases in Japan, and wounded and high priority cargo were flown back. While new loads were put aboard and planes were made ready, flight crews would sleep on the ground. This airlift to U. N. forces continued throughout the entire Korean war.

In late 1953, French troops and loyal Vietnamese soldiers were fighting a last-ditch stand against the Communist armies of General Ho Chi Minh in Indochina. With the French needing air transport badly, once again General Chennault and his team were called in to assist. In addition to flying C-46 and C-47 transports, crews were needed for Fairchild C-119 Flying Boxcars furnished to the French under U. S. aid programs. The veteran American pilots were checked out in the Boxcars, and in a matter of days launched the airlift from Haiphong.

Passengers aboard C-46s and C-47s were provided with bucket seats and had to share cabin with cargo.

First they flew refugee evacuation flights and routine supply runs. But then the defenders of the encircled Dien Bien Phu went under tremendous Red pressure and the French high command ordered a step-up in aerial resupply. Old China hands like Felix Smith, Steve Kusak and "Earthquake McGoon" McGovern climbed back into their cockpits and went back to work. Once the airlift began, Red anti-aircraft guns were rushed in to ring the tiny French outpost with steel.

Since the American aircraft had to make their runs from fixed angles and altitudes, the Communist gunners found perfect targets in their sights. On May 7, 1954, the Reds stepped up their attack on the 1,000-yard-wide defended wasteland of shell-blasted trenches and bunkers. All-out air support was needed if the French forces were to survive this last assault.

From their bases in the south of Indochina, the pilots boarded their ships and six C-119s took off for a mass air drop mission. Flying in Bird Two was Earthquake McGoon McGovern with 28-year-old Wally Buford as his co-pilot. As the aerial train turned into its drop run, Red anti-aircraft guns opened up. The lumbering C-119s held on course, right into the black smudges of exploding shells.

Suddenly Steve Kusak in another plane saw McGovern's ship take a hit in the left engine. Earthquake McGoon feathered his prop and for a second it looked as though he'd make it. But then he was hit again, this time in the tail assembly.

Steve got on the air and yelled to Earthquake McGoon to try and make it to a river bed. But the C-119 was falling out of control. It yawed and lost altitude. Steve flew in over the stricken ship, trying to talk his buddy across the ridges and down toward a spot where a crash landing might be possible. The ship leaned over crazily to one side as it skipped over the ground. Steve heard McGovern say, "Looks like this is it, son." The left wing dug into the barren hillside; the ship cartwheeled twice and exploded. Earthquake McGoon and Buford were gone.

It Rebounded With Vigor

The next day Dien Bien Phu fell to the Reds. The Indochina airlift was over. CAT's special capabilities had been proven again, though in a losing cause. Wearily the American crews packed their bags and left Hanoi and Haiphong.

Since the dark days following the loss of the mainland, CAT has rebounded with vigor. Within five years, it became the official overseas flag carrier for the Republic of China. And to its two initial ports of call, CAT added Tokyo, then Seoul, Naha, Okinawa, Manila, and finally Bangkok.

CAT maintenance, which began with an old LST chugging down river from Canton, today ranks with the best in the world. The LST Chung 118 remained at Kaohsiung at the mouth of the River of Love in Taiwan as CAT's primary maintenance base for years. It was later joined by a barge called Buddha which became a floating supply shop stocking more than 60,000 different parts. Today a maintenance base at Tainan, an airport at the southern end of Taiwan near the old Kaohsiung floating base, not only performs CAT maintenance but does contract work for a variety of civilian and military clients.

Its facilities have been approved by the Civil Aviation Administration of the Republic of China and have been awarded an air agency certificate by the U. S. Federal Aviation Agency. Some 1,800 persons are employed at the Tainan installation and a $1 million consolidation and equipment program is now under way to improve the base's jet aircraft and engine repair facilities.

In the skies, too, CAT has moved ahead. New aircraft have come to bear the golden dragon insignia of CAT — Douglas DC-4s and, in time, a Douglas DC-6B, one of the last and most modern models of this famous series ever made.

Colors Are Chinese Favorites

Late in 1958, CAT introduced its distinctive Mandarin Flight as an innovation in personalized passenger service. The DC-6B cabin interior was designed to emphasize the cultural heritage of China. Cabins are done in rich red, black, and gold — favored colors among the Chinese. The proud, five-toed dragon, CAT's own symbol, stands guard at the entrance panels while the golden phoenix, legendary ruler of the bird world, shares a place in the decor and on in-flight service items.

The Convair 880-M jetliner, equipped with a Hamilton Standard air conditioning and pressurization system, which CAT introduced last summer on its routes to seven countries in the Orient, makes the line the first regional carrier to offer pure jet service.

All CAT stewardesses wear uniforms smartly tailored to reflect the traditional and eye-catching Chinese cheongsam. The high-collared blouse primly sets off the intriguing split-sided skirts. Aboard the Mandarin flight, stewardesses in first class don a formal brocade cheongsam which vies with the cuisine for passenger attention. Picked for their charm, intelligence, and linguistic ability as well as for their beauty, the stewardesses have played an important role in CAT's acceptance as an international air carrier.

For all its experience, CAT is still operated by an amazingly young group of men. Its president, Hugh L. Grundy, who joined the airline as chief engineer in the China days, is now only 44 and became president when he was 38. Captain Bob Rousselot, 39, has moved from chief pilot to vice president for operations. Even so, he hasn't traded his cockpit seat for the upholstered leather of an executive's chair. Rousselot is probably the only major airline executive in the world who still flies the line. He averages one run a week as a regular captain and has 13,000 hours in his logbooks.

Of the original six pilots who heard Chennault articulate his dream for an American-operated airline in China, three are still with the company. Var Green is now vice president for traffic and sales, while Weldon Bigony and Felix Smith are senior captains.

CAT is something more than a carrier concerned with revenue and schedules. It has a heritage linked to the never-ending battle for freedom's cause.

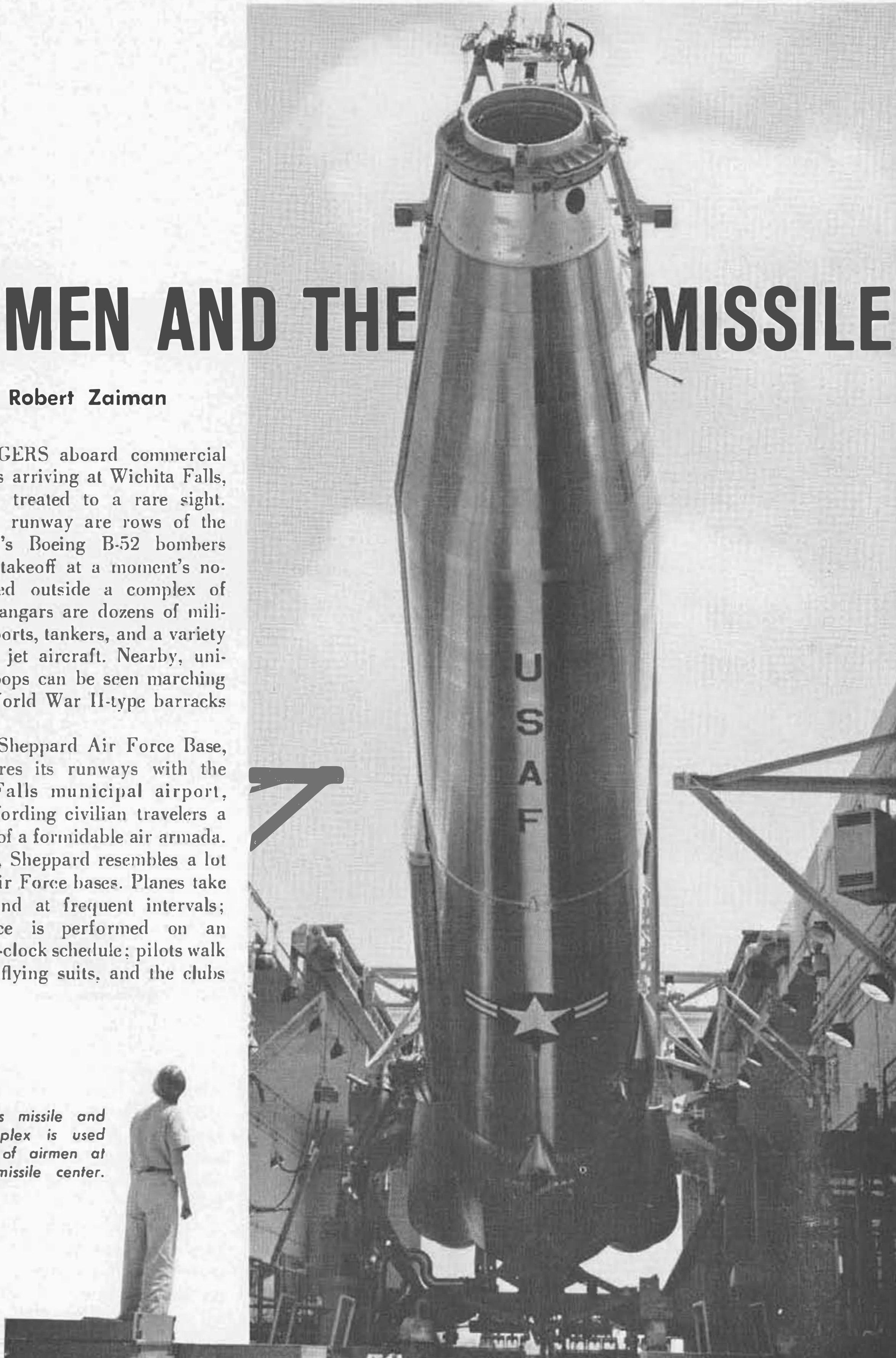
CAT stewardesses, shown modeling gowns at Taipei fashion show, wear flight uniforms tailored to reflect Chinese cheongsam.

AIRMEN AND THE MISSILE

By Robert Zaiman

PASSENGERS aboard commercial airliners arriving at Wichita Falls, Texas, are treated to a rare sight. Lining the runway are rows of the Air Force's Boeing B-52 bombers ready for takeoff at a moment's notice. Parked outside a complex of spacious hangars are dozens of military transports, tankers, and a variety of smaller jet aircraft. Nearby, uniformed troops can be seen marching between World War II-type barracks buildings.

This is Sheppard Air Force Base, which shares its runways with the Wichita Falls municipal airport, thereby affording civilian travelers a close view of a formidable air armada. Outwardly, Sheppard resembles a lot of other Air Force bases. Planes take off and land at frequent intervals; maintenance is performed on an around-the-clock schedule; pilots walk around in flying suits, and the clubs

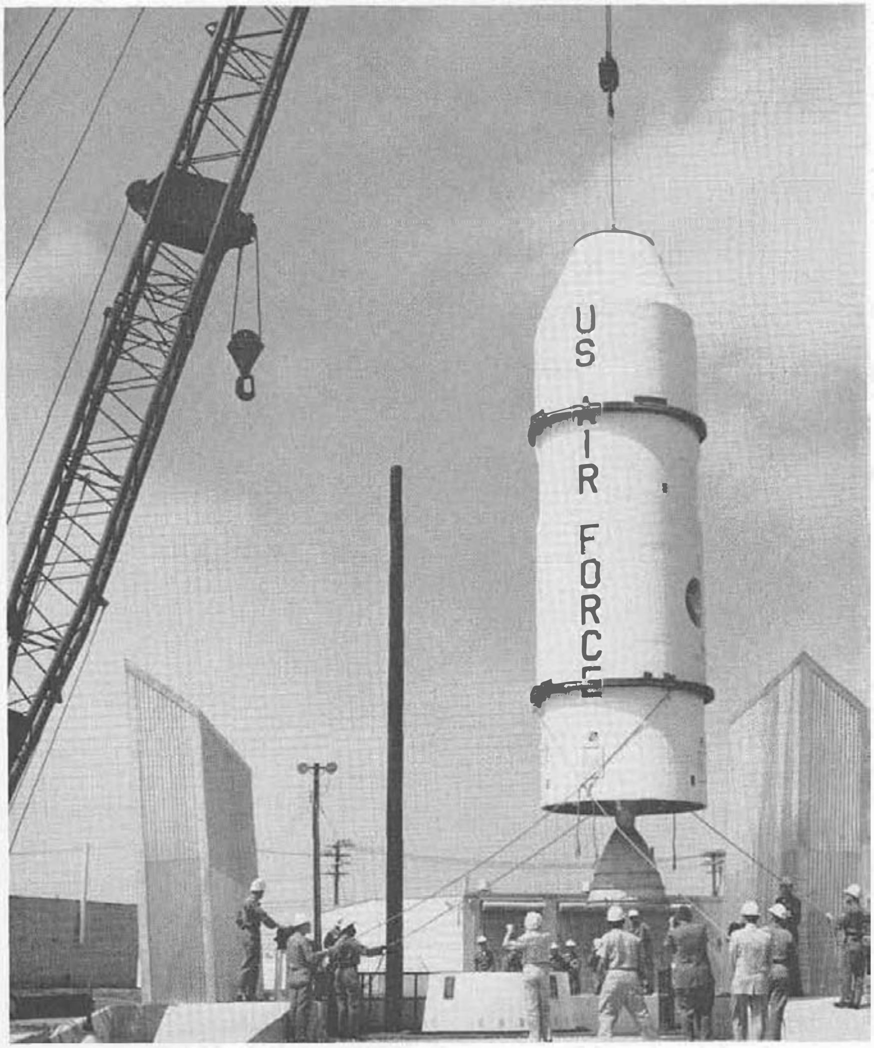


Actual Atlas missile and launch complex is used in training of airmen at Sheppard missile center.

for officers and airmen are well patronized.

But, strangely enough, many of the officers and airmen at the sprawling north Texas training facility have little or nothing to do with manned aircraft despite the fact that a large percentage of them are veteran pilots and crewmen. They are involved in an equally vital Air Force program — the manning and maintenance of intercontinental ballistic missiles. While they wear the same blue uniform as their airborne counterparts, these missilemen perform work that is vastly different. They even speak in a different vernacular, much of which is largely numbers.

In a large, windowless structure adjacent to the airfield — the first Air Force building conceived for the sole purpose of training missilemen — a staff of 1,132 instructors, supervisors, and administrative personnel are converting these former pilots, crewmen, and a host of fresh recruits into missile technicians. For the veteran Air Force men it means going back to school to learn the fundamentals of electronics, mathematics, hydraulics, and other technical subjects. For the recruits fresh out of high school or college, it means a continuation of classroom work they thought they had left behind them when they enlisted. The fundamental courses take up to 22 weeks and are followed by months of intensive training on actual missiles and launch complexes.



Stages of a Titan missile are mated in this operation directed by Sheppard students.

The Courses Will Change

At present, the Air Training Command staff at Sheppard is striving to provide as swiftly as possible the officers and men needed to man the nation's operational Atlas and Titan ICBM squadrons. But as new missiles enter the Air Force inventory, the curriculum at Sheppard will change accordingly.

For the most part, these earthbound Air Force members possess little or no background in missile technology when they enter the Sheppard missile training center.

"The best graduate we have had thus far," said Lieutenant Richard C. Reynolds, Jr., a Titan instructor, "was a music major in college. Another top student here had been in personnel work for 19 years. We even had a former tree surgeon pass with flying colors."

So concentrated and intensive are the courses that illness or injury usually are not allowed to interrupt the training cycle.

"One of our students has the mumps," said Lieutenant James W. Reynolds, an Atlas instructor and no relation to his fellow staffman, "and we have to go to the hospital to keep him up to date in his studies. A few weeks ago two of our students were injured in an accident. We also carried on their instruction in the hospital."

The prerequisites for a competent missileman in the modern Air Force are stringent. For example, ATC feels that a trainee for a guided missile maintenance officer post should have completed college-level courses in the theory of electricity and electronics; have knowledge of mathematics through differential calculus; possess a bachelor's degree in electrical, aeronautical, or mechanical engineering; and have basic knowledge of theory of flight and principles of jet and rocket engines.

Demand Exceeds Supply

The demand for people with this type of educational background, however, far exceeds the supply. Because rated pilots receive much of this background in pilot training and flying experience, it has been found that a two-year college level will allow most pilots to complete the courses successfully.

Airmen and recruits whose aptitude tests show proficiency in electronics, mathematics, and physics are selected for the fundamental course in missilry. Later they go on to one of the more than 20 advanced courses on the Atlas and Titan, learning jobs that range from electronic digital data-processing technicians to plumbers.

"Some people are surprised to learn that we have a need for plumbers in our missile work," Lieutenant Richard Reynolds said. "Actually, a skilled plumber is vital to the maintenance of a launch complex. The silos which house the Atlas and Titan have numerous pumps and lots of piping that must be in top working condition if we expect to have successful launches."

Not Many Flunk Out

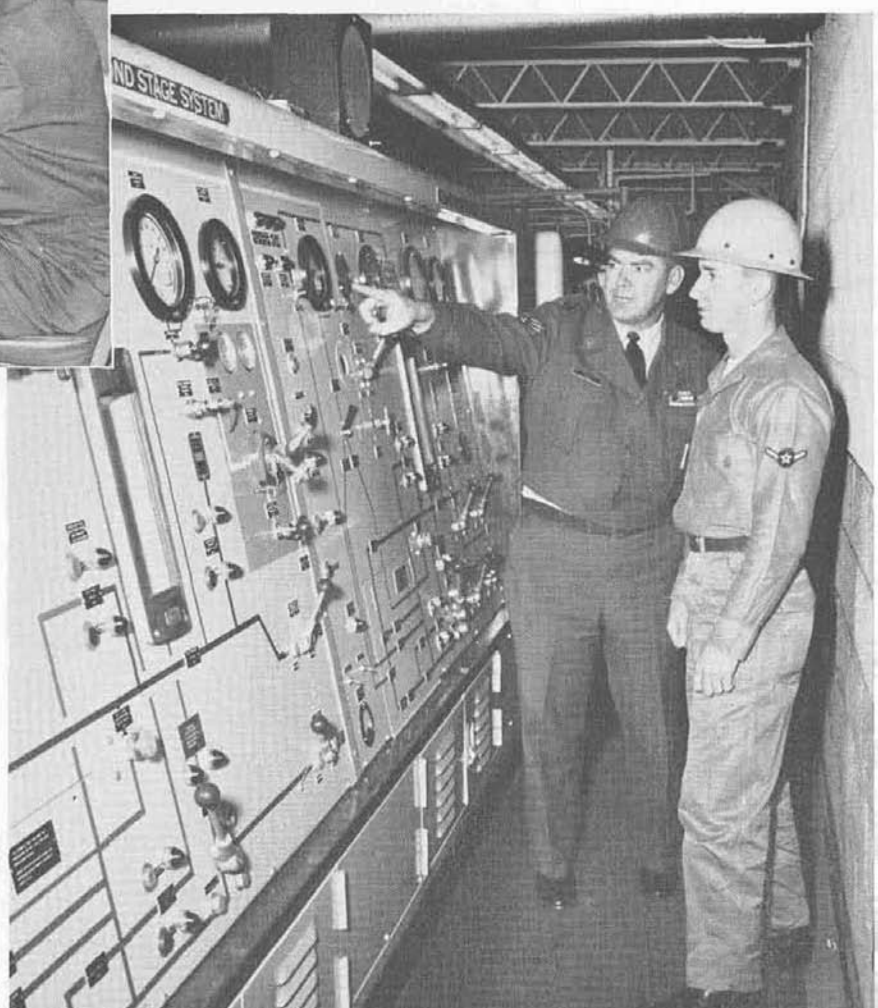
With so much technical knowledge and so many maintenance procedures contain the actual equipment used in maintaining and launching Atlas and Titan missiles. There is a huge missile bay area in which several missiles can be placed at one time with sufficient room to conduct training on each simultaneously. In addition the center has a maintenance building, launch complexes, launch pads, Atlas blockhouses and launchers, a Titan ground guidance station, and a Titan mating/demating trainer where students practice putting the Titan into the silo.

Once the students have finished the courses in fundamentals, they go through an intensive familiarization program on the missile to which they will be eventually assigned. At Sheppard, they are able, under expert supervision, to check, trouble-shoot, and simulate the launch of the same life-size missiles they will handle when they take up active duties.

The new language that has grown up with the program is always a puzzle to the new students and even to newcomers to the Air Training Command staff, which directs operations from Randolph Air Force Base near San Antonio, Texas. Colonel Charles W. Johnstone, who finished

Captain Joseph Elliott, an instructor in the Titan missile program, monitors the launch control console during a simulated countdown.

T/Sgt. Billy E. Cook, Atlas missile hydraulics instructor, explains the operation of complex ground support equipment to A3C John McCoy.



to absorb in a comparatively short period of time, the pressure on the student body at Sheppard is tremendous. Yet an average of only 1.4 per cent of the officers and airmen who enter the training cycle flunk out.

"Some of them have an extremely hard time of it," said Lieutenant James Reynolds. "Instead of trying to adjust to the task, a few students try to fight it. We know what they're going through, particularly the older men, and we're here to help them. Once they realize this, they get along."

One officer fought the program so fiercely, Reynolds added, that he had a nervous breakdown while attempting to direct a simulated Atlas launch during his final examinations.

The Sheppard missile center was dedicated only 26 months ago. It is equipped with the most elaborate and expensive training devices available. Its 126 classrooms and laboratories a tour of duty as a wing commander in Japan and came to Randolph as director of missile and space weapon systems training, confessed that he had to learn the numbers vernacular before he could tackle his new assignment.

"One of my men came in the first day I was here and started talking about the 1824-slash-3124 course," he said. "I stopped him and asked him to explain that. It turned out that the 1824 was the designation for a missile operations officer and the 3124 meant that the man had a maintenance background in missiles. It took me a while to learn all these designations and the special technical terms that have become commonplace at Sheppard and our other training bases."

The missileer student body at Sheppard, which now numbers more than 1,600, is made up of both volunteers and "draftees," the latter category comprising mainly former bomber and fighter pilots and crewmen. Some of them readily admit that they are not too happy about the prospect of living in a "mole hole," their term for a launch silo.

Typical of this group is Captain Joseph Elliott, a 30-year-old pilot from Philadelphia who until a year ago was flying F-89s in Alaska.

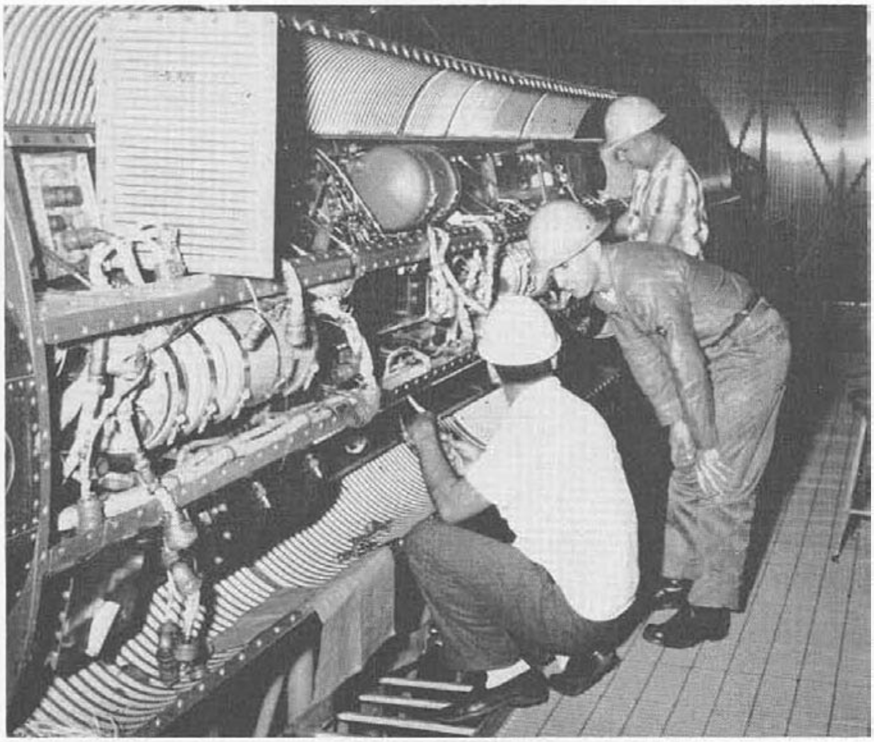
"I was drafted into this training center," he said, "and frankly I'd like to be back in a flying job. Sitting in a hole manning a missile is a lot different from sitting in a jet plane and flying a mission. The loss of flight pay hurts, too."

He Is Now An Instructor

And yet despite his outspoken remarks about his latest assignment, Captain Elliott did so well as a student at Sheppard that he is now serving as an instructor.

Airman Third Class John L. McCoy, a 19-year-old recruit from Hyndman, Pennsylvania, feels differently about his missile work. He is a 1961 high school graduate who had no specific job preference in mind when he enlisted in the Air Force a few months ago. Now, he is in the advanced Atlas course at Sheppard and he likes it.

"I learned more in six weeks here than I learned in six months in high school," McCoy said. "I haven't made up my mind yet whether I will make a career of the Air Force but I sure don't mind being in missiles."



Technicians Valentine Sanchez, left, and Boyd Perry show student John McCoy how to perform equipment modifications on electrical system of Atlas missile.

> **Sheppard Training Base Is One Of Five Centers**
>
> While the training at Sheppard Air Force Base is concentrated on the Atlas and Titan, vigorous programs are also being conducted for other Air Force missiles by the Air Training Command at four other bases.
>
> At Chanute Air Force Base, Illinois, a support base for propulsion training on all ballistic missile systems — the Pratt & Whitney Aircraft-powered Hound Dog air-to-surface missile; the Minuteman; and the Bomarc.
>
> At Lowry Air Force Base, Colorado — the Skybolt, the Mace, the Matador, and the Sidewinder.
>
> At Amarillo Air Force Base, Texas — the Pratt & Whitney Aircraft-powered Snark; the Quail, the Bull Pup, and a variety of drones.
>
> At Keesler Air Force Base, Mississippi, an electronics training center and support base for ground guidance training on ICBMs — the Midas early-warning satellite, the Tiros weather surveillance system, and the Dyna-Soar manned boost-glider space vehicle.

Lieutenant Lawrence Hillenbrand, 22, of St. Louis, is one of still another category of students at the center. A 1960 graduate of St. Louis University with a degree in aeronautical engineering, he had hoped to be able to do research and development work in the Air Force. Instead his first assignment was the missile training center.

The Job Is A Challenge

Like Captain Elliott, he was proficient in his studies and became an instructor.

"Even though it's not what I really want to do, this is a challenge," he said. "I'm involved in propulsion and I like that."

Airman First Class Claire Black, a ten-year Air Force veteran from Rock Island, Illinois, has had by his calculations a "world of jobs" since his enlistment.

"They volunteered me for missiles," he said. "I've been to a lot of schools and to me this is just the same as the others. I'm learning a lot but I don't think I'm going to like sitting in a hole manning a missile."

How to keep the highly trained missilemen in service for extended tours of duty after they graduate is a problem that has yet to be solved by the Air Training Command.

"In certain critical skills, we are losing as many as four out of five of our young airmen after their first enlistment," said Lieutenant General James E. Briggs, commander of ATC. "And we lose six out of ten of our young officers after they have served their obligated tour of duty."

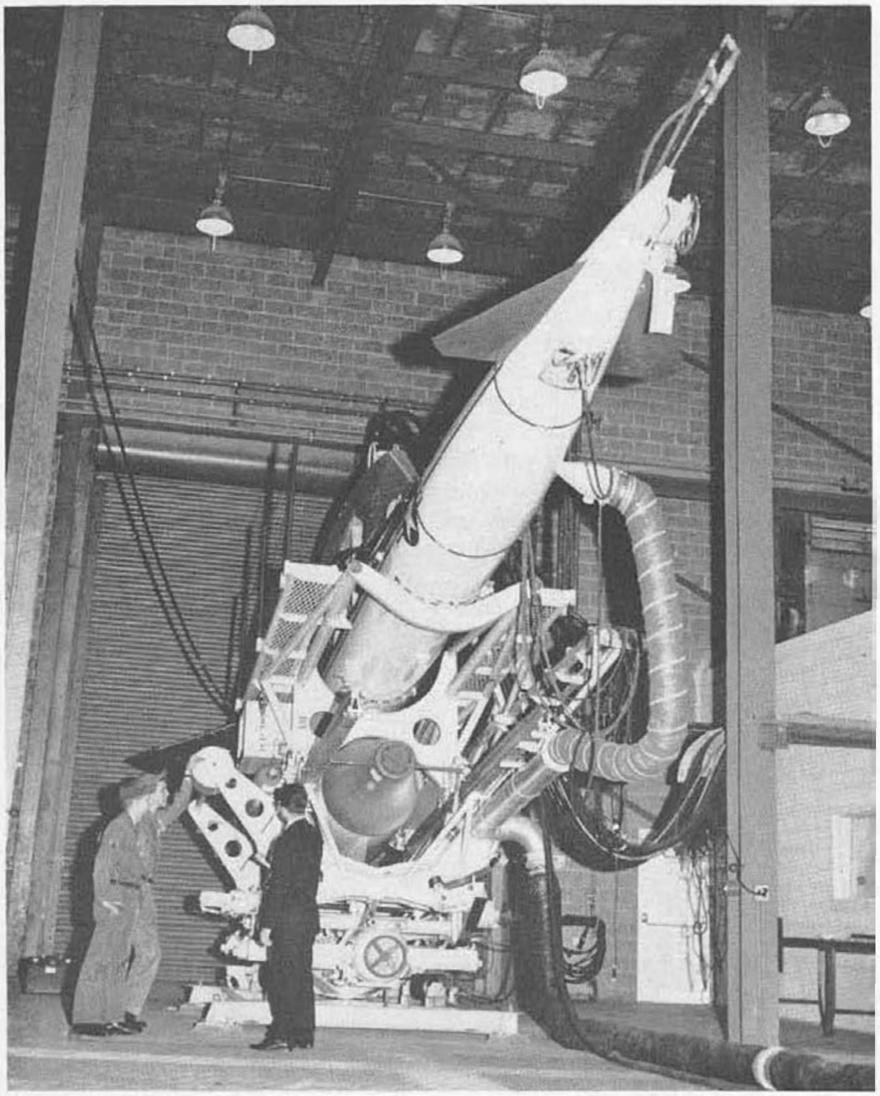
Thousands More Are Needed

The answer at the moment, the Air Force believes, is simply to keep training as many missilemen as possible and hope that once they get accustomed to the new routine they will like it well enough to extend their tours of duty. Thus far, slightly over 2,800 students have graduated from the Sheppard missile school but thousands more are needed to man ICBMs at bases throughout the nation. To handle an expected influx of new students, Sheppard is expanding its facilities and will soon add courses in propellant handling and storage.

Until a few years ago, all missile training had to be conducted in the plants of the missile manufacturers simply because the Air Force had neither qualified instructors nor a single textbook. This in-plant training, while vital to the nation's defense effort, was expensive. In the nine-month period from July, 1959, through March, 1960, for example, living expenses for airmen at factories amounted to over $5 million.

Actually, Sheppard Air Force Base was assigned the responsibility for training missile crews in the fall of 1955 but at the time it had only one man qualified to begin planning and developing a suitable program of instruction. However, as soon as officers and airmen training at the factories gained sufficient experience they were rushed to the new missile training center. By late 1957, there were 28 people in the program and within a year this number had increased to 92.

At Chanute Air Force Base, Illinois, intensive training is conducted on the Minuteman, the Bomarc, and this Pratt & Whitney Aircraft-powered Hound Dog.



Center Completed In 1958

The design of Sheppard's spacious missile training center was completed in mid-1958, and construction began six months later. The structure, which has 300,000 square feet of floor space, was built in a record 270 days, and the first training classes went into session in October, 1959. The center was dedicated on November 14, 1959, and named in honor of Colonel Neel E. Kearby, a World War II Medal of Honor winner.

The early days at the new center were difficult ones for the instructors. They had to write the textbooks and map the programs and, even as they worked feverishly at these tasks, continuing changes in missile design and operation forced them to go back and revise the work they had completed.

But it wasn't long before they had their courses accurately channeled and students began to flock to the school in increasing numbers.

Because of the complex nature of the subjects, the classes are small in number, usually about 12 men.

"We have to work with each student individually on the equipment," said Lieutenant Richard Reynolds. "Our training aids permit the instructor to simulate malfunctions in all systems and in this manner the student soon gets to recognize immediately the source of the trouble. With large classes we couldn't do this readily."

The final examinations at Sheppard are unique. The officers and airmen go through an entire simulated launch procedure with instructors frequently channeling in simulated malfunctions. Only after they have successfully passed this test are the students allowed to graduate.

"Some of them miss out the first time around," Lieutenant Reynolds said, "but we give them some more work and they usually make it the second time."

THE AIR HUB IN

Passengers board and debark and bags are loaded on DC-3 of Ozark Air Lines during five-minute stopover at Baldwin.

ON sunny Sunday afternoons at Baldwin Field, the municipal airport at Quincy, Illinois, the pastime of airplane watching reaches a weekly peak. Late in the afternoon two Douglas DC-3 airplanes of Ozark Air Lines land within six minutes. As a rule more than 20 passengers board the flights, and the spectators who drive up to watch usually total several times that number. There is parking space for about 20 automobiles along the fence at the loading ramp, and on sunny Sundays it is filled.

The airplane watchers get out of their cars and stand at the fence or take a stroll through the one-story, modern terminal or pause in Myrt's Skylane Coffee Shop.

When the planes arrive, the show is short and efficient. The Baldwin Field stops are five minutes long. The pilot brings the plane up to the ramp with the right side facing the terminal. He leaves the left engine running and two Ozark agents open the passenger door and baggage door. While the arriving passengers get off and the departing passengers get on, the agents hustle the baggage and freight onto a cart. They close the baggage door, and then, just before the passenger door swings up, the pretty stewardess leans out and waves to all those watching. The door closes, the right engine starts, and the plane rolls out along the taxi strip for the takeoff. The action is the same for both

MARK TWAIN'S COUNTRY

By Robert Sanford

flights. After the second plane is loaded, some spectators start for their cars but most stand outside until the plane takes off, watching it as it wings overhead with a roar that signals the end of the show.

Airplane watching is a national sport. There are about 550 airports in the United States served by scheduled airlines. Some of the big ports have fancy observation galleries complete with pinball machines for between-flight entertainment, but at the smaller ports the plane-watching facilities usually consist of a paved area and a fence to lean on. Of the 550 airports, about 350 are served only by short-hop, local service airlines, as is the case at Baldwin Field.

Flights From Quincy Feed To Big Cities In All Directions

Baldwin Field exemplifies the good, small-city airport. Last year nearly 17,000 persons boarded or got off the Ozark DC-3s there. Ozark operates seven flights a day in and out, connecting the port with St. Louis to the south, Kansas City on the west, Chicago to the north, and Louisville on the east. The flights are arranged for morning-evening commuter trips to the cities or scheduled to correspond with coastal jet flights which stop at the bigger airports.

"We're only 38 minutes from St. Louis or two hours from Chicago or Kansas City," Bill Schafer, Ozark's station manager at Quincy, says. "That means we're four to six hours from New York or Los Angeles. A couple of weeks ago I spent a weekend with friends who live near Santa Barbara. I left here on Friday eveniug and was back Sunday evening. I keep telling people we're enjoying the benefits of the jet age even though the big planes don't land here."

Inside the terminal building there are about 30 comfortable chairs, a picture window facing the loading ramp, a television set that plays an hour for 25 cents, candy and pop vending machines, a car rental booth, and the Ozark ticket counter. The loading ramp also can be seen from the four booths in the coffee shop. Mrs. Myrt Jordan, who runs the coffee shop, is a sort of unofficial historian for the terminal. With a small, plastic camera she has recorded some of the more outstanding airplane-and-people-watching events. She keeps a scrapbook behind the counter. In it are photographs of former Vice President Nixon, Vice President Johnson (drinking a cup of Mrs. Jordan's coffee beside an airplane), actor Vincent Price, two winners of the National Honey Queen title, and, incidentally, a letter and half a dollar from a Springfield, Illinois, man who sent the money after forgetting to pay for his coffee.

Baldwin Field is located among cornfields in rolling country a few miles east of the Mississippi River. It is 10 miles from Quincy and 20 miles from Hannibal, Missouri. The roads to the airport pass field after field of corn as tall as a man can reach. At the terminal, the view of the loading ramp includes a barn and silo at the far side of the field. Its setting is provincial, yet its service is the antithesis of provinciality. Posters in the terminal advertise Air France and Pan American World Airways; one sign reads, "Jet to Europe, Ozark — Lufthansa." Schafer estimates that each year about 500 persons from Quincy, Hannibal, Keokuk, Iowa, and the farms roundabout board the Ozark DC-3s to do expressly what the posters suggest — fly jets to Europe.

The airport is operated by the city of Quincy and a six-man, non-political aviation commission. Its facilities include a Federal Aviation Agency weather and

Last of the Mississippi packets is the Delta Queen, here passing under Mark Twain Bridge at Hannibal during her annual run.

communications station and a hangar housing about 25 light planes and a charter and flight instruction service. The whole operation has been self-supporting for several years, its revenues bolstered by good crops of wheat and soybeans raised on the more than 400 acres of tillable land in the field.

Although the field is operated by Quincy, Ozark's service there is certificated as Quincy-Hannibal. So, in effect, Baldwin Field is also Hannibal's airport. Nobody in Quincy seems to mind. Aviation is transportation, and the people in Quincy and Hannibal have been aware of the importance of transportation ever since the places were settled. Originally they were river towns, supplied by barges and packet steamers. As the westward push increased, they became railroad towns. Now they are industrial cities because of air, rail, and motor transportation.

"Scheduled airline service keeps us in touch with the world," says Arthur Higgins, editor of the daily Quincy Herald-Whig. "An industrial city like this, even though not too large, must keep in touch with metropolitan areas like Chicago and St. Louis. People can leave here on the morning flight, take care of their business in Chicago, and return on the evening flight."

Industries Thrive In Bottom Land Of Proud River

Transportation has shaped the cities. Quincy was once a stove-manufacturing center for the growing frontier. Hannibal was a lumber mill town supplied by great floats of logs down the Mississippi from Wisconsin and Minnesota. Today the bottom land along the Mississippi at Quincy abounds in industries: companies that make radio and electronic equipment, heavy compressors and pumps, electric generators and transformers, paper boxes, stock feeds, fertilizers, trailers, metal wheels, chairs, furnaces, and more. At Hannibal there are plants making cement, shoes, tools, textiles, optical supplies, doors, and burial vaults, and a printing plant that specializes in college yearbooks.

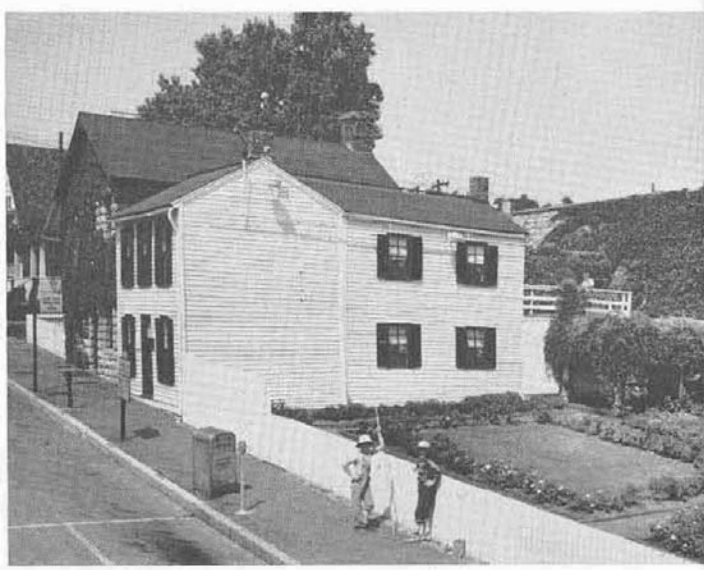
The DC-3s that land at Baldwin Field bring radio repair and assembly parts, transformers, parts for speedboats and sports cars and farm machinery, proofs and plates for the yearbook printers, orchids from Hawaii, live lobsters from Maine, dogs and cats and white mice and a thousand other things. Sometimes the planes deliver human eyes from an eye bank in St. Louis. No charge is made for the service. The eye packages are not flown in the baggage compartment but are kept under watch by the pilots or stewardess and delivered personally to the medical worker who meets the plane.

Like the residents of seaports, the people in the river cities on the Mississippi have a rather special legacy in the art of transportation watching. Their grandparents and great-grandparents gathered at the steamboat landing to watch the packets arrive. Later the railroads provided the show, and now it is the airplanes. Today there is only one packet steamer on the Mississippi, the Delta Queen. She makes only one round trip up the river each summer. And the trains don't hold the same fascination they once did. "In the old days I could tell you the number of a steam engine approaching, just by listening to its whistle," a railroad man in Hannibal said. "Now the engines are diesels and their horns all sound alike."

One who watched the packets and was instrumental in organizing a railroad was John M. Clemens, a Hannibal lawyer. The organization meeting for the Hannibal and St. Joseph Railroad was held in his office in 1837. The road later became part of the Chicago, Burlington and Quincy line. One of Clemens's sons, Samuel L. Clemens, grew up in Hannibal and, writing under the pen name of Mark Twain, told wonderful stories of the great river and its steamboats and islands, of Hannibal and the bluffs roundabout and their mysterious caves.

After Twain was famous — long after he left Hannibal — he continued to refer to Hannibal as his home town. On one occasion, when he was the featured speaker at a dinner, he was subjected to a long, long introduction that went on into the evening. When he finally was presented as the man who was going to give the address, he rose and said, "My address is Hannibal, Missouri," and sat down. In Hannibal today they like to think that because of Twain and his books and stories, Hannibal is everybody's home town.

Hannibal bills itself as "America's Stratford-on-Avon," and each year about 175,000 visitors sign their names in the guest book at the Mark Twain museum on Hill Street next door to the Clemens home where Twain lived as a boy. Adjacent to the home is the board fence which Tom Sawyer's friends paid him for the honor of whitewashing. Across the street is the Becky Thatcher house with a bookstore downstairs full of Twain's books. Among the buildings that have been restored to their earlier style is the law office of Twain's father. There is a statue of Twain in Riverview Park, and near the Twain home a statue of Tom Sawyer and Huckleberry Finn. Down the river a couple



Boyhood home of Mark Twain in Hannibal adjoins the fence Tom Sawyer's pals paid him for the honor of whitewashing.

Friendly service with personal touch is given at Baldwin by Bill Schafer, seated, Mrs. Kay Downey, and Jim Twyman.

of miles is the cave in which Tom and Becky got lost. All around Hannibal commercial establishments preserve the names: the Mark Twain hotel, the Tom Sawyer theater, the Injun Joe motel, and even the Huck Finn Finance Company.

Twain once said that when he was a boy in Hannibal it was the greatest ambition of Hannibal boys to become a steamboat man. Schafer reports today that in a poll of girls who are high school students in the area, the career of airline stewardess received the third highest number of votes when students were asked last year what career they would like to follow. (The two choices receiving more votes were secretarial and nursing careers.) These modern-day results might have pained Mark Twain in that girls outnumbered boys in the top three choices, but he would have noted the similarity between his ambition to be a steamboat man and the girls' choice of stewardess work — both suggest a restlessness, a longing for travel and adventure.

As it was with Twain and steamboat men, people today have a high respect for aviation. Such a feeling seems more pronounced in a small city. For instance, the office of Ozark Air Lines at Baldwin Field received 360 Christmas cards last year, almost all of them from passengers who apparently felt more than a commercial tie to the air service. And each winter the office receives a number of postcards from Florida. Schafer said a typical message on the Florida cards goes something like this: "The flight to St. Louis was fine and so was the jet to Miami. We just wanted to let you know we had a nice trip and we're coming home next Sunday afternoon."

Schafer and his agents offer a personal touch to their service. For instance, an 87-year-old widow who flies to Chicago frequently to visit her daughter makes her reservations only with Schafer, gets her tickets from him, and insists that he take her to her seat on the plane. He does so gladly.

And it's part of the Ozark staff's job to acquaint people with airplanes, Schafer says. "I remember one day when several members of a family got on a flight," he recalled. "It was obvious that the grandfather had bought the tickets. He wasn't going on the flight but he said he wanted to go inside the plane. He said he had always wanted to get inside one of those things. I took him on and showed him the cockpit. Maybe it cost us a couple of minutes of time, but the important thing was that a man interested in airplanes had got to see one from the inside."

Schafer has been Ozark's manager at Baldwin Field for 10 years. To ride with him through his native Quincy or to walk with him in the business district is a bit disconcerting — he never seems able to finish a sentence because he is constantly interrupting himself to greet someone. An Ozark executive visiting him once noticed this and, apparently seeking some sort of correlation between Schafer's popularity and the success of the Quincy operation, asked Schafer to keep a list of all the people he spoke to for a week.

"I did it a couple of days," Schafer recalls, "but I had to quit. I was spending all my time just writing names in my notebook."

Schafer Foresees More Air Travel By Young And Old

His is a friendly, non-ulcer job, Schafer says. In the 10 years he has been at Baldwin Field, the business has grown a lot and he sees new growth in airline travel by elderly people and children. That stewardesses can care for a child alone on a flight is a real service. To better acquaint children with travel, Schafer advertised a "down-by-plane, back-by-train" family tour to St. Louis. That was two years ago and the idea still is popular.

In 1951 the passenger total at Baldwin Field was 9,800. There were three airlines serving the field then — Ozark, Trans World Airlines, and Mid-Continent (now Braniff). In rearranging routes, the other two lines discontinued service at Baldwin Field, but Ozark's business has continued to increase to the point where the line served nearly 17,000 passengers at Quincy-Hannibal last year.

Such growth has been the national trend for local service airlines. In the last decade the number of airports served by short-hop carriers has increased from 315 to about 550, and the population they serve has been increased from 72,000,000 to 115,000,000. Their passenger traffic has grown seven-fold. Each hour of an average 16-hour operational day, 350 local airliners take off or land, averaging one takeoff or landing every 10 seconds.

Far from being passed by in the jet age, Schafer says, small-city airports are an important part of it. At Baldwin Field, he says, 70 per cent of the passengers use Ozark as a connecting line to another flight.

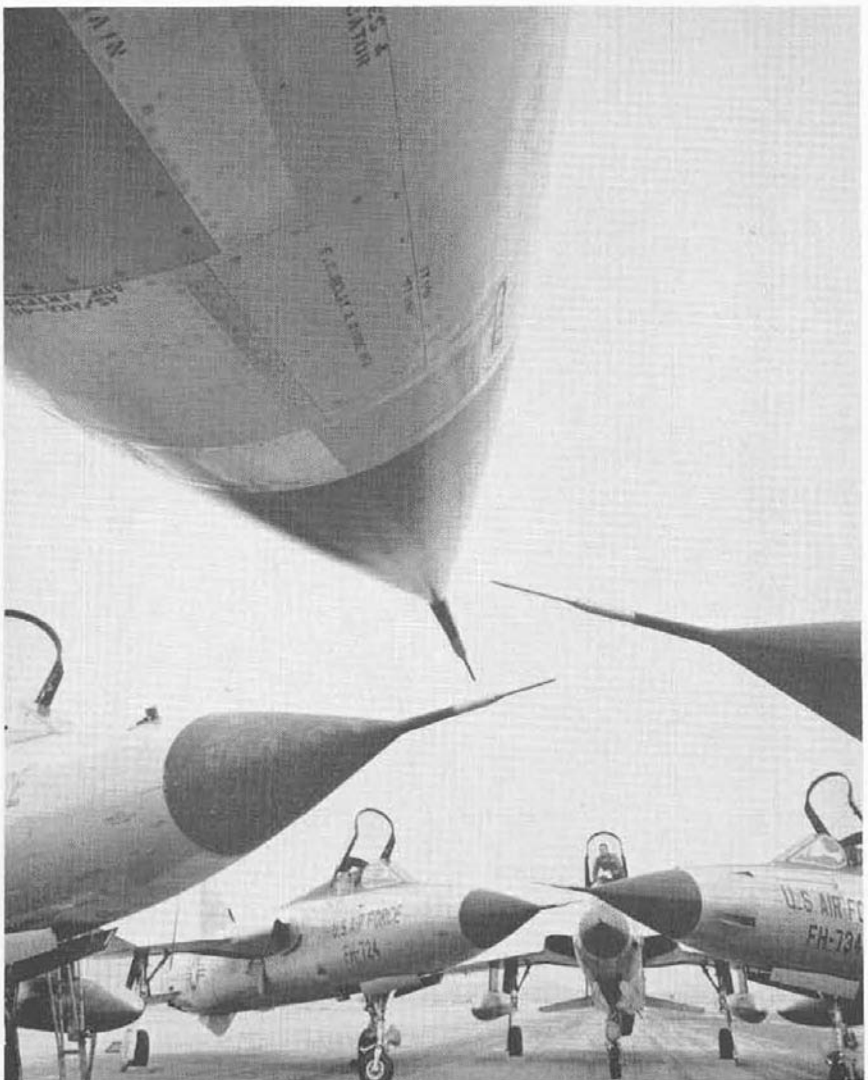
"Sure, we have smaller airplanes and smaller groups of people than the big jet terminals," he says, "but it seems to me that small-city airports like this one make up one of the real frontiers of the jet age and aviation."

A few weeks ago, the Air Force ferried the entire complement of jet pilots in its 49th Tactical Fighter Wing from its base of operations at Spangdahlem, West Germany, to the desert expanses of Nellis Air Force Base near Las Vegas, Nevada. The mission assigned this highly experienced group, by normal Air Force standards, was a strange one. The pilots of the 49th were to undergo an intensive nine-week course in basic flight training.

Most of them had thousands of flight hours in North American F-100s and earlier Air Force jet fighters. Many had flown piston-powered aircraft in World War II combat. And yet all of them regarded their new assignment as necessary. They were at Nellis to learn to fly the most advanced tactical fighter in the Air Force inventory — Republic's F-105D Thunderchief.

An all-weather aircraft that delivers both the sting of a fighter plane and the heavy punch of a bomber, the Thunderchief can fly at 1,400 miles an hour. It can also slow down, relatively speaking, to a walk in support of infantry action on the ground. It can carry a greater bomb load than a World War II B-24. In addition to short takeoff, steep climb, and long range capabilities, the F-105D is equipped with such an array of highly advanced

Schooling A NEW WING For



The needle-nosed F-105D Thunderchief, built by Republic Aviation, couples the sting of a fighter plane with the punch of a bomber.

Day's flights are mapped out in planning room. Trainees underwent many hours of actual flights simulating combat missions.

Pilots spent 19 hours in classroom familiarizing themselves with F-105D and its electronic systems.

THUNDERCHIEFS

electronic equipment, including radar, that it is regarded as the closest thing to a fully automatic airplane yet developed.

Before the pilots could qualify to fly the F-105D, they had to have 270 hours of academic instruction in such subjects as meteorology, electronics, advanced navigation, radar analysis, and related sciences. The Tactical Air Command provided them with the most advanced teaching tools to speed their training. These included two cockpit simulators, exact duplicates of those in the real plane even to the roar of the Pratt & Whitney Aircraft J-75 engine.

By "flying" missions in these simulators, the pilots were introduced to flight radar and became familiar with the controls, dials, and switches of the Thunderchief. Instructors operating duplicate instrument panels outside the simulators were able to induce sudden problems into the simulated flights and to observe the reactions of the students and offer advice.

Once the men of the 49th mastered this phase of their training, they underwent many hours of actual flight training, first in the North American T-39 and then in the same type F-105s they would fly on their return to Spangdahlem. The six-place T-39s, with their Pratt & Whitney Aircraft J-60 jet engines, are equipped with duplicates of the radar equipment carried in the Thunderchief. The student pilots, flying as passengers in these craft, were able for the first time to work with a radarscope in actual flight.

Since the F-105D is a single-seat aircraft, the 49th pilots were virtually on their own once they started their flights in the new craft. The only help they received was by radio from instructor pilots flying alongside in other planes.

On its return to West Germany, the 49th Tactical Fighter Wing became the second wing in the European area equipped with F-105Ds. The 36th Tactical Fighter Wing based at Bitburg completed its training at Nellis last summer.

Autopilot training device permits flier to maneuver craft automatically as he would in actual flight.

Lieut. Col. James E. Bean briefs instructors of his training squadron who are schooling combat-ready pilots of the Tactical Air Command to fly the F-105D.

The top teacher at Nellis on the Thunderchief is Lieutenant Colonel James E. Bean, 38, a wiry, sandy-haired officer whose proprietary feelings about the airplane are so strong he sometimes acts as if it were designed exclusively for him. Bean is commander of the 4526th Combat Crew Training Squadron, a unit of TAC's 4520th Combat Crew Training Wing under Brigadier General Boyd Hubbard, Jr.

Colonel Bean's squadron has adopted the cobra as its mascot and this has inevitably led to his being known affectionately as the Head Snake. Bean has been a fighter pilot since 1942 and during World War II his flying time included 100 combat hours as a Republic P-47 Thunderbolt pilot.

"Our job here," he said, "is to take experienced pilots who have been flying other models of the Air Force's Century series of supersonic fighters and give them the capability to fly the F-105D. How skillful they eventually become depends on themselves and how hard they work at it, but generally speaking, when they graduate from our course they're the Ph.D.s of combat pilots."

The safety record of the Nellis unit reflects the careful, serious approach of Colonel Bean and his instructor pilots. In more than 13,000 hours of flying through December, 1961, the squadron did not have a major accident.

Most of the pilots who come to Nellis for instruction on the Thunderchief are in fact returning to the base where they first acquired many of their combat flying skills. Ever since it was first opened by the Army Air Corps in 1941, the base's mission has been primarily training.

The dice tables, slot machines, and supper shows of Las Vegas are only eight miles from Nellis, but the taxing mental and physical demands of the F-105D training course restrain any desire on the part of students and instructors to leave the base during off-duty hours on a weekday. They generally arise at 4:30 each morning to start their rigorous schedule.

"Come sundown," said Captain Walter M. Burkett, one of the instructor pilots, "we're just people looking for a pad. When I get home I like to settle down with a book. As for those so-called 'old days' the veteran pilots sometimes talk about, well, they're just gone. The physical challenges of the job are tough and demanding enough to absorb all our energy."

— **Frank L. Murphy**

F-105D is powered by Pratt & Whitney Aircraft J-75 and equipped with two Hamilton Standard air conditioning units.

Operation of the heat-seeking Sidewinder air-to-air missile is thoroughly reviewed by F-105D pilots in classroom session.

More than twice the size of a normal cockpit in the F-105D, this walk-in version permits group work on familiarization.

Captain Walter M. Burkett, left, and Captain Saul Waxman, instructor pilots, discuss controls in pre-mission briefing.

With modern technology relying increasingly on analytical methods, Edwin Nilson exemplifies the applied mathematician who has become

Engineering's Prized New Ally

Edwin N. Nilson heads mathematician group supporting P&WA engineering department.

By Frank Giusti

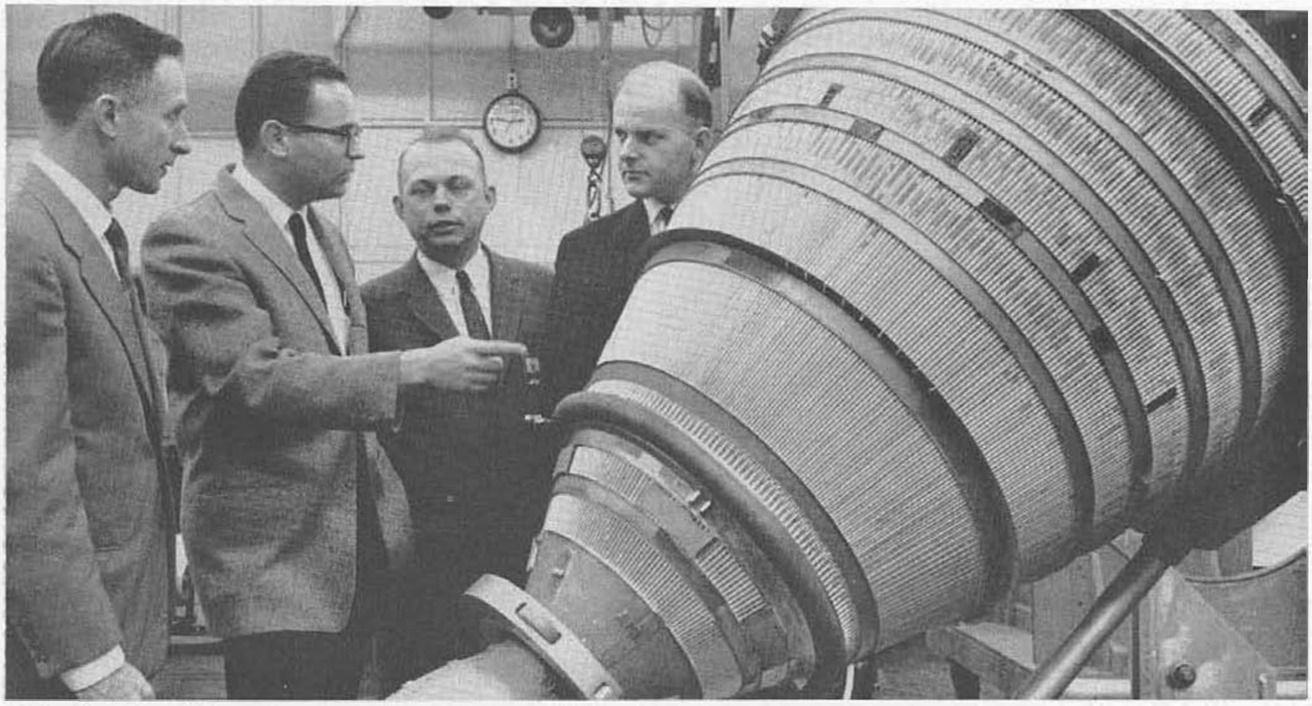
TAKE an angle, any angle. In the purest sense, slicing it into three absolutely equal parts is mathematically impossible. It cannot be done because there is no geometrical construction which will trisect an angle, as there is, say, for bisecting one.

Yet, through simple measurement and calculation, any angle can be divided easily into three angles of equal size with sufficient accuracy to satisfy practically any requirement.

In a grossly oversimplified way, this suggests the distinction between mathematics as practiced by the pure mathematician, dealing mainly in theoretics, and the applied mathematician, who brings his discipline to bear on matters of a hard practicality, such as determining by statistics whether an added power unit should be installed for a group of test rigs.

To carry the point even further just for illustration's sake, a pure mathematician, asked to trisect an angle, would reply that the problem is mathematically insoluble . . . next problem, please. If the same problem were given to an applied mathematician such as Dr. Edwin N. Nilson, he too would know, of course, that in theory it was incapable of solution, but he would also know that it was his job to produce the best possible answer because a specific application depended on it. So he would trisect the angle as best he could.

As a college teacher — he taught at the U. S. Naval Academy and three



Mathematics team for RL-10 thrust nozzle included, left to right, Stuart Hamilton, David Migdal, John Ahlberg, Dr. Nilson.

eastern colleges — Dr. Nilson spent nearly 15 years in the ivy-clad cloisters of the pure mathematician, concerning himself with developing the tools of his science and imparting their use to others. For the last six years he has been putting those tools to work as an applied mathematician with Pratt & Whitney Aircraft. In this job he comes to grips with problems which, in their complexity and concreteness of application, bear little similarity to trisecting an angle.

Dr. Nilson, a trim, quiet-spoken man of 44 with thinning, sandy hair, exemplifies the applied mathematician whose role is expanding rapidly in such technically oriented companies as United Aircraft where analysis is taking on increased importance as a handmaiden to engineering.

"The traditional cut-and-try techniques of engineering are important and always will be used for ultimate refinements in an article," Dr. Nilson said the other day. "At the same time, analytical methods have now become indispensable in engineering for penetrating new fields and extending developments beyond their seeming technological limitations. And in these analytical methods, applied mathematics is a key ingredient."

Applied mathematics helps chart a direct path to engineering achievement, eliminating much of the experimentation in design and test that the engineers would have to undertake in the absence of analytical methods. An example is one of the first projects Dr. Nilson worked on, in collaboration with others, soon after he joined Pratt & Whitney Aircraft in 1956, fresh from a college teaching post.

The division at the time was in the early stages of developing liquid hydrogen propulsion for space, and its engineers were striving to design a rocket nozzle meshing the optimum in size and weight for a given thrust.

Nilson's Specialty Helped UTC

Since liquid hydrogen was an entirely new technology in this country, there was scant mathematical work in existence on certain phases of the gas flow through the nozzle to point out the exact course the engineers should take. Dr. Nilson was one of several who immersed themselves in the analysis. The results, now in wide use throughout the industry, formed the basis for shaping the contour of the nozzle for what is now the RL-10, the nation's first liquid hydrogen engine.

In the field of solid rocketry, Dr. Nilson has brought his mathematical prowess into play in support of the activities of the West Coast subsidiary, United Technology Corporation. Here the problem was to calculate the effect of solid particles, mingled with the exhaust flow, in eroding the nozzle wall and causing a loss in thrust.

One of the projects now occupying the applied math team which he heads relates to the design of inlets for jet engines to operate at extremely high Mach numbers. "It involves setting up methods for studying the air flow in the inlet so the designers can determine what happens when the engine is operating at varying conditions," he said. "There are shocks intersecting shocks, slipstreams intersecting shocks, shocks intercepting slipstreams, and so on — all making the problem more complex."

Such large-scale projects are attacked, he said, first by formulating the physical problem in suitable mathematical terms that satisfy the engineers' needs and then by determining and adapting the mathematical techniques for handling it.

At this point, the pure and the applied mathematicians likely would part company. The pure mathematician, having formulated the problem and thus arrived at a mathematical solution, might say in effect, "The job is done."

But the applied mathematician's job is to supply answers the engineers can use. Since they need numerical answers, Dr. Nilson and his group must carry the problem beyond the *mathematical* solution to produce a *numerical* solution. The final calculations, because of their sheer mass and complexity, are performed by the electronic computers at United Aircraft Research Laboratories.

"This involves a branch of applied mathematics with an important identity of its own — numerical analysis," Dr. Nilson said. "It consists of translating complex mathematical systems or formulations into simple arithmetical operations and elementary decisions which can be handled by the computers."

If everything about a problem falls into place neatly, its solution may take only a couple of months to produce. More often, there are all kinds of complicating elements and subsidiary problems arising and details to chase down, and it may take six or eight months, or even a year or more, before a deck of punched cards from the computer, detailing the completed analysis, is delivered to the engineers.

Math Team Has Six Members

Dr. Nilson heads a group of six applied mathematicians who serve as consultants and trouble-shooters for Pratt & Whitney Aircraft's engineering department, particularly its advanced power systems section. When problems of real complexity and magnitude arise, these men take on the main mathematical burden themselves, either singly or as a group, working closely with engineers, analysts, computer specialists, and others concerned.

In addition, they cope with a ceaseless flow of whatever lesser problems may be baffling individual engineers. Rather than dig into such problems themselves, Dr. Nilson and his staff take the role of advisers, pointing out the avenue to the solution and encouraging the engineer to work it out himself so that he will be able to provide the answer unaided when next he faces a kindred problem.

As student and teacher, Dr. Nilson has spent years accumulating the mathematical knowledge needed for the analytical methodology now contributing to the research and development which Pratt & Whitney Aircraft is carrying out in rocket propulsion, advanced gas turbine engines, fuel cells, magnetohydrodynamic generators, and other forward areas. Practically from his two-plus-two days in Wethersfield, Connecticut, he displayed a bent in math, and by the time he was in high school, it was clear that this was the field he would pursue as a career.

"It wasn't so much a conscious, firm decision as a drift in a natural direction," he said. "It was simply the field I seemed to make out best in."

Career Opportunities Were Few

When he was graduated from Wethersfield High School, with the depression at its depth, there were few funds available in the Nilson family to send him to college, but he was awarded a full tuition scholarship through which he attended Trinity College in Hartford, graduating in 1937 with honors in math and physics.

"There weren't many career opportunities available in mathematics then, apart from teaching," he recalled. "I was all set to go into actuarial work with one of the Hartford life insurance companies."

The underwriter lost an actuarial candidate when Dr. Nilson was granted a graduate fellowship which, together with a subsequent post as an instructor, enabled him to take advanced studies at Harvard, where he earned his master's degree in 1938 and his doctorate in 1941.

After serving as an instructor at the University of Maryland and assistant professor at Mount Holyoke College in Massachusetts, he was assigned in 1944, as a naval reservist, to the faculty of the U. S. Naval Academy at Annapolis. At war's end, he felt drawn to applied mathematics, which until Pearl Harbor was a small field nationally with few practitioners and little recognition.

"The general neglect of applied mathematics came to an abrupt halt during the war," he said. "Mathematicians were now in the war effort and were turning their science to new interests, new fields — strategic bombing, for example. How mathematical principles could be applied to produce solutions in important areas came to be recognized in competent circles. I joined United Aircraft's research department because applied mathematics was an area in which I hadn't worked, it was coming into its own, and it interested me. It posed new challenges."

He was an analytical engineer on the staff of the research department for two years, working on engineering problems in which the solutions lay primarily in mathematical procedures. Then teaching beckoned again, and from 1948 to 1956 he was back at Trinity, first as assistant professor, later as associate professor in the mathematics department, all the while maintaining his association with United Aircraft as a consultant. Today he gives expression to his drive to teach by serving on the faculty of the Hartford graduate division of Rensselaer Polytechnic Institute.

He retreats from the realm of calculus, differential equations, and such by doing physical work around his home on a wooded tract in suburban Bloomfield, where he lives with his wife, Edith, and their children, Jean, Richard, and David. He helped build the house and graded much of the land himself.

He Typifies The Breed

Since joining Pratt & Whitney Aircraft in 1956, his senior associates say, Dr. Nilson has come to typify the academic men needed to help catalyze today's fast-moving technologies: the scientist who combines integrity in his discipline with the practical skills and personal adaptability to apply his knowledge to nuts-and-bolts engineering problems.

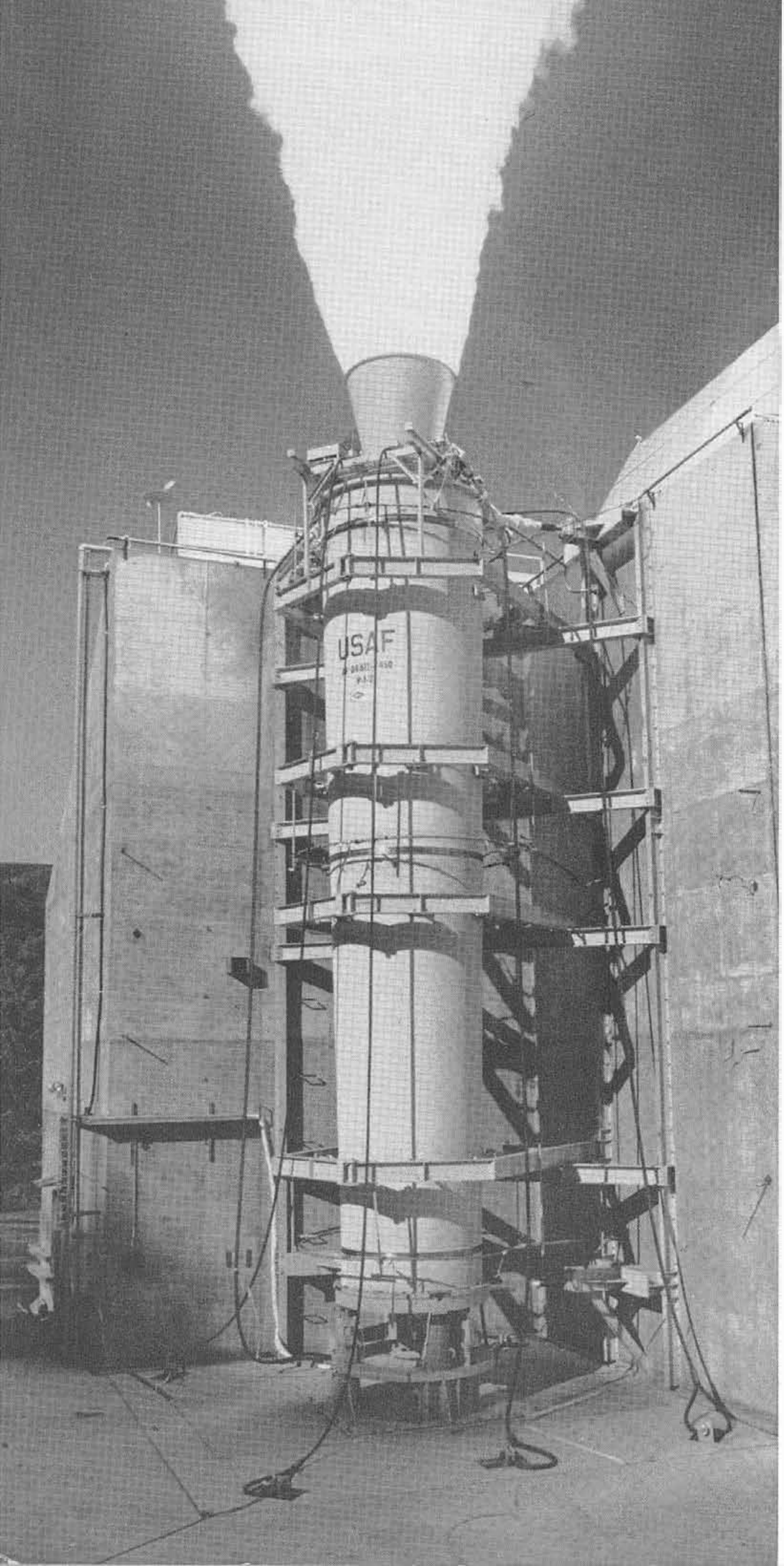
As an academician, Dr. Nilson has savored the pleasure the pure mathematician experiences in carrying forward a problem until it is all wrapped up in "elegant form," as they say in mathematics circles. This is a satisfaction sometimes denied to the applied mathematician, concerned as he is less with mathematical elegance than with specific, applicable solutions.

When he generates such solutions contributing importantly to key engineering problems, he feels pretty good about it. A mathematical construction, for instance, is translated effectively into hardware. Or tests on experimental equipment produce results identical to those predicted in advance mathematically.

"These are the things that give the applied mathematician his sense of satisfaction," Dr. Nilson said.

DIRECT-LIFT SPEEDSTER

The Navy's Sikorsky HSS-2 recently established new standards in four of the five major international speed records for helicopters. Over closed-circuit courses in Connecticut, it flew 199.01 miles an hour for three kilometers, 182.8 mph for 100 kilometers, 179.5 mph for 500 kilometers, and 175.3 mph for 1,000 kilometers. The twin-turbine, amphibious HSS-2, shown rounding a course marker during one of the speed runs, is now entering fleet service as the Navy's most advanced anti-submarine weapons system.



BIG SHOT

Standing over 40 feet tall in its concrete test bay, United Technology Corporation's booster-size, solid propellant rocket motor blasts a plume of fire and smoke skyward during successful test-firing near Morgan Hill, California. The 70-ton segmented motor, measuring over eight feet in diameter, developed nearly 500,000 pounds of thrust in its extended burning time. The test was conducted for the Air Force.