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Editor: CHESTER CHATFIELD

Associate Editor: DARRELL BARTEE (Wichita)

Art and Production Mgr.: KEITH KINSMAN

Staff Artists: ALDEN METCALF, BILL HARCUS, PHIL VON PHUL



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ON OUR COVER—Ancient windmills with cloth sails add to charm of Portugal, a country of sunshine and fine tourist accommodations. The trip there soon will be speeded by Boeing jetliners flown by the Portuguese international airline—see next page.

THE **BOEING** COMPANY

HEADQUARTERS OFFICES

7755 East Marginal Way, Seattle, Washington 98124



BRIEFING

➤ For the first time in 44½ years, Boeing was without a fixed-wing military airplane production project in mid-January as the last KC-135A jet aerial tanker was delivered to the U. S. Air Force. The KC-135 program, one of the most successful in aircraft history, began in 1956, and the last plane departed for Plattsburgh Air Force Base, New York, on January 12, 1965.

➤ Reorders, sign of the satisfied customer and meat for any manufacturer's table, are the most tangible results of recent Boeing airplane sales efforts. They include: one 727 for Pacific Southwest Airlines short-haul jet fleet in Central and Southern California; one 720B to be used by Ethiopian Airlines on Europe-Africa and Trans-Africa routes; one 320C for World Airways to increase its cargo and passenger capabilities, especially in the Pacific areas.

➤ Boeing's Airplane Division in Renton, Washington, last month was reorganized into two new divisions: a Commercial Airplane Division headed by John O. Yeasting, vice president-general manager, and a Military Airplane Division, headed by T. A. Wilson, vice president-general manager. Both Yeasting and Wilson report to E. C. Wells, group vice president-airplanes.

The company's Wichita, Kansas, Branch, directed by Ben M. Wheat, vice president-manager, is a part of the new Military Airplane Division, and will continue to handle all B-47 and B-52 bomber activity. The KC-135 and C-135 military jet tankers and transports will be the responsibility of the Commercial Airplane Division, in order to maintain continuity of support for these aircraft.

➤ A device for spreading airplane landing gear wheels far apart on extendible axles, thus increasing the flotation capability of the gear by 5 to 50 times is the feature of a patent application made recently by W. B. Fehring, F. W. Scherer and L. E. Shuman of the Boeing product development organization. The gear, designed for huge airplanes to use on soft landing fields, also incorporates self-jacking equipment and is so arranged that it can be retracted into a small stowage cavity.





Long-range TAP 707s will link continents.

Farm couple is driving to market.

Transportes Aereos Portugueses will fly 320Bs.

IN THE SPIRIT OF MAGELLAN



By ROBERT NEPRUD

DURING THE 15th and 16th centuries, Portuguese admirals sailed their small vessels across virtually uncharted oceans to the earth's farthest corners. One of them, Ferdinand Magellan, captained the ship that was first to circle the globe (though he made that voyage for Spain and lost his life enroute). Aided by maps and new navigational techniques developed under Portugal's Prince Henry, Bartholomeu Dias, Vasco da Gama and other Portuguese seafaring men embarked on epic voyages around the tip of Africa and to the Orient, defying mythical sea serpents, legendary abysses and assorted unknown perils.

Before the middle of 1966, modern Portuguese captains—attired in the crisp black uniforms of Transportes Aereos Portugueses, the national Portuguese airline—will guide far-ranging 707-320B turbofan jetliners on routes linking Por-

tuguese-speaking communities with Lisbon, one of Europe's oldest and most delightful capitals.

In announcing TAP's decision to buy two of the 600-mile-an-hour Boeing Intercontinentals, Alfredo Vaz Pinto, president of the Lisbon-based airline, had this to say:

"Since inaugurating European continental jet flights in 1962, it has always been our objective to extend the same service to our overseas provinces and to Brazil. These new aircraft, which are very well suited to our route pattern, now make this possible with our own equipment."

In addition to flying to Rio de Janeiro, the red-on-white 164-passenger TAP jets will link the Portuguese homeland with its major African possessions, notably Angola and Mozambique, and at the same time will be dispatched over other routes calculated to assist Portugal's territorial economy and its fast-growing tourist industry.

Comparatively young as major

airlines go, TAP traces its earliest beginnings to the late '40s when it was operated as a government carrier within Portugal and over a few international routes.

Reorganized as a private corporation serving the public interest, the modern-day Transportes Aereos Portugueses emerged in 1953. This was the beginning of a period of progress which continues to the present time. In recent years, TAP has had pooling arrangements with British European Airways, Air France, Swissair, Iberia and Pan Air do Brasil.

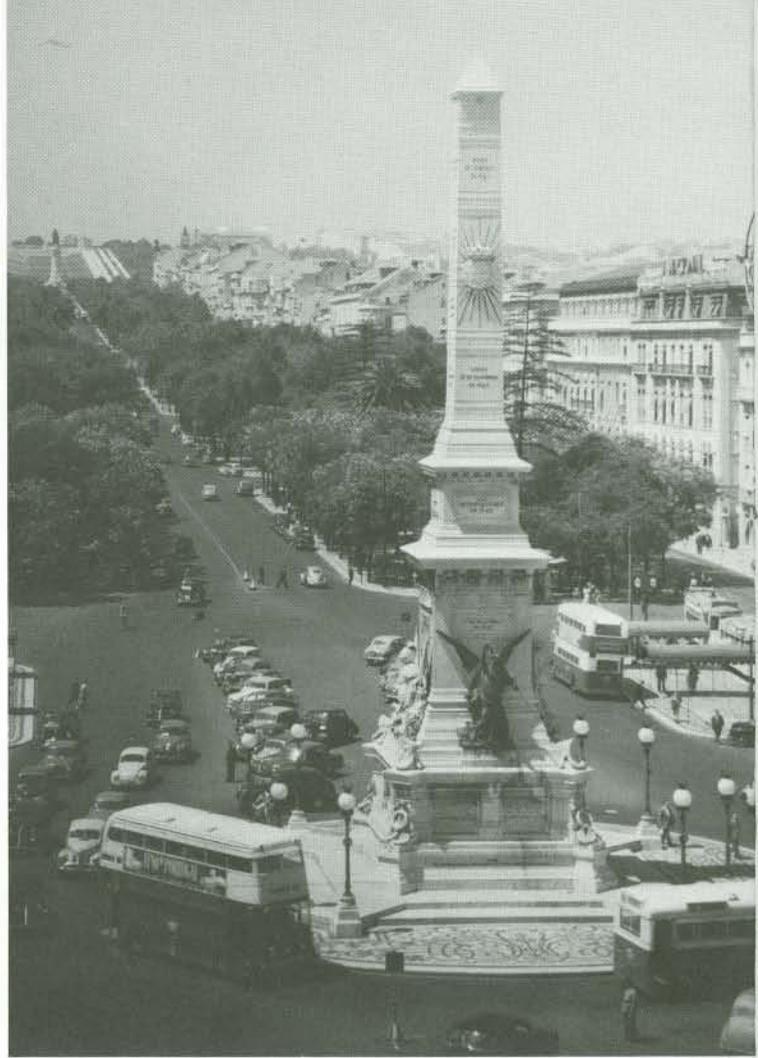
The agreement with Pan Air do Brasil paved the way for the famous "Friendship Flight" between Lisbon and Rio de Janeiro, inaugurated in 1960. At approximately the same time, frequent schedules to Madeira were established, capitalizing on the unmistakable tourist appeal of this sun-drenched Portuguese island off the northwest coast of Africa and of the neighboring Azores and Canaries.



Queluz Palace, near Lisbon, was residence of king.



TAP President Alfredo Vaz Pinto and crew welcome the airline's first jet, in 1962.



Restauradores Plaza is on Avenida da Liberdade in Lisbon.

High prow and stern keep fishing boat from swamping in surf at Praia da Vieira.



TAP formally entered the Jet Age in 1962 when it took delivery of the three Caravelles which now link Lisbon with Paris, London, Frankfurt, Geneva and Madrid. Super Constellations continue to serve its African, Middle East and island services.

In addition to operating and maintaining its own fleet, TAP furnishes ground services to a number of the international carriers which fly in and out of Lisbon's busy and attractive Portela de Sacavem International Airport. Some 1,800 employees, the majority stationed in Portugal but some based far afield, staff the airline.

Recent visitors to Portugal agree heartily with travel pundits who point to the Indiana-sized nation as one of Europe's most tempting tourist bargains. Along with its ancient castles, fortresses and churches, the country offers a wide choice of scenery—ranging from golden beaches to peaceful valleys to rugged mountain terrain—and blends the whole with a predominantly sunny climate.

Portugal abounds in superlative seafoods and excellent wines. Typical music of the country and its overseas possessions is the *fado*, a variety of folksong distinguished by its eerie minor tones and tragic, blood-and-thunder themes. On the sports spectacular side, soccer is the big game. Comic bullfights and community free-for-alls pitting men and boys against bulls with padded horns also are popular.

Like Rome, the capital city of Lisbon perches atop seven hills. Situated on the north bank of the Tagus River, only a few miles from the Atlantic Ocean, Lisbon boasts a colorful inland waterfront. There are narrow, cobblestone streets which date back to the Middle Ages and earlier; and there are broad and fashionable avenues where donkey carts and limousines sometimes collide.

Within a few minutes of Lisbon, facing south to the Atlantic, is the seacoast delight known as Estoril. Here are beaches teeming with sun-worshippers and blossoming with cabanas and bright umbrellas. Here, too, is a lavish casino surrounded by magnificent gardens.

A few miles away is the town of Sintra, a beach resort with a Moorish castle to its credit.

Nazare, up the coast from Lisbon, is a classic fishing village and a renowned summer resort—a good place to observe fishermen at work and to dine on sardines cooked over open charcoal fires. Nearby is Obidos, a walled city which dates back a thousand years. Here a one-time castle has been turned into a fabulous inn where visitors can relax, dine well and sample choice wines—all for less than \$10 a day per couple. This is in line with going prices in Portugal, where comfortable lodgings and good meals can be had at prices ranging from \$5-\$10 a day per couple in most areas.

AMONG other sightseeing favorites is Oporto, the nation's second largest city, renowned as the home of port wine and as a jumping-off place for excursions to surrounding vineyards and pinewoods country—a region considered to be among the most beautiful in all of Portugal. Then there is Coimbra, Portugal's third city, where one may poke about in Roman ruins, tour medieval churches and visit a 16th Century university that is still going strong. Near Coimbra is Fatima, world-famous Catholic shrine visited by more than a million people every May.

Madeira Island, called "the pearl of the Atlantic," is a tourist favorite—a Portuguese jewel set in a sapphire ocean some 625 miles southwest of Lisbon. Reached by air or by steamer, the island features fine beaches, a wonderful year-around climate, rugged sports such as mountain-climbing and deep-sea fishing, and the not-so-Spartan attractions of a fine casino. It is the home of Madeira wine and Madeira lace and is famous the world over for its "toboggan ride" down a cobbled hill in Funchal, the capital, where passenger-carrying sledges careen madly to the bottom, guided by two disaster-cheating attendants.

The Azores, a cluster of nine small Portuguese islands to the northwest of Madeira, also please travelers who enjoy unspoiled beauty and a gentle tempo of living.

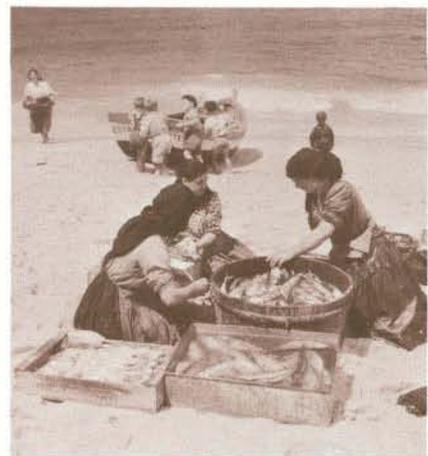
Most of Portuguese Africa dates back to claims established by explorers in the 15th and 16th centuries. It consists of Angola and Portuguese Guinea on the west coast, Mozambique on the east coast, and two jointly-governed islands—Sao Tome and Principe—in the Gulf of Guinea. Their aggregate area is approximately 23 times that of Portugal.

The Portuguese government has encouraged the immigration of settlers to its overseas territories through the years and has carried on an especially active economic development program since World War II. Principal exports from the African possessions include coffee, corn, sugar, tea, copra, cotton and sisal, along with diamonds mined in Angola.

To a greater extent than most countries, Portugal and its island possessions offer that X quality known as character, thanks both to natural beauties and to its friendly, courteous and highly individualistic people. Home of many of history's great discoverers, it—in turn—is in the process of being discovered by increasing numbers of appreciative travelers.

When it takes delivery of its two long-haul 707 turbofan Intercontinentals, Transportes Aereos Portugueses will be able to an even greater extent than currently to assist in this turnabout discovery of Portugal by the rest of the world.

Women of Nazare count fish catch.



New gas turbine slashes fuel consumption.

ENGINE NO. 551

By ALLEN HOBBS

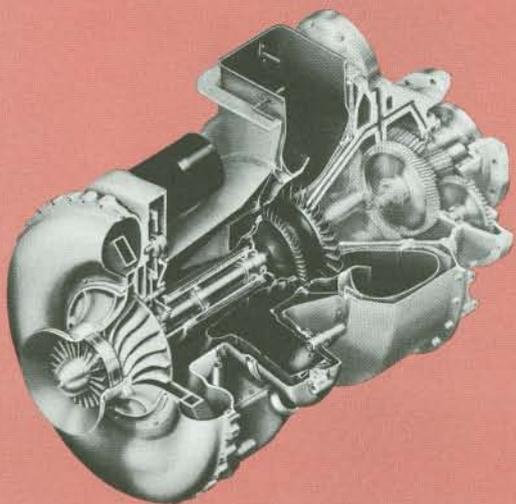
BOEING'S new industrial gas turbine engine—Model No. 551—is running like a greyhound as it makes new economy and power output records.

The basic engine has been under development at the company's Turbine Division in Seattle for three years and has accumulated more than 7,000 hours of operation ex-

clusive of component tests. Numerous endurance runs are included. A series of final endurance tests are under way.

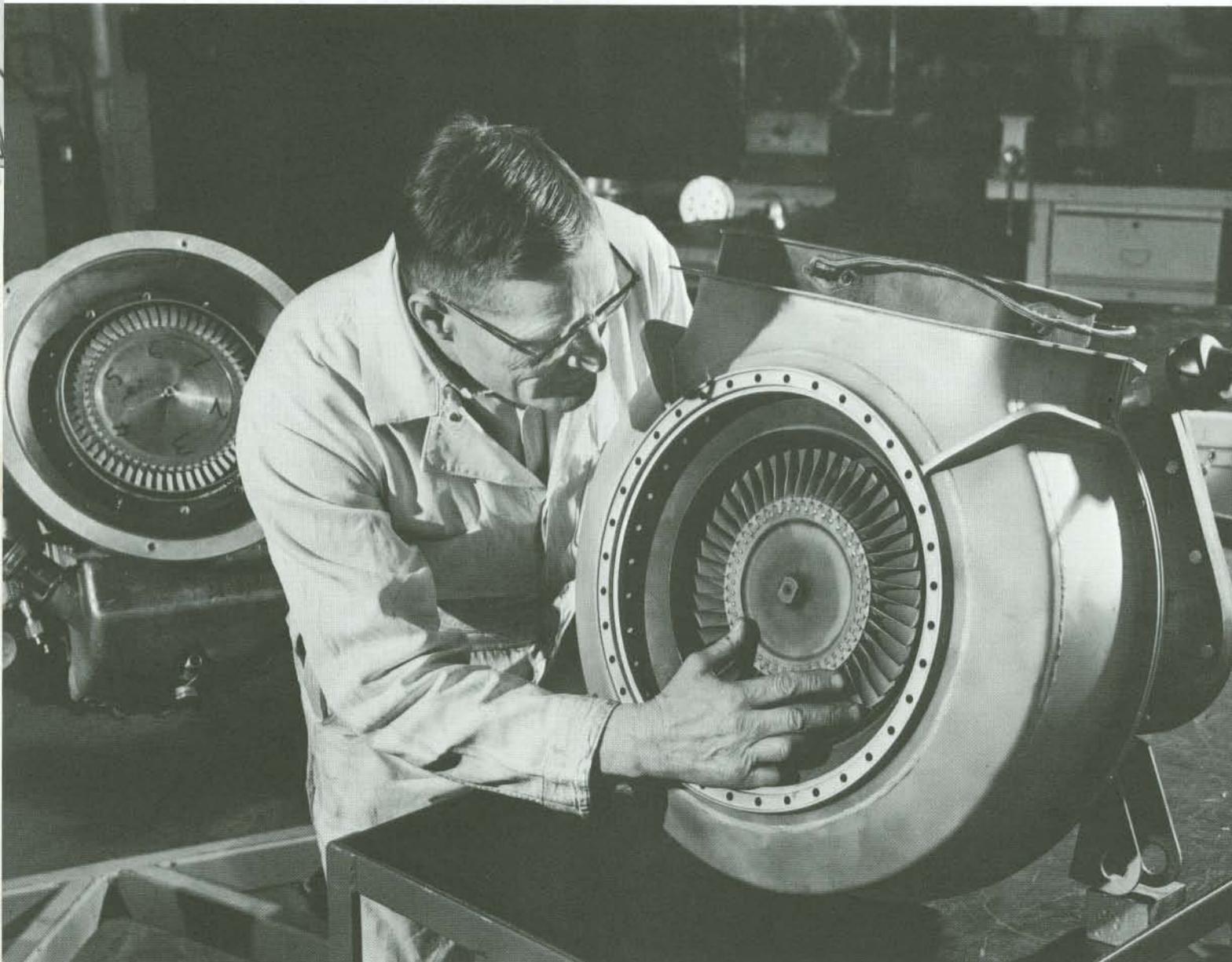
The engine has an initial maximum rating of 400 shaft horsepower and an intermittent or normal rating of 360 horsepower. The 551 weighs 385 pounds and is 40 inches in length, 22½ inches high and 27 inches wide.

First installations of the new tur-



New engine delivers 400 horsepower.

Turbine wheels have replaceable blades for low-cost maintenance.



bines are expected to be made in several pump-drive applications in the oil fields.

The engine also is intended for use in high-speed marine craft and in special-purpose vehicles.

The 551 represents the second generation of Boeing turbines. The company's first-generation turbine—the Model 502—is in world-wide operation in a great variety of applications.

The experience in turbine installations and applications gained during the past decade of 502 engine activity provided an invaluable background for development of the new engine.

In performance, the largest advance in the 551 has been in the area of fuel consumption. At the 400-hp rating, specific fuel consumption is 0.75 pounds per brake-horsepower hour. At intermittent rating the fuel consumption is 0.76 lbs/bhp/hr. The new 551 design represents a fuel consumption 22 percent lower than the earlier 502 series engine.

The 551 is a two-shaft turbine with no mechanical connection between the two turbine wheels. The engine operates over a wide range of output speeds and has the ability to start and pick up a load without a clutch.

The torque converter characteristic of the two-shaft engine reduces the need for an additional transmission. As output speed of the 551 decreases, torque actually increases. When the output shaft is stopped by a brake, torque exerted on it is 2.7 times the torque at rated speeds. The basic engine is stall-proof and can provide the 270% torque continuously when the output shaft is stalled.

The 551's built-in torque converter is a decided advantage compared to separate torque converters on other types of engines, which are more complex and costly.

Field maintenance has been a major consideration of designers in laying out the 551. For instance, the loosening of a single clamp allows easy removal of either of the two combustor cans to permit quick hot-section inspection.

Disassembly of the 551 into its three major subassemblies can be

done by splitting two easy-to-reach bolt circles.

The Boeing hydrodynamic bearing system permits rotors to be replaced and even rotor components to be interchanged in the field. The bearing system uses oil-cushioned bearings which permit the rotor to seek its mass center instead of being forced to ride on its geometric center as is the case with the rolling-contact bearings.

Boeing has used this type of bearing with noteworthy success in its earlier turbines. Field experience with this system approaches 1,000,000 hours.

The gas producer and power turbine wheels have replaceable blades to aid low-cost maintenance.

The industrial character of the engine is seen easily in its reduction unit where emphasis is on a decidedly husky gear train. The unit has been designed to accept the extremely high transient torque loads anticipated in tracked-vehicle applications and in reciprocating-pump installations.

The fuel system at present is designed to operate on diesel fuel. A

natural-gas fuel system will be made available.

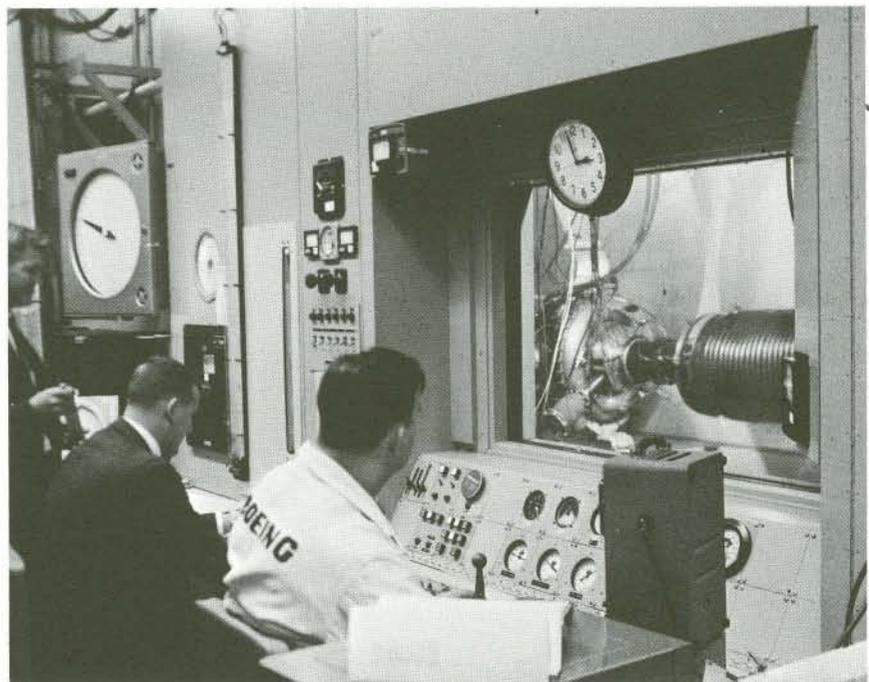
Although the 551 represents significant advances in industrial turbine performance, the components of the engine have been conservatively rated.

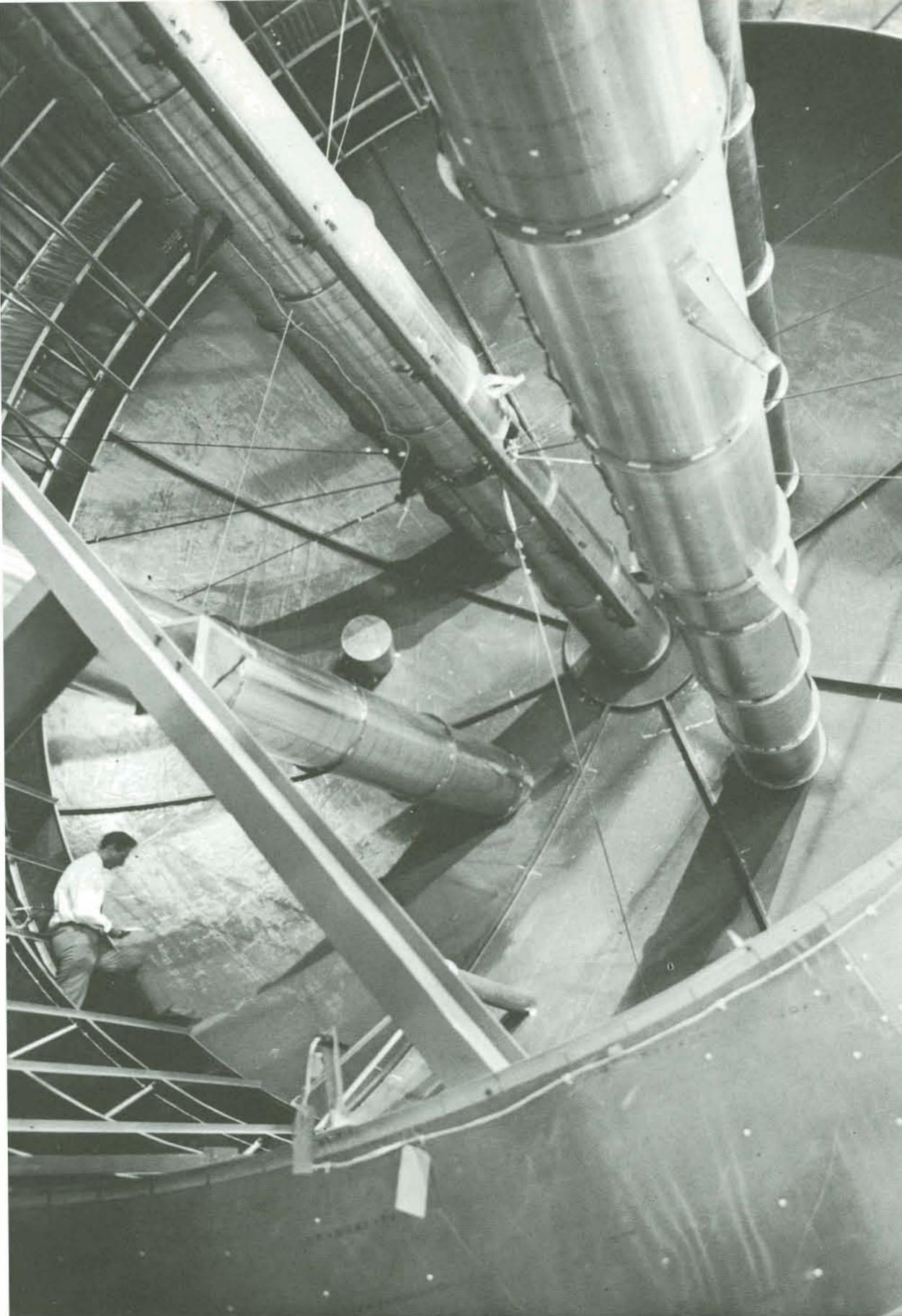
This practice of rating the engine conservatively has allowed Boeing to provide for considerable power growth in the 551 series.

Future models of the 551, with little component change, are planned at industrial ratings of more than 500 hp and less than 0.70 lbs/bhp/hr specific fuel consumption.

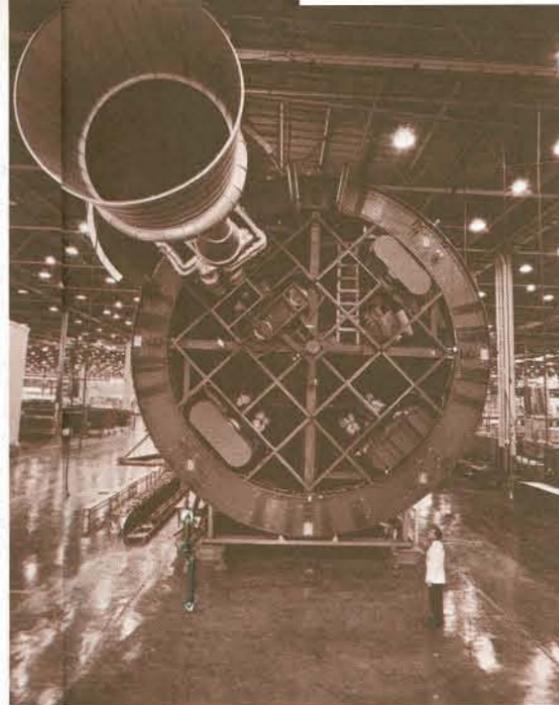
The company's Turbine Division expects great things from the new 551 engine. John Mangan, who heads Boeing's engine marketing strategy in the industrial field, put it this way, "There is no question but that there are many industrial jobs that can be done better and more cheaply with turbine power. All that has been needed is a simple two-shaft turbine engine with more competitive fuel consumption and geared to industrial field maintenance. The 551 has been developed with this aim." 

Model 551 engines have more than 7,000 hours total test time.





Interior of fuel tank has tubes running through it to carry liquid oxygen from another tank to five engines below.



Booster will have five engines like this.



Fin on engine reaches almost to 40-foot ceiling.

Bulkheads are lined up early in assembly.



Engine mockup is part wood.

Saturn booster design is checked on mockup.

TRY THIS ON FOR SIZE

By WILLIAM CLARKE

PROBABLY THE BIGGEST mockup in the world, a full-scale model of the Saturn booster rocket, also called the S-1C, has reached completion in New Orleans. The giant structure is in the Michoud factory. Over-all length is 138 feet and diameter is 33 feet.

Designed as an engineering tool for development of the Saturn 5 moon rocket, the mockup undergoes almost continuous revision. Boeing is building the booster for the National Aeronautics and Space Administration.

Primary functions of the mockup are to help fix the shapes and sizes of production parts, to determine the lengths and angles of tubes and to solve such problems as how wire bundles are to be formed and where they will run.

Two tanks for fuel and liquid oxygen are open on one side of the mockup. Baffles, tunnels, tubes and sensors which run through them are exposed. Until recently, when work was begun to change the configuration of the mockup to meet

flight-stage requirements, the model was loaded with miles of wiring and tubing.

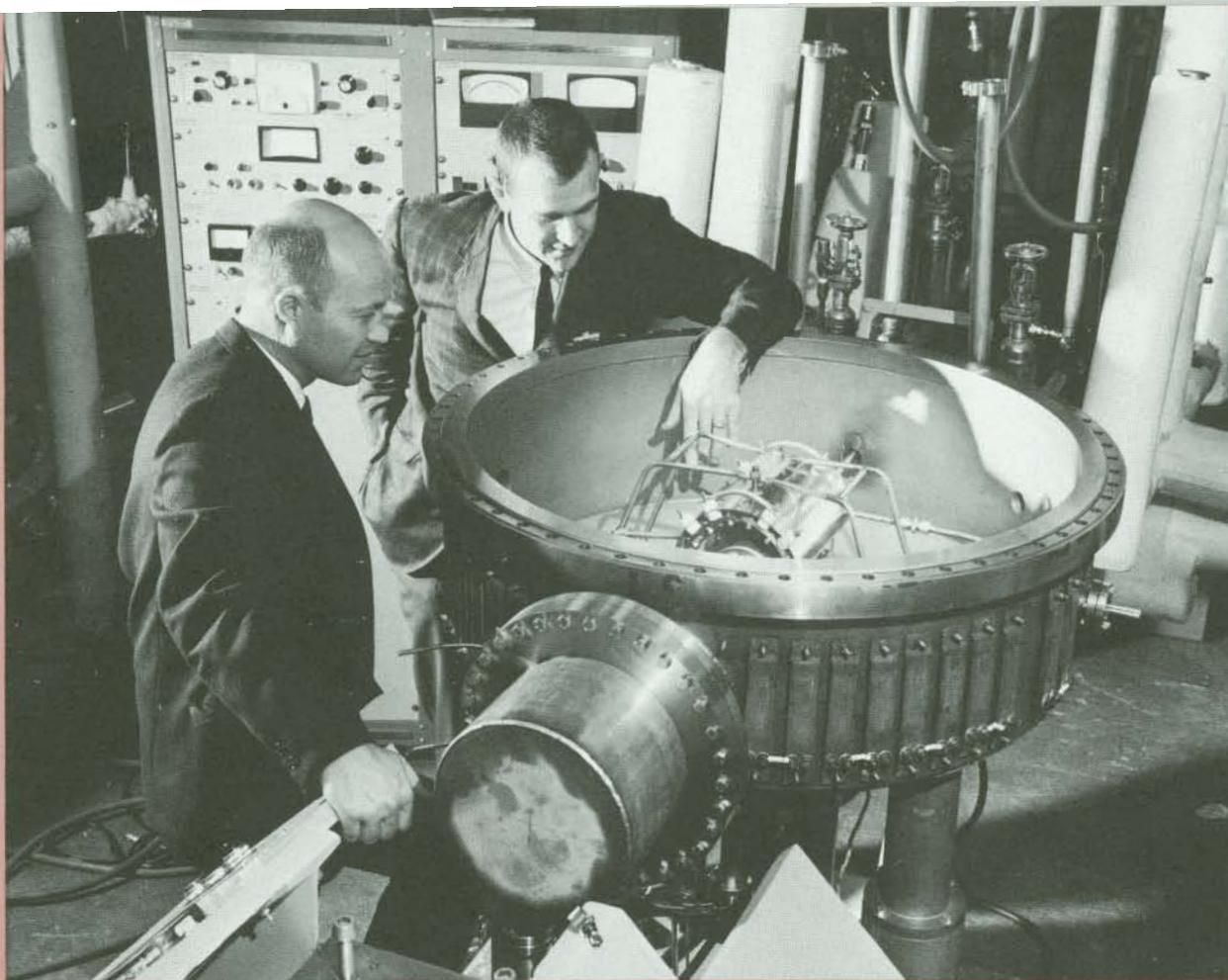
Future configurations of the S-1C stage will include such refinements as cameras to take pictures of the liquid oxygen as it is withdrawn from the LOX tank, and television cameras to photograph the engines in action. Cameras which will take pictures of the second stage during its initial firing, 40 miles above the earth, also are to be mounted on the S-1C.

The mockup at times will hold 77 miles of wire and 5,100 pounds of valves. The actual S-1C will have five engines, but for engineering purposes one is sufficient on the mockup.

The big model is exact in most of its dimensions. At the base, in the thrust structure, the measurements are precise. In the rest of the structure the over-all dimensions, from fitting surface to fitting surface, are accurate.

A number of materials were used to construct the mockup, including scrap aluminum, wood, fiberglass and steel.

2/65



Spacecraft lubricant is successfully tested in this machine.

A new compound is devised to

GREASE THE WHEELS IN SPACE

By WESLEY ROBINSON

HOW do you lubricate your spacecraft when you're 20 million miles from earth?

Oil and grease freeze or evaporate in outer-space extremes. Graphite turns into an abrasive. But the myriad complex moving parts in a spacecraft's heart must be lubricated, nevertheless.

A spaceman confronted with the problem of choosing the right space lubricant would do well to check with Boeing's Aero-Space Division materials and processes group. It has devised bearings and gears which will lubricate themselves.

An expected important application of the new lubrication system will be in manned orbital laboratory programs.

The trick is to combine a lubricant that works in a vacuum with a

metal that is difficult to melt. Once compounded, this unusual substance can be formed into circular bands with holes cut out to contain the ball parts of ball bearings.

As the bearings turn, the balls rub lightly and easily against this metal-lubricant band, picking up a thin film of lubricant. The ball in turn smears lubricant onto the ring in which it rolls.

Gears work basically the same way. A small lubricating gear, made entirely of the metal-lubricant compound, meshes with the working gear.

Blending molybdenum disulfide powder, which will lubricate in ultra-high vacuum, with tantalum and iron is one of the ways to produce the solid lubricant. Other combinations of lubricating powder and metal have been tested successfully.

Boeing is pioneering the research in the metal-lubricant field. When graphite's abrasiveness under vacuum was discovered, most researchers sought to spray a coating of molybdenum disulfide onto friction-bearing surfaces.

Up to now, however, spray-on lubrication has been effective for only a few minutes under punishing high-speed, high-vacuum conditions. In contrast, the metal-and-lubricant bands and gears will operate efficiently for long periods of time.

The metal-lubricant is not economically competitive with oil and grease for use in such equipment as automobiles. But Army and Air Force helicopters soon may use self-lubricating gears and bearings in rotor transmissions, to get away from the possibility that a bullet through the oil pan might put the 'copter out of combat action. 

Modified missile carriers have more muscle.

A CARRIAGE FOR BIG BROTHER

By ROBERT KEENE

MINUTEMAN II has outgrown the carriage originally provided for its older but smaller brother, the Minuteman I intercontinental ballistic missile. A modification program by Boeing, General Motors and Bendix is increasing the carriage's capacity.

The carriage is the Minuteman transporter-erector, developed for the Air Force by Boeing. As its name implies, this vehicle carries missiles to operational sites, stands them upright and lowers them into underground silos. The transporter-erector serves in a third capacity, pulling the missile from its launch silo when necessary.

The modified carrier accommodates either the older missile or the larger, more powerful Minuteman II. Four modernized carriers already have been delivered to the Air Force. Another 36 will undergo modification before the program is scheduled for termination in January, 1966.

Of those delivered, one went to the Eastern Test Range, one each to Vandenberg and Chanute Air Force Bases, and a fourth remains at Boeing's Seattle test facility. The first to appear on a highway is likely to be the one operated near Grand Forks Air Force Base, North Dakota, where Minuteman Wing 6 is under construction. First delivery of a modified transporter-erector is

expected there during the coming spring.

The transporter-erector's gross weight, increased to nearly 121,000 pounds when used with the Minuteman II, posed a problem when balanced against state highway and bridge axle-load limits.

To meet these limits, a load-carrying fifth axle has been added to the truck tractor and the semi-trailer frame has been modified. The changes have reduced axle-load on the three dual-wheel axles of the trailer and the rear axles of the tractor to approximately 17,000 pounds each and dropped the axle load on the tractor front wheels (steering) to under 10,000 pounds each while carrying an 80,000-pound roll transfer payload.

The 80,000 pounds is a payload heavier than a Minuteman II and its separate engine carriers which roll into the container with it. Thus the modified transporter-erector provides room for growth.

Tractor changes, in addition to the non-drive fifth axle, include extensive frame redesign; relocation of the "fifth wheel," the point at which tractor and trailer are joined; revised axle spacing and increased capability to withstand stresses.

The Minuteman II's additional length has been accommodated without changing the trailer's 62-foot length through modification of the forward envelope and placement of the missile three feet farther for-

ward within the container. Externally this appears as a change in the slant of the trailer portion overhanging the tractor from an angle of 45 degrees to one of approximately 30 degrees.

The capability of withstanding unusual stresses, such as those imposed when being towed out of a mud hole, will permit recovery of the transporter-erector from conditions where it cannot proceed under its own power.

Major structural changes have given the modified trailer greater strength. One important change permits continued support of the erected container in the event one actuator fails. Another provides for lowering the missile with one cable in case either of the two hoist cables fails during emplacement. Hoist capacity has been increased both in load capability and in missile-lowering capability.

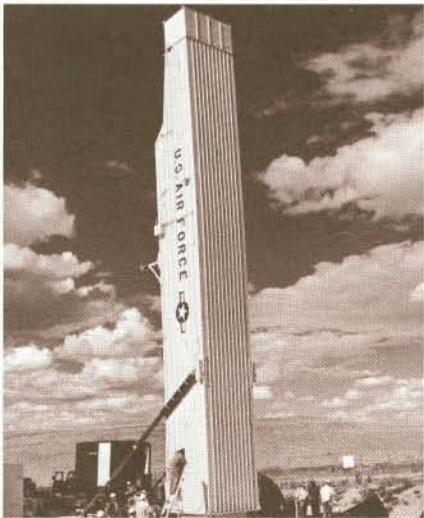
Right-angle turns require careful planning by the driver because of increased wheelbase, but the reduction in trailer overhang means fewer clearance problems at the outside of a turn.

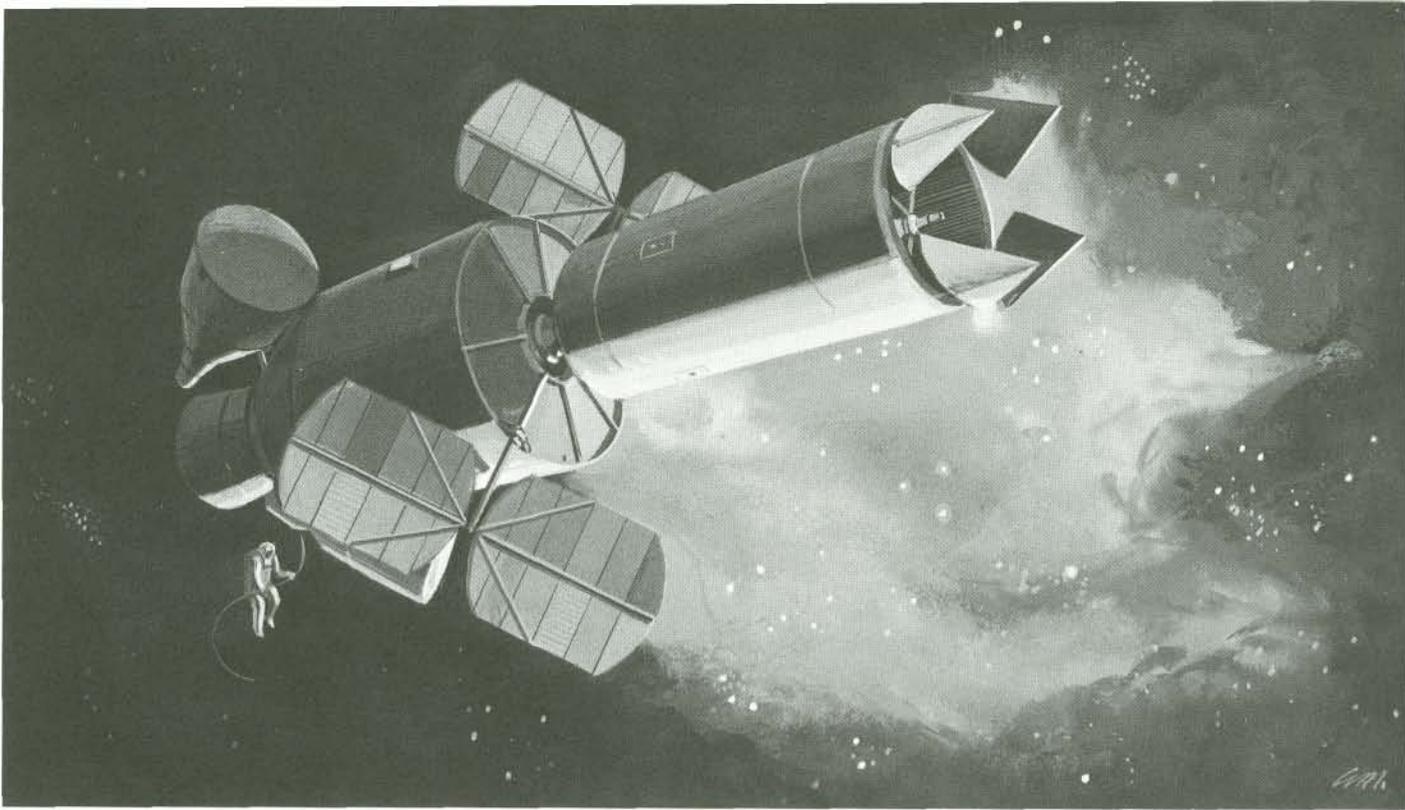
Icy highways, mud and snow of a North Dakota winter won't present as much of a problem. An emergency traction-control device shifts weight from the tractor fifth axle to a drive axle under such conditions. Thus the big T-E has added ability to dig in its heels when the going gets tough. 

Modified transporter-erector has added an axle.



Transporter-erector raises upright.





Telescope would be 200 miles above earth.

Telescope in sky might look back 20 billion years.

ORBITING EYE

By WILLIAM CLOTHIER

CONSIDER the lowly olive submerged in a 2-to-1 martini, being gently swirled in a glass, but observe it through blue-tinted, smoked glasses. Then remove the glasses, take out the olive and discard the liquid (who'd drink a 2-to-1 martini, anyway) and notice the improvement in detail afforded an olive inspector.

Roughly speaking, that's about the degree of improvement in visual clarity which man would obtain by placing a telescope above the earth's atmosphere to examine the stars and planets.

Everyone on earth has impaired vision when it comes to looking at other stars and planets. The smudgy window of the earth's atmosphere is a wavy curtain of gas, water droplets and other material.

Although no hardware program is yet planned to build and launch an orbiting telescope, a systems study being conducted by Boeing could result in a revolutionary ad-

vance in visual examination of the universe we live in. A manned orbital telescope circling the globe 200 miles high would by-pass most of the atmosphere to afford a clear view.

The giant telescope would be placed in orbit by a booster of the Saturn S-1B class and would have an operating lifetime of from three to five years. Launch could be made within the next 15 years, if the Boeing study shows the project to be feasible.

The 10-month study is being conducted under a \$191,853 contract with the National Aeronautics and Space Administration's Langley Research Center at Hampton, Virginia. David Bogdanoff of Boeing's Aero-Space Division in Seattle is directing the study.

Teamed with Boeing is a group from the General Electric Company, which provides assistance in guidance and control. GE has worked on the Orbiting Astronomical Observatory, a smaller, unmanned orbital telescope program.

Dr. Zdenek Kopal, a professor and chairman of the Department of Astronomy at the University of Manchester, England, is presently doing research work at the Boeing Scientific Research Laboratories and will serve as consultant for the study.

Says Dr. Kopal, "When telescopes begin operations outside the atmosphere it will mark the real beginning of astronomy. Within five years after a manned telescope has been placed in orbit, all that has been learned during 3,000 years may be considered the pre-history of astronomy. Our knowledge will be increased by a factor greater than the discovery of the telescope itself."

Dr. Kopal has 30 years of experience in the astronomy field. He has written 16 books and more than 200 technical papers on his favorite subject, and has visited most of the world's observatories.

The study is investigating methods of integrating the orbital telescope with a manned space station.

Man's ability to adjust, calibrate and maintain the equipment is being defined.

Three possible methods of operation are being studied. In one mode the telescope could be operated while rigidly coupled to a space station. In another the telescope might be moved away from the station during operation and brought back when observations are completed. The third mode involves leaving the telescope in orbit near the space station, never making physical contact with it. In this case, men probably would move between the station and the telescope in space suits or shuttle vehicles.

The precise aim of the telescope would be disrupted by any sort of vibration. Part of the Boeing study will determine how much simple body movement can be tolerated in the telescope section without affecting the mission performance.

Problems associated with earth-bound star gazing include the fact that free electrons in the upper atmosphere act as mirrors and reflect radio waves reaching us from the stars. Light in the infrared portion of the spectrum is gobbled up by water droplets and carbon dioxide in the atmosphere. Much of the light from the very hot stars is invisible on earth because high temperature shifts light to the x-ray side of the spectrum. Much of the light we now see comes from relatively cool stars with temperatures ranging from a few thousand to 30,000 degrees. An orbital telescope would enable us to see light across the entire spectrum from x-rays to radio waves.

When stars die in cataclysmic fury, only a portion of the light is seen on earth, even though the light from such stellar explosions may

last for weeks, years, or even centuries.

"Humdrum stars like our sun just sit there and don't change much," says Dr. Kopal. "They don't teach us a great deal. Once we get above the atmosphere we can expect to see very hot stars, exploding stars, and close binary stars."

Light from the Crab Nebula explosion first reached earth in 1054 A.D. It was seen by the Chinese and their eyewitness reports are the only records we have. The portion of light from this explosion which penetrates our atmosphere still is reaching earth 910 years later.

An orbiting telescope operating in the Middle Ages might have shown the beginning of this greatest of all recorded explosions. "The star committed suicide," says Dr. Kopal. "Apparently without any outside help—and all that is left of it are a few tiny nebular wisps."

An orbital telescope might offer tremendous advantages in locating those aging patriarchs of the stellar systems—the white dwarfs, which are only faintly luminous. They are believed to be stars in the final stage of evolution, and they are fantastic creations. Instead of normal atomic structure, their atoms are crushed together with the electrons mingled with atomic nuclei.

One such white dwarf (numbered but unnamed) is known to have an average density of 10 million times that of the sun. A cubic inch of material from this star would weigh 620 tons. A 150-pound man on the star's surface would weigh 250,000 tons. An ant would be crushed to a grease spot by its own weight.

An orbiting telescope should make it possible to see other stars with their planets, if any. Dr. Kopal believes the chances are better than

50 percent that other stars have planets.

"Whatever the process is for forming planets," he says, "it cannot be so unique that it hasn't happened elsewhere."

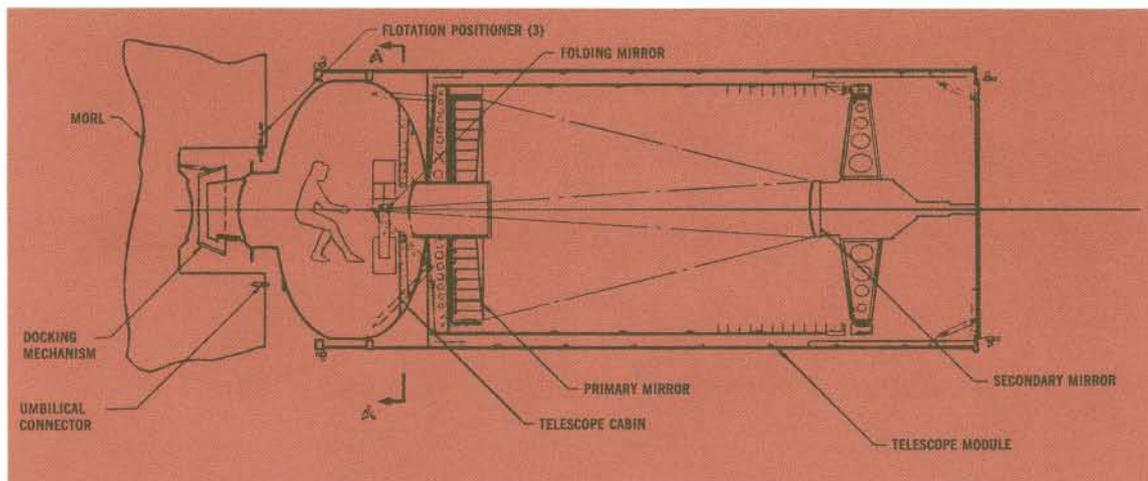
Dr. Kopal believes an orbiting telescope should give man a good look at the binary stars, "the dancing partners of the universe," two stars so close together that they attract and hold each other in their gravitational embrace. The speed at which they revolve will reveal their mass. ("One star doesn't tell us much, but put two stars together and like humans, they react.")

At present man can see from two to three billion light years into space—or into the past, if you will, since it took that long for the light we observe today to reach earth. The view from a manned orbital telescope might increase this penetration by a factor of ten—perhaps twenty billion light years, an incredible back-track view.

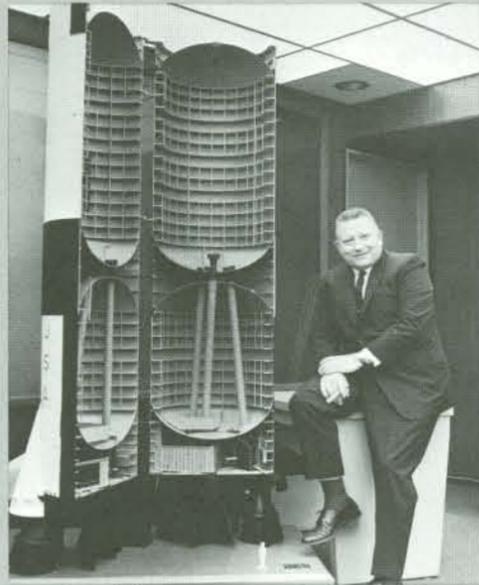
Such a long look into space would test such theories as the one that the universe is expanding. This concept is predicated on the fact that some stars appear to be getting redder and redder, indicating that these stars are moving away from our galaxy at tremendous speeds.

Other astronomers offer this intriguing thought: perhaps the light which began moving so long ago at 186,000 miles per second is just getting tired. Is the light that reaches earth from far-away galaxies of the same energy as when it began? Does something happen to it en route? An orbital telescope facility could show whether the red shift occurs over a full spectrum. If not, it would suggest that something other than a receding star causes the light to dim. 

Study will determine if movement of operator would affect telescope.



BIG ENOUGH



ONE OF Bob Dunigan's first contacts with a Boeing product was in the cold drizzle of England as a mechanic on the old B-17 bomber. Now, 20 years later and half a world away, he is hard at work in the warm deep south on Boeing's S-1C booster for the Saturn 5 moon rocket.

Robert Calvin Dunigan, ex-sheet metal instructor, sparring partner and groceryman, at 40 probably has put his bull neck to more than the average number of jobs at Boeing and in 15 years has risen as fast as the rocket he oversees.

Dunigan accepted the Saturn assignment September 12, 1961, during the proposal effort, and helped win the job. At that time he was booster test manager, responsible for the S-1C booster from the time

it was pushed out the factory door until it was on its way to the moon.

Currently, he is program executive for the S-1C, which means he is the man responsible for the administrative direction of the S-1C job in New Orleans and is working out plans, policies, procedures and objectives to ensure that the booster is designed, built, tested and delivered on schedule. He took the job last April with characteristic energy—he has the reputation of being first to work in the morning and last to leave in the evening.

His greatest talent lies in getting to the bottom of a problem and solving it in a hurry. "There are situations when the only way out seems to be suicide," says an associate, "but Bob can always find a better solution."

MAN TOWARD MARS



A GOLFER who has hit a tiny cup with a tee shot from 150 yards away probably is less awed by the task of hitting Mars with a spacecraft than someone who hasn't.

Gagsters suggest that is why Edwin C. Czarnecki (a hole-in-one on the 13th at a Renton, Washington, golf course) was selected recently to head Boeing's efforts to win a National Aeronautics and Space Administration assignment to develop an unmanned Martian spacecraft.

Czarnecki, an all-county guard as a Massachusetts high school player, sought a football scholarship at the University of Alabama but switched to digging ditches instead when football turnout conflicted with his classes. A good digger, he was an even better student, and the dean

of the engineering school moved him inside where he could earn his tuition helping in a physics lab.

Czarnecki took his aeronautical engineering degree to Connecticut where he built flying wings and fighter planes. He joined Boeing in 1948.

Experienced now in airplane building, missile engineering and spacecraft designing, Czarnecki is confident he could build submarines if the assignment were given to him.

Czarnecki, who seldom loses an argument involving technical matters, also has a winning formula for managing people: "Keep a tight hand on a new man. When he shows he can do the job, take your hands off and let him go."

Czarnecki showed what he could do long ago and has been going

His first job with the company was in reliability and quality control. He became chief inspector for the Moses Lake Flight Center in Washington.

In 1960 Dunigan was named manager of the base installation department for the Boeing Bomarc ground-to-air missile.

Some persons think that all Dunigan does is work. His close friends report, however, that he plays a passable hand of poker, likes to be in the middle of a crowd, laughs easily and enjoys hunting and fishing.

An expression heard frequently in his office is: "Do what you think is right and what you are big enough to do." Bob Dunigan, by almost any measurement, stacks up big enough.

ever since. Before his appointment as manager for the Mars Exploration Program, he served as chief of missile technology for Boeing's Missile Branch. He was chief of technical staff for the X-20 (Dyna-Soar Branch) from 1962 until early 1964. He handed the company's structures technology department from 1959 to 1962.

A heavy reader of technical literature, he keeps himself neck-and-neck with a galloping technology by taking part in conferences and symposiums. He is chairman of the Pacific Northwest section of the American Institute of Aeronautics and Astronautics, a member of the NASA Research Advisory Committee on Space Vehicle Structures, and has served on National Academy of Science and American Rocket Society committees.



Flight crew of 97th Bomb Wing brings record-making B-52 to Wichita.

Strategic Air Command record is set.

BLUE-RIBBON BOMBER

By DARRELL BARTEE

UNOFFICIALLY, a frosty-nosed performer at Blytheville Air Force Base, Arkansas, has been dubbed "queen of the fleet."

The Boeing bomber, flown by the 340th Bomb Squadron, 97th Bomb Wing, recently made its 303rd consecutive on-time takeoff. At the time, this record of readiness was believed to be tops for B-52s in the Strategic Air Command.

"Best part of it is," says S/Sgt. Frank O. Davis, crew chief on the go-go Stratofort, "the string is still alive. We can improve this record."

Sergeant Davis is a member of the 97th Organizational Maintenance Squadron at Blytheville. His crew, and the supporting ground units, have been responsible for 65 of the on-timers. Two other crew chiefs helped build the record before him. For a takeoff to be counted as an on-timer, SAC allows no deviation from the flight schedule; the rule is more demanding than formerly.

The always-ready bomber, a "G"

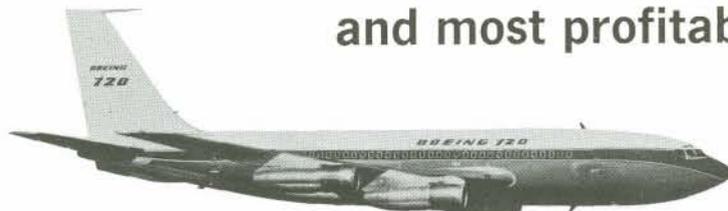
model built at Boeing's Wichita plant, is logging its remarkable record of reliability during its sixth year of service with SAC. As a brand new airplane, No. 57-6513 was delivered to the 42nd Bomb Wing at Loring AFB, Maine, in July 1959. The bomber has since been continually on the go at SAC bases, except for off-duty periods required for normal up-dating and maintenance.

The current string of on-time takeoffs for the Blytheville airplane has been continuous since May 1961. It has included flight duty in the U. S. and abroad, in temperatures ranging from sub-zero to tropical, day and night, on alert status and routine missions.

On its 303rd takeoff, the veteran bomber came back to Wichita to be cycled through routine modernization. Crew Chief Davis came along and carefully checked every detail of the airplane's status with the modification teams at the home plant. He wants the bomber back. To him, that 303 is strictly a temporary mark.



**"... our most completely satisfactory
and most profitable airplane."**



**"... the most profitable airplane
we have ever operated."**



**"... has helped this airline
achieve record profits."**

The above quotes are by executives of three different airlines, flying three different Boeing jets, on different kinds of routes.

In each case, the report is the same: Boeing jets make money. On short routes. On intermediate routes. On over-ocean routes. There are many reasons. Boeing jets are *designed* and *built* to produce profits. They are rugged and reliable. They've demon-

strated unmatched passenger appeal.

Boeing jets have set more speed and distance records than all other jetliners combined. These records, significantly, were set in routine day-in, day-out commercial operations.

Boeing jets have carried over 75 million passengers. They've flown more than 1 $\frac{3}{4}$ billion miles and have logged four million hours (456 years) in the air.

Boeing jets have proved themselves so profitable that airlines, during 1964 alone, ordered more Boeing jetliners than have ever been ordered in a single year from one manufacturer.

Another measure of profitable performance: two-thirds of all Boeing sales have been *re-orders* from airlines already operating Boeing equipment.

BOEING Jetliners
LONG-RANGE 707 • MEDIUM-RANGE 720 • SHORT-RANGE 727