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Including Space Technology

March 17, 1958 75 cents

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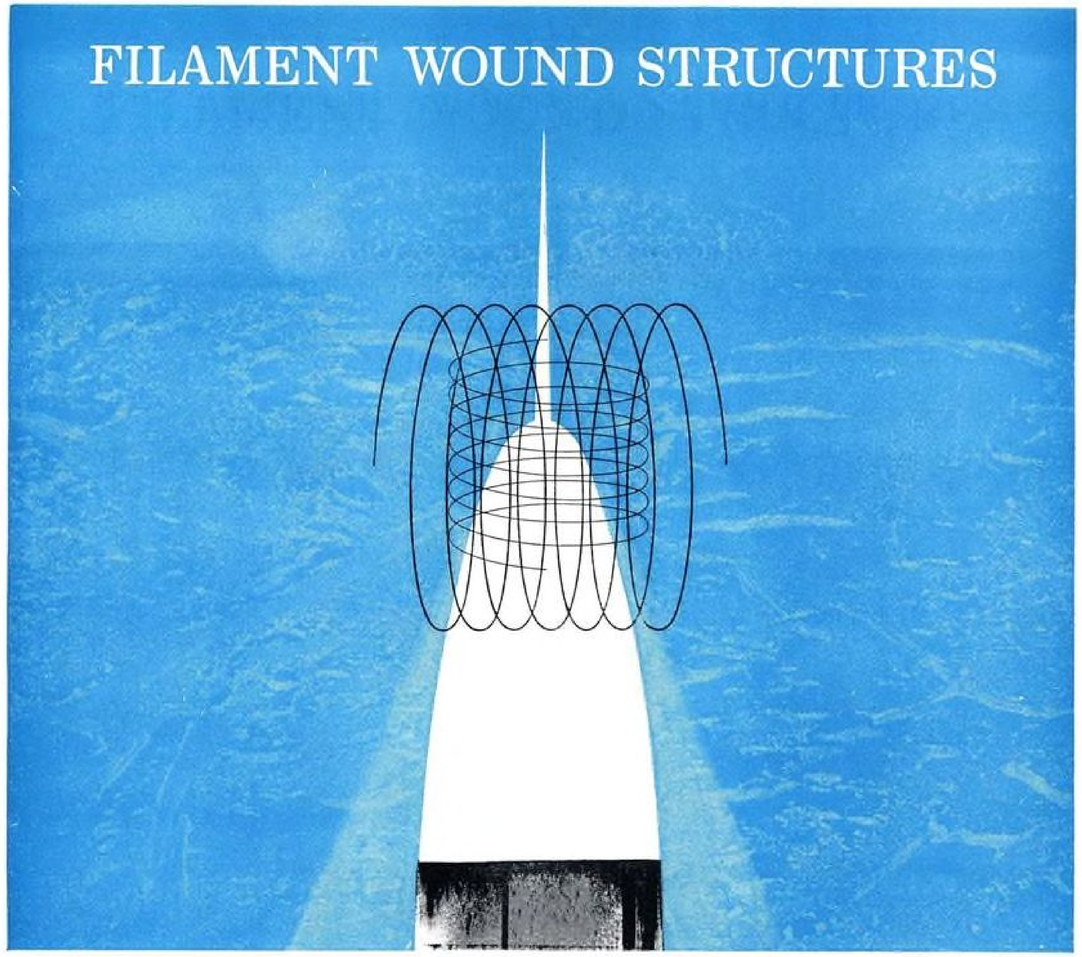

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AVIATION CALENDAR

Mar. 24-26—Annual Meeting, Aero Medical Assn., Statler Hotel, Washington, D. C.
Mar. 24-27—Institute of Radio Engineers, National Convention, Waldorf-Astoria Hotel and New York Coliseum, New York City.
Apr. 8-10—Eighth International Symposia, Electronic Waveguides, Engineering Societies Bldg., 29 W. 39 St., New York City.
Apr. 8-11—National Aeronautic Meeting, Society of Automotive Engineers, Inc., Hotel Commodore, New York, N. Y.
Apr. 10-11—Aeronautical Training Society Annual Meeting, Mayflower Hotel, Washington, D. C.
Apr. 10-12—Southwestern Institute of Radio Engineers Conference and Electronic Show, St. Anthony Hotel and Municipal Auditorium, San Antonio, Tex.
Apr. 14-17—Design Engineering Show and four-day conference sponsored by the American Society of Mechanical Engineers, International Amphitheatre, Chicago, Ill.
Apr. 16—"Inductive Testing Requirements of Contacts Used in Aircraft Electric Systems," M. Trbovich, Hartman Electrical Mfg. Co., Engineers Club, Philadelphia.
Apr. 16-19—14th Annual National Forum, American Helicopter Society, Sheraton-Park Hotel, Washington, D. C.
Apr. 17-18—Institute of Environmental Engineers, Second Annual Technical Meeting, New Yorker Hotel, New York City.
Apr. 22-24—1958 Electronic Components Conference, Ambassador Hotel, Los Angeles, Calif.
Apr. 22-24—1958 Annual Convention, International Airline Navigators Council, Piccadilly Hotel, New York, N. Y.
Apr. 28-30—Second Annual Astronautics

(Continued on page 6)

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AVIATION CALENDAR

(*Continued from page 5*)

Conference, sponsored by Air Force Office of Scientific Research and Institute of Aeronautical Sciences, Shirley Savoy Hotel, Denver, Colo.

May 1-8—26th Annual Meeting, American Society of Tool Engineers, Philadelphia Convention Center, Philadelphia, Pa.

May 4-7—Fourth National Flight Test Instrumentation Symposium, Park Sheraton Hotel, New York City.

May 5-7—1958 National Symposium, Professional Group on Microwave Theory and Techniques of the Institute of Radio Engineers, Cubberley Auditorium, Stanford University, Stanford, Calif.

May 10-14—16th Miami-Havana Air Cruise sponsored by the Florida Air Pilot's Assn., Miami, Fla.

May 12-14—National Conference on Aeronautical Electronics, sponsored by Institute of Radio Engineers, Biltmore Hotel, Dayton, Ohio.

May 14-16—Spring Meeting, Society for Experimental Stress Analysis, Hotel Manger, Cleveland, Ohio.

May 19-22—17th Annual National Conference, Society of Aeronautical Weight Engineers, Inc., Belmont Plaza Hotel, New York, N. Y.

June 2-4—1958 National Telemetering Conference, Lord Baltimore Hotel, Baltimore.

June 9-13—Fourth International Automation Exposition and Congress, Coliseum, N. Y., N. Y.

June 16-18—Second National Convention on Military Electronics, Sheraton Park Hotel, Washington, D. C.

June 24-26—31st Meeting, Aviation Distributors and Manufacturers Assn., Mount Washington Hotel, Bretton Woods, N. H.

June 25-27—Air Transportation Conference, sponsored by American Institute of Electrical Engineers, Hotel Statler, Buffalo, N. Y. For information: S. H. Hanville, Jack & Heintz, Cleveland 1, Ohio.

July 4-6—All-American Aviation Exposition, County Airport, Pittsburgh, Pa. For details write: All-American Aviation Exposition, Executive Headquarters, 210 Semple St., Pittsburgh 13, Pa.

July 4-8—12th Annual All-Woman Transcontinental Air Race from San Diego, Calif., to Charleston, S. C. For information write: All-Woman Transcontinental Air Race, Inc., 2611 East Spring St., Long Beach 6, Calif.

Aug. 19-22—Western Electronic Show & Convention, Institute of Radio Engineers, Ambassador Hotel, Los Angeles, Calif.

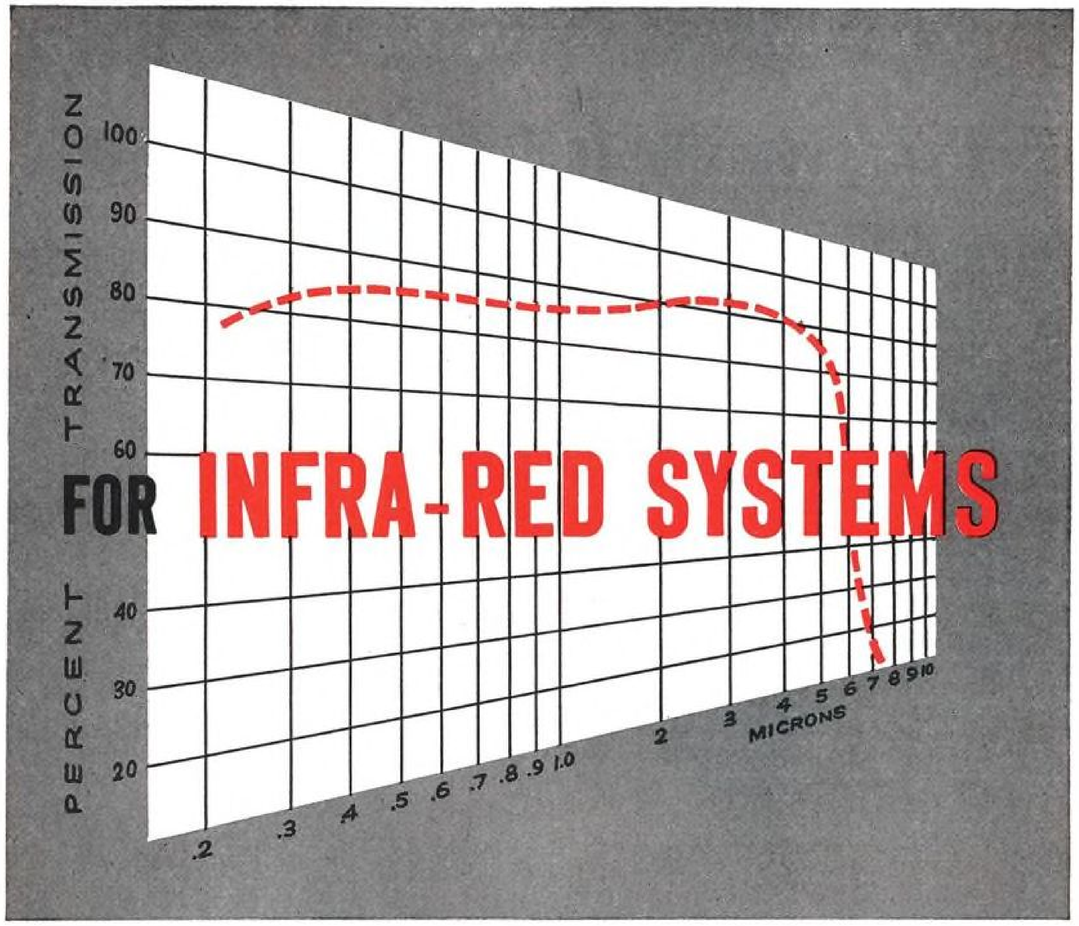
Sept. 1-7—1958 Farnborough Flying Display and Exhibition, Society of British Aircraft Constructors, Farnborough, England.

Sept. 6-14—International Aviation Show, Coliseum, New York, N. Y.

Sept. 8-13—First International Congress of the Aeronautical Sciences, Palace Hotel, Madrid, Spain.

Sept. 22-24—1958 Meeting, Professional Group on Telemetry and Remote Control, Americana Hotel, Bal Harbor, Miami Beach, Fla.

Oct. 27—14th Annual General Meeting of the International Air Transport Assn., New Delhi, India.



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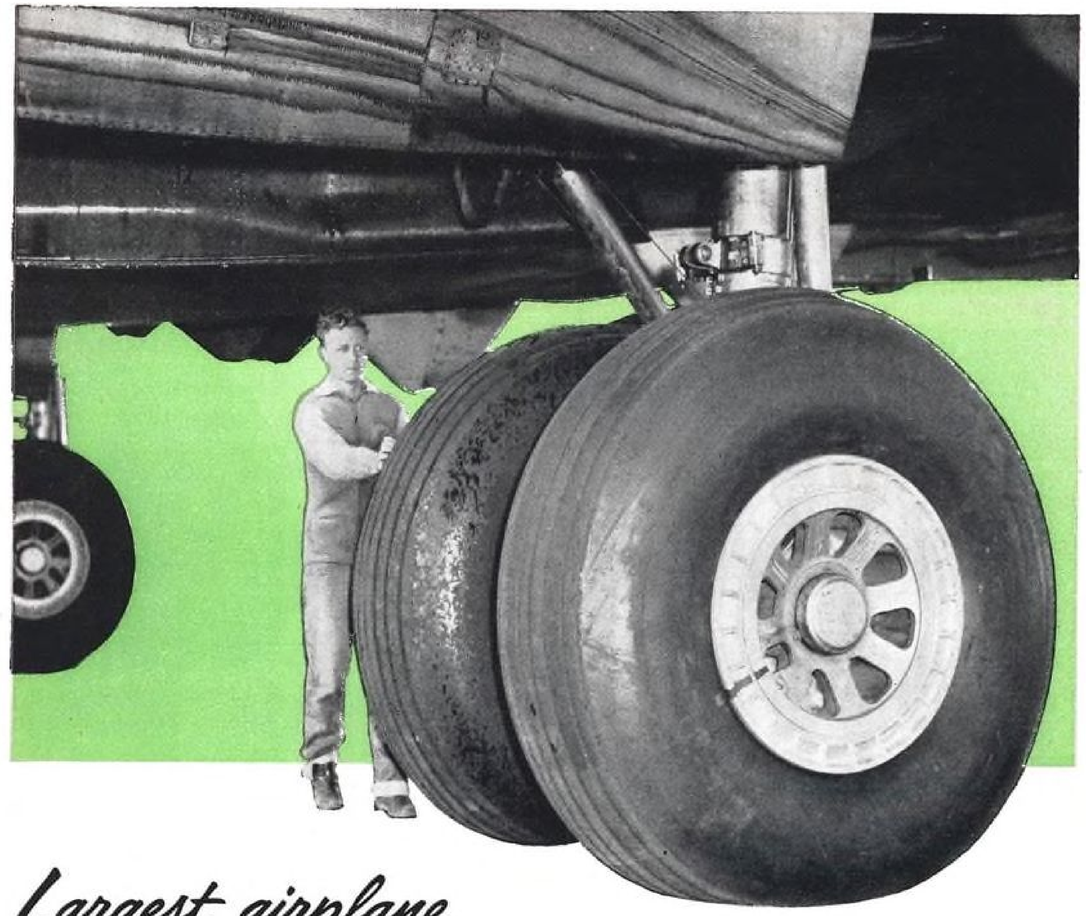

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COVER: ROTI II long range photo of a 62 ft. Thor firing taken when missile was at an 18 mi. altitude and 35 mi. slant range from tracking telescope. Lens used has a 500 in. focal length. Linked diamond exhaust shock pattern is expanded due to decreased atmospheric pressure at altitude; length of flame is approximately 130 ft. ROTI II tracking telescope which took picture is located five miles south of Melbourne, Fla., some 30 airline miles from Cape Canaveral launching site. Second ROTI system was recently installed at Vero Beach, Fla., and third system is nearing completion on San Salvador, BWI., one of the islands along the 5,000 mi. Air Force Missile Test Range. ROTI tracking telescope systems are made by Perkin-Elmer Corp., Norwalk, Conn.

PICTURE CREDITS

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EDITORIAL

Salute to Al Boyd

The future of manned flight vehicles now stretches out in an awesome curve to almost infinite speeds and destinations in outer space. Not so long ago many technical snake-oil salesmen were trying to peddle the pitch that ballistic missiles were an "ultimate weapon" that would obliterate manned flight vehicles from the future. Knowledgeable observers aware of the "man in space" research and hypersonic glider developments retained a more accurate fix on the future which will surely see a mixed bag of missiles and manned flight vehicles as far ahead as anybody can reasonably predict.

This fantastic future of manned flight vehicles will be built on a solid foundation of experimental knowledge gained during the first decade of supersonic flight (1947-57) which saw man first push a powered flight vehicle literally out of the earth's atmosphere envelope into the fringe of outer space.

These pioneering flights of the Bell X-2 will be followed next year by concerted probing into space at seven times the speed of sound by the North American X-15 rocket research plane manned by company, USAF and NACA pilots.

Progress of the U.S. during the first supersonic decade has been a bright spot in an otherwise misty technical picture.

This country was the first to fly a man faster than the speed of sound, the first to reach Mach 2, the first to put a straight and level supersonic fighter into operational service and the first to fly a bomber capable of sustained operations at Mach 2. At this writing, U.S. pilots have flown higher and faster than anybody.

Ingredient for Success

One of the vital ingredients in this successful formula for maximum technical progress in minimum time has been a new breed of experimental test pilots and a new philosophy of flight testing that changed this operation from an empirical art into a reasonably exact science. In this endeavor, the work of Al Boyd, a tall, lean taciturn man from the Great Smoky Mountains of Tennessee who wore the wings of an active Air Force pilot for 28 years, deserves special commendation. The significance of his efforts would be hard to find in his own conversation or the record of his official honors before his retirement from the Air Force last fall after 30 years service. It can be found, however, in a myriad of design details in military aircraft now flying on four continents, in the sharp climb of performance parameters of military aircraft during the first supersonic decade and in the achievements of a whole generation of test pilots he taught and inspired.

There are some official benchmarks that provide a clue to Al Boyd's efforts. He commanded the postwar flight test section at Wright Field in 1945 when the advent of reaction power and the first glimmer of supersonic aerodynamics sparked the drive to push piloted aircraft past the speed of sound; he established the flight test center at Muroc dry lake, and he organized the USAF flight test pilot school. He brought the world speed record back to the U.S. in 1947 after it had reposed abroad 24 years, and he directed the weapon systems development concept both at Wright Field and as a deputy commander of Air Research and Development Command during his final years in a blue uniform.

Valued Opinion

He flew every type of U.S., British and French aircraft of the post-war generation, fittingly climaxing his military flying experience piloting the Convair B-58 bomber past Mach 2. During the first supersonic decade, Al Boyd's opinion after flying a new aircraft became universally accepted as the final word on that vehicle. USAF did not buy a single flying machine in the past 10 years that Al Boyd had not flown and given his personal stamp of approval, and few U.S. dollars flowed to finance foreign aircraft that could not pass his strict flight testing standards.

But the genuine value of his work and the real scope of his influence does not emerge from the bare official records. It glows rather in the talk around the design shops and flight test centers in this country, England and France and in the long hours of bull sessions with the pilots who worked for him. The alumni of his exacting school are now famous in their own right—Pat Fleming, Dick Johnson, Glen Edwards (for whom Edwards AFB was named) Chuck Yeager, Pete Everest, Austin Davis, Bob Hoover, Joe Lynch, Russ Schleeh, Guy Townsend, Slade Nash and many others. Some of them have paid for progress with their lives and others are still transmitting the Boyd teachings to the second and third generations of supersonic test pilots and the first generation of space pilots.

Perceiving the Need

"Al Boyd was really the father of modern flight testing," one of his now famous pupils told me during the course of a long night aboard a transcontinental nonstop homeward bound flight from Los Angeles. "He first perceived the need for an engineering-scientist in the cockpit with the ability to grasp the significance of the experiences encountered in flight and translate them into state of the art advances. He taught us how to take new aircraft way out to the ragged edge of their performance possibilities and to adequately report and understand what we encountered there."

A page such as this is much too short to adequately sketch the character of such a man or catch the flavor of his work. The Air Force has bestowed on him some of its formal honors, and he is working now as an industrial executive. But, wherever men fly either inside the atmosphere or out in space, they should pause periodically in their work and think of Al Boyd who made so much of it possible.

—Robert Hotz

WHO'S WHERE

In the Front Office

Dr. Lloyd V. Berkner, president of Associated Universities, Inc., a director, Texas Instruments, Inc., Dallas, Tex.

Joseph M. Looney, Jr., president, Technology Instrument Corporation of Calif., North Hollywood, Calif.

James Cox, executive vice president, and **Paul W. Booth,** vice president-engineering, Hofman Laboratories, Inc., Hillside, N. J.

Dr. George L. Haller, a vice president, General Electric Co., New York, N. Y. Dr. Haller is general manager of General Electric's Defense Electronics Division, Syracuse, N. Y.

Dr. E. M. Baldwin, a vice president, director, and general manager of Fairchild Semiconductor Corp., Palo Alto, Calif.

Frank J. Phillips, vice president and general manager, The Cyril Bath Co., Solon, Ohio.

Irving Green, administrative vice president, Summit Industries, Gardena, Calif.

Charles Gundrum, executive vice president, Electronics Division, Van Norman Industries, Manchester, N. H.

S. D. Heller, vice president, Ballistic Missile Early Warning System service, Radio Corporation of America Service Co., Camden, N. J. **K. M. McLaren** succeeds Mr. Heller as vice president, Missile Test Project.

Leon Parker, vice president, H. I. Thompson Fiber Glass Co., Los Angeles, Calif. Also: **W. E. Benke,** vice president-sales.

Claude B. Nolte, vice president-product engineering and development, Barton Instrument Corp., Monterey Park, Calif. Also: **Everette M. Furr,** factory superintendent, and **William S. Christian,** sales manager.

Edgar J. Jones, vice president-research and development, Metrix Corp., Newton, Mass.

John F. Strickler, Jr., assistant to the vice president and general manager of the Pilotless Aircraft Division, Boeing Airplane Co., Seattle, Wash.

Col. Harvey P. Huglin, Deputy Commander for Development, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. **Col. Donald B. Diehl** succeeds Col. Huglin as Deputy Commander for Resources.

Lt. Col. Francis J. Karlin, Special Assistant for Ballistic Missiles, Headquarters, Air Materiel Command, Wright-Patterson Air Force Base, Ohio. Col. Karlin succeeds **Lt. Col. W. H. Price,** now Deputy Air Force Plant Representative, The Martin Co., Denver, Colo.

Rear Adm. Fitzhugh Lee, Chief, Naval Air Technical Training, Memphis, Tenn.

Paul E. Hovgard, assistant to the president, Helio Aircraft Corp., Norwood, Mass.

Honors and Elections

Whitley C. Collins, president and chief executive officer of Northrop Aircraft, Inc., has been elected a member of the board of trustees of the California Institute of Technology.

(*Continued on p. 92*)

INDUSTRY OBSERVER

► **Radio-command guidance that will direct Convair's Atlas intercontinental ballistic missile is expected to give the missile somewhat greater accuracy than the inertially guided Titan ICBM. Estimated target miss distance for Atlas reportedly is one-third to one-tenth that of Titan. However, Titan's inertial guidance permits firing of mass salvos whereas Atlas' radio command guidance limits the number of simultaneous launchings.**

► First series of Navy's Polaris fleet ballistic missile may have ranges of less than the programmed 1,500 mi. in order to meet present operational date of October, 1960, for the initial submarine-missile weapon system. Specific impulse of the solid propellant powerplant probably will be later increased to fire Polaris well beyond the 1,500 mi. range.

► **Best metal additive developed thus far to help raise the specific impulse of the Polaris is powdered aluminum which is poured into and molded with the solid propellant. At present, the additive represents between 10% and 15% of the total propellant weight.**

► Atlas ICBM is trucked across country under pressure to keep its thin skin from collapsing. Integral tankage is kept pressurized by bottled gas transported on the cradle-like Atlas trailer.

► **New Navy attack plane will launch its atomic stores by firing them from a rearward-facing tube in the fuselage. New firing method is designed to circumvent the serious problems involved in high supersonic bomb drops from under the wing or out of a conventional bay.**

► Complete Navaho intercontinental cruise missile was flown nine times from Cape Canaveral, Fla., following numerous flights by the X-10, test vehicle for the cruise part of the missile. Hardware remaining at North American Aviation Inc.'s plant at Downey, Calif., will not be used in any continuation of the Navaho program but may be put to use in Air Force space programs. Booster, using Rocketdyne engines, obtains 400,000 lb. thrust before Navaho's ramjet engines take over for continued flight.

► **Air Force may purchase a number of A3J supersonic attack aircraft now being built for the Navy by North American Aviation's Columbus Division. The plane is scheduled to be the largest ever to operate off an aircraft carrier.**

► Lockheed 357 is a new light fighter project in the same size category as the Northrop N156. Plane is being pushed heavily in Europe as having the same general mission capabilities as the N156 plus greater speed.

► **Air Research and Development Command is considering the transfer of its Ballistic Missile Division headquarters from Inglewood, Calif., to Edwards AFB, Calif.**

► Grumman F11F-1F aft fuselage is fitted with two retractable ventral fins that automatically descend when landing gear retracts during takeoff to avoid chance of pilot forgetting to extend them during later critical maneuvers. Addition of two fins gives effectiveness to many times the area of the plane's vertical stabilizer.

► **Ford Motor Co. is considering feasibility of design for convertible automobile-aircraft with vertical takeoff and landing capability as part of its overall planning.**

► Fuel bay aft of cockpit in Lockheed F-104 incorporates no floor to support bladder-type cells which drape over internal structure for maximum volume.

► **Solar Aircraft Co. is developing 50 hp. Titan gas turbine unit for one-man helicopter and flying platform applications under Navy contract funded jointly by Bureau of Aeronautics and Army. Two versions of development include a constant speed YT-62 turbine and a variable speed YT-66 unit. Engine components are already being tested.**

Washington Roundup

Killian Space Proposal

Watch for Dr. James R. Killian, presidential scientific and technological adviser, to recommend that a new civilian space agency be built around the existing National Advisory Committee for Aeronautics facilities and staff. Recommendation is expected to go to the President within the near future.

NATO: More Missiles

NATO countries will receive more missiles and less planes and conventional weapons under the Military Assistance Program, according to testimony released by the House Foreign Affairs Committee last week.

The shift in Military Aid Funds was revealed by Mansfield Sprague, Assistant Defense Secretary for Military Assistance Programs, and his deputy Charles H. Shuff.

Shuff said $144 million was originally planned for missiles in Fiscal 1958 but that the total had been increased to $312 million. This will include $222 million for Nike anti-aircraft missiles, $56 million for Honest John and $34 million for Corporals, Sergeants, Sidewinders and other missiles.

Employment Stimulus

Mounting unemployment is spurring the Administration and the Democratic leadership in Congress to take steps to accelerate defense programs to create jobs.

President Eisenhower says contracts for military procurement and construction will be accelerated, with rate of spending increased by $5 billion during the first six months of this year as compared with the previous six months. He directed this order of priorities in contract letting: first, small business in labor surplus areas; second, other firms in labor surplus areas; third, small business not in surplus areas. Deputy Defense Secretary Donald A. Quarles has implemented this policy with a directive to the three military departments.

In addition, a new clause is being inserted in defense contracts urging prime contractors to give preference in subcontracting to firms in surplus areas if the subcontractors are qualified and if no price increase results.

Unemployment hit a 16-year peak in February with 6.7% of the total labor force without jobs. This compared with 25% during the depths of the depression in the early 1930s.

Airport Acceleration

Civil Aeronautics Administration plans to substantially accelerate its airport construction program. CAA is authorized to make grants up to $60 million for domestic projects annually—and expects to do it in Fiscal 1958. During the first eight months of the year—through February—grants to local governments totaled approximately $33 million, an average $4 million a month. This will be increased to an average of over $6.7 million for the four remaining months to use the full $27 million remaining authorization.

Space Decline

Switch in emphasis from space to recession in the House (AW March 10, p. 17) is also evident in the Senate. A spokesman for Sen. Lyndon Johnson (D.-Tex.) chairman of the Senate Preparedness Subcommittee, said last week that a subcommittee staff has not been selected but that the committee was "planning." Earlier, Johnson called for immediate action on the part of everyone to put the U. S. back in the race for outer space. Meanwhile, in the House, which was slower in establishing a space committee, George Feldman, New York and Boston attorney, has been named director and general counsel of its Special Committee on Astronautics and Space Exploration. A spokesman for Rep. John W. McCormack (D., Mass.) committee chairman, said selection of the remainder of the staff is under way.

Capital Gains

Civil Aeronautics Board has concluded that capital gains cannot be retained for capital purposes despite pending legislation that will permit subsidized airlines to reinvest funds from the sale of aircraft in new equipment. Majority of the Board has decided that it is "required by the law to offset against subsidies the profits which airlines may make on the sale of aircraft."

However, two of the five Board members declared that the Board not only has the legal power to permit airlines on subsidy to retain capital gains but that it should approve such a program as a matter of policy. Meanwhile, a bill backing the Board minority is now awaiting House approval of Senate amendments. On this point, the Board majority noted that, "without expressing opinions as to merits of individual provisions of the proposed legislation," there was "no objection to the legislation's basic objective."

Civil Aviation Block

Investigation of Federal Regulatory Agencies by the House Subcommittee on Legislative Oversight is blocking action on civil aviation matters now pending before the Transportation Subcommittee of the House Commerce Committee. Five members of the Transportation Subcommittee, including Rep. Oren Harris (D.-Ark.) chairman, are also members of the Oversight Subcommittee.

As a result of the time consumed in the investigation of the Federal Communications Commission, the Transportation Subcommittee has found it difficult to raise a quorum. A Commerce Committee spokesman said an effort will be made soon to clear the way for action on the many small matters now pending before Transportation Subcommittee.

MATS Investigations

Investigations by two congressional groups into the operations of Military Air Transport Service are moving forward:

- **House Government Operations Subcommittee** headed by Rep. Chet Holifield (D., Calif.) is evaluating several weeks of testimony, expects to have a report with recommendations by about mid-April.
- **Senate Commerce Subcommittee** headed by Sen. Mike Monroney (D., Okla.) is reviewing replies to comprehensive questionnaires which it is due to receive by the end of this month at the latest. The subcommittee expects to be prepared to hold hearings on MATS operations about mid-April. **—Washington staff**

Companies Vie for Minuteman Contract

At least six contractors compete for airframe; Thiokol, Aerojet, Astrodyne developing engines.

By Irving Stone

Los Angeles—At least six major contractors—North American, Convair, Lockheed, Douglas, Martin and Ramo-Wooldridge—are competing for USAF's solid-propellant Minuteman multi-purpose ballistic missile, on which propulsion development already is well along. Minuteman has top national priority.

Firms developing multi-stage solid engines for Minuteman are Thiokol Corp., Aerojet-General Corp., Phillips Petroleum and others. Phillips and North American's Rocketdyne Division recently formed Astrodyne Inc. (AW Jan. 20, p. 34) and North American and Astrodyne would be an airframe-propulsion team. Convair and Thiokol managements have worked out a semi-permanent airframe-solid propellant team arrangement for this and other projects.

Operational status probably can be attained by Minuteman as early as for USAF's Atlas ICBM and Navy's submarine-launched Polaris IRBM. Component development is being accelerated, and completion of development of the nose cone, warhead and accessory power packages is considered close.

Guidance is an outgrowth of the Thor IRBM guidance system and is the result of component development by several contractors to ensure that the system will be ready in the time scale now projected.

Minuteman began as a broad concept. Except for the special-engine program, it has drawn heavily on existing ballistic missile development programs and is aimed at achieving very high reliability and very low cost and complexity.

Cost per successful mission is expected to be considerably higher than anything developed or proposed so far.

'Tinker Toy' Concept

Another basic characteristic of the Minuteman program is the "Tinker Toy" or building block technique of varying the engine stages to produce missiles of various ranges with the same basic components (AW March 10, p. 22).

Engine stages will have a high mass ratio of propellant weight to engine weight.

Propellant probably is polyurethane plus oxidizer, which has a specific impulse of about 270.

Grains are bonded to the wall of the engine case, which is formed by winding thin steel strips. This saves space and improves mass ratio.

Differential in coefficients of expansion is no problem since the grains squeeze together as heat expands the propellant.

General concept of the propellant is an outgrowth of pioneering work done for USAF's JATO units for B-47 takeoffs.

Development of the engine case, nozzle, thrust termination method and thrust vector control has been done by the manufacturers. Thrust termination chosen, now in an advanced state of development, resulted from Air Force and Navy cooperation.

It is not a new concept, but Minuteman and probably Polaris will be the first missiles to put it to use.

Rejected Schemes

Four thrust termination schemes which were rejected are:

- **Bursting seam** in combustion chamber to drop pressure.
- **Bursting discharge nozzle.**
- **Reversing thrust.** Thrust also must be reversed on the booster after separation so that it cannot catch the vehicle in case it has some burning time left.
- **Quenching propellant.**

Objectives of the Minuteman program are:

- **Lightweight, simple** thrust vector control systems.
- **Rapid, repeatable rocket** shutdown with a repeatable residual thrust.
- **Lightweight discharge nozzles.**
- **Light, high-yield warhead.**
- **Light, highly effective** nose cone.
- **Light, accurate** guidance system.
- **Light, reliable** accessory power supplies.

In addition to the low cost of the solid propellant rocket, observers close to Minuteman development also cite these advantages of the concept:

- **Minimum manpower requirement.** Large numbers of weapons will be operated automatically under surveillance on a small group of controllers.
- **Minimum amount of support** equipment is required.
- **No complex base installation** is required for operational status.
- **"Tinker Toy" philosophy** provides a number of types of missiles using same basic components.
- **System is designed** for minimum obsolescence. Aim is to eliminate the need for replacing whole systems as technology advances. This applies also to communications networks, launch techniques, personnel training and component fabrication and assembly techniques.

History of Minuteman's solid propellant development is one of Air Force and Navy first taking separate approaches and later joining their efforts. Success of Polaris program's propulsion system is due largely to USAF's work and the USAF-Navy cooperation.

In November, 1954, USAF called in solid propellant contractors to discuss ways to attack the problem of developing engines for long range missiles.

Sergeant Utilized

In March, 1955, it hired a consultant team to work out a technical development program. The resulting concept was to cluster on-the-shelf rockets and stage them. Rockets were the one-third scale Sergeants designed and developed by California Institute of Technology's Jet Propulsion Laboratory in 1949 and used since in the Army's Jupiter-C test vehicle for nose cone work and Explorer satellite launch attempts.

Navy approved of the plan and it became the original Polaris configuration.

This configuration and the fact that lightweight hardware was not available then would have resulted in an IRBM weighing 162,000 lb. Navy later abandoned this in favor of the present Polaris.

USAF rejected the consultant team's program at the start. Among the reasons were:

- **It did not believe** lightweight guidance and control systems could be developed to contend with the moments induced by differences in starting and shutdown transients of the clustered rockets.
- **It believed poor performance** and great weight of the vehicle would make solid propellants look bad and constitute poor propaganda for other solid development proposals in which it had great confidence.

USAF accordingly decided to begin a vigorous solid propellant development program of its own. On Jan. 7, 1956, it presented this concept to Defense Department. Navy presented its original Polaris concept on the same day. Within a year, it had abandoned the concept.

Early in 1957, Navy asked Air Force to help it reorient its program along USAF lines, and Air Force readily agreed. Since then cooperation has been very close and both Minuteman and Polaris have proceeded successfully.

Navy has put more funds into its project and has accelerated testing of solid rockets. Navy also has gone farther in development of its own polymer, although this work is based on prior USAF development. Navy also has used USAF-developed propellant motor case and lightweight nozzle.

Navy's guidance problem is much greater than Minuteman's because of limited space in the launching submarine, need for the submarine's position to be located precisely and need for underwater launch. Navy in testimony before Congress has given USAF credit for helping it support the work done at Massachusetts Institute of Technology, which contributed both to the Polaris missile guidance itself and to the Ship's Inertial Guidance System, basis of the navigation system that will determine the submarine's position.

Defense Department Guided Missiles Director William Holaday has ordered Air Force to consider use of Polaris as a second-generation IRBM. Close USAF-Navy cooperation probably means Polaris and Minuteman will be operational close to the same date.

Dulles Doubts Wisdom Of Moon Launch

Washington—Members of both the House and Senate last week took issue with Secretary of State John Foster Dulles on the importance of any U. S. program to reach the moon.

Most critical of Dulles' testimony before the House Foreign Affairs Committee was Rep. Daniel J. Flood (D.-Pa.) who criticized the Administration for failing to take action on Air Force and Army proposals to hit the moon or put a vehicle in orbit around the moon within the next year.

Others calling for action were Sen. Henry M. Jackson (D.-Wash.) a member of Senate committees on Armed Services and Government Operations as well as the Joint Committee on Atomic Energy, and Sen. George A. Smathers (D.-Fla.) a member of the Senate committees on Finance and Interstate and Foreign Commerce.

Dulles testified that he failed to see much point in spending large sums of money to send a rocket to the moon when the Russians probably will get one there first anyway.

He said that one of the Administration's major problems is determining whether it is justified in spending tax money on a program that "let us assume has no practical value."

Flood said he regretted the apparent policy to "deliberately ignore the psychological defeat the U. S. suffered when Russia became first to place a satellite in orbit."

"It is particularly disturbing," he added, "when we consider that the Army could have put a satellite into orbit a year before Russia."

"There is no doubt in my mind, and I hope in the minds of most Americans," Flood said, "that it is important for reasons other than military that this country be first to shoot a rocket to the moon, first to orbit the moon and first to fly a nuclear propelled aircraft.

Sen. Jackson said shooting to the moon is not only important for the prestige the U. S. would gain but also because of the scientific data the nation could procure. Such information, he said, is of inestimable importance for carrying out outer space exploration.

As to the psychological impact of being first Jackson said, "I do not believe that the damage to our prestige by Russia's first with Sputnik should now be repeated by our being second to the moon.

USAF Appeals Anti-Missile Decision

Washington—Air Force Secretary James H. Douglas has appealed to Defense Secretary Neil H. McElroy to reverse a two-month-old decision and allow Air Force to continue development of its Wizard anti-missile missile system.

USAF still does not believe Army's Nike-Zeus system has the growth capability to handle possible enemy evasion, decoy and countermeasure tactics.

Also, USAF feels too great a risk is involved in relying on only one system at this stage, and says competing efforts should be allowed. It cites Senate Preparedness Investigating Committee's 17 points "upon which decisive action must be taken," one of which is: "Put more effort into developing anti-missile missiles."

Meanwhile, McElroy issued a one-sentence directive to halt Army's plans to make Nike-Zeus installations capable of handling intermediate and intercontinental missiles.

"In order to avoid any misunderstanding regarding the responsibility for future (second generation) research and development in the field of land-based IRBMs and ICBMs, it should be understood that this function is the responsibility of the Department of the Air Force," the memo said.

Not only would USAF not develop the Nike-Zeus system for immediate operational deployment if it had the choice; it has not yet decided which of the Wizard proposals is most desirable.

Under USAF's plan, Wizard development would continue for perhaps another year at $2 million to $3 million per company before the final selection was made. Teams are Lockheed-Raytheon and Convair-Radio Corp. of America. General Electric is developing nose cones. Air Force also had a contract on the Douglas Aircraft-Bell Telephone Laboratories study which is the basis of the Army Nike-Zeus project.

Determination of the requirements and deficiencies in the nation's overall air defense system will be influenced by reorganization of the Defense Department. Secretary McElroy's recommendations on reorganization were due to be made by the end of this month.

Secretary Douglas told the House Armed Service Committee recently that he did not believe the present defense organization "has assured the kind of overall objective consideration that should be given to as complicated a system as this and its component parts."

"I think if there is anything in Defense Department organization that should have attention, and that will have attention in the present discussions looking to some reorganization, it is establishing an overall basis for determination of requirements in the air defense area so that there is no longer the element of the fortuitous in determining the mix that we have of manned interceptors, of Bomarc controlled by Sage and of Nike battalions spread out through the country," Douglas said.

Although Douglas told the same committee on the same day that Air Force agreed to and had accepted McElroy's mid-January order assigning anti-missile development to Army and long range anti-missile detection to USAF, the Air Force is clearly on record as having little faith in Nike-Zeus.

The mid-January decision (AW Jan. 27, p. 26) specifically ordered USAF to drop missile development under the Wizard program and to continue only with detection and data handling phases, and to coordinate this work closely with Army and with Advanced Research Projects Agency.

German F-104 Choice

Scales are strongly tipped in favor of Lockheed's F-104 Starfighter as the choice of West Germany for re-equipping its air force, Aviation Week learned last week. The choice results from what Lt. Gen. Josef Kammhuber, West German air force chief, saw on his month-long U. S. tour. Estimates of the size of the order, for which Grumman's F11F-1F was nearest competitor, have ranged from 100 to 400 aircraft.

Captive Test Program Proves Value in Atlas 'Flight' Data

By Richard Sweeney

San Diego—Captive flight and static firing test program on Atlas intercontinental ballistic missile has proved itself financially and made possible early flight testing of Atlas from USAF Missile Test Center, Cape Canaveral, Fla.

Facilities involved in part of static test program were outlined last week at Convair's Sycamore Canyon test site, where work in slightly more than a year's operation has yielded 14 "flights" worth of data. One missile stayed in test stand eight months, yielded equivalent of 10 test flights in data.

Extensiveness of test effort can be seen in fact that of 9,500 persons working for Convair Astronautics Division, more than half are engaged in test program. In engineering talent, again one half are assigned to test work. Twenty per cent of test workers are at sites away from Convair's main San Diego facilities.

Missile in the stand was the A configuration, which differs slightly from the operational B model configuration, due to have its first flight test at Cape Canaveral, Fla., in near future.

Atlas Model B has Mark I General Electric Co. nose cone, propulsion system includes 60,000 lb. sustainer thrust chamber as well as two 165,000 lb. thrust chambers which are booster. Full, three chamber propulsion system has not yet been flown on any vehicle.

Sycamore Canyon site was chosen for its location on government property, the fact that water and electrical power in required amounts were available, and its remoteness from populated areas.

Facility consists of two test complexes, each having test stand capable of handling thrusts in excess of one-million pounds, control center, propellants supply. Common source serves both units with liquid nitrogen, water and helium.

Some 600,000 cu. ft. of helium is available, stored at 5,000 psi. Water supply has 750,000 gal. stored, with usage being at rate of 30,000 gpm. in the flame deflector bucket, plus availability for .75 gpm. for every square foot of the missile in case of fire.

In propellants, 16,000 gal. of hydrocarbon fuel is stored for each stand, along with 30,000 gal. of liquid oxygen. Pumping facilities enable loading missiles with propellants at 1,000 gpm.

Test stands consist of large service tower which surrounds missile in erected condition position, yet is not attached directly to the missile. Missile itself rests on and is held by launcher assembly identical to that at USAF MTC, with exception that assembly has additional special hold-down struts which prevent accidental movement of release arms during a test run. Launcher is welded steel assembly weighing some 62,000 lb., considerably lighter than gross weight of missile ready for takeoff.

Service towers are approximately 100 ft. high, enclose over top of 81 ft. long Atlas missile. Tower is about 25 x 30 ft. at base, and includes winch and cable mechanism which raises the missile trailer into position during erection of missile to vertical position.

Control centers are located 400 ft. back from test stands. Buildings are designed to withstand blast equivalent to 100,000 lb. of TNT. Centers have 40 x 60 ft. interior, are equipped with emergency ventilation, lighting, communication and escape facilities.

From control center, tunnel runs from center toward stand to a reinforced concrete underground chamber known as transfer room where battery and generator for missile power supply is located, as well as certain instrumentation and control equipment which must be closer to test stand than blockhouse. Room also serves as site for junction boxes for data system and control system. Some 15,000 wires run from stand to control center, including both control and data functions. About 500 instruments are in center.

Instrumentation for complexes is the same as that at Cape Canaveral, enabling test data from the two places to be compared directly.

Data system makes use of analog equipment, with some digital direct information. Provisions for quick check exist at Sycamore, but detailed data reduction is conducted at San Diego where there is an IBM 704 computer.

Instrumentation includes oscillographs, camera-equipped sonic analyzer, direct writing recorders, movie cameras, closed circuit television and an FM telemetry system. FM system, with which commutation technique can be used, has 60 channels available, with overall multiple of 300 to 500 different type samples capability per run.

Use of the missile itself at Sycamore makes data compatible with that of Cape Canaveral, but requires extra safety provisions since thin wall missile tanks are used rather than the heavy boiler plate "battleship" tanks such as are used in some test stand facilities like Pt. Loma, one stand of Convair's at Edwards AFB rocket base.

Countdown for an Atlas run at Sycamore is like that at AFMTC. Preparations begin on X minus one, the day before the firing. Some 4,000 items are covered from written lists.

Actual firing count approximates four hours, with hold provisions (i.e., the count can be stopped for required fixes, repairs) at all points.

Titan ICBM Static Firing

Smoke surrounds Titan intercontinental ballistic missile; first static firing of complete propulsion system has been completed at Denver, Colo., by the Martin Co. Further test firings, up to three minutes in duration, will proceed at a rate of not more than two a week for the next month or so. Test version of the Titan propulsion system made by Aerojet-General Corp. is realistic in every way except that heavy gage "battleship" tanks have been substituted for the lightweight fuel cells of the operational missile. While these tanks are internally similar to the service equipment, their strength allows them to be used through many tests. The engine stand used for the test is one of four.

Space Technology

Pt. Mugu May Become U.S. Space Base

Los Angeles—New National Pacific Missile Test Range at Pt. Mugu, Calif., may become the leading U. S. space and satellite base.

Although no specific satellite or space programs have yet been assigned the new Navy-managed range, it has three important advantages over USAF's Missile Test Center at Cape Canaveral, Fla.:

• **Polar orbits** can be established by satellites fired from Pt. Mugu but not from Canaveral, which has to fire for generally east-west orbits. Advantage of a polar orbit is that a reconnaissance satellite could map almost all the earth's surface in one day's time from an altitude of 1,000 mi. plus. Extensive area that can be mapped from a polar orbit is due to the earth's rotation beneath the satellite vehicle. An east-west orbit generally conforms with the rotation of the earth, and the area that can be covered is relatively smaller.

Cape Canaveral is restricted to east-west orbits because of the population centers to both the north and south that might be endangered by falling boosters if a north-south launch necessary for a polar orbit was attempted. Boosters from a north-south launch at Pt. Mugu would fall into the Pacific.

• **Property**—Approximately 93,000 acres as compared to 12,000 for Cape Canaveral. Some officials believe that the limited area of Air Force's test center will restrict it to firing vehicles with thrusts of no more than one-half to a million pounds thrust because of the explosive and noise hazards. Mugu, with its large, mountain-ringed acreage, could handle vehicles with as much thrust as its designers could put into them.

• **Availability.** Mugu is in close proximity to most of the large aircraft manufacturers who are now engaged in the manufacture of missiles and are scheduled for space and satellite roles. Vehicles to be fired from Cape Canaveral, such as Convair's Atlas intercontinental ballistic missile, have to be laboriously trucked across country.

These facts lead some top officials working with missile-satellite programs to believe that within five years most U. S. missile, satellite and space firings will be made from Pt. Mugu.

Canaveral Still Important

Cape Canaveral, however, will continue to play an important role. An attempt for an east-west orbit from Pt. Mugu is impractical. A firing to the east might drop a booster over populated areas; to the west, the satellite would be pushing against the earth's rotation.

Pt. Mugu's present role is restricted to training and support, primarily of USAF's missile training units at nearby Camp Cooke, Calif. Cape Canaveral will continue with its research and development role.

In the recent expansion of Mugu from the previous Naval Air Missile Test Center to the National Pacific Missile Test Range, Navy took over the southern portion of Camp Cooke for additional support, including instrumentation, communications and launch sites for the use of all three services.

Firings of large missiles and satellite vehicles probably will be made from the Camp Cooke section of the range, with the older Pt. Mugu complex handling the smaller tactical missiles.

First firings of Douglas Thor intermediate range ballistic missiles are scheduled to be made from Cooke by Air Force training units later this year. The firings to sea will be monitored and controlled by Navy telemetering ships.

Later, an east-west monitoring system similar to the present north-south Minitrack range constructed in connection with the Vanguard earth satellite program will be established across the Pacific. Such a system could monitor and control satellite and space vehicles following a polar orbit as well as ICBM and IRBM firings.

Some of the monitoring units of the east-west range will be permanent installations on Pacific islands; others will be located aboard ships so that the range can be shifted to accommodate various orbits.

A 500-mi. inland range stretching from Pt. Mugu to Army's Proving Ground at Dugway, Utah, also is being established for firings of missiles with guidance systems such as ATRAN which are dependent upon terrain features. Missiles, notably the Regulus II, can be fired from launching pads at Pt. Mugu or from ships in the vicinity of San Nicholas Island.

Flights will end in either recovery or in programmed terminal dives on targets at the Dugway proving ground.

Instrumentation of the inland range will be carried aboard mobile vans and located principally at Edwards AFB, Calif.—where Regulus II tests are now being conducted—and at Dugway.

Inland Range Cost

Total cost of equipping the range is estimated at $5 million. It will be operated by a private firm under Navy contract which has not yet been awarded. The full range is scheduled to be ready for use by August.

All flights will be made over pre-inspected areas, and the missiles kept away from populated areas. In the case of Regulus II, for example, almost any type flight pattern can be cranked into the missile's inertial guidance system to allow it to fly an erratic course and avoid population centers.

The Regulus II will fly the range at altitudes above 60,000 ft. and be kept under positive control at all times. It will be equipped with a self-destruct mechanism that can be triggered from the chase plane or from the ground.

Republic Delivers First Alouette Jet Copter

New York—Era of commercial use of turbine-powered rotary wing aircraft in the U. S. began last week with delivery of a Republic Aviation-assembled Alouette II helicopter to Aetna Helicopters, Inc., Etna, Calif.

Price of the Alouette II was disclosed as $88,665, with instrumentation and radio. Aetna Helicopters, which has three Bell 47s, does considerable work for U. S. Forest Service in Northern California.

Republic Aviation's newly formed Helicopter Division will deliver additional civil Alouette IIs to five more operators in the next few weeks, Manager Herbert Munsey told Aviation Week. Among these will be a helicopter for executive transportation.

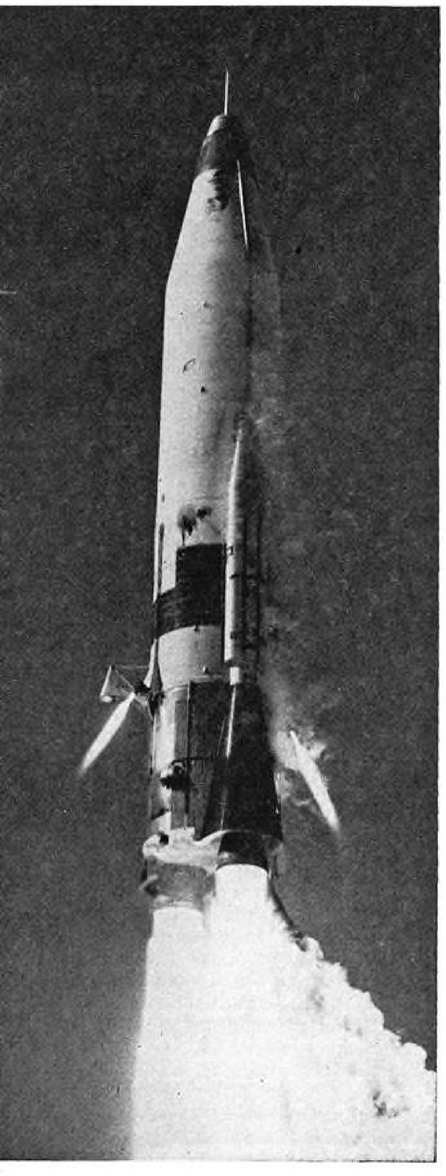
707 Sound Test Set

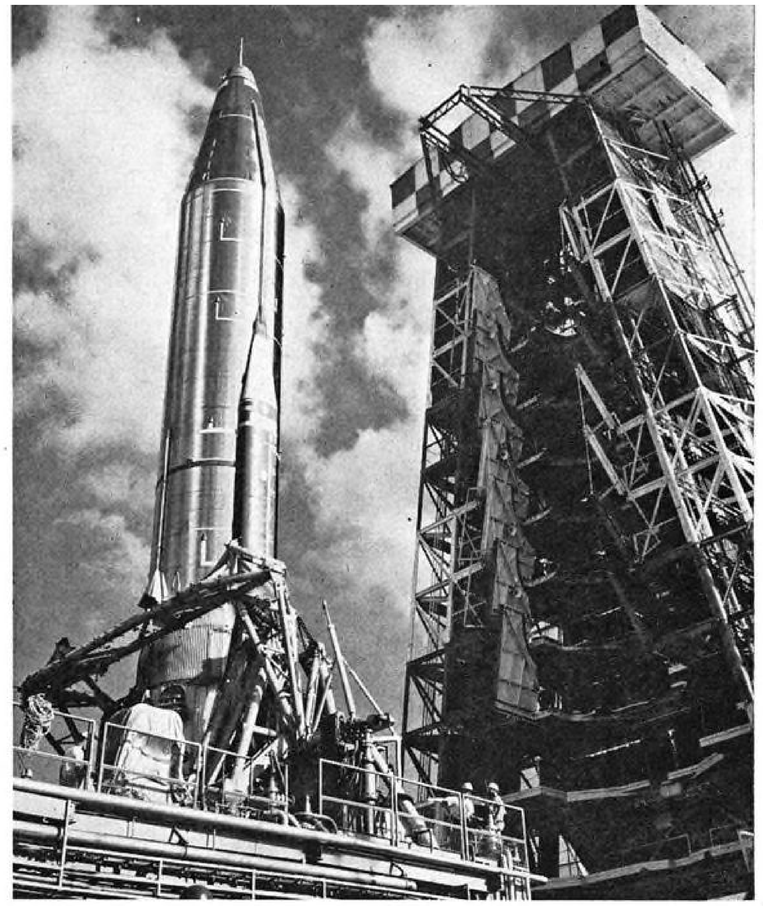
Renton, Wash.—Sound tests on the Boeing 707 jet transport will be made by the Port Authority of New York this spring at Boeing Field, Seattle, and Edwards AFB, Calif., officials said here last week.

The decision followed demonstration here of Boeing jet sound suppressor which has been undergoing flight tests. Tests this spring will include sound recordings made by Port Authority staff and its consultants, Bolt, Beranek & Newman, Cambridge, Mass.

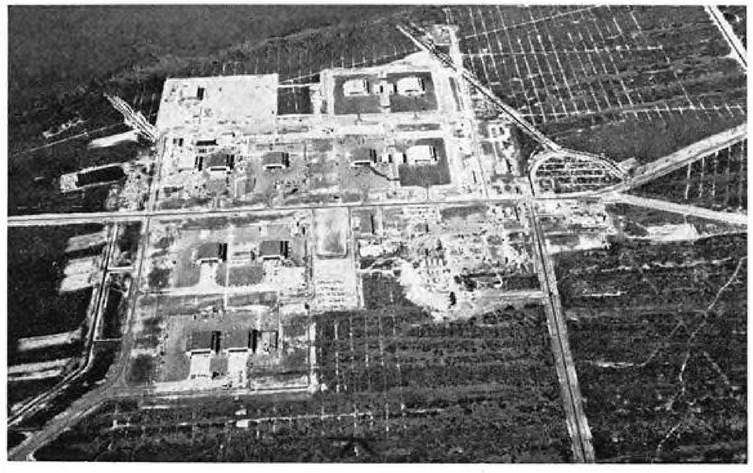
Tests will duplicate those previously conducted by the Port Authority for evaluation of the French Caravelle and British Comet IV jet transports.

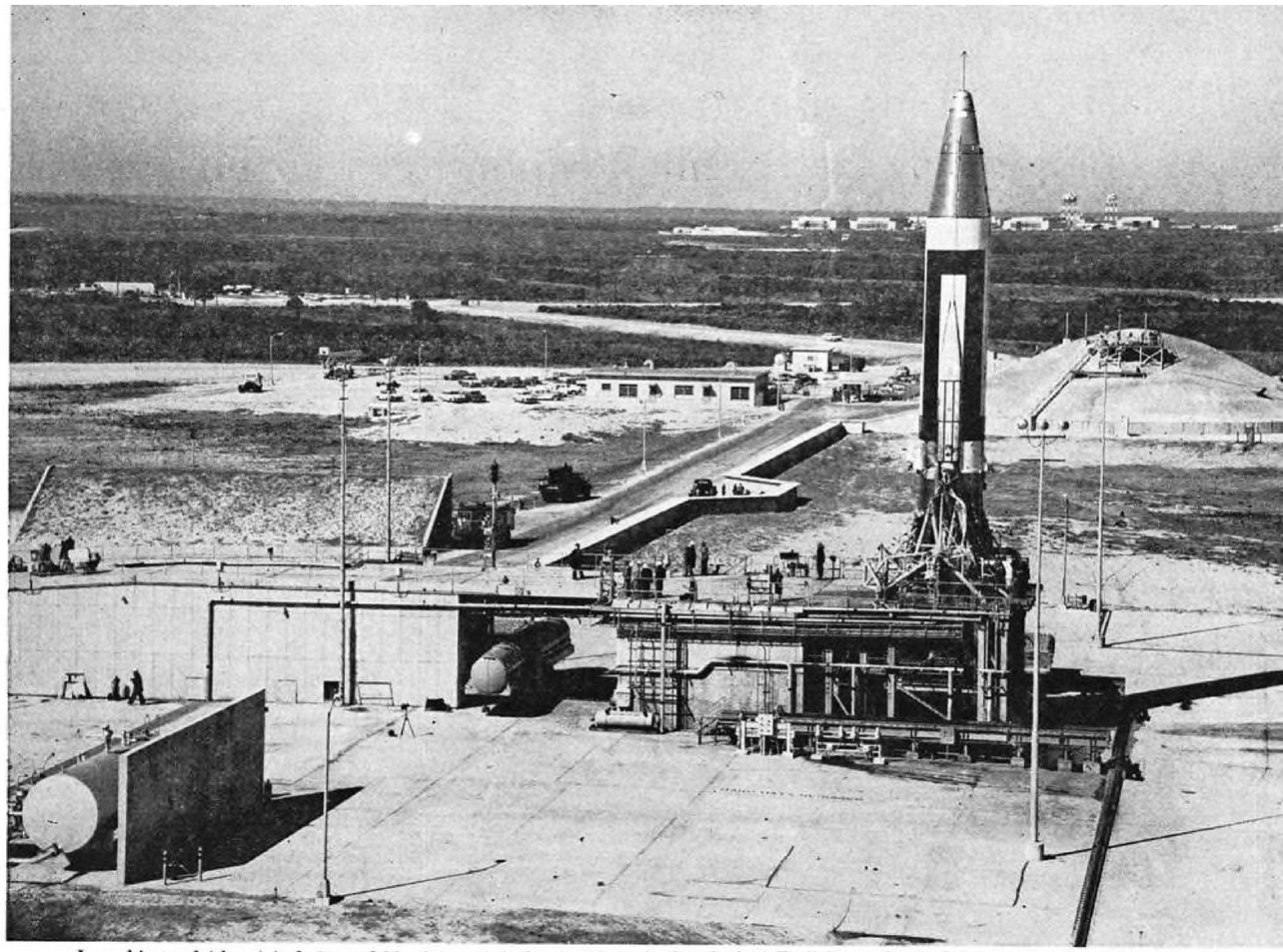
Support Complex Surrounds Atlas Missile Launch Site



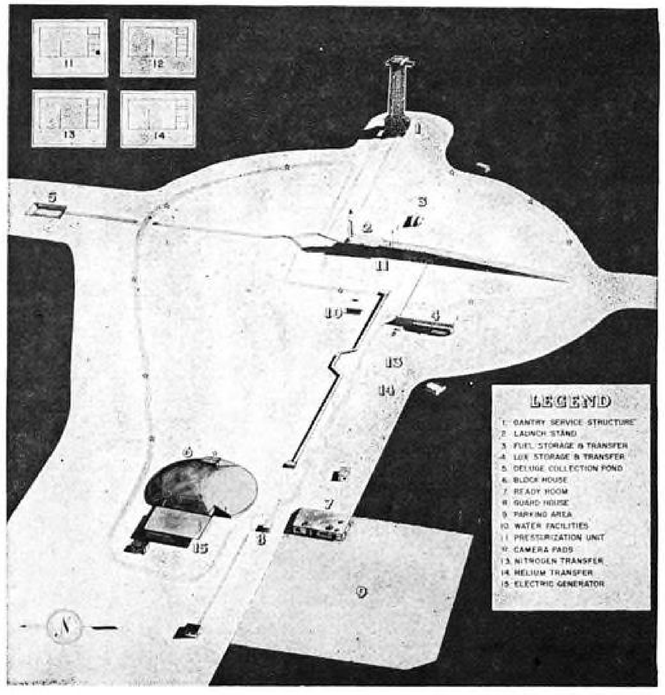


With its two powerful booster engines pushing it upward, another Atlas ICBM takes off from Cape Canaveral, Fla. (left), its ascent steadied by two slant-firing vernier engines. Small cone near the left vernier is used for tracking. First pictures of large launch complex show facilities required to get the huge missile airborne. Among the many elements that make up this complex are the 11-story gantry service structure (above) and cluster of industrial support hangars of various Atlas component contractors (below). View of Atlas on launching stand (right, top), shows fuel tank, in foreground, behind blast wall. Beyond is the second blast wall which protects liquid oxygen tanks. Low, shed-like structure, running from stand to blockhouse, houses power and instrumentation cables. It is fabricated from fire-resistant composition board and has corrugated roof to cut down heat from the sun.





Launching pad (above) is designated No. 1 in artist's drawing (below). Standard traffic light at the road behind the launching pad (left center) shows safety condition of area. Behind missile is the blockhouse and, in far background, the support hangars.



Polaris Fleet Missile Stressed As Inexpensive Deterrent Weapon

Sunnyvale, Calif.—Role of Polaris fleet ballistic missile as a deterrent weapon was stressed by Rear Adm. William F. Raborn, Director, Special Projects Office, Navy Bureau of Ordnance, during his visit to Lockheed Missile System Division here.

Raborn declared that the U.S. should not be stampeded into building mass destruction systems and should take a good look at the money going into these systems. Raborn predicted that if the Polaris were successful, its deterrent capacity would mean that the "conventional war would be the only type we would have to fight." In this connection he stressed the importance of the aircraft carrier.

Polaris is the most inexpensive ballistic missile development to date, Raborn indicated, adding that the Navy had capitalized on work of Air Force and Army. He mentioned that the Navy had used the Air Force-sponsored Lockheed X-17 test vehicle as an off-the-shelf item. Citing the Polaris guidance system as using the very latest in components, Raborn again stressed inter-service cooperation, stating that in Polaris Navy was using the latest gyros "which have come back to us as bread upon the waters." Navy had started development in this field at Massachusetts Institute of Technology about eight years ago, he said, then "got poor," after which Air Force took over the project, and now Navy was getting benefit of this development.

Raborn declared that life of a submarine is figured at 15 to 20 years and that the money required to bring the Polaris weapon system into being will be amortized over this period with a resultant relatively low cost. Raborn said that perhaps too much economy had been practiced in the Polaris program and that there was a lot of backup that should be done, adding "but we have been very lucky so far." Progress, he pointed out, has been phenomenally good to date, but those associated with the program were trying to avoid becoming over-confident. Raborn declared that there would be setbacks, but developers were trying to anticipate soft spots and proper action as far ahead as possible.

Raborn declared that Polaris had been referred to by scientists as the most complicated weapon system ever undertaken. Despite this complication, simplicity is being stressed. He mentioned these highlights:

- **Development of the first** Polaris solid propellant motor is "essentially in hand."
- **Solid propellant** is a "plasticized rubber" as simple as the material in a hairbrush.
- **Control rates** for solid propellant burning cutoff "have been well worked out in static and flight tests."
- **Launching techniques** have been successfully worked out and there is no problem in firing Polaris directly from the submarine.

Questioned on the possibility of dropping floating pods containing Polaris, and firing missile from remote position, Raborn declared there was "no authenticity" to this technique.

Commenting on possibility of launching the Polaris from a bomber, Raborn declared technical difficulties would be three to five times as great as plan Navy is undertaking with submarine launching, which is the most difficult of the technical problems yet attempted by the Navy.

In Washington, Rear Adm. F. S. Withington also reported that, initially, the first firing of Polaris fleet ballistic missiles will be from fixed launchers at USAF's Missile Test Center. Next step will be firings from moving launchers.

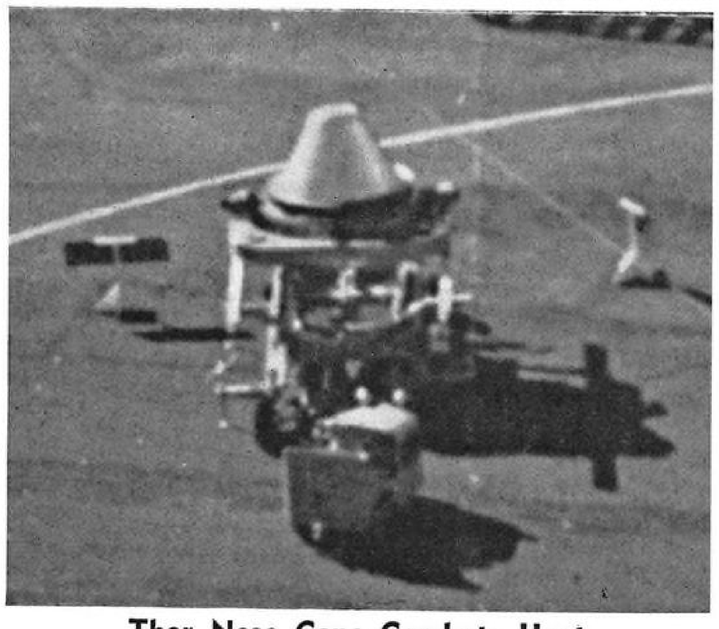
In the last step before actually being fired from missile submarines, Polaris will go to sea for launch from the ship Observation Island.

The Observation Island is a follow-on to the Polaris navigation ship Compass Island (AW Dec. 10, 1956, p. 28) and will be capable of solving both the navigation and launch problems associated with a ballistic missile sea-firing.

A converted 17,600-ton C-4 Mariner secured from the Merchant Marine reserve fleet, the Observation Island will be converted to its new mission sometime this summer. It will be equipped with twin launchers and be capable of carrying two of the 28,000 lb. Polaris missiles.

- **Loss of weight** in the submarine, as result of launching large number of missiles, will be no problem. Number of Polaris missiles submarine will carry is 16, Raborn declared.
- **Adequate number** of Polaris missiles will be available for ships which will be ready for use in 1960, when Polaris will become operational.
- **Nine nuclear submarines** will comprise the first complement of undersea ships for carrying Polaris, but there will be more of these craft in the program.
- **Polaris weapon system** will include certain safeguards against countermeasures.
- **Progress in navigational art** at sea is two years ahead in development with respect to anticipated progress. Raborn indicated that the vessel Compass Island, operating in the Atlantic Ocean with its ship inertial navigation system (SINS), "is doing quite well."
- **Numerous studies** in the selection and training of officers and crew are underway to ensure highest reliability in personnel responsible for operation of the weapon.

Raborn said he feels that company performing research and development should continue with production phase, indicating that Lockheed (missile system manager) would produce the Polaris.



Thor Nose Cone Combats Heat

Thor nose cone, shown above in its special cradle, follows flattened contours of Atlas nose cone configuration. Choice of blunt shape indicates that metallurgists are still unable to come up with a new high-temperature material that is able to withstand extreme aerodynamic heating associated with high-speed re-entry of streamlined, slender cones. While bluntness slows nose cone sufficiently to keep heat buildup within acceptable limits, it introduces larger wind drift errors into trajectory and also makes warhead easier to intercept with anti-missile missile. Air Force has ordered the General Electric Co.'s Missile and Ordnance Systems Department in Philadelphia, Pa., to start production of Thor nose cones and ground support equipment.

Anti-ICBM Version of Talos Proposed

Washington—Johns Hopkins Applied Research Laboratory is proposing a Mach 5-to-10 version of the Talos ramjet surface-to-air missile for possible anti-missile missile applications.

Proposal to boost the Talos from its present Mach 2 speeds to the Mach 10 range envisions use of an advanced twin-ramjet engine and might require as long as 10 years to develop.

Range of the Talos also would be increased to 100-mi.-plus. Longest successful intercept and kill achieved thus far with the present Talos is 70 mi.

Rear Adm. F. S. Withington, outgoing chief of Navy's Bureau of Ordnance, says the primary advantage of such a ground-based anti-missile system would be its mobility. If such a proposal were adopted, the ultimate missile probably would go to the Army for operational use.

An advanced Talos, Adm. Withington said, would be capable of intercepting and destroying an intercontinental ballistic missile "if he's coming right at you." Present Talos models already can carry nuclear warheads.

Greatest problem, the Admiral said, would be detection of the ICBM in time to take counter action.

Adm. Withington also described the air search radar to go aboard the Galveston, first Talos cruiser to enter the fleet, as the weapon system's "Achilles heel." Maximum range of the air search radar aboard the Galveston, which will go to sea this fall, is scheduled to be 200 mi. and Adm. Withington said, "I'll be pleasantly surprised if we get it."

One of the greatest difficulties in obtaining better range, the Admiral said, is the heavy weight of the rotating antenna. Weight limit for shipboard antennas is between 10 and 16 tons.

In an effort to solve the problem, Navy is now asking electronics manufacturers to push development of a fixed antenna that would have less weight and provide all-around coverage.

Discussing the air-dropped Betty anti-submarine depth charge equipped with a nuclear warhead, Adm. Withington said that, again, one of the Navy's concerns is target detection.

In this case, he said, a detection gear needs to be improved to ensure that the target is worth the cost of the missile—at least $1 million each—and that the comparatively few Bettys scheduled to be produced are not wasted.

Betty has been operational with the fleet for approximately one year. A second air-dropped nuclear depth charge, the more sophisticated Lulu, is still in the development stage.

Nuclear Rocket Power Test Site Construction Spurred by AEC

Jackass Flats, Nev.—Test sites to explore feasibility of using nuclear power for rockets, under Project Rover, and reactor heat for ramjet engines, under Project Pluto, were shown here by the Atomic Energy Commission.

First tests of reactor systems, designed and developed under Project Rover, being conducted by Los Alamos Scientific Laboratory, are scheduled to be held late this year. Construction at Project Rover test site has begun.

Advance notice to bidders for roads, utilities and facilities in test area for Project Pluto, being conducted by University of California Radiation Laboratory, Livermore, are being issued this month.

Studies of nuclear rocket propulsion systems at Los Alamos still are in the research and development stage. Various concepts have been evolved, some promising enough to justify incorporation into detailed design studies. One or more reactors based on these early design studies, will be tested at Jackass Flats. Information gained from tests is expected to help in formulation of more advanced design concepts which may lead to construction of prototype nuclear propulsion engines for rockets.

Theory of the work at UC's radiation laboratory is that if a nuclear reactor were used to heat inrushing air for ramjet engine, heat could be sustained over a longer period of time, and vehicle could be airborne for a correspondingly longer period. Experimental and theoretical work at Livermore, related to research propulsion for missiles, has been under way since early last year and studies will be extended to the Jackass Flats test site later this year.

About $10 million will be committed for facilities in the Rover test area of Jackass Flats. Work under construction includes:

- **Control building** with a floor area of 9,700 sq. ft., accommodating controls and instruments for operating and recording tests performed in test cell area. Other buildings in same area include generator station for standby power, administration building, warehouses and miscellaneous structures.
- **Mechanical** assembly - disassembly building, with 30,000 sq. ft. of floor area for work on reactors and reactor components before and after tests. Structure will include shielding and facilities for remote handling of large assemblies which have become radioactive in tests.
- **Test cell,** containing 1,680 sq. ft. Reactors and reactor systems to be tested will not be housed in the cell, but will be supported on a railway car backed up to the cell, and be connected to receiving instruments inside the cell, which will transmit data to recording instruments inside the cell, which will transmit data to recording instruments in control building, located about 1½ mi. away. Railway car supporting the reactor will be moved by remotely-controlled locomotive to shielded portion of mechanical assembly-disassembly building.

Project Pluto facilities in Jackass Flats area will include 2,880-sq. ft. control building, 4,000-sq. ft. critical assembly building, and assembly and shop building enclosing 2,880 sq. ft.

Burns & McDonnell Engineering Co., Kansas City, Mo., is architect-engineer for Rover and Pluto test areas. Support services such as maintenance and minor construction will be provided by Reynolds Electrical and Engineering Co.

Other contracts include:

- **Control building area** facilities for Rover to J. A. Tiberti Construction Co., Las Vegas, Nev.
- **Mechanical** assembly - disassembly building for Rover to Sierra Construction Co., Inc., Las Vegas, Nev.
- **Test cell and tank farm** for Rover to Petroleum Combustion Engineering Co., Los Angeles, Calif.
- **Installation and operation** of some control and recording instrumentation systems in Rover area to Edgerton, Germeshausen & Grier, Inc. under extension of an earlier contract.

Legislators Prod Administration To Speed Atomic Plane Project

Washington—Joint Congressional Atomic Energy Committee will continue "to push and prod" the Administration until it gives a green light to move forward with a crash program for development of a "fly early" nuclear-powered aircraft, Rep. Mel Price (D., Ill.), chairman of the group's subcommittee on research and development, said last week.

"We've had to do this before—with the H-bomb, expansion of the atomic energy program, and the submarine Nautilus," Price said.

President Eisenhower rejected the "fly early" program, sponsored by the Air Force and Atomic Energy Commission, on the recommendation of an advisory group established by Presidential Assistant Dr. James R. Killian.

President's Letter

In a letter to Price, the President explained:

"If striving to be first were our shortest road to an operational military aircraft, we long ago would have pursued that course. But at the present state of the art, such an effort would divert extremely scarce talent from attacking fundamental problems that must be solved before a militarily important aircraft can be produced. My conviction is that our need for the development of the high priority military aircraft overrides the first nuclear flight objective.

"Accordingly, I have decided that we should continue to go forward as rapidly as we effectively can with our development program, which at this stage places major emphasis on materials and reactor research, rather than to rush development of a first nuclear flight aircraft which would have little or no practical utility and would delay achievement of an effective military aircraft."

Sen. Clinton Anderson (D., N.M.), vice chairman of the committee, declared that the decision makes it "almost inevitable" that Russia will be first to fly an aircraft with atomic power. Price estimated that Russia would have an aircraft in the sky in two to three years.

"Coming on the heels of the Sputnik fiasco, a Russian victory in this field could well prove disastrous to world confidence in America's scientific abilities," Rep. Carl Durham (D., N.C.), chairman of the full committee, declared.

Price and Durham objected that the Killian committee made "only a cursory review of the program after a brief inspection trip to the field and decided that the early flight concept with a modified conventional plane be scrapped in favor of a vague development program aimed at the ultimate achievement of a high performance craft," disregarding the advice of experts who "have been living with the program." Price added that the members of the committee, although top personnel, have been "at arm's length from the atomic aircraft program for from three to seven years."

Price called the President's statement that development of a "fly early" aircraft would waste scientific manpower "a smoke screen for inaction" and "without basis in fact." He added:

"I have been informed categorically by the people actually working on the project that, far from wasting manpower, the development of an early flying nuclear plane would in fact be the best possible utilization of existing scientific and engineering talent and would serve as a strong incentive for them to get on with the job.

"It has been clearly brought out in testimony to the joint committee that an adequate supply of such talent exists not only for present needs, but for an accelerated program as well."

Challenge by Price

Challenging the President's argument that the "fly early" project would delay achievement of a high performance military plane, he commented:

"The history of research and development is replete with examples, such as the hydrogen bomb, which demonstrate beyond argument that successive stages of development are necessary before the finished product can be achieved and that actual operating experience serves as an impetus, not a deterrent, to the achievement of our ultimate objectives."

The President also rejected Price's request for the establishment of "a well-defined future objective for the program, including target dates for completion."

"The development of a nuclear-propelled aircraft capable of military missions has always been the prime goal of this program," the President said. "This objective is clearly understood by all engaged on the project.

"Because the program required development of new materials and techniques beyond the present state of knowledge, the specifying of dates for completion of these endeavors must be somewhat arbitrary and therefore may be unrealistic."

Durham protested that "progress can be achieved and will be achieved when we have a concrete program with clear objectives and target dates for completion, up to and including a proven flight capability. Without such goals, there can only be a hopeless, hapless and helpless policy of drift and indecision. This is where we have been for the last 10 years, and this is where we stand today."

Defending the Administration's position in testimony before the joint committee, Deputy Secretary of Defense Donald A. Quarles acknowledged that "we are quite conscious of the fact that the Soviets may adopt a different view and may seek to make propaganda capital" by achieving the first flight of an atomic aircraft. He added:

"As for the 'cold war' significance of first nuclear flight, several years ago we actually flew an operating nuclear reactor in a military aircraft (Convair's NB-36) without, however, attempting to use the power for propulsion purposes. We have also, of course, demonstrated the use of nuclear reactors as a source of power for driving more or less conventional aircraft jet engines in ground tests. To combine these in a first flight demonstration would not be an important addition to what has already been done. Moreover, it would add substantially to the cost of the project. . . ."

The present plan will continue the aircraft nuclear project at a $150 million-a-year level. This is a downward revision of a previous program for a $250 million-a-year level, Quarles noted, "resulting from the decision to de-emphasize the aircraft and weapon system aspect of the development and to place primary emphasis on the research and fundamental development problems involved in advancing the atomic reactor art as applied to aircraft propulsion."

Promise From Quarles

Price said the joint committee "has at least achieved one encouragement—Quarles has assured that there will be a re-evaluation in a few months."

In this re-evaluation, Quarles told the committee that nuclear aircraft studies now being made by the Navy as well as "significant results" anticipated from reactor development work now under way, will be considered. Although the present conclusion is that the state of the art does not permit the application of nuclear propulsion to the design of a military aircraft with satisfactory performance, Quarles said that:

"We must recognize that this is a fast-moving art and that the fundamental development work that is being carried on might well uncover practical possibilities not now visualized. We will . . . want to propose a change in our course and perhaps an accelerated program of development and flight test if and when the feasibility of an accelerated program can be established."

Defense Spending Limit Bills Get House, Senate Approval

Washington—Defense Department will be called upon to operate within a legally-set spending ceiling under congressional legislation that last week appeared certain of passage.

The ceiling would be written into law at the beginning of each fiscal year. Military production schedules and payments to contractors could be accelerated during the year if it appeared the ceiling would not be reached. Conversely, they would have to be slowed down if it appeared the ceiling would be exceeded.

A determined effort to kill off the measure in the House, led by leaders of the Appropriations Committee, failed on a 110-to-275 vote. The bill already has passed the Senate and has the strong support of the Administration, particularly the Treasury Department and the Bureau of the Budget.

Rep. George Mahon (D., Tex.), chairman of the Appropriations Subcommittee on the Armed Services, pointed in House debate to the fiasco of Budget Bureau's attempt last year to impose a $38 billion ceiling on defense expenditures which resulted in a series of production slow-downs. Mahon asked:

"Had that limitation been in the law and had it been written in the defense bill, where would you have been last fall, when the launching of Sputniks dictated a defense speed-up? You would have been apologizing to your constituents and imploring the speaker and praying to the Almighty to let you return to Washington quickly and undo this defense limitation, which was slowing us down at a critical moment."

Provisions of the measure are:

- **In submitting the budget** to Congress in January, the President would propose a spending limitation for the fiscal year beginning the following July. There is this loophole—the President could refrain if he determined that a satisfactory accounting system on which to base a firm expenditure ceiling had not been established in a department. There appears little likelihood, however, that this loophole will be used because of Administration's position.
- **If the ceiling was not reached,** the unspent funds would lapse at the end of the fiscal year.
- **Appropriations fully funding** long-term production and research programs would be continued. But the expenditures against these programs would have to be fitted under the annual spending ceiling.
- **Expiration date of the measure** is April 1, 1962. This is to give the new President a free hand in determining federal budgeting procedure.

One concession was made in the House to opponents of the measure—full funding is provided for long-range programs. As passed by the Senate and originally proposed by House sponsors, there would only be authority to enter contracts to back up such programs.

Arinc Plans to Open Facilities to Industry

Washington—Services of one of nation's oldest and largest groups of avionic reliability experts will be made available to industry on a contract basis as result of plan announced by Aeronautical Radio Inc. (Arinc).

Arinc's Reliability Research Department, originally established 12 years ago to improve reliability of airline avionic equipment and vacuum tubes and later expanded to conduct reliability studies for the Defense Department, will now accept assignments from private industry under a new policy announced by Arinc President John S. Anderson.

Ten-fold improvement in reliability of airline-military vacuum tubes over past five years has been a direct outgrowth of efforts by Arinc's Reliability Research Department headed by C. R. Knight.

Availability of Arinc's reliability know-how is expected to be a boon to smaller avionic companies with limited or no previous experience in the relatively new art of reliability measurement and prediction. Many smaller companies were concerned over last year's disclosure by Defense Department that reliability specifications would be included in future procurements.

Arinc, however, does not intend to limit its services to smaller firms and currently is negotiating contracts with several major avionics producers, each of which already has sizable reliability groups in being, according to Knight.

Here are some of the services which Arinc's 120-man reliability group plans to offer to industry:

- **Reliability evaluation** of avionic systems while they are still in the design stages with recommendations for improving reliability.
- **Guidance in planning** and executing laboratory evaluations of reliability.
- **Field evaluation** of system reliability or assistance in establishing a company program for measuring operational reliability in the field.
- **Assistance in preparing** reliability specifications for vendors and subcontractors and in evaluating their designs.
- **Training engineers** and production supervisors in fundamentals of reliability techniques.

Fare Increase Stand

Washington—Civil Aeronautics Board last week refused a request to terminate the General Passenger Fare Investigation but said that, if necessary, additional fare increases can be granted before the end of the investigation.

CAB was asked by American Airlines, which was supported by Continental, Eastern and Western, to terminate the case within a month after receipt of rate of return evidence. The request was opposed by United, Trans World and Braniff airlines.

In its opinion, the Board said the object of the fare investigation is to arrive at a reasonable formula for determining rates and that the objective should not be sacrificed by hasty consideration. CAB added, however, that it can grant emergency fare relief without interfering with the progress of the case.

News Digest

Continental Air Lines won Civil Aeronautics Board examiner's recommendation as the airline to compete with American Airlines on routes from Dallas to Los Angeles and San Francisco. In making his recommendation in the Dallas to the West Service Case, the examiner recommended that applications of Braniff, California Eastern, Delta, Eastern, National and Western airlines be denied.

Missile production increase is indicated by increased activity on the subcontractor level. Clary Dynamics, San Gabriel, Calif., missile valve and component producer, reports February orders exceeding $400,000, highest for any month since December, 1956.

Chance Vought reported 1957 sales of $237,292,770, double those of 1956. Net income for 1957 totaled $6,152,383, which is equivalent to 2.6% of sales. Income in 1956 was $4,135,181, equivalent to 3.5% of sales. Company paid regular dividend of $1.60 per share.

Department of Astronautics will be created at the Air Force Academy to teach fundamental physics of manned and unmanned flight through space. Revised program will include six semester hours of astronautics study.

First Jets Will Use Interim Facilities

Only San Francisco is completely ready to handle passengers when the airline begins 707 service next year.

By Glenn Garrison

New York—American Airlines will rely on temporary facilities at most airports when it becomes the first domestic jet operator around the first of next year.

Passenger terminal at only one city, San Francisco, will be completely ready for the carrier's Boeing 707 operation, according to Marvin Whitlock, vice president, operations. Interim facilities will serve the others for periods of six months to two years or more.

American expects to receive the first of its 30 707-120s next November and will begin scheduled jet service about Jan. 1, 1959. Los Angeles-New York nonstops will be the first inaugurated, unless American gets San Francisco nonstop rights by that time. In that case the two California cities may see simultaneous inaugurals of transcontinental jet service. Within the first year Chicago, Boston, Baltimore, Detroit, Ft. Worth, Dallas, St. Louis, Phoenix and perhaps Tucson should be boarding passengers on American's jetliners.

Nonstop Flights

The first 707 flights should be able to make it nonstop with a full load of passengers and cargo about 90% of the time from Los Angeles to New York International Airport, Whitlock told AVIATION WEEK. Westbound, the percentage is expected to be about 60%. When temperature and wind conditions start cutting into transcontinental payload capacity, American plans to start offloading cargo first. So a full load of about 100 passengers could be carried westbound about 90% of the time at the expense of some of the 10,000 lb. cargo capacity.

Idlewild will be the first full-grown installation for jet flights after San Francisco, Whitlock said. American plans a $14 million individual terminal at the New York field, with special features for jet age passenger handling (AW Dec. 23, p. 79). Target date for the terminal's completion now is June, 1959. New facilities at San Francisco are due for November, 1958, completion.

The airline plans to spend about $50,000 for interim improvements at Idlewild, according to Whitlock. These include enclosing concourses, adding a new departure room, installing air conditioning or forced ventilation.

American hopes to taxi its jets in and out at all airports, but there is a possibility that the Port of New York Authority may require towing at Idlewild. Another uncertainty at that airport is whether the Port Authority will guarantee American some kind of gate priority. There are no exclusive gates at the field, and American doesn't want to spend money on jet positions if it can't be sure of a place for a jet when it comes in or loads.

Idlewild Runway

Idlewild, with a 9,500 ft. landing strip, presents no runway problem of major proportions, Whitlock said. Extension to 11,500 ft. in early 1959 should bring the westbound full-load possibilities up to 90%.

Concerning runway lengths elsewhere, Whitlock said increases in engine thrust "lessen the pain a bit" and that Cleveland, with a 6,500 ft. strip and needing 8,000 ft., is the only airport where the jets won't be able to operate with "a pretty darn good payload."

Thrust of American's J57 engines projected for Jan. 1, 1959, is now 13,500 lb., an increase from the 12,500 lb. previously expected, Whitlock said. The figures assume water injection.

Taxiways at Idlewild and at every other station except Boston are inadequate now, but widening is planned everywhere except Baltimore. Needed width is 125 ft., although 25 ft. on either edge need not be stressed for the aircraft weight.

American will serve Baltimore's Friendship International Airport and not Washington National during initial operations because Washington is keeping jet operators out. They will eventually serve Washington from the projected second airport at Chantilly.

An example of the interim facilities American plans to build is Chicago, where the airline will spend about $300,000 for temporary gate provisions, according to Whitlock. These will be installed at O'Hare, where all jet operations will take place. Facilities will include a relatively modest concrete block finger and blast fences.

The blast fences will be of ¾ in. plywood construction, 7 ft. 4 in. high, extending 110 ft. onto the ramp. They will be built at a 60 deg. angle. The jets definitely will taxi in and out of gates at O'Hare, and the fences and enclosed sound-tightened concourses are expected to take care of noise and blast problems as far as passengers are concerned.

Interim concourses, as at Chicago, will be at ground level, although American's major permanent facilities will use the cabin-level design. At Idlewild, for example, plans call for two-level fingers with telescoping bridges for rear as well as forward loading of passengers. But while committed to the rear-bridge idea for the long range, American will start some operations without them until the equipment is proven out. Meanwhile, loading at the front of the jets only may be used. Whitlock doesn't expect this to create a problem, however, even with the high-capacity jets. Douglas Aircraft Co. studies showed that a jet can be unloaded faster (by one minute) with one cabin-level door than through two doors where stairs to the ramp are used. American studies of the same question showed only a small time loss of 3-4 sec. with the single cabin-level operation.

The airline was disappointed, Whitlock said, that Lockheed Aircraft Corp. is the only company building the bridge type of equipment. American approached eight or nine companies for proposals along this line, he said, but none came even close to Lockheed's design. So American, along with United, decided that no second source of the equipment is satisfactory, Whitlock said.

Fueling Equipment

Various items of ground equipment for handling the jets either have been received or are on order. Hydrant fueling will be available at some interim facilities, including San Francisco, Dallas and perhaps Ft. Worth and St. Louis. All power supplies will be mobile during the interim and later built-in in some cases and mobile in others.

American's ramp power requirement is greater than that of some other carriers because American has taken a different approach to air conditioning.

Eliminating compressed air from the ground equipment that will service its airborne air conditioning systems, American arrived at a need for 150 kva. of electricity. Some other airlines require only 75 kva. but must also provide compressed air.

Permanent facilities may be slow in coming to some of the stations American's jets will serve. At Dallas, for example, Whitlock expects a peak of two simultaneous jet flights. Economic justification for building a second-level concourse, therefore, depends on finding the proper balance between this relatively light requirement and the passenger service advantages.

The carrier's first Boeings will be equipped with both noise suppressing and thrust reversing devices, Whitlock said. This equipment is working out better than expected and will exceed guarantees.

Noise Cut

A 10-12 decibel takeoff noise reduction now is expected from the equipment, whereas 9 db. was considered sufficient to make the noise acceptable. Overall thrust-drag handicap is 3% of fuel—4% for takeoff power, 2% for cruise, Whitlock said.

The reverser, which is of shingle design resembling a cowl flap, will give up to 60% of takeoff power in reverse.

American's turboprop Lockheed Electras should go into service at about the same time as the jets, according to Whitlock. No special problems are expected with these new planes, which he describes as quieter than the Vickers Viscount. The Electra will improve on its specifications. "That airplane is under-rated," he said. Landing requirement at maximum landing weight is working out to about 1,100 ft., or around 900 ft. with prop reversal and brakes. This performance is better than expected, Whitlock said, apparently because of more drag from props in idle range position than anticipated.

First Electra schedules will be between New York and Chicago.

Both Electras and 707s will solve their fuel problems at alternate airports without kerosene by using aviation gas, Whitlock said. He said the round-the-world flight of last year of Air Force B-52s was partially made with aviation gasoline.

Runway Needs

There is a difference of emphasis in American's estimate of runway adequacies as compared with the approach of some other carriers. American tends to base its requirements on a primary runway that can be used consistently with little or no offloading, and to take a greater penalty on secondary strips when wind makes their use necessary. The other point of view is to accept a slightly greater penalty on the primary runway under bad conditions, but to demand a secondary runway with fewer penalties than American is willing to accept. Either view, of course, accepts a compromise from the ideal of both being 100% suitable.

American will use the same cross-wind component—20 mph.—with its jets as it does with present equipment.

The big decision for airlines in operating their jets, Whitlock believes, will be whether to operate them at maximum economy or to enter a competitive scheduling race. The problem has never faced the carriers with their piston fleets because piston aircraft operate economically at near their maximum cruise speeds.

Whitlock foresees the possibility that airlines will start off economically and then somebody will trim a schedule to beat the competition. The race could then be on and a lot of potential profit would be gone from the airline tills.

Trans World Airlines last year stressed the same point and warned that schedule racing would lead to economic disaster (AW Oct. 14, p. 38).

Electronic Tape System Speeds Reservations; Uses Metal Disks

Denver—United Air Lines has converted its space control center here to a largely electronic operation involving new IBM Random Method of Accounting and Control Inventory equipment.

With aid of the first two production RAMACs, along with punch cards processed by transceivers and teletype tapes, the airline's systemwide reservations are handled faster and more accurately. The new system went into full operation last month after a gradual changeover last Thanksgiving.

System is an interim one, however, and United expects to amortize its cost within two years and to install a completely new system about that time.

RAMAC stores its information on 50 metal disks rotating at 1,200 rpm. Up to five million characters per machine are recorded magnetically on both sides of the disks by means of a moving arm. The arm also serves as a pickup for outgoing data. RAMAC's memory unit resembles a high-speed juke box. Only 75% of one RAMAC's memory capacity could store all United reservations for a year in advance, according to the airline.

Information goes into RAMAC from IBM punch cards fed automatically into the unit. The cards, containing reservations information from all over the airline's system, are punched in two ways: by automatic transceiver from stations equipped with these devices, and by teletype tape from stations not so equipped.

Seven cities—New York, Cleveland, Chicago, Denver, San Francisco, Los Angeles and Seattle—are equipped with transceivers and United calls them "machine cities." Transceiver information is transmitted by private telephone line.

The rest are "manual cities" which work with leased teletype circuits. The machine cities, however, represent about two-thirds of United's total traffic volume.

RAMAC itself produces a punched control card when bookings on a particular flight near capacity, and a stop-sales message is sent to all points. RAMAC keeps a running inventory on all reservations and can be queried at random for information on any flight. It replies by automatic typewriter.

The system-wide space situation is recapitulated every midnight on a chart produced by RAMAC, the process requiring about one hour.

Before RAMAC went into operation, the space control center received messages from all points by telephone and teletype and transcribed the information manually on charts for each flight.

Next year United expects RAMAC to eliminate 20-25 people from Denver alone. The equipment is leased from IBM for about $19,000 a month.

Cost of the changeover is estimated at $150,000 exclusive of the RAMAC rental, but savings are expected to more than compensate for this expense.

Improved accuracy and speed in handling reservations are the main advantages United finds in using RAMAC. Time lag is reduced by as much as 75% United says.

Pilot Error Blamed In Northeast Crash

Washington—Civil Aeronautics Board last week placed the probable cause of the crash of a Northeast Airlines DC-6A on Rikers Island, N. Y., on Feb. 1, 1957, to failure of the captain to maintain control of the aircraft and properly observe and interpret his flight instruments.

In its final report on the accident, the Board said its investigation showed "beyond a reasonable doubt" that the aircraft and its accessories were functioning normally throughout the short flight.

It concluded that events leading up to the accident "point to the actions of the captain . . . in that he did not demonstrate the skill and care required of an airline pilot." Captain in command of the flight was Alva V. R. Marsh.

The accident, involving a DC-6A on

lease from Flying Tiger Line, occurred at night under IFR conditions less than one minute after takeoff from New York's LaGuardia Field (AW Feb. 11, p. 38). The plane crashed on Rikers Island about one mile north of the takeoff point while descending in a slightly low left wing turn.

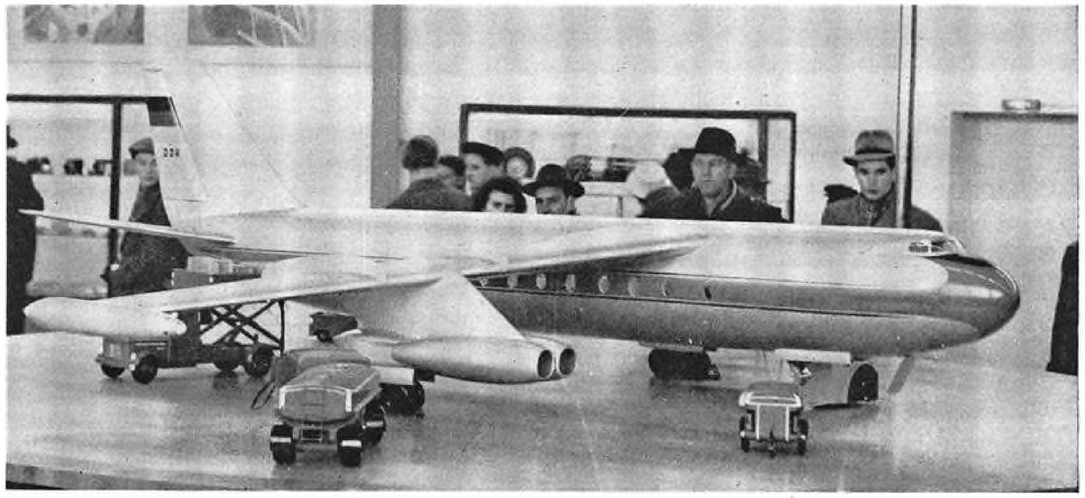
A total of 101 persons, including six crew members, were aboard the flight. Twenty passengers were fatally injured, 25 passengers and three stewardesses were seriously injured and 50 persons suffered minor injuries. Pilot, copilot and flight engineer were uninjured.

The Board expressed concern over difficulties experienced in evacuating the passengers after the aircraft came to rest and noted that fatalities and serious injuries were caused by the intense fire following impact.

It found that deformation of the fuselage during the 1,500 ft. ground slide after the crash jammed the main cabin door and "possibly other exits as well." Absence of cabin lights "undoubtedly hindered the evacuation of many occupants," the Board reported and added: "The Board is studying this problem from the standpoint of adequacy of the regulations and their application."

In its conclusions, the Board found that the gross takeoff weight of the aircraft was under the maximum allowable and was properly distributed. Weather at the time of takeoff was above prescribed company minimums. It said that course indicator instruments had been functioning properly until the time of impact and that there was no failure or malfunction of the powerplants or airframe.

In its report, the Board also noted that Capt. Marsh had previously been in command of two Northeast Airlines Convairs involved in accidents at LaGuardia Field. One, in 1952, was found by the Board to be the result of pilot error culminating in a water landing during final approach. The other, in 1953, was attributed by the Board to propeller malfunctioning during the landing. Neither resulted in fatalities.



East German BB-152 Model Displayed

Model display of East Germany's Baade/Bonin 152 jet transport was open to public at Leipzig Fair last week and emphasized high-wing mockup, with circular passenger windows well below wings. Plane will carry 40 to 70 passengers at cruise speeds of 500 mph. Four jet engines produce more than 27,000 lb. total thrust (AW Dec. 2, p. 43). Medium range jet is expected to be completed in May. East German designers claim BB-152 can take off in 2,620 ft.

Pilots Like 'Golden Triangle' Plan

Chicago—Airline pilots have stamped their "Golden Triangle" experiment a success in reducing en route air traffic delays but warn that outmoded airports are blocking an overall improvement in on-time performance.

In a series of papers delivered at the Air Line Pilots Assn. Sixth Annual Air Safety Forum here, pilots tackled the airport problem as the main reason behind flight delays and as a threat to the "orderly expansion of commercial aviation." According to Capt. J. D. Smith of Capital Airlines, airport inadequacies have been pinpointed by the Golden Triangle operation which was introduced by the pilots in July (AW July 8, p. 45). The program requires all airline flights operating over any segment of the triangular routes between New York, Chicago and Washington to fly under instrument flight rules at all altitudes above 9,500 ft.

Smith charged that out-bound delays at airports would continue to backlog traffic whether the Golden Triangle program existed or not because of the insufficient and inadequate runways at most airports. Capt. Homer Mouden of Braniff Airways said the greatest runway deficiency lies in inadequate length.

He added:

"As little as 1,000 ft. of runway length on 70% of the commercial airports in the U.S. would provide, for most airplanes, an average increase in the operational performance margin equivalent to an 8% decrease in gross weight."

Smith admitted that the implementation of the Golden Triangle program was "somewhat slow at first" but said it did not bring about the "mass chaos . . . originally feared by some." He said that near-miss reports have all but disappeared within the Golden Triangle area and added that many pilots have urged further expansion of the plan.

Smith reported that use of en route radar by air route traffic control centers for climbing and descending aircraft has resulted in the first reduction in workload by both controllers and pilots in many years. He said that maximum use of lateral radar separation instead of sole use of longitudinal spacing in moving aircraft has also brought about a major reduction of delays.

Direct communications has brought about a more effective means of providing maximum air traffic control service, Smith said.

Airlift Report Urges Action by Industry

By Richard Sweeney

Santa Monica—Airlift is a vital part of today's weapon systems and warfare techniques. The U.S. does not have adequate cargo airlift to sustain its commitments in case of attack on one of its treaty allies. The U.S. aircraft industry should be committed now to developing cargo airlift airplanes to have them operational in the shortest possible time.

These facts sum up a comprehensive presentation on airlift which culminated six months' work by pertinent study groups in the Tulsa, Long Beach and Santa Monica divisions of Douglas Aircraft Co., as well as corporate level efforts. The presentation will be given widely to industry and public gatherings in coming months.

Presentation, being given by L. T. Peyton under auspices of military sales within the company, covers present status, projected needs, actions deemed necessary to satisfy the needs.

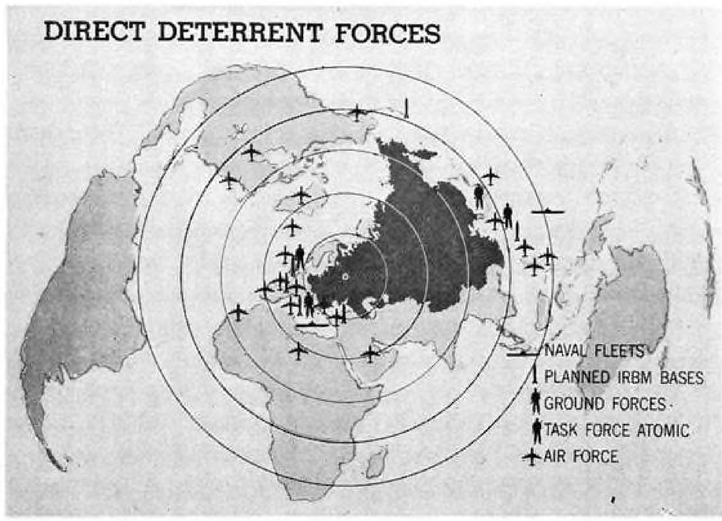


FIG. 1. Artist's chart shows U.S. deterrent force station pattern in northern hemisphere.

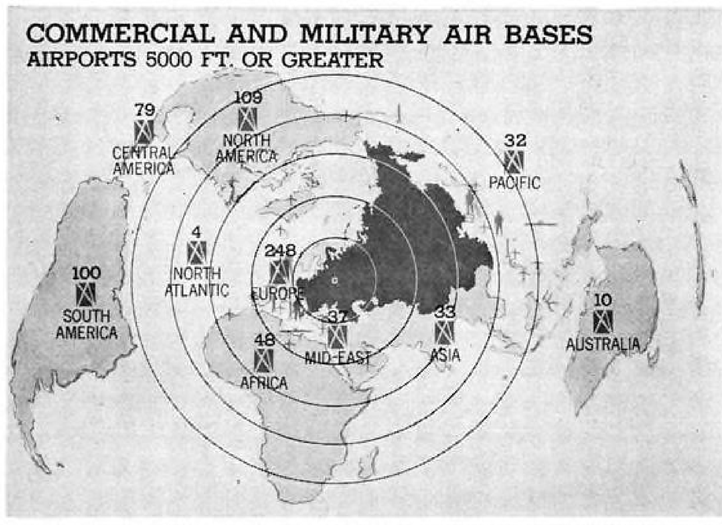


FIG. 2. Available airfields outside United States have runways at least 5,000 ft. long.

Airlift Philosophy

Airlift is considered as a transportation system with the ability to:

- **Transport men, materials** and weapons at high speeds for long distances, providing a quick reaction time for national emergency.
- **Provide maximum economy** of supply by reducing pipeline time and total inventories of men, material and weapons required.
- **Provide fast evacuation** of our own friendly civilians from trouble spots such as Korea, Suez and Hungary, return wounded personnel to U.S. for medical treatment.

Use of air supply for high-cost USAF items during past five years has saved approximately $9 billion, according to data gathered for the study.

With expansion of Russian control to more than 27.2% of the world's land area and almost 30% of its population, U.S. has formed a number of defensive alliances: NATO, SEATO, RIO and ANZUS. Figure 1 shows U.S. deterrent forces, armed with modern weapons, stationed at strategic locations throughout northern hemisphere. Maintaining these forces at a high level of combat capability requires large quantities of materiel to be moved on a continuous basis.

Three basic requirements for any transportation system are terminal facilities, fuel supplies and route systems. Figure 2 shows airfields outside the continental United States with runway lengths of 5,000 ft. or more, of which most are equipped with trained personnel and modern electronic flight aids. These fields are the ones capable of handling large, logistic-type aircraft.

Potential supplies of fuel available are shown in Figure 3, which locates oil fields, refining plants and airfields with fuel storage facilities capable of sustaining present commercial or military operations. Additional fuel facilities are located throughout the world, in classified locations.

Combination of terminal facilities, fuel supplies and route system indicates facilities meeting requirements of a highly efficient air transportation system are now in existence and use.

Notable, the study emphasizes, is the discrepancy between U.S. supply line distances and those of U.S.S.R., which basically has a short, internal system compared to United States' extended one.

Comparing the required abilities of airlift, the Berlin blockade and Korean war illustrated a wide disparity in the abilities of a given airlift configuration.

USAF had a large number of aircraft which met requirements for Berlin situation, i.e., aircraft which could move many small packages a few hundred miles. However, with the same aircraft available for Korea, USAF found itself in a bad spot, where requirement was

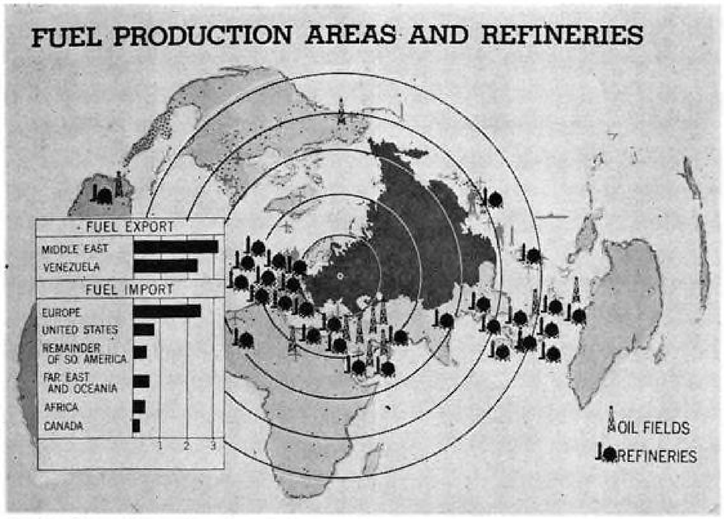


FIG. 3. Potential supplies of available fuel fields, refineries, storage for military use.

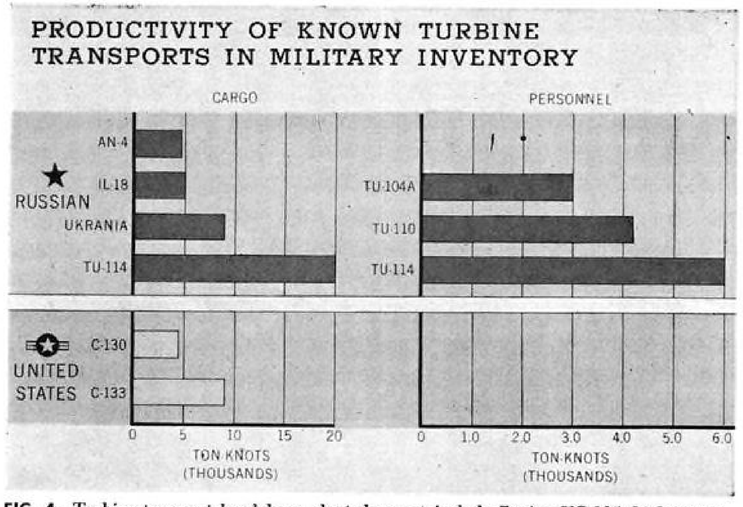


FIG. 4. Turbine transport breakdown chart does not include Boeing KC-135 SAC tanker.

to move large packages long distances. Airlift proved inadequate for demand.

Advent of turbine-powered aircraft has made air logistics a real possibility for the first time. It also has put piston-engine aircraft in the position of being used past their economic service life, lacking range, speed, payload capacities required for current logistics, and also lacking configuration required for lifting current cargo.

Figure 4 shows comparative U.S. and Russian turbine transport situation, in type categories and work-producing capabilities. Douglas study did not include Boeing KC-135, since it was regarded as being restricted to the tanker role with Strategic Air Command. And it was noted that U.S. commercial airlines have ordered large numbers of turbine transports which could be assigned to Civil Reserve Air Fleet program, although USAF has no such aircraft in the inventory or planned.

United States currently has, the presentation indicates, a deficiency in the required types of aircraft for a complete airlift system.

Second deficiency the presentation displays is in the quantity of airlift required to sustain present U.S. commitments. Changes in weapon technology have created changes in concepts and methods of warfare. Mobility is the key to modern warfare—the ability to shift strength rapidly as a changing tactical situation requires, or to avoid retaliatory blows.

Airlift is indispensible to this type warfare. Intratheater and intertheater movement of men and materiel is required by the fastest means, and supplies must go from factory to battlefront with the same ability to shift quickly en route as the tactical situation makes changes in terminal necessary. Speed and flexibility are dominant factors in combat condition, while an additional peacetime factor is the high cost of the pipeline being kept full as necessary of expensive items, both going and coming.

These factors dictate the amount of airlift required, numbers and types of planes needed to fulfill these conditions of peacetime cold war, limited "brush fire" war or all-out war.

Considering the Civil Reserve Air Fleet addition to currently available military airlift, the entire capability still falls short of that required for a limited-type war, specifically in cargo airlift. Adding greater utilization of aircraft by a factor of two, the requirement still is not met with all military and CRAF increments included in the summation.

What U. S. Needs

The summary of aircraft requirements indicates that the United States currently needs modern aircraft with required range, speed and payload capacities, also needs more airplanes in sheer numbers alone as well as in numbers of the required capabilities.

In the "what do we do about it" section, the presentation declares the first necessity to be acceptance of airlift as a necessary part of the modern weapon system.

Needed are long, medium and short range turbine-powered cargo planes, long range turbine-powered high speed personnel carriers, short range personnel carriers. The short range airplane is regarded as adaptable to personnel and cargo mission.

The presentation does not specify whether the required numbers and types of aircraft should be in the existing military fleet or in commercial operations. It urges simply that they be available as necessary.

In view of the present seven-year development cycle of aircraft, or the required two years to modify existing planes, the presentation urges commitments now to insure that the required types of airplanes and numbers as well will be available as soon as possible.

To finance the fleet, three methods are outlined:

- **Military funding** of the entire operation.
- **Limited military funding,** plus government assistance to industry to provide private financing.
- **Entire funding** by industry.

The second method is advocated as the most logical and practical, the presentation concludes.

SHORTLINES

► **Air France** has extended its Central Atlantic route to include Lima, Peru, and Quito, Ecuador. Beginning April 3, when Air France starts its summer schedules, the Lockheed Super Constellation flight will leave Paris Thursdays at 2:50 p. m. Paris time and arrive in Quito Fridays at 11:15 a. m. local time. The return flight will depart Quito Saturdays at 12:15 p. m. and arrive at Paris at 9 p. m. Air France says the new extension brings the route network of Air France to a total of more than 188,000 mi.

► **Alitalia,** National Airlines of Italy, has announced the purchase of four Douglas DC-8 turbojet airliners. The airline also picked up options on two additional DC-8s. The Italian carrier will receive the first planes of the $27 million order in time to provide intercontinental service during the summer of 1960. The Italian purchase brings to 138 the number of DC-8s now on order.

► **American Airlines** flew 550,000 passengers more than 341,500,000 revenue passenger miles during February, a decline of 1.2% and 2.7% respectively from the same period of 1957.

► **Braniff Airways** is now paying commissions to its travel agents for off-line, domestic transportation purchased by holders of Braniff courtesy cards. Under the new policy of commissions for credit card sales, Braniff passengers may pick up their tickets at the airline ticket counters or at the travel agent's office.

► **Bristol Aeroplane Co. Ltd.** has formed a subsidiary company in Johannesburg, South Africa, to coordinate sales, service and other activities of the Bristol group in that area.

► **British Overseas Airways Corp.** will move its Southwest headquarters to the 17th floor of the Mercantile Building in Dallas under terms of a 10-year lease.

► **Chicago Helicopter Airways** flew 6,280 revenue passengers in February on its triangular service between Midway-O'Hare-Chicago Loop-Midway. Airline operates 86 daily flights.

► **Columbus Airport Commission** has approved a $2.1 million 6,000 ft. runway at Port Columbus designed for use by non-jet aircraft. The new runway will permit exclusive use of an existing 8,000 runway by jet airliners. Also, a new terminal at the airport is scheduled to be dedicated next Sept. 21.

AIRLINE OBSERVER

► **Chances that Civil Aeronautics Board will expedite the General Passenger Fare Investigation as originally proposed by American Airlines (AW Jan. 27, p. 38) now appear slight, and the case probably will continue throughout most of 1958 before a final decision is made. Third and final phase of hearings in the investigation began last week. At the present rate of progress, hearings should be concluded about mid-April.**

► Airline traffic in February continued to follow the recent pattern of declining load factors and increasing available seat miles. Load factors during the month dropped to 56.13%, a 2.85 point decline from February, 1957. Both available seat miles and total revenue passenger miles showed increases. First-class revenue passenger miles during the month decreased but a substantial rise in coach revenue passenger miles resulted in a total increase for all types of travel. First-class load factor for the month was 56.65%, a 2.46 point decline and coach load factor was 55.29%, a 3.46 point drop.

► **Bill designed to prevent any domestic trunkline carrier from applying for subsidy for any period after it has once been established that the carrier is ineligible for subsidy has been introduced in the House by Rep. J. Arthur Younger (R., Cal.).**

► Elwood R. Quesada has been sworn in as chairman of the Air Coordinating Committee to replace former chairman Louis C. Rothschild, Undersecretary of Commerce for Transportation. The appointment represents the final step in the implementation of the interim phase of the Edward P. Curtis plan for aviation facilities. In addition to the ACC post, Quesada is chairman of the Air Modernization Board and special assistant to the President. He now sits in a relatively powerful governmental seat in the aviation field, but his authority is still far from all-encompassing. However, the amount of power that eventually will rest in one position will be determined by the scope granted to the permanent Federal Aviation Agency when it is established two years from now, and Quesada is charged with the responsibility of making recommendations for its basic organizational structure.

► **Civil Aeronautics Administration is conducting experiments with "light reflectant" paints to test their value in reducing chances of mid-air collisions by improving visibility of aircraft. The Daylight Fluorescent Paint used in the tests is approximately four times more visible than International Orange, the standard color now being used on aircraft operated by the civil aviation agency.**

► Baltimore control tower operators were required to handle the approach of the Russian Tu-104 during its recent landing at Friendship Airport by anticipating the airplane's maneuvers by about two miles to overcome time lag caused by the translation of instructions to the pilot. MATS personnel aboard the Tu-104 on the U. S. leg of the Moscow-Baltimore flight received controller's directions and passed the information to a translator for interpretation to the pilot.

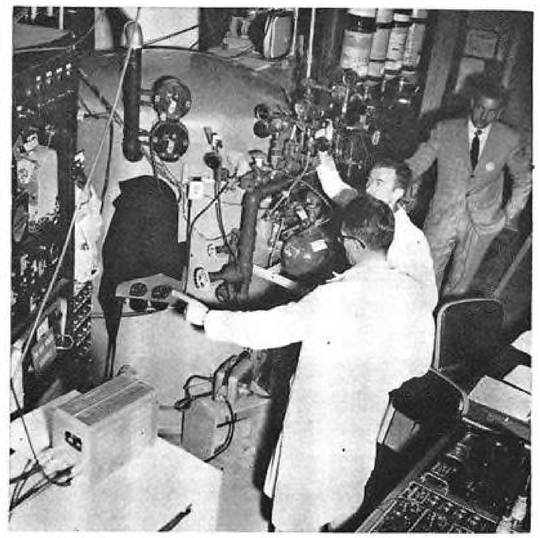
► **Capital Airlines is resisting a Civil Aeronautics Board subpoena to produce a study prepared and used by Convair covering the airline's recent purchase of a fleet of 880 jet transports. Examiner Ralph Wisner wants the documents because he considers them relevant to the General Passenger Fare Investigation, but Capital considers them a private matter. Meanwhile, Capital operations officials have been on the West Coast discussing the transaction with Convair people, while other officials, including President David Baker, have been in England discussing the carrier's current loan with Vickers-Armstrongs.**

► Effect of heavy snow storms on airline traffic in the northeastern area of the U. S. during February is underscored by an American Airlines experience in Boston on Feb. 16 and 17. During the two days, the airline boarded only 55 passengers at the Boston airport as compared with the 2,400 normally handled in two days.

Airline Traffic—January, 1958

	Revenue Passenger Miles (000)	Revenue Passengers	Load Factor %	U. S. Mail	Express	Freight	Total Revenue Ton-Miles	% Revenue to Available Ton-Miles
DOMESTIC TRUNK								
American	601,263	402,723	63.5	1,624,818	774,260	6,505,113	47,674,569	54.5
Braniff	173,873	76,586	57.8	289,467	137,750	429,097	8,215,795	46.3
Capital	331,455	130,100	57.9	500,279	230,963	323,499	13,488,041	46.8
Continental	69,132	31,971	53.9	92,626	46,264	141,560	3,354,606	44.5
Delta	230,479	119,785	57.0	373,370	246,348	921,101	13,096,737	51.0
Eastern	656,063	394,749	56.92	938,744	415,530	1,028,508	40,470,323	50.74
National	143,589	102,159	57.1	328,155	59,200	541,202	10,880,199	48.0
Northeast	61,943	34,994	46.2	105,111	29,754	75,680	3,574,596	37.8
Northwest	110,619	73,091	52.1	373,395	214,288	686,065	8,295,699	45.9
Trans World	361,497	295,661	60.7	1,035,705	536,826	1,743,930	31,702,451	53.0
United	487,998	352,532	61.3	2,346,915	799,666	4,402,067	41,461,218	54.5
Western	117,748	62,499	56.9	267,016	98,628	223,950	6,534,572	47.8
INTERNATIONAL								
American	10,715	9,371	54.3	9,655	278	282,966	1,281,483	61.8
Braniff	3,910	7,767	47.7	17,198	.....	77,918	974,883	44.3
Caribbean-Atlantic	21,411	1,504	57.7	1,563	.....	3,557	162,879	63.2
Delta	6,496	7,507	64.5	7,305	.....	36,535	887,640	55.8
Eastern	29,793	41,932	49.35	106,996	.....	89,574	4,555,498	50.05
National	11,012	7,636	50.4	9,348	5,440	48,794	876,788	45.5
Northwest	8,382	19,474	47.7	951,885	15,722	477,714	3,530,601	55.5
Pan American								
Alaska	2,801	3,358	52.0	28,843	.....	150,382	540,241	51.4
Atlantic	65,438	81,622	50.2	1,139,773	.....	2,074,058	11,984,040	51.5
Latin America	102,268	108,104	63.0	385,095	.....	3,974,686	14,981,009	63.1
Pacific	19,628	70,538	60.8	990,457	.....	1,309,271	9,620,588	55.1
Panagra	11,073	13,687	53.4	66,191	.....	386,153	1,948,276	56.2
Trans World	15,876	44,588	47.8	791,367	.....	571,201	6,131,941	50.9
United	6,632	16,478	54.3	99,866	.....	59,519	1,849,484	52.1
Western	2,115	3,289	61.3	498	.....	5,589	362,354	63.8
LOCAL								
Allegheny	32,832	5,568	40.5	9,143	13,715	11,951	566,945	40.3
Bonanza	14,847	3,416	44.5	5,117	2,334	5,885	340,068	42.5
Central	10,255	2,107	34.4	3,615	1,994	7,359	215,101	30.6
Frontier	17,871	4,851	48.8	16,940	5,799	50,497	538,871	56.9
Lake Central	14,194	2,260	36.1	3,073	13,020	.....	232,218	38.4
Mohawk	30,490	5,708	48.1	4,518	11,899	14,670	577,377	48.6
North Central	55,341	9,008	43.5	21,025	26,488	.....	913,324	44.1
Ozark	31,999	5,195	42.2	11,155	13,440	9,835	531,392	43.8
Piedmont	30,696	6,318	46.8	13,177	8,328	8,225	636,380	46.2
Southern	17,462	3,173	36.6	7,843	8,638	3,651	324,844	36.3
Southwest	26,446	8,746	47.1	9,526	3,890	4,310	566,179	45.2
Trans-Texas	19,547	4,457	37.7	13,221	9,251	21,926	472,659	38.3
West Coast	19,083	3,495	45.53	3,895	1,673	3,756	343,397	42.89
HAWAIIAN								
Hawaiian	28,874	4,176	57.8	3,582	.....	106,726	446,728	52.9
Trans-Pacific*	.....	.....	.....	.....	.....	.....	.....	.....
CARGO LINES								
Aerovias Sud Americana	.....	.....	.....	.....	.....	571,833	571,833	78.7
Flying Tiger	5,028	23,823	99.4	34,502	17,562	8,120,935	10,555,305	87.6
Riddle*	.....	.....	.....	.....	.....	.....	.....	.....
Seaboard & Western	6,346	24,219	100	.....	.....	1,054,970	3,479,364	63
Slick*	.....	.....	.....	.....	.....	.....	.....	.....
HELICOPTER								
Chicago Helicopter	6,321	109.4	35.3	1,630.7	.....	.....	11,972.4	28.0
Los Angeles Airways	2,243	88	52.1	3,840	1,657	.....	13,878	55.4
New York Airways*	.....	.....	.....	.....	.....	.....	.....	.....
ALASKA								
Alaska Airlines	3,977	1,133	33.1	22,958	.....	107,990	241,552	46.0
Alaska Coastal*	.....	.....	.....	.....	.....	.....	.....	.....
Cordova	772	98	32.7	3,215	.....	6,920	20,066	39.8
Ellis	2,918	179	55.9	1,843	.....	1,480	21,513	67.4
Pacific Northern	6,674	5,952	39.6	94,306	.....	194,796	934,706	50.5

* Not available.
Compiled by Aviation Week from airline reports to the Civil Aeronautics Board.



WORK-REST schedule helped Donald Farrell (left) overcome psychological hazards of isolation in space cabin simulator experiment at USAF School of Aviation Medicine, San Antonio, Tex. TV picture shows him winding alarm clock. Researchers monitor at right.

Work Helps Man Endure Space Isolation

Experiments simulating a flight to the Moon demonstrate that a man can overcome the psychological hazards of isolation if he follows a schedule of work and rest which keeps his mind busy.

A volunteer airman, Donald G. Farrell, spent a full week working in a space cabin simulator at the USAF School of Aviation Medicine at San Antonio, Tex., and he emerged from the experiment in good health and with none of the serious psychological problems which can occur in an extended period of isolation.

Total Isolation Difficult

In contrast, experiments in total isolation conducted by Wright Air Development Center at Dayton, Ohio, indicate that it is very difficult for man to endure this condition for more than 24 hr. Longest period a man has been able to stand this high degree of isolation has been 44 hr., and the experiments show a serious degree of psychological hazard for humans in this state of confinement.

Difference between the experiments at Dayton and San Antonio lies in the fact that WADC is exploring the basic patterns of human response to pure isolation while the School of Aviation Medicine is experimenting with work schedules which will keep the subject's mind busy and combat the psychological problems of isolation.

Of the two approaches, the San Antonio experiment is closer to the practical aspects of the era of space flight man is now entering. A man going into a satellite orbit or traveling to the Moon will have a variety of stimuli to help him combat isolation problems. These will include constant communication with his base on Earth, tasks involved in handling the space vehicle and the excitement of exploring.

Conducted in an atmosphere of intense and widespread publicity, the San Antonio experiment showed that a man isolated in a space cabin under a working schedule which keeps his mind occupied will not suffer the hallucinations or other problems associated with boredom and isolation. The unsolved problem now is to set a work schedule that will effectively combat fatigue and keep the space flier's proficiency up.

Environmental Conditions

The vehicle which carries man into space will have to provide the same kind of environment Farrell had in the space cabin simulator. Temperature and humidity will have to be kept at acceptable levels, as will atmospheric pressure. The system must provide oxygen and absorb carbon dioxide; it must furnish food and water, and it must dispose of human wastes.

Although Farrell's cabin provided this kind of environment, it was not a completely self-contained machine. The cabin has about 100 cu. ft. of space, most of it in a cylinder which is approximately 5 ft. high and 3 ft. in diameter. Farrell sat in this cylinder facing a battery of testing and recording equipment with which the experiment was conducted.

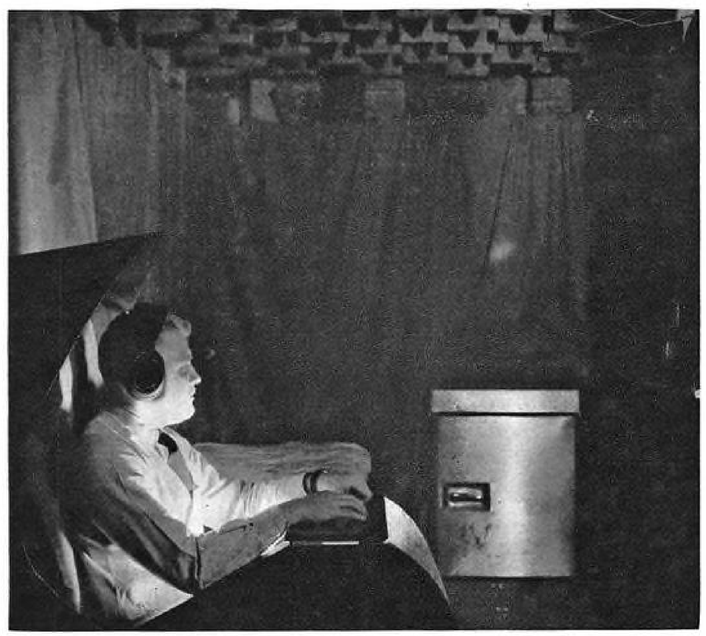
Farrell took his water and food into the cabin with him. In the seven days, he drank an average of two liters of water per day. Fresh oxygen was supplied from an outside source, and Farrell kept the carbon dioxide level down by using a baralyme absorbent. His waste material was stored in sealed plastic containers.

18,000 ft. Simulated

Atmosphere was maintained at a simulated altitude of 18,000 ft., although oxygen content was kept at ground level pressure. Humidity ranged between 40% and 52%, and temperature was maintained near 75F, although it occasionally got as high as 85F.

Farrell was chosen for the experiment because, the medical researchers say, he is a "good, normal human being." He was probably higher than average in his will to perform and had a high level of motivation all the way through.

Cabin atmosphere was taken to the 18,000 ft. level at a rate of 500 fpm., and Farrell began a week of working and resting on a schedule based on a 4-hr. cycle. During the test, doctors



SUBJECT in Aero Medical Laboratory's isolation room. He is seated in an escape capsule mockup. Note anechoic forms on ceiling, refrigerator in back. Officer's goggles are off.

took frequent electrocardiograms and measured the airman's respiratory rate. Other physiological data will come from analysis of Farrell's waste material.

The cabin was fitted with two television circuits. A camera inside the chamber was designed to give researchers a view of Farrell on their monitor, but this system broke down after the second day and researchers were forced to rely on a small peephole and signals from the subject.

The second TV circuit broadcast the problems that Farrell had to solve during his 4-hr. work periods. The problems appeared on the screen, and Farrell responded to them on a panel of buttons and switches under the TV tube (AW Jan. 27, p. 49). A command panel at the side of the screen contained such things as switches for TV adjustment, signals to begin or stop work and a switch marked "I'm okay."

Fatigue Problem

Television display was on only during the 4-hr. work period. Farrell was allowed to improvise his activities during the rest period to see what pace for exercise and other activities he would set for himself. Psychologists also wanted to see how the subject would arrange his sleep schedule to compensate for sleeping time stolen from him by the work-rest cycle.

This work-rest cycle eliminated such problems as hallucinations which occur during long periods of isolation or boredom. But the cycle did not do a good job of combating fatigue. Preliminary results indicate that fatigue started to affect Farrell's proficiency on the third day, and it followed a general downward trend through the experiment. This was reversed on the last day when Farrell perked up somewhat with the "end spurt" that human beings seem to be able to produce when they know the end of an ordeal is in sight.

Further experiments will be conducted to find the best work-rest cycle for flights of any given duration. Basic problem in this testing will be to find a schedule that eliminates the fatigue factor and keeps the airman's proficiency at a continuing high level.

Separate Test

Separate test was performed by Farrell in addition to the problem-solving with the TV screen. During one of his rest periods, the subject worked on a simple performance test for an hour each day. It involved making 4,000 additions of one-digit numbers, and Farrell not only maintained his pre-experiment performance level, but improved it. Through practice, he was able to finish the test before the end of the hour by the time the week ended.

This indicates that the simulated medium altitude and isolation did not impair performance in this measurement of concentration, vigilance and motivation. Motivation is a consideration here because the subject knows he must work as fast as possible, and the psychologist wants to know whether the subject still cares enough to make the effort.

Unlike experiments where the subject was kept in complete isolation, the experiment at Randolph AFB provided Farrell with plenty to do in order to supply his mind with the normal ratio of sensory inputs. This factor made it a more accurate simulation of space flight than the pure isolation tests.

An important consideration in the effects of boredom and isolation in space flight is the fact that the space explorer will have constant two-way communication with his base on Earth and will have various technical func-

Tracker Photographs Sputnik I Rocket

Sputnik I missile stage is photographed at about 350-mi. distance by Perkin-Elmer ROTI optical missile tracking system operating at Melbourne Beach, Fla. Tracker has varying focal lengths up to 500 in., has 24-in. aperture. Fuzziness is probably caused by variations in air density as a result of currents and turbulence at high altitude.

LOCKHEED ELECTRA

BASIC DESIGN OBJECTIVE:

Economically Sound—for "Turbine-Age" Short-to-Medium Haul Airline Operations!

Why Emphasis on Sound Economics?

The Airline Enigma—"Profitless Prosperity"

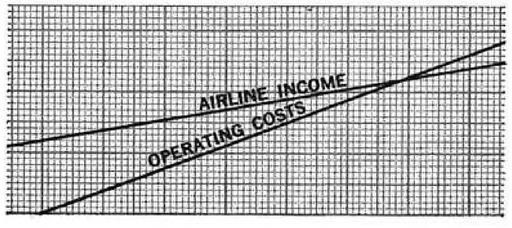
Today, airlines in all parts of the world face a unique dilemma. Traffic and gross revenue are growing rapidly. *But* costs of operation are growing even *more* rapidly, shrinking or even wiping out profit margins.

Airline directors, management, banking firms and government agencies are confronted with this problem at a time when airlines face monumental *new capital costs* in re-equipping for the turbine-age.

The Importance of Sound Aircraft Economics

Passenger-airplane economics involve two interacting groups of factors: (1) First costs, flight and maintenance costs, overhead. (2) The airplane's payload and revenue potential at pre-fixed rates.

This relationship establishes the relative profitability of any airplane.



However, analysis of an airplane's relative profitability is valid only when these economic factors are applied to the specialized "use and environment" in which it will operate.

Airline "uses and environments" divide into three basic patterns. The clearly defined "long haul" and "short haul"...and the less clearly defined "medium haul."

"Short-to-medium hauls" generate 35% to 65% of all the world's air traffic. However, overhead and operating costs are relatively higher in this area because of shorter flights, comparatively more time spent on the ground *and* higher passenger unit overhead.

Yet profit or loss in "short-to-medium haul" operations determines over-all airline financial success!

LOCKHEED ELECTRA—The Only Realistic Answer to the Turbine-Age Need for Sound Economics in Short-to-Medium Haul Operations.

Specific Economic Design Objective:

SIZE

Not too big to operate profitably with few passengers on thinner traffic density routes...

But big enough to operate on high density routes with frequent schedules for maximum passenger appeal.

TURBINE POWER

Turbo-prop NOT Turbo-jet, to produce wide margins of superiority in operations requiring many stops, many take-offs and landings *which require:* (1) Wide choice of cruise altitude flexibility; (2) No new techniques in air traffic control, approach, holding or landing. (3) Sure stops on short or icy runways. (4) Quick acceleration for "go-arounds." (5) Shorter maneuver times. (6) Lower "holding" altitude and costs.

SPEED

Fastest cruise speed needed, considering short average times at lower cruise altitudes. Produces *shortest elapsed times* on "many-stop" schedules—with full all-weather operation.

SHORT-HAUL EFFICIENCY DESIGNED IN

Electra special abilities include:
—Ability to make many stops without en route refueling.
—Quick en route servicing for short stop times accomplished by: *"Packaged,"* separate electrical, hydraulic and air-conditioning centers. *"One point"* high speed refueling. *"Systematized"* simultaneous servicing and passenger loading. *"Broad Vision"* windshield. *"Carry on"* baggage facilities.

Electra functional design features were defined by the experience of American Airlines and Eastern Airlines, checked by the sponsorship of:

Aeronaves de Mexico • American Airlines • Ansett/ANA of Australia • Braniff Airways • Cathay-Pacific Airways • Eastern Air Lines • Garuda Indonesian Airways • KLM Royal Dutch Airlines • National Airlines • PSA—Pacific Southwest Airlines • Western Air Lines

THE PROPER TOOL FITTED TO THE JOB

LOCKHEED
AIRCRAFT CORPORATION
Burbank, California

tions to keep his mind occupied. He also will have the stimulation of discovering new things and an awareness of the importance of what he is doing. All these things will combat whatever psychological dangers exist from isolation.

More Experiments Planned

Space Medicine Department here will conduct more experiments of this type to find out more about how man works best in a sealed environment.

Some tests will be shorter than the Farrell experiment, and others will be longer, although 14 days is probably the practical limit on tests in the one man chamber.

A two-man space cabin simulator is in the works and should be ready for operation when the School of Aviation Medicine moves to new quarters about a year from now.

In Dayton, WADC is conducting comprehensive tests which indicate that total isolation is a difficult condition for man to endure for more than 24 hr.

Fact that a high degree of isolation rapidly breaks down the resistance of even seasoned scientists who have experienced previous bouts with the silent treatment is underscored by these results.

Longest stay in the isolation chamber was 44 hr. A medical officer who volunteered for the test was told to try to stay in for 72 hr., although he could abort at 48 hr. But he could not remain in the chamber for two full days. Other men, trying to stay in as long as possible, lasted 28 and 20 hr. respectively. All three tests have been conducted since the first of the year.

Like prolonged weightlessness, another of the several unknown conditions of space flight, (AW Feb. 3, p. 50), true isolation does not exist on Earth unless produced synthetically.

Unlike weightlessness, isolation can be created on the ground for extended periods of time without undue difficulty.

Continuing Research Program

A continuing research program in isolation studies is being conducted by WADC's Stress and Fatigue Section, Biophysics Branch, Aero Medical Laboratory, by shutting men in a 6 x 12 ft. room with an 8 ft. ceiling and subjecting them to a very high degree of isolation.

Program started last year with short periods of exposure to isolation. Initial duration was 4 hr. This was quickly extended to periods of 6, 16, 24 hr. and more, if the subjects could take it.

Door to the room is always unlocked so subject can walk out on the experiment any time he is so inclined.

A medical officer of the Stress and Fatigue Section told AVIATION WEEK that "we are trying to study the basic patterns of human response to isolation, confinement and sensory deprivation. . . . The dual goals of our isolation studies are:

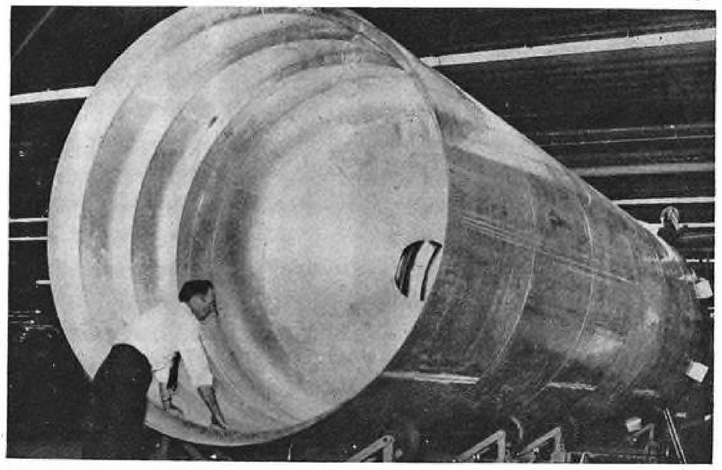
- **"To broaden** medical horizons concerning what conditions of perceptual input allow a man to operate most efficiently under isolated conditions. Purpose is to allow space vehicle designers to give crewmen the best environment possible to facilitate performance of their tasks. Conversely, studies will also show what perceptual inputs to avoid because of their potential danger to the crew.
- **"To produce a stress** on subjects which is analogous to stresses which will be found in space flight. Purpose is to accumulate data on what type of men, psychologically, are best suited to space flight."

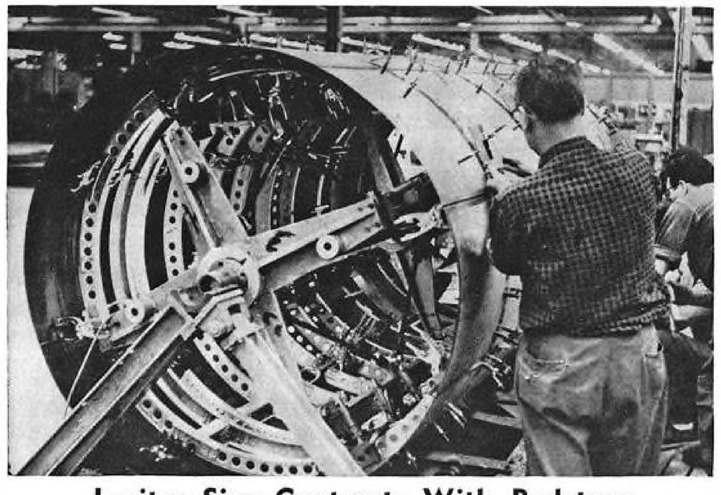
Tests to date are far from complete. However, WADC medical specialists are drawing these preliminary conclusions:

- **Isolation tends** to bring out any unconscious psychological problems within an individual.
- **Persons who** rely on external stimuli to maintain internal psychological equilibrium will probably make poor space travelers as will people with schizophrenic tendencies.

To duplicate total isolation as closely as possible, Fiberglas wedges were installed throughout the room to make it a sound-deadening chamber. Temperature was maintained at a comfortable 76-80F.

Two basic ingredients of the isolation produced by the stress and fatigue





Jupiter Size Contrasts With Redstone

Inspector examines mockup of 1,500-mi. Jupiter (top) which is being used during fabrication of production equipment at Chrysler Corp. Army missile plant near Detroit. Below, mid-section of 200-mi. Redstone is assembled at same plant, where both missiles are in production.

USAF Group Gets Bomarc Training

Officers from 4751st Air Defense Missile Wing, 73rd Air Division, Tyndall AFB, Fla., have finished five-month course in use of Bomarc interceptor missile (background) at Boeing school in Seattle. Model in foreground is of proposed Bomarc base. Officers will transfer to Boeing Pilotless Aircraft Division, Seattle, for additional training, then to test firing unit at Cape Canaveral, Fla., finally to Bomarc operational test base near Eglin AFB, Fla.

medical research personnel were unpatterned sound and light.

• **Unpatterned sound,** also called "white" sound because, like white light, it is a combination of all sounds, is produced by a special electronic sound generator. The sound is a combination of roar and hiss—a scrambled sound.

• **Unpatterned light** is achieved by providing a very dim light source in the room—too dim to read by. Subject is required to wear goggles of frosted glass which so diffuse the light that he cannot determine point of light source, see or distinguish anything. Researchers expressed the subject's light sensation as, "like living in a heavy fog."

Subject had no time orientation because the light remained constant, without any indication of diurnal change, and he could not see a watch if he had one.

Room provides the subject with basic necessities for a reasonable degree of physical comfort. He has a cot on which to relax and sleep, a mockup of a cockpit capsule which gives him a place to sit and a desk-like board which serves as an eating tray. He has a refrigerator supplied with cold foods and liquids, and a chemical toilet and relief tube.

Before starting the experiment, subject and dietician work out a menu. All food, contained in plastic boxes, is coded with strips of tape so subject can identify by feel the three basic constituents: meat, vegetables and bread or pastry. Several liquids, such as water, milk and fruit juices, are also provided. Subject maneuvers around his room by groping.

Observers cannot look into the isolation chamber. They depend on a two-way intercommunication system and a skin resistance meter to follow the subject's progress. The meter is an index of changes in the subject's autonomic nervous system. Resistance of the skin's surface to a very small electric current varies with his activity; the higher the activity, the lower the resistance.

Output of the skin resistance meter is inked on a strip chart to give a permanent record of the subject's activities from the time he enters the isolation chamber to the time he leaves.

Sources of current for the skin

resistance meter are strips of special, electrically-conductive cloth which are sewn into the inner soles of each of the subject's socks.

They are held against his feet by foam rubber pads to keep pressure between conductive cloth and foot as constant as possible.

Wires from the foot conductors run up the man's legs to a special harness attached to his belt to prevent him from tripping over the wires.

Longest stint in the isolation chamber was conducted in January. A medical officer—a captain—was told to try to stay isolated for 72 hr., although he could abort after 48 hr. in the chamber. (Important factor is that the same man had three other exposures to isolation conditions and technicians have determined that experience helps subjects to endure such an environment).

Subject Irritated

First 24 hr. were spent going through the normal routines of eating, walking, sitting and sleeping. However, not having any time reference, subject compressed the intervals between eating and sleeping and shortened his sleeping time to the extent that, in 24 hr., he thought he had been in the chamber 36 hr. Period from 24 hr. to 40 hr. was spent mostly by eating snacks and napping.

At about 40 hr. the fact that he had no time orientation began to irritate subject and he became agitated. He repeatedly asked what time it was. Observers, although they could have answered him, remained silent.

He then started complaining that the chamber was getting hot, although the temperature remained constant. Toward the end, the subject began to threaten to walk out if nobody told him the time.

Leaves Chamber

Finally, when repeated requests and threats made in an effort to get the correct time resulted in nothing but silence, the officer walked out of the chamber 44 hr. after he had entered.

Although the subject was highly irritated, he quickly recovered. Later, he said it was illogical of him to have stopped the experiment because of the time factor.

Another volunteer, who aborted after 20 hr. of isolation, did so because the refrigerator broke down. Yet he knew that the food would have kept for another 24 hr. at least, which would have allowed him to tie the 44 hr. record.

Next step at WADC's Stress and Fatigue Section is to vary the patterns of light and sound to determine which are the most easily supported by isolation study subjects.

RAF to Buy Missiles, Cut Aircraft Outlay

London—Royal Air Force will spend much less on airframes and engines and substantially more on armament, particularly guided weapons, in the coming financial year. Air estimates for 1958-59 show net RAF spending will be $1,308 million, compared with $1,365 million for 1957-58.

Reduced spending on aircraft and engines is due in part to fact that RAF now has all its Hunter fighters and Valiant bombers. Spending will be mainly on the later V-bombers—Avro Vulcan and the Handley Page Victor—and on the English Electric P. 1. Missile force buildup will continue.

Thor Missile Personnel Training at Douglas Plant

First Thor missile squadron personnel are in training at the Douglas plant, Santa Monica, Calif. Officers and men now in training will instruct Air Force personnel in the Douglas intermediate range ballistic missile. Hand-picked from Air Force bases throughout the world, the group is on temporary duty from the Strategic Air Command's 392nd Missile Training Squadron, Cooke AFB, Calif.

Light Rubber Balls Store Missile's Air

Pneumatic system for the first stage of Army's Jupiter-C ballistic missile utilizes rubber spheres, reinforced with glass and resin, for storage of high pressure air. Containers are said to be up to 40% lighter than steel containers for the same volume and pressure.

Rubber compound used in the spheres was developed by the B.F. Goodrich Industrial Products Co., Akron, Ohio. Goodrich ships hemispheres of the one-eighth inch material to Apex Reinforced Plastics Co., division of White Sewing Machine Co. Apex bonds the halves with adhesive and reinforces the balls by winding them with a continuous cord of epoxy resin-impregnated glass fiber yarn. The 15-in. spheres are given a half-inch protective shell of glass fiber yarn, which totals 39,200 mi. of filament for each ball. Rubber spheres operate successfully in a temperature range from −65 to +200F. Balls have survived 65,000 test cycles, from zero pressure to 3,000 psi. and return to zero, without failure. Apex says balls can be used wherever a liquid or gas must be contained at high pressure.

Inter-Conference Missiles

Missile age terminology, fabricated in the aircraft plants and launched from the pads of Cape Canaveral, often misses the pre-selected target area and impacts in the Madison Avenue conference room. Word engineers there design their own models, product-improve them rapidly, and press them into operational service on a crash basis.

Terms now undergoing flight test or already in the inventory:

- "Let's recycle to T Minus 180, gentlemen, to make sure everyone has the picture."
- "It's already in the nose cone, Harve. We'll have to wait and see if it orbits."
- "What a campaign! BBD&O will really dump the LOX when we launch this one!"
- "Frankly, I don't think we have to worry about the front office until we actually get into the countdown."
- "Sam's got a good idea. He just can't seem to get off external power."
- "It's tough, man, tough!" I hear they had to roll the gantry back up again."
- "It's got feasibility, Jim. Let's put it on the Atlas and see if it gets off at Ascension."
- "We could still punch the destruct button, but the client won't want to pick up the tab."

These are rapidly becoming known, of course, as "Inter-Conference Ballistic Missiles."

Digital Computer

Transistorized airborne digital computer, called APAC (Airborne Parabolic Arc Computer), has been developed by Northrop Aircraft Inc.'s Northronics Division—possibly for use in Snark missile's stellar-inertial guidance system. Computer weighs less than 100 lb., occupies 1½ cu. ft., employs small magnetic drum storage. Program is entered into computer by punched tape contained in small plug-in cartridge (right) which permits speedy change of missile target location.

Bell Puts Space Study Under New Division

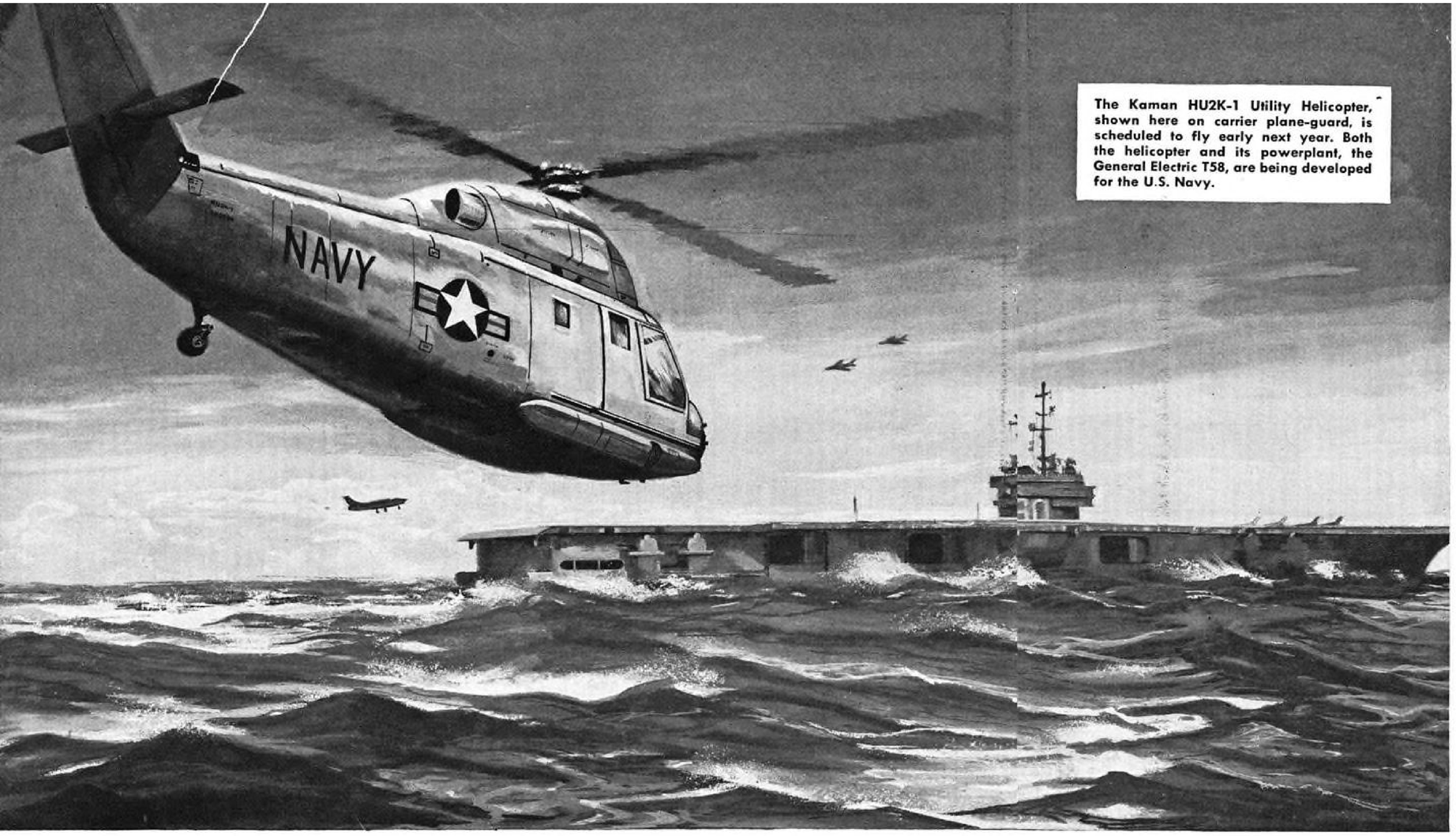
In a management reorganization move expected to improve administrative efficiency, Bell Aircraft Corp. will coordinate all Buffalo and Niagara Frontier defense activities, including space technological projects, under its newly established autonomously operating Niagara Frontier Division.

Heading the new division as general manager will be Ray P. Whitman, first vice president of the firm. Reporting to Whitman as director of satellite and space vehicle activities will be Roy J. Sandstrom, vice president of the firm. Sandstrom will intensify Bell's efforts in space technology.

Included among the company's development plans are moves toward greater diversification both in and out of the defense industry.

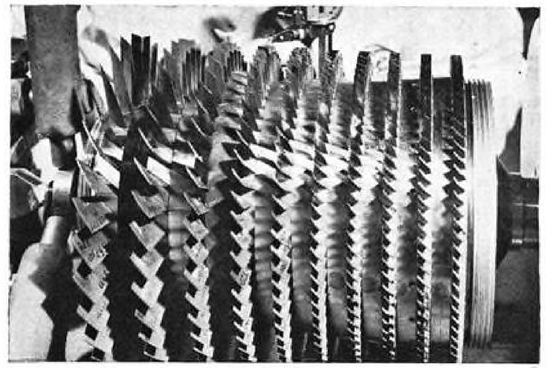
Previously, he had headed such projects as the Bell X-1 and X-2, and development of the GAM-63 Rascal ground-to-air missile.

Operating on a level with seven other Bell operations, the Niagara Frontier Division will include, in addition to the space projects group, the Aircraft Division, the Special Weapons Division, the Rockets Division and the Avionics Division. Bell's corporate office will concentrate on financial planning and fiscal controls and long-range product planning on a corporate basis.



The Kaman HU2K-1 Utility Helicopter, shown here on carrier plane-guard, is scheduled to fly early next year. Both the helicopter and its powerplant, the General Electric T58, are being developed for the U.S. Navy.

Typical Components of Modern T58 Design Help Insure Superior Mission Performance



One-piece steel construction of last eight stages of the 10-stage compressor rotor hub provides ruggedness, dimensional stability.

Durable combustion liners have survived 150-hour Model Test without trace of deterioration . . . combustor's altitude re-start ability proven.

HOW MODERN **T58** *POWERPLANT DESIGN PROVIDES . . .*

Payload Superiority, Greater Flight Endurance and Range

GENERAL ELECTRIC T58 REFLECTS LATEST PROGRESS IN POWERPLANT STATE-OF-THE-ART

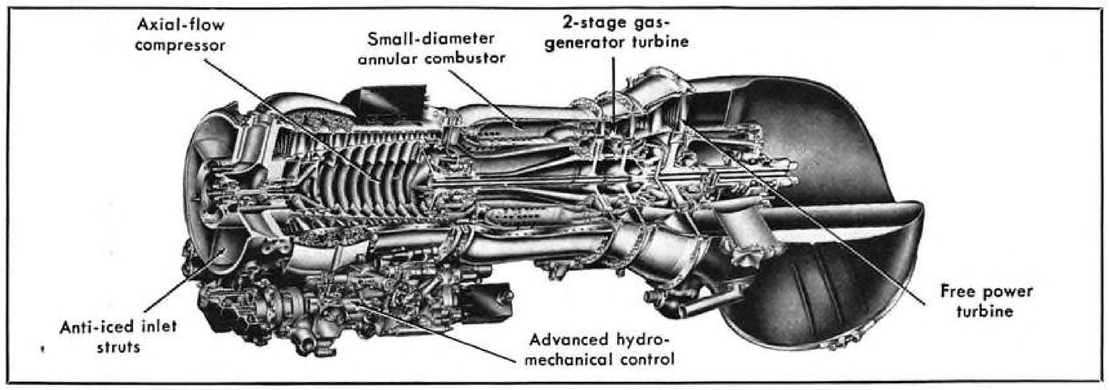
T58's light weight and low SFC offer helicopters the low installed weight and minimum fuel consumption vital to payload superiority, increased flight endurance and longer range. The story behind this modern powerplant design? Thoroughly-tested gas turbine design concepts applied to all major T58 components. For example . . .

Small, compact axial-flow compressor—modern aerodynamic design uses fewer compressor stages to achieve maximum operating efficiency . . . fewer parts increase reliability, reduce total engine weight.

Short, small-diameter annular combustor—modern combustion design provides higher burner efficiency, longer life, simplicity and light weight.

Lightweight gas-generator turbine—two-stage, axial-flow turbine features short-chord turbine buckets which cut turbine weight, yet retain ability to absorb punishment.

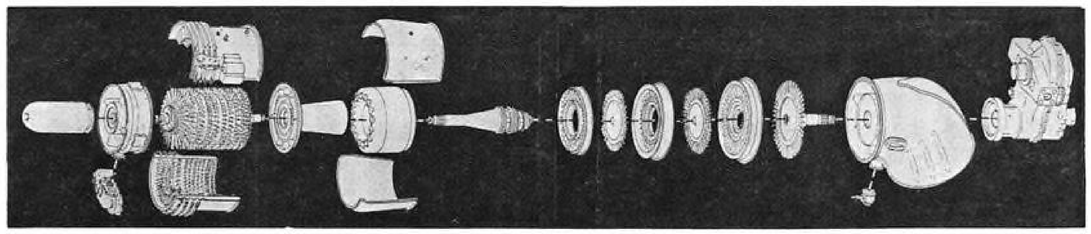
Proven concepts? *Last Fall, the T58 passed its official Model Test—without deviations—thus becoming this nation's first 150-hour qualified gas turbine engine specifically designed for helicopters* . . . In addition, since early last year, twin T58's have been undergoing intensive flight testing in the Sikorsky HSS-1 and, later last year, aboard the Vertol H-21D . . . For new T58 technical information brochure, write to: General Electric Co., Section 233-14, Schenectady 5, N. Y.



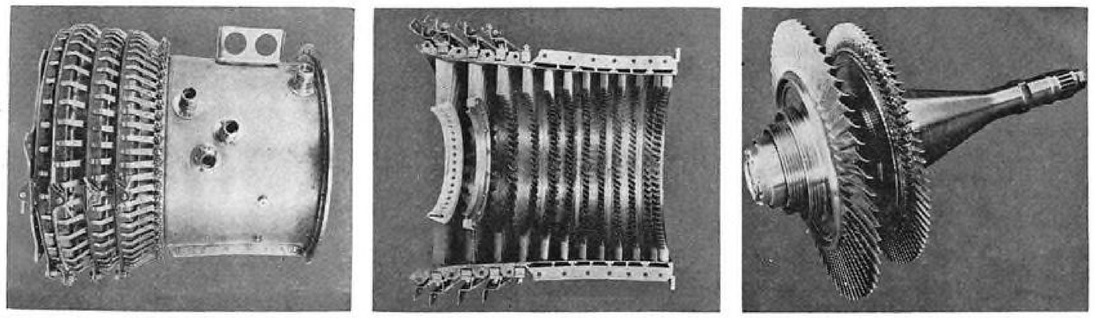
Production T58's will deliver 1050 hp, weigh only 267 lbs, not including 75-lb optional reduction gear and will burn JP-4 or JP-5 fuel. Almost 4 to 1 power-to-weight ratio, 0.64 SFC guarantees are practical expressions of modern design principles and development techniques that reflect progress in powerplant state-of-the-art.

Progress Is Our Most Important Product

GENERAL ELECTRIC



EXPLODED T58 shows straight-through flow design. Gas generator and power turbine systems are not connected mechanically.



COMPRESSOR STATOR ASSEMBLY (left), shown from outside. Actuator arms control variable inlet guide vanes and first three stator stages. Internal view of compressor stator assembly is in center. Gas generator turbine rotor is shown at right.

T58 Engine Refined for Wider Uses

Numerous design refinements to provide high power-to-weight ratio while maintaining maximum ease of producibility are being cranked into General Electric Corp.'s Small Aircraft Engine Department's 1,000-shp.-class T58 free turbine powerplant.

This engine is expected to provide the company with a wide range of sales possibilities including helicopter and fixed wing aircraft applications and others across a broad band of non-aviation fields. The latter may mean sea and land transportation vehicles, easily transportable powerplant sources for the petroleum industry or as an auxiliary installation to provide emergency electrical power.

Sales Potential

Indications are that sales volume of the T58 in its non-aviation applications could easily overshadow that of its original purpose, AVIATION WEEK was told by sources close to the small turbine's development. Such a development, tending to provide a stabilizing diversity to the Small Aircraft Engine Department's operations, is a major factor in the overall importance of this powerplant to management of the Lynn, Mass., facility.

Primary design purpose of the T58 was application to helicopters. Navy's BuAer, seeking to boost the payload-to-gross weight ratio of rotary wing aircraft, initiated a development contract for the new generation of lightweight turbine powerplants in 1953.

Current installations are in the Sikorsky HSS-1 and Vertol H-21D testbeds, which have provided considerable operating experience (AW Dec. 16, p. 69).

Firm installations for production types include the Sikorsky S-61 and S-62 and the Kaman HU2K-1.

General Electric expects to have the T58-GE-6 certificated for civilian helicopter operation in 1959. Outlook now is that it will be shipping "sizable" production quantities early next year, with initial allotments slated for military use. Production planning provides for considerable excess capacity over that necessary to fill initial orders.

New T58-GE-6 version, which is expected to complete its military model test this year, features numerous improvements providing greater versatility over the earlier T58-GE-2, which has passed its 150-hr. test and is in prototype production.

Latter version incorporates a reduction gear to reduce main drive shaft speed from 19,500 to 6,000 rpm. Engines being shipped are exceeding the 1,024 shp. specification, are averaging 1,063 shp. with specific fuel consumption of .654 lb. hr./hp. and are meeting the weight specification, Small Aircraft Engine Department reports.

New T58-GE-6 features greater installation flexibility by having a power takeoff in any one of three positions either fore or aft, optional main reduction gear, three-position exhaust, and torque sensor. It will be qualified on JP-4 and JP-5 fuel.

Other Installations

In addition to helicopter installations or conventional applications to fixed wing aircraft, T58 will also be available in twin turboprop configuration with propeller reduction gear.

Such installation would make possible economical long-range, long-endurance civil or military aircraft, the latter having extended "loiter" capabilities, by shutdown of one engine during cruise flight.

First detailed analysis of the new engine's features was given recently at an American Society of Mechanical Engineers' Gas Turbine Power Conference by Floyd W. Heglund, manager-design engineering, T58 projects, GE's Small Aircraft Engine Department.

T58 is a straight-through flow free turbine, comprising two independent systems: a gas generator and a free turbine. Gas generator section consists of 10-stage axial-flow compressor, combustion system and a two-stage turbine. Rotor system of the gas generator is a three-bearing type with the center bearing carrying the rotor thrust. Power section is a single-stage two-bearing turbine driven to the rear, there being no mechanical connection between the two rotors.

Front frame of the engine is an aluminum casting having four struts. Horizontal and top struts are the forward mounting pads. Front compressor bearing housing and anti-icing passages are integrally cast into the aluminum. A starter pad on the hub connects to the compressor rotor shaft by means of a three-jaw clutch.

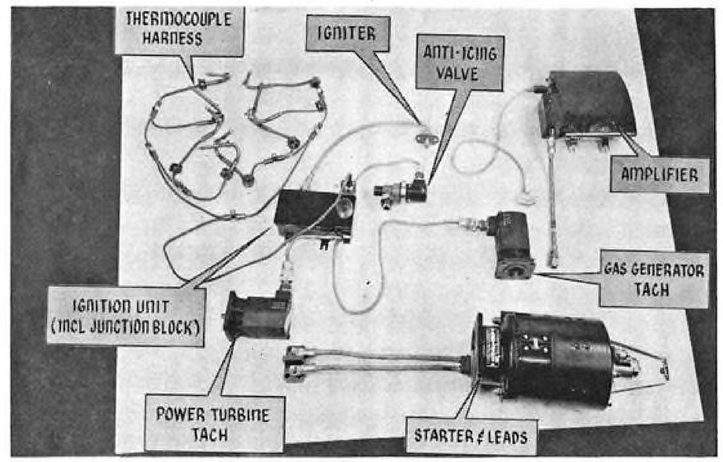
An accessory gear drive box on the bottom of the forward frame is driven by a high speed radial shaft and spiral bevel gears. Two drive pads face to the rear, one for the fuel pump and the control. The other drives the lubrication pump and the gas generator tachometer generator. A forward-facing pad drives the centrifuge fuel filter. Oil filter housing is integral with the accessory drive casings.

Compressor Layout

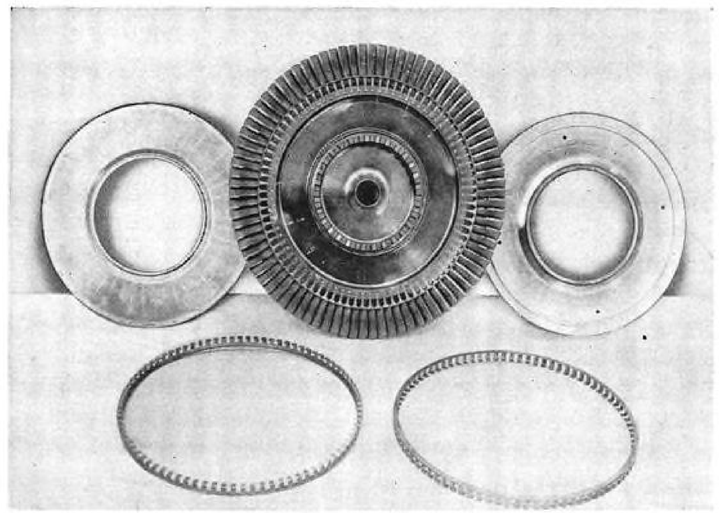
Early in the T58's design, GE Small Aircraft Engine Department engineers studied the possibility of scaling down the 12-stage compressor on the J47, but this was abandoned since the result would have been an engine too heavy (400 lb.) with too high a specific fuel consumption (.70).

Current 10-stage configuration provides weight of 325 lb. for the T58-GE-2 and 267 lb. for the GE-6 engine without gear. Pressure ratio is 8.3:1 at maximum military power.

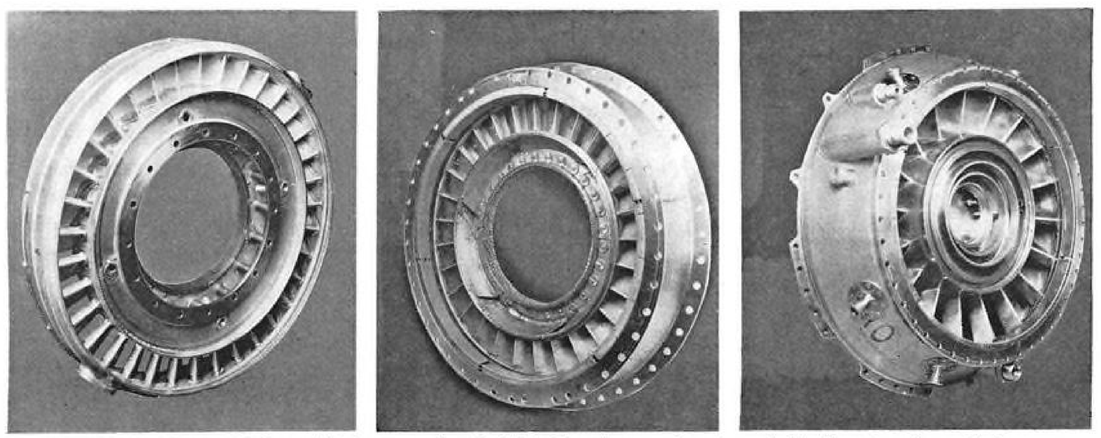
Inlet guide vanes and the first stage stator are of shrouded construction with remaining stages being smooth



STARTER (lower right) and accessories for T58.

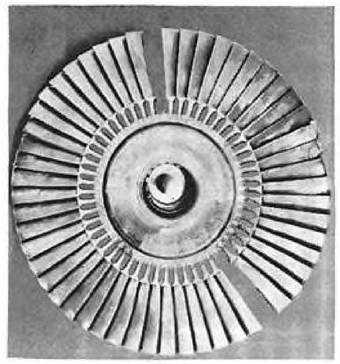


FIRST STAGE TURBINE WHEEL with cooling plates and seals.



TURBINE NOZZLE STAGES, left to right: first, second and third. Note honeycomb seal on inside diameter of second stage.

DAMPERS between bucket shanks of power turbine eliminate certain resonance that caused earlier fatigue failures (below). Dark material (photo above) shows final damper configuration.



spool. Inlet guide vanes and first three stator stages are variable, providing increased stall margin in engine starting regime. They are closed 30 deg. from their nominal open position at starting, open linearly with speed until they are fully open at 85% speed. They do not move during the engine's normal operation range.

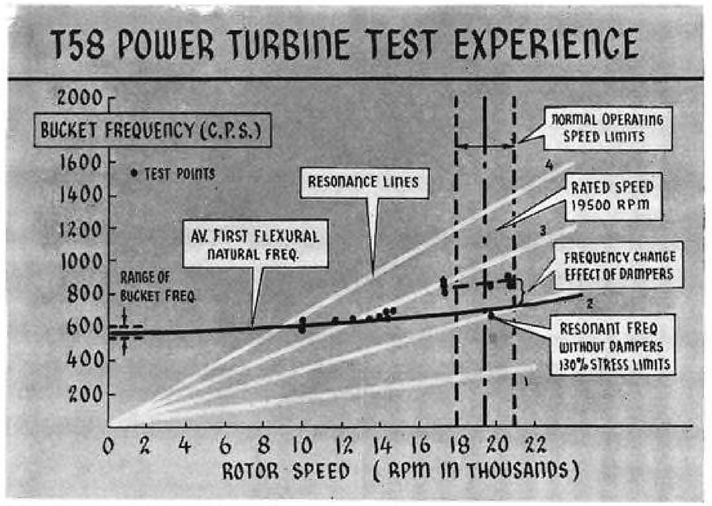
Among the novel mechanical design features of the compressor noted by Heglund is that the compressor spool comprising the last eight rotor stages is machined in one piece from 4340 high tensile steel forging. Single-piece spool eliminates the complexity of stacking and fitting multiple disks and results in a lighter weight, lower cost rotor drum having good dimensional stability, permitting General Electric engineers to design for minimum blade tip clearances.

Compressor rear shaft is bolted to the spool at the outside diameter and is located by a rabbet with an interference fit. Forward shaft and second-stage wheel are integral and are bolted to the forward end of the spool at the outside diameter, also with an interference fit. First stage wheel is overhung from the second stage wheel. A labyrinth seal is carried in the first stage wheel to form the outer seal of balance piston cavity.

First and second stage rotor blade retention is of axial two-tang fir tree type. Rotor blades for the third through 10th stages are retained in the single-piece spool by circumferential dovetails with platforms on the blades to preserve the smooth effect on the rotor. This combination of compressed blade retention provides for easy field replacement of blades without disassembling the engine.

By removing the top half of the compressor, first and second stage blades are accessible since the shrouds give axial clearance for blade removal; stages three through 10 can be easily removed from the circumferential dovetail. This has been demonstrated in the field as a practical procedure.

Up to three stages have been re-



STRAIN GAGED TEST RUNS on hot gas with and without dampers showed these results.

placed on the engine without removing it, Heglund reported. He feels there is no reason why maintenance personnel could not change all the blades without need for balancing the whole wheel. General Electric balances the rotor by inserting small slugs in the circumferential dovetail between blades; blade replacement would merely require that slugs be replaced in their prior positions when new blades are inserted.

One of the criticisms of small axial-flow compressors has been cost of small compressor blades; during the past year Small Aircraft Engine Department developed a roll and pinch process for producing satisfactory blades inexpensively.

Compressor stator is fabricated of Chromalloy, the compressor casing and stator rings being split horizontally and the stator vane rings being carried by T-slots. Each stator ring has two stages of fixed stator vanes. Fixed stator vanes are made from mill-rolled stock. Vanes are joined to the rings by the stabbing process and are furnace-brazed. Inlet guide vanes and first stage vanes are supported by the shrouds at the inside diameter. Second and third stages are cantilevered from the outside diameter.

Concentric Rings

In addition to the rings for actuating the variable guide vanes, there are four additional rings. Held concentrically independent of the stator casing by the vanes acting as spokes, these rings contain bearings for the vanes as well as circumferential grooves to support actuating rings.

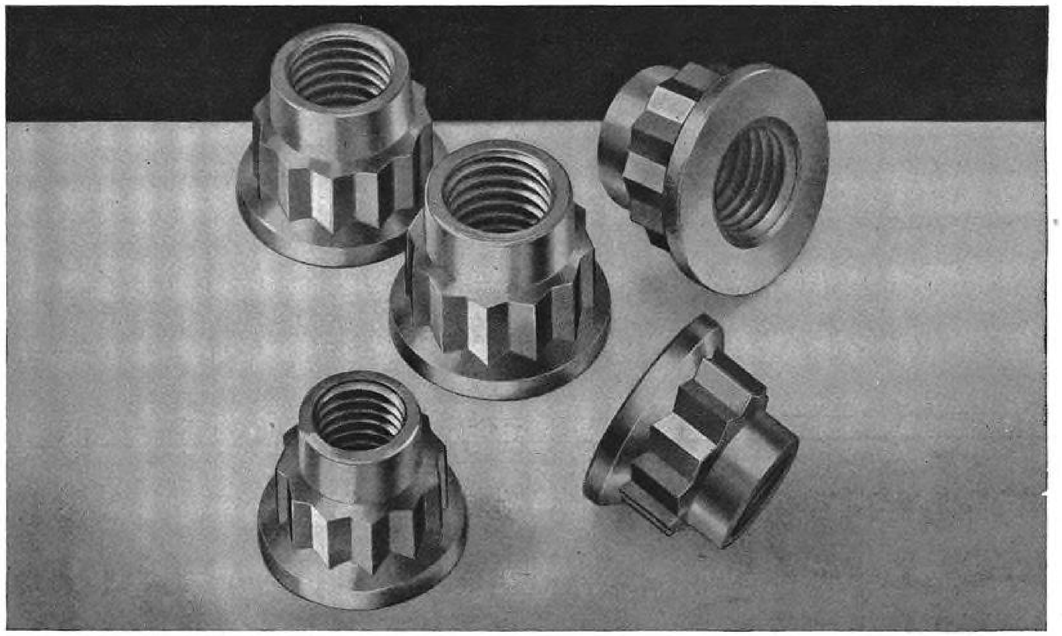
Actuating ring for the third stage is carried on the ring which has bearings for the first stage stator vanes; actuating ring for the second stage is carried on the ring which has bearings for the first stage stator vanes. Ring which has the bearings for the inlet guide vanes carries two actuating rings; the ring for the first stage stator is on the aft side and the ring for the inlet guide vanes is on the forward side.

Isolating the actuating rings from the compressor casing minimizes inaccuracies in vane settings over the operating range of the engine due to thermal effects, also permits long lever arms reducing inaccuracies due to parts stack-up.

Combustion Section

Annular combustion system has a one-piece liner designed to provide simplicity of construction and longer life by eliminating joints and flanges susceptible to thermal stresses. T58 liners have operated more than 330 hr. without deterioration, Heglund reported A flow splitter, an annular ring, fits in the throat of the stepped diffuser and extends axially until it butts against the liner. This is to provide positive division of compressor air to assure equal distribution over outer and inner shell. Outer combustion casing has a horizontal split flange to permit inspection of the inner liner and replacement of fuel manifolds and nozzles.

Fuel manifold assemblies have 16 single-orifice nozzles. Nozzles for carrying the fuel nozzles proper are carried on a pair of tubes which constitute the fuel manifolds. Manifolds consist of left and right hand assemblies to simplify removal. The two tubes feed alternate fuel nozzles. At low flows, such as starting, half of the nozzles are supplied from each manifold; as fuel requirements increase beyond a given



FLEXLOC FLW SERIES SELF-LOCKING NUTS are formed from alloy steel, cadmium plated, with optional molybdenum disulfide dry lubrication. Although weighing up to 40% less than ordinary 12-point nuts, the FLW has a tensile strength of 180,000 psi min.

New SPS lightweight, high strength locknuts help you keep airframe weight down

hiRf High Reliability factor

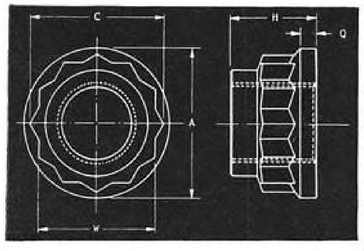
At SPS we apply a dynamic standard of quality—continually refined—so that our fasteners will always have the high reliability factor required by today's faster speeds, higher temperatures, and greater dynamic forces. By using SPS fasteners in your assemblies, you increase overall reliability—the certainty of predictable performance under actual service conditions.

For more information on the full meaning of reliability, write for a copy of the SPS booklet "Concerning High Reliability," recently issued.

A development of SPS research, these new FLEXLOC FLW Series locknuts help you reduce airframe weight without compromising strength or reliability. Designed for fastening airframe structural members, FLW Series locknuts weigh up to 40% less than ordinary 12-point nuts, yet offer equal tensile values. Tensile strength of the FLW locknut—180,000 psi min.—exceeds minimum requirements of Government specification MIL-N-25027.

In addition to important savings in weight, FLEXLOC FLW Series locknuts offer the advantages of 1-piece, self-locking design. Positive locking action is provided by the collar section—need for lockwashers, jam nuts, cotter pins or wiring is entirely eliminated. There are no auxiliary locking elements to put together, come apart or get lost; no inserts to pop out or deteriorate. A FLEXLOC locks, seated or not, wherever wrenching stops and will not vibrate loose. Used to fasten your critical components and assemblies, FLEXLOC assures you of high reliability.

For more information, write for Catalog Sheet 2386. Aircraft/Missiles Division, STANDARD PRESSED STEEL CO., Jenkintown 3, Pa.



SIZE	PART NUMBER		A	C	W		H	Q	Weight* Lb. Per 100 Pcs.	Ultimate Tensile Lb. Min.
	Cadmium Plate	Cadmium Plate with MOS_2		Ref.	Max.	Min.	Max.			
1/4 -28 UNF-3B	42 FLW-428	48 FLW-428	.439	.419	.376	.367	.312	.045	.60	7,200
5/16-24 UNF-3B	42 FLW-524	48 FLW-524	.542	.491	.439	.430	.375	.050	1.00	11,500
3/8 -24 UNF-3B	42 FLW-624	48 FLW-624	.649	.561	.502	.492	.452	.060	1.50	17,130
7/16-20 UNF-3B	42 FLW-720	48 FLW-720	.748	.631	.564	.553	.525	.075	2.15	23,200
1/2 -20 UNF-3B	42 FLW-820	48 FLW-820	.858	.703	.627	.616	.568	.080	2.80	31,000

*Average production weight

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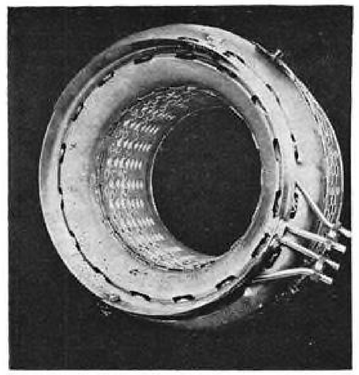
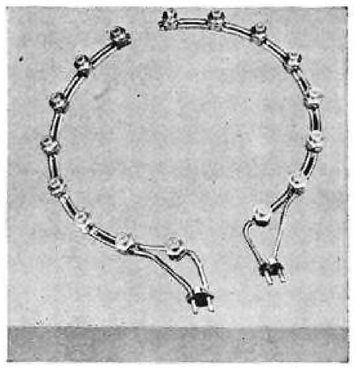


COMBUSTION LINER showing splitter ring and fuel manifolds (below) assembled.



point, a flow divider opens and feeds the remaining eight nozzles.

Gas generator turbine rotor parts are stacked on face couplings and held together by a center tie bolt to provide for easy and rapid disassembly of the wheels and pieces are match-marked to assure reassembly in their proper relationship to maintain balance. This system embodying keys and pins is used to ensure that wheels cannot be inadvertently assembled backwards.

Third bearing of the trio which carry the complete gas generator rotor is outboard of the second stage turbine to provide a sturdy gas generator rotor system. Stacking and unstacking the complete turbine rotor eliminates need for horizontal flanges on the turbine casings, contributing to dimensional stability and long life of the assembly. It also allows close control of diaphragm area which is important to consistent performance in this type of powerplant, Heglund stated.

Buckets are forged and attached to the turbine wheels by a dovetail fastening.

Each bucket has a shank to isolate the wheel rim and retaining dovetail from the hot gas stream.

Turbine shrouds are segmented and stamped from 321 stainless steel to permit minimum turbine tip clearance and

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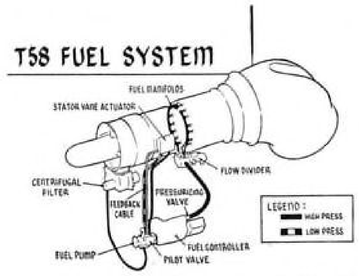


FUEL SYSTEM meets new military contamination specification XPP-36.

providing ease of manufacturing.

Nozzle diaphragms are high-temperature brazed assemblies to provide light weight and simplicity. Partitions for all three stages are cast Vitallium and are brazed from .020 sheet metal. By closely controlling the slots in the bands and carefully preparing partitions prior to brazing, the area is controlled to ½%.

Inter-turbine seal of honeycomb makeup using 321 material, former silver braze and also silver materials used showed unsatisfactory life, according to Heglund.

Third stage turbine diaphragm is mounted inside the second stage turbine casing. Three axial fittings provide cooling air for the forward face of the power turbine wheel and for lubricating oil in and scavenge oil out of the rear gas generator rotor bearing, which is carried by the third stage diaphragm.

Power Turbine

Power turbine is coaxial with the gas generator but is completely independent. This assembly is a complete unit that can be interchanged with any gas generator assembly.

Exhaust duct casing provides flow passage around the power turbine shaft and through a 60-deg. bend, to allow access to the power turbine shaft and also provide a single discharge. Pad at the power turbine shaft is the rear mounting point for the engine. Power turbine wheel and shaft are integrally forged from Lapelloy, buckets are forged from A286 material. The wheel has two main bearings. The one directly behind the wheel is a roller bearing, the second is a ball bearing to take the thrust load.

Passages between the bucket shanks are closed off by light metal sheet pieces which also serve as dampers. Before the dampers were added to the power turbine, General Electric engineers noted that the T58 has a two-per-revolution resonance in the engine's normal operating range, responsible for bucket failures. The bucket frequency was shifted from this excitation by the dampers.

Damper design evolved three stages. In addition to this mission, they also

Turbine-Powered HU-1A Makes First Flight

First YH-40 Iroquois turbine-powered helicopter makes initial flight at Bell Helicopter Corp. plant at Fort Worth, Texas. Powered by Lycoming T53, production version for Army has been designated HU-1A.

had to block the passage to prevent hot gases from circulating through the shanks and had to be light to keep the dead load on the buckets low. First design failed when the end cover came off when the spot welds let go. Second design—of one piece to avoid weld failures—went when the turned-down tabs at the top broke. Third attempt was of one piece construction with a continuous surface across the top; this is working satisfactorily.

On the bottom of the power turbine is a small angle gear box driving a flexible shaft connected to the main control. Shaft provides the power turbine speed signal to the control and drives a tachometer generator. Angle gear box is driven by a radial shaft through a worm drive and two spur gears. Worm sleeve is keyed to the power turbine shaft by means of a three-lobe polygon spline. Output connection from the shaft is also a polygon spline permitting acceptable shaft misalignment with a reasonably sized spline.

Power turbine is designed so that it can exhaust either right, left or vertically downward, due to symmetrical design of components.

Reduction gear optional on the T58-GE-6 is a straight reduction offset design having a 3.25: 1 ratio. Gears are herringbone to eliminate end thrust. Casings are cast magnesium and use sleeve bearings. Weight of the complete reduction gear box is under 75 lb. Gear box has an integral lubrication and scavenge pump supplying gears and bearings and making it independent of the basic engine lubricating system.

Lubricating system is designed to use MIL-L7808ve synthetic oil. Lubricating pump contains one service and four scavenging elements. Oil passes from the service element by flange port through an integral passage in the accessory gear case to the filter. The pressure system is protected by a relief valve and an oil filter bypass valve, both housed in the accessory gear box. A check valve in the lubricating pump discharge prevents static oil leakage.

Maximum oil flow at military power is 3 gpm. Scavenge-to-service ratio for the pump is 2.8:1. All oil jets are .050 or larger diameter to prevent clogging.

Fuel system embodies a centrifuge filter to permit engine operation with fuel contaminated to the new military specification XPP-36. From the engine pump discharge, fuel passes into the control where it is metered, unused fuel is bypassed back to the pump inlet.

Engine control system maintains a selected power turbine speed; prevents gas generator and power turbine overspeed; prevents compressor stall, turbine over-temperature and rich or lean blowouts; governs gas generator idle speed and schedules inlet guide vane and rotor vane positions for optimum airflow. It also protects from excessive pressures and meters fuel for distribution to the combustor.

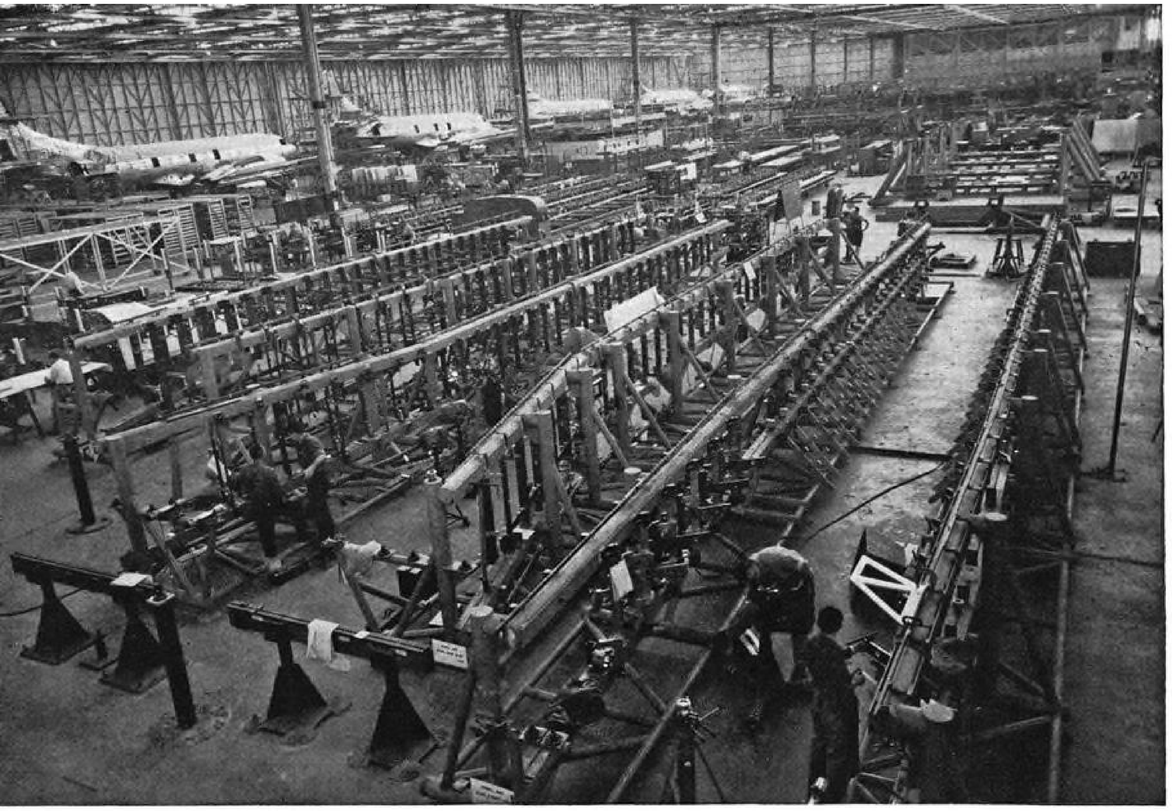
A single speed control lever with 120-deg. rotation does these jobs. At positions from zero to three degrees, the engine is shut off. Engine idle is obtained at 50 deg. From 50 to 70 deg. is a transition stage used to bring the T58 from idle up to the free turbine governing range. Between 70 and 120 deg. the engine control system automatically regulates fuel flow to maintain shaft output at the selected speed. Range of rotor speed control is 15%. The rpm. selected will be maintained automatically and independent of the power required.

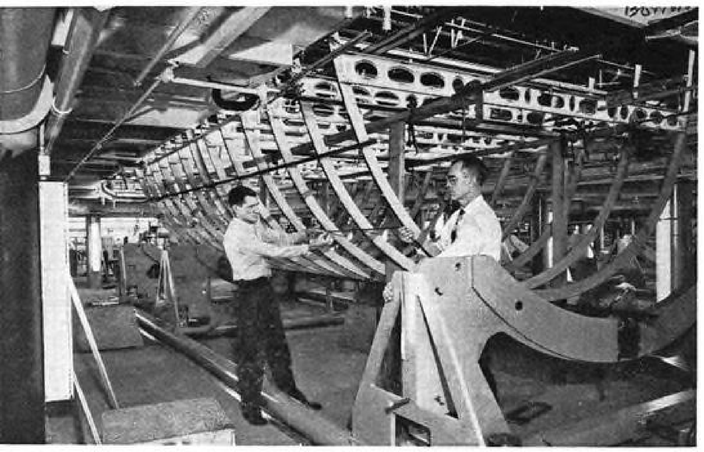
Convair Will Convert C-54s for Air Rescue

Conversion and modernization of five Air Force C-54s, slated to be sent to Portugal under the Mutual Assistance Program, will be accomplished by the Fort Worth, Tex., plant of Convair. Four of the airplanes will be converted to SC-54 air-sea rescue planes, the fifth will remain a cargo aircraft.

Conversion work on the SC-54s includes major changes in the planes' interiors, reworking of the cockpits and relocation of instruments. Navigator's station will be relocated and fuel and reserve oil tanks added. Installation of "bubble-type" scanning stations and a large door for making equipment drops also is included in the conversion.

Convair expects to complete the conversion operation by early summer.

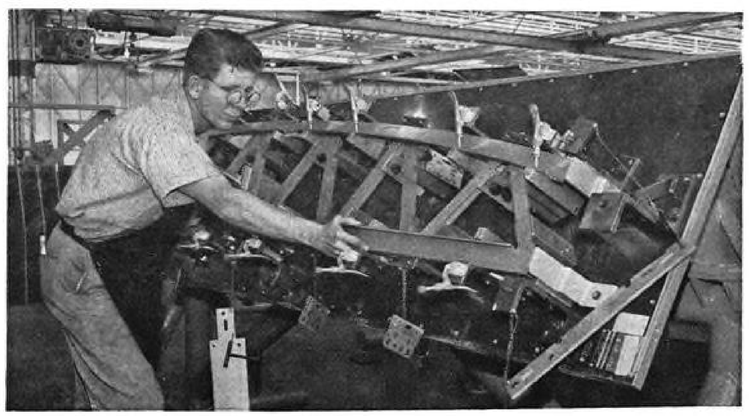




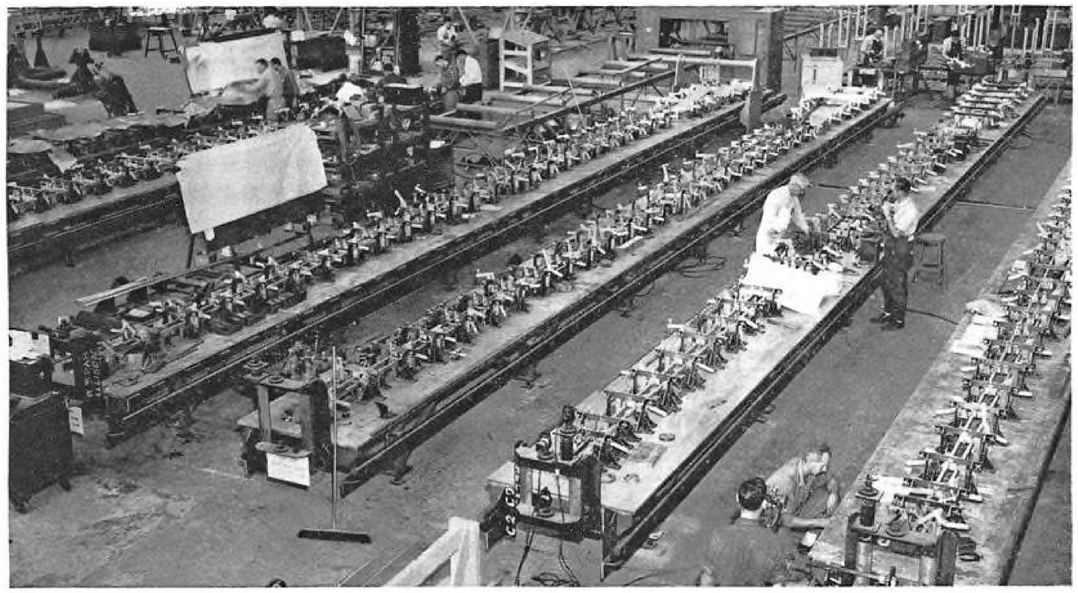
Additional fixtures for wing spar manufacture are completed by tooling crews in part of 632,000-sq. ft. of plant area for Convair 880 production. Convair 440 line is in background.

Parts Assembly Is Under Way On Convair 880

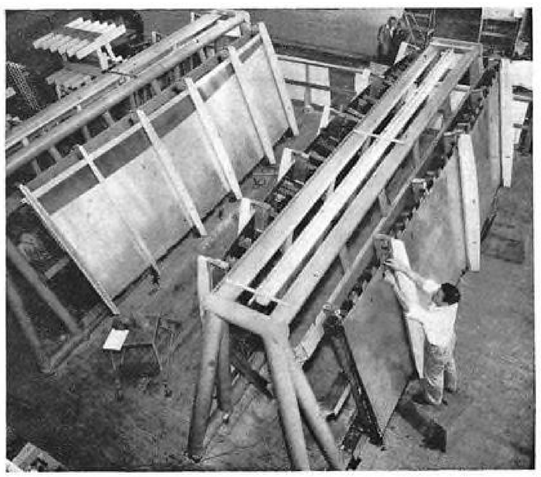
Mockup section of forward fuselage is checked for spacing on belt frames in San Diego plant (above). This is first unit to be assembled in the production fixture. Fabrication of this section for No. 1 airplane is scheduled to begin April 14.



Bulkhead of truss type is assembled for wing of the 880 transport (right). Start of major assembly is expected to begin April 10.

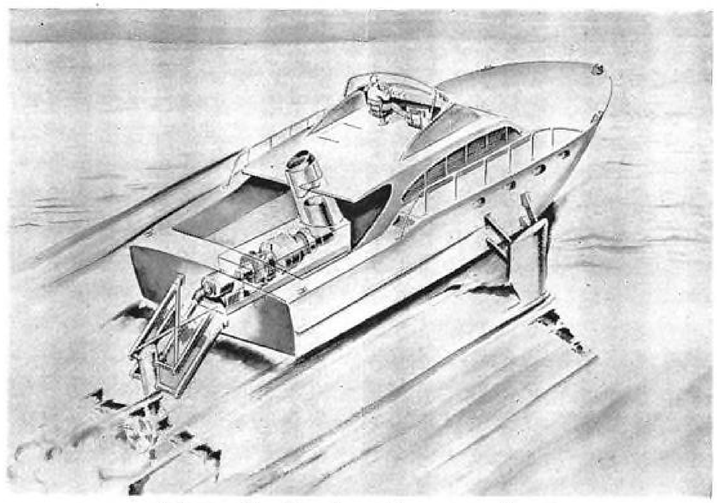


Photographs show factory area for the 880 jet transport being produced by Convair Division of General Dynamics Corp. at plant in San Diego, Calif. Production tooling will be housed in two factory buildings. Wing spar fabrication for the transport will make use of primary assembly fixtures (above). At right, a crew is shown assembling the first center wing spar, the shortest of three that will go into each half of the 880's swept wings. At right, below, skin and stringer panels for the center tie-box section of the wing are shown in production. Workman below, left, is shown riveting one of several types of wing bulkheads for major assembly of the jet transport.



Russians Display Rockets, Bombers

Red Army barrage rockets (above), called Katushas by the Russians, are shown on parade in Moscow. Smaller rockets on trucks in background are similar to World War II equipment which had a range of three to six miles. Larger rockets in foreground are more modern, presumably have greater range and warhead weight. Below, Red air force squadron of Il-28 Beagle light bombers is readied for flight. Form-fitting covers are placed on aircraft when they are left out in the weather (note Beagles in the background). The Il-28 is a subsonic bomber used in large numbers by the satellite nations as well as the Russians.



Aircraft Engine Powers Boat

Artist's conception of hydrofoil boat, like one being developed by Miami Ship-Building Corp. under Navy Bureau of Ships contract, can reach speeds in excess of 30 kt. using T53 gas turbine engine modified by Lycoming Division of Avco Mfg. Corp. Lycoming said installation is the first for hydrofoil boat. Aircraft applications include Army HU-1 and USAF H-43B helicopters.

Allison Establishes Propulsion Committee

Advanced aeronautical propulsion systems will be studied at the Allison Division of General Motors Corp. by a 10-man board, the Allison Scientific Advisory Committee. During its first semi-annual meeting, the group made recommendations to the firm concerning types of powerplants necessary to fulfill military and scientific research requirements.

Chairman of the committee is Dr. Theodore von Karman, chairman emeritus of the USAF Scientific Advisory Board. Dr. von Karman, an international authority on aeronautical science, is also chairman of the Advisory Group for Aeronautical Research and Development for NATO.

Vice chairman of the committee is Dr. Lawrence R. Hafstad, vice president of General Motors in charge of the GM Research Staff. Other members of the committee are: Dr. Luigi Crocco, director of the Guggenheim Jet Propulsion Center at Princeton University; Dr. John R. Markham, professor of aeronautical engineering at Massachusetts Institute of Technology; Dr. Courtland Perkins, chairman of the Aeronautical Engineering Department, Princeton University; Dr. William R. Sears, director of the Graduate School of Aeronautical Engineering, Cornell University; Dr. Maurice J. Zucrow, professor of gas turbines and jet propulsion, Purdue University; Dr. Pol Duwez and Dr. W. Duncan Rannie, professors of mechanical engineering, California Institute of Technology, and Dr. Antonio Ferri, professor of aerodynamics and head of aerodynamics laboratory, Polytechnic Institute of Brooklyn.

Each member of the committee is a recognized authority in one or more fields of the aeronautical and physical sciences. In addition to semi-annual meetings, Allison will consult members of the committee individually.

Closed-Circuit Tunnel Tests Jet Engines

Jet engines installed in aircraft assemblies are being successfully tested in a closed-circuit wind tunnel by the Air Force's Air Research and Development Command.

The propulsion wind tunnel, located at the Arnold Engineering Development Center near Tullahoma, Tenn., can test full-scale engines or large aircraft and missile models at velocities from 350 to 1,100 mph. over a wide range of temperatures and pressures. Tunnel's closed-circuit design allows various pressure levels to be maintained and achieves air speeds with a total of 216,000 hp., driving compressors and exhausters that would require more than 1,000,000 hp. in an open-circuit tunnel.

Wind tunnel testing permits the simulation of external airflow as well as in-flight attitude changes of the packaged engine, and allows simultaneous study of the aerodynamics and internal burning characteristics. Engines may

be tilted up or down or positioned in a yawed attitude to simulate free flight conditions.

Originally designed for propulsion testing, the transonic circuit of the tunnel has been used for conducting aerodynamic tests for more than a year. Tests have been conducted on a model of Convair's B-58, General Electric and Avco ICBM nose cones, and the Army's Jupiter IRBM.

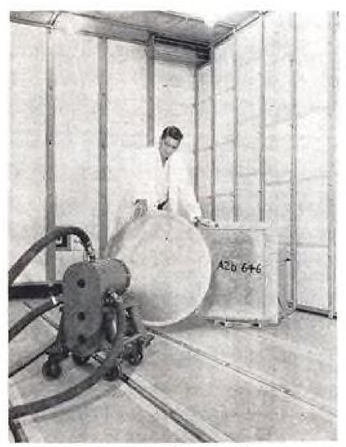
Propulsion Wind Tunnel Facility has a supersonic circuit under construction which is designed for a velocity range of 1,000 to 3,300 mph. Both circuits are part of Unitary Wind Tunnel Plan and have test sections 16 ft. square and 40 ft. long that permit testing of full-scale, operating ramjet and turbojet engines in pods, nacelles and fuselage sections.

Navy to Use Sub Unit For Altitude Testing

Navy will remake the deck hangar unit from the troop transport submarine U.S.S. Sea Lion into a high altitude chamber for testing ignition and combustion of new propellants at extremely high altitudes. Conversion and test work will be performed at the Naval Ordnance Test Station, China Lake, Calif.

Together with combustion properties of new propellants, the Navy will study pyrotechnics in the 52-ton unit. A Naval Ordnance spokesman reports that pyrotechnic items such as flares and flash signals suffer a considerable drop in luminous intensity at extreme altitudes, but at the present time the reason for this is unknown. Test chamber is expected to yield much information in this field alone.

Originally, the submarine section was a separate chamber on the deck of the troop transport sub; it served as additional storage space. Prior to shipment to China Lake, unit was in "mothball" storage at Philadelphia.



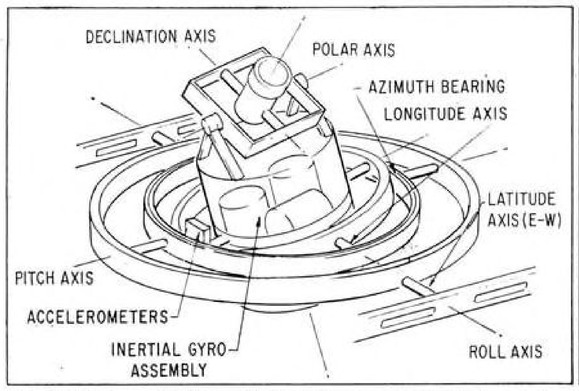
Sound Chamber

Technician places test panel in front of sound generator's exponential horn in Boeing's sonic test cell. Generator converts 4,000 cu. ft. of air per min. into 190 decibles of sound in study of destructive effects of sonic vibration.

Overhaul Firm Delivers 10,000th USAF Engine

Dallas—Southwest Airmotive Co. has overhauled 10,000 engines under Air Force contract in its engine facility here at Love Field since the end of World War II. Total includes 4,180 turbojet engines.

Southwest Airmotive delivered the 10,000th engine, an Allison J33, to Maj. Gen. Thomas P. Gerrity, commander of Oklahoma City Air Materiel Area, at a ceremony in Dallas on Feb. 12. Military overhaul work on the J33 has given Southwest Airmotive the background necessary to obtain authority from the Civil Aeronautics Administration for overhauling civil turbojet engines, and the company plans to do contract overhaul of jet engines for the airlines. Braniff Airways has decided to have its Pratt & Whitney J75 engines overhauled by Southwest Airmotive.



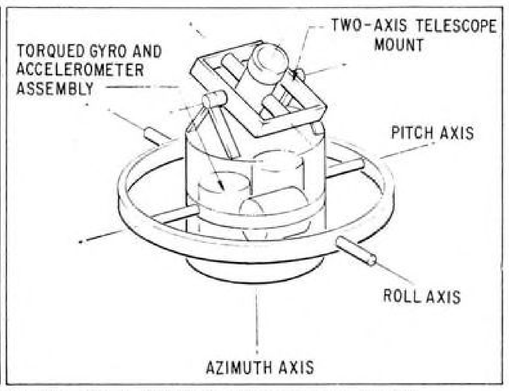


FIG. 1 (left) shows platform with inertial gyro assembly. Note complex gimbaling. Fig. 2 (right) shows torqued gyro assembly.

Stellar-Inertial Guidance Reduces Error

By Dr. R. B. Horsfall*

Combination of stellar and inertial navigation techniques in a hybrid system offers an attractive means of obtaining the accuracies required for guidance of long-range supersonic aircraft and cruise missiles, and for space travel.

Use of proper Schuler tuning in a pure-inertial system prevents the buildup of certain, but not all, types of errors with time. For example, Schuler tuning does not eliminate the buildup of errors due to drift in the gyro used for directional reference.

The addition of an automatic star tracker, however, provides a celestial reference that helps determine:

- **Stable platform attitude,** which can be used to prevent accumulation of gyro drift errors, or . . .
- **Vehicle position,** which can be used to correct periodically the inertial system. Here the Schuler-tuned pendulous system provides a horizontal reference for celestial navigation.

Fundamental theory of both types is the same. What differences exist are largely a matter of the ease of mechanization, or of special transient conditions of operation.

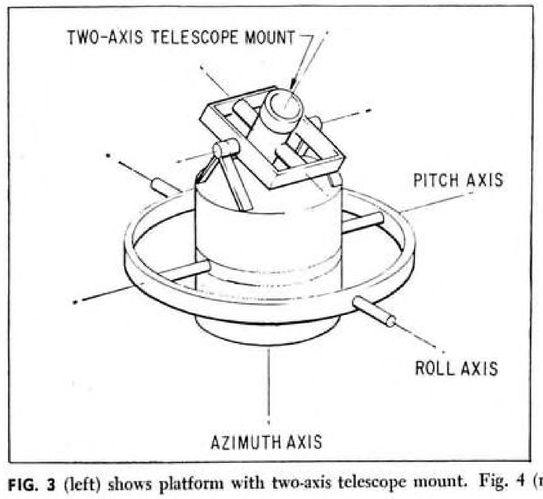
Stellar Inertial Problems

In order to avoid operational restrictions, any system requiring stellar information must be able to start under overcast and continue to work during periods when star visibility may be interrupted by high altitude clouds during flight. It must also be able to work during daylight.

The brightest astronomical objects (Sun, Moon, and planets) are generally undesirable for automatic systems because of their size and relatively complex apparent motion. Also, since they all lie within about 8 deg. of the plane of the ecliptic they may not be visible from polar regions, so operational problems in such regions would also rule them out.

In order to keep oscillatory errors due to Schuler tuning from building up too much during periods of overcast and to carry along satisfactory information during such periods, it is essential that any stellar-inertial system have high quality gyros. This in turn lets the star trackers use a small angular field which, with present sensing techniques, helps pro-

* Dr. Horsfall is a research scientist in North American Aviation's Autonetics Division.



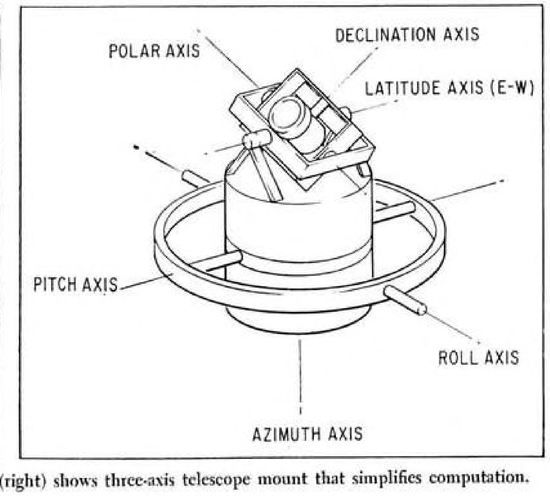


FIG. 3 (left) shows platform with two-axis telescope mount. Fig. 4 (right) shows three-axis telescope mount that simplifies computation.

Digital Display

Electroluminescent indicator which can be used to display letters or numbers in wide choice of colors has been developed by Westinghouse Research Laboratories. Individual thin panels have series of phosphor-coated electroluminescent strips which glow when voltage is applied. Seven such strips are needed to display numbers from 0 to 9; 14 strips are required to display any letter from "AA" to "ZZ." Panel coated with 21 strips makes it possible to display any letter or number by application of voltage to proper choice of strips.

vide daytime operation. It also allows use of a single telescope and alternating observation of the two or more stars required for complete control. The number, and therefore the brightness, of the stars which must be trackable in order to avoid geographic limitations depends critically on the size of the zenith cone which can be covered.

Two general types of stellar-inertial systems have been developed over the past 10 years:

- **Preprogrammed trajectory**, in which vehicle's course is pre-set, permitting some departure from plan but not complete freedom of path. Such systems were less complex to build to required accuracy when airborne computers were of the analog type.
- **Flexible trajectory**, which permits vehicle to operate at will over surface of the Earth, became feasible only with the advent of airborne digital computers which could solve more sophisticated problems with greater accuracy.

Stable Platform

In general, automatic navigation equipment is made up of an assemblage of inertial instruments (gyros, accelerometers, telescopes) called a stable platform—computers—and a variety of auxiliaries such as power supplies and environmental controls. Details of stable platform configuration are as numerous as the groups designing them.

Two main gyro arrangements are of practical significance. The first may be called an inertial assembly and involves gyros which are not intentionally torqued (Fig. 1). This type, therefore, tends to remain fixed in inertial space and tumble with respect to local gravity as the Earth rotates and the vehicle travels over the surface of the Earth.

The second involves torqued gyros which are forced to precess in a controlled manner with respect to inertial space (Fig. 2). The usual purpose of such torquing is to keep the orientation of the gyros constant with respect to local gravity so as to minimize the effect of gyro asymmetry in producing drift. In the absence of other considerations it is evident that the inertial gyro system would be more desirable for stellar supervision since the directions of the navigational stars would remain constant with reference to the gyro cluster.

Because of problems of platform support and star visibility this usually doesn't work out well. As described later, flat windows are best for high accuracy star tracking and unless they can be kept small it is hard to fair them into an airframe without increasing drag. Use of a completely inertial stable element keeps the center of rotation of the line of sight farther from the skin of the ship and so demands larger windows.

Consequently, all successful stellar inertial systems have been built with platforms which remain level or near level so as to keep the star tracker units always on top and close to the necessary window. Obviously, this kind of platform requires that the telescope line of sight must be provided with at least 2 deg. of angular freedom relative to the level system to permit pointing at an arbitrary celestial object.

Computer Problems

Computations involved in determining the drive angles for a two-axis tracker mount (Fig. 3) are relatively complex. In view of the high precision required, analog methods are not suitable. If a third mechanical axis (Fig. 4) is provided so as to form an equatorial mount for the star tracker, the computational requirements are minimized and analog methods become feasible. Such a structure, however, is generally awkward and adds the extra precision drive as a source of pointing error. With the development of adequate airborne digital computers, such configurations have lost what appeal they had originally.

A further choice remains between an integral telescope mounted in pointing gimbals and a periscope device in which the telescope proper is fixed on the platform and the line of sight is controlled by suitable rotation of one or more reflectors. Both forms have been built and tested and there appears to be no

Swedish Alouette Mounts Radar

Sud Aviation Alouette helicopter belonging to the Swedish Navy is equipped with radar, apparently for surface surveillance and navigation. High definition K-band radar mounted in this way could detect all but the smallest surface craft at night and under poor visibility.

overwhelming advantage in either case. Because of the need for relatively long focal lengths and critical photoelectric and electronic accessories, there seems to be some advantage on the side of the periscope arrangement.

Two critical features of stellar-inertial system computers which differentiate them from pure-inertial computers are:

- **Computation of gimbal angles** required to aim telescope at a star.
- **Interpretation of telescope error** signals to provide appropriate gyro correction torques or position corrections.

The following discussion of these two factors is equally applicable to single or multiple-telescope systems.

Navigation Mathematics

For a system operating in latitude-longitude coordinates with the platform oriented N-S and E-W and with the telescope gimbal attached to the platform along the N-S axis, the telescope pointing equations can be expressed in the form

$$\beta = \sin^{-1}[\sin\delta\cos\lambda + \cos\delta\sin\lambda\cos\sigma] \tag{1}$$

$$\alpha = \tan^{-1}\left[\frac{-\cos\delta\sin\sigma}{\sin\delta\sin\lambda + \cos\delta\cos\lambda\cos\sigma}\right]$$

where α is the angle between the telescope gimbal and the platform horizontal and β is the angle of the telescope axis relative to the gimbal normal, δ is star declination, λ is platform latitude, and σ is the angle between the local meridian and the meridian passing through the star. In actual computation σ is a function of the right ascension of the star, sidereal time, and local longitude obtained by a summation process.

While the particular form of these telescope pointing equations depends on the choice of system coordinates and telescope gimbaling arrangements, the complexity remains approximately the same. However, with some particular choices it is possible to separate the effects of vehicle motion from the balance of the computation. The complex portions of the equations then involve only constant parameters and may be carried out by ground equipment and recorded. They may then be played back in the airborne autonavigator using some form of chronometer drive, and the vehicle motion effects can be simply added to the recorded signals.

For stellar correction signals in the same sample system one form of solution can be expressed as follows:

$$\epsilon_y = \frac{\epsilon_\eta^1 \sin\alpha^2 - \epsilon_\eta^2 \sin\alpha^1}{\sin(\alpha^2 - \alpha^1)}$$

$$\epsilon_z = \frac{\epsilon_\eta^2 \cos\alpha^1 - \epsilon_\eta^1 \cos\alpha^2}{\sin(\alpha^2 - \alpha^1)} \tag{2}$$

$$\epsilon_x = \frac{\epsilon_\xi^1}{\cos\beta^1} + \frac{\epsilon_\eta^2 \tan\beta^1}{\sin(\alpha^2 - \alpha^1)} - \frac{\epsilon_\eta^1 \tan\beta^1}{\tan(\alpha^2 - \alpha^1)}$$

In these equations the ϵs are error angles measured around the axis indicated by the subscript and the numerical superscripts correspond to two different stars; x, y, z, are respectively North, West and upward platform axes, and ξ and η are telescope axes which coincide with x and y when the telescope is pointed toward the zenith.

Corrective torques proportional to these values may be applied to the gyros to cause the entire platform to precess toward alignment with the stars. Alternatively, ϵ_y may be interpreted directly as an error in latitude and $\epsilon_x\cos\lambda + \epsilon_y\sin\lambda$ as an error in longitude. When these corrections are applied to the indicated position, equations (1) will give new values of α and β which in turn should result in telescope alignment with the stars.

It is evident that there are as many variations of the foregoing equations as there are choices of coordinate systems and methods of mechanizing the stellar corrections. Skillful selection of advantageous coordinates and mechanizations to meet specific requirements is responsible for differences in performance of actual systems. Security considerations prevent more detailed discussion of such details at the present time.

High Accuracy Needed

It is evident from the foregoing mathematics that the general case of telescope pointing involves more or less complex combinations of trigonometric functions of the angles involved.

Inasmuch as a one second of arc error in angle is equivalent to approximately 100 ft. on the surface of the Earth, it is obvious that such computations must be carried out with very high precision if performance better than that available by ordinary bubble octant observations is to be attained.

Such precision is far beyond the capacity of straightforward analog equipment and special multistage computing tricks would be required to approach satisfactory performance.

Digital computation on the other hand is capable of being carried to the required degree of precision with little, if any, increase in computer equipment requirements.

If the nature of the vehicle trajectory is known in advance, it is possible to select a coordinate system whose use simplifies the telescope pointing equations.

Then the precision (digital) computation may be carried out in advance with ground equipment and recorded in a form which may be played back and interpreted by relatively simple analog equipment in the airborne autonavigator. Such techniques were actually used in early successful experimental systems.

Earlier mention was made of the necessity for providing a window or windows in the airframe through which stellar observations could be made. Only two forms of window are possible when accuracies measured in seconds of arc are involved. These two are a flat, i.e., plane parallel, window and a concentric spherical shell dome. The flat window has the advantage that it has no focal properties and therefore the precise location of the line of sight is not critical. The spherical dome, on the other hand, behaves like a negative lens and therefore requires that the line of sight (optical axis of the telescope system) be

accurately radial to avoid introduction of deviation errors.

A third theoretical possibility should be mentioned. If at some future time an optical material of suitable transparency is developed which is capable of being made in very thin sheets (one or two mm.) and strong enough to be self-supporting as a portion of the airframe skin, a curved window made in this form would produce negligible errors.

Small, But Important

In the practical development of a stellar-inertial autonavigator system there are numerous small effects which must be considered in order to attain adequate accuracy. The atmospheric refraction of starlight commonly known as the Comstock correction causes stars to appear at a higher elevation than they actually are. This effect is well known and can be adequately predicted when the atmospheric density in front of the telescope is known. Related to this phenomenon is the refractive bias which will occur when a flat window, separating regions of different atmospheric density, is tilted with respect to the horizon. This amounts to the introduction of a wedge of air whose refractive effect is measured by the difference in density on the two sides of the window. Again, this effect is one which can be computed when the difference in density is known.

Windows of practicable dimensions will bend under a pressure difference and cause lens effects which may require compensation. This effect can also be predicted and computed when the pressure difference and resultant deformation are known. If the window is made of a material having an appreciable thermal expansion coefficient, it may also bend under a temperature differential and therefore produce refractive effects. With the advent of high quality fused silica in large pieces, this effect and the danger of window destruction due to thermal shock may be minimized.

The magnitudes of these effects in general vary with the zenith angle and become rapidly more critical as the line of sight drops below the 45 deg. line. Also the required window size increases rapidly as lower lines of sight are required. Therefore, as a practical matter, the minimum zenith cone which will give adequate star coverage and inertial control is desirable. It requires only a survey of the distribution of stars to show that with a zenith cone of approximately 45 deg. half angle it is necessary to be able to work with nearly 100 of the brightest stars in order to get unlimited operational coverage.

Other small factors which are common to all inertial systems involve

Compact Power Pack

Turbonator, combination air-turbine driving a 40 kva. alternator on a common shaft, delivers constant frequency 400 cps. power, weighs 96 lb. Developed by General Electric Co.'s Aircraft Accessory Turbine Department, turbine can be driven from ram or bleed air, rotates at 24,000 rpm., can be used up to Mach 3.5 flight speeds, General Electric says.

effects of coordinate system rotation such as Coriolis acceleration and centripetal acceleration terms in the equations of motion, and the effects of Earth ellipticity and related variations in gravity. While these are small, they must be mechanized in any precision autonavigator system.

Designing Auxiliaries

In the practical design of a stellar inertial system, it is necessary to consider environmental control of the platform enclosure since temperature differences and temperature gradients can cause mechanical disturbances and other influences which would disturb the performance of the inertial system. Many items such as electrical elements and telescopes may also be sensitive to pressure variations.

Provision of mechanical drives which are capable of pointing the telescope line of sight with an accuracy measured in seconds of arc is obviously no mean engineering undertaking. Here the factor to keep in mind is that an error of five micro-inches per inch of radius corresponds to a one-second angular error. Suppose that a mechanical drive involving a final gear of 2-in. radius was used in a system aimed at an accuracy of one nautical mile. The maximum tolerable error in operation of this final gear would then be .0006 in. if the entire error were to be allocated to this one source and no error buildup were involved. Obviously a much smaller tolerance than this would be required if the one-mile objective were to be attained in any practical system where many other error sources must be considered.

Outside Assist

The stellar-inertial system accuracy can be adversely affected by oscillatory errors in the horizontal reference resulting from outside disturbances and Schuler tuning, and by noise inputs which accumulate with time.

Feedback damping can be used to minimize oscillations, but system accuracy will be hurt by unpredicted wind changes.

If, however, an independent source of information on vehicle velocity is available it can be compared with the inertially derived vehicle velocity and the difference used to provide damping. A true airspeed indicator, or Doppler radar, can provide this source of information.

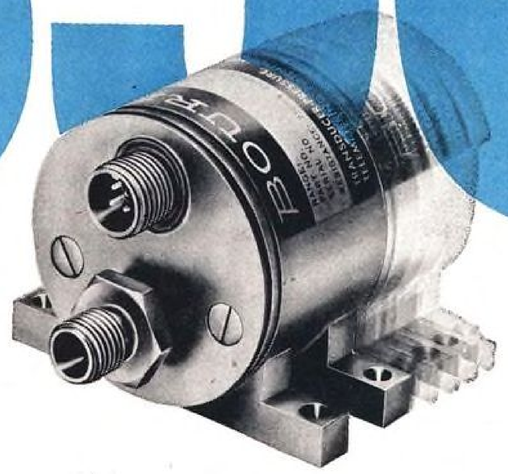
By proper adjustment of the damping coefficient, it is possible for such a system to provide damped velocity data which is accurate to within a small fraction of the instantaneous error in the auxiliary system and to attain a correspondingly reduced amplitude of position error oscillation.

A true airspeed indicator, as a source of such data, has the advantage of simplicity and light weight, but wind uncertainties minimize improvement.

At the cost of greater complexity and weight, Doppler radar is generally capable of better performance as a damping aid. It has the disadvantage of requiring radiation from the aircraft which may be undesirable in certain military applications. Also operation is uncertain over smooth water.

However, the use of a Doppler system during the early portion of a mission when over friendly or neutral territory is capable of improving performance, even if radar silence is imposed during the terminal portion of the mission. Furthermore, it is possible to consider the use of landmarks observed either optically or by radar to provide checkpoints which may improve the available position information in the autonavigator at one or more instants during the flight.

35G



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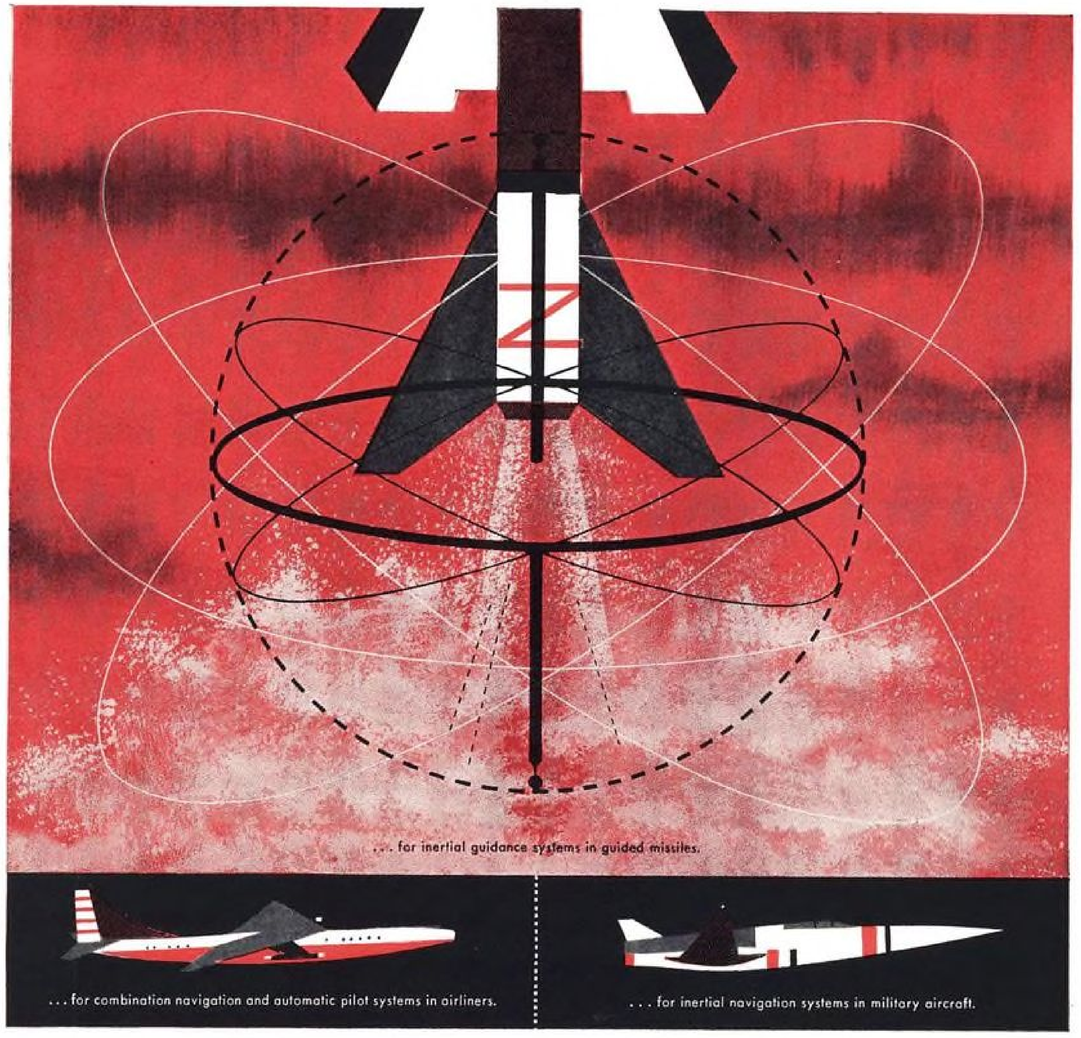

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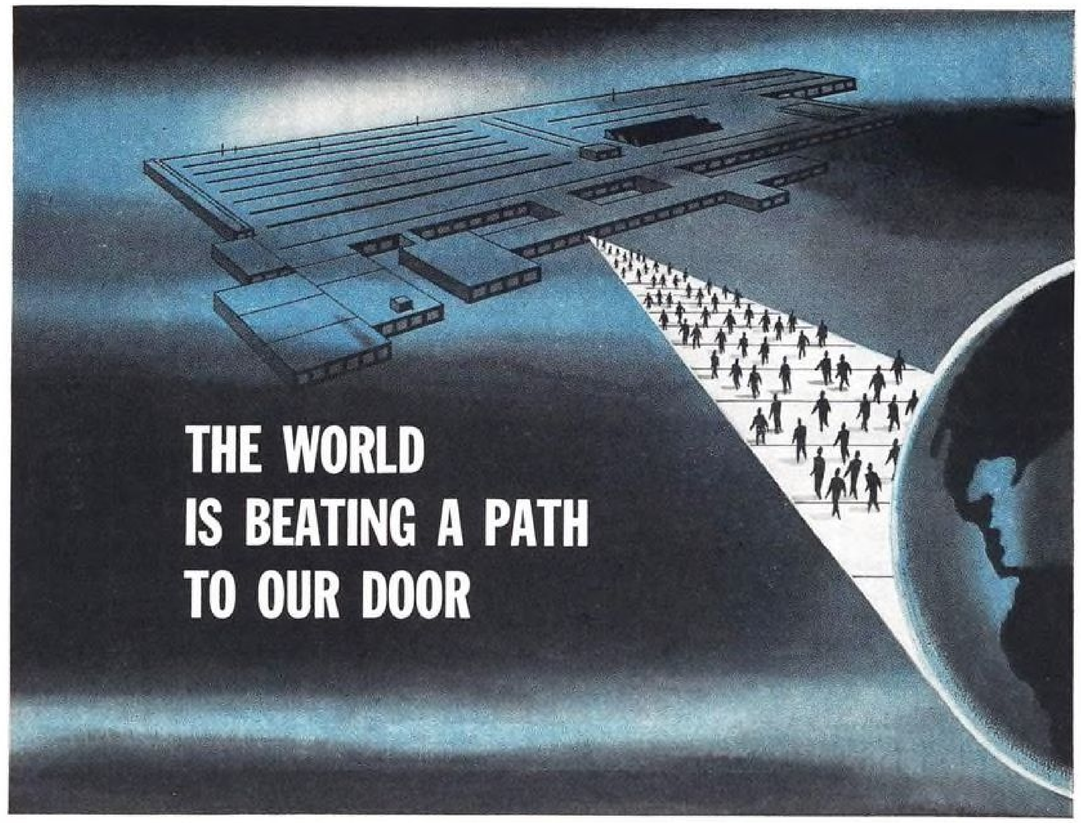

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"Build a better mouse trap," the old saying goes, "and the world will beat a path to your door." We've never built a mouse trap (although professional pride would never let us admit that we *couldn't* build a better one), but the path to our door is getting pretty worn all the same.

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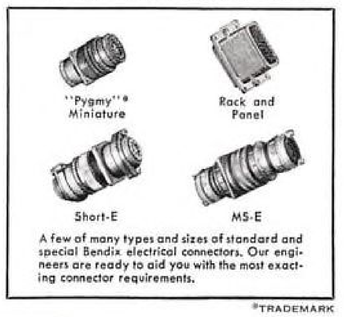

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LINEUP of Do.27s at left represents a week's production. Right, Do.27 for Luftwaffe takes off from grass at Munich-Neuaubing factory.

Dornier Building 15-20 Do.27s Monthly

By David A. Anderton

Munich—First one-hundred Dornier Do.27 STOL aircraft have been delivered to the West German Luftwaffe and a second batch of 50 is expected to be picked up by pilots this month.

Five-place plane, being used by the Germans for communications and other specialized work, is being produced at a rate between 15 and 20 per month at the Neuaubing factory of Dornier-Werke GmbH near here. Total order for the plane from the West German Defense Ministry is 428, the largest German postwar order for aircraft placed either inside or outside the country. Deliveries will be completed during 1959.

Observers at the Paris Air Show last May were impressed by the low-speed handling qualities of the airplane and the demonstration put on by Dornier Chief Pilot Heinrich Schaefer. In a "friendly" competition between the Dornier plane and the Czech-designed Avia Brigadyr of similar configuration, the palm for slow flying went to the Czech. But the Dornier's maneuverability at extremely low forward speeds and at angles of attack up to what seemed like 45 deg. left technicians tremendously impressed.

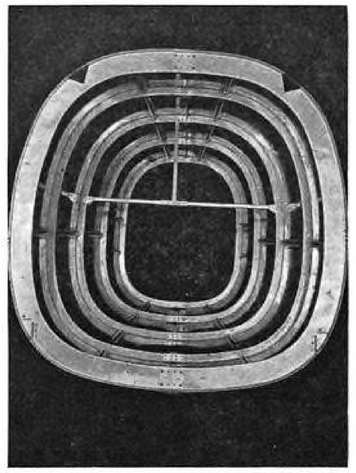
Like many other STOL airplanes of the past—Fieseler Storch, Ryan Dragonfly, Robertson Skylark—the Dornier uses a high-wing layout with a single engine and long landing gear. The wing lift is obtained from full-span leading-edge slats and partial-span trailing-edge double slotted flaps and drooped ailerons.

Trailing-edge lift devices are in three segments spanwise; the outer and middle segments act as ailerons, the inner as flaps only. Middle segment can be drooped but not to the full deflection

Dornier Do. 27 STOL Airplane

PHYSICAL CHARACTERISTICS:	
Wingspan, ft.	39.37
Overall length, ft.	31.33
Maximum height, three-point, ft.	11.48
Usable cabin volume, cu. ft.	123.6
Wing area, sq. ft.	208.8
Normal gross weight, lb.	3,307
Maximum gross weight, lb.	3,528
PERFORMANCE CHARACTERISTICS: (Normal gross weight)	
Maximum speed, mph.	155
Cruise speed, 60% power, mph.	127
Minimum speed, mph.	35.5
Takeoff run, zero wind, ft.	289
Landing run, zero wind, ft	246
Takeoff distance over 49-ft. obstacle, ft.	541
Landing distance over 49-ft. obstacle, ft.	525
Time to climb to 9,843 ft., min.	12
Range at 60% power, mi.	541

SKI-WHEEL combination, shown here on demonstrator, has not been standardized for plane.



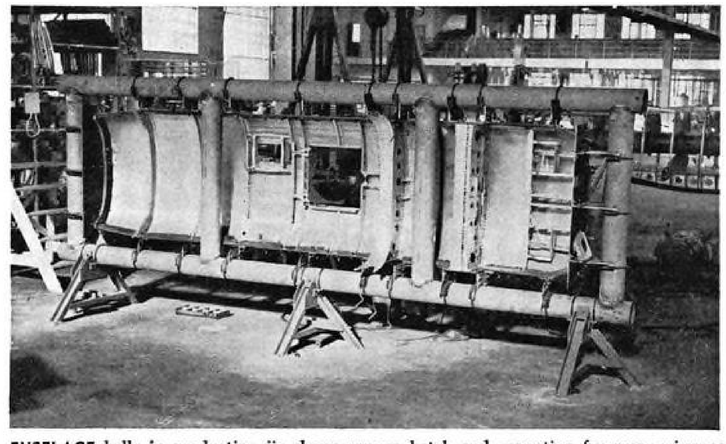
REAR fuselage structure approaches pure monocoque type (left). Finished fuselage bellies (right) await wiring, plumbing installation.

of the flap, and the ailerons can then be operated differentially for lateral control.

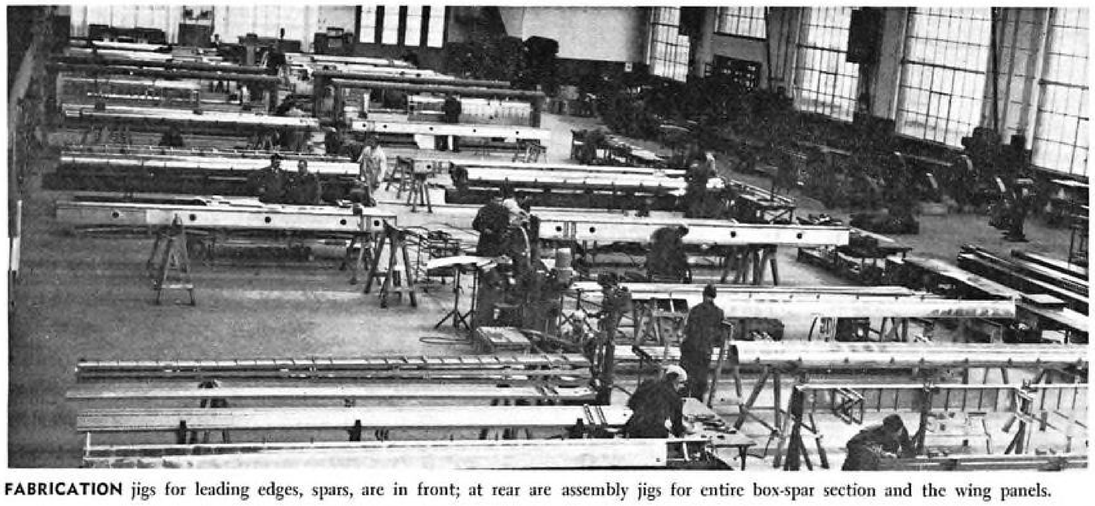
For takeoff under normal conditions, only the inner segment flap is used. For landing or when extreme performance is needed, everything but the outer ailerons comes down.

Powerplant for the Do. 27 is a U.S.-built Lycoming GO-480-B1A6 rated at 270 hp. for takeoff. It drives a Hartzell constant-speed two-blade propeller. Fuel consumption at 60% power cruise condition is about 81 lb./hr., or just under 13.5 U.S. gallons.

The Do. 27 started life as a development in Spain, where Dornier–like Messerschmitt–set up design offices after World War II to be able to keep a core of technicians abreast of aviation progress. They also found this a useful stratagem to get around con-



FUSELAGE belly in production jig shows camera hatch and mounting for reconnaissance equipment.



FABRICATION jigs for leading edges, spars, are in front; at rear are assembly jigs for entire box-spar section and the wing panels.

COWLING, designed for accessibility, has two side panels that swing up; belly panel that drops out and forward. Engine cooling flap is at rear of belly panel. Engine is Lycoming.

ditions imposed on Germany by the Allies at the end of the war, and only lifted in 1956 by the Paris Agreement.

In Spain, Dornier engineers designed the Do. 25, an STOL airplane sponsored as one result of a design competition by the Spanish Ministry of Aviation. Expatriate French designer Emile Dewoitine also entered the competition and evolved a similar airplane.

Powerplant for the Do. 25 was a Spanish engine, the ENMA Tigre G4B, rated at 150 hp.

First flight of the Do. 25 was on June 25, 1954. Less than one year later—April 8, 1955—the prototype Do. 27 flew. It also was designed and built in Spain, and was powered by a Continental O470-J engine rated at 225 hp.

After the Paris Agreement, Dornier moved back to the Munich area and started production on the Do. 27 for West Germany. First production airplane flew on Oct. 17, 1956.

Although the current customer for the airplane wants a military version, Claude Dornier, Jr., told AVIATION WEEK the company is convinced the plane is excellent for business flying. Dornier has had some inquiries from other countries for the airplane and expects to announce an order soon.

Some indication of the short-field performance of the airplane is given by takeoff and landing distance over a 50-ft. obstacle in a zero wind. At normal gross weight of 3,307 lb., takeoff run is 289 ft., and to clear the obstacle the distance is 541 ft. Landing distance over the obstacle is 525 ft., of which the run itself is 246 ft.

Minimum speed is 35.5 mph., and cruise at 60% power is 127 mph.

PRIVATE LINES

Deliveries of 250-hp. Piper Comanche four-place low-wing business plane are expected to begin next month with basic model having price tag of $17,900. Piper will produce both 180-hp. and 250-hp. Comanches simultaneously, with output split 50-50 on each. New model cruises at 180 mph.

Altitude hold control for pneumatically operated Tactair autopilot probably will be available to public this summer. Current Tactair owners will be able to add new feature to present unit. Control will sell for approximately $500.

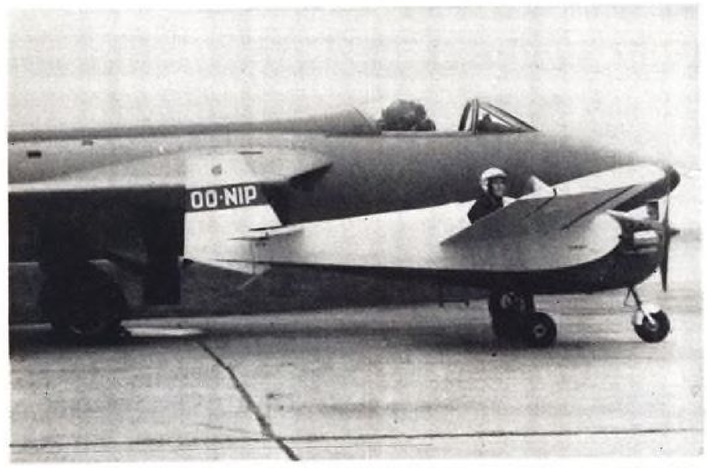
Edo is studying application of its amphibious twin-float landing gear to Piper Comanche.

National Aeronautical Corp. (Narco) will increase authorized no par common stock from 150,000 shares to 1 million. Narco reports sales for three months ended Feb. 28 are expected to approximate $930,000, a 3% gain over quarter ended Nov. 30. Narco sales for year ended Nov. 30 totaled $3,852,000, a 53% jump over previous year.

HOMEBUILT single-seater, assembled by Mark Horn, W. Palm Beach, Fla., in spare time for $1,500, has 100-hp. Continental. At 145 mph. it burns 6.2 gph. of 100 octane.

New U.S., Foreign Lightplanes

ITALIAN Aviamilano F.14 Nibbio four-placer has a 180-hp. Lycoming 0360 and cruises at 180 mph. at 6,500 ft. Range is 621 mi. Gross weight is 2,420 lb. with 40 gal. fuel.



BELGIAN Tipsy Nipper single-seater, offered in kit form for $1,500, is powered by Volkswagen engine and cruises at 65 mph. It grosses 660 lb., has 19.7-ft. wingspan.

WHO'S WHERE

(*Continued from page 15*)

Changes

Dr. Wendell B. Sell, general manager, Associated Missile Products Co., Pomona, Calif. Associated Missile Products Co., formerly a subsidiary, is now a division of American Machine & Foundry Co.; Dr. Sell is a divisional vice president of AMF.

N. A. Keller, Jetstar project engineer, Georgia Division, Lockheed Aircraft Corp., Marietta, Ga.

Angus MacDonald, director of engineering, Military Electronics Center and the Communications and Industrial Electronics Division, Motorola, Inc., Chicago, Ill.

Richard E. Cross, director-aircraft maintenance, Skymotive, Inc., Park Ridge, Ill. Also: **Herbert M. Bradbury,** director-engineering and quality control.

Roy P. Jackson, assistant to the vice president, Aeromutronic Systems, Inc., subsidiary of Ford Motor Co., Los Angeles, Calif.

Dr. Kenneth D. Johnson, staff assistant to the vice president, Atlantic Research Corp., Alexandria, Va.

J. E. Ashworth, Dayton, Ohio, representative, Avco Manufacturing Corp.'s Research and Advanced Development Division, Lawrence, Mass.

Kenneth D. Sneed, general manager-field engineering, American Electronics, Inc., Los Angeles, Calif.

Walter Helms, chief engineer, Transducer Division, G. M. Giannini & Co., Inc., Pasadena, Calif. Also: **Raymond G. Hanson, Jr.** appointed manager of sales promotion and advertising for the five divisions of Giannini.

Walker M. Mahurin, divisional representative-Western Region office, Autonetics, division of North American Aviation, Inc., Downey, Calif.

Fred W. Newman, manager-aircraft product service, Instrument Department, General Electric Co., West Lynn, Mass.

Ross F. Miller, chief engineer-electronic systems and equipment, Nortronics, division of Northrop Aircraft, Inc., Hawthorne, Calif.

Paul D. Williams, assistant director of research, Eitel-McCullough, Inc., San Bruno, Calif. Also: **Myron C. Pogue,** manager-market research.

Col. Charles W. Gordon (USAF, ret.), manager-Rome, N. Y., office, Defense Electronic Products, Radio Corporation of America, Camden, N. J.

Dr. Henry G. Giuliana has joined Stavid Engineering, Inc., Plainfield, N. J.; he will be associated with the company's work on weapon systems engineering.

Samuel Agabian, vice president, Sperry Gyroscope Co., division of Sperry Rand Corp., Great Neck, N. Y. **Herbert Harris, Jr.,** succeeds Mr. Agabian as manager of Sperry Gyroscope's Air Armament Division.

Bernard Bernstein, general manager-newly established Advanced Development and Systems Division, Gulton Industries, Inc., Metuchen, N. J.

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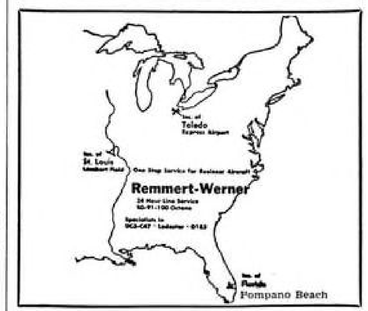

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ADVERTISERS IN THIS ISSUE

AVIATION WEEK, MARCH 17, 1958

LETTERS

Tail Giveaway

Referring to your AVIATION WEEK dated Feb. 3, someone must have slipped up on the information given on p. 69. The plane pictured on this page is captioned "F-100D Picks Up Target." This cannot be, as this aircraft is an early F-100A-1 painted with North American Aviation's test aircraft color scheme.

The vertical tail surface was the giveaway, and a check of the serial number proved it.

BRUCE KELLEY
San Jose, Calif.

(Sharp eyed readers keep AVIATION WEEK's desk men on their toes.—Ed.)

Cold Facts

I was disgusted by the stream of whining letters from so-called engineers in support of James Rarick (AW Dec. 30, p. 102). There will never be a shortage of such men as these.

I wish to stand up and be counted in support of Charles McMorrow (AW Jan. 27, p. 122) for putting the cold facts to the whiners.

SAM E. COOPER, Engineer
American Machine & Foundry Co.
Defense Products Group
Alexandria, Va.

"Captains' Union . . ."

Have been following the pilot-flight engineer controversy since its start, and have read and heard most all the comments and arguments from both sides. I'm sure most everything that can be said has been said; however, here are a few comments about ALPA in general as well as the above-mentioned controversy.

I have attended some of our local ALPA pilots' meetings whenever scheduling would permit, and of the meetings I've attended all pertained to gripes of captains who are unhappy because they have to get up at 2 a.m. to cover a 5 a.m. departure and it interrupts their sleep, and why they can't get more money and all other crew members less. Within the past few years quite a few flight navigators and engineers have told me that they have been actually told by some captains that they think that the flight engineers and the navigators are overpaid. So it is no wonder that the captains want to put a third jockey in the engineer's seat at $350 per month so the captains can get another raise. A few years back I was chairman of a flight radio operators' local just prior to the inauguration of radio telephone, and the ALPA local notified the company that the captains would not fly the North Atlantic without a flight radio operator, but also let the company know that if they received a $50 a month raise they would gladly fly without an FRO.

One of the most disgraceful plights is that of the copilot. At the meetings that I attended the copilot would hardly dare to request the floor for he usually would be shouted down or out-voted, and if he was allowed to speak his piece he could be assured that he would get a downgrading on his next proficiency check. Yet the copilot is compelled to join ALPA's "captains' union" and pay dues if he desires to remain with the company. This situation may be relative only to our own local, although I doubt this very much. But, if it is so, I still deplore ALPA in Chicago for allowing this condition to exist in any of their locals.

The fundamental argument concerning the FEIA is how long the airlines are going to allow ALPA to dictate company policy. If they (ALPA) accomplish what they demand by refusing to fly the jets (AW Dec. 9, p. 47 and Feb. 10, p. 43), airline management might better resign and turn everything over to ALPA. This is apparently what the pilots want. Then they could take over the FE's job, the Nav's job, the stewardess' job, and even empty the honey buckets for an additional $25 a month.

To qualify myself to make these statements and assure you that I am not anti-union, I organized a Flight Radio Operators Union in the late 40's and was instrumental in the organization of a Flight Navigators Union. Thank you for your unbiased journalism on all matters in aviation, as well as the FEIA situation.

RADIO OPERATOR
Reseda, Calif.

Aviation Week welcomes the opinion 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.

. . . For "Simple" Jets?

I have noted a few points which I feel should be emphasized at this time in the pilot vs. flight engineer controversy over the forthcoming jet crew complement. Jet airspeeds will be greatly increased over present piston engine airspeeds. Passenger capacity per aircraft will be nearly doubled. All existing long range flights will be short range flights calling for single instead of multiple crew operations, and navigators (ALPA men) will not be used. By adding these factors we can see that unless there is a new tremendous surge of growth in passenger potential to absorb the manifold growth of flight crew productivity, there will be a large cutback of flight crew personnel as jet equipment replaces piston engine equipment.

The ALPA knows that airline management will not "buy" featherbedding, therefore, the obvious solution is to "case out" the skilled professional flight engineer in order to accommodate the junior inexperienced pilot.

What would a third pilot do? There will be two sets of flight controls and two flight instrument panels, the same as now. The three-pilot jet crew would be like a football team with everyone a fullback.

We are being promised simplicity in our forthcoming engines. Even if the jet engines were simple, which is certainly not the case, we must not forget the rest of the airplane. We cannot head out over the ocean "riding herd" on our four SIMPLE jet engines and leave the airframe, with its dozen or more systems, behind. Do we know of any series of heavy transport aircraft where a new model was made simpler than its predecessor? Let us look at existing transport aircraft and the auxiliary equipment, instruments and controls that have been added by both the manufacturers and operators (after the basic model had been placed in service), either because they were vital for safety or important for efficiency.

Our new jets are heavy but sensitive, clean but complex aircraft demanding the finest piloting technique from their pilots and the highest degree of technical skill, competence and knowledge from their flight engineers. Who can say what it is worth to be able to recognize a dangerous condition promptly, evaluate it, and take the necessary action? We have flight engineers who have been doing just this for up to 20 years and longer. Would you not use them now at a time when their training and experience are at a peak value for forthcoming safety and efficiency on this new, different and comparatively untried equipment? Civil aviation cannot tolerate a series of disasters such as plagued the military in its initial experience with heavy jet aircraft.

ALPA exerts great economic pressure and will go to extremes to further its selfish interest in this matter. The traveling public assumes that when it steps on an airplane everything has been and will be done by all the various departments and personnel to ensure a safe, comfortable flight. Travelers entrust their lives to us and they deserve a better shake than this.

ARTHUR A. DELANO
Flight Engineer
Huntington, N. Y.

Neglected Danger

Your magazine AVIATION WEEK is so good that it is endangering the safety of this country.

Because of your excellent coverage, millions of Americans have been alerted to the needs of airpower and air defense.

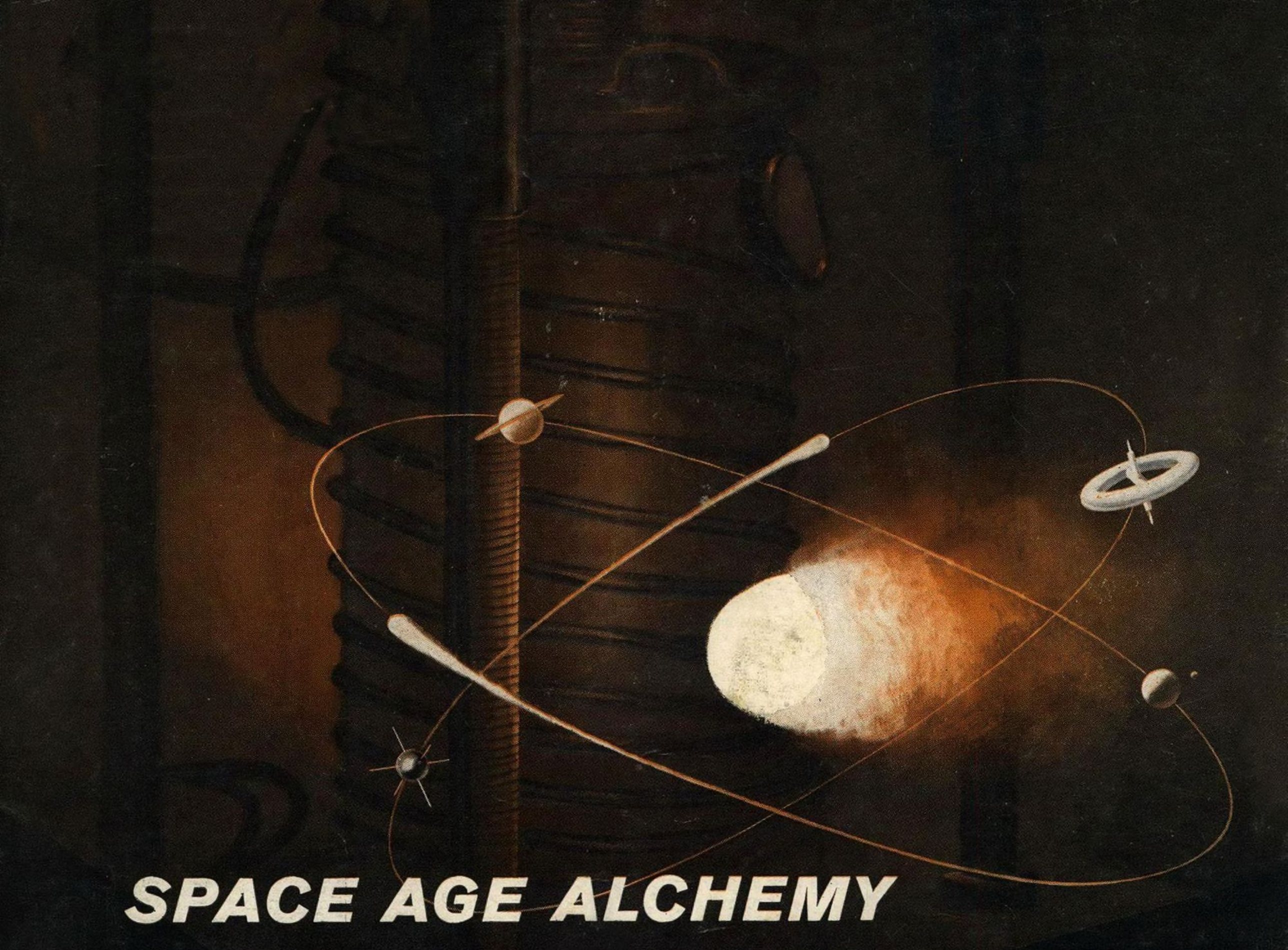
However, I believe your efforts have attracted attention away from our greatest danger; i.e., a fleet of 700 submarines, all carrying detachable time-fused hydrogen bombs, to be planted adjacent to all of our coastal cities. I would appreciate an editorial which would call attention to this neglected danger.

R. T. BARRETT
Environmental Test Engineer
South Laguna, Calif.

Cruising Speed

Re: "Boeing 707 Basic Data" on p. 53 of the Jan. 20 issue of AVIATION WEEK, the cruising speed (595 mph.) for the 707-420 is now obsolete. It should be the same as for the 707-320 (605 mph.).

GORDON S. WILLIAMS
Boeing Airplane Co.
Renton, Wash.



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The above illustration pictures an experimental hot press, developed by SMI, for basic investigations into these new materials. The press subjects various compounds to 3,600°C and 6,000 PSI in a vacuum or inert gas.

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