Aviation Week and Space Technology

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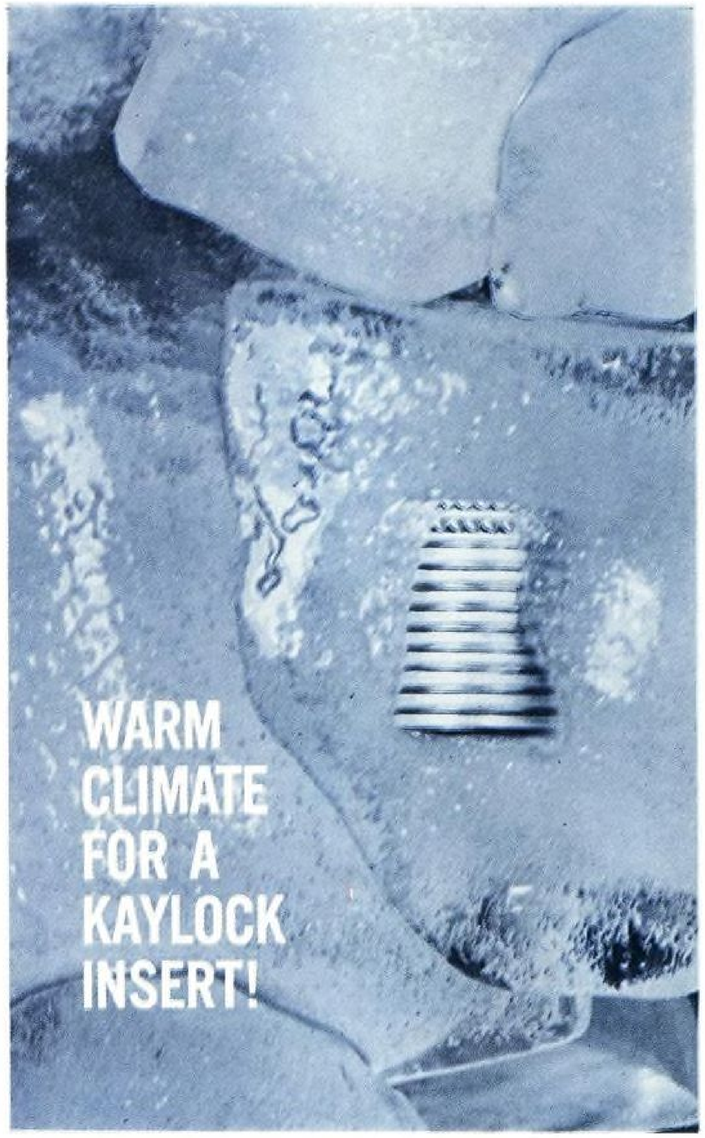
February 26, 1962

Orbiting Solar Observatory To Detect Radiation

Breguet 941 STOL Transport

Pilot Report on Convair 990 Transport



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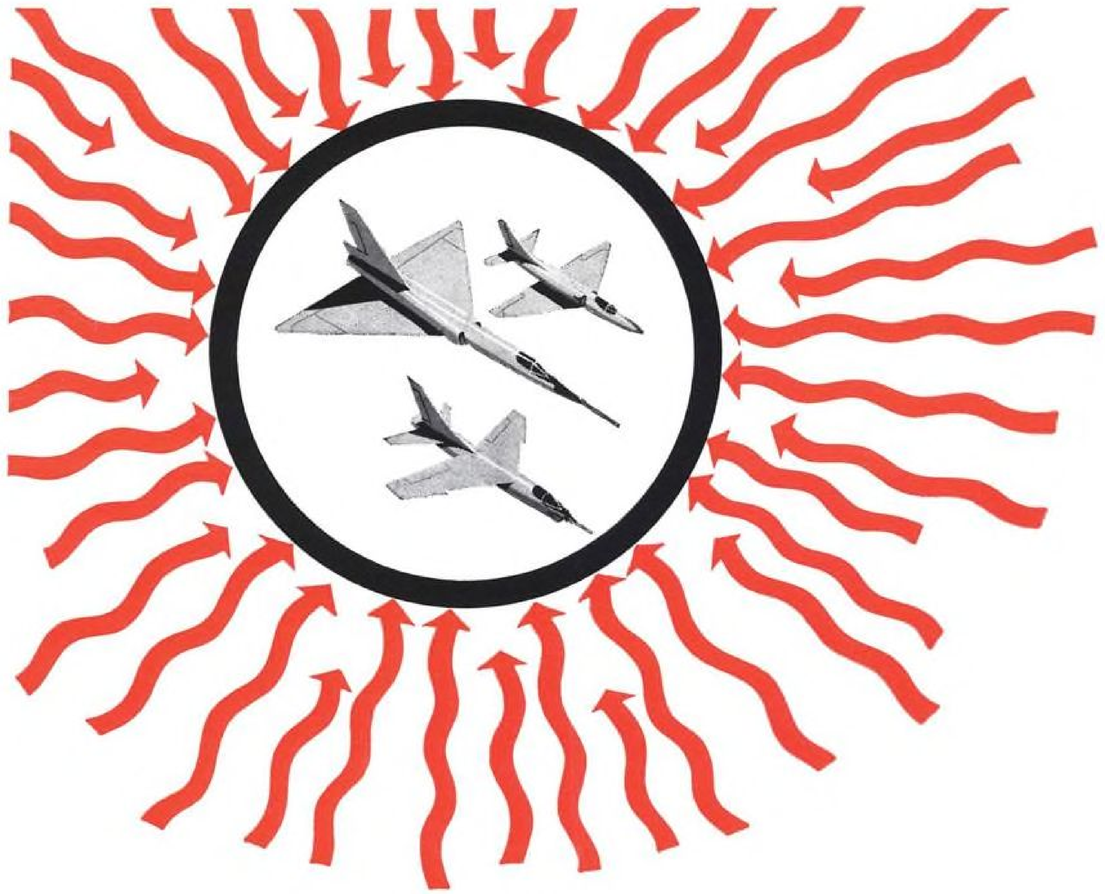

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AEROSPACE CALENDAR

Mar. 5-8—Seventh Annual Gas Turbine Conference and Products Show, American Society of Mechanical Engineers, Shamrock Hilton Hotel, Houston, Tex.

Mar. 6-7—Annual Meeting, Society of American Value Engineers, Marriott Motor Hotel, Washington, D. C.

Mar. 6-7—Fifth Annual Technical Conference, Society of Vacuum Coaters, Sheraton Cleveland Hotel, Cleveland, Ohio.

Mar. 8-9—Institute of the Aerospace Sciences' Propulsion Meeting (classified), Cleveland, Ohio.

Mar. 14-16—Electric Propulsion Conference, American Rocket Society, Hotel Claremont, Berkeley, Calif.

Mar. 16—Annual Robert H. Goddard Memorial Symposium, "Torques and Attitude Sensing in Satellites," American Astronautical Society, Washington, D. C.

Mar. 20-21—University of Denver's Second National Symposium on Hypervelocity Techniques, Denver, Colo.

Mar. 26-29—International Convention, Institute of Radio Engineers, Coliseum and Waldorf Astoria, New York.

Mar. 28-29—Third Symposium on Engineering Aspects of Magnetohydrodynamics, University of Rochester, Rochester, N. Y. Sponsors: American Institute of Electrical Engineers; Institute of the Aerospace Sciences; Institute of Radio Engineers; University of Rochester.

Mar. 29-30—Fourth Annual Electron Beam Symposium, Alloyd Electronics Corp., Cambridge, Mass.

(Continued on page 7)

AVIATION WEEK and Space Technology

February 26, 1962

Vol. 76, No. 9

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AEROSPACE CALENDAR

(Continued from page 5)

Apr. 1-4—Mid-Year Conference, Airport Operators Council, Shoreham Hotel, Washington, D. C.

Apr. 3-5—Launch Vehicles: Structures and Materials Conference, American Rocket Society, Ramada Inn, Phoenix, Ariz.

Apr. 3-6—National Aeronautic Meeting (including production forum), Society of Automotive Engineers, Hotel Commodore, New York, N. Y.

Apr. 10-12—Second Symposium on The Plasma Sheath—Its Effect Upon Re-entry Communication and Detection, New England Mutual Hall, Boston. Sponsor: AF Cambridge Research Laboratories.

Apr. 11-13—Southwestern Conference and Electronics Show, Institute of Radio Engineers, Rice Hotel, Houston, Tex.

Apr. 11-13—Annual Technical Meeting and Equipment Exposition, Institute of Environmental Sciences, Sheraton Chicago Hotel, Chicago, Ill.

Apr. 12-13—Eighth Annual Heat Transfer Conference, Oklahoma State University, Stillwater, Okla.

Apr. 13—Government Contracts Symposium, National Assn. of Professional Contracts Administrators, Ambassador Hotel, Los Angeles, Calif.

Apr. 14-16—Second Conference on Kinetics, Equilibria, and Performance of High Temperature Systems, University of California, Los Angeles, Calif. Sponsor: Western States Section/Combustion Institute.

Apr. 16-18—Second International Flight Test Instrumentation Symposium, College of Aeronautics, Cranfield, England.

Apr. 16-18—Aerospace Systems Reliability Symposium, Institute of the Aerospace Sciences, Salt Lake City, Utah.

Apr. 24-26—Polytechnic Institute of Brooklyn's Symposium on the Mathematical Theory of Automata, United Engineering Center, New York, N. Y.

Apr. 25-29—Western Space Age Industries and Engineering Exposition, Cow Palace, San Francisco, Calif.

Apr. 30-May 2—Meeting on Manned Space Flight, Institute of the Aerospace Sciences, Hotel Chase, St. Louis, Mo.

May 1-3—Spring Joint Computer Conference, Fairmont Hotel, San Francisco.

May 2-4—18th Annual National Forum, American Helicopter Society, Sheraton Park Hotel, Washington, D. C.

May 2-11—International Space Research and Technology Exhibition, London, England. Sponsor: British Interplanetary Society.

May 3-4—First International Congress on Human Factors in Electronics, Institute of Radio Engineers, Lafayette Hotel, Long Beach, Calif.

May 7-9—Materials & Processing for Space Environments Symposium, Society of Aerospace Material and Process Engineers, Hotel Statler, St. Louis, Mo.

May 7-11—Annual Conference, Society of Photographic Scientists and Engineers, Somerset Hotel, Boston, Mass. Cosponsor: AF Cambridge Research Laboratories.

May 7-11—1962 Tool Exposition & Engineering Conference, Public Auditorium, Cleveland, Ohio.

May 8-10—12th Annual Electronics Compo-

(Continued on page 9)

AEROSPACE CALENDAR

(*Continued from page 7*)

nents Conference, Marriott Twin Bridges Motor Hotel, Washington, D. C.

May 14-16—National Aerospace Electronics Conference, Institute of Radio Engineers, Biltmore Hotel, Dayton, Ohio.

May 14-16—Joint Technical Society-Department of Defense Symposium on Thermionic Power Conversion, Antlers Hotel, Colorado Springs, Colo.

May 14-17—21st Annual National Conference, Society of Aeronautical Weight Engineers, Benjamin Franklin Hotel, Seattle.

May 20-24—Annual Conference, American Assn. of Airport Executives, Ambassador Hotel, Los Angeles, Calif.

May 21-25—Eighth Aerospace Instrumentation Symposium and National Telemetering Conference, Sheraton Park Hotel, Washington, D. C.

May 22-24—Conference on Self-Organizing Systems, Museum of Science and Industry, Chicago, Ill. Sponsors: Office of Naval Research; Armour Research Foundation.

May 22-24—National Microwave Theory & Techniques Symposium, Institute of Radio Engineers, Boulder, Colo.

May 24-26—Seventh Region Conference on Space Communications, Institute of Radio Engineers, Seattle, Wash.

June 6-7—Symposium on Standards for Filament-Wound Reinforced Plastics, Naval Ordnance Laboratory, Silver Spring, Md.

June 6-8—Eighth Annual Radar Symposium (classified secret), Institute of Science and Technology's Radar Laboratory, University of Michigan, Ann Arbor.

June 8-9—13th National Maintenance and Operations Meeting, Reading Aviation Service, Inc., Reading, Pa.

June 13-15—Annual Meeting, Heat Transfer and Fluid Mechanics Institute, University of Washington, Seattle, Wash.

June 19-21—39th Meeting, Aviation Distributors and Manufacturers Assn., Ambassador Hotel, Los Angeles.

June 19-22—Summer Meeting, Institute of the Aerospace Sciences, Ambassador Hotel, Los Angeles, Calif.

June 25-27—Sixth National Convention on Military Electronics, Institute of Radio Engineers, Shoreham Hotel, Washington.

June 25-30—Symposium on Electromagnetic Theory & Antennas, Copenhagen, Denmark. Sponsors: Technical University of Denmark; International Scientific Radio Union.

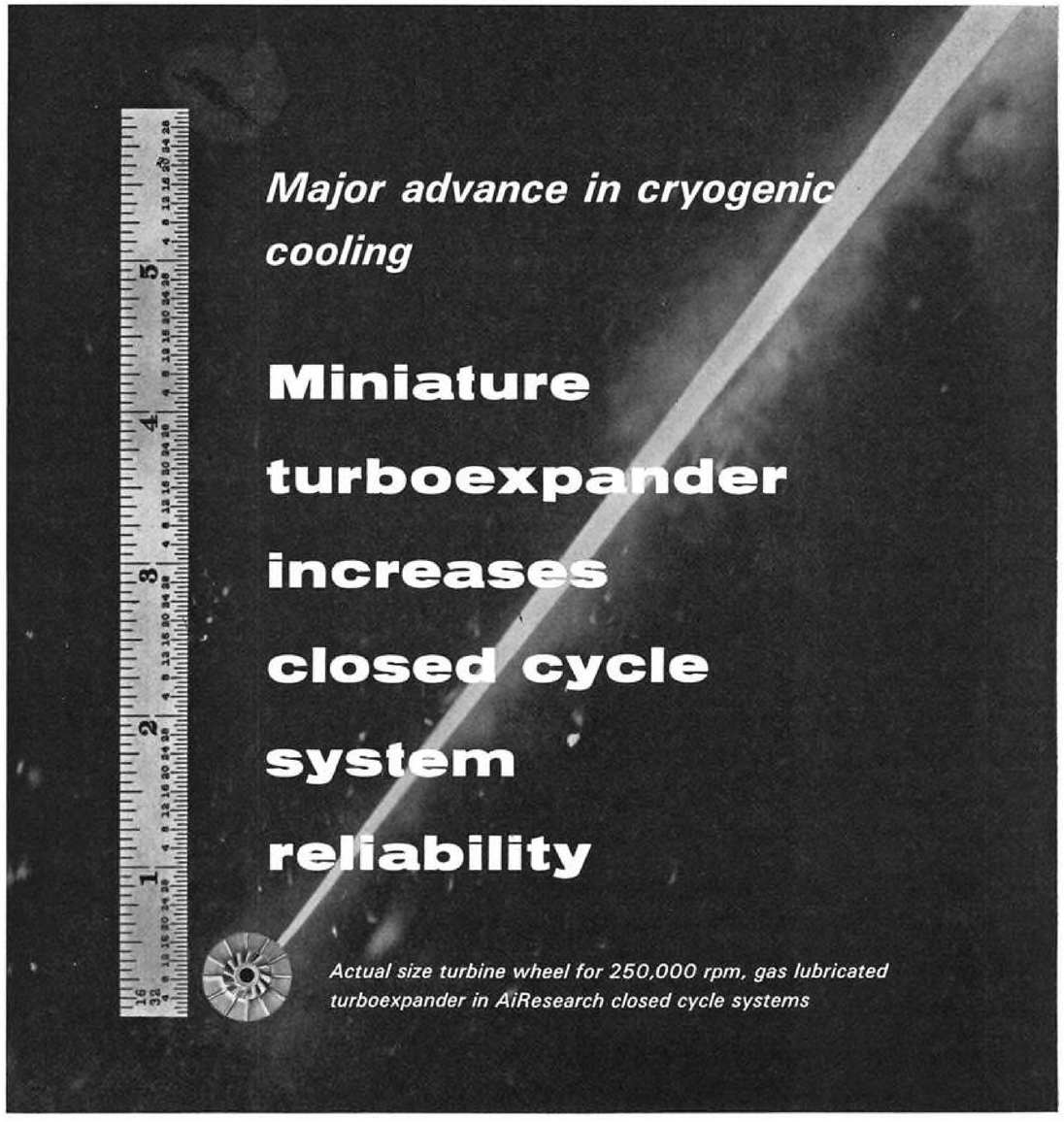
June 27-28—Ninth Annual Symposium on Computers and Data Processing by the University of Denver's Denver Research Institute, Elkhorn Lodge, Estes Park, Colo.

June 27-29—Joint Automatic Control Conference, Institute of Radio Engineers, New York University, New York, N. Y.

July 16-18—Lunar Missions Meeting, American Rocket Society, Pick Carter and Statler Hilton Hotels, Cleveland, Ohio.

Aug. 10-11—Future of Manned Vehicles in Air and Space, Institute of the Aerospace Sciences, Olympic Hotel, Seattle, Wash.

Aug. 21-24—Western Electronics Show and Conference, Institute of Radio Engineers, Los Angeles, Calif.



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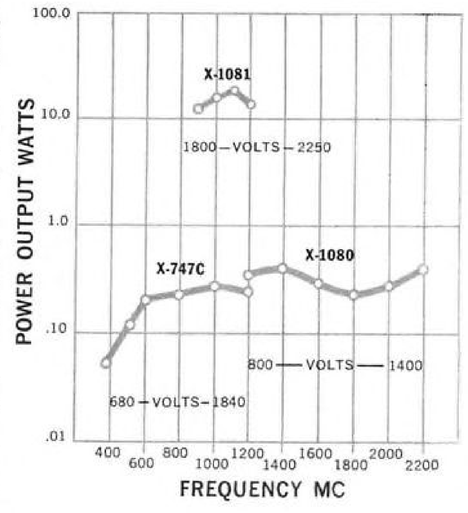

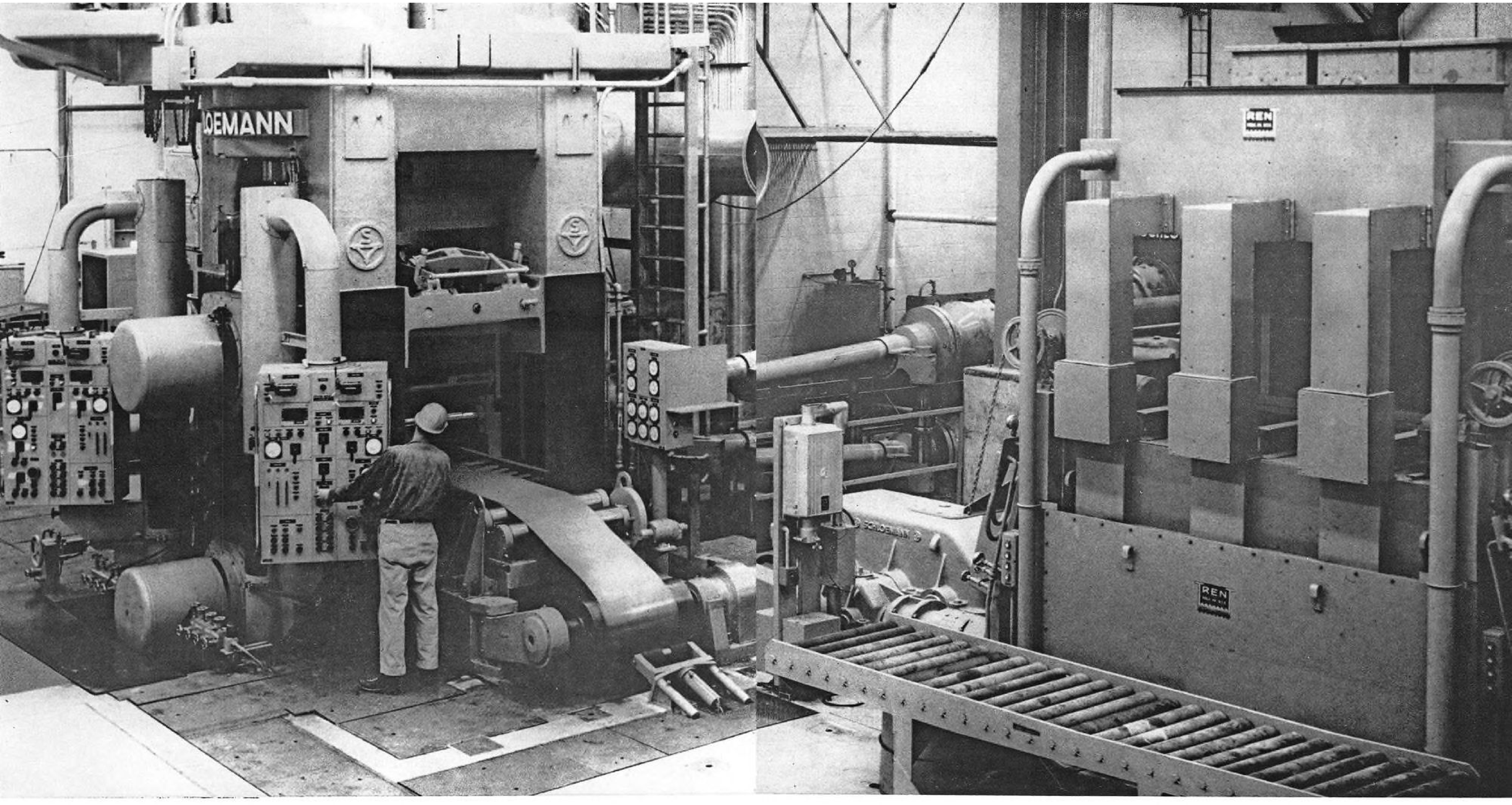

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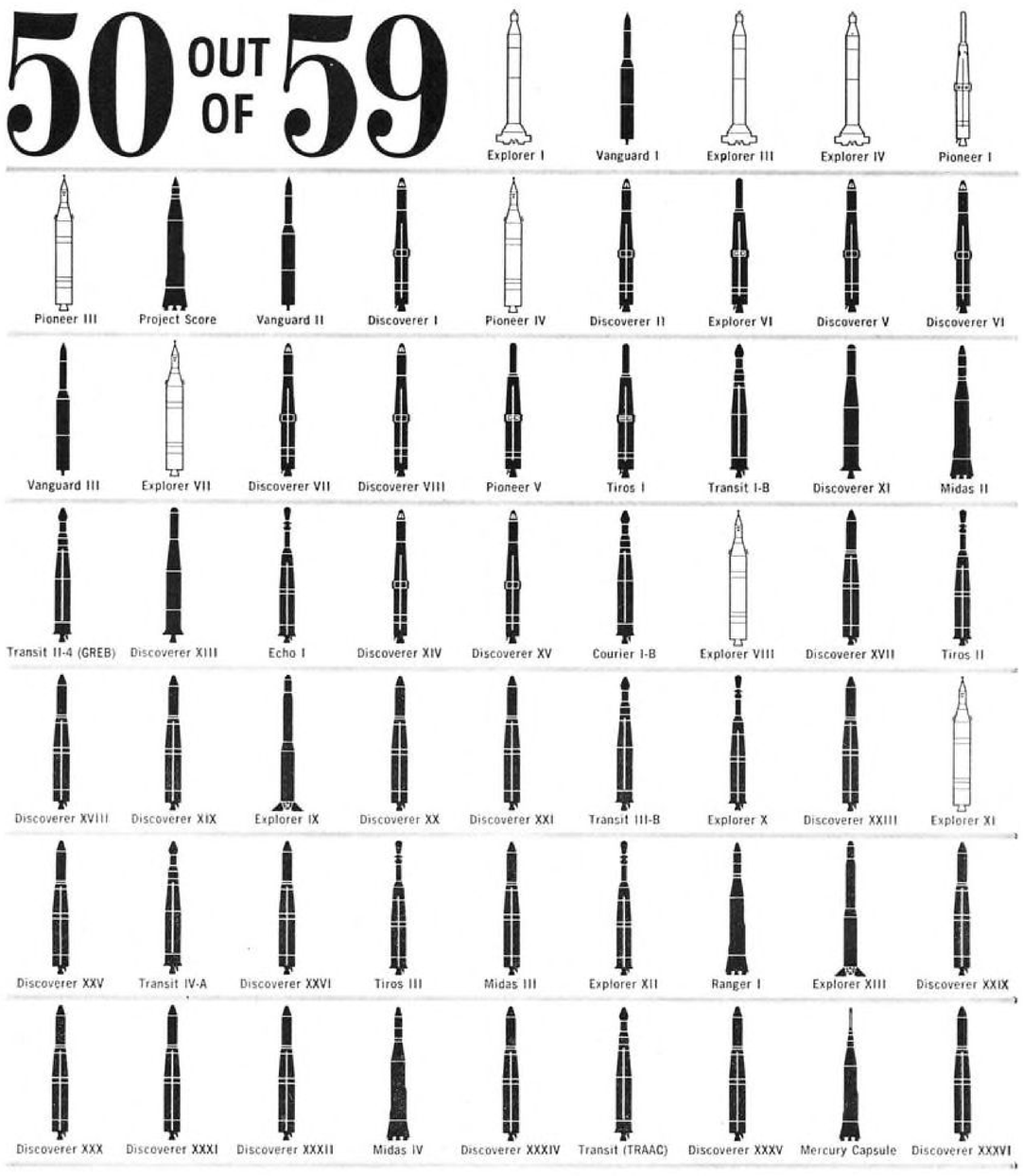

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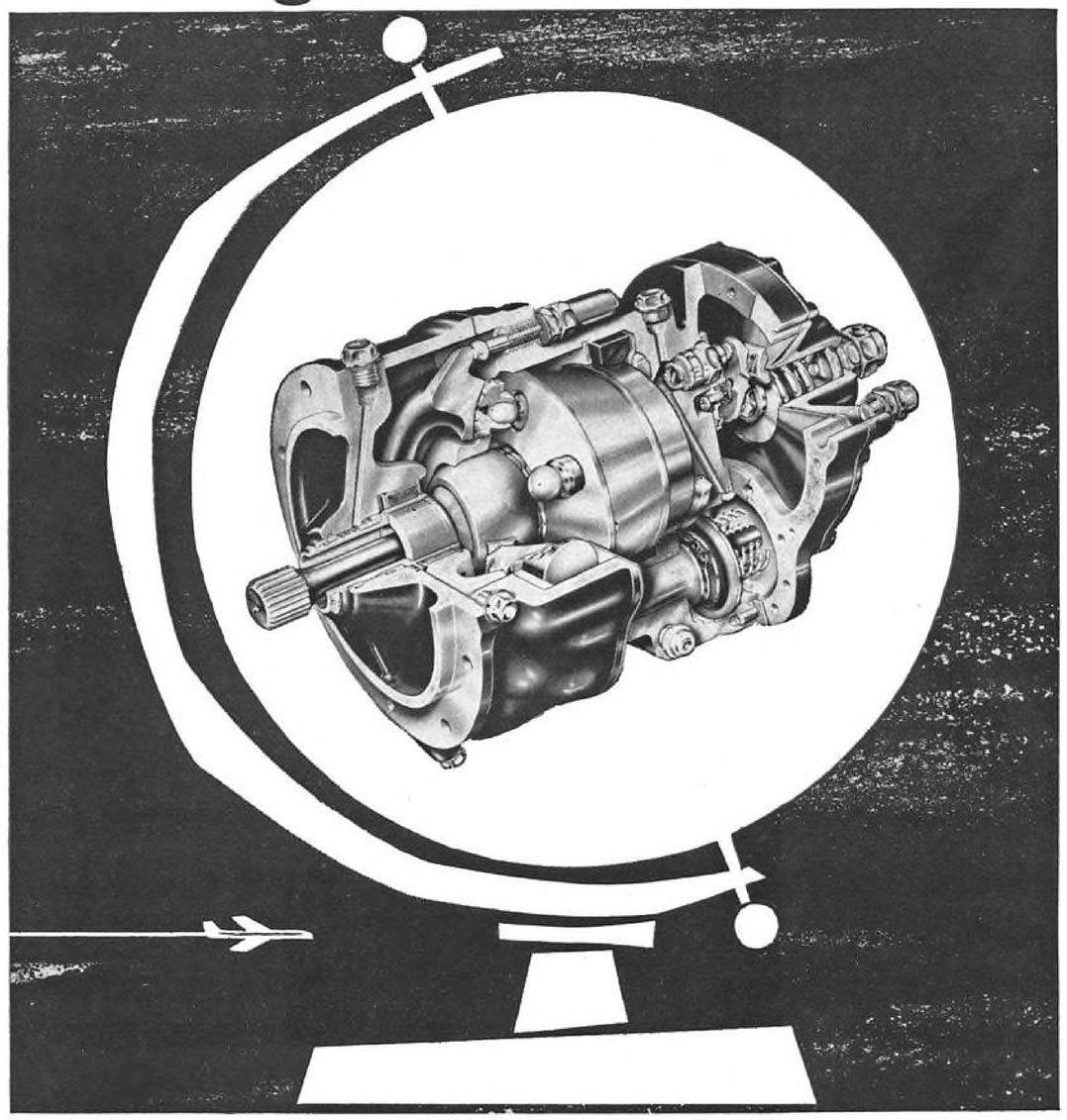

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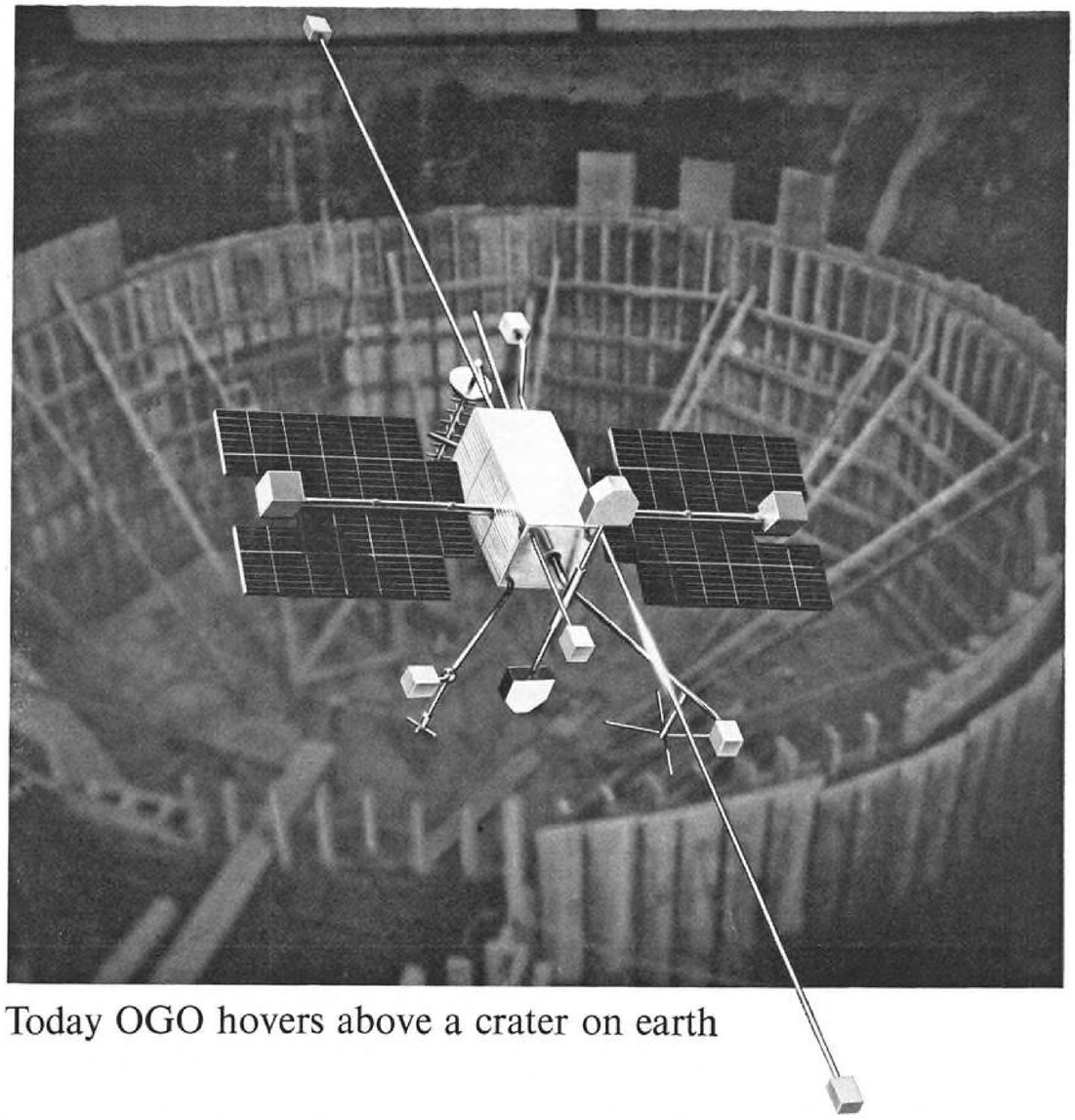

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COVER: Breguet 941 uses vectored slipstream principle to achieve STOL capability. Flaps in STOL configuration deflect propeller slipstream downward, inducing lift. The transport, designed for both civil and military applications, is powered by four Turbomeca Turmo 3D free turbines delivering 1,250 shp. each (AW July 31, p. 35). Earlier, the aircraft underwent flight testing which confirmed manufacturer's takeoff performance figures—770 ft. on grass strip at 20-ton gross weight—and cruising speed of 215 kt.

PICTURE CREDITS
Cover—Breguet; 27, 28, 30, 31—Wide World; 29—UPI; 40, 41, 43—Lufthansa; 45—Boeing Co.; 55, 57—NASA; 61—Aviation Week; 64—Geophysics Corp. of America; 65, 66—Aerojet-General Corp.; 69, 75, 77—Convair; 84, 85—Ralph M. Parsons Co.; 93 (right)—Federal Aviation Agency; (left) ACF Electronics; 94, 95—ACF Electronics; 103—C. W. Holland; 105 (top)—Britten-Norman, (bottom)—Westland Aircraft.

87,062 copies of this issue printed

EDITORIAL

End of the Beginning

The long sweat is over. The successful three-orbit space flight of Lt. Col. John Glenn marks the end of the beginning for the U.S. manned space flight effort. It is a thorough technical vindication for the hard core of National Advisory Committee for Aeronautics veterans who began the research and planning for the Mercury program at NACA's Langley and Ames laboratories in the summer of 1958, before the National Aeronautics and Space Administration was created the next fall. Many of these same, largely unsung, technical heroes also played key roles in the highly successful supersonic research aircraft program from the X-1 through X-15.

This hard core of former NACA personnel was subjected to enormous pressures from technical kibitzing and political timidity in the three years since the first funds were formally allocated to Mercury in the fall of 1958. It took a major amount of quiet and unpublicized courage for them to stick to their technical guns and press onward with the Mercury program in the face of domestic skepticism, indifferent political support and the successful Soviet manned orbital flights of 1961. They are too numerous to list by name in this space but among those who merit special mention are Dr. Hugh L. Dryden, who bore the brunt of the technical kibitzing and stubbornly resisted the erosion of early political indifference to the program. Bob Gilruth, Walt Williams, Max Faget, Chris Kraft, George Low and Hartley Soule were other leaders of this technical team who did their work on civil service pay and sold no serial rights to national magazines.

The international adulation now engulfing Astronaut John Glenn is well deserved. He performed flawlessly as a test pilot in man's most ambitious assault on a completely hostile environment. With his courage and skill he presented an image to his fellow Americans of the qualities that made this nation great. To our friends abroad, like the B-58 crews at the Paris air show last spring, he presented a picture of Americans the way they hope we still are.

But the real significance of this successful triple-orbit manned space flight is the foundation of national scientific, engineering and industrial resources on which it was based. When our political leaders belatedly made a decision to go into space, creating NASA almost a year after the Soviet Sputnik 1 went into orbit, the basic resources to implement this decision already existed in the aircraft industry, in the military services and in the researchers of NACA.

From the Air Force ICBM program came the Atlas booster and its guidance system without which U.S. manned orbital flights would still loom in a fuzzy future. The successful adaption of what was designed as a military weapon into a reliable space booster (and the Atlas performance as a space booster now has certainly silenced its early maligners) drew on the technical capabilities and experience of Convair's Astronautics Division and USAF Systems Command's Ballistic and Space Systems divisions to fulfill the NASA requirements. From USAF and Naval aviation came the bioastronautics capability utilized in Mercury, and also from the military services' long experience in experimental testing of manned flight vehicles came the seven astronauts themselves. From industry—North American's Rocketdyne engines; General Electric's guidance system; Convair's Atlas, McDonnell's capsule and many others (see p. 35)—came the technical skills and fabricating facilities to translate the Mercury concept into reliable performing hardware.

Even though John Glenn, as the pilot on this first U.S. orbital mission, was the focal point for public adulation, all of his fellow astronauts played solid support roles and it was far more of a team effort than is generally understood.

It is important for the American public as well as the world at large, and particularly the Soviet Union, to understand that the success of the first U.S. manned orbital space flight is not based on the concept of supermen supported by rigid political doctrine, but rather on this extensive, sound foundation of national technical resources that can be concentrated on specific objectives by imaginative and alert national leadership to produce results such as the manned space flight program. In retrospect, the record of Mercury from initial funding to first successful manned orbital flight in a trifle over three years should be equally impressive to friend and foe.

President John Kennedy and Vice President Lyndon Johnson also deserve a share in the Mercury success. Early last year they rejected the advice of their predecessors, who recommended retarding the manned space flight program. Instead they made the basic policy decision to extend manned space flight objectives to the moon and at the same time infused solid and strong support into Mercury. They also ignored some of their "best" scientific advice in ordering an "open door" policy of full public view of all Mercury flights, in direct contrast to the Soviet Union's policy of black secrecy.

The result of the international spotlight focused on the U.S. ballistic and manned orbital space flights has given this country its greatest international prestige boost in a decade. It has also blunted the Soviets' advantages of being first and longest with man into orbit by contrasting our candor with their secrecy. It is significant that Mr. Khrushchev is now asking for international space cooperation (see page 33) after scornfully rejecting it until after Col. Glenn's flight, and Soviet scientists are now hinting to Americans in Moscow that they may allow foreign observers at their next space spectacular. It is certainly much too early to assess the sincerity of these Soviet gestures. But there is no doubt that the glare of international publicity focused on the U.S. space shots is generating an uncomfortable pressure of world opinion against their super secrecy, and is raising a general air of skepticism regarding their manned space achievements.

Col. Glenn's orbital flight marks the end of the difficult beginning of the U.S. manned space flight program. The road ahead is still murky with risk and the detours of inevitable experimental failures. The cold white light of the moon glows as the next goal.

We think President Kennedy put the U.S. space position in its proper perspective after Col. Glenn's flight when he said from the White House rose garden:

"We have a long way to go in this space race. We started late. But this is the new ocean and I believe the United States must sail on it and be in a position second to none."

—Robert Hotz

WHO'S WHERE

In the Front Office

Dr. Arch C. Scurlock, board chairman, Nuclear Science and Engineering Corp., Pittsburgh, Pa. Dr. Scurlock continues as president of Atlantic Research Corp.

Donald T. Spaulding, president, Federal Systems Division of International Business Machines Corp., Rockville, Md., succeeding **Charles Benton, Jr.,** now executive assistant to the IBM vice president and group executive for the company's Data Processing and Federal Systems Divisions.

E. R. Peterson, vice president in charge of new projects, General Dynamics/Pomona, Pomona, Calif.

Hughes Aircraft Co., Culver City, Calif., has announced the appointment of the following vice presidents: Aerospace Group—**John W. Black,** manager of the Aeronautical Systems Division, and **Joseph Ferderber,** manager of the El Segundo (Calif.) Division; Components Group—**Lester M. Field,** assistant group executive; General Offices—**William L. Hoffman,** administration and materiel, and **Charles B. Huestis,** treasurer, **John L. Winkel,** in charge of district offices with headquarters in Washington, D. C.

C. B. Gracey, formerly vice president-general manager of the Wichita (Kan.) Branch of The Boeing Co.'s Military Aircraft Systems Division has been appointed vice president-manufacturing in Boeing's headquarters organization, Seattle, Wash., succeeding **Fred P. Laudan,** who will continue as a vice president and serve as consultant to Mr. Gracey. **Ben M. Wheat,** assistant general manager of the Wichita Branch, will be in charge in the absence of **Edward C. Wells,** vice president-general manager of the MAS Division, who will divide his time between Seattle and Wichita.

Charles H. Calhoun, a vice president, Pacific Airmotive Corp., Burbank, Calif., in charge of the Engine Division.

Richard M. Adams, vice president-engineering and maintenance, Continental Air Lines, Inc.

Edwin A. Andress, vice president-sales, Ling Electronics, Anaheim, Calif., a division of Ling-Temco-Vought, Inc.

Rulon Gene Shelley, vice president-engineering and marketing, Tamar Electronics, Inc., Anaheim, Calif.

Capt. William B. Whitacre, vice president-personnel, American Airlines, Inc., succeeding **Paul W. Kayser,** resigning. At the company's request, Capt. Whitacre has deferred his retirement (AW Dec. 25, p. 11).

George Thompson, vice president and general manager, Microtech, Inc., Cheshire, Conn., a subsidiary of Talley Industries, Inc.

Sylvania Electronic Systems, a division of Sylvania Electric Products, Inc., has appointed the following as vice presidents and general managers of divisional operations: **Jesse R. Lien**-western operation, Mountain View, Calif.; **Richard M. Osgood,** eastern operation, Waltham, Mass.; **H. C. Tittle,** central operation, Buffalo, N. Y.

William F. Tait, division vice president-marketing, Government Services, RCA Service Co., Radio Corporation of America, Cherry Hill, N. J.

(Continued on page 109)

INDUSTRY OBSERVER

► Engine cut off delay of Atlas booster used in NASA's Jet Propulsion Laboratory Ranger 3 lunar mission (AW Feb. 12, p. 28) resulted from malfunction of transistorized versions of guidance system components, which are not standard in the Air Force's Atlas operational configuration.

► **Submission of proposals to Air Force Systems Command's Space Systems Division in competition for 120-in.-dia. solid-propellant rocket motor has been advanced from 12:01 p.m. on Mar. 13 to 4:45 p.m. on Mar. 12. Follow-up verbal presentations will be allowed on Mar. 15 for contenders Lockheed Propulsion Co., Hercules, Thiokol, and Atlantic Research, and on Mar. 16 for Aerojet, United Technology Corp., and Rocketdyne.**

► Army may make significant changes in guidance and propulsion of its Tactical Missile B, expected to enter development this spring. Original concept called for extremely high thrust rocket engine for brief high-g boost; guidance was planned around a single two-axis gyro for boost-phase guidance with an accelerometer compensating for winds aloft during coasting flight. New proposal would use a lower-g, longer-burning rocket motor and a simple inertial guidance system for control throughout powered flight.

► **Specially instrumented de Havilland Comet 1A has completed two-month test program at Edwards AFB measuring infrared radiation from a Convair B-58 during close supersonic passes. Instrumentation was designed by de Havilland and British Ministry of Aviation.**

► Russian helicopter blade de-icing system, using alcohol forced out through tiny holes in the blade leading edge, is used on Bell HU-1 Iroquois and Boeing-Vertol HC-1B Chinook Army helicopters. Use of the system came from informal exchange of information between U. S. manufacturers and Russian technicians from the Mil design office when the Russians took delivery of their Sikorsky and Vertol helicopters last year.

► **Air Force's Solar Power Unit Demonstrator (Spud), formerly designated Spur, is a closed-loop mechanical conversion solar power system using mercury as the working fluid. Unit was designed to fit a capsule for a piggy-back ride on a General Dynamics Atlas to get long-time cycle characteristics under zero-gravity conditions. Test was originally scheduled for late 1961, but is now on an available-vehicle basis with no firm date.**

► Russian Designer O. K. Antonov continues to experiment with the twin-engined An-14 Pchelka light transport to reduce its takeoff run to approximately 100 ft. Pchelka has been modified many times since its introduction in 1957, and these changes have delayed its production.

► **Russian investigations of the moon's surface by means of radio waves have led to conclusions that a very light, porous, cinder-like matter covers the surface. Temperature of the layer is constant at −50C to a depth of about six feet, but may increase with depth because of the possibility of a hot core structure at the center of the moon.**

► New heavy helicopter to be developed for the Marine Corps this year will have a gross weight approximating 30,000 lb. Other characteristics will include a design cruise speed of 150 kt., power folding of the blades, and all fuel carried in self-sealing tanks.

► **Bristol T.188 stainless-steel supersonic research aircraft is scheduled to start new taxi tests, including runs with afterburner power, during this week. First flight has been delayed for modifications of Goodyear braking system, following overheating of the system during earlier taxi tests.**

► Samos and Midas observation satellite launching facilities plus two tracking and telemetry stations cost USAF $9.1 million during Fiscal 1961. Facilities of Tern Island at French Frigate Shoals halfway between the Hawaiian Islands and Midway Island have been improved so that Lockheed C-130 aircraft, used for recovery of the Samos photographic capsule, can be based there.

Washington Roundup

Air Force Space Plan

Air Force has completed its long-awaited Space Plan, a 10-year blueprint for regaining the lead in military space technology. The plan has been circulated to research and development offices as a basic guide. One of its most interesting conclusions is that a manned military test station is essential for testing equipment.

Air Force would like to build such a station in cooperation with the National Aeronautics and Space Administration, using the two-man Gemini as the initial transport vehicle. Lt. Gen. James Ferguson, deputy chief of staff for research and technology, briefed the House Armed Services Committee on these plans in a closed session last week. In a statement released later, he said cooperation with NASA would be expanded beyond the 10 formal agreements signed since 1959, and noted that 93 Air Force research and development officers are now on duty with NASA. But he said Air Force must do some development on its own because of the different demands imposed by warfare.

Studies have already indicated that the most effective weapons in space may be non-nuclear, Gen. Ferguson said. They also indicate that space may prove to be the best place for command and control systems that would be vulnerable on earth. Although most of what Gen. Ferguson discussed is in the formative stage, he said an over-all facilities plan has been prepared to support the Space Plan. It is now being reviewed by the Air Force Scientific Advisory Board.

Apollo Plant Switch

Watch for NASA to take over from Air Force the function of plant representative at North American Aviation's Space and Information Systems Division at Downey, Calif., because of the importance of the Apollo spacecraft and Saturn S-2 rocket stage being built there for NASA. Original discussions were conducted between NASA Administrator James E. Webb and USAF Secretary Eugene Zuckert. They were followed by talks between NASA personnel and Maj. Gen. W. T. Thurman, USAF's director of procurement management. Only major Air Force program being handled by that NAA division now is the air-to-surface Hound Dog missile for the B-52.

Air Force Aeronautical Systems Division engine selection board, which was expected to make its recommendations last week on an engine for the Air Force-Navy TFX tactical fighter, has delayed relaying its findings to USAF headquarters. In spite of the re-examination (AW Feb. 19, p. 31) and the delay, the report is not expected to change the original recommendation that the Pratt & Whitney TF-30 engine be used.

Incentive Contracts

Two main points of controversy remaining between Defense Department and industry after a series of conferences on a proposed increase in incentive contracts are more government control over contractor management—chiefly through "make or buy" decisions in which the contractor is directed to subcontract work—and the profit ceiling on incentive contracts. Law sets these ceilings at 15% for research and development contracts and 10% for production contracts. By regulation, Defense has limited this to 10% for research and development and 7% for production.

Aerospace companies have strongly endorsed the basic approach of rewards or penalties for performance. They still object to the requirement for a written certification that the costs included in the original price estimate are accurate. In the past this has made the contractor subject to recapture of funds for any overcalculation, but has not carried re-imbursement for an undercalculation.

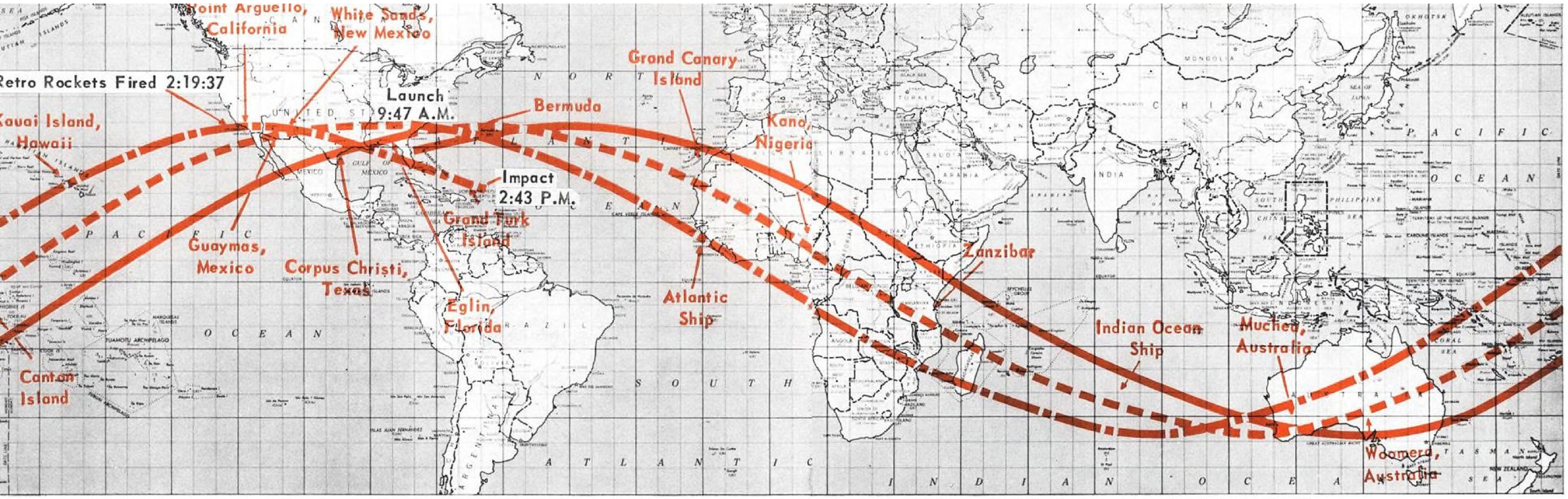
Defense has agreed to ask Renegotiation Board to give special consideration to profits earned on incentive contracts but has refused to support industry efforts to get the board to amend its practice of weighing profits against net worth, which is low in aerospace firms since government-owned facilities are not counted in net worth.

Latin Transport Study

U.S. delegates to the Regional Conference for Civil Aviation held recently in Bogota, Colombia, feel that the long-standing discord between the U.S. and Latin American countries over airline capacity restrictions has been eased. Decision to conduct a study of airline problems in Latin America under the auspices of the Organization of American States is seen as an indication that the nations involved believe some solution to the capacity issue must be made if the airlines are to provide proper service in the future. More pessimistic observers believe that South American countries still want capacity restrictions imposed on U.S. carriers and that the OAS study will simply be a delaying action. One encouraging result of the conference was a decision to promote tourism through a joint industry program.

Gen. Bernard A. Schriever, chief of the Air Force Systems Command, speaking after the successful Mercury Atlas 6 flight last week, called the Atlas booster much maligned and said the last eight Strategic Air Command firings of operational Atlases from Vandenberg AFB, Calif., had been successful.

—Washington Staff



THREE ORBITAL PATHS of Astronaut John Glenn's Friendship 7 capsule, projected on world map, show flight from launch at Cape Canaveral. Solid line is first orbit; broken line is second orbit; dot-dash line is third orbit.

Three Similar Manned Flights to Follow MA-6 Triumph

Ambitious schedule calls for launch of three-orbit missions every 60 days; 24-hr. efforts due next year.

By Edward H. Kolcum

Cape Canaveral, Fla.—U. S. will follow last week's spectacularly successful Mercury Atlas-6 mission with at least three more manned, three-orbit flights on an ambitious schedule that calls for a launch every 60 days. Detailed preparations already are under way for MA-7, which now is planned for launching in April.

MA-6 was launched from Pad 14 here at 9:47 a.m. EST Feb. 20, and although attitude control problems threatened to end the flight after two orbits, Marine Lt. Col. John H. Glenn, Jr., performed his test pilot role by manually overriding the automatic control system and meeting the full three-orbit objective. He had complete manual control of the Friendship 7 capsule for most of the second and third orbits and during the critical re-entry maneuver.

Col. Glenn's orbit had an apogee of 158.85 mi., a perigee of 97.695 mi., and a period of 88 min., 29 sec. Orbital inclination was 33.34 deg. to the equator, and velocity at injection into orbit was 25,728 fps. He landed at 2:43 p.m. EST, 166 mi. due east of Grand Turk Island, six miles from the destroyer Noa, which retrieved the capsule 18 min. later. It took 23 min. for the astronaut to leave the capsule after it was taken aboard the Noa. Col. Glenn got out through the side hatch after experiencing difficulty in trying to leave through the capsule neck.

There are four capsules remaining in the inventory for three-orbit missions. MA-7 capsule, to be flown by USAF Maj. Donald K. Slayton, has arrived here and the launch vehicle, Atlas 107D, will be delivered by General Dynamics/Astronautics from San Diego, Calif., in about two weeks.

The General Dynamics plant has eight Atlas D vehicles to deliver in the Mercury order, but it is likely that some of them will be used for 18-orbit missions, which probably will begin early next year. With slight modification, the Mercury Atlas vehicles could be used to launch Agena B target vehicles for the rendezvous development mission, which will use the two-man Gemini capsule.

Greatest problem Col. Glenn faced on his flight occurred just prior to re-entry, when an erroneous signal indicated that the ablative heat shield might drop prematurely. As a result, the package containing deceleration rockets was not jettisoned until the capsule was over Texas. The rocket package is strapped to the bottom of the shield and normally is dropped over the Pacific Ocean when the retrofire sequence is completed.

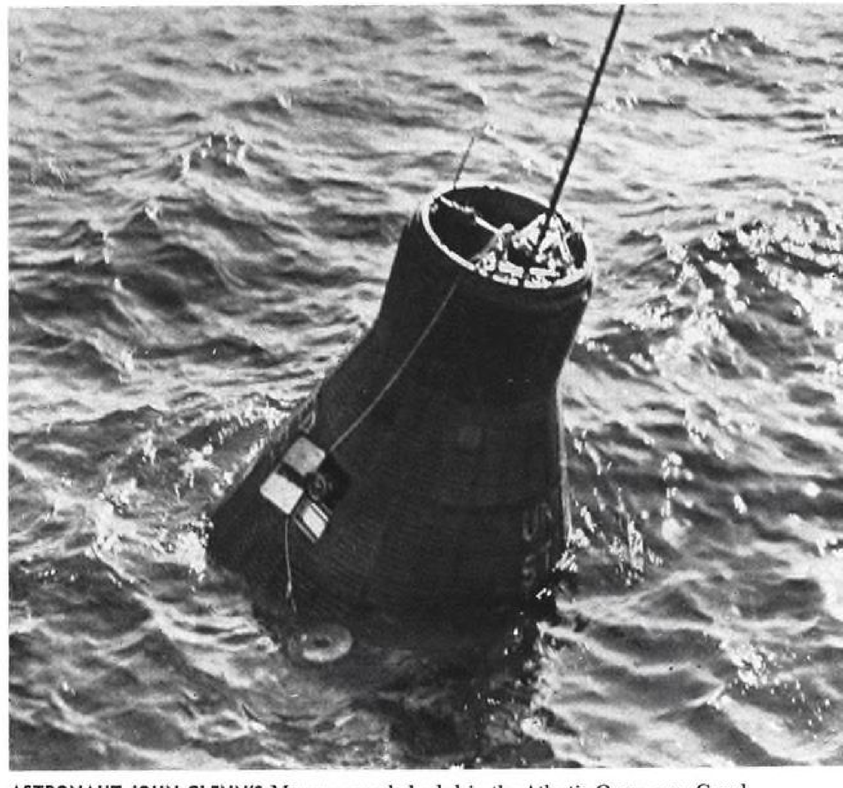
It was decided that the pack should be retained to provide some insurance for securing the shield to the Mercury capsule.

If the heat shield had deployed during any part of the re-entry maneuver, the results to the astronaut would have been catastrophic because there would have been no protection against the 3,000F heat, according to Mercury Operations Director Walter G. Williams.

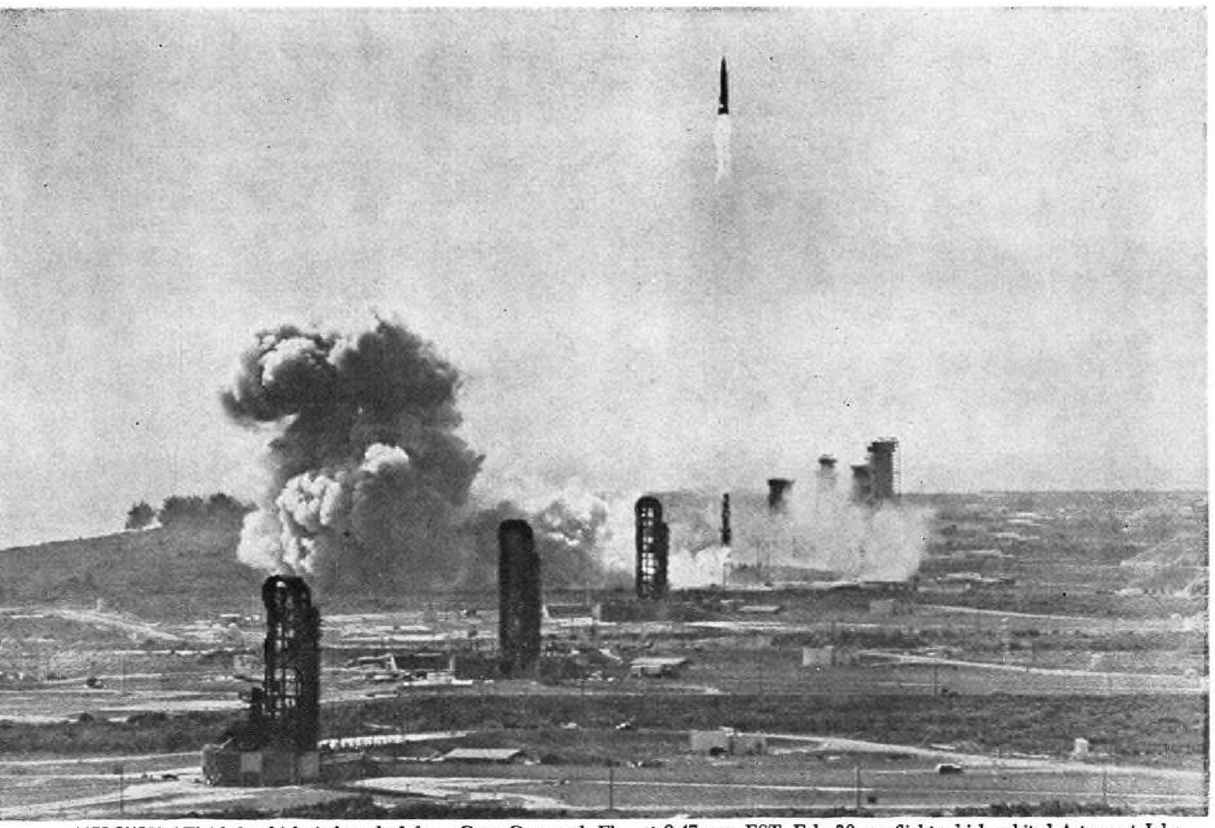
Because MA-6 proved that the U. S. has the capability to orbit a man in space, the psychological impact was immediate and universal. After 11 frustrating delays caused by minor technical problems and the weather (AW Feb. 19, p. 21, p. 30), the success of the first U. S. manned orbital flight greatly reduced what had been a growing concern over the progress of the space program, and vindicated those in the National Aeronautics and Space Administration and industry who were forced to defend the Mercury concept.

But more significant, the flight demonstrated the excellence with which man can perform in space in the largest step ever undertaken by the U. S. to expand the scope of manned flight. Col. Glenn's piloting, although it was made necessary by a malfunction, proved to be an unexpected bonanza because he carried out the performance tasks assigned to him while he controlled the capsule manually.

The problem arose on the first orbit as he approached the Guaymas, Mex., tracking station while the capsule's attitude was being controlled automatically. The capsule began to drift in right yaw



ASTRONAUT JOHN GLENN'S Mercury capsule landed in the Atlantic Ocean near Grand Turk Island, Bahamas, about 700 mi. southeast of Cape Canaveral, Fla., after flight.



MERCURY ATLAS-6 vehicle is launched from Cape Canaveral, Fla., at 9:47 a.m. EST, Feb. 20, on flight which orbited Astronaut John H. Glenn, Jr., three times around the earth. The capsule landed in the Atlantic Ocean at 2:43 p.m., 4 hr. 56 min. after launching.

at the rate of about 1 deg./sec. When a 20 deg. right yaw attitude was reached, the capsule re-oriented itself on the proper flight path.

Col. Glenn decided to go into the fly-by-wire mode, which is basically a manual control linked through the autopilot from the pilot's three-axis control stick.

His motions were converted to electrical signals, which actuated valves in the hydrogen peroxide reaction jets.

Manual System

The fully manual system, which Col. Glenn used in the late stages of his third orbit, mechanically links the pilot's movements of the stick to proportional throttle valves in front of reaction jet thrust chambers.

Separate jets are used for each attitude mode, and apparently the right yaw motor plugged and became inoperative in the automatic mode. Col. Glenn simply overrode the automatic system with the fly-by-wire system, and he made the decision to extend the flight through all three orbits.

The problem was similar to the one experienced in the MA-5 flight of the chimpanzee Enos last Nov. 29, when one of the roll jets apparently became plugged and the planned three-orbit mission was reduced to a two-orbit flight (AW Dec. 4, p. 27).

The automatic control system uses two sets of yaw jets—one with a 1-lb. thrust for fine corrections and the other with a 24-lb. thrust for radical attitude changes. In the Enos flight, the feed system to the larger roll jet was expending too much fuel because it was compensating for corrections not being made by the smaller jet, which was clogged.

The faulty heat shield signal could have stemmed either from a microswitch which gave a false signal or an electrical relay failure.

Initially, the MA-6 launch date appeared to be headed for another weather postponement. A heavy cloud layer covered the launch area, although weather in the recovery areas was considered well within limits. At about 8 a.m., winds aloft had cleared most of the clouds from the sky, but then a succession of technical problems made it appear certain that the launch could not be made in time to complete three orbits. Col. Glenn had entered the capsule at 6:03 a.m.

NASA had said last month that it probably would not attempt three orbits if the flight began after 9:30 a.m., but said there were a few minutes of leeway in the takeoff time for a three-orbit flight, depending on weather in the recovery areas.

The hatch had to be removed when one of the bolts broke, and later 10 gal. of RP-4 fuel had to be added to the tanks. An overload on the Bermuda computer—used as backup for the Goddard Space Flight Center command station—blew a fuse, which had to be replaced.

Earlier, the Atlas rate beacon transponder heated up too quickly and was replaced, and Col. Glenn's lip microphone, used as a respiration rate indicator, was replaced.

It was necessary to top off the fuels because a cold front passed through Cape Canaveral on Monday, changing the tank capacity after it had been fueled.

The transponder replaced was one of two in the General Electric guidance system. The other, a pulse beacon, provides position data. Rate beacon operates through the autopilot to provide velocity data.

The launch itself was flawless. Robert R. Gilruth, Mercury director, said the Atlas booster performed perfectly. Hold-down arms restrained liftoff for about 3 sec. while the engines built up thrust to some 367,000 lb. At about 60 sec. after ignition, the vehicle went through its maximum dynamic pressure zone (35,000-40,000 ft.) with no unexpected buffeting. Booster engine cutoff came at about 130 sec., just after the vehicle pitched over at an altitude of about 56 mi. Powered flight continued until 300 sec. after launch to an altitude of about 100 mi., just above perigee.

The spent Atlas spaceframe followed the Mercury capsule into orbit, but the astronaut saw it tumbling, and it was not expected to remain in orbit for more than one cycle.

As sustainer and vernier engines shut down, the clamp ring holding the capsule to the booster was explosively broken, and separation occurred when the acceleration rockets in the capsule were fired.

The astronaut experienced about 8g acceleration during launch, and slightly more than 8g during re-entry. At orbital insertion, the capsule was turned 180 deg. so that the blunt face was forward, and oriented 34 deg. above the orbital plane.

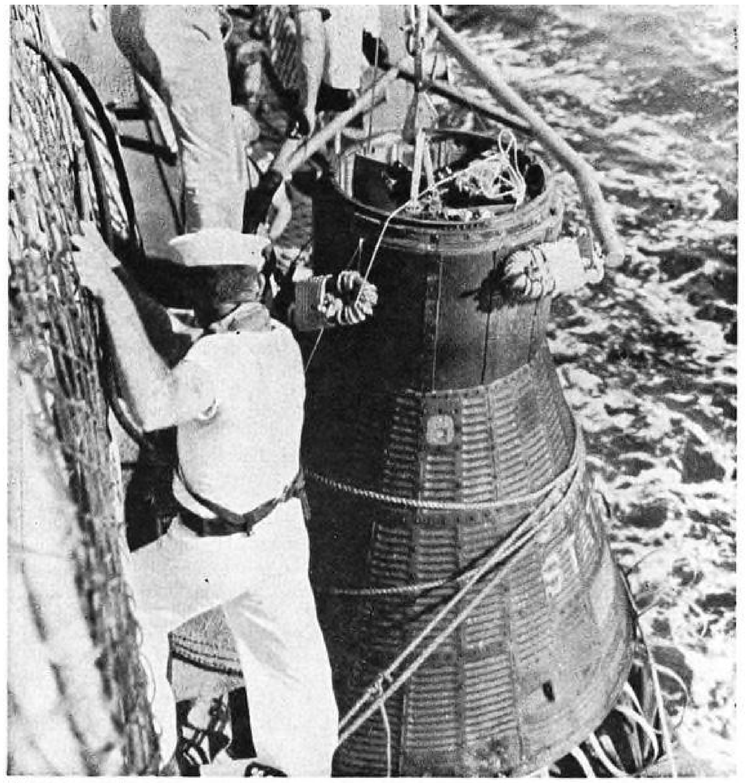
Attitude control was automatic until the approach to Guaymas in the first orbit and from this point it was either fly-by-wire or manual.

The astronaut sampled food—malt tablets, semi-solid applesauce and a beef-vegetable mixture—early in his first orbit, at 10:09 a.m. as he was approaching the Kano, Nigeria, tracking station.

MA-6 Tracking

Cape Canaveral, Fla.—Mercury Atlas 6, launched from here at 9:47 a.m. Feb. 20, impacted at 2:43 p.m. It was acquired and tracked by 16 primary stations in the Mercury network. Following is a log of acquisition times. All times are Eastern Standard. Dashes indicate that the spacecraft was not acquired or that time was not reported:

- **Bermuda, 9:51, 11:26, 12:58.**
- **Atlantic Ocean Ship, —, —, 1:12.**
- **Canary Islands, 10:06, 11:37, —.**
- **Kano, Nigeria, 10:09, 11:42, —.**
- **Zanzibar, 10:18, 11:51, —.**
- **Indian Ocean Ship, 10:28, 12:01, 1:34.**
- **Muchea, Australia, 10:40, 12:10, 1:43.**
- **Woomera, Australia, 10:43, 12:16, —.**
- **Canton Island, —, 12:31, 2:03.**
- **Hawaii, —, 12:39, 2:10.**
- **Guaymas, Mexico, 11:09, —, 2:23.**
- **Pt. Arguello, Calif., —, 12:46, 2:18.**
- **White Sands, N. M., —, 12:50, —.**
- **Corpus Christi, Tex., —, 12:52, 2:26.**
- **Eglin AFB, —, —, —.**
- **Cape Canaveral, 11:21, 12:56, 2:28.**



MERCURY CAPSULE, with Astronaut Glenn inside, is raised to deck of destroyer USS Noa. The astronaut was then transferred by helicopter to aircraft carrier Randolph.

The fruit and meat were in aluminum tubes.

After the fourth Mercury-Redstone flight, piloted by USAF Capt. Virgil I. Grissom last July, in which the capsule sank after shipping water, National Aeronautics and Space Administration made significant changes in recovery techniques. A basic rule remained the same, however—the ship or helicopter closest to the impact point was to make the recovery.

Col. Glenn's personal equipment kit was considerably larger than those used by Cdr. Alan B. Shepard, Jr., and Capt. Grissom on their ballistic flights. Medical equipment included hypodermics containing morphine to be used as a painkiller; wyamine, a stimulant; and tigan, an anti-motion sickness drug. He did not use any of these. The astronaut was scheduled to urinate sometime during the flight as one of the biomedical performance tasks. There was no immediate report on the results.

The destroyer Noa retrieved the capsule and its pilot by coming alongside and hooking a lifting bail in the capsule neck by means of a "shepherd's crook" attached to an aluminum pole.

The capsule was hoisted on board by boat davits. Crew of the Noa helped Col. Glenn attempt to get himself out through the neck, since blowing of explosive bolts holding the emergency door results in some deformation of the capsule. Exit through the neck involves removing a pressure bulkhead, lifting the instrument panel and pushing the empty parachute canister out. This could not be done, so a line was tied around the capsule afterbody and the door was blown. The line prevented the door from becoming a hazard.

Col. Glenn skinned his knuckles—the only injury he suffered—when he pulled the escape hatch actuator. He spent 30 min. talking into a tape recorder on the destroyer, and arrived on the carrier Randolph at 5:44 p.m. after being transferred by helicopter. He remained on the carrier until 8:04 p.m.

The pilot said he became slightly overheated in his pressure suit during the orbital flight, and kept the suit temperature down to an average of 67F.

Cabin temperature during the flight varied considerably from day to dark, from about 90F to 108F. Early reports on immediate postflight physical examinations indicated Col. Glenn came through this mission with no abnormalities.

The formal physiological debriefing and physical examinations took place at Grand Turk Island in the Bahamas. Vice President Lyndon Johnson was to greet Col. Glenn there, and President Kennedy was planning to meet the astronaut here at Cape Canaveral last week.

Communications Provide MA-6 Narrative

Following excerpts from communications between Lt. Col. John H. Glenn, Jr., and ground stations and announcements by the Mercury control center provide a narrative account of the first U.S. orbital flight:

Mercury Control: This is Mercury control. T minus 1 min. and counting. All systems are reported in a go position. John Glenn is ready. . . . T minus 30 and counting. The Mercury space capsule umbilical is out. We are at T minus 19 sec. T minus 10 sec., 8, 7, 6, 5, 4, 3, 2, 1, 0, ignition, liftoff. The MA-6 vehicle has lifted off, trajectory looks good. The MA-6 is off the launch pad at 47 min. after the hour, it is climbing nicely, all systems are reported go. The MA-6 vehicle is climbing freely. The trajectory is going O.K., the MA-6 vehicle is still climbing nicely, it has passed through the area of maximum dynamic pressure. Pilot John Glenn is reporting all systems go. . . . John Glenn reports the flight very smooth now. The MA-6 launch vehicle is proceeding on its pre-planned trajectory. John Glenn reporting his cabin pressure is now holding at 6.1 psi.

Booster engine cutoff has been confirmed by the pilot. Telemetry indications in the Mercury control center confirm booster engine staging. The pilot has confirmed booster engine staging. The pilot reports that the escape tower has separated. All telemetry in the Mercury control center confirms that the tower has separated. The MA-6 vehicle is now climbing on its trajectory 2 min. and 5 sec. of flight time. It is on its pre-planned trajectory. The pilot reports that the g-forces are building up. Bermuda reports that it has acquired telemetry signals from the spacecraft.

John Glenn reports everything looks good. The MA-6 vehicle is climbing nicely on its trajectory. John Glenn reports his fuel system as planned, his oxygen system is all O.K. He reports his electrical power all O.K. Our Bermuda station reports it has a track on the MA-6 vehicle. Glenn's cabin pressure now holding at 5.8 psi. . . . The MA-6 vehicle is approaching its sustainer engine cutoff point.

From the Mercury spacecraft, the sustainer has cut off as planned. John Glenn reports zero g: "I feel fine." He says the view is tremendous. Glenn reports he can see the booster turn around behind him. He advised that the sight of the booster behind him was a beautiful sight to see.

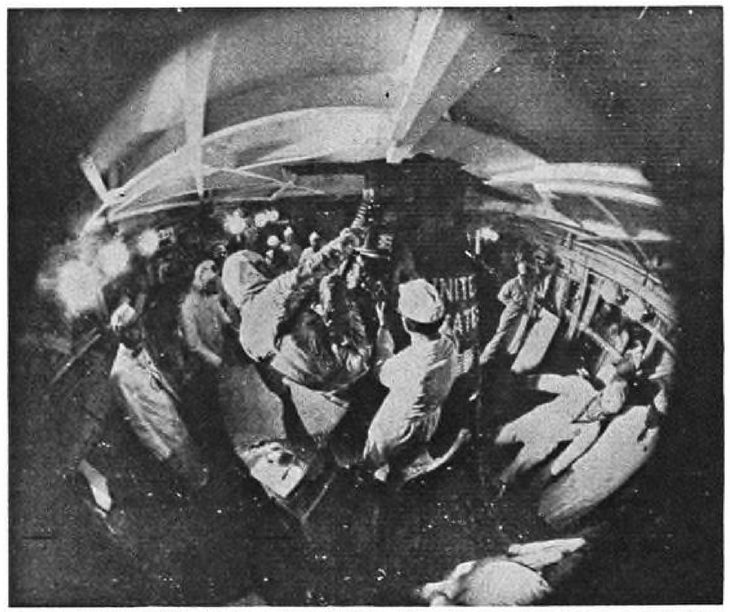
John Glenn reports he can see a very large cloud pattern back towards Cape Canaveral and says it is a beautiful sight. . . . Now reports his spacecraft has turned around, the blunt heat shield facing the direction of flight and is tilted up about 34 deg. above horizontal. This is the desired pre-planned orbital attitude. All indications are that we will be able to confirm orbit within a couple of minutes. . . . Atlas 109D carrying the Friendship Seven spacecraft cut its final [vernier] engine approximately 503 mi. east of Cape Canaveral at an altitude of approximately 100 mi. Its velocity at that time was approximately 17,500 mph. That means that the orbit of the Friendship Seven spacecraft will vary from a low altitude of about 100 mi. to peak altitude of about 160 mi. We estimate at this time that the period of the orbit will be about 89 min. . . .

First Tape Recording of Capsule Communications: 5, 4, 3, 2, 1, zero, liftoff. The clock is operating. We are under way. We are programing O.K. It is a little bumpy along about here. Backup clock has started. Coming into high gear a little bit. A little contrail went by the window, or something. Flight path is very good. Pitch 43. Coming out real fine. Flight very smooth now. Flight path is good. Cabin pressure is holding at 6.1. Have had some oscillations but they seem to be damped. The clock is 2 min. and the fuel is 102/101 [normal and emergency supply] oxygen 78/102. Gs are building up to six. I see the tower go. I saw the smoke go by the window.

Flight path looks good. Retrojettison. Emergency retrojettison slips off. Flight path looks good. Steering is good. Gs starting to build up a little bit. Oxygen 78/100. All voltages above 2.5, amps 2.6. Pitch minus 3. [Ground to capsule: check that minus 7 on your minus 3] Roger seven. Cabin pressure holding at 5.8. I am in good shape. All systems go. Oxygen 78/100. Cabin pressure holding steady at 5.8. Amps is 2.6. Zero g and I feel fine. Capsule is turning around. Oh, that view is tremendous. Capsule turning around and I can see the booster doing turnarounds just a couple of hundred yards behind. It looks beautiful. [Ground to capsule: you have a go of at least seven orbits.] Can see clear back, a big cloud pattern away back across the Cape. Beautiful sight.

Mercury Control: As the capsule passed in the vicinity of the Canaries, John Glenn reported "I am very comfortable. All systems are O.K." He reported that the horizon was a brilliant blue and he had the Canaries in sight out through his window. He also said he had a beautiful view of the African coast and part of the Canaries were obscured by clouds . . . Speed of the Friendship Seven spacecraft is now 17,545 mph. All information we have as of this time indicates the mission is proceeding as planned.

ILLUMINATED FLIGHT MAP at Mercury control center at Cape Canaveral shows capsule as having just passed Australia, lower right. White circles indicate tracking stations. Wavy lines show projected orbital paths.



GLENN ENTERS CAPSULE from eleventh floor of service gantry on launch pad at Cape Canaveral. Photo was taken by camera equipped with 180-deg. lens.

Second Tape Recording: Fuel flow is 90/98. Roll of 2 deg. right. The rates are all indicating zero. I am on ASCS at the present time. The clock is still set for time period for retrograde of 4 plus 32. I have a retrograde time O.K. from Bermuda. Cabin pressure is holding steady at 5.7. Cabin air 90F. Relative humidity 30, coolant quantity 68. Suit environment is 65. Suit pressure is indicating 5.8. Temperature is 60 on the suit. I am very comfortable.

Third Tape Recording: All frequencies are on automatic. The pressure regulator is still in the in position. Launch control is off. Panel positions are normal. Fuel flow is 90/98. Roll zero. Yaw 3 deg. right. Pitch 33 deg. The rates are all indicating zero. The clock is still set for time period for retrograde of 4:30:28. I have a retrograde time O.K. from Bermuda.

Cabin pressure holding steady at 5.7. Cabin air 90F. Relative humidity 30. Coolant quality 68. Suit environment is 65. Cabin pressure indicating 5.8. Primary oxygen is 78, secondary 102. Ammeters indicating 2.3 . . . The horizon is a brilliant blue. There, I have the [African] mainland in sight at the present time coming up on the scope and have the Canaries in sight through the window and picked them up on the scope just before I saw them out the window.

Mercury Control: A report from Kano station indicates that the astronaut's status is go. He sounds like he is in excellent voice, his heart action is excellent and we have an indication he did his first eating as he passed over Kano. He performed a yaw maneuver and has exercised the manual control system. Friendship Seven made initial contact with the Indian Ocean ship at 10:28 EST. All the information here at this time indicates the flight is proceeding normally. All of our contacts with the pilot indicate that he is feeling fine. Our flight surgeon here at the control center, looking at data fed him from the control network, indicates the pilot is in a completely normal situation and proceeding in an excellent condition. . . .

. . . Glenn is now in voice contact with Astronaut Gordon Cooper, who is the communicator at Muchea [Australia]. In the conversation, John has indicated he is doing well. . . . "I am having no problems at all." He describes his sighting and talked about cloud cover after he passed over the coast of Africa and the Indian Ocean. He reported a high glare on the night side of the world . . . It is reported that he has observed very bright lights, and from his discussion with Gordon Cooper, assumes that he is observing the city of Perth, Australia. In a message to Gordon Cooper, he said "thank everybody for turning them on."

Tape Recording of Glenn-Cooper Conversation: Hello, Coop, this is Friendship Seven reading you loud and clear. Roger, Friendship Seven, this is Coop . . . How are you doing, Colonel? We are doing real fine up here, everything is going real well. Very good, John, you sound good. Control fuel is 90/100, oxygen is 75/100. Amps are 2.2. All systems are still go. Having no problems at all. Control system operating fine. Do you have any landmark observation? I was just making some for the recorder, and the only unusual thing I have noticed was the rather high, what appeared to be a haze layer, up from 7 or 8 deg. above the horizon on the night side . . . I had a lot of cloud cover coming off Africa. It has thinned out considerably now, and although I can't definitely see, there is a lot of moonlight here that reflects off of what clouds there are. Did you have your visor closed? I did have it open for a little while. It is closed now. Cabin pressure is holding in good shape. Relay inverter is 180 deg. That sure was a short day. That was about the shortest day I have ever run into.

Do you have time to send us a blood pressure reading? Stand by, I am already sending it to be picked up. Roger, you are in good shape. Just to my right I can see a big pattern of light. Apparently right on the coast . . . That is Perth and Rockingham you see there. The lights show very well. On down to the south and inland, I can see lights. There are two, actually four patterns in that area. Also coming in sight in the window now another one, almost down under me. The lights are very clear from up here. We have your blood pressure read . . . Let's have the results of your physiological tests. I have had no ill effects at all yet . . . No nausea or discomforts whatsoever.

Mercury Control: During the voice broadcast between Glenn and Guaymas, [Mexico] Glenn reported he had observed some small particles near the capsule moving at approximately the same speed as it came through the sunrise phenomena. These particles caused him no difficulty, but he did observe them during the flight. They appeared to glow in the sunrise.

As he passed across the southern part of the U.S., Glenn reported some minor difficulty with his attitude control system. As of this time, Glenn is manually flying his spacecraft on what we call fly-by-wire, a form of automatic pilot device . . . He reported that it was very smooth and that he was not having any trouble controlling the spacecraft. As he passed across the East Coast of the United States, he reported he had a beautiful view of the coast . . . Based on data recorded for the first orbit, we have a period of 88 min. 29 sec.

. . . At the time Glenn made contact with the Canary Islands tracking station, he reported his status was excellent. He was maintaining control of the spacecraft by using his manual fly-by-wire system. He was asked by the

ground controller to take a deep breath so that we might get an indication of his respiration rate. His answer was "Roger, taking a deep breath." Apparently John was getting quite a bit of sunshine through his window. He reported that the sun was bright and he was feeling pretty warm as a result of the sun streaming through the window.

Aside from the problem that we are having with his attitude control system, and these apparently are not serious because he is maintaining good control over the spacecraft, all systems appear to be operating properly.

Drift Reported

Tape Recording of Conversation between Glenn and Astronaut Alan S. Shepard, Jr., at Mercury Control: . . . I am going on fly-by-wire so I can control more accurately. It just started as I got to Guaymas and it appears to drift off yaw to the right at about 1 deg. per sec. It would go over to attitude of about 20 deg., then hold, and then when it hits at about a 20 deg. point, it then goes into orientation mode and comes back to zero, and it was cycling back and forth in that mode. I am on fly-by-wire now, I am controlling manually. Do you have retrofire times for 2B and 2C? [emergency landing areas] Negative. O.K., 2B–01:50:00 and 2C–02:05:59 . . . What appears to have happened is, I believe I have 1-lb. thrust in left yaw, so it drifts over out of limits and then hits it with the high thrust. We concur here, recommend you remain fly-by-wire. Roger, am remaining fly-by-wire. Controlling manually on fly-by-wire, having no trouble controlling, very smooth and easy, it controls very nicely.

Fly-by-wire autogyro is normal. All T handles are in, retro-delay is normal. I have a beautiful view out of the window of the coast at the present time, am just departing, can see away down across Florida, cannot quite see the Cape yet. Continuing this report, there are no sequence panel lights showing, only abnormal position landing bag is off, the EPI is indicating O.K., the control fuel is 80 auto, 100 manual. Retrograde time set in is 04:32:28. . . . Cabin pressure 5.5 and holding nicely. Cabin air is 95, relative humidity is 20 . . . temperature is 67 on the suit. Oxygen is 70/100, amps are 2.2. The only real unusual thing so far, besides ASCS trouble, were the little particles, luminous particles, around the capsule. Just thousands of them right at sunrise over the Pacific.

Mercury Control: . . . Fly-by-wire is the system in which the pilot moves the control handle. This sends a signal to a type of black box system, which in turn operates the valve. This is different from the manual system, in which the astronaut also controls the handle, but the connection with the valve is by mechanical linkage. In fly-by-wire, he controls the handle electronically.

Tape Recording of Conversation between Glenn and the Canary Island Tracking Station: Have Cape Verde Islands in sight off my left. Your medical status is excellent. The sun is coming through the window and is very warm where it hits the suit. I get quite a bit of heat from it . . . I have no problem at all controlling on the horizon.

Mercury Control: . . . We are continuing to analyze the difficulties in the attitude control system. The fact that the pilot is on board and has the ability to analyze his problem and take judgmental corrective action is a demonstration of the value of man in space flight. We will continue to analyze the progress of the flight and make our decisions to make sure that we fly the mission as best as possible. . . .

In a voice contact broadcast and relayed remotely to the control center, Astronaut John Glenn reported he is go for another orbit. Our analysis of the situation at this time is that we are in a go condition. Our flight director, Chris Kraft, has made a preliminary decision at this time that we are go and will continue the mission.

Tape Recording of Conversation between Glenn and Astronaut Walter M. Schirra at Pt. Arguello, Calif.: . . . I had some erratic ASCS operation and I caged and uncaged on the night side and it appears to be working very well now, although I was drifting again in roll a moment ago. It appears to have corrected itself in roll, without my caging it again. . . . Your roll is 5 left, yaw 3 right, pitch minus 32 . . . I appeared to have a drift in the scope [Ground: Apparently it is more difficult to pick up drift than I thought it would be. Your best bet is to look out the window and get something moving away from you out the window . . . you understand that your capsule elapsed time is running about a second slow compared to EET] No, I was not aware of that on the elapsed time . . . [The tape was unclear during this transmission when Schirra and Glenn were discussing changes in the retrofire setting] [Schirra: We recommend for the third orbit that you use the gyro as you desire . . . so that in the event that the scanners in ASCS do not program properly, you may use the gyros for your attitude reference . . . Also, we recommend that you allow capsule to drift on manual control to conserve fuel.]

Tape Recording of Glenn's remarks to Astronaut Virgil I. Grissom in Bermuda: I have the Cape in sight. I can see the whole state of Florida just laid out like a map. Beautiful. I can still see clear back to the Mississippi delta . . . It looks like we will have no problem on recovery.

Tape Recording of Glenn-Cooper conversation: Hey Gordon, I want you to send a message for me. Send a message to the Commandant of the U. S. Marine Corps that reads: Have four hours required flight time. Request flight check be prepared for me. . . . What is your opinion on the general problem, John? I don't know. I want to start lining up just as carefully as I can here in a minute to see whether the scanners will pick it up and correct it so we have a retrofire. If not, I will align it myself. [Ground: I give you a recommended change of retrofire to 04:32:37.]

Mercury Control: . . . The retrorocket sequence was initiated at 2:20 EST. Retrofiring attitude was assumed, and the three retrorockets have fired. This has been confirmed by the pilot and our telemetry here in the Mercury control center. John Glenn's comment was that it felt like it was going to send him clear back to Hawaii . . . We have instructed Mr. John Glenn to retain his retrorocket packet until he gets over Texas. This is a precautionary measure to further check on the erroneous switch location information we had earlier. John feels that he held his attitude properly during the retrofiring process, and says that he can see the coast of California.

Flight Plan

He is now reporting cloud cover down toward Mexico . . . On the basis of his present flight plan, we would estimate a landing at approximately 37 or 38 min. after the hour . . . We have advised him that the weather in his landing area involves one tenth cloud cover and 10 mi. visibility. This should not present any hazard at all during the landing operation . . . He is now maintaining control of his spacecraft using the fly-by-wire system as a backup.

We estimate that the Friendship Seven spacecraft is now encountering the atmosphere above the east coast of Florida . . . We estimate that an ionization layer involved in the re-entry process is prohibiting us from having direct communication with him. We have an indication that receiving equipment at Grand Bahama Island is receiving beacon transmissions from the spacecraft. We are not receiving any voice communication at this time. On the basis of his present flight trajectory, we estimate that he will land about a mile from a destroyer associated with the USS Randolph at the end of the third orbit . . . We have established good voice communications with Astronaut John Glenn. His comment just a second ago was "Boy, that was a real fireball."

[Glenn landed at 2:43 p.m. He was picked up at 3:04 p.m. and came out of the capsule at 3:24 p.m.]

U.S. Offers Russia Space Cooperation

Washington—Most significant reaction to the orbital flight of Marine Col. John H. Glenn, Jr., last week was an official exchange of suggestions between Soviet Premier Nikita Khrushchev and President John F. Kennedy that the U.S. and the Soviet Union cooperate in the peaceful exploration of space.

Premier Khrushchev made the suggestion in a cable to President Kennedy that offered "hearty congratulations" to Col. Glenn. Soviet Cosmonauts Maj. Yuri Gagarin and Maj. Gherman Titov also sent congratulations, as did more than 30 heads of state.

The President welcomed Khrushchev's statement. He said he believed in strong support of the United Nations in space efforts, but said that "special opportunities and responsibilities" fall on the U.S. and Russia.

"I am instructing the appropriate officers of this government to prepare new and concrete proposals for immediate projects of common action, and I hope that at a very early date our representatives may meet to discuss our ideas and yours in a spirit of practical cooperation," the President said.

The President also pointed out that the U.S. has offered to cooperate with Russia and other nations as long ago as 1958, and said he could not predict whether the current "general expressions" would be transformed into specific agreements "until we see whether the rain follows the warm wind in this case."

The President was to fly to Cape Canaveral, Fla., late last week to congratulate Col. Glenn. They were then to fly here Feb. 26 and the astronaut was to address a joint meeting of Congress. He will be the first astronaut to do so. Both houses passed resolutions commending him for his "personal courage, skill and dedication in the cause of scientific achievement in his successful and epoch-making three orbital flights." An elaborate Washington reception was planned for Glenn and the other astronauts.

Shortly after Col. Glenn's flight ended, the President expressed "great happiness and thanksgiving" and added "a word for all those who participated . . . They faced many disappointments and delays—the burdens upon them were great—but they kept their heads and made a judgment and I think their judgment has been vindicated.

"We have a long way to go in this space race," the President said. "We started late. But this is the new ocean, and I believe the United States must sail on it and be in a position second to none."

Much of the reaction around the world centered on the fact that the launching and all the delays preceding it were made known to the public. Russia did not jam Voice of America radio broadcasts reporting the flight. Communist China maintained a 17-hr. silence and then allowed Radio Peiping and newspapers to report the flight.

The U.S. issued through 300 post offices a secretly-prepared stamp commemorating the man-in-space program at the moment when Col. Glenn landed —the first previously unannounced commemorative U.S. stamp to be issued simultaneously with the event it memorialized.

Hugh L. Dryden, deputy administrator of the National Aeronautics and Space Administration, said at Cape Canaveral: "This is a historic day, a beginning, a first step. One day we will look on the Mercury capsule as we do today on the Wright brothers' airplane." Walter G. Williams, Mercury operations director, said: "Today I feel like the day school let out. The mission was 100% successful when John Glenn stepped out on the deck of that destroyer."

Brainerd Holmes, director of NASA's office of manned space flight programs, said the flight was "a tremendous testimonial to the engineering capability of the United States."

Reliability Given Highest Priority In Preparing MA-6 Atlas Booster

By Russell Hawkes

San Diego, Calif.—General Dynamics Atlas 109D, which boosted Marine Lt. Col. John H. Glenn, Jr., into the first manned Mercury orbit, was modified and constructed of selected components in an effort to ensure reliability and safety for the manned space mission.

Most significant modification to the basic Atlas missile was the installation of an Abort Sensing and Implementation System (ASIS) to trigger the capsule escape sequence automatically (AW Sept. 25, p. 96). Another major modification was strengthening of skin segments in the conical front section of the booster to withstand the drag and the impingement of shock waves produced by the unusual aerodynamic shape of the Mercury capsule and its escape tower at supersonic speeds. The shock wave effect was discovered when it resulted in the failure of MA-2.

The man-rating program conducted by General Dynamics/Astronautics to convert a vehicle designed primarily as an expendable weapon into a means of human transportation included a search through the entire production output of 67 key components for those that conformed most closely to specification. Nothing requiring rework was used. The chosen items were marked with a characteristic decal and reserved for the Mercury program. The same policy was applied to missile 107D, which is slated to launch the second Mercury orbital flight, and will be applied to all future Atlases assigned to Project Mercury.

Atlas ballistic missiles are sometimes shipped to Cape Canaveral, Fla. and other bases short of components that are being delayed for modification and are shipped later for installation at the launch site. This will not be done in the case of the Mercury boosters. They are to be launched exactly as they come from the plant except when malfunctions during pre-launch tests require last-minute changes.

A total of 117 Atlas launches has been made, of which 79 are described by General Dynamics as successful and 25 as partially successful. Because of the short duration of missile flights, there is no more than 10 hr. of total flight test data on the Atlas. Later E and F models were not adopted for the Mercury program because most of their modifications were intended not to improve safety and reliability but to provide greater military performance.

Other changes to the D-model Atlas used in the Mercury program include:

- **Removal of the retrograde** rockets which assures a clean separation of the military rocket and its warhead. In the Mercury program, posigrade rockets on the capsule serve this purpose.
- **Modified autopilot** functions to allow for the effect of the odd-shaped Mercury capsule on vehicle dynamics.
- **Addition of more** backup circuitry in electronic systems and wider use of solid state components in an attempt to improve reliability.

The final provision for the safety of the astronaut is in the various manual and automatic abort or escape systems. The last link in all these systems is the three-nozzle Lockheed Propulsion Co. solid-propellant rocket at the top of the escape tower. There is no back-up for this rocket, but it was designed especially for reliability at the expense of performance and sophistication. None has been known to fail in tests. To protect against igniter failure, this component is duplicated.

Importance of Man-in-Space Flight Shown by Glenn's Performance

Cape Canaveral, Fla.—Pilot performance in the Mercury Atlas 6 mission was as good as that on any experimental mission flown by a test pilot, Walter G. Williams, Project Mercury operations director, said last week.

Williams was instrumental in development of the X-series aircraft and he headed the high-speed flight research station at Edwards AFB under the old National Advisory Committee for Aeronautics and the National Aeronautics and Space Administration for several years before he was named to his present job in 1960.

Research Areas

Marine Lt. Col. John H. Glenn, the MA-6 astronaut, was given a complex set of tasks in eight critical research areas, and his performance was considerably more extensive than planned because he was forced to control the capsule manually for more than half of his flight.

Col. Glenn performed two experiments to determine if the report of nausea made by Soviet Cosmonaut Gherman Titov on his 17-orbit flight last August is a condition that occurs generally after extended weightlessness. The U. S. pilot ate solid malt tablets and liquid and semi-solid fruit and meat from tubes midway through his first and second orbits to demonstrate that weightlessness does not cause an upset stomach. He also made quick head movements in an attempt to trigger any inner ear response.

Lt. Col. Stanley White, chief of the Mercury life systems division, said Col. Glenn had no problems, was completely in command throughout the flight and kept his sense of humor.

Performance Tasks

Research areas in which the astronaut was given performance tasks were:

• **Systems management,** calling for pilot determination of which primary and which backup systems should be activated during the flight for attitude control, environmental control, electrical power and communications. Col. Glenn excelled in this area when he activated the fly-by-wire attitude control system following a failure in the automatic system (see story p. 30).

Systems management function is essentially one of monitoring basic components throughout the flight and using emergency procedures to offset failures.

• **Sequence monitoring,** a task which gives the pilot manual override of the automatic sequencing program.

• **Attitude control** during orbit, firing the retrograde rockets, oscillation damping during re-entry and recovery from any tumbling.

• **Navigation,** in which the pilot used external reference points on the earth and in the sky to maintain a precise fix on his position.

• **Communicating,** which involved responding to ground communications and transmitting data to ground stations.

• **In-flight research,** including evaluations of capsule performance, observation of the space environment and reporting on physiological symptoms throughout the flight. Col. Glenn used a hand-held camera and four rolls of film for photography from the capsule. He also exercised with a large rubber band and took his own blood pressure before and after exercise.

• **Physical stress management,** in which Col. Glenn used techniques learned as a test pilot and in Mercury training to reduce the effects of multiple g-forces, isolation and re-entry and post-landing heat in the pressure vessel.

Task Force to Study Labor Cost Allowance

Washington—Labor Secretary Arthur Goldberg announced establishment of an inter-governmental task force to study policy on contract allowances for labor costs in a speech last week to a joint conference of 300 leaders of the two major unions in the aerospace field.

It will be headed by Goldberg, and include representatives from the Defense Department, National Aeronautics and Space Administration; and Federal Aviation Agency.

In a later statement, the two unions —International Assn. of Machinists and United Automobile, Aircraft and Agricultural Implement Workers of America—urged the President to also appoint a labor-management committee to determine an approach to the problem of economic insecurity for workers in the aerospace industry. It proposed that the government finance lay-off payments due to procurement shifts and cancellations. According to the statement, the maximum lay-off benefit of $500 in the aerospace field compares with $7,200 in other industries.

Other developments included:

• **Rep. Frank Kowalski (D.-Conn.)** introduced legislation which would ban employers from charging strike costs to government contracts. Kowalski has charged that Defense Department plans to pay United Aircraft Corp. $7.5 million for 1960 strike costs, including overtime to strikebreakers, training, spoiled work and recruiting costs.

• **Joint IAM-UAW conference** adopted a comprehensive program for bargaining on 26 labor-management agreements due to expire this year. It calls for extensive wage and security benefits.

U.S. Plans to Meet Varied War Threats

Kennedy Administration has unveiled its blueprint for deterring all types of wars, with emphasis on strengthening the nation's ability to stop conflicts involving guerilla type warfare.

Defense Secretary Robert S. McNamara, in a speech described by Pentagon officials as a major policy statement cleared by the President and Secretary of State, told the American Bar Foundation in Chicago Feb. 17 that the U. S. is determined to support such actions as the current conflict in South Vietnam, where more than 3,000 American military men are training and advising local troops.

McNamara quoted from Soviet Premier Khrushchev's Jan. 6, 1961, speech to the Soviet Communist Party Organizations in which he analyzed three categories of wars—world wars, local wars and liberation wars or popular uprisings. The latter are really wars of subversion or covert aggression, McNamara said.

Khrushchev, he said, rejected all-out nuclear war as unthinkable and opposed local wars because they might grow into "a thermonuclear rocket war," but embraced less drastic actions.

McNamara said that the West's response to this threat cannot be a simple one, but must make use of many different types of strategy and forces. He hinted that the United States has not yet achieved an effective balance of military power. He outlined what the U. S. could do in this manner:

• **Nuclear war.** The U. S. already has a deterrent because it is "able to survive a surprise nuclear attack and strike back with sufficient power to destroy the enemy target system." Alternate command posts at sea and in the air are being provided to assure continued direction of strategic forces.

• **Local war.** The U. S. must become ready to engage in large scale non-nuclear warfare, he said, so as to keep such conflicts from growing into nuclear warfare. "However," he said, "we will use nuclear weapons to prevail, if this becomes necessary."

• **Guerilla war.** This requires "some shift in our military thinking. We have been used to developing big weapons and mounting large forces. Here we must work with companies and squads and individual soldiers, rather than with battle groups and divisions."

Glenn Flight Was Result of Vast Government-Industry Organization

Cape Canaveral, Fla.—Orbital flight of the Project Mercury manned capsule is the culmination of a national effort under the National Aeronautics and Space Administration which involves the operational skills of a half-dozen other government agencies and the technical capabilities of 2,000 separate industrial organizations.

The government-industry organization has been built during the past 39 months and forms the basis for management and operation of NASA's advanced manned space flight projects—the 18-orbit Mercury, two-man Gemini, and three-man Apollo spacecraft.

The Mercury capsule industrial team, headed by McDonnell Aircraft Corp. as prime contractor, has these top tier subcontractors: AiResearch Manufacturing Co., environmental control system; Atlantic Research, posigrade and pylon jettison rockets; Barnes Engineering Co., horizon scanners; Bell Aerosystems, reaction control system; Collins Radio, communications system; Minneapolis-Honeywell Regulator Co., automatic stabilization control system, earth path indicator and explosive hatch, and Perkin-Elmer Corp., periscope, and Radioplane, recovery system.

Space Technology Laboratory is technical manager of the Atlas D launch vehicle. General Dynamics/Astronautics provides airframes and launch, Rocketdyne, the engines, and General Electric and Burroughs, radio command guidance system. Aerospace Corp., is technical consultant.

Western Electric Co. is prime range contractor and provides technical management for the 18 tracking and telemetry stations in the Mercury network. Technical assistants are Lincoln Laboratories of the Massachusetts Institute of Technology, Ford Aeronutronic, Space Electronics and Radio Corp. of America. The systems engineering contract is held by Bell Telephone Laboratories, which also is responsible for communications and control displays.

Other range contractors are International Business Machines, computer programing and simulation displays; Bendix Aviation, radar installation ground-air communications, telemetry and site display equipment, and Burns and Roe, Inc., site facilities, construction and logistic support.

Defense Department contribution to the Mercury project includes supply of 15 Atlas D boosters and general booster support by Air Force Systems Command's Space Systems Division, a prime Navy recovery force of 82 aircraft and 26 ships, plus an alert to all ships in the Atlantic and Pacific steaming under the capsule track; special weather facilities here, in Washington and Miami to collate data from all possible landing sites; Marine Corps. helicopters here and aboard recovery ships: a force of Army light amphibious vehicles (Larcs) and crash boats in the abort area, and 48 patrol and rescue aircraft and 63 Air Rescue Service pararescue divers.

In addition to top tier subcontractors providing systems and materials for the Mercury capsule, other major subcontractors are: Beckman Instruments, oxygen sensors and charges; Cannon Electric, electrical plugs; Cincinnati Testing Laboratory, ablation shield; Connecticut Hard Rubber Co., impact skirt; Consolidated Electrodynamics, tape recorders and pressure transducers; Control Switch Corp., Cutler Hammer, Harris Manufacturing Co., Haydon Co., Leach Corp., Lourdes Corp., Texas Instruments Metals and Controls Division and Microswitch, all of which provide switches; Corning Glass Works, windows; Donner Scientific Corp., accelerometer; Dorsett Laboratory, oscillators; Eagle Picher, batteries; Filtors, Inc., relays; Lockheed Propulsion Co., escape rocket; and General Controls, potentiometers.

Others are Grimes Manufacturing Co., light assembly; Interelectronics, static inverters; Kollsman, Inc. and Milliken, altimeters and cabin pressure indicators; Maurer, Inc., cameras; Olin Mathieson, explosive bolts; Pioneer Central, rate of descent indicator; Raymond Manufacturing Co., whip antenna; Thompson Ramo Wooldridge, amplifier; Transonics, transducers, and Thiokol, braking rocket.

Major materials suppliers are: Artra Aluminum Foundry, aluminum castings and forgings; Continental Metals, Inc., and Titanium Metals Corp., titanium; General Electric Metallurgical Products Department, René "41"; Haynes-Stellite Co., Inconel X, René "41" and titanium; Johns Mansville Metals Corp., insulation; Ladish Co. Pacific Division, castings and forgings and Raychem Corp., electrical wires.

Apollo Tower Jettison Bids Submitted

Industry proposals for the solid-propellant rocket motor system to jettison the tower above the Apollo command module following successful launch were submitted last week to North American Aviation's Space and Information Systems Div.

Jettison system requirements, established by North American as a basis for the proposals, included these details:

- **Maximum diameter of the motor will be 26 in. Bidder will be required to specify the length, to be kept as short as possible. Maximum weight will be 450 lb.**
- **Motor will have two nozzles, 180 deg. apart.**
- **Minimum thrust requirement will be 40,000 lb., with tail-off to 4,000 lb. and 90% of burnout will have to occur in 0.125 sec.**
- **Motor reliability factor will have to be 0.99995. Motor will be required to operate in a temperature range of 20F to 140F, withstand 20g load along vertical axis, and 15g shock for 11 milliseconds in any direction.**
- **Operation will be required at altitudes as high as 400,000 ft.**
- **In event of launch abort, the jettison motor will be fired together with the Apollo command module escape motor (awarded to Lockheed Propulsion Co.).**
- **If go-ahead is given by Mar. 1, first prequalification flight worthiness units will be available by the middle of September. First boilerplate motor for static firing will be available by mid-January, 1963. Approximately one year later, 10 fully qualified motors will be delivered. Number of rocket motors to be delivered has not been decided, but it is expected that deliveries will continue through 1964.**

Parker Is Confirmed In Disarmament Post

Washington—Vice Adm. Edward Nelson Parker, former deputy director of strategic target planning at the Omaha headquarters of the Strategic Air Command, was confirmed by the Senate last week as an assistant director of the Arms Control and Disarmament Agency.

He will head the Weapons Evaluation and Control Office, which is to weigh the effect of arms control and disarmament proposals on the relative military position of the U. S. Adm. Parker served five years as deputy chief and chief of Defense Atomic Support Agency.

Dr. Franklin Long has been named to head the Science and Technology Office, which is to conduct a program for implementation of arms control and disarmament through surveillance techniques. A $150,000 contract has been let to Bendix Corp. to study techniques for monitoring production of strategic bombers and missiles.

Long served on former President Eisenhower's Scientific Advisory Council.

U.K. Adds $200 Million to Defense Budget

By Herbert J. Coleman

London—British government last week boosted its defense budget by $200 million and moved its three military forces closer toward eventual complete integration. Nuclear deterrent force will shift from Royal Air Force Thor bases to airborne weapons carried by the V-bomber fleet.

A White Paper, presented by Minister of Defense Harold Watkinson, outlined the British defense program for the next five years in these terms:

• **Budget for 1962-63** will be hiked $200 million to $4.8 billion, or 7% of the gross national product. A rough breakdown is: Royal Navy—$1.2 billion, Royal Air Force—$1.6 billion, Royal Army—$1.5 billion, Ministry of Aviation—$600 million, and Ministry of Defense—$64 million.

• **Bomber fleet**, composed of Avro Vulcan and Handley Page Victor V-bombers, now capable of carrying nuclear bombs, will take over the deterrent with Avro Blue Steel standoff bomb, due this year, and later the Douglas Skybolt, due in 1965.

• **Defense forces** will assume a task force profile in an effort to use maximum forces in highly mobile states, combining RAF, Army and Navy forces as often as possible.

• **Studies into possible** military uses of space for communications and reconnaissance.

• **Design study** has been ordered for a new type of aircraft carrier, and for a logistics support ship for the British army.

• **Beefup of Royal Air Force** Transport Command in long- and short-range capabilities, using de Havilland Comet 4 and Vickers VC.10 jets, the Short Belfast four-engine turboprop, all for long range, and the Avro 748 twin-turboprop for medium and short ranges (see box below).

• **Emphasis on vertical** and short takeoff aircraft for all three services, probably concentrating on two standard types—one fighter and one light transport. An indication of this was a White Paper comment that all RAF VTOL planes in the future must be capable of operating from naval carriers.

• **Tripartite agreement** between the British, West Germans and United States to support development of the Hawker P.1127 VTOL fighter and its Bristol Siddeley BS.53 Pegasus deflected thrust engine, and also continuing development of the Rolls-Royce RB.162 pure-lift engine.

Each country will buy three P.1127s for both military and civil evaluation, for a total of nine airplanes. This is in addition to six already ordered by the Ministry of Aviation in Britain.

Significance of this move is, in effect, another lease on life for the Pegasus, which has been 75% funded by the Mutual Weapons Defense Program. The money allocated was due to expire in June.

Another important factor is purely political. The P.1127, as submitted in the NATO strike fighter competition, was hampered by the fact that it is all-British in both airframe and engine. The new agreement joins three major NATO powers in a single plane development. The NATO entry by Hawker is designated the P.1134 and is powered by the Bristol Siddeley BS.100, a Pegasus follow-on of 38,000 lb. thrust, against 15,000 lb. in the BS.53. The BS.100, still in the design stage, features duct burning in its four nozzles for Mach 2.4 performance.

Defense policy in this decade will be to regard all VTOL aircraft in view of British Army needs, for close cooperation in the field, according to the White Paper.

RAF Role

Despite the move toward complete service integration, admittedly gradual, the Royal Air Force will take a dominant strike and support role, starting with the V-bomber fleet as the major deterrent. RAF will continue to fly maritime reconnaissance planes in cooperation with Royal Navy.

Growing emphasis on air mobility will center more activity on RAF Transport Command and on the RAF's helicopter forces, which include the Westland Whirlwind and Belvedere, now in service, and the Wessex, currently on order.

The White Paper notes that the TSR.2 fighter, now under construction at various British Aircraft Corp. production plants, will come into RAF service in the mid-1960s, to replace the English Electric Lightnings now in service.

An unknown factor in the British nuclear deterrent, blurred by unwillingness of top government spokesmen to discuss it, is the future of the RAF Thor bases now operational in the United Kingdom. However, there are strong indications that the bases will be quietly dismantled when the V-bomber force is entirely equipped with Skybolt.

Political Question

The question is politically touchy because of heavy expenditures in the weapon since the 1957 White Paper turned the defense effort toward missiles, rather than manned aircraft.

High mobility will be the keynote of future British army training, with increasing reliance on missiles such as the Malkara and Vigilant anti-tank missiles, and the Blue Water, still under development.

In the Royal Navy, a design team is starting on development of a new carrier, with a seven-year date to completion. The carrier would replace HMS Victorious, which will be obsolete in about 1971. Victorious now is preparing to take aboard the Blackburn NA.39 Buccaneer.

All submarines in the future will be nuclear-powered, although the plan for deployment is hunter-killer, rather than as missile-launching platforms such as Polaris submarines. Defense spokesmen kept the door open for such future development, explaining that the nuclear hunter-killer role will provide needed experience if the future plans call for a Polaris-type weapon.

While Britain has allocated about 10% of its defense budget to the nuclear deterrent, the White Paper points out that the country faces a particular problem in its commitment of forces to NATO, in that deployment of forces overseas is a burden on balance of payments.

Future policy is indicated in this statement: "During this [five-year] period, the proportion of these forces to be stationed on the mainland of Europe and in Britain respectively must depend to a large extent on the balance of payments position. In effect, this reflects the trend toward high mobility of integrated forces, maintaining the European NATO commitment if possible, but from United Kingdom bases. Meanwhile, strength of BAOR (British Army on Rhine) will be maintained, although further discussions with NATO are planned."

To streamline the present command and staff setup, aimed at total integration, the Ministry of Defense is replacing its Land/Air Warfare Committee and Amphibious Warfare Headquarters with a new Joint Service Staff under a senior officer who will serve as director.

The new Joint Service Staff will serve a committee comprising representatives of the naval, general, air and defense staffs under the chairmanship of the deputy chief of the defense staff, and responsible to the chiefs of staff.

The White Paper said identity of the three services must be retained, but added that the present high degree of cooperation will necessarily be increased.

RAF to Order Avro 748

London—Royal Air Force last week selected the Avro 748 twin-turboprop aircraft as its short-medium range Transport Command airplane after eliminating the Handley Page Dart Herald in a competition highly charged with politics.

Both airplanes had been competing in a three-month evaluation for an order involving about 40 airplanes (AW Feb. 19, p. 57). Political aspect was government policy to award contracts to aviation companies which had combined into groups at its urging.

One holdout was Handley Page, builder of the Dart Herald and the Victor V-bomber, which resisted merger offers from Hawker Siddeley, owners of Avro, and British Aircraft Corp., despite government pressure.

In performance, both planes are quite close. The balance of power tipped toward Avro because it has joined Hawker Siddeley. Both aircraft are powered by Rolls-Royce Dart engines and have rough-field characteristics. Both were acceptable to RAF and Royal Army.

The Avro 748, in addition, features variable landing gear to enable vertical and horizontal adjustment of floor height of aircraft for mating with a loading or unloading vehicle. Maximum payload is 14,000 lb. and the airplane can operate out of 1,500 ft. strips. Rear-door loading was offered on both aircraft.

Loss of the RAF order leaves Handley Page with firm orders for 20 Dart Heralds. The company, however, said it has a considerable volume of work, both government and civil, that will keep it occupied for several years.

Handley Page, which employs 8,000 persons, is known to be negotiating with the South African government for an order for eight Victor bombers. The company also has a government contract to explore laminar flow wings.

T-38 Climb Records

Four time-to-climb records are claimed by the U. S. Air Force for the Northrop T-38 Talon supersonic trainer. The records to 3,000, 6,000, 9,000 and 12,000 meters were set at Edwards AFB, Calif., by Maj. Walter F. Daniel, chief of Fighter Test Operations.

Officially clocked by the National Aeronautic Assn. on Feb. 18 under rules of the Federation Aeronautique Internationale, the records are for climbing to:

3,000 meters (9,843 ft.)....35.624 sec.
6,000 meters (19,686 ft.)....51.429 sec.
9,000 meters (29,529 ft.)....64.76 sec.
12,000 meters (39,372 ft.)....95.74 sec.

The old records set by the Air Force in a Lockheed F-104 were 41.85 sec., 58.41 sec., 81.14 sec. and 99.90 sec. respectively.

The T-38 was powered by two General Electric J85-5 engines generating 4,011 lb. of thrust each in afterburner. Guaranteed thrust is 3,850 lb.

The T-38's rate of climb between 6,000 and 9,000 meters was 44,100 fpm.

U.S. Continues Flights Over Berlin Corridors

Bonn—United States civil and military aircraft maintained normal flight schedules through the three Western air corridors into West Berlin last week despite Soviet threats and harassing tactics by Russian fighter aircraft.

Civil aircraft had not been bothered by Soviet fighter tactics by late last week since they were flying at their normal operating altitude—above 7,500 ft.—which the Russians have unsuccessfully attempted to block off for their own use during specific time periods.

Three Western airlines—Pan American World Airways, Air France and British European Airways—fly through the corridors across East Germany and into Berlin on a scheduled basis. A Pan American official said last week that the airline's flights into the city had been unmolested thus far. Operations, he added, "have been perfectly normal, and we expect no change from our regular schedules."

Soviet fighter aircraft generally have been reported by lower-flying piston-engine transport aircraft of the U. S., British and French air forces. Corridor rules stipulate a minimum altitude separation of 500 ft., but a U. S. spokesman said last week that the Soviet aircraft had failed to observe this requirement.

The Russian aircraft involved were not officially identified, but they were believed to be MiG-19s.

Since beginning their corridor push on Feb. 7, the Russians have made at least six demands for exclusive use of corridor airspace during specific periods of specific days. All have been declined by the U.S., French and British authorities on the grounds that no one country can impose such stipulations and that all flights must be handled on a flight-plan basis through the four-power air safety center in Berlin. The Russians, with representation on the safety center staff, have followed this procedure in the past.

Over-all, the Soviet requests—generally demanding exclusive use of the airways up to an altitude of 7,500 ft. for 3-4 hr. periods—have involved all three air corridors into Berlin.

After their first demands were denied, the Russians apparently backed off but, after subsequent requests also were declined, the fighter aircraft began to appear in the corridor lanes without clearance through safety center channels, and the Soviets warned that the West would be responsible for any "disagreeable" incidents.

These Soviet flights were continuing late last week, but on at least one occasion general flight plans were filed with the safety center.

News Digest

Rift (reactor in-flight test) bidders' conference will be held Mar. 1 at the Marshall Space Flight Center for General Dynamics, Lockheed and Martin, winners of Phase One of a National Aeronautics and Space Administration competition (AW Feb. 5, p. 27) for development of a nuclear rocket stage. Proposals for the project will be due Apr. 1.

Satellite carrying test components for the Midas early warning or Samos surveillance satellite program was launched Feb. 21 from Vandenberg AFB, Calif., and identified by the Air Force only as "a Thor-Agena B combination."

Jackass Flats area of the Atomic Energy Commission's Nevada Test Site has been designated as the Nuclear Rocket Development Station. It is centered on the area used since 1959 for ground tests of Kiwi reactors in the AEC-National Aeronautics and Space Administration nuclear rocket program (see p. 65).

Richard Helms, a Central Intelligence Agency employe since 1947, has replaced Dr. Richard M. Bissell, Jr., as the agency's deputy director-plans. Bissell has been appointed executive vice president of the Institute for Defense Analysis, a corporation formed by several universities to furnish a staff for Defense Department weapon systems evaluation.

Radio Corp. of America, Aerospace Communications and Controls Division, Burlington, Mass., has received a $400,000 contract awarded jointly by USAF and National Aeronautics and Space Administration for a nine-month study of an operational flight control plan for Saturn-type vehicles. Study objectives include increased vehicle reliability, maximum test data to be taken from any one flight and continuous acquisition conditions during powered flight.

Senate Revises Supplemental Legislation

Stricter measure is sought to effect compromise with House; operating authority to expire Mar. 14.

By George C. Wilson

Washington—Senate is rewriting its supplemental airlines bill in a last ditch effort to win the political support needed to assure those carriers a permanent place in the U. S. aviation system.

The revamping of the bill follows a series of meetings between Senate and House aviation leaders on possible ways to compromise the differences in the bills passed by each chamber last year.

Chairman Warren G. Magnuson (D.-Wash.) of the Senate Commerce Committee told AVIATION WEEK the revisions are so extensive that they must be made by sending the bill back to committee rather than by a legislative conference with the House. He said his committee may hold a hearing on the changes.

The House, meanwhile, is sticking to the measure it passed last year. Its bill is far less liberal than the Senate-passed measure, principally because the House strictly limited the individually ticketed authority of the supplemental airlines.

Chairman John Bell Williams (D.-Miss.) of the House aviation subcommittee said in light of the Imperial Airlines crash the House is in no mood to make many liberal changes in its legislation.

He predicted the individually ticketed authority could be broadened some, but not much.

Mar. 14 Deadline

Impelling the Senate to reach agreement soon with the House on the legislation is the fact that the supplemental carriers currently are operating under a law which expires Mar. 14. Both Rep. Williams and Chairman A. S. Mike Monroney (D.-Okla.) of the Senate aviation subcommittee said they hoped to have new legislation passed by then.

Senate efforts are focused on language to provide additional assurance that the Civil Aeronautics Board will have adequate powers to put unsafe supplemental carriers out of business. Sen. Monroney said there should be no automatic carry over of operating authority from the old to the new legislation.

Under both the Senate- and House-passed bills, supplemental airlines would have to apply to the CAB for new authority to fly within 30 days after the new law was passed. But a supplemental airline could operate in the interim between passage of the law and CAB's decision on its application. Conceivably, therefore, even undesirable carriers could continue operating in their usual way while the CAB considered their applications. The Federal Aviation Agency still would have authority to ground such carriers for unsafe practices.

Language now being drafted would limit this interim operating authority to 60 days after the new law was passed, regardless of whether an application for permanent certification was still pending. The only way a supplemental carrier could operate beyond that 60-day period would be if the Board specifically granted interim operating authority or granted permanent certification. In no case would the Board be obligated to reassign the carrier its previous operating rights.

It is probable, however, that a supplemental carrier grounded while its application is pending before the CAB would challenge the procedure in the courts.

The intensive effort to reach agreement on a supplemental airlines bill has gone beyond congressional aviation leaders and included such Executive Department officials as Chairman Alan S. Boyd of the CAB and Administrator N. E. Halaby of the Federal Aviation Agency.

Boyd recommended liberalizing the House bill's individually ticketed authority. The bill now restricts this authority to a maximum of 90 days during such peak traffic periods as Christmas. Boyd said the supplementals should be allowed in addition to carry individually ticketed servicemen to or from a military base or an airport serving it. But he said the amount of such individually ticketed business should be limited to a fixed percentage of the carrier's charter operations.

Boyd also recommended giving the CAB authority to revoke certificates for failure to operate minimum service prescribed by the Board. He said the Board is thinking of establishing common carriage minimums of $10,000 for each of two successive calendar quarters.

Other suggestions were authority for the Board to suspend supplemental certificates on grounds of financial fitness and to require the airlines to carry liability insurance and maintain performance bonds.

More Authority Sought

Halaby irked Sen. Magnuson, who prides himself on acting on any requests designed to increase air safety, when he told the House armed services special subcommittee investigating the Imperial Airlines crash that FAA needed additional legislative authority. Halaby said FAA's authority over the management standards and financial capabilities of carriers should "be more carefully defined," (AW Jan. 22, p. 45).

Sen Magnuson on Jan. 26 asked Halaby to specify the legislation he needed. Last week Halaby wrote back that FAA's interest in the carriers' financial capabilities "is met by supporting CAB jurisdiction" in this area. Halaby said the only additional authority likely to be requested is an increase from $1,000 to $5,000 in the Federal Aviation Act's civil penalties and broader grounds for revoking aircraft registration certificates.

Although the Imperial Airlines crash at Richmond, Va. on Nov. 8, 1961, in which 74 Army recruits were killed, pushed safety considerations to the forefront, the central economic issue remains the amount of individually ticketed authority the supplemental airlines should be granted. Sen. Monroney still maintains that safety and solvency go hand-in-hand and that Congress should give the supplementals enough individually ticketed authority to enable them to survive.

ATA Position

The Air Transport Assn. has been attacking this position. It contends the individually ticketed authority in the Senate bill would result in the supplementals taking business away from scheduled carriers. The Senate bill—in addition to letting the supplementals carry individually ticketed passengers and freight during rush periods—empowers the CAB to grant this authority on a permanent basis. However, the Board would have to find that public convenience and necessity required such service and that there would be no "significant diversion" of traffic from scheduled carriers.

Another difference to be resolved is the definition of charter service. The House bill leaves the definition to the CAB while the Senate measure specifically defines charter service to include air transportation provided for members of a group on an all-expense-paid tour.

Supplemental carriers see great economic potential in such tours, especially for groups of Europeans who want to visit the U. S.

Caravelle Pact Ended

Caravelle sales agreement between Sud Aviation of France and Douglas Aircraft Co. was dissolved last week because of the failure of the arrangement to produce new business. Another factor behind the rupture was pressure from the French government which contended that the agreement was damaging to French national prestige. This could have been resisted only if sales by Douglas had produced an important profit.

A possible source of discord may have been Douglas interest in producing a short-haul turbofan airliner designated the Model 2086 (AW Jan. 22, p. 48) which would be somewhat competitive with the Caravelle, though designed for shorter stages than the French jet transport.

CAB to Study Light Aircraft Service

Washington—Civil Aeronautics Board soon expects to test the practicality of using light aircraft on local routes which are now unprofitable to serve with standard type transports.

G. Joseph Minetti told the Senate commerce committee last week during hearings on his renomination to the Board that negotiations with a firm to conduct this experiment already are under way.

Chairman Warren G. Magnuson (D.-Wash.) of the Senate commerce committee welcomed the step, declaring "there ought to be some way local service lines can use more economic, smaller equipment to serve these small communities." Chairman A. S. Mike Monroney (D.-Okla.) prompted Minetti's announcement by declaring Civil Aeronautics Board's staff "has been very uncooperative in working on a third level of service."

The Assn. of Local Transport Airlines has opposed such an experiment in the past on grounds it will demand additional subsidies at the very time the Board is trying to reduce them by cutting unprofitable services. Further, the Association contends the local transport lines themselves will buy light aircraft if the Board decides it wants to offer such service.

At the same hearing, Maj. Gen. Harold Grant, USAF, deputy administrator of the Federal Aviation Agency, said "I decidedly do feel that the ground environment [ground control system] that the military has created can be used in solving the common problem of federal airways and air traffic control.

Sen. Monroney agreed, saying "there is not too much difference" between the military and civilian air traffic control systems and that the government could save "hundreds of millions of dollars" if the two systems were properly coordinated and developed.

FAA Administrator N. E. Halaby and the Project Beacon report contend that it is not practical to integrate fully the civil air traffic control system with the military's Sage air defense system.

Both Minetti and Gen. Grant were confirmed by the Senate last week.

Helicopter Carrier Asks Mail Authority

Washington—San Francisco & Oakland Helicopter Airlines, now providing 72 scheduled flights daily in the Bay Area without subsidy (AW Oct. 30 p. 39), has asked Civil Aeronautics Board for permission to carry mail on a non-subsidy basis pending Board certification.

The carrier, whose announced goal is to be the first scheduled helicopter airline to operate profitably without subsidy, says it needs the mail authority because it has not yet operated at a profit.

SFO's passenger traffic has increased from 150 passengers daily last October to over 200, but is still short of the 300 passenger break-even mark reported last fall.

The airline has an application for a certificate of public convenience and necessity pending before CAB, but says it needs an exemption to carry non-subsidy mail in the meantime. The carrier told CAB that the "unusual circumstances" necessary for such an exemption exist and to deny it would be an "undue burden."

The carrier, which now operates flights between the cities of San Francisco and Oakland and their airports with two turbine powered Sikorsky S-62 helicopters, intends to begin service to Palo Alto with a third Sikorsky S-62 in April.

With the new route, SFO says it expects to carry 300-400 passengers daily over the system.

Supplementals Protest Fare Advertisements

Washington—Four U. S. supplemental airlines have protested advertising practices used by one U. S. flag carrier and five foreign airlines in promoting North Atlantic group fares adopted by the International Air Transport Assn. (AW Feb. 12, p. 38).

The supplementals, Overseas National, Saturn, Modern Air Transport and Trans-International Airlines, told the Civil Aeronautics Board they objected to certain group fare advertisements as being "misleading" and creating an atmosphere which would make it difficult for CAB to judge the fares on their merits. These supplementals have been conducting transatlantic group charters under CAB blanket exemptions (AW Feb. 19, p. 41), and could be hurt by CAB approval of the International Air Transport Assn. group fare plan.

The advertisements to which the supplementals objected appeared in the New York Times on Feb. 8 and in the Washington Post on Feb. 13. The supplementals named Pan American, Alitalia, Lufthansa, Irish Air Lines, British Overseas Airways Corp. and Air France as sponsors of the ads.

The protest asserted that the advertisements implied that the group fares were for individuals rather than true groups. Under the IATA resolution approving the fares, the group must contain at least 25 persons and be "spontaneous"—that is, the group must not be solicited by either an airline or a travel agent.

The supplementals said that in some of the advertisements, readers did not discover until they reached the fine print at the bottom that the fares are still subject to CAB approval and for true groups.

In other activity on the group fares, the American Society of Travel Agents (ASTA) told CAB that it did not disapprove the group fares, but felt they discriminated against individual passengers.

ASTA said it felt individual economy fares would provide a better solution to broadening the North Atlantic market.

The group fares, ASTA said, would be hard to police and left unanswered such questions as how to obtain an additional passenger without violating the agreement if one passenger drops out of a group of 25.

LUFTHANSA 720-030 is shown undergoing proving flight. Three of the aircraft are now serving the West German carrier's South Atlantic, Near and Far East routes as well as its Frankfurt-London network. Four more of the aircraft are scheduled for delivery early this year, and will operate on Lufthansa's new routes to West and South Africa to be introduced this spring in addition to the airline's South Atlantic service to Santiago, Chile.

Lufthansa Plans Major Route Expansions

By Edith Walford

Cologne—Lufthansa West German Airlines, despite considerable increase in estimated loss in Fiscal Year 1961 over that of FY 1960, is continuing rapid operational development and expansion to attain its pre-war eminence among the international carriers.

New Lufthansa routes to be inaugurated this spring include services to West and South Africa and Japan and, if bilateral agreements are signed, to Lima, Peru, and to Caracas via Mexico City and Central America. According to company officials, this expansion program is aimed at offsetting potential losses this year over Lufthansa's North Atlantic network.

The West German carrier's preliminary FY 1961 financial results show a loss of between $25 million and $31 million, including depreciation and amortization charges, compared with a $9.75-million deficit reported for FY 1960. Factors cited by the company include:

- **Payments on jet equipment** purchased in recent years.
- **Upward revaluation** of the West German currency.
- **East-West political tensions,** which slowed tourist traffic to Europe and adversely affected business on the transatlantic routes during the peak travel months last summer.

However, the carrier's preliminary operational figures showed marked increases:

- **316.8 million ton/mi. flown,** an increase of 25% over 1960.
- **1.5 million passengers carried,** an increase of 22%.
- **23,320 tons of freight carried,** an increase of 55%.
- **8,230 tons of mail carried,** an increase of 81% over the 1960 total.

Increase in Mail

The gain in mail resulted from the introduction on Sept. 1 of a new network of domestic night airmail services, after an agreement between Lufthansa and the West German Postmaster General. The service is restricted to ordinary and registered letters, postcards and postal money transfers. Airmail collecting center is Frankfurt/Main Airport. From there four Convair 440 Metropolitans and one Vickers Viscount 814 fly to eight major West German air terminals—Dusseldorf, Cologne, Hanover, Bremen, Hamburg, Stuttgart, Nuremberg and Munich—throughout the night. The aircraft are operated every night except Saturdays, Sundays and the nights preceding holidays.

There is no additional charge for the service, since the postal authorities are absorbing the additional cost estimated at $1.5-million annually. Lufthansa's remuneration is based on the block hours required or, where the carrier's scheduled flights are used, on the ton/miles flown.

Explaining why Lufthansa voted against a reduction in transatlantic passenger fares in an International Air Transport Assn. poll of member airlines competing on the North Atlantic route, a spokesman for the West German airline said:

"In our opinion a reduction might result in more passengers than we could cater for during the peak travel season while leaving more seats, than previously was the case, empty during the off-season.

"This would give the non-scheduled companies an added advantage. Whether the tariff is reduced or increased doesn't affect the charter companies very much since they already benefit from their normal practice of quoting a price for the entire aircraft and leaving the headache of filling the seats to the travel agent."

Company officials, however, are adamant in their stand against any increase in transatlantic jet fares. Count Joachim von Frankenberg, Lufthansa's sales director, says any future tariff discussions with IATA should be based on the route structure of the individual carriers and catered to meet the needs of each. One solution could not be acceptable to all concerned, he believes.

According to their various route patterns von Frankenberg said, some airlines would prefer higher, others lower fares. Consequently, the question would have to be reviewed from time to time and again settled on an individual basis.

Von Frankenberg also is strongly critical of last year's "Fly American" campaign instituted as part of the U.S. government's gold-flow policy.

"We have a very strong argument against this kind of flag discrimination," he said—"Fly American with Lufthansa.

"With the exception of our Vickers Viscount 814 fleet costing approximately $11.85 million for 11 aircraft, Lufthansa's equipment is all American. Up to the end of 1960, the latest figure I have at hand, we have invested about $90 million including spares in our fleet of 11 U.S.-produced Convair 440 Metropolitans, 9 Lockheed 1049 and 1049As, 5 Boeing 707-430s and 8 Boeing 720-030s.

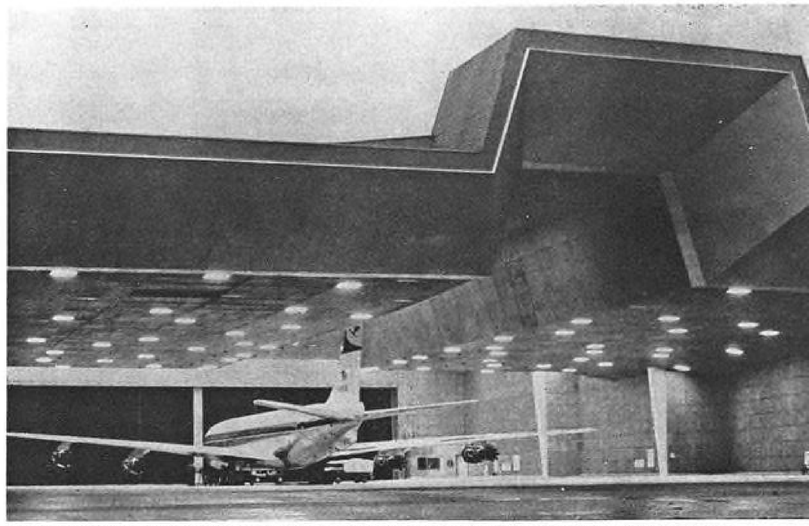
"With two additional Boeing 707-320s ordered last December and the 12 Boeing 727s ordered previously, Lufthansa's total investment in American equipment, including spares, will be approximately $225 million by 1965."

The West German carrier's jet fleet is composed of five Boeing 707-430s and three Boeing 720-030Bs. A fourth Boeing 720B, which Lufthansa introduced on its South Atlantic route last May, crashed on a routine training flight from Frankfurt/Main Airport, home base of the carrier's turbojet fleet, to Cologne last December (AW Dec. 11, p. 42).

Between February and March, Lufthansa is scheduled to take delivery of four additional 720Bs for use on the South Atlantic route to Santiago de Chile. Some time this spring they also will be introduced on the carrier's new route to West Africa. In addition, another service to South Africa will be inaugurated by mid-May.

The proposed new services to Africa, still awaiting the approval of the governments of Ghana, Nigeria and South Africa, will extend from Frankfurt via Lagos to Accra and Johannesburg. Two round trips per week will be flown on each route. Flights from Frankfurt to Lagos and Frankfurt to Johannesburg will be nonstop.

Lufthansa says that, with its Boeing 720B fleet, it will be possible to cover the 6,210-mi. distance from Frankfurt to Johannesburg in 15 hr. 30 min., including an actual flying time of only 12 hr. 30 min. and the distance of 3,726 mi. between Frankfurt and Accra in 7 hr. 45 min.



LUFTHANSA'S new sound-suppressing hangar at the Hamburg-Fuhlsbüttel technical center is tailored to the requirements of the carrier's 707 fleet.

Lufthansa also hopes to extend its Boeing 720B services to Lima, Peru, within the near future, pending completion of a bilateral agreement presently being negotiated with the Peruvian government.

Early last year, Boeing 707-430s were placed in service on Lufthansa's twice weekly Frankfurt-Tokyo service via Paris, Rome, Athens, Cairo, Teheran, Karachi, Calcutta, Bangkok and Hong Kong. They were relieved on this segment later in the year with the arrival of the carrier's Boeing 720B fleet.

Subject to Japanese government approval now being negotiated, Lufthansa says it hopes to introduce a third Boeing 720B service to the Far East, probably some time later this year. It will follow the same route as at present to Tokyo, but the Teheran stop will be eliminated. The 9,355-mi. Frankfurt-Tokyo flight is the longest on the West German carrier's present network.

During 1963 and 1964, Lufthansa expects delivery of two Boeing 707-320s ordered last December to augment its long-range Boeing 707-430 network. The new 707s will be powered by Pratt & Whitney engines instead of the Rolls-Royce powerplants of the earlier Boeing 707-430 version.

The long, drawn-out negotiations between Lufthansa and its three remaining Air Union partners—Air France, Alitalia and Sabena—are now showing signs of bearing fruit, according to another Lufthansa spokesman. Individual problems have blocked the establishment of the proposed four-airline partnership over the past several years, but, in Lufthansa's opinion, it has "been essential to gain time in which to consolidate our ideas. That is accomplished and Air Union should soon become a reality."

The official added that the redistribution of quotas following KLM Royal Dutch Airlines' resignation from Air Union on Apr. 27, 1959, has remained unchanged—Air France 34%, Lufthansa 30%, Alitalia 26% and Sabena 10%. KLM recently has shown interest in rejoining Air Union, but Lufthansa says the present partners are agreed that consideration of such matters as application for membership at the moment would only further delay the signing of the four-partner agreement and should be deferred until present negotiations have been completed.

In another area, Lufthansa remains dissatisfied with the truce existing between the German carrier and Scandinavian Airlines System pending a final new cabotage agreement to be reached on government level. The frequency with which Lufthansa may in the future land in Scandinavia and SAS in West Germany is to be determined.

The first post-war agreement between the two countries expired on Mar. 31, 1960. Thus far, repeated negotiations over the last two years have failed to result in any clear-cut solution. According to Lufthansa, its relations with SAS are now more amicable because SAS is adhering to the West German regulations regarding the frequency with which foreign carriers may land in the Federal German Republic. The German carrier is hoping, however, that a new, mutually acceptable agreement will soon be reached between the two governments.

With delivery by the summer of 1965 of the 12 medium-range Boeing

727 jet transports on order, Lufthansa says it will be the first European airline operating a uniform fleet of 25 Boeing short-, medium- and long-range turbojet aircraft.

Jet Family Dividends

Lufthansa says its choice of a one manufacturer fleet of jet transports has been a happy one which is paying off, particularly in simplified maintenance and the cost and space required for spares.

The marked increase in operational results following the introduction in 1960 of its first Boeing 707-430 services on the North Atlantic route (AW Sept. 26, 1960, p. 45) sparked Lufthansa's interest in a future medium-range jet fleet of the same make. Apart from some early trouble requiring replacement of powerplant generators, the guaranteed performance of the first Boeing 720Bs now in service has been surpassed in almost all categories, Lufthansa says.

When the carrier first considered the choice of a medium-range jet transport, the Sud Caravelle was high on the list of contenders for Lufthansa's order. Later delivery dates of the Caravelle was a determining factor in the 720B's favor.

Other considerations included insufficient freight space and less over-all economic operation of the Caravelle for Lufthansa's specific needs and route structure.

During the carrier's first nine months of activity after its post war re-establishment in 1955, its fleet consisted of four Lockheed L-1049G Super Constellations, four Convair 340s, three Douglas DC-3s—one used exclusively for training purposes—and two Saab Safir trainers.

Soviet Airmail Slow

Moscow—Russians are voicing dissatisfaction over the speed of Soviet air mail service.

In the official government newspaper, Izvestia, a resident of the Siberian city of Tomsk noted that the USSR's Ministry of Communications has distributed posters assuring the populace that "airmail is the fastest." But, said citizen N. Lavrovsky, "experience refutes this assertion."

Tomsk is 69 hr. from Moscow by express train and surface mail from the capital is usually delivered in four or five days. Flying time is less than 6 hr.

Lavrovsky complained that valuable material airmailed from Moscow on Nov. 23 did not reach Tomsk until Nov. 29. Documents airmailed from Tomsk on Nov. 20 were received in Moscow on Nov. 26.

"I wish," Lavrovsky concluded, "to ask the workers in the USSR's Ministry of Communications one question: what do they now recommend for faster mail service—the airplane or the train?"

Now, in addition to the turbojets Lufthansa's fleet consists of 11 Vickers Viscount 814s, seven Lockheed L-1049G Super Constellations, two Lockheed 1649A converted Super Star freighters and nine Convair 440 Metropolitans. In addition, it acquired three Convair 340s and two Lockheed 1649A Super Star aircraft from its subsidiary, the former Deutsche Flugdienst GmbH., when the latter merged with Condor Luftreederei GmbH., Hamburg, last November. These are now used for extra non-scheduled flights at peak periods.

Taking into account all flights beyond West Germany's frontiers, including the Boeing 720B service once-a-week via Paris and Zurich to South America and twice weekly via Rome to the Far East, Lufthansa's present operations amount to 321 services per week. They include:

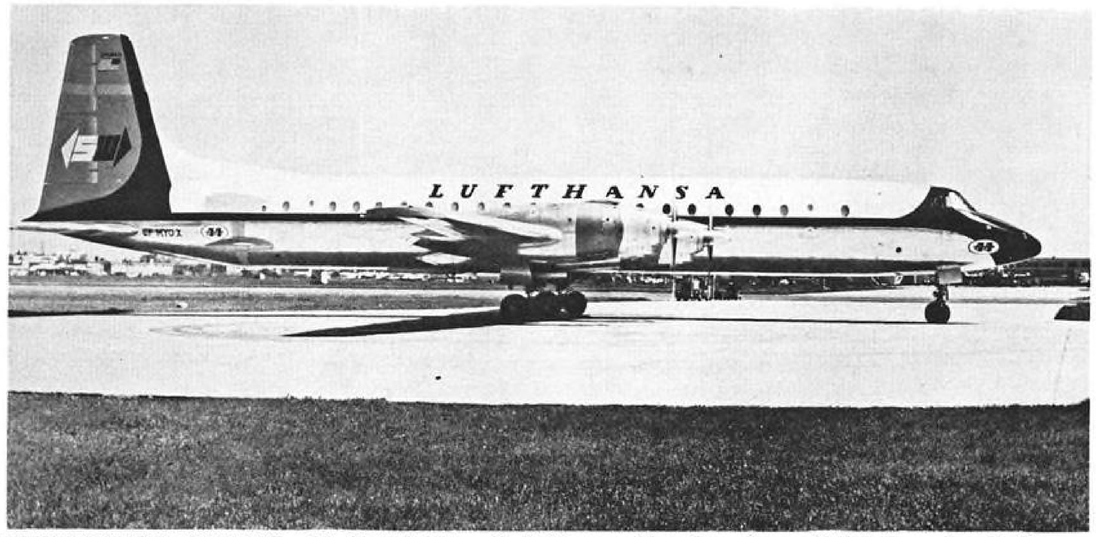
- **North Atlantic**—Frankfurt-New York, 11 flights; Frankfurt-Chicago, 2 flights and Frankfurt-San Francisco via Montreal, 2 flights.
- **South Atlantic** – Frankfurt-Santiago via Rio de Janeiro, Montevideo and Buenos Aires, two flights.
- **Far East** – Frankfurt-Tokyo, two flights.
- **Near East**—Frankfurt-Teheran, three flights.
- **West Germany**—London, 42 flights. Lufthansa introduced its first inter-European Boeing 720B jet services on a nonstop once-a-day basis between Frankfurt and London on Nov. 1. All other West Germany-London services are operated by the carrier's Viscount 814s.

Remaining Lufthansa services within Europe include 21 flights to Paris weekly, 14 to Scandinavia, 8 to Spain, 21 to Italy, 21 to Austria, 28 to Switzerland and 7 flights per week to Greece and Turkey, in addition to 42 domestic flights weekly.

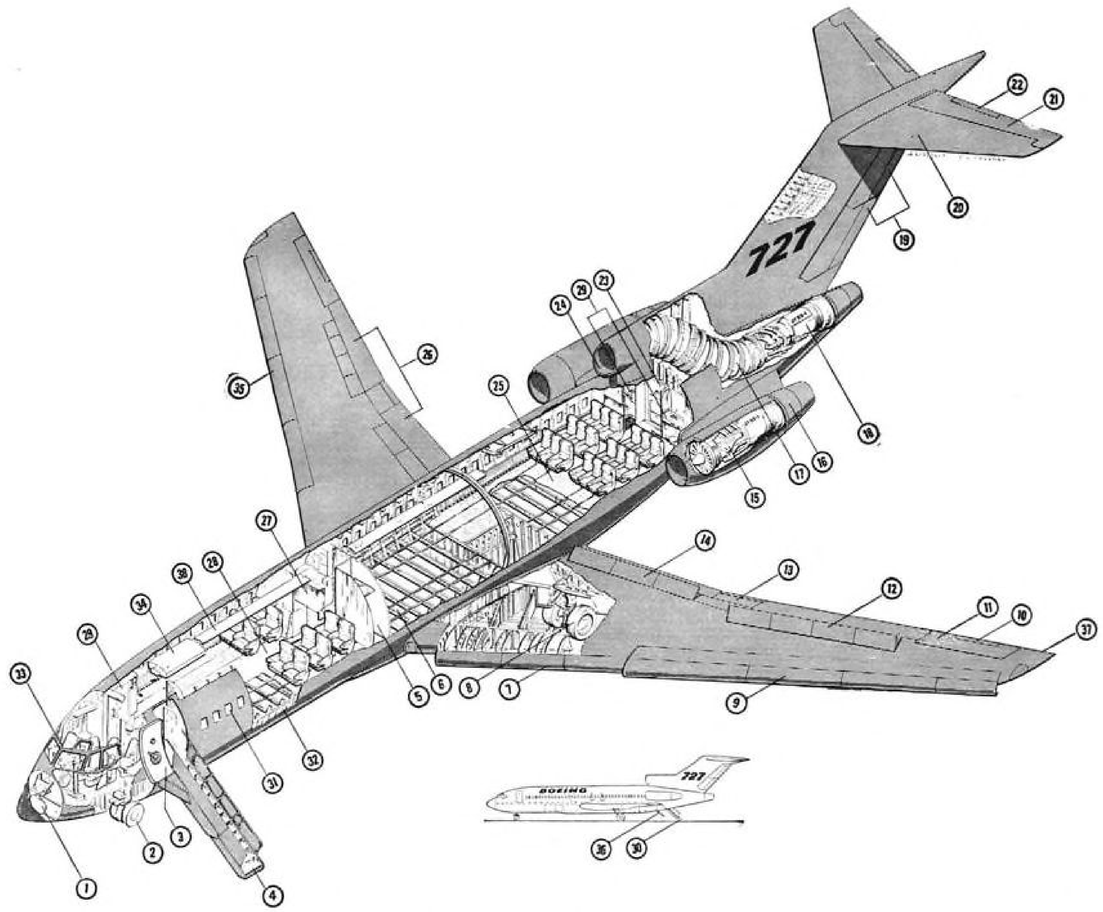
Supersonic Transport Needs

Lufthansa is now apparently thinking in terms of a Mach 2-2.5 supersonic jet transport as an interim step before purchase of a Mach 3 aircraft as future replacement for its subsonic transatlantic jet fleet.

Such an aircraft could be used to bridge the gap until the mid-1970s when a Mach 3 aircraft is expected to



SEABOARD WORLD AIRLINES' Canadair CL-44 freighter with Lufthansa markings takes off on a SWA-Lufthansa transatlantic cargo flight, a joint six-day-a-week service between Frankfurt and New York.



Inside story of the new, short-range Boeing 727

These are the features that will help make the versatile Boeing 727 the outstanding jetliner in its field. Already, American Airlines, Eastern Air Lines, Lufthansa German Airlines and United Air Lines have ordered 117 Boeing 727s for delivery beginning late in 1963.

1. Weather radar scanner
2. Forward retracting nose gear; dual wheels with brakes
3. Outward opening forward plug-type passenger entry door
4. Integral passenger stairs (telescope under floor)
5. Coat closet
6. Wing center section containing bladder-type fuel cells
7. Krueger flap
8. Main landing gear; dual wheels inward retracting
9. Leading edge slats
10. Aileron control tab
11. Low speed outboard aileron
12. Flight speed brakes and lateral control spoilers
13. High speed inboard aileron
14. Ground speed brakes
15. Pratt & Whitney JT8D turbofan engine (14,000 lbs. static thrust)
16. Thrust reverser unit with covering door
17. Intake duct for center engine
18. Center engine
19. Dual, separately powered rudder segments
20. Movable horizontal stabilizer
21. Elevator
22. Elevator control tab
23. Rear plug-type passenger entry door (inward opening)
24. Center engine air inlet
25. Tourist section (six abreast seating)
26. Triple slotted, high lift trailing edge flaps
27. Double unit mid-cabin galley
28. First class section (four abreast seating)
29. Lavatory (one forward; two aft)
30. Aft integral passenger stairs
31. Windows: three pane acrylic plastic on 20" spacing
32. Fail-safe fuselage structure; semi-monocoque, aluminum alloy skin, stringers Z-type frames
33. Control cabin
34. Life raft stowage
35. Wing leading edge and engine inlets anti-iced by engine bleed air
36. Retractable tail skid
37. Fuel dump chute
38. Overhead air distribution system (side wall system not shown)

BOEING 727

become available. Previously, Lufthansa officials had been thinking only in terms of the Mach 3 aircraft (AW Nov. 6, p. 45.)

Lufthansa's freight services were operated up to the end of last year by two converted Lockheed 1649A Super Constellations on a four times per week round-trip basis between Frankfurt and New York.

The service constituted 20% of the carrier's total North Atlantic business and helped compensate for the generally disappointing passenger year in 1961 over the highly competitive transatlantic routes.

Interline Agreements

A cargo-space sharing agreement, negotiated in October between Lufthansa and Seaboard World Airlines and recently approved by the Civil Aeronautics Board, already is paying dividends, according to airline officials, and shows promise of boosting the German carrier's North Atlantic freight traffic still further. The one-year agreement became effective on Jan. 2.

Using Seaboard's swing-tail 60,000-lb. capacity Canadair CL-44s, the two carriers now operate a once-a-day round-trip freight service, except Sundays, between Frankfurt/Main and New York on a joint basis. During the initial week of operation, Lufthansa's share of the total freight carried on the joint venture amounted to 70%, according to a company spokesman.

In 1961, Lufthansa also concluded a cost and profit sharing agreement with British European Airways covering joint use of BEA all-cargo Armstrong Whitworth AW 650 Argosy aircraft between London, Dusseldorf, Frankfurt/Main and London on a once-a-day basis, Sundays excepted. BEA's Argosy fleet already flies to most countries within the proposed Common Market area and the new agreement, which came into force on Jan. 3, should enable the German airline to further establish itself and increase its freight operations in this area also.

Freight Growth

Lufthansa says recent studies show there is room for further development of its freight operations, particularly to Lagos, Nigeria and Acera, Ghana in West Africa and to Johannesburg. Demand in these areas is steadily increasing for German industrial machinery as well as for German textiles, medicine, optical equipment and automobiles. Lufthansa says it cannot afford to limit its operations to one-way traffic to these regions and is now studying various potential means of filling its freighters on the return flights.

Air France, for example, is flying loads of pineapples to Munich from various tropical centers for distribution in Germany, and Lufthansa feels it is entitled to some of this traffic. It is assured of government financial support in any steps taken to capture a share of this freight traffic, a company official told AVIATION WEEK.

With the acquisition last November of Condor Luftreederei GmbH., Hamburg, Lufthansa renamed its wholly-owned subsidiary, the former Deutsche Flugdienst GmbH., Condor Flugdienst GmbH. Simultaneously, it turned over to Condor one of its Vickers Viscount 814s and will put a second 814 at Condor's disposal soon. The charter company now is using the aircraft to increase its nonscheduled passenger flights to Spain and North Africa.

Condor's fleet also includes four Convair 240s, two Vickers Viking Super Cargo and two Lockheed 1649 freighter aircraft. The four Convair 240s recently were sold to an American firm, which took delivery of the first of them last November.

The remaining three will be retired from service this fall.

Condor operates passenger and freight charter flights to 17 major cities in Europe and the Near East, including Teheran-Lisbon and Cairo-Helsinki routes. Its present route network covers 15,525 mi. This winter Condor is planning to operate tourist charter flights to Teneriffe via Tangiers with calls at Marrakech, Cairo and Athens on the return trip. This will mark Condor's first operation into these points.

When rebuilding began in 1955, Lufthansa had a total staff of 179, including 44 first pilots, 15 pilots and 19 copilots. Lufthansa's employment figure has now grown to 12,200, 1,400 of them flight personnel.

The figure also includes employes who are serving in the company's overseas operations.

Until recently, Air France, with a total of 40 offices spread over the U.S., had the largest number of U.S. agents of any European carrier. Lufthansa now tops the list with 44 offices and says this is an indication of the importance it attaches to the long-range development of its transatlantic network.

Technical Center

The carrier's technical center is at Hamburg-Fuhlsbuttel, and its pilot training school, established in 1956, is at Bremen Airport, where civil aircraft movements, limited to a dozen or so daily, enable uninterrupted flight training courses to be carried out. The school's fleet comprises two Beechcraft Twin Bonanza D-50s, three Saab Safir 91Bs, nine de Havilland Chipmunk Mk. 22s, one Klemm Kl-107C chartered from its German producer, Klemm-Flugzeuge GmbH., and 20 Piaggio FWP-149-DA3s built under license by Focke-Wulf in Bremen. These last are being used on a temporary basis for military pilot training.

Boeing 707-320B Has High-Lift Devices

High-lift devices on Boeing 707-320B Intercontinental turbojet transport include double-slotted inboard fillet flaps (top photo) in place of split flap used on earlier 707 series aircraft. New leading edge flaps (lower photo) cover approximately two-thirds of the wing span. The aircraft now is undergoing company flight tests and will begin Federal Aviation Agency certification flight testing in approximately a month.

American Airlines Reveals Data From Extensive Market Surveys

Washington—American Airlines, reflecting an industry-wide dilemma over ways to tap a mass air travel market, has released details of several marketing surveys conducted in the past decade.

American pointed out that it has conducted 48 separate market studies in the past 10 years. It contends that the studies show "exactly where the airline stands and how it can improve." However, answers to the problems highlighted in the studies—which were conducted primarily by Opinion Research Corp., of Princeton, N.J.—were not supplied by the carrier.

American said its studies are continuing and it is participating, along with Trans World Airlines, Eastern Air Lines, United Air Lines, The Boeing Co. and Douglas Aircraft Corp., in a more comprehensive study of the travel market. Results of the study are expected in spring (AW Feb. 19, p. 38).

On the basis of its three most recent studies, involving 18,000 interviews, American generally found that 15% of air travelers took five or more trips in the year and accounted for 64% of the air trips. Twenty-six per cent of the travelers took two to four trips a year, while more than half of those questioned took only one trip in a year. Noting that more than half of the population of the United States does not travel beyond a 200-mi. radius at all and 78% have never flown on a commercial airline, American concluded that air travelers represent a "relatively small proportion of the population."

Business travelers were pinpointed by the study as the backbone of industry traffic. More than half of such travelers have incomes exceeding $10,000 per year. Eighty-six per cent of this group's travel is paid for by companies through expense accounts, the research indicated (AW May 1, p. 38).

Vacation travelers were cited by the studies as a logical market source for air travel. American described the vacationers making up this potential market as coming primarily from the middle income level of just under $10,000 a year but having wages higher than the national average. It found that vacations were the most important attraction of first-time passengers. Those who made only one trip a year accounted for 59% of the total number of travelers, yet accounted for only 16% of the trips taken. Slight reductions in air fares on transcontinental routes tended more to divert passengers from first-class travel than to generate any new passengers, research indicated.

An estimated 3% of the present auto travel market represents an important target group for diversion to airline travel, American said, since this market is limited by travelers' feelings about the convenience of driving and the costs of airline travel.

Comparison of trip costs between auto and airline travel decreases when trips of more than 1,000 mi. are involved, the studies indicated. It was also estimated that the airlines could consider about 4% of the present train and bus transportation customers as a potential for airline travel.

Convenience and economy of the auto for family travel were cited by those interviewed as major advantages. American considers this a possible limitation on diverting this market to air.

Citing figures from a study made in conjunction with the Florida Development Commission, American said that despite heavy outlays by the airlines for promotional fares and advertising promotions, the airlines' share of business into the state dropped from 15% down to 14% for the first six months of 1961, as compared with the same period of the previous year. By comparison, the actual number of tourists to the state increased 10% in this period (AW Nov. 13, p. 47).

C-141A Avionics Gear Scheduled

Air Force C-141A turbojet cargo plane, under development by Lockheed Marietta, will make extensive use of commercial avionics equipment designed to Aeronautical Radio, Inc. (Arinc) characteristics wherever practical as part of a plan to make the aircraft suitable for commercial airline cargo operations. Tentative list of avionics equipment scheduled for use on C-141A, most of which will be procured on open bid:

Quantity	Function	Type
2	UHF Communications	AN/ARC-90
2	VHF Communications	Arinc Solid-State
2	HF/SSB Communications	Arinc-Commercial
1	Intercommunications	AN/AIC-18
1	Public Address	AN/AIC-13
2	VOR/LOC. Receiver	Arinc Solid-State
2	Glide Slope Receiver	Arinc Solid-State
2	ADF	Arinc Solid-State
2	Tacan	AN/ARN-21
1	Marker Beacon Receiver	Arinc Solid-State
1	Doppler Radar	AN/APN-147
1	Doppler Nav. Computer	AN/ASN-35
1	Digital Nav. Computer	AN/ASN-24
1	Astro-Navigation Set	AN/AVN-1A
1	Loran-C Nav. Receiver	————*
1	Weather/Nav. Radar	AN/APN-59B
1	IFF/ATC Transponder	AN/APX-46
1	Flight Recorder	Arinc
2	Gyro Compasses	Commercial
1 or 2	Air Data Computer	Arinc
2	Flight Directors	CPU-27

* Loran-C Receiver is expected to be procured by Coast Guard/Arinc

Note: If solid-state versions are not available in time, existing Arinc characteristic equipment is expected to be procured.

SAS Reorganizes As Economy Measure

Stockholm — Scandinavian Airlines System is reorganizing its management in a belt-tightening effort to streamline the traditional three nation structure in the capital cities of the participating Scandinavian countries.

Under the new reorganization plans recommended by Interim President Curt Nicolin and approved by the board of governors, SAS management will be concentrated primarily in Stockholm under the administration of four executive vice presidents responsible to Nicolin. The departments they will head are:

- **Technical,** under Executive Vice President Olof Carlstein. Carlstein formerly was an executive vice president of the entire company.
- **Operations,** under Executive Vice President Knut Hagrup, former vice president for technical services.
- **Finance,** which is perhaps the most difficult post of them all during the airline's current fiscal pinch. The executive vice presidency for this post has not yet been filled.

BRITISH AIRCRAFT CORPORATION

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399 JEFFERSON DAVIS HIGHWAY ARLINGTON VIRGINIA

AIRLINE OBSERVER

► Indications are strong that transatlantic carriers will report substantial traffic increases during the balance of the winter season. Advanced bookings for both east and westbound flights indicate new records will be set for the off-peak period.

► **Federal Aviation Agency will meet with representatives of the aviation industry Mar. 5-9 to discuss the Project Horizon report on air traffic control. System design team, established to accelerate implementation of the report, will represent FAA at the sessions. In a separate conference, scheduled for Feb. 27, FAA will meet with aircraft operators and equipment manufacturers to review future airborne equipment requirements developed in the Beacon study.**

► President Frank W. Hulse of Southern Airways, in a letter to key senators and representatives from the southeast, has charged that public hearings on the Southern pilot strike will be exploited to "develop sympathy for the 100-odd strikers who have not accepted employment elsewhere." Pressure from the Air Line Pilots Assn. is responsible for the hearings on a subject having no nation-wide significance, Hulse said. Prof. Nathan P. Feinsinger has announced hearings will resume Feb. 28. Earlier sessions were held Feb. 7 and 8.

► **Efficient use of Aeroflot's large, double-decked Tu-114 turboprop transport apparently is still a considerable distance in the future. After almost a year of scheduled Tu-114 use, Russian officials still talk hopefully of achieving a 5- to 6-hr. daily aircraft utilization on the trans-Siberian route.**

► Decision to shave 8½ in. from the circumference of the two control columns, as a means of reducing weight by 6 lb. in a new jet transport now under construction in Europe, was recently approved by chief pilot of the project after several hours of discussion. However, not known to the pilot at the time was a simultaneous decision by a catering group to install double-weight chromium racks which increased weight by 8 lb. Net result: a 2 lb. gain.

► **Civil Aeronautics Board has found that discontinuance of National Airlines service to Ft. Lauderdale, Fla., on June 11, with Board authorization, constitutes a violation of the carrier's certificate of public convenience and necessity. The Board directed National to resume the service within 45 days.**

► Monorail link between London's Heathrow Airport and downtown will be explored during the next six months by Hawker Siddeley's engineering department and a French company representing a group of engineering and banking firms. The monorail, with a maximum speed of 75 mph., would cut traveling time to 10-15 min. The monorail has unofficial support of the influential London County Council which opposes construction of a city center heliport because of noise.

► **Traffic upsurge on domestic trunkline routes during mid-winter months has created new optimism over prospects for 1962. One airline is now forecasting a 1962 increase in passenger revenue miles up to 20% over 1961.**

► Department of Justice has petitioned the CAB for the right to intervene in the Board's hearing on the merger application of American Airlines and Eastern Air Lines. In filing the petition, Justice emphasized the move does not indicate that it either opposes or supports the proposed merger, but added that the merger "raises substantial questions involving the public interest . . . and we believe the government should be in a position to remain fully informed and, if necessary, present appropriate arguments."

► **Eastern Air Lines will seek a reduction of flight schedules it is being forced to operate into Baltimore as a result of the CAB's decision in the Washington-Baltimore Adequacy of Service Investigation. Eastern holds that many of these new schedules are uneconomic, and that the burden of complying with the Board order will be even greater when jet service to Washington is inaugurated at Dulles International.**

SHORTLINES

► **Alitalia** has been recommended for a route extension into Chicago by a Civil Aeronautics Board examiner. The carrier plans to operate two round-trip flights weekly between Italy and Chicago via Montreal, subject to Board and presidential approval.

► **American Airlines'** nonstop authority between New York and San Francisco has been reaffirmed by CAB. The Board reviewed the case on instructions from the U. S. Court of Appeals to determine whether any rules of practice had been violated in the original route award. CAB noted certain violations by American and the city of San Francisco, but said they did not prejudice the validity of their original award.

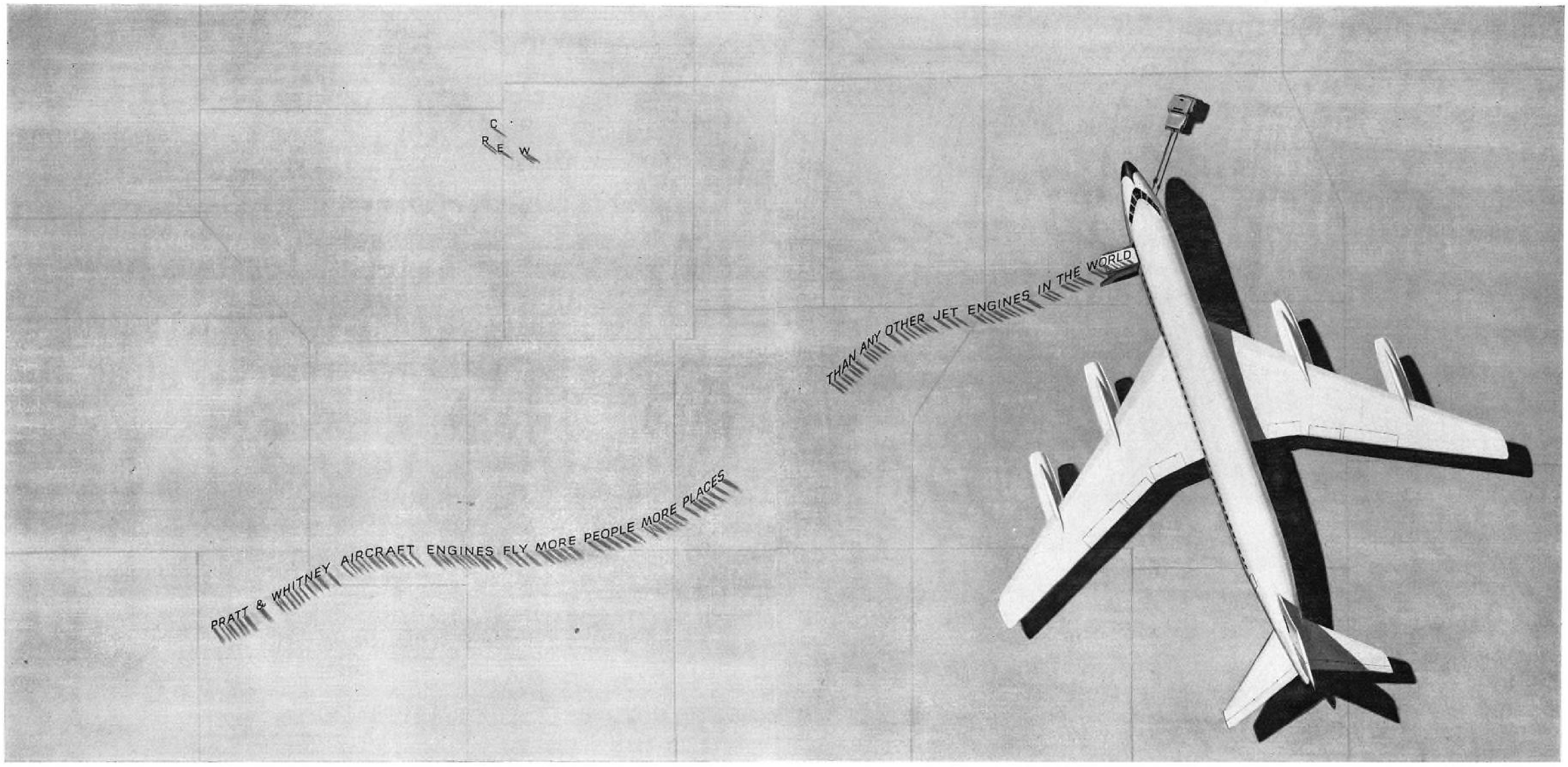
► **Delta Air Lines** reports it flew 206.7 million revenue passenger miles during January—the highest monthly traffic figure in the company's history. Previous high was 200.1 million, flown in March, 1961.

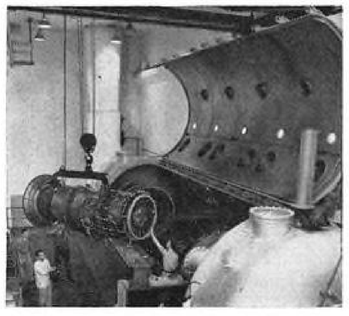
► **Federal Aviation Agency** is proposing rules requiring that packages containing magnets or magnetic devices such as magnetrons or light meters be plainly marked for air shipment. Permanent magnets would have to have a keeper bar installed to neutralize the magnet whenever possible. The proposed rule is to combat effects on aircraft instruments caused by magnetic materials.

► **Iberia Air Lines** has ordered a fourth DC-8 jet transport from Douglas Aircraft Co. Delivery is scheduled for September.

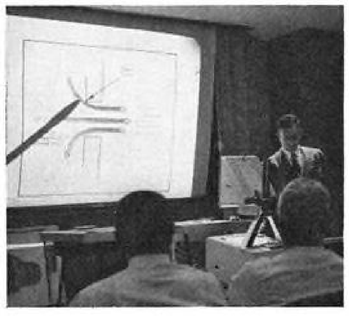
► **Pacific Northern Airlines** ground crews are using ultra-high frequency (UHF) radios to speed aircraft handling at Seattle-Tacoma International Airport. The system uses a fixed station located in the dispatch office and two remote stations, one in the cargo and maintenance area, one in load control and three portable stations. One portable station is carried by the lead maintenance man, another by the lead cargo man and a third by the passenger agent in charge of loading and unloading aircraft.

► **Suspension period** of Continental Air Lines' proposed economy fares (AW Dec. 4, p. 38), has been extended until May 29 to give CAB time to complete its investigation. The suspension period was to end Mar. 14. Trans World and American airlines' economy fares are also under CAB suspension subject to the same dates.

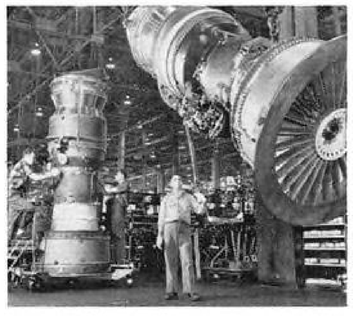




Engines and components can be tested to 100,000 feet over a wide range of Mach numbers, temperatures, and pressures in our multi-million dollar Willgoos Laboratory.



Service representatives stationed with customers throughout the world assist with all phases of engine operation. Factory training is also available for key airline technicians.



Over 23,000 axial-flow, twin-spool, high-compression engines have logged 25,000,000 flight hours. This proven design system has an unmatched performance record.

The men who build and buy jetliners understand the importance of dependable engines.

It's not surprising, then, that the majority of the world's jet transports are powered by Pratt & Whitney Aircraft, including 75 per cent of the Boeing and Douglas jetliners ordered to date. As a matter of fact, 34 airlines currently rely on these powerplants to speed 1,000,000 passengers a month to hundreds of cities in 79 countries and six continents.

Pratt & Whitney Aircraft engines not only do a big job, but do it well. The nation's first commercial jet transport was powered by Pratt & Whitney Aircraft. So were the first turbofan transports. These engines have demonstrated outstanding reliability (some are now authorized 2,600 hours time between overhaul). And, parts replacement costs per flight hour are the lowest in the industry.

In short, Pratt & Whitney Aircraft has achieved flight propulsion leadership through proven performance. That's why Pratt & Whitney Aircraft jet engines fly more people more places than any other engines in the world.

Pratt & Whitney Aircraft
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U A

OSO-1 to Refine Solar Flare Predictions

By Edward H. Kolcum

Cape Canaveral, Fla.—First satellite designed to refine solar flare prediction techniques to permit flexibility in launching Apollo manned lunar landing flights is scheduled this week from the Atlantic Missile Range as part of a program to establish an accurate statistical analysis of "safe" and "dangerous" manned space flight periods.

The 450-lb. satellite, called Orbiting Solar Observatory 1 (OSO-1), will be launched into a 300-mi. circular orbit by a Douglas Thor-Delta launch vehicle.

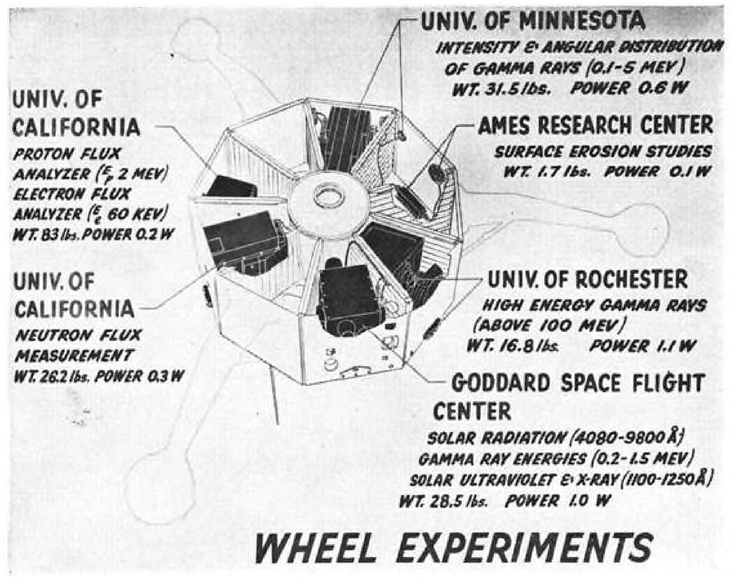
It will carry 13 scientific experiments housed in two sections—one continuously pointed at the center of the sun to measure radiation emissions, and the other in a rotation wheel to compare solar radiation with radiations in other portions of the sky. It has an estimated lifetime of six months. Data from OSO-1 and other solar observatories to follow are expected to extend the "window" during which Apollo lunar launches can be made.

This factor is critical in scheduling Apollo flights because the 1967 target date for manned lunar landing coincides with the next period of maximum solar activity. Although solar emissions and the deadly radiations they cause have been studied in detail only since 1956, scientists have established that solar flares are possible only when these conditions exist on the sun:

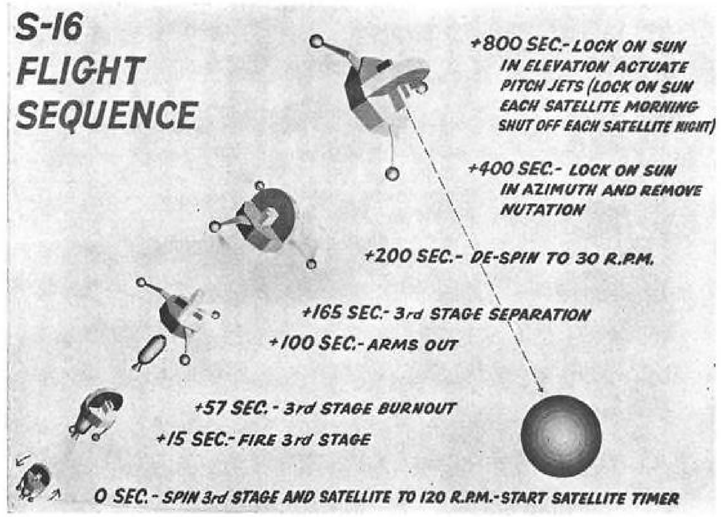
- Large, complex sun spot grouping.
- Complex magnetic field in a sunspot group, with many opposite poles.
- Unusually bright patches, called plages, in ionized calcium.
- Frequent bursts of radio emission, and a high level of solar radio noise.
- Hot spots in the corona, with appearance of the yellow line of calcium 15 at the edge of the visible disk.
- Many small flares in an active region, along with characteristic prominences.

The problem is that although a safe period can be predicted with accuracy, in most cases a large, dangerous flare does not occur even with observation of flare indicators. Task of the OSO series is to refine prediction techniques so that the danger periods will be shorter, and the safe periods longer. To contribute to a better understanding of solar flare prediction, OSO-1 will contain these experiments in the non-rotation section:

- **Solar X-ray spectrometer** in the 10-400 angstrom range, designed by Dr. William Behring and Dr. Werner M. Neupert of National Aeronautics and Space Administration's Goddard Space Flight Center. This detector will measure X-ray emissions from the sun while it is in a quiet period, to establish baseline information. Direct solar radiation enters a slit and then is dispersed on a prism into its characteristic wave lengths. Pulse output is converted into binary waves and sent to tracking stations as coded telemetry.
- **Gamma-ray monitor,** designed by Kenneth Frost and William White of Goddard. This device will measure gamma-ray leakage from the sun, and will provide information on the solar thermonuclear process which causes solar heat and light. The detector consists of a scintillator and photo-multiplier tube, detecting at the 0.510 million electron volt line where gamma rays are generated by the conversion of mass into energy.
- **X-ray monitor,** in the 20,000-100,000 electron volt range, designed by White and Frost. Emissions in this range may be associated with solar radio frequency changes, and observations by OSO-1 will be compared with ground observations. The monitor is a scintillator with a crystal thinner than that in the gamma-ray experiments.
- **X-ray monitor,** in the 1-8 angstrom wave length range, also designed by White and Frost, to obtain wave length discrimination of solar emissions. The detector consists of two ion chambers in combination.
- **Dust particle detector** to measure rate, momentums and energies of microscopic dust particles, designed by W. M. Alexander and Curtis W. McCracken of Goddard. This is a photo-multiplier tube coated with aluminum, which registers impacts through a microphone. The rotating structure contains nine wedge-shaped compartments, five of which house experiments and the other four containing electronic controls, batteries, telemetry, radio command and data storage systems. The wheel experiments are considered sky-mapping devices, and they spin at a rate of two revolutions per second. They are:
- **Solar radiation photodiode,** with a filter to restrict light emissions except those in the 3,800-4,800 angstrom range, designed by Kenneth L. Hallan and White. Data will help understand how hydrogen is converted to helium, with the excess hydrogen converted to heat energy.
- **Solar ultraviolet ion chamber,** in the 1,100-1,250 angstrom wave length range, also designed by White and Hallan. Experiment will determine if Lyman-Alpha emission line changes during active and quiet solar periods.
- **Solar gamma-ray** high energy dis-



OSO-1'S "WHEEL" makes two revolutions per second, has nine wedge-shaped compartments, five containing experiments and the others housing avionic equipment. Wheel diameter is 44 in.; diameter increases to 92 in. when three arms are extended.



EACH OF THE THREE extendable arms on OSO-1 (designated Project S-16 by NASA) supports a nitrogen gas sphere to control stabilizing spin rate. The satellite is to be launched into a 300-mi. circular orbit by a Douglas Thor-Delta launch vehicle.

tribution in the 0.2-1.5 million electron volt range, designed by White and Frost. This experiment is the same as the one in the pointing section, with one detector shielded to get a 20 deg. view angle, and the other unshielded to determine if any radiations are generated within the satellite from energetic particles encountered in space.

• **Solar gamma-ray detector** using a telescope-like sensor called a "Compton telescope," which measures Gamma rays in the 50,000-3 million electron volt range designed by John R. Winckler and L. E. Peterson of the University of Minnesota. The instrument is able to take measurements despite large cosmic ray background.

• **Neutron monitor,** designed by Dr. Wilmont Hess when he was at the University of California. He now is with Goddard. This sensor will give a measurement of the earth's neutron output during the day and at sunset, important because decay of these neutrons is a vital source of the Van Allen radiation belt.

• **Proton-electron scintillator,** designed by Dr. S. Bloom of the University of California, using an advanced electronic detector to study the Van Allen belt.

• **Emissivity stability** of surfaces detector, designed by G. C. Robinson of Ames Research Center. Temperatures will be measured on several parts of the satellite to determine the amount and rate of change of thermal radiation.

• **Solar gamma-ray experiment** in the 100-500 million electron volt range, designed by M. Savedoff and G. Fazio of the University of Rochester. The instrument will observe high-energy rays emanating from solar flares, and gamma radiation from the quiet sun and from other regions in the sky.

The OSO-1 spacecraft, designed and built by Ball Brothers Research Corp., is basically a stabilized platform with experiments powered by 1,860 solar cells in 31 modules of 18 volts each. The satellite has a wheel diameter of 44 in., the maximum allowed by the Delta launch vehicle shroud. After payload separation, the diameter increases to 92 in. when three arms are extended. On the end of each arm is a nitrogen gas sphere to control stabilizing spin rate. After third-stage burnout, the stage and satellite are spun to 100 rpm., reduced to 30 rpm. after satellite separation.

The control system which actuates precession jets maintains a spin axis perpendicular to the solar vector within 3 deg. Azimuth and fine elevation positioning are controlled by an electrical servo motor, with position errors sensed by four coarse and two fine detectors. Nickel cadmium storage batteries have a power output of about 16 watts, with telemetry and control to use 7 watts, and the experiments, 9 watts. Data are recorded during 90 min. of the 95-min. orbit on a tape running 0.75 in./sec. and played to a receiving station during the remaining 5 min. Tracking and telemetry will be performed by the Minitrack network.

The OSO-1 payload is the latest assignment for the highly successful Douglas Thor-Delta, which has placed six successive payloads in precise orbits after a first-launch attempt failure.

Ball Brothers' OSO research program resulted in development of a new lubricant not affected by high vacuum environments. The lubricant is used on slip rings, bearings and brushes. The orbital launch of OSO-1 was preceded by extensive component testing, including use of an Aerobee rocket to test the Ball Brothers solar pointing control system.

In this flight from Wallops Island, Va., the system maintained an accuracy of one minute in elevation and three minutes in azimuth for 328 sec.

Telemetry and control systems were tested when the complete communications system was flown over the Ft. Myers, Fla., Minitrack station by helicopter at an altitude of 5,000 ft.

Soviets Discuss Space Weightlessness Effect

Moscow—Although the human nervous system is highly adaptable and has considerable compensating ability to restore normal contact with the outside world, it is not known how much it can compensate for deleterious effects of weightlessness, Soviet scientists reported here recently.

At a meeting of the USSR Academy of Medical Sciences, Vasili Parin, Vladimir Yazdovsky and Dr. Oleg Gazenko presented a report on ground experiments and the flights of Maj. Yuri Gagarin and Gherman Titov as an extension of a report presented at the 12th International Astronautical Congress last fall in Washington (AW Oct. 9, p. 22).

They contend that these factors dictate effects on the nervous system in any space venture:

• **Low barometric pressures,** altered gaseous composition marked by absence of molecular oxygen, ionizing radiation, heat loads, meteoroid impact and other physical factors in a spacecraft.

• **Rocket flight noise,** accelerations and weightlesssness.

• **Environmental system,** food, work-rest cycles, complete isolation and emotional tension.

While ground centrifuge experiments obtained complete data on the boost phase of the Gagarin and Titov flights, the physiological reactions of the cosmonauts "were somewhat more pronounced" during actual flight, the report said. This was attributed primarily to emotional stress.

Scientists were said to have established that weightlessness induced functional changes of the heart, but cardiac disturbances disappeared after the first two hours of space flight.

The absence of gravity excludes the activity of the otilith receptor of the inner ear, according to the report. This apparently resulted in a distinct feeling of nausea reportedly experienced by Titov.

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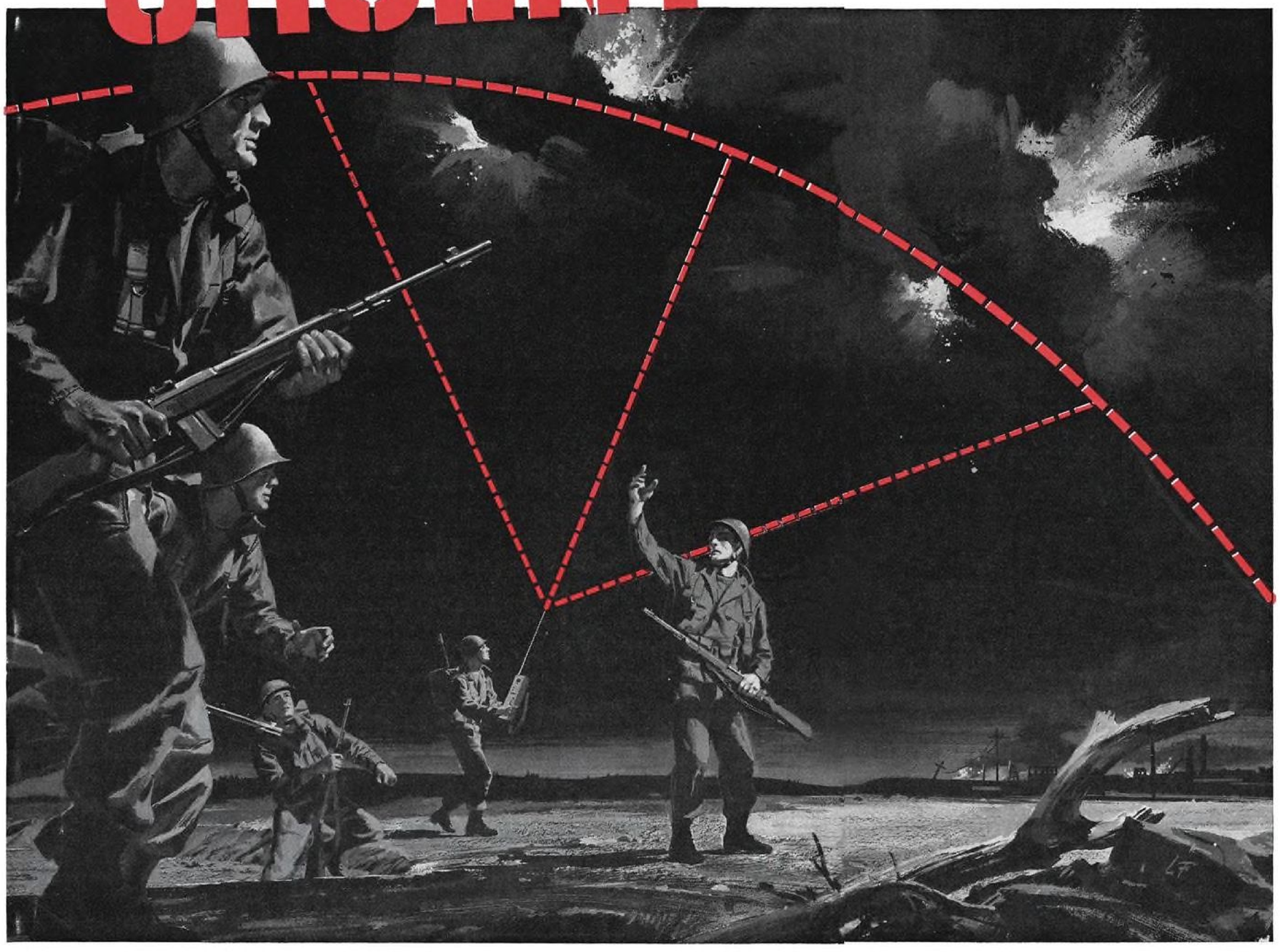

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Atlas Boosters Repaired on Launch Pad

By George Alexander

Cape Canaveral, Fla.—Repairs to the Atlas boosters used as the Mercury-Atlas 6 (MA-6) and Ranger 3 launch vehicles were performed through a 24-in.-dia. access hole at the bottom of the fuel tank—an engineering feat comparable to building a model ship in a bottle.

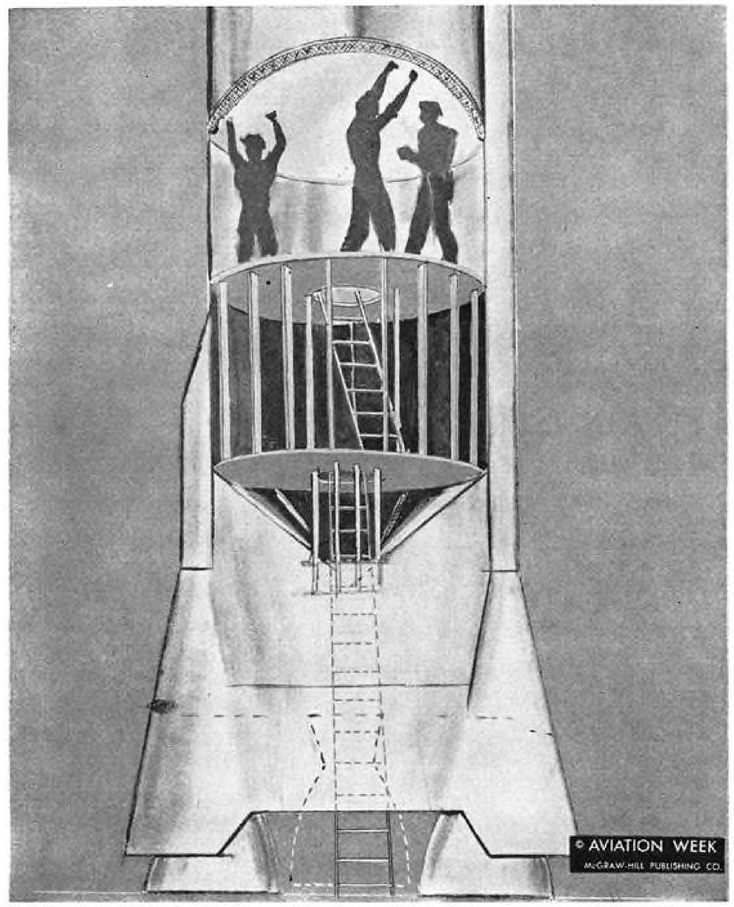
Repairs, performed by the Cape Canaveral operations group of General Dynamics/Astronautics, builder of the Atlas, were necessitated when RP-1 kerosene fuel seeped into the insulating bulkhead between the missile's fuel and oxidizer tanks (AW Feb. 12, p. 29).

Rather than remove the boosters from their launch stands to get at the fuel-soaked insulation, General Dynamics engineers here suggested that the vehicles be left standing and that only the sustainer engines be pulled out. Removal of the sustainer, they argued, would provide a 24-in.-dia. access hole through which men could crawl up through the fuel tank to reach the insulation.

The Atlas is so constructed that the liquid propellant tankage and airframe are integral. RP-1 kerosene fuel, stored in the lower section of the airframe, is separated from the liquid oxygen above it by a thin stainless steel structural dome. The underside, or fuel side, of this dome is lined with a 3-in.-thick blanket of styrofoam held in place by a .016-in. thin aluminum membrane. Design purpose of this foam blanket was to prevent freezing of the kerosene fuel by the −297F temperature of the liquid oxygen and to reduce the boiloff rate of the liquid oxygen from heat transfer of the warmer 70F RP-1.

In preparing Atlas 55-D for launch in October, 1960, the General Dynamics crew accidentally overfueled the missile with RP-1. A combination of too much fuel and too high internal pressure ruptured the aluminum membrane, allowing fuel to soak the styrofoam. The missile was removed from its stand, its three engines and aft bulkhead removed and the fuel-soaked foam liner, along the aluminum membrane, peeled off the structural dome.

Tests with styrofoam had shown that it would soak up approximately twice its own weight, although its wick action was generally only .5 to .75 in. above the fuel line. Completely soaked with fuel, the 80-lb. blanket would weigh about 240 lb., and USAF and General Dynamics feared that at 9g acceleration loads, the blanket and membrane would collapse into the fuel tank and that particles might enter the turbopumps, causing violent failure.



SUSTAINER ENGINE, plumbing and bottom of fuel tank were removed from Mercury-Atlas 6 (MA-6) and Ranger 3 Atlases to provide 24-in. dia. access hole. Scaffold was built up inside tank to permit removal of fuel-soaked insulation.

After removing the fuel-soaked foam liner, USAF and General Dynamics decided to fly 55-D without insulation between the fuel and liquid oxygen to see if it was really necessary. This missile flew Oct. 22, 1960, and the complete success of this flight led to a decision to build E and F models of Atlas without foam insulation.

The D-series Atlases, as used in the Ranger and Mercury programs, were fabricated with foam liners and it was thought unnecessary to modify them.

In the final preflight examination of the Ranger 3 Atlas booster during the week of last Jan. 22, a check was made to see if any fuel had leaked into the styrofoam blanket. This is standard preflight procedure with D-models, and is accomplished by checking for the presence of fuel in a small copper tube which runs from a point in the foam liner slightly above the fuel level within the tank to an external plug on the missile skin. When the plug was opened, a steady stream of RP-1 ran out, indicating that a rupture had occurred somewhere in the aluminum membrane, allowing the foam to become soaked.

To have repeated the procedures that had been followed with Atlas 55-F would have meant the loss of a five-day "window" of optimum moon-earth relative positions for Ranger 3. The General Dynamics launch crew suggested that it be allowed to dump the RP-1 aboard the Atlas, pull the sustainer and go up through the fuel tank to remove the blanket. The crew estimated the job would take four days, permitting launch of Ranger on the last day of the window.

USAF and National Aeronautics and

Space Administration agreed to take a chance and General Dynamics personnel went to work.

First, the sustainer engine, with all associated pumps, lines and hardware, was removed. The two outboard booster engines were not touched at all. The bottom of the fuel tank is conical-shaped and this cap was removed at the 24-in.-dia. level.

Two General Dynamics carpenters then began construction of wooden scaffolding to go up through this 24-in.-dia. access hole. They placed vertical supports within the tank around the perimeter of the access port and then built a 10-ft.-dia. platform atop the supports, leaving another 24-in.-dia. access hole for personnel to mount the platform.

Using 2 x 4 in. stanchions as supports, the carpenters then built a second working 10-ft.-dia. platform, again with a 24-in.-dia. access port, atop the first platform. The second platform was high enough and strong enough to allow three men to work on the foam blanket overhead. Work shifts inside the tank were limited at first to 20-min. periods and later extended to one hour per man. The carpenters did such precise work in cutting parts of the scaffold that when masking tape was wrapped around edges of the supports and platforms to protect personnel from splinters, the structure was found to exceed the internal tank dimensions by thousandths of an inch—due to the thickness of the tape—and had to be planed.

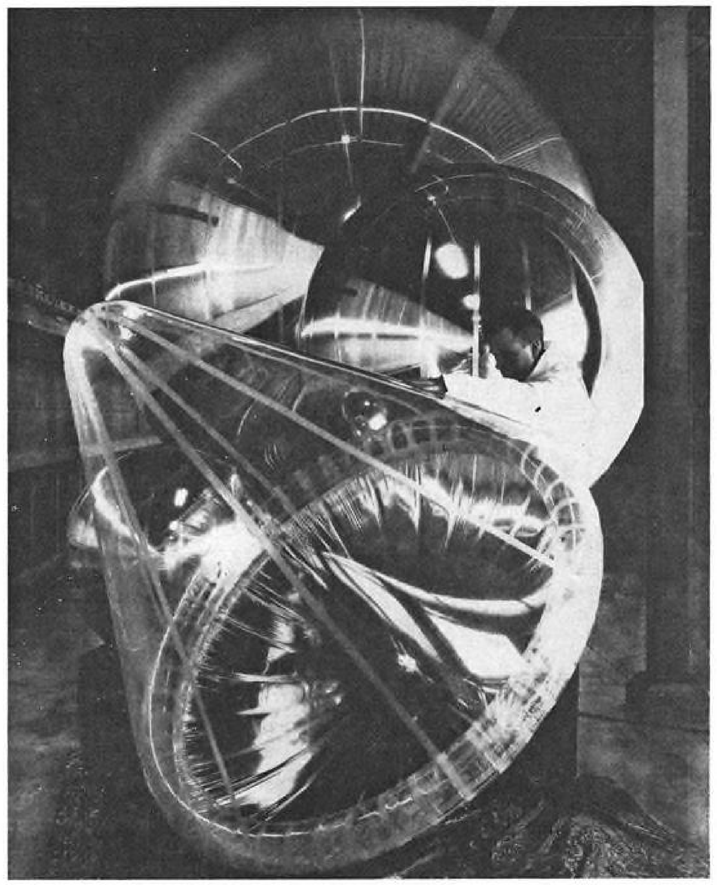
The aluminum membrane and foam liner, which was glued to the membrane, were cut into "pie-segments" with tin snips and passed down through the 24-in.-dia. holes.

The entire job, from removal of the sustainer to replacement of the sustainer, took four days and Ranger 3 was ready for launch on Jan. 26.

The scaffolding was dismantled, crated and stored as ground support equipment for possible future use. Project Mercury personnel are understood to have scoffed at the suggestion that they might someday want to make use of the technique and equipment, but five days after Ranger 3 flew, fuel was detected in the little copper tube on the MA-6 booster and they asked for the equipment.

Because the Mercury 109-D booster is a man-rated booster, (designed to launch a manned capsule), General Dynamics wrote a detailed engineering procedure, which USAF and NASA approved, that outlined every step to be taken in removing the fuel-soaked blanket from the MA-6 vehicle. Every part pulled from the sustainer envelope was tagged sequentially, and every scaffold part was numbered according to a construction plan.

Every step in removal of engine parts,



Rigidized Solar Collector Prototype Shown

Inflatable space structure, six feet in diameter, is the prototype of a rigidized solar collector able to serve as a satellite or space vehicle piggy-back power generating device. The structure, developed by Viron Division of Geophysics Corp. of America, is made of metallized plastic laminate and is designed to be inflated outside the space vehicle. It has a focal length of four feet for beaming sunlight at a thermionic power unit inside the unit. Inflatable target spheres are visible in the background.

erection of the scaffold, removal of the foam liner, dismantling of the scaffold and replacement of the sustainer had to be certified by an inspector, then a second independent inspector, then by an inspection supervisor and finally by a USAF quality control representative.

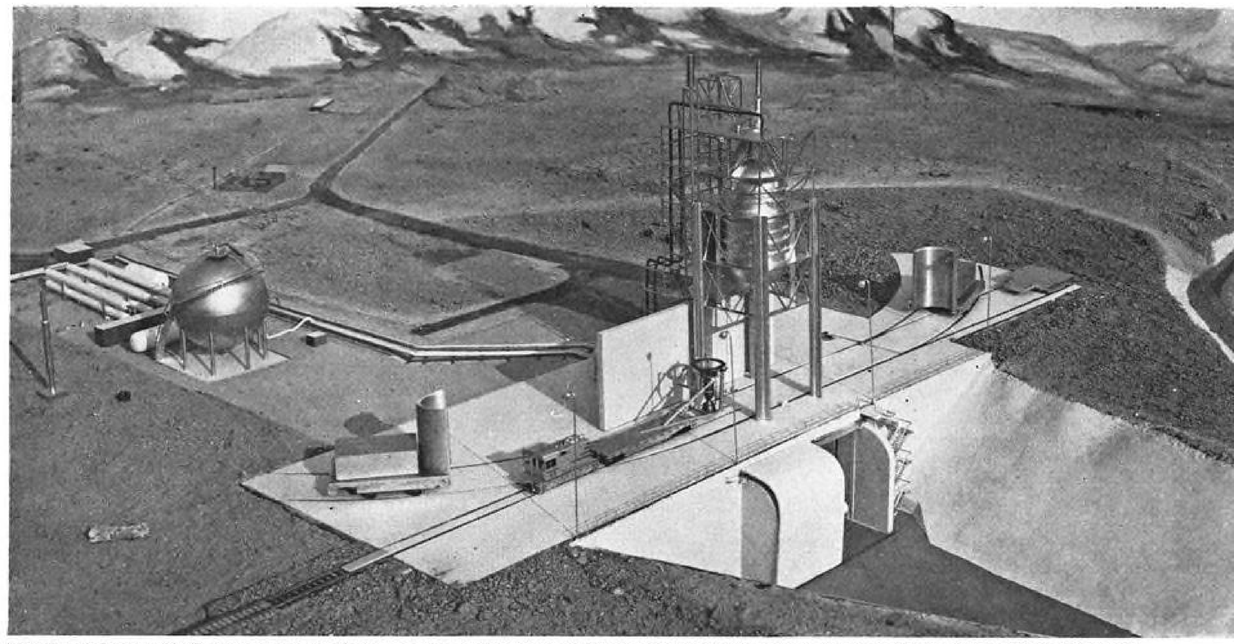
After every action had been taken, four inspectors checked the work against a procedure list. The vehicle was re-certified as being man-rated after the blanket had been removed and the engine compartment put back together four days later.

There were three fears about removing the foam blanket from the man-rated booster:

- **RP-1 might freeze** in small chunks near the top of the fuel tank and that, during flight, they might enter the turbopump and cause a failure.
- **Boil-off rate** of liquid oxygen might increase significantly because of heat transfer from the comparatively higher temperature RP-1 fuel, and might result in less liquid oxygen than was required for orbital injection.
- **Helium**, used to pressurize tanks, might contract because of the cryogenic effect of liquid oxygen and then be less than the amount required for flight.

Fueling Tests

To put these fears to rest, General Dynamics ran five fueling tests after the foam blanket had been removed and the missile reassembled. It was found that with only the stainless steel structural dome between the RP-1 and liquid oxygen, the temperature of the kerosene fuel dropped only from 70F to 50F and did not freeze. Liquid oxygen boil-off was only a few pounds more than normal and helium loss was very slight



MODEL of test stand for first downward-firing nuclear rocket tests of Project Rover Nerva engine shows rocket engine at front of remote-control railroad car, semi-cylindrical aluminum shields that enclose engine in the stand, the 3-ft.-thick concrete wall that forms shield behind stand. Spherical Dewar storage tank at left would hold 250,000 gal. of liquid hydrogen. Gunite channel at right drains away water used to cool flame deflector duct at rate of 45,000 gpm. Fill station is behind storage tanks which are at left rear of Dewar tank. Aerojet-General's Aetron Division designed facility for Atomic Energy Commission's Nevada Test Site.

Nerva Test Stand Construction Advances

By Russell Hawkes

Construction of the first downward-firing nuclear rocket test stand for the Project Rover Nerva engine is now 20% completed and approximately on schedule toward its completion date of Jan. 15, 1963.

Handling and support functions on test stand No. 1 at the Jackass Flats, Nev., site will be conducted by remote control using many techniques developed by Atomic Energy Commission's Los Alamos Scientific Laboratory scientists for the earlier Kiwi series reactors in Project Rover.

Test stand No. 1 was designed for AEC by Aetron Division of Aerojet-General Corp. Aetron also has a contract for test stand No. 2 and the Aerojet Azusa, Calif. plant has recently been awarded the prime contract for the development of the Nerva engine. Engine development contract from the joint NASA-AEC Space Nuclear Propulsion Office provides $26.5 million for work through September, 1962. First flight of the nuclear rocket is not expected before late 1966 or early 1967. AEC contract for test stand No. 1 construction is for $4.6 million.

The 106-ft. high test stand No. 1 is to be made almost entirely of aluminum because other structural materials acquire more intense neutron-induced radioactivity in the presence of an operating reactor. Also, the isotopes activated in aluminum have a much shorter half-life than those produced in such materials as steel and will allow maintenance workers or emergency crews to approach the test stand much sooner after a power run.

The Nerva engine will be brought to the test stand on the front of a special railroad flat-car pushed by a remotely controlled electric locomotive. It will be positioned in the test stand and connected to the permanently emplaced liquid hydrogen propellant tank by remote controls operated by engineers in the control point building a quarter of a mile away. The engineers will observe the operation by closed circuit television. When the engine is locked to its thrust mount and the plumbing, control circuits and instrumentation wiring are connected, the flat-car is to be withdrawn to a shielded site and semi-cylindrical radiation shields are to be brought in on flatcars and closed about the engine.

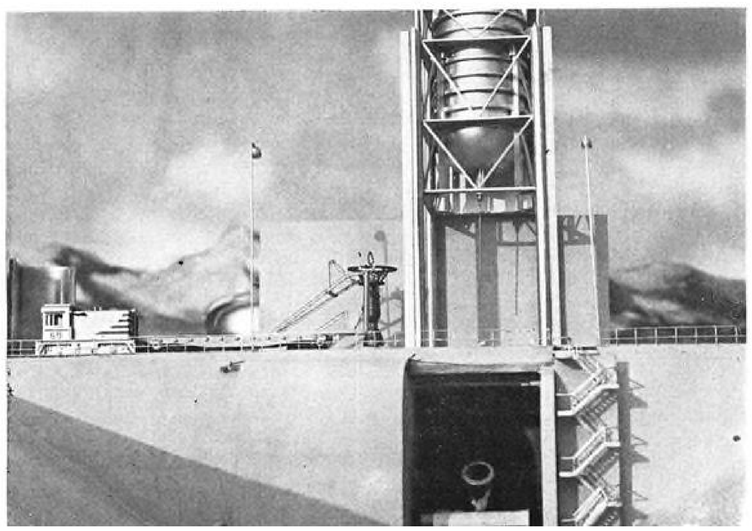
The shielding consists of four hollow aluminum vessels which are filled with water before each run to serve as the shielding agent. This makes it possible to drain off much of the radioactivity induced in the shield. The shield vessels are 30-in. thick. Beside the two movable semi-cylinders, there is one vessel above the engine in the stand and one beneath the ground level of the stand. Together, the four vessels form a sealed chamber which can be evacuated by steam ejector pumps to simulate the low atmospheric pressure of high altitude operations.

A permanent, 3-ft. thick concrete wall provides additional radiation shielding for the fill station building, tank farm and other facilities directly behind the stand. The wall is to be 38 ft. tall and 95 ft. long. Another 30-in. water shield constructed as a sliding door will be used to block radiation from the exhaust deflector duct after each test run.

When the hot engine has been removed, the upper end of the duct will be closed by a cart-mounted, 10-ft. square plug of depleted uranium moved into the stand on the rails.

Exhaust deflector duct of the test stand is much narrower than the open flame buckets of test stands for chemical rockets. This feature is intended to prevent radioactive exhaust gas from curling back into the superstructure of the stand. The duct will be cooled by demineralized water flowing through at 45,000 gpm. during a test. A Gunite ditch in front of the stand will channel

CYLINDRICAL REACTOR CHAMBER of the Nerva nuclear rocket engine (smooth center section) is shown in artist's conception above. Hook-shaped flame deflector duct in chamber in the Nerva test stand's reinforced concrete substructure is shown in model below.



the contaminated water into the desert to sink harmlessly in the sand.

Demineralization of shielding water and duct cooling water cuts the residual radiation in the used water and also reduces scaling in pipes, tanks and components. The processed water comes from a 2.5 million gallon tank located approximately 2,200 yards from the test stand.

The demineralized water is also used to make steam for the altitude simulator ejector pumps. There is a separate utility water system for air-conditioning, drinking, etc.

Superstructure Construction

Superstructure of the stand is made of 6061-T6 aluminum. Main structural members are four hollow, 40-in. dia., 78-ft. tall columns. The 77,000 gal. liquid hydrogen propellant tank can be moved vertically within a 15 ft. range if specific tests require it. A five-ton capacity elevator gives access to five work platforms in the tower. The liquid hydrogen system includes a 250,000 gal. storage dewar in the tank farm and a 4,400 gal. high pressure run tank at the foot of the stand. The latter contains fuel for the hot gas generator that powers the propellant turbopump. Oxidizer for the gas generator is liquid oxygen from a 550 gal. high pressure run tank. There is a 22,000 gal. liquid oxygen storage vessel on the site.

A steam generator for the ejector pump, located in the exhaust duct, burns propane fuel.

Liquid Nitrogen

Liquid nitrogen from a 31,000-gal. storage tank is carried through jacketed piping to be used for cool-down and purging of the engine and deflector duct.

The control point building for the entire nuclear rocket test facility is located 1,050 ft. from the stand below a utility equipment building and under five feet of earth.

The test stand and all the underground facilities are linked by an 8-ft. wide tunnel with a shielded entrance 1,258 ft. from the stand. The tunnel is the air discharge duct for all the underground buildings. The air is discharged at the test stand end of the tunnel so that it is always moving away from workers.

Off-set turns in the tunnel serve as radiation traps. Controls and instrumentation for transferring fluids and electronic repair facilities are located in a forward control room below the fill station. A test cell building is located 100 ft. behind the test stand and a test stand equipment room is buried 9 ft. under the test stand. Neither would be occupied during a run.

CONVAIR 990, shown here in Scandinavian Airlines System markings, is one of seven ordered by Swissair, two of which will be leased to SAS. Drag reduction program will include fairings on the aft portion of the engine nacelles and a smoother leading edge on the wing.

Aviation Week Pilot Report:

990 Demonstrates Safety and Economy

By William S. Reed

San Diego, Calif.—Handling qualities of the General Dynamics Convair 990, latest of the jet transports to receive approval for passenger service, compare very favorably with previous Convair transports.

From a maximum speed of 620 mph. at 21,500 ft. to a post-stall indicated airspeed of 98 kt., characteristics of the 990 are predictable, control forces and movements are at pilot-preferred levels and operating crews should find the 990 a pleasant aircraft to fly. Increased thrust of the General Electric CJ805-23B aft-fan engines makes the heavier 990 perform in the same field lengths as its predecessors, the 880 and 880-M transports.

Economical cruising speeds with good specific fuel consumption make the 990 competitive from an operating standpoint.

This Aviation Week pilot flew the No. 8 990, serial number SE-DAY, which is one of seven ordered by Swissair and one of the two which that carrier will lease to Scandinavian Airlines System. In SAS markings, the 990 weighed in at 162,832 lb. including a fuel load of 50,000 lb. The interior of the aircraft is configured for 42 first-class and 57 coach passengers.

The crew consisted of Convair Engineering Test Pilot William H. Harse, Production Test Pilot H. L. Burt, and Flight Engineers L. A. Scrivener and J. J. Coil. Maximum certificated gross weight for the 990 is 246,200 lb. so that this flight was not very representative of the performance characteristics of the aircraft at full load. However, general flight characteristics and handling qualities were assessable.

Takeoff from Lindbergh Field was made on Runway 27 which is 8,100 ft. long. Maximum gross weight operation with the 990 is not permitted out of Lindbergh because rising terrain on both ends of the longest runway does not afford sufficient clearway.

Layout of the 990 cockpit is very similar to that of the 880 series (AW May 29, 1961, p. 48) with the exception of a few minor changes. The elevator trim wheel has been replaced by a knob for longitudinal trim. Trim also is provided for in a thumb-operated switch on the control wheel and emergency switches on center pedestal.

The General Electric CJ805-23B aft-fan engines used on the 990 require the addition of one more engine performance instrument on the panel—fan rpm. In the 990, the tachometers for the fans are located directly under the EPR (Exhaust Pressure Ratio) gages and show rpm. in per cent. Under the fan rpm. gages are the EGT (Exhaust Gas Temperature) gages, below them are the main engine tachometers and, on the bottom, the fuel flow gages. Confusing in this arrangement is the fact that the gages for the two most important parameters, EPR and engine rpm., are not together. Takeoff, climb and cruise thrust are set by EPR and cross checked with engine rpm. and EGT. Fan rpm. actually tells the pilot nothing after it has been cross checked for takeoff thrust—fans add about 40% to total sea level thrust—and once in the air, fan rpm. tells nothing beyond the fact that the fans are turning. Fan rpm. is proportional to the exhaust flow through the turbine and is neither controllable nor governed. It would seem that the fan tachometers should be moved to the bottom of the panel or to the flight engineer's panel.

One other troublesome area was the nose wheel steering which requires considerable force both because of its small diameter and a rather high force gradient. Control with the wheel is positive and not subject to rapid deflections even at relatively high speeds on takeoff roll. The 990 does not have nose gear steering coupled to the rudder, a feature that was found useful during ground operation.

Takeoff was made on Runway 27. Ambient temperature was 70F and wind was calm. Takeoff performance charts

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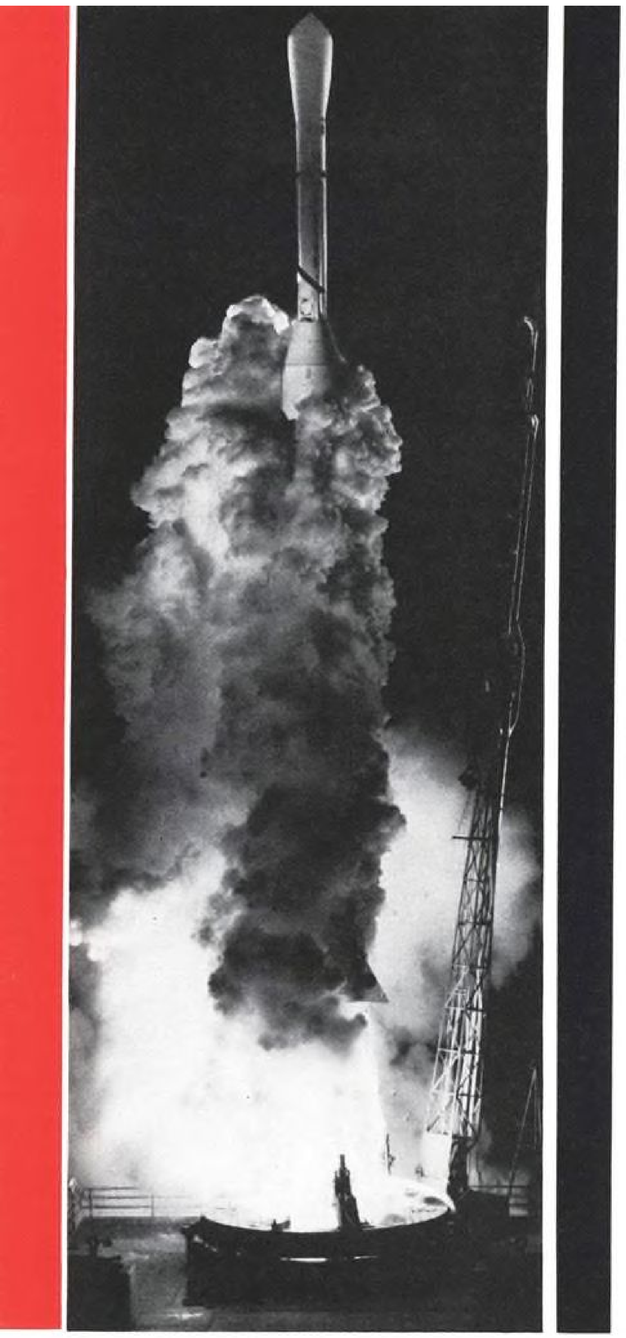

EHR was developed by Texas Instruments, working with Douglas Missiles and Space Systems Division, prime contractor to NASA for the Delta space vehicle program. EHR helps assure the success of programs such as the TIROS II, shown here boosted by the NASA/Douglas Delta space vehicle.

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A new concept in semiconductor reliability has evolved from Douglas Missiles and Space Systems Division's and the National Aeronautics and Space Administration's determination to assure 100% systems success in Delta space vehicles. This concept, termed **EHR** for Extreme High Reliability, is concerned at present with orbital and deep space probes launched by the Douglas-built Delta. Texas Instruments engineers worked with NASA and Douglas personnel, beginning with a complete re-examination of current manufacturing philosophies . . . all the way through to helping establish the systems reliability standards. In essence, this program defines **EHR** as "building-in quality in addition to testing for it." **EHR** had to be much more than just another testing program, for testing the finished product cannot guarantee the conditions under which it was made. To provide NASA and Douglas with "Space-Quality" parts, Texas Instruments began its evaluation procedures by 100% testing and inspection of every piece of material and equipment used in the manufacture of devices. **EHR** Quality Control procedures include microscopic inspection at each stage of manufacture, beginning with materials and parts inspections before the assembly process is started. Assembly is performed in controlled atmosphere, under positive pressure to help ensure the elimination of all foreign material. Even the jigs used to hold the devices throughout the assembly processes are subject to the same microscopic scrutiny as the devices they carry. ■ These are but a few points in the **EHR** program, developed jointly by NASA, Douglas and Texas Instruments. A partial list of tests given **EHR** devices AFTER manufacture are listed below. ■ **Particle Detection** — This test checks for possible foreign material (internal wire leads, solder balls, etc.) in the encapsulated unit. This method uses a vibration table set at 10g zero to peak in conjunction with a piezoelectric accelerometer, electrical filter and oscilloscope, with the accelerometer mounted in a special fixture designed to hold the accelerometer directly against the can. This test detects metallic contamination weighing 9 micrograms or greater. ■ **Constant Acceleration** — The purpose of this test is to demonstrate the mechanical endurance of the device under extreme conditions, to simulate actual intended system usage. Depending on the device, each transistor is tested in the Y_1 plane with a centrifugal acceleration of 5,000 to 35,000 g's applied to the device (non-operating) for one minute. ■ **Operating Test** — Since the first 250 hours of device operation are the most critical, the "Power Burn-In" test is performed on each unit to assure device stability. Each device is operated for a minimum of 250 hours at T_A = 25°C under full dissipation (P_C) condition. ■ **Dew Point** — This test is to determine if moisture is present within the encapsulated device. I_{CBO} is monitored as the device temperature is varied from T_A = −65°C to 25°C under operating conditions. Continuity with respect to temperature must be observed in I_{CBO}. ■ **Vibration (Monitored)**—This test establishes the device's electrical characteristics in an environment similar to that seen in actual missile system application usages. The device is subjected to vibration at 60 – 5 cps at a minimum peak acceleration of 15 g's for a period of 30 seconds. During the test, the forward voltage vs current characteristics are monitored for flutter, shift, discontinuity, ringing or other instability. ■ **High Temperature Test (non-operating)** — This test is to determine the stability of the devices electrically after elevated temperature conditions. The transistors are stored at an ambient temperature of 200°C ± 50°C for 250 hours minimum. ■ **EHR** is an all-out effort by Texas Instruments to achieve the long sought goal of providing the Systems Designer with "Space-Quality" parts, i.e., devices approaching 100% reliability. ■ You can give **your** circuits semiconductor reliability far in excess of that previously available. You can specify devices produced under all of TI's **EHR** techniques or only those applicable to your specific military or industrial needs. ■ The manufacturing techniques and testing that comprise **EHR** result from TI's depth of technological skills, plus the determination and willingness to meet every TI customer's requirements. Today, more than ever before, in service, reliability and experience, you can rely on TI.

The basic concept of EHR is "building-in reliability in addition to testing for it." Pictured above is an EHR semiconductor line at Texas Instruments. Each EHR device is subjected to repeated 100% microscopic inspection under positive pressure, controlled atmosphere by TI's independent Quality Assurance department. EHR is an all-out effort by TI to achieve the long sought goal of providing the systems designer with "Space-Quality" parts.

For complete details on how you can take advantage of these new TI **EHR** techniques to improve your product reliability, write on your company letterhead for **EHR** Brochure to Department 59, Texas Instruments Incorporated, 13500 N. Central Expressway, P. O. Box 5012, Dallas 22, Texas. Or call your local TI sales office and ask how **EHR** can help you.

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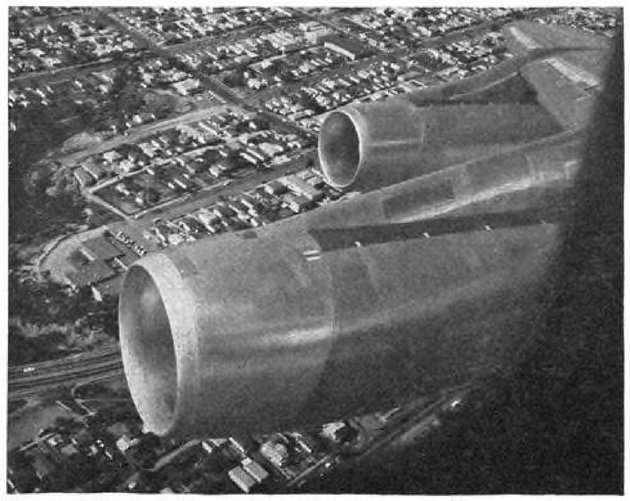
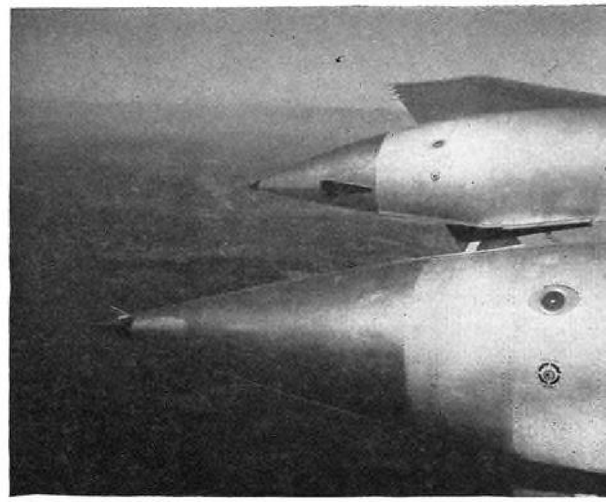




LEADING EDGE SLATS, extended here on final approach to landing (left), will be replaced by Kreuger flaps to provide cleaner wing leading edge for cruise condition. Deep engine intakes are standard with fan engines. Wing anti-shock bodies (ASB) on the 990 (right), are used for fuel storage—outboard pods holding 6,265 usable pounds and inboard pods 4,942 lb. Speed is restricted to 355 kt. or Mach .78 with fuel in the ASBs, but this generally does not affect cruise performance as this fuel is used first. Area rule effect of the anti-shock bodies is most effective above Mach .90.

showed that for the prevailing conditions at a gross weight of 162,832 lb., V_1 speed was 121 kt., V_R was 125 kt. and V_2 was 141 kt. These figures meant that if everything was going well at 121 kt., it would be safer to continue takeoff than to attempt to abort, that the aircraft should be rotated into takeoff position as 125 kt. appeared on the airspeed indicator and that initial climb speed was to be held at 141 kt. until 1,500 ft. altitude had been gained. At maximum gross weight, the speeds would have been: V_1-156, V_R-163 kt., V_2-175 kt. Power settings for the 70F day were: EPR 1.93, engine rpm. 94.5%, EGT 640C. Throttles were pushed up to power by the pilot and the final EPR settings trimmed up by the copilot while on takeoff roll.

Extra thrust of the CJ805-23B engines was readily apparent during takeoff, especially at the light gross weight. Rudder control became effective at about 70 kt. at which time the nose wheel steering could be abandoned. A pull force of about 40 lb. on the control was sufficient to produce a smooth takeoff.

Deck angle during initial climbout is quite steep at low weights but over-the-nose visibility was not a problem because the wing on the 990 is mounted at 4 deg. incidence rather than the 2 deg. of the 880. The extra 2 deg. of incidence also allows for more reasonable angles during takeoff and landing with less possibility of scraping the tail.

Power was reduced to maintain 250 kt. IAS (indicated airspeed) at 1,500 ft. until departure from the San Diego Control Area. Once this was accomplished, the engines were increased to climb power, EPR 1.76 and the 990 allowed to accelerate to 350 kt. IAS.

At 21,500 ft., the aircraft was leveled off and the engines set at maximum cruise power in order to check the top speed attainable with this power. Reason for selecting 21,500 ft. is that at this altitude the greatest true airspeed can be attained before reaching maximum permissible indicated airspeed.

Maximum Speeds

It is this altitude at which maximum speeds for advertising purposes are determined. At a higher altitude, the aircraft becomes Mach-limited, and at a lower speed, it becomes limited by maximum dynamic pressure, or "q" force. Then too, as altitude increases, temperature drops and so does the speed of sound. Thus, at 21,500 ft., Mach 1 is 610 kt. while at 35,000 ft. Mach 1 is 575 kt. In theory then, as well as in practice, maximum level flight speed is attainable in subsonic aircraft at approximately 21,500 ft. It is interesting that the airlines' boasts of speed are based on the cruising speed at maximum continuous power at 21,500 ft. altitude. Certainly no airline would operate at this altitude over any but the shortest route segments. Consider fuel consumption at two different altitudes and two different speeds:

• **At 20,000 ft.** speed-power curves for the 990 at a gross weight of 160,000 lb. show that specific range at a high Mach number cruise, 0.835, is .0250 nautical air miles per pound of fuel (NAMPPF). In other words, the aircraft will travel 25 naut. mi. on 1,000 lb. of fuel. This Mach number at 20,000 ft. on a standard day yields a true air speed of 485 kt. or 560 mph. At a more economical cruise of Mach .565 or 259 kt., specific range increases to .0358 NAMPPF, a 30% increase.

• **At 35,000 ft.,** specific range is enhanced even further. Cruising at Mach 0.863, or a true airspeed of 467 kt. yields a specific range of .0420 NAMPPF. Most economical cruise at 35,000 ft. is Mach .768 or 420 kt. TAS, and this yields a specific range of .0485 NAMPPF. The latter shows an increase of about 13% in specific range.

Thus, while factors other than fuel consumption enter into direct operating costs, it can be shown that fuel costs rise so rapidly near the high speed end of the cruising spectrum that advertised speed is seldom flown by an airline. Fuel consumption is nearly doubled by cruising at maximum cruise thrust at 20,000 ft. as against maximum cruise thrust at a more economical altitude. It is doubtful that any operator would cruise at 20,000 ft. and burn twice as much fuel in order to attain an increase of 18 kt. in speed. Although the fuel consumption figures quoted are directly applicable in this case to the 990, they are representative of the specifics for all jet aircraft. Numbers would vary slightly but the percentages would hold true.

A check of the 990's top speed at maximum cruise thrust was made at at 21,500 ft. EPR for maximum cruise thrust was set at 1.76 and the craft settled down at an indicated true airspeed of 535 kt. This airspeed reading is not corrected for standard day nor for instrument error but can be taken as close to true because of built-in corrections to the TAS indicator. Gross

INSTRUMENT PANEL of the 990 has 20 major engine instruments grouped in the center panel. Gages in rows are, top to bottom, exhaust pressure ratio (EPR), fan rpm., exhaust gas temperature (EGT), engine rpm. and fuel flow in kilograms per hour.

weight at this time was about 150,000 lb. and guaranteed speed must be made at nearer to 200,000 lb. gross weight.

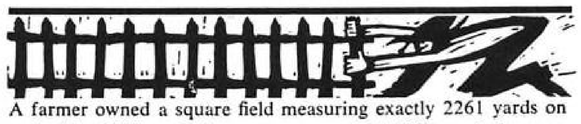
The 990 handled well at high speed with an indicated air speed of about 430 kt. Buffet was barely perceptible and about the only noticeable change was an increase in aerodynamic noise. Although the noise level increased appreciably in the cockpit area as speed increased, the cabin noise level increased very little because of better acoustical damping there than in the flight compartment.

Taking advantage of the speed which the 990 had built up at 21,500 ft., the velocity was traded for altitude and the craft climbed rapidly to 35,000 ft. for a check of cruising conditions at a more nearly optimum altitude. At the light gross weight, the 990 settled out at an indicated airspeed of 300 kt. after engine power had been set according to the ram air temperature (RAT).

EPR setting for cruise was 1.87 which was obtained from the engine chart after temperature rise of 24C due to velocity was subtracted from the RAT reading of −25C. Engine rpm. was 92%, fan rpm. was 87%, fuel flow 2,980 lb./hr./engine, indicated Mach number was .88 and true airspeed worked out to 503 kt. (580 mph.). Roughly calculating, the 990 was achieving a specific fuel consumption of 0.0423 NAMPPF.

Handling qualities at 35,000 ft. were good. Positive speed stability (increased nose-up tendency with increased speed) is provided by a pitch trim compensator, a standard practice among manufacturers because swept wing aircraft tend to pitch down as the Mach divergence drag number is approached. None of the axes of control seemed critical near the limiting Mach number. Lateral control is not critical. Response rate and force gradient on the ailerons is such that positive control is assured and there is no tendency to hunt for neutral. Even with the yaw damper turned off, the 990 showed no tendency to Dutch roll when uncoordinated rudder-aileron pulses were fed in. Damping with the yaw damper on was very rapid and without the assistance of the damper,

PROBLEMATICAL RECREATIONS 107



A farmer owned a square field measuring exactly 2261 yards on each side. 1898 yards from one corner and 1009 yards from an adjacent corner stood a beech tree. A neighbor offered to purchase a triangular portion of the field stipulating that a fence should be erected in a straight line from one side of the field to an adjacent side so that the beech tree was part of the fence. The farmer accepted the offer but made sure that the triangular portion was of minimum area. What was the area of the field the neighbor received, and how long was the fence? — *Contributed*

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ANSWER TO LAST WEEK'S PROBLEM: The solution is to find a symbol or group of symbols that in themselves represent a whole number and by repeating these expand the total to any value. One such group is $e^{i\pi} = -1$. Therefore $\sqrt{4} + e^{i\pi} + e^{i\pi} = 0$; $\sqrt{4} + e^{i\pi} = 1$; or $4 - e^{i\pi} = 5$; etc.

the induced oscillations damped out in a positive manner with each succeeding oscillation reaching about one-half the amplitude of the previous one. Without dampers, the pilot could correct for an induced Dutch roll without any tendency for the maneuver to become divergent.

Letting down from 35,000 ft. while heading for landing and system checks, handling at maximum normal operating speeds, V_{no}, was assessed. V_{no} is 375 kt. below 21,400 ft., and 415 kt. or Mach .91 whichever is less, above 21,400 ft. V_{ne} never exceed speed, is 430 kt. or Mach .92. Emergency descents at V_{ne} with idle power, speed brakes out and main landing gear extended can be quite rapid. Extreme deck angles of 30 deg. can be attained with little effort and such procedures should be used only during emergency conditions, such as loss of cabin pressure.

Stall Characteristics

A full stall at 12,000 ft. proved the docile handling characteristics of the craft. At idle power, flaps and gear down, the onset of buffet started at about 120 kt. With decreasing airspeed, buffet became progressively heavier, getting unmistakably severe near the stall in the classic tradition. At the stall, Harse, in the right hand seat, pulled the yoke full aft to demonstrate a complete stall. Airspeed showed 98 kt. and the aircraft unquestionably was stalled. Aileron control remained good until the last.

Recovery from stall was performed in a conventional manner and about the only difficulty experienced by this pilot was a little overworking of the rudder. Some directional instability seemed present until the 990 started to fly again but most of this was pilot-induced. There was no apparent tendency to pitch up or roll uncontrollably at stall and the heavy buffet provides enough natural stall warning to make inadvertent stalling virtually impossible.

The 990 handles well in the approach configuration. Reference speed, V_{ref} for landing at 140,000 lb. gross weight was 129 kt. and airspeed was held at 140 to 145 kt. on the final approach after the flaps had been lowered to 50 deg. Airspeed gradually was decreased to 135 kt. over the fence. Lightness of the rudder forces on the 990 with the full-powered rudder control is conducive initially to over-controlling on the directional axis but this can be compensated for with a little practice. Anticipating higher forces, which by experience are expected in jet transports, causes more rudder deflection than is necessary initially. This was especially true on the first landing approach in moderate turbulence at Ontario International Airport. Lateral-directional stability seems ample although some pilot-induced instability was apparent at first because of the light rudder forces.

Indicated speed of around 100 kt. showed on the airspeed meter as the aircraft touched down and it was evident that sufficient elevator power was available to fully stall the aircraft. Attitude at touchdown seemed moderate but turned out to be quite nose-high as the nose dropped through after touchdown. A somewhat lower attitude had been anticipated because of the 2 deg. added incidence in the wing and probably at a more operationally realistic landing weight the attitude would not have been so great. Added angle of wing incidence also virtually assures that the tail will not drag even under severe conditions. However, it is possible to scrape it.

Spoilers on the 990 can be actuated by the pilot even before the nose contacts the ground and will contribute to initial deceleration and shortening of the landing roll as do the nose wheel brakes. The latter permit stopping the aircraft about 400 ft. shorter on landing roll. Reverse thrust actuates rapidly and proved effective. The clamshells reversed thrust of both the fans and the engines. Actuation of the reversers probably will be delayed somewhat in the modified versions of the 990 because of the fairing on the aft end of the nacelles designed to give better aerodynamic flow. During reverser operation, this fairing will have to move aft on a track before the clamshells can close to begin forward diversion of the thrust.

Modifications Tested

Modifications to the airframe designed to reduce drag to the point where the aircraft will exceed guaranteed speed already have been tested. Boilerplate fixes consisting of glass fiber and balsa wood fairings have been flown on the No. 1 aircraft and Convair engineers have taken data showing that 539 kt. true airspeed (620 mph.) has been reached. Actually, the test aircraft has surpassed 539 kt. but the fixes are being refined to ensure that sufficient increase in speed is gained to provide a margin to take care of production tolerances. Just what margin is sought Convair will not say since the ultimate speed attained will be a basis for negotiation between the company and American Airlines. Confidence has been expressed that the extra speed picked up in the modification program will be sufficient to ensure that American exercises an option on the purchase of five additional 990s. The option is contingent on meeting guaranteed speed.

Fixes include:

• **Engine nacelle fairings** to reduce the high boat-tail drag caused by the large diameter exhaust nozzle of the aft-fan engine. Shape of the nacelle is changed for better aerodynamic qualities. Thrust reversing will be complicated because the fairing will have to slide aft before the reverser clamshells can be actuated.

• **Smoother wing leading edge** contour which is achieved by eliminating slats. Kreuger-type flaps, now used only on the inboard leading edge, will be put on full span. A smoother contour can be maintained because the Kreugers can be faired into the wing and be made to fit flush when retracted whereas slats present a more difficult fairing problem.

• **Aerodynamic cleanliness fixes** which, although small in nature separately, will be incorporated to ensure that the extra margin is gained which will ensure compliance allowing for production tolerances. These include smoothing the engine pylons and extending the wing fillet at the trailing edge root.

Replacement of leading edge slats with the Kreuger flaps will result in no degradation of landing performance, Convair engineers say, adding that landing performance will be demonstrated on the No. 1 aircraft in boilerplate fashion with bolt-on flaps. Date for demonstration of the first aircraft with production fixes will be about May 15. Incorporating the fixes in the production line will be accomplished as approved and it is likely that all or most of the 990s delivered will be modified. Actual dates or terms of modifying aircraft delivered in the interim configuration are not settled.

American will begin service Mar. 18 on its New York-Chicago route with unfixed aircraft.

990 Certification

Certification of the 990 has been plagued by difficulties almost from the beginning when a six-month delay in obtaining Federal Aviation Agency approval for the aircraft was necessitated when a limited-cycle pod oscillation was discovered (AW Mar. 20, p. 34). Present modification program to increase speed has no bearing on the operation of those aircraft in service except that the higher speeds will have to be demonstrated to the FAA prior to certification.

Sales of the 990, and of General Dynamics/Convair's entire commercial jet program, have been disappointing. As it stands now, General Dynamics/Convair will build a total of 101 jet transports, 90 of which have been definitely sold, if American Airlines exercises its option for the purchase of five additional 990s. Convair has built and sold 47 880s. Production on the 880-M

will total 17 aircraft of which 13 have been sold so far. Just where the break-even point is would be hard to define. Usually it lies near the 200 mark but whether or not the development of the 990 model can be considered an entirely separate program is not yet certain.

Even barring the delays due to unforeseen developmental problems, break-even for both models probably was around 350 aircraft. The losses of around $400 million Convair suffered in the program are not hard to understand considering high development costs balanced against sales of about one-fourth the total required to show a profit.

RW.3 Multoplane Production Dropped

Geneva—Rhein-Flugzeugbau GmbH., German aircraft firm, is discontinuing production of its RW.3 two-seat Multoplane series.

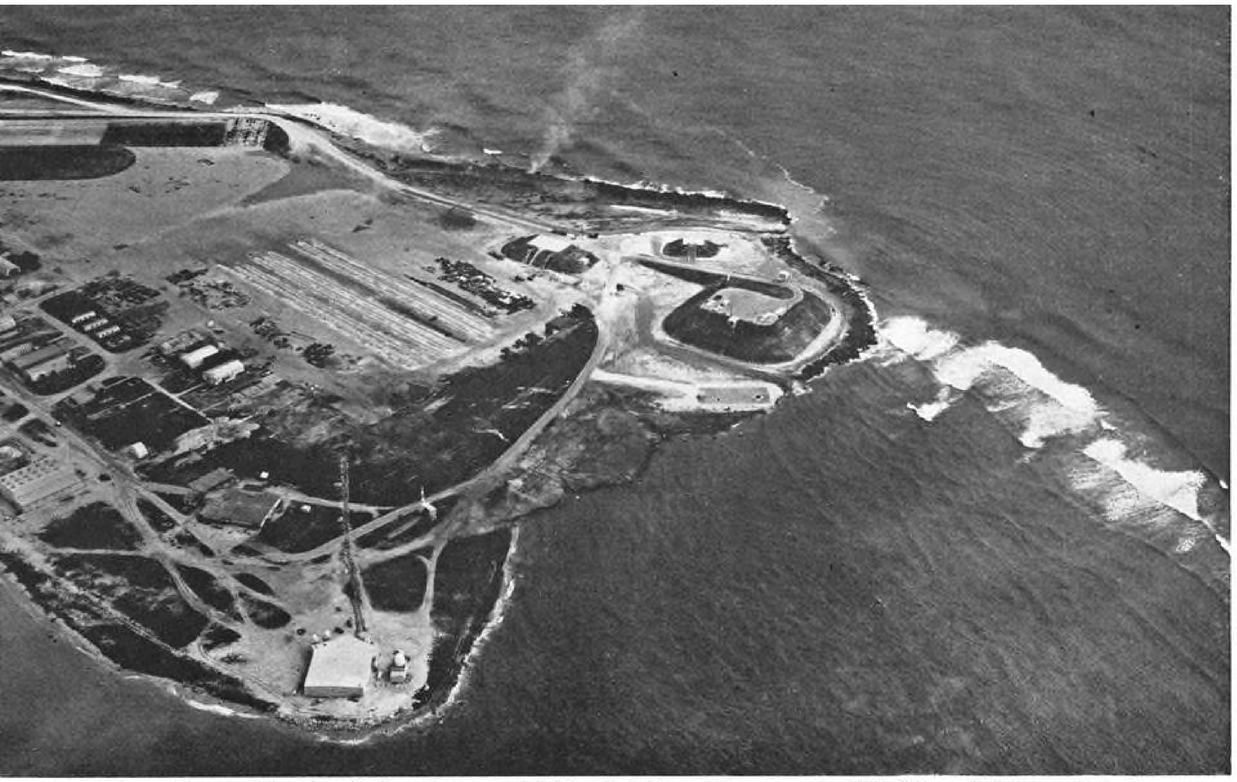
Powered by a single 678/4 Porsche engine rated at 75 hp. at 4,600 rpm., which replaced an earlier Porsche 65-hp. unit, the aircraft still proved to be underpowered, according to company officials.

This was particularly true of its performance in the warm climates of Central and South America where officials had anticipated a relatively large market potential.

A second version powered by a 150-hp. Lycoming engine was considered, but production costs proved too high for any large-scale production.

Rhein-Flugzeugbau, located in Krefeld-Uerdingen, near Dusseldorf, acquired production rights to the RW.3 in 1957 from Rhein-West Flug Fischer and Co., the firm responsible for the original design. With cancellation of its agreement with the Krefeld company, Rhein-West Flug is now seeking another manufacturer to continue to build and develop the RW.3 series under license.

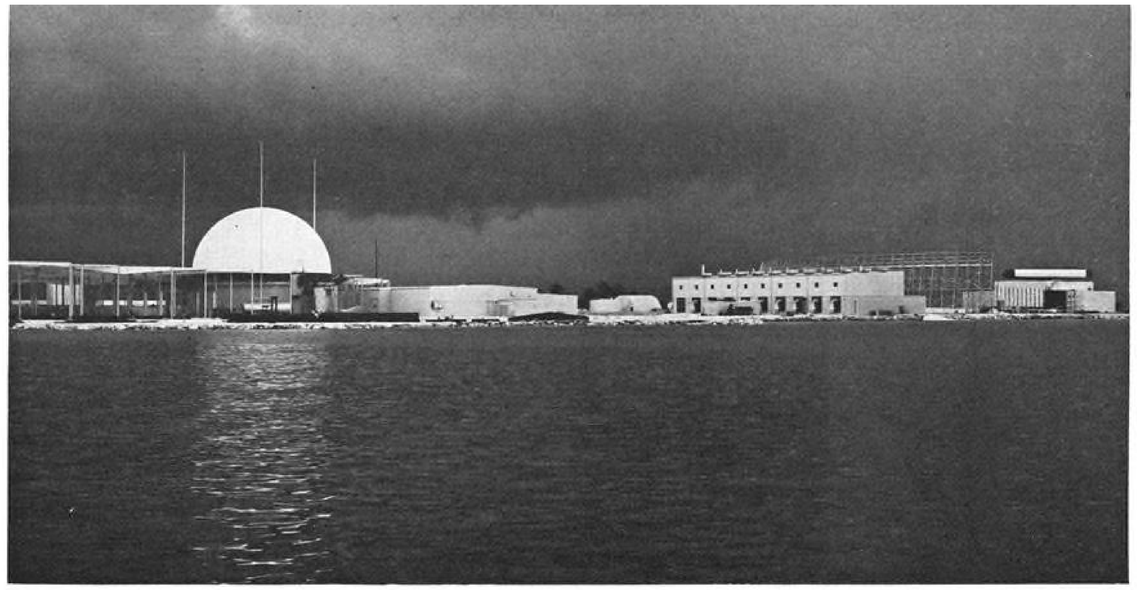
Rhein-Flugzeugbau says it is now concentrating on the completion of its twin-engine RF-1 six-seat executive aircraft, a channel-wing monocoque structure made primarily of plastics to reduce maintenance costs (AW Dec. 19, 1960, p. 108). Pending completion of a number of modifications being made to the RF-1, which embodies several unconventional design features, first flight of the prototype has been delayed for over a year. According to the manufacturers, it will now be used as an experimental aircraft for other pusher plane developments. In addition, Rhein-Flugzeugbau is currently undertaking the manufacture of aircraft parts and spares for several other German companies.



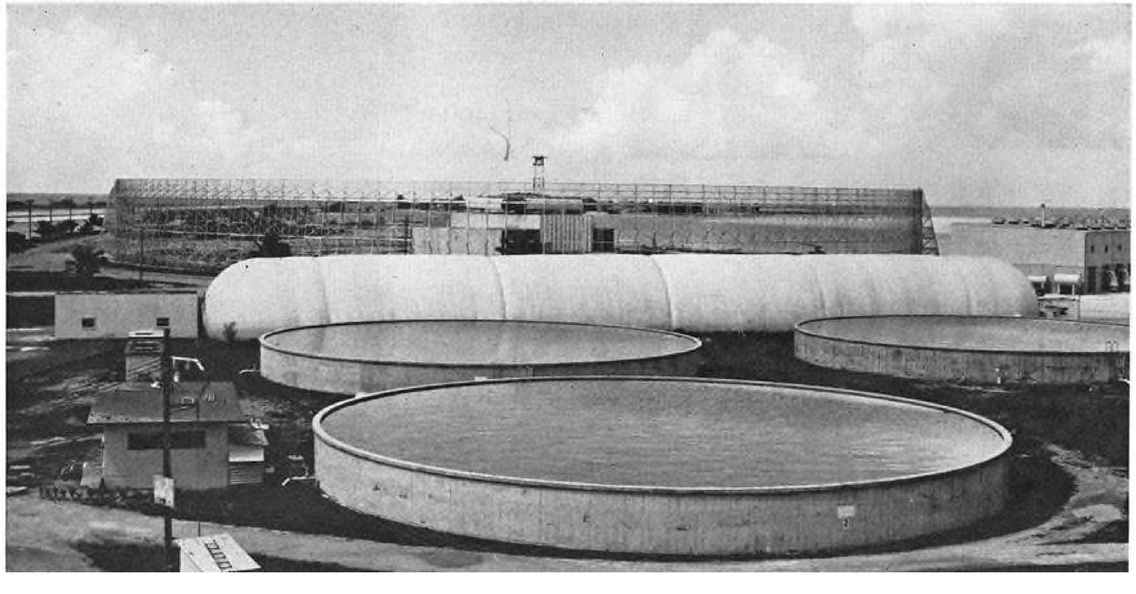
All four underground launch cells have been completed in Kwajalein atoll's man-made "Mt. Olympus" (center, right) to accommodate Nike Zeus anti-ICBM missiles to be fired this summer in interception tests against Atlas-boosted re-entry vehicles.

Kwajalein Site Pushed for Re-entry Target Tests

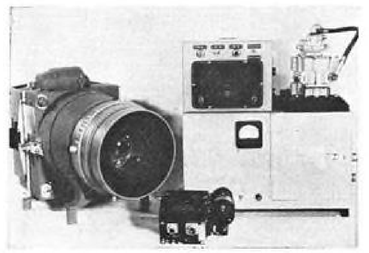
Two battery control radars (right) each will guide a Nike Zeus to intercept re-entry vehicle. Third control radar is under construction to complete the installation. Askania optical tracker (left), an auxiliary element, also checks intercept course (AW Dec. 18, p. 79).



Upper half of acquisition radar's receiver (top photo) appears as white dome surrounded by three lightning-arrester poles. On top of building at far right is transmitter of acquisition radar, which can scan 360 deg. in azimuth and 180 deg. in altitude for full hemisphere vision. Adjacent to transmitter is anti-clutter beam-forming fence which eliminates ground interference for the transmitter. Fence has now been continued so that it is a complete circle for 360-deg. coverage. Target track radar (center photo) looks at oncoming re-entry vehicle and feeds its instantaneous space position to Nike Zeus battery control radar. Bottom photo shows drinking-water storage tanks on Kwajalein, the sausage-type inflated building used for storage of foam blocks used in the receiver (Lunesberg lens) dome and, in the rear, the circular beam-forming fence for the transmitter. The Ralph M. Parsons Co., Los Angeles, is architect and engineering contractor for all of Army's Nike Zeus facilities.



NEW AEROSPACE PRODUCTS

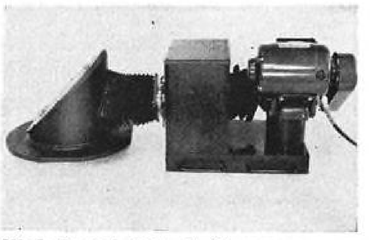


Large-Negative Camera

New 57-GE Recording Camera is designed to photograph large groups of panel-mounted instruments, wind tunnel monotubes and other data recording equipment.

The camera can take a series of single exposures, be remotely controlled or operated automatically in conjunction with an intervalometer at pre-selected intervals. The camera has a 3-sec. cycling rate and incorporates a 12-in. f/2.5 lens in a focusing mount to provide sharp focus from 10-15 ft. Film format is 9 in. square. Film magazines, which can be changed rapidly, have a capacity of 200 ft. of 9½-in.-wide film with 250 exposures.

Gordon Enterprises, 5362 N. Cahuenga Blvd., North Hollywood, Calif.



High-Speed Streak Camera

New camera was designed to record the pinch flash during operation of a plasma engine. A special mirror system is incorporated to permit single or compound image recording.

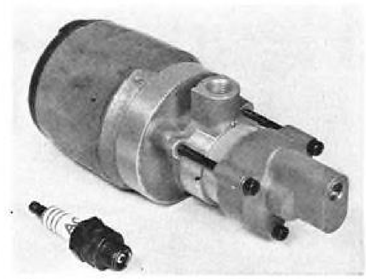
Primary optical system records the pinch flash as a long modulated streak on a 10-in. strip of 16 mm. film moving at 5,000 in./sec. Secondary optical system projects precise, synchronized time marks at 10-microsecond intervals on the film edge from an electronic mark generator within the camera to determine energy variation by time in the pinch flash.

To attain high velocity, the film is placed inside a cast aluminum rotor driven at 30,000 rpm. by an electric motor.

Photomechanisms, Inc., 15 Stepar Pl., Huntington Station, N. Y.

Electric Fuel Pump

New pump, applicable to small aircraft, is said to provide automatic pressure control without need for return lines to the fuel tank.

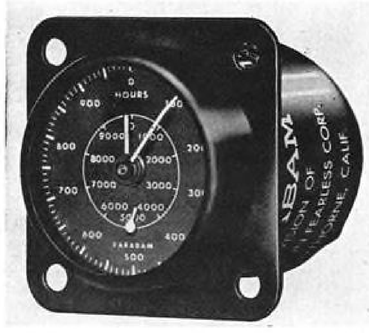


Pump operates at pressures up to 60 psi., with sufficient output for engines up to 400 hp. The device is less than 8 in. long with 3 in. dia., incorporates three moving plungers actuated by a wobble plate, and requires no lubrication. Fuel enters the pump through hollow plungers to maintain unidirectional flow. Automatic pressure control is achieved with a pressure-sensitive valve operating in the pump's high pressure area.

AC Spark Plug Division, General Motors Corp., Flint, Mich.

Subminiature Time Meter

Time totalizing meter is said to accurately indicate elapsed operating time of aircraft and missile electronic equipment and systems for determination of



reliability, prevention of failures and improvement of maintenance.

The meter incorporates a 21-jewel watch movement and a spring-coupled 28 v.d.c. torque motor. The instrument weighs approximately 2 oz. and has a face diameter of 1.04 in. It is available in operating ranges of 1 to 1,000 hr. or 10 to 10,000 hr.

Parabam Division, Houston Fearless Corp., 12822 Yukon Ave., Hawthorne, Calif.

USAF Contracts

Air Force has recently awarded these contracts within the aerospace industry:

Hughes Aircraft Co., Culver City, Calif.—$2.5 million (supplemental) for research and development of an aircraft fire control system; $1,051,926 (supplemental) for provision of technical services for the F-106A/B in-service engineering test program.

Lockheed Aircraft Corp., Burbank, Calif.—$2,139,640 (supplemental) for services and materials used in maintenance and modification of C-121 aircraft; Sunnyvale, Calif.—$1,084,480 (supplemental) for Agena equipment and launch support; $5.5 million (supplemental) for design, development and fabrication of Agena B space vehicles, $1.3 million (supplemental) for production of long lead-time follow-on items for Agena B vehicles.

Sylvania Electric Products, Inc., Mountain View, Calif.—$4,435,000 (supplemental) for engineering, fabrication and installation of prototype radar equipment; $3,203,520 (supplemental) for engineering and fabrication to complete a communications system prototype.

Cessna Aircraft Co., Wichita, Kan.—$1.65 million (supplemental) for T-37B aircraft production.

Douglas Aircraft Co., Santa Monica, Calif.—$1.25 million for production of Thor boosters.

Avco Corp., Stratford, Conn.—$9,104,962 for production of T-53 turboprop engines for Army AO-1BF aircraft; $5.3 million (supplemental) for production of ICBM re-entry vehicles; $1,778,396 (supplemental) for research, development, test, fabrication and related work on a Minuteman re-entry vehicle.

General Dynamics Corp., San Diego, Calif.—$1,939,005 (supplemental) for Atlas missile spares; $1,496,308 (supplemental) for Atlas F series missile site activation; $1,009,451 (supplemental) for Atlas test program works; $7,621,776 (supplemental) for product improvement on ground support equipment for Atlas E series missiles; Fort Worth, Tex.—$1.5 million (supplemental) for engineering data for B-58 ground equipment; $2 million (supplemental) for conduct of B-58 flight test program.

Radio Corp. of America, Camden, N. J.—$4,057,782 (supplemental) for F-102 aircraft communications equipment; Burlington, Mass.—$4.4 million (supplemental) for production of final stage vehicles and provision of services to support a satellite program.

Republic Aviation Corp., Farmingdale, N. Y.—$1,091,802 (supplemental) for production of modification kits for the F/RF-84F aircraft ejection system; $2,875,250 for modification of F-105D aircraft.

Boeing Co., Seattle, Wash.—$2,252,000 (supplemental) for Minuteman ICBM assembly and checkout; $32,716,000 (supplemental) for research, development and test of Minuteman missiles; $3,945,947 (supplemental) for Minuteman assembly and disassembly; $1,848,688 (supplemental) for Bomarc B missile spare parts; $2.57 million (supplemental) for work on hardened and dispersed Minuteman ICBMs.

Chrysler Corp., Detroit, Mich.—$1 million (supplemental) for re-entry vehicle studies.

North American Aviation, Inc., Downey, Calif.—$1,786,450 (supplemental) for depot tooling of Minuteman ICBM test equipment; Canoga Park, Calif.—$2,600,857 (supplemental) for Atlas missile propulsion systems production; $5 million for production of MA-3 engines for the Atlas ICBM; Los Angeles, Calif.—$1 million (supplemental) for maintenance and modification of F-100C aircraft.

The Aerospace Corp., El Segundo, Calif.—$5,871,685 (supplemental) for systems engineering, technical direction, management services and administrative support of ballistic missile and space programs.

Philco Corp., Palo Alto, Calif.—$1 million (supplemental) for work on the Army's Advent communications satellite program.

Economics of National Security to Be Studied

Industrial College of the Armed Forces will conduct a graduate-level correspondence course, "The Economics of National Security," in which qualified civilians in business, industry and the professions may enroll.

Operating under the direction of the Joint Chiefs of Staff, the Industrial College conducts courses of study in the economic and industrial aspects of national security under all conditions and in the context of both national and world affairs, giving due consideration to the interrelated military, logistical, administrative, scientific, technological, political, and social factors affecting national security.

Adapted to the correspondence method, "The Economics of National Security" consists of small bound volumes organized into five integrated units of study: Background Information, Resources and Facilities, Processes in the Economics of National Security, Foreign Aspects of National Security and Problems of National Security. All texts and instructional materials are furnished at no cost; about one year is necessary to complete all units.

Qualified persons (a college education or its equivalent) may apply directly to: Commandant, Industrial College of the Armed Forces, Washington 25, D. C., Attn: Correspondence Course Division.

PRODUCTION BRIEFING

U. S. Army Corps of Engineers is inviting bids from prequalified bidders on about $10-million worth of Minuteman missile facility construction at Whiteman AFB, Mo. Bids are expected to be opened around Mar. 15.

Homestead AFB, Fla., home of the 19th Bomb Group (H), is the fifth base to receive Boeing B-52H Stratofortresses. Grand Forks AFB, N. D., will receive its first B-52H in April. Delivery of B-52Hs to Strategic Air Command will be completed in September.

Remote-controlled 40-ft. glass fiber boat is being tested at Eglin AFB, Fla., to study feasibility of recovering missile nose cones at sea by aircraft utilizing remote-controlled boats.

Hazeltine Corp., Little Neck, N. Y., has received a contract from FAA for development of a SLATE altitude beacon. SLATE (small lightweight altitude transmission equipment) will operate at ranges up to 50 mi. when interrogated by a ground station. It will pro-

vide altitude information in 500 ft. increments up to 10,000 ft. and will meet power requirements of most business and executive aircraft.

Navy and Air Force will support a $300,000 aerophysics and electrophysics shock tunnel now under construction at Brooklyn Polytechnic Institute's Graduate Center. The tunnel will simulate velocities up to Mach 35, and heat loads of 17,500F.

North American Aviation is designing a $300,000 pressure chamber able to simulate 300 mi. altitudes. The chamber will be a horizontal cylinder, 15 ft. in dia. and 26 ft. long. It will be located at the company's Aerospace Laboratory in Los Angeles.

Federal Aviation Agency has set Mar. 16 as cutoff date for receiving requests from airport operators who seek government aid for Fiscal 1963 construction. A list of approved projects will be announced in late May or early June. Most will be funded on a 50-50 basis through local authorities and the $75 million per year Federal Aid to Airports program.

Catalytic Construction Co. of Philadelphia has been selected to supervise construction of Rover test facilities at Jackass Flats, Nev. The company will administer, inspect and coordinate activities of construction contractors, whose work currently totals $15 million and will expand rapidly in the coming months.

Swiss Air Force has ordered Hughes HM-55 (GAR-3) Falcon air-to-air radar guided missiles for use aboard the 100 Dassault Mirage 3C interceptors it plans to begin receiving in 1964. Missile is the first guided air-to-air missile system ordered by the Swiss.

General Dynamics/San Diego has received a $1,110,400 Air Force contract to produce modification kits and mobile training units for F-106 jet fighter aircraft.

Leach Corp.'s Relay Division, Los Angeles, will produce general purpose relays for actuation of controls aboard the Boeing 727 jet transport. Relays are of the same general type as those used in Project Mercury manned spacecraft.

Yardney Electric Corp., New York, will provide silver-zinc emergency power batteries for Republic F-105 Thunderchief fighter bombers under contracts totaling more than $500,000 from USAF and Republic Aviation Corp.

NEW COMBINED PICTORIAL DISPLAY and course-line computer, developed by ACF Electronics, will soon undergo Federal Aviation Agency flight evaluation in a Grumman Gulfstream in which the device is installed (right). Combining computer and display function in a single unit simplifies pilot's use and reduces chance of human error. Marker on display (left) shows aircraft position and heading.

FAA to Evaluate New Pictorial Computer

By Philip J. Klass

Washington—New pictorial computer which permits direct flight to off-airways destinations by giving pilot VOR type steering and DME type distance information while simultaneously displaying aircraft position and heading pictorially, will soon undergo flight evaluation by the Federal Aviation Agency.

New device combines the functions previously performed by a separate course-line computer and a pictorial display, with resulting simplification in pilot operation and saving in weight.

The new pictorial computer, developed by ACF Electronics Division, ACF Industries, Paramus, N. J. under FAA contract, has been installed on a Gulfstream for flight tests at the agency's National Aviation Facilities Experimental Center (NAFEC) in Atlantic City, N. J.

How It Operates

From the pilot's point of view, here is how the new pictorial computer operates:

• **Insert plastic chart** for the area to be flown. Present plans call for providing aeronautical charts with four different scales: 5, 10, 20 and 40 naut. mi. per inch. Individual charts, with a display area diameter of 8 in., show maximum distances of 40, 80, 160 and 320 naut. mi., respectively. Perforations along the edge of each plastic chart automatically set the proper scale factor into the computer for the particular chart. The Vortac station which serves as navigation reference appears in the center of the chart.

• **Tune VOR/DME receivers** to frequencies shown on the top edge of plastic chart. When this is done, a miniature airplane marker on the display will assume a bearing and distance with respect to the Vortac station on the chart corresponding to the airplane's actual bearing and distance. The miniature airplane marker, operating from signals obtained from the gyrocompass, will rotate to assume a magnetic heading corresponding to that of the airplane.

• **Set destination into display** and computer using two control knobs to position a second small marker (with crosshairs) over the desired destination or waypoint.

• **Rotate course knob** on the pictorial display until grid lines scribed on lucite plate connect the aircraft and desired destination, or are parallel to this course. This course heading, measured against a compass rose on the display, is read by pilot and then set into the regular VOR omni-bearing selector (OBS) and the "to-from" switch on the OBS panel is set to the correct position.

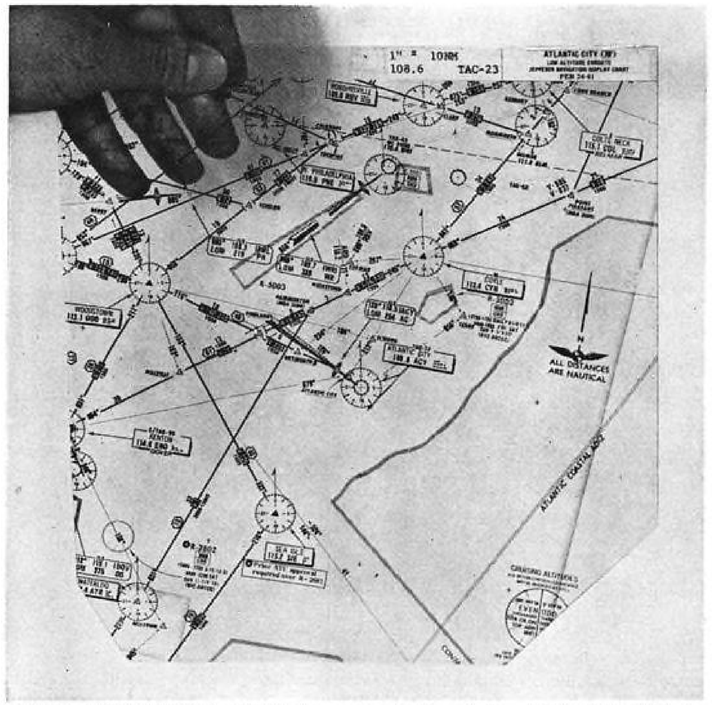
Pictorial computer now is ready for operation. The pilot can select either of two types of steering displays for his regular VOR deviation indicator. One type shows the angular deviation between aircraft position and the course to destination, similar to the angular deviation obtained from conventional VOR.

Alternate Display

The alternate display, called lateral offset, shows the pilot his displacement in miles to the left or right of the course, regardless of the airplane's distance from its destination. In this mode, full scale deflection of the vertical deviation needle can be set to correspond to a course width of 3.6 or 10 mi. This would permit a pilot to fly a parallel (offset) course to his destination. Choice of type of steering signal is made with selector switch on left-hand side of the display.

Distance to the destination will be displayed on the regular cockpit DME indicator. The miniature aircraft marker on the pictorial display continuously moves to show the pilot his position on the chart with respect to the selected destination.

Under certain conditions, such as departure from a high-traffic area, the pilot may want to use an expanded scale (small area) chart, subsequently



PLASTIC AERONAUTICAL CHART for area to be flown is inserted in pictorial display. Four different scale factors are provided, enabling the 8-in. dia. display area to show distances of 40, 80, 160, 320 naut. mi. Vortac used as reference is at center of display.

changing to a larger-area chart after he has left the terminal area.

In such a situation, the pilot could first insert the large-area chart on which the intended destination or waypoint appears, set the destination marker over it, then remove the chart and insert the smaller-area (expanded scale) chart. Because the destination does not show on the smaller-area chart, the destination marker will disappear from the display. But the destination marker will return when the pilot leaves the terminal area and again inserts the large-area chart.

The new ACF device also can be used as a pictorial display for conventional VOR airways flights. By setting the selector switch to "VOR Radial," the destination automatically becomes the Vortac station at the center of the chart, and the cockpit deviation and DME indicators show regular omni-range radial deviation and distance to the station. The small aircraft marker then shows aircraft position relative to the station.

Although the largest scale factor chart displays a maximum distance of 320 mi., the dead reckoning computer can handle a destination up to 200 mi. from the Vortac and up to 400 mi. from the aircraft's present position. For such extreme distances, the destination marker moves off the display, but the destination coordinates (bearing and distance) with respect to the Vortac station can be set in on two counters on the display.

When the destination is visible on the inserted chart so that marker can be visually positioned above it, the counters on the display automatically indicate the destination's bearing and distance with respect to the Vortac station.

Illumination of the display can be varied by means of a control knob located along the right hand portion of the display.

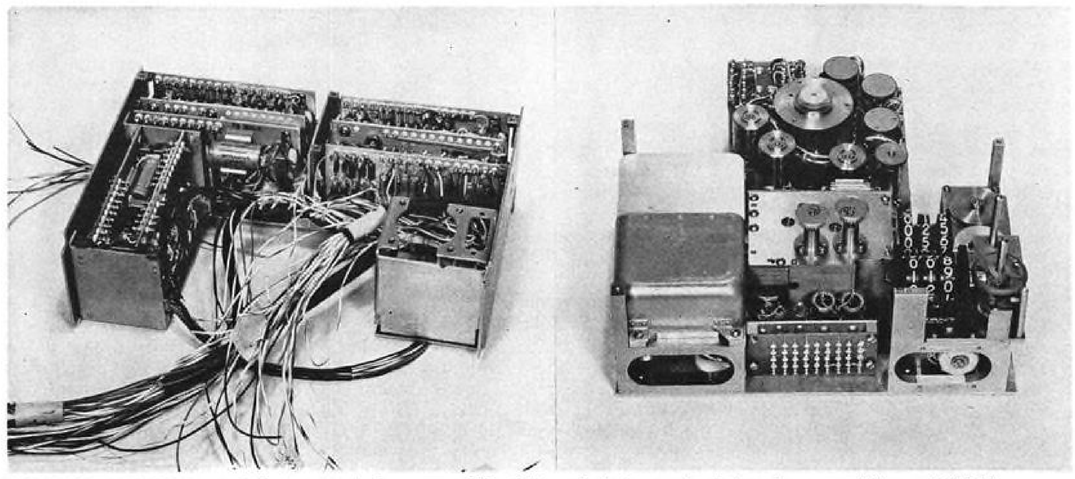
A warning flag directly below the aeronautical chart shows whether the pictorial computer is in operation. Failure of the navigation receivers, or gross errors in the computer amplifiers which position the aircraft marker, will cause the flag to automatically go to the "Off" position.

Small, Lightweight

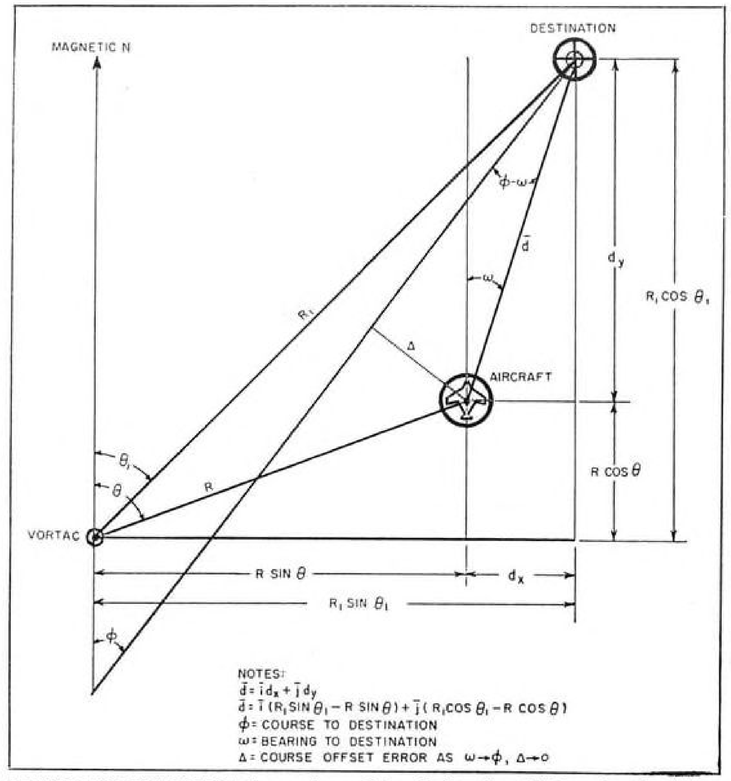
ACF Electronics has used transistorization and miniaturization techniques to build the combined off-course computer and display into a unit which measures only 12 x 9½ x 4 in. Uninstalled weight is 17 lb.

Power consumption is quoted at 70 watts of which 30 watts is 115 v., 400 cycles, while the remainder is 28 v.d.c.

An ACF Electronics spokesman says that the computational portion of the device could be located remotely from the display, without changing its operation, if cockpit space is critical. The volume of the display could be reduced about 30% by this means, but the minimum display surface area is limited by the smallest size chart which the pilots find acceptable.



PICTORIAL COMPUTER uses fully transistorized servo amplifier (left) and electro mechanical analog computation unit (right).



COURSE-LINE COMPUTER trigonometry used to calculate direct flight path, offset course and distance to off-airways destination is shown in sketch above.

By combining the off-course computer and the pictorial display, the pilot's operating procedure will be greatly simplified, according to FAA's Richard Munnikheysen, program manager.

In the older type of separate off-course computer it was necessary for the pilot to use an aeronautical chart and protractor to measure off the bearing and distance from the destination to the Vortac station, then set these values into the computer. This takes time and raises the possibility of human error. With the new ACF Electronics combined pictorial computer, this step is eliminated and the required data automatically is fed to the computer when the pilot positions the crosshair marker over the destination on the display chart.

FAA's National Aviation Facilities Experimental Center has completed flight tests on separate pictorial displays produced by ACF Electronics, International Telephone & Telegraph Co., and an FAA-designed unit (AW July 25, 1960, p. 96). NAFEC also has completed tests on an off-course computer developed by Butler Aviation, and is readying computers developed by Collins Radio and Bendix for flight evaluations.

The forthcoming flight tests on the new pictorial computer, expected to last about three months, are intended to determine the operational advantages of using such a device, rather than to check the accuracy of the unit, according to NAFEC's Byron Fisher, in charge of the tests.

The latter can be adequately measured in the laboratory.

Airlines' Response

The response of the airlines generally has been that there is little economic justification for adding pictorial computers or pictorial displays unless such gear will give equipped aircraft increased operational flexibility and freedom, compared with non-equipped aircraft.

NAFEC tests will seek to determine what increased navigational capability accrues from the use of the pictorial computer, and how it can be used effectively in combination with existing ground navigation aids and traffic control radar, Fisher says.

TV to Monitor Centaur Liquid Hydrogen Effect

Cape Canaveral, Fla.—Behavior of liquid hydrogen under extended zero-g conditions will be monitored by a television camera mounted on the tankage of the Centaur space vehicle during the initial flight testing of this upper stage.

Developed by Hallamore Electronics Division of the Siegler Corp., Anaheim, Calif., the small—8 in. long (without lens), 2.5 in. diameter, 6.5 lb. with control equipment—TV camera will be flown aboard the first three Centaurs, and possibly the fourth, according to present National Aeronautics and Space Administration plans.

The camera, similar to the one carried aboard the recent Thor-Echo 2 launch (AW Jan. 22, p. 33 and Jan. 8, p. 28), is a slow-scan unit which will take one half-frame picture every second with a resolution of 600 lines per scan at the center of the frame and 350-400 lines at the edges.

The Echo 2 camera had a frame rate of 30 cps.

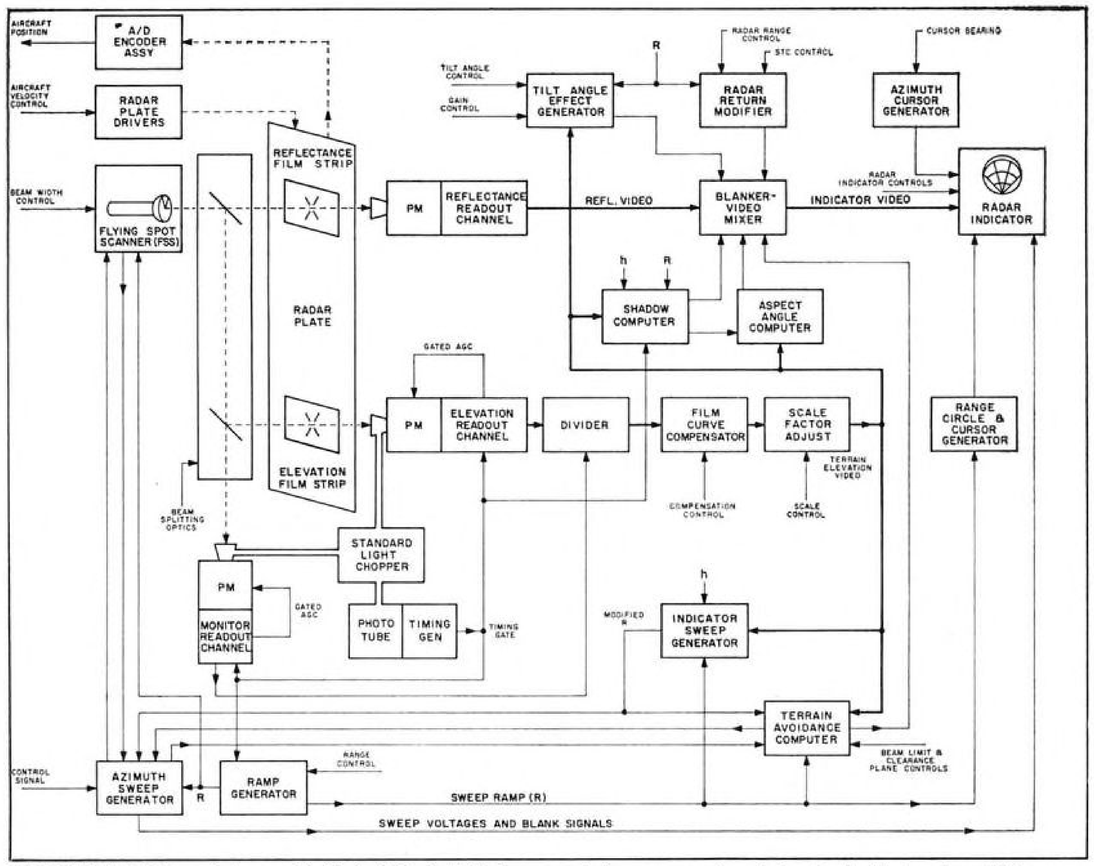
To watch the effect of acceleration and extended zero-g on liquid hydrogen, the camera and its associated pulsed strobe light are installed in individual windows on the shoulders of the liquid hydrogen tank dome. Strobe pulse is commanded by the camera.

NASA and General Dynamics/Astronautics, builder of the Centaur, believe that the TV pictures will provide data on the flow characteristics of both the liquid hydrogen and the hydrogen gas bubble which is expected to form in the center of the tank, as well as sloshing and liquid hydrogen adherence to the tank walls.

Data obtained will be used for proper design of fuel inlets for the vehicle's restart capability.

Bandwidth of the TV system will be about 75 kc. Power input to the transistorized camera is 28 v. at 15w. The unit can operate in a temperature spread from 0 to +158F with a glass seal between the videcon tube and the 16-mm. lens to guard against the −423F of the liquid hydrogen. Hallamore has built the camera to withstand random vibrations of 10g for 1 min., 50g shock along three axes for 11 millisec. and 10g accelerations along any one axis without the loss of picture clarity.

First flight of a Centaur aboard an Atlas booster is scheduled for Mar. 1 and will be a ballistic launch down the Atlantic Missile Range. Beset by troubles almost since its inception (AW Oct. 2, p. 26; Oct. 23, p. 22), Centaur missed a scheduled January launch date when minor problems with flight hardware and ground support equipment cropped up.



RADAR SIMULATOR now being used by Sanford Naval Air Station as part of a weapon system trainer for North American A3J-1 appears in block diagram. System has a number of subsystems, such as shadow computer and aspect angle computer.

Simulator Shows Airborne Radar Returns

By Barry Miller

Simulator displaying airborne radar returns from targets and land masses at simulated altitudes from 50 ft. to 80,000 ft., through radar sweep ranges from 20 to 140 naut. mi., has gone into operation at Sanford Naval Air Station, Sanford, Fla. Simulator is part of a weapon systems trainer for the North American A3J-1.

System presents, on a plan position indicator, simulated returns incorporating three dimensional effects from prepared topographical information stored on replaceable photographic film. Resolution of the system which is designed to simulate the aircraft's AN/ASP-12 radar can approach ¼ milli-inch for a single element of film. Since a scale factor of 1 to 5 million is employed, the resolution roughly equals about 200 ft.

Western Laboratories of Link Division, General Precision, Inc., Palo Alto, Calif., designed and developed the simulator system for North American's Columbus Division and delivered it to Sanford NAS. It is deployed there with the remainder of a weapon system trainer in trailer vans for training of naval aircraft crews.

Film plate for the system, prepared by the Naval Photographic Interpretation Center, contains radar reflectivity and terrain contour information for a land area roughly 1,200 naut. mi. x 250 naut. mi., Link explains. Density of information stored on film varies in steps, analogous to reflectance and elevation levels. Thirty grey scale steps represent different terrain levels thereby giving a realistic impression of land mass. Five different grey scale steps are provided for radar reflectance weighting, according to the company.

Like a functionally similar system built by ACF Electronics as a training device for use with the Republic F-105D (AW Jan. 2, 1961, p. 74), the Link system departs from more familiar types of land mass simulators, such as those which use water tank models and ultrasonic transducers.

It simulates terrain and targets by computing aspect angles so as to enhance or degrade radar returns according to the aircraft's simulated relation to land areas. This makes possible variations in area and strength of simulated returns as a function of elevation angle, Link points out.

Radar shadow zones are created by blanking video pulses, thereby preventing the display of land mass and terrain that normally would not be illuminated by the radar. This combination of computed aspect angle and shadow computation creates the three-dimensional picture depth through brightening and shadowing of the displays. Two analog computers calculate breakup and en-

hancement of radar returns as a function of azimuth view angles.

Trigonometric and arithmetic computations are performed at high speeds and a computation accuracy of 5% is maintained over the entire frequency range, according to Link. Computing amplifiers are designed to provide high output levels, multiple input and output connections and also inherent stabilization.

In the simulator system, a flying spot scanner generates and focuses light that is deflected over a sector pattern on the face of a high-resolution cathode ray tube. As the spot is deflected radially from the center of the cathode ray tube, the beam is modulated normal to its radial motion. Effectively, this simulates the azimuth beamwidth of the radar. In addition, an azimuth sweep generator (as shown in an accompanying block diagram) provides an azimuth sweep motion on the tube face. Resulting pie-shaped sector scan generated on the tube face simulates, at the one to five million scale factor, the scan pattern of the actual radar on the earth's surface.

Beam Splitting

As indicated in the block diagram, a beam splitting optical system images the scan pattern upon reflectance and elevation film emulsion strips situated on a glass radar plate. Intensity modulated light from elevation and reflectance film strips is collected by optical condensing assemblies, and uniformly focused onto photomultiplier tubes of the reflectance and elevation channels. Surface sensitivity variations of photomultiplier tubes is overcome by keeping the light spot stationary on these tubes so only changes in light level are received.

A light chopper assembly provides system timing by chopping the output from a standard light source at the radar system pulse repetition frequency. Timing light pulses are read out by a phototube and a minimum timing gate is generated by a timing generator.

Aircraft motion over land masses is simulated by moving the radar plate in a plane normal to the fixed scanned light beams. Radar plate drivers provide two-dimensional velocity drive to a transport table that supports the plate. Instantaneous plate position, corresponding to aircraft position over the land mass, is read out by an analog-to-digital encoder assembly. Aircraft heading, velocity, altitude and attitude and radar control parameters constitute controllable inputs to the radar simulator.

Terrain elevation video signals undergo compensation for non-linearities in light transmission of the film emulsion on the radar plate and for elevation scale factor. The former is achieved with the use of adjustable non-linear network in the forward and feedback paths of a wide band operational amplifier. Scale factor is normalized by scaling of terrain elevation represented by the radar plate. The compensated elevation readout channel video output is fed to the terrain avoidance computer, indicator sweep generator, aspect angle computer, shadow computer and tilt angle effect generator.

Basic Radar Video

Basic radar video which intensity-modulates the radar indicator is available from the reflectance readout channel.

The video is first processed by a blanker-video mixer which functions as a master gate and gain modifier.

Ramp generator supplies the basic ground-range sweep for the system, sending bipolar sawtooth signals to several subsystems and to the azimuth sweep generator to be resolved into sweep deflection signals for the flying spot scanner.

Indicator sweep generator both makes available sweeps for the radar indicator and is used for computing pseudo radar range effects—the concept by which targets at the same radar slant range are made to appear as a single target on the indicator. This assembly simulates this inherent operational feature of the radar system, according to Link.

Five computing subsystems contributing to the achievement of a realistic indicator video signal are:

- **Shadow computer** for simulating effects of shadow zones.
- **Terrain function generator** similarly rejects by blanking returns from targets below a clearance plane and outside of antenna beam limits.
- **Tilt angle effect generator** modifies video gain for returns from selected sections of a ground map that is a function of antenna vertical tilt angle.
- **Radar return modifier** varies video gain as a function of the radar ground range.
- **Aspect angle computer,** handles weighting of video gain as a function of target aspect angle.

FILTER CENTER

►**New TWT Design Technique Reported**—Technique for increasing efficiency of traveling wave tubes by 40 to 100%, permitting significant reduction in size, weight and power consumption, has been developed by University of Michigan scientists working under Rome Air Development Center sponsorship. Technique involves varying the number of turns per inch of the helix near the end of the tube to slow down signal velocity and thereby permit more efficient energy transfer. In an experimental tube operating at 2.6 gc. (2,600 mc.), with the normal helix pitch of 18½ turns/in. increased to 37 per inch in the last 1¼ in. of the tube, Michigan University scientists report they have achieved an efficiency of 35% at 200 watts output, and that gain has been increased by 2 db. over frequency range of 2.0 to 3.8 gc.

►**Radiation-Resistant Computer Under Design**—Miniature digital computer whose tunnel diode and majority logic circuitry should enable it to operate in the presence of high steady state and transient nuclear radiation, is under construction by International Business Machines Corp. Based on tests of the computer's tunnel diode majority logic circuits in Atomic Energy Commission's Godiva reactor and steady state radiation tests at the Battelle Memorial Institute reactor, IBM says the computer can tolerate steady state radiation greater than 10^{16} nvt. and impulse radiation more than 10^{7} rad/tissue per second. Computer will have 12,000 words of storage for instructions and data and be able to perform computations at rate of 70,000 per second, IBM says. Computer is expected to weigh 100 lb., occupy about 2 cu. ft., and consume 150 watts power.

►**Temperature Stabilization for Magnetrons**—Change in structure of voltage tunable magnetrons which improves their temperature stability by factor of 15:1 has been developed by General Electric. Company says the new design provides maximum frequency variation of only 0.2% from −55C to 110C, compared with previous figure of 2% per 100C temperature change.

►**Gyro-Substitute Research Funded**—Bureau of Naval Weapons shortly will contract for research and development program to explore a proprietary idea submitted by Development Laboratories, Santa Monica, Calif., for an "instrument to be used as a substitute for a gyroscope."

►**Self-Organizing Systems Meeting Organized**—Three-day conference on self-organizing systems (COSOS), sponsored by Office of Naval Research and Armour Research Foundation, will be held in Chicago, May 22-24, at Museum of Science & Industry. Attendance is open to interested scientists. Additional information can be obtained from George J. Jacobi, Armour Research Foundation, 10 West 35th St., Chicago 16, Ill.

CAB Accident Investigation Report:

Stall Led to Delta 880 Training Crash

On May 23, 1960, at 1152 EST, a Delta Air Lines Convair 880, N 8804E, crashed and burned during takeoff at Atlanta, Georgia. Four crew members, the only occupants, received fatal injuries.

The flight was scheduled for training for two pilots who were to "check out" in the CV-880. A pilot-trainee occupied the left seat and a qualified instructor-pilot occupied the right. Immediately after liftoff the aircraft assumed an extremely nose-high attitude and banked steeply to the left. It then rolled to a vertical right bank, the nose fell through, and the aircraft struck the ground.

The Board determines the probable cause of this accident was that the aircraft was stalled, for reasons undetermined, at an altitude too low to effect recovery.

A Delta Air Lines Convair 880, N 8804E, was scheduled as Flight 1903. It was to be a training flight for the purpose of giving flight instruction to two captain-trainees prior to their checkout in the CV-880. Delta Captain James H. Longino was the instructor-pilot and occupied the right (co-pilot's seat). Captain-trainee Henry L. Laube occupied the left (pilot's seat). Captain-trainee William F. Williams was in the observer's seat and Bryan E. Bolt was serving as Flight Engineer.

No flight plan was filed; however, according to Delta officials, the flight was planned for approximately four hours. It was to be operated in the area between Atlanta, Georgia, and Columbia, South Carolina, with landing and takeoff training to be conducted at North Field, North, South Carolina.

Delta Form O-18 (fuel-service record) was completed for the flight and indicated that the aircraft had been serviced to approximately 60,000 lb. of fuel, distributed properly. The aircraft gross weight on departure from the ramp was 144,599 lb. (maximum allowable for this flight, 155,750 lb.) and the center of gravity location was within limits at 29.5% MAC.

The weather at the time of takeoff was scattered clouds at 3,000 ft., visibility 15 mi.; wind west 15 kt. variable; temperature 80 deg.

Flight 1903 departed the ramp at 1140[1] and taxied into takeoff position on Runway 27. After landing-traffic on an intersecting runway was clear, N 8804E started its takeoff roll at approximately 1151. Observers indicated that acceleration appeared to be normal and the aircraft rotated at a point just west of the intersection of Runway 27 and a taxiway paralleling Runway 21 about 3,450 ft. from the threshold. Tower operators were also in agreement that the liftoff appeared to be normal and at a point on the runway opposite the new fire station which is approximately 4,425 ft. from the threshold. Runway 27 is 7,860 ft. long.

Within a very few seconds after liftoff the attitude of the aircraft changed from normal to an angle of pitch described by many qualified witnesses to be as much as 45 deg. This abrupt nose-up was followed by a lowering of the left wing to an angle of bank estimated as 20 deg. and a change of heading to the left of about 45 deg. Witnesses described the flight of the aircraft at this point as a "left skid" or "slip" with the nose still extremely high. Next the aircraft rolled from the left bank to a vertical bank to the right. In this vertical right bank the nose fell through and the right wing contacted the ground followed immediately by the nose of the aircraft. As the breakup progressed an intense fire developed which largely consumed the wreckage. All occupants received fatal injuries at impact. Most witnesses said that the aircraft's speed appeared to be extremely slow after becoming airborne. Some described a "stall" and "shuddering" of the entire aircraft. Others described a "fishtailing movement" after takeoff. There were also several witnesses who indicated that the No. 4 engine was not producing the trail of black smoke which is normally seen on takeoff. All were in agreement that the maximum height attained was about 200-300 ft. The wreckage distribution indicated that the initial ground contact was on the right wing while the aircraft was in a 70 to 80 deg. right wing low angle of bank. The aircraft skidded along on the right wing and nose, and cartwheeled to the right. It came to rest heading in the opposite direction from which it had been traveling. The Nos. 3 and 4 engines were torn off as the wing was down and the Nos. 1 and 2 engines separated from the wing as the aircraft became headed in the opposite direction.

Wreckage Examination

Examination of the wreckage did not reveal any evidence of structural failure prior to impact. In addition, no malfunction or failure in the control surfaces, control cables, or systems was found which could have caused or contributed to the unusual flight attitudes described by witnesses.

All aircraft systems and instruments were examined and no failure or irregularity was found. It was determined that the landing gear was fully extended and locked. The wing flaps were extended symmetrically to 20 deg. The spoilers were operable and the stabilizer was set 4½ to 5 deg. noscup. Information obtained from the remaining systems or instruments, i.e., engine performance gauges, etc., was determined to be unreliable because of the probability that impact forces would change the indications.

Examination of the engines showed that Nos. 1 and 2 at impact were producing thrust at an engine speed of at least 96% rpm. There were indications of considerable damage and metal spatter from internal interference within the engine which occurred as breakup progressed and rotating parts were forced into stationary sections of the engines. The variable stator vanes on the compressors of both engines were in the full open position.

It was determined that engines Nos. 3 and 4 at impact were operating at reduced speeds. The variable stator vanes on No. 3 were found at an angle of —8 deg. 45 sec. Those of No. 4 were fully closed. Because the angle of these variable vanes is a function of engine rpm., and compressor inlet temperature, it was possible to determine that the engine rpm. represented by these angles were 79% for No. 3 and 66% (or flight idle) for No. 4. In addition, the damage and metal spatter from internal interference and foreign object damage within these two engines were less than that noted on Nos. 1 and 2. There were no indications of pre-impact mechanical failure or malfunction in any of the four engines. Bearings showed no indications of operating distress or unusual wear. There were no overtemperature indications on any of the combustion or turbine assemblies and nothing was found which would have prevented the engines from developing full rpm., or full thrust prior to impact.

The metal spatter on the first stage turbine blades and nozzle guide vanes of engines 1 and 2 consisted of aluminum alloy which had been scraped from the variable stator shrouds by the stators at impact. This metal had passed down the engine and was fused to the turbine. The turbine blades of engine No. 3 evidenced no such fusion and only a slight amount of deposit on the vanes. Engine No. 4 had slightly more fused material than No. 3 on the vanes and a small amount on the first stage turbine blades.

The Delta Air Lines captain training program for the CV-880 consists of 120 hr. of ground school instruction which covers jet weather, high-altitude indoctrination, CV-880 familiarization, systems familiarization, electrical systems, and CJ-805 engine familiarization. After completing this, each student must pass a written examination.

Following the ground school training, each captain-trainee receives a minimum of 13 hr. of instruction in the CV-880 simulator, including three hours of panel time. The simulator airwork accomplished in this training includes emphasis on takeoff and landing practice with asymmetric power.

The captain-trainee is then given a minimum of 12 hr. of flight training. In addition, he is given four hours of panel time and eight hours as observer. As in the simulator training, each captain is given practice in takeoff procedures with one engine out at V_1, V_R and V_2. In addition, practice is given in operation with two engines "out" with the second being "failed" after takeoff at traffic pattern altitude.

Several prior incidents during which heavy yaw rolling tendencies were encoun-

[1] All times herein are Eastern Standard based on the 24-hour clock.

tered in the Delta Air Lines CV-880 training program were investigated. All of these were found to have involved simulated failure of an outboard engine at V_1. Testimony indicated that a directional oscillation developed with coincident rolling tendency after an initial yaw toward the "cut" engine. No extremely nose-high attitude was associated with any of these incidents. Recovery even in the most severe case was easily effected by nosing the aircraft down sufficiently to allow speed to develop. Captain Longino had been the instructor-pilot during several of these incidents.

Captain Longino, age 42, had a total of 13,197 flying hours. Of this total, 273 hr. had been obtained in the DC-8 and 227 hr. in the CV-880. Captain Longino's total jet experience of 500 hr. included 208 hr. of instructor-pilot time in the DC-8 and 179 hr. of instructor-pilot time in the CV-880.

Captain Laube was 45 years of age. He held a current ATR with ratings in DC-3, DC-4, DC-6, DC-7, CV-340, Lockheed Constellation, and DC-8 aircraft. He had a total of 17,221 flying hours, of which 14 had been obtained in the DC-8 and 10 in the CV-880.

The flight of May 23, 1960, would have completed Captain Laube's flight training in the CV-880 and would have prepared him for a type rating check-ride in the aircraft.

The training curriculum required that the failure of an outboard engine at V_1 during takeoff be simulated on this flight. It was not unusual to simulate this three-engine takeoff at the Atlanta Airport.

Captain Laube had passed his most recent first-class medical examination Dec. 23, 1959. At that time an electrocardiogram examination was given to him and noted as satisfactory. Immediately following the accident of May 23, an autopsy was performed on Captain Laube, as well as all other members of the crew. This examination disclosed that Captain Laube's heart exhibited atherosclerosis to a marked degree. This condition was found to have decreased the inside diameter of the left main coronary artery of the heart 70-90%; the circumflex coronary artery 25-100% with evidence of an old occlusion; and the right main coronary artery 50-80%. No evidence was found to indicate acute infarction or coronary thrombosis. In addition, nothing was found to indicate incapacitation due to coronary insufficiency.

Analysis and Conclusions

From the evidence adduced during this investigation it appears that the flight preparations, taxi to takeoff position and runup, were normal. The takeoff roll and aircraft rotation-to-climb attitude were also normal. Liftoff occurred at a point on the runway which was later calculated to be normal for the conditions existing.

The Board cannot determine the reason for the abrupt "nosing up" of the aircraft shortly after liftoff. In its investigation the Board has reviewed the manufacturer's performance records, flying qualities, and capabilities of the CV-880. No unusual or unsafe characteristics were noted and nothing was found which could account for this unusual flight attitude.

It appears certain that the aircraft was in a stalled condition while in this extreme nose-high attitude. It also appears certain that a large amount of yaw to the right was present along with considerable skid or slip. In swept-wing aircraft these conditions can create an uncontrollable rolling moment to the right. Briefly, this is a result of greatly increased lift generated by the advance wing, coupled with a large decrease in lift on the retreating wing. The Board believes the description of the "flightpath," as derived from witness statements, is entirely consistent with this assumption.

It is believed that the takeoff incidents which involved heavy rolling immediately following liftoff were the result of overcontrolling by pilots unfamiliar with the extremely sensitive lateral control of the Convair. Again, nothing was found in any of these incidents which could help explain the accident, except that all occurred at low speeds on takeoff with one engine out.

Several witness observations indicated that the No. 4 engine was throttled prior to liftoff. Under normal procedures for a training flight such as this, it is possible that an engine would be throttled after V_1 speed had been reached to simulate engine failure. Moreover, it is most likely that an outboard engine would be the one "cut," because its loss is more critical during this regime of flight.

For these reasons and the fact that on impact No. 4 engine was at flight idle (66%), the Board believes it reasonable to assume that the No. 4 engine was throttled prior to liftoff. This condition is also consistent with the initial left wing-down attitude as a result of overcontrolling, and was probably the reason a large degree of yaw developed.

The amount and distribution of fused metal found in the engines can be related directly to the temperatures at which the engines were operating. The minimum turbine inlet temperature necessary to fuse metal to the inlet guide vanes and turbine blades ranges from 750° to 850°F. Temperatures at least this high were therefore present in Nos. 1 and 2 engines. The amount of fused metal found in engine No. 4 was considerably less and that in No. 3 was the least of all four engines. The stabilized turbine inlet temperature at flight idle (66%) is 850° to 900°F. These temperatures are sufficient for fusion; however, the engine speed and airflow within the engine during breakup would be less and would account for the lesser amount of metal found in engine No. 4.

Transient Temperature

At 79% engine rpm. stabilized turbine inlet temperature is from 850° to 915°F. During engine deceleration the transient temperature will fall below the given values at flight idle and rise to normal when engine speed has stabilized. The average time required for engine temperature to stabilize during deceleration from 103% to 79% is four seconds.

Based on the lesser amount of fused metal, as compared to the other engines, it

Rogallo-Wing Glider Tested

Flightsail, a Rogallo-wing glider built by two engineers in a month of spare time for less than $100, has been flown by NASA personnel for comparison with other designs. Wing is 0.004-in. thick commercial polyethylene which has been stripped with glass-reinforced tape on a one-foot module for reinforcement and as a rip stopper. Control lines, attached to bottom of stick, run to four points on the structure to change the relative angle between the wing and the fuselage. Wing planform is a diamond with a 50-deg. leading-edge sweep. Empty weight of the vehicle is 75 lb. Flightsail has been flown as a towed glider behind an automobile; it has reached 30-ft. altitude at about 35 mph. Drawings and instructions for construction are being prepared and should be ready shortly, according to Thomas H. Purcell, Jr., president of Flight Dynamics, Inc., State College Station, Raleigh, N. C. Purcell and Mack G. Bass, manager of maintenance for aircraft of the State of North Carolina and the 30th Infantry Division N. C. National Guard, designed and built the Flightsail Rogallo-wing glider.

appears that temperatures in No. 3 were below those at stabilized flight idle. This indicates the engine was in a decelerating condition at the time of impact. It appears probable that this deceleration occurred within about two seconds during impact. This appears likely because if the engine had been cut as much as four seconds before impact, the temperature would have been stabilized in the 850° to 915°F range.

All attempts to correlate this information to the flightpath of the aircraft are again irreconcilable. It is estimated that for at least five seconds prior to impact, the aircraft had to be in a rolling condition from a left to right bank. The final three seconds of flight must have been in a right wing-down attitude. Therefore, it appears that the engine cut on No. 3 would have to have occurred while the aircraft was rolling to the side, on which power had already been reduced (No. 4 was at flight idle at liftoff). The Board believes it doubtful that No. 3 was retarded intentionally at this time because this would greatly increase the asymmetry of power and aggravate the yaw and tendency to roll to the right. It is also unlikely that the throttle was closed inadvertently.

Finally, no evidence was found during the course of the investigation to indicate structural failure or mechanical malfunction prior to the aircraft's impact with the ground. As far as could be determined the aircraft systems were normal and should have been capable of normal operation at impact.

In further study of this accident the Board attempted to determine if Captain Laube had any history of heart trouble. None of the doctors known to have treated Captain Laube, including an insurance doctor, had knowledge of this condition. In addition, several of his electrocardiographs were examined and no abnormalities were present. Further, no evidence could be found from autopsy to indicate incapacitation as a result of a thrombosis or infarction.

Although Captain Laube's atherosclerosis was considerably advanced for his age, the Board cannot find evidence to support any sudden incapacitating condition on which to base a finding of probable cause of this accident.

Probable Cause

The Board determines the probable cause of this accident to be the stalling of the aircraft, for reasons undetermined, at an altitude too low to effect recovery.

By the Civil Aeronautics Board:

ALAN S. BOYD
Chairman
ROBERT T. MURPHY
Vice Chairman
CHAN GURNEY
Member
G. JOSEPH MINETTI
Member
WHITNEY GILLILLAND
Member

The Civil Aeronautics Board was notified of this accident shortly after it had occurred. An investigation was immediately initiated in accordance with Title VII of the Federal Aviation Act of 1958. A public hearing was held in Atlanta, Georgia, Aug. 30-31 and Sept. 1, 1960.

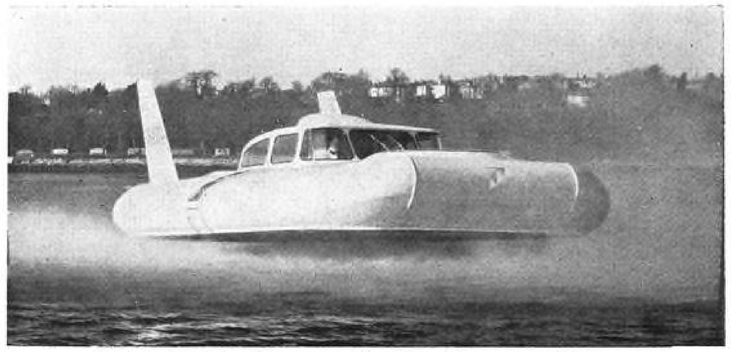
Delta Air Lines holds a current certificate of public convenience and necessity issued by the Civil Aeronautics Board to engage in the transportation of persons, property and mail. It also possesses a valid air carrier operating certificate issued by the Federal Aviation Agency.

Captain James H. Longino, age 42, was employed by Delta Air Lines May 30, 1945, and promoted to captain Aug. 12, 1946. He held a valid FAA airline transport pilot certificate with ratings for the DC-3, DC-4, DC-6, DC-7, Convair 340, Lockheed Constellation, C-46, DC-8, and Convair 880. He had a total of 13,197 flying hours of which 273 were in the DC-8 and 227 were in the Convair 880. He was also an instructor-pilot for Delta Air Lines. His last Federal Aviation Agency first-class physical was dated Nov. 17, 1959.

Captain Henry L. Laube, age 45, was employed by Delta Air Lines Mar. 25, 1942, and promoted to captain Mar. 16, 1955. He held a valid FAA airline transport pilot certificate with ratings for DC-3, DC-4, DC-6, DC-7, Convair 340, Lockheed Constellation, and DC-8. He had a total of 17,221 flying hours of which 14 were in the DC-8 and 10 were in the Convair 880. His last Federal Aviation Agency first-class physical examination was Dec. 23, 1959, at which time an EKG was performed which was satisfactory.

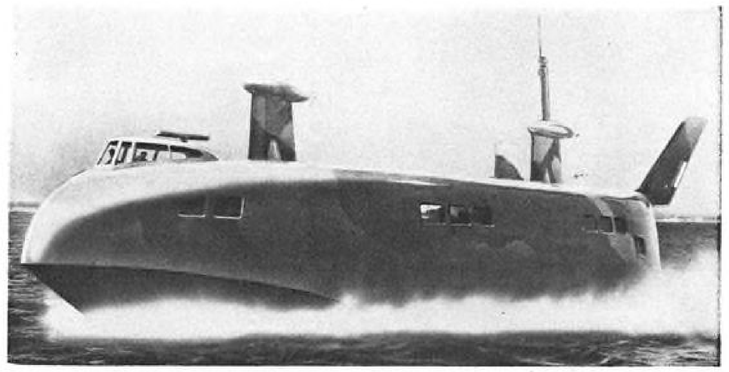
Captain William F. Williams, age 50, was employed by Delta Air Lines June 23, 1941, and promoted to captain on Apr. 26, 1943. He held a valid FAA airline transport pilot certificate with ratings in the DC-3, DC-4, Convair 340, DC-6, DC-7, and DC-8. He had a total of 17,196 flying hours of which 13 were in the DC-8 and 12 were in the Convair 880. His last FAA first-class physical examination was dated Jan. 12, 1960.

Flight Engineer Bryan E. Bolt, age 31, was employed by Delta Air Lines Jan. 2, 1956. He held a valid FAA commercial pilot certificate with aircraft single-engine and multiengine land and instrument rating. He also held a valid FAA flight engineer's certificate. He had a total of 5,810 flying hr. of which 210 were in the Convair 880.



British Cushioncraft Undergoes Tests

Britten-Norman CC-2 Cushioncraft (above) is shown during test trials near the Isle of Wight. Prototype vehicle has been purchased by British Ministry of Aviation for hovercraft test program at its Bedford research facility. Cushioncraft seats 10 persons and is powered by a Rolls-Royce V-8 automobile type engine. It is 27 ft. long, 17 ft. wide, has a gross weight of 5,500 lb. Hovering height is 12-14 in. depending on load and maximum speed is about 50 kt., with range calculated at 500 mi. Selling price will be under $56,000. Artist's concept of the Westland SRN.3 Hovercraft (below) is the follow-on to the SRN.2, built by Saunders-Roe Division and now in operational testing program also at the Isle of Wight (AW Jan. 15, p. 34). SRN.2, which carries 66 passengers and a two-man crew, has been submitted to the U. S. Navy under study program designated Black Lace (AW Dec. 25, p. 13). The vehicle will carry 110 passengers at 80-kt. speeds. Metal is now being cut at Saunders-Roe East Cowes, Isle of Wight, factory for the vehicle.



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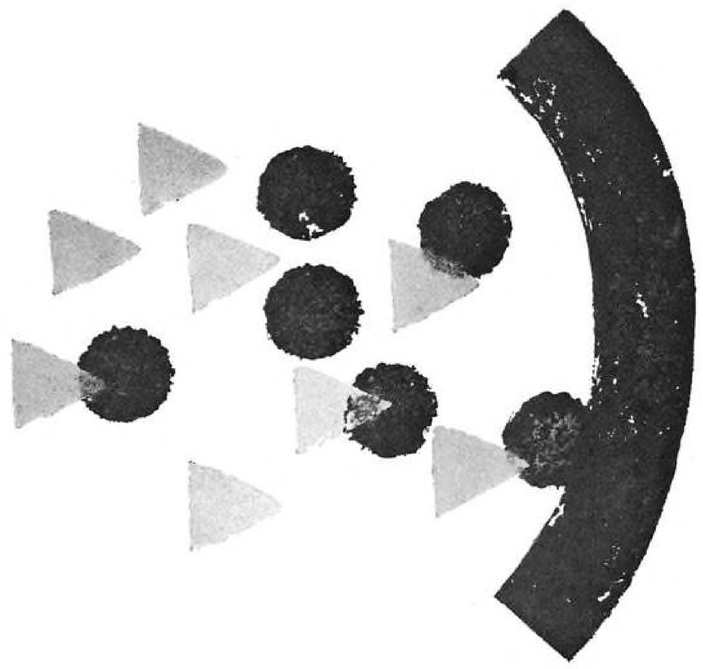

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WHO'S WHERE

(*Continued from page 23*)

Honors and Elections

Mrs. O. A. Beech, president of Beech Aircraft Corp., has been elected 1962 chairman of the Aerospace Industries Assn.'s Utility Airplane Council, and also elected a member of AIA's Board of Governors.

Changes

Cdr. John T. Griffith, USN, range operations officer, Pacific Missile Range, Point Mugu, Calif., relieving **Capt. Joseph Garrett,** now director of range support.

Frederick C. Durant, III, senior representative, Washington (D. C.) office, Bell Aerosystems Co.

Cdr. Forrest S. Petersen, formerly assigned to the X-15 project has returned to Navy duty at Miramar Naval Air Station; he will command Fighter Squadron 154.

Lt. Gen. Clayton C. Jerome (USMC, ret.), technical consultant, Piasecki Aircraft Corp., Philadelphia, Pa.

Dr. H. T. Tomlinson, chief-tracking systems, Communications Branch, Temco Electronics Division of Temco Electronics & Missiles Co., Garland, Tex., a division of Ling-Temco-Vought, Inc.

Dr. Thomas E. Tice, chief engineer, Antenna and Microwave Group, Motorola, Inc., Military Electronics Division, Scottsdale, Ariz.

John K. Records, manager-Apollo Study Contract, General Electric Co.'s Defense Systems Department, Syracuse, N. Y.

Kenneth C. Sanderson, chairman-Dyna-Soar Instrument Development Team, National Aeronautics and Space Administration's Flight Research Center, Edwards, Calif.

Dr. Albert Muller, director of technical activities, Air Reduction Company, Inc., New York, N. Y.

G. Clark Cochran, government sales manager-avionic products, Bendix Radio Division, The Bendix Corp., Baltimore, Md.

Dr. Edward Gerjuoy, director of plasma and space applied physics, Radio Corporation of America's Defense Electronic Products, Princeton, N. J.

Ward B. Masden, deputy director for Helicopter Matters, Flight Standards Service, Federal Aviation Agency, Washington, D. C. **James F. Rudolph** succeeds Mr. Masden as chief of Flight Standards Service's Operations Division.

Louis H. Benzing, director of operations-military systems, Lockheed Electronics Co., Plainfield, N. J., a division of Lockheed Aircraft Corp.

Rolls-Royce of Canada, Ltd., Montreal, has announced the following appointments: **Charles J. Mignault,** comptroller; **Gerald T. E. Rayner,** commercial manager; **Leo Charlebois,** industrial relations manager.

Dr. France B. Berger, director of the newly established Research and Advanced Development Division, GPL Division of General Precision, Inc., Pleasantville, N. Y., and **Ivan A. Greenwood,** associate director.

Philip D. Doersam, manager, Advanced Systems Engineering, Raytheon Co.'s Missile and Space Division, Santa Barbara, Calif.

Walter F. Velgot, Jr., manager-engine overhaul, Pacific Airmotive Corp., Burbank, Calif.

Robert Booth, sales development manager, Braniff International Airways.

Leigh A. Taylor, director of marketing, Electronic Communications, Inc., St. Petersburg, Fla.

Lionel H. Naum, manager-information services, Systems Operation of General Electric Co.'s Heavy Military Electronics Department, Syracuse, N. Y.

Gordon R. Green, chief engineer, Astronetic Research, Inc., Nashua, N. H.

Frederick W. Howells, head of The Mitre Corp.'s Foreign Technology Department, Bedford, Mass.

Capt. Bruce G. Kroger (USN, ret.), product line manager, Anti-Submarine Warfare, Loral Electronics Corp., New York, N. Y.

Frank J. Kiernan, director of market research, General Precision, Inc., Tarrytown, N. Y.

Robert B. Mapp, manager of technical services, Boots Aircraft Nut Division of Townsend Co., Norwalk, Conn.

Dale O. Moeller, program manager for a new life support system, AiResearch Manufacturing Division of The Garrett Corp., Los Angeles, Calif.

Frederick J. Anderson, director of engineering-Eastern operation, Sylvania Electronic Systems, a division of Sylvania Products, Inc., Waltham, Mass.

James O. Seamans, associate director-research and engineering, Baird-Atomic, Inc., Cambridge, Mass.

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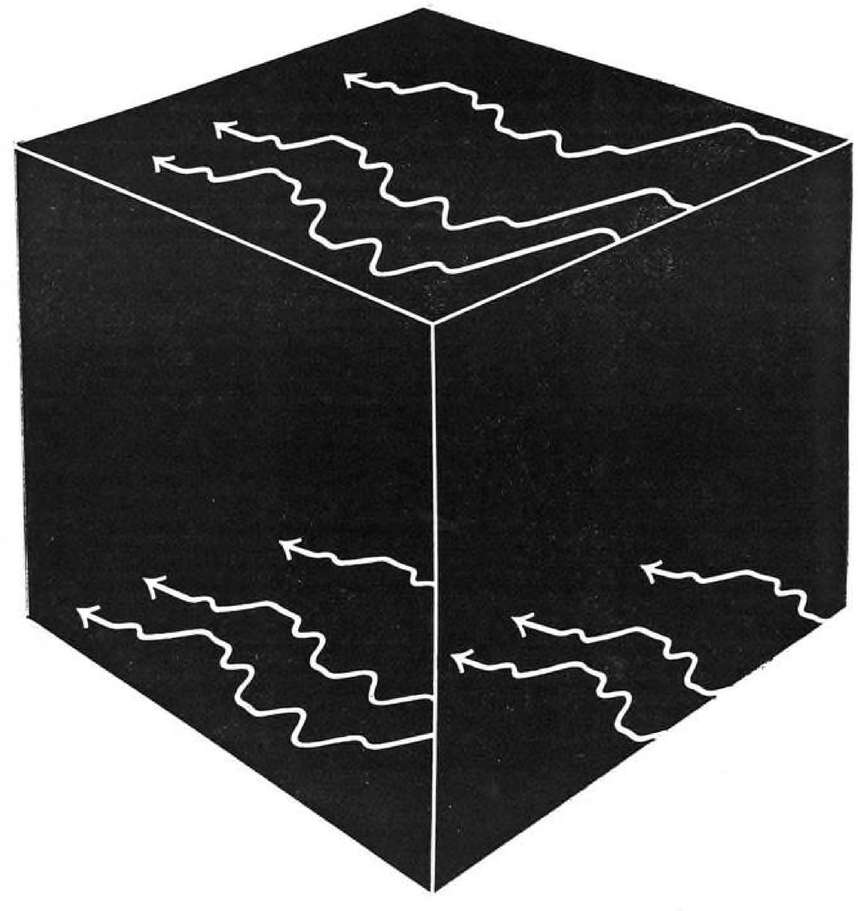

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F. J. Eberle, Business Mgr.

ADVERTISERS INDEX

LETTERS

Aviation Week welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to the Editor, Aviation Week, 330 W. 42nd St., New York 36, N. Y. Try to keep letters under 500 words and give a genuine identification. We will not print anonymous letters, but names of writers will be withheld on request.

Support of Space

Your editorial of Jan. 15, Space Pace Accelerates, is exceptionally fine. I am personally aware of the common misconception by public and government people of the purposes of our space program. In our national euphoria many have completely forgotten the difference between daring feats and well prepared exploration. They look to the "stunt" only and relate it to the past "record." The press does not help in most cases.

You are to be continually congratulated for not being in this class.

You say that the American people and legislators must be motivated to support the program for the long pull lest their indifference drag it down (financial strangulation). I would suggest you solicit your thousands of subscribers to take upon themselves the challenge of gaining this support. Every PTA, church group, service organization, labor and professional club should be getting at least a semi-annual, exciting review of the multitude of direct fallouts from the space programs and research; things which every citizen can see and know help his livelihood.

Who else but we in the space programs can do this? The explaining, as you call it, must be done by our "clan."

STARR J. COLBY
Chief, Advance Space Projects
Missiles & Space Systems Division
Douglas Aircraft Co.
Santa, Monica, Calif.

(AVIATION WEEK and SPACE TECHNOLOGY *endorses Reader Colby's proposal and urges all qualified readers to help carry the space technology message to the American people.*—Ed.)

Wasted Talent

President Kennedy announced to the nation last week that he was extremely concerned over the small number of students working toward degrees in science and engineering. He also described the ever increasing need that exists for men with these qualifications.

This week the Department of Defense announced the award of a study contract to Boeing and the team of General Dynamics and Grumman to study and present further plans for the production of the TFX airplane.

This is what has transpired before this statement was issued. Six teams, made up of aircraft and electronic companies throughout the U. S., have had their most experienced scientists and engineers working on this project for years. Some idea may be gained from the statement in the Long Island newspaper Newsday that Republic Aviation Corp. was reported to have spent three years and $5 million.

The consequence of this whole project was that the companies involved have lost two or three years of productive time, hundreds of engineers were duplicating each other's work in the various companies, and millions of dollars that might have been channeled into important areas of research were instead wasted.

There is only one type TFX airplane to be constructed. Chances of further contracts in this field seem remote at this time. Many persons will claim that this is free enterprise, the American system, etc.; however, if they can show that this is not a waste of time, money and professional effort it would be quite a trick.

Solutions to this dilemma will not be come by easily. If we are to use our scientific and engineering manpower resources to their potential we will have to overcome the paradox of a critical shortage on one hand and a crying waste of valuable talent on the other.

URBAN J. SWEENEY
Commack, N. Y.

Computer Reliance

I have been wanting to write you for some time and congratulate you on an excellent job of summarizing our report on "Computers in Command and Control" in the Dec. 11 issue of AVIATION WEEK (p. 32). You captured the intent of our report almost completely, except perhaps in the title of the article, which was "Study Urges Less Reliance on Computers." I think what we urged was less reliance on computer manufacturers. While it is true that we suggested that systems not be automated just for the sake of automation, our strongest recommendation was that the military commands not delegate their responsibilities to computer manufacturers or other system planning organizations outside their commands.

Other members of the study group have made similar comments to the ones voiced here. We thought you did an excellent job in a surprisingly short time on a very complex subject.

MARLIN G. KROGER
Associate Director R&D
Military Electronics Division
Motorola, Inc.
Riverside, Calif.

Public Concern

Flipping through my back issues of AVIATION WEEK just now, I again came upon the July 24 editorial, Another Surprise Coming?, warning us of the lesson taught us by the Tushino show in 1961. In particular, the editorial singled out the then continuing nuclear moratorium as a ripe area for the next Soviet surprise. Since then, as we know, Russia has indeed fulfilled the prophesy. The insight of your writing is subtle, like a sledgehammer. Such seems to be the norm rather than the exception for AVIATION WEEK. Congratulations.

One wonders at the seeming indecision and lack of direction of the American people in the face of the Russian-Chinese offensive. If we truly want to preserve our way of life for ourselves and the rest of the world that desires it, as we profess to want to do, we as individuals should be more concerned with the path our country is traveling. If, to gain this concern, we must disregard concern with the traffic jam on the way to work, the bowling score, the butcher, baker, and the candlestick maker, then let's make the conscious effort to put things into perspective. And with the clear insights into the problem of such professionals as yourself readily available, every citizen is duty bound to know the problem well enough to apply his knowledge in the two places the average citizen has an easy chance to: at the polls, and in his expressed opinion.

Such an action would be a sacrifice for no one, yet would make America and our way of life impregnable. We won the world wars by becoming concerned on a wide popular basis. We will win this conflict the same way. The only difference—and it is a small one— is that we cannot this time wait until after hostilities begin to be concerned as we did during the world wars. Let's all set our goals now and start moving toward them. The free world's straw has traveled quite far enough in the face of the Soviet wind.

It's time to say to the Communist way of life, "If you aren't content to leave us alone, we will bury you!"

DAVID A. SKILLING
Cadet
U. S. Air Force Academy
Colorado

Transducer Producer

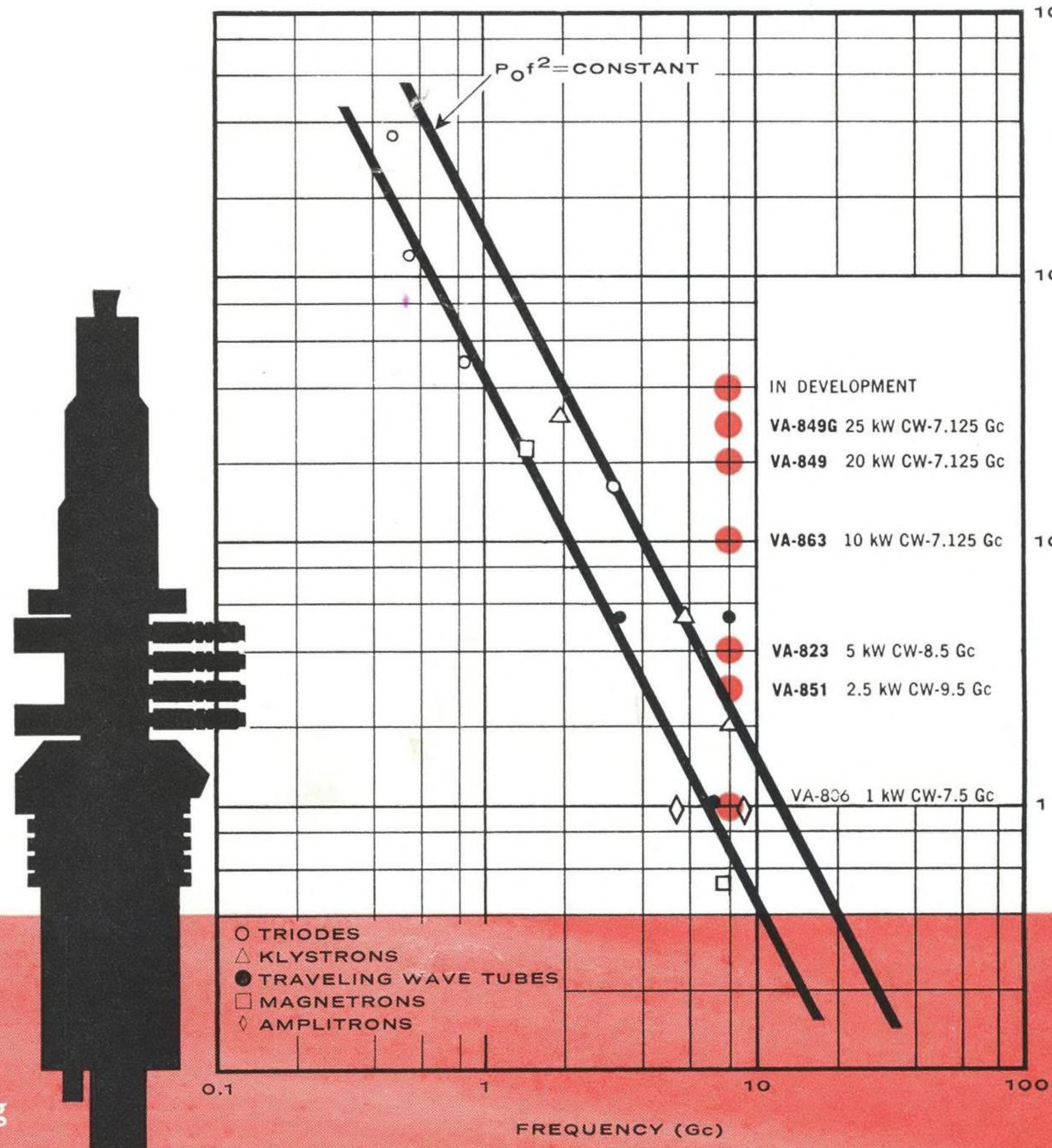
This will call attention to an error reported in your article beginning on p. 68 of the Feb. 5 issue of AVIATION WEEK entitled "Artemis Gear Detects Far Underwater Blast." The error concerns the reported manufacturer of the enormous transducer for generating the underwater sound. The transducer was manufactured completely by the Massa Division of Cohu Electronics, Inc. in its Hingham, Mass., plant.

This transducer is a very major contribution to the state of the art in high-power low-frequency underwater sound generation and is a proprietary development carried on at this company's expense and is covered by several U. S. Patent applications which are under Secrecy Order by the Commissioner of Patents.

FRANK MASSA
President
Massa Division
Cohu Electronics, Inc.
Hingham, Mass.

(*Mr. Massa is right.* AVIATION WEEK *erred in crediting Ling Electronics with manufacture of the transducer.*—Ed.)

AVERAGE POWER OUTPUT AS A FUNCTION OF FREQUENCY
FOR MICROWAVE TUBES. (MODIFIED FROM NERGAARD)



Power surveys by Nergaard,* plotting power output as a function of frequency for tubes of varying powers, predicted that maximum wattage available in X-band would be less than 10 kW CW.

Varian research indicates this figure to be extremely conservative. Varian's recent introduction of the VA-849 amplifier klystron provided the industry with a tube capable of developing 20 kW CW power at 7.125-8.5 Gc. A modified VA-849 developed 51.5 kW power in the laboratory, and is now available as the VA-849G, conservatively rated at 25 kW CW. Varian accomplishments do not stop there. The company is now developing an X-band tube rated at a *minimum* of 50 kW CW.

If *your* microwave project calls for such out-ahead capability in power tube development, write Tube Division. *L. S. Nergaard, RCA Review, Dec., 1960

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