Aviation Week

Including Space Technology

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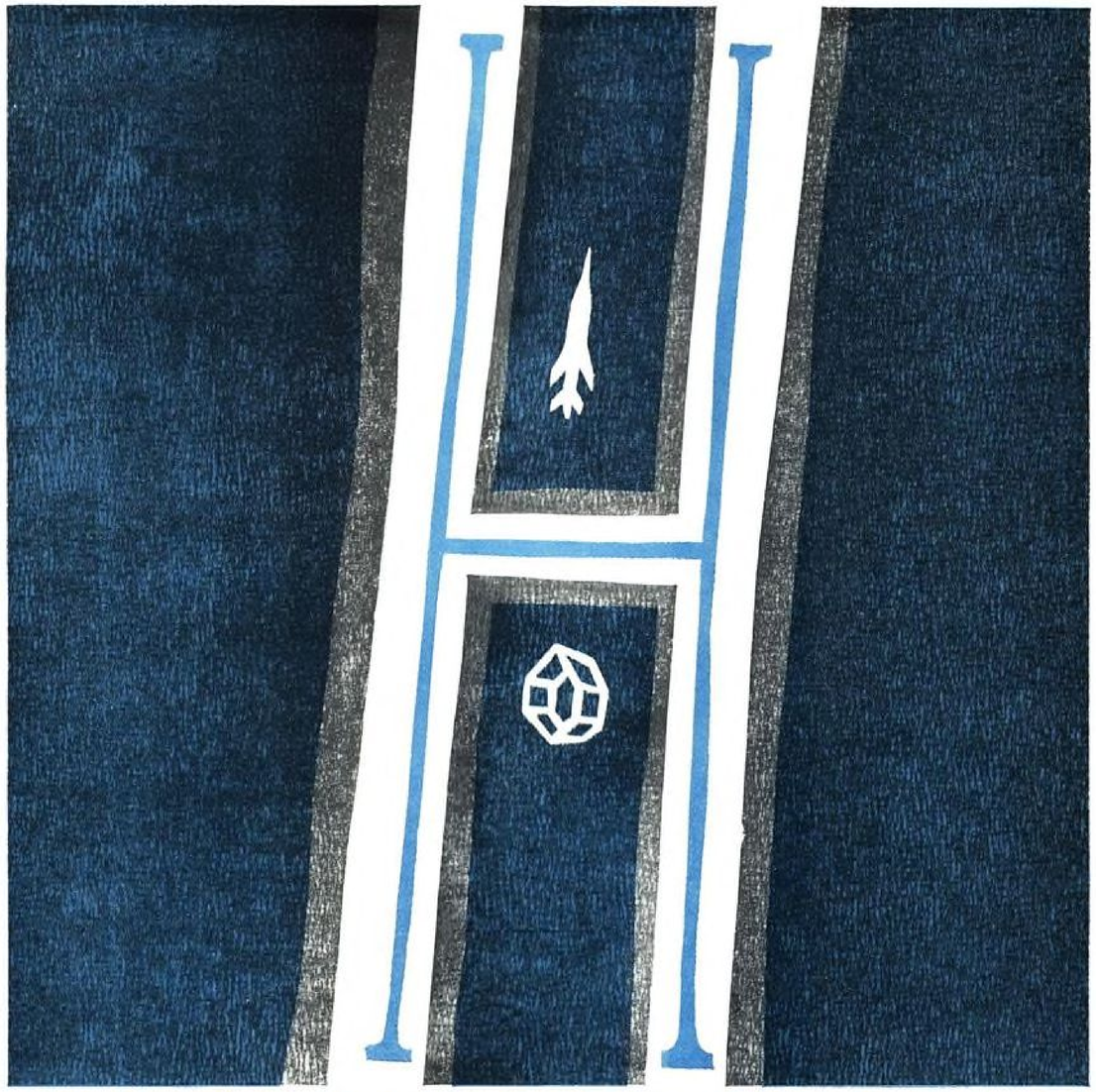
A McGraw-Hill Publication

June 9, 1958

F4H Stresses Long Range

Pilot Report On Skimmer IV

McDonnell F4H-1 With Sparrow III



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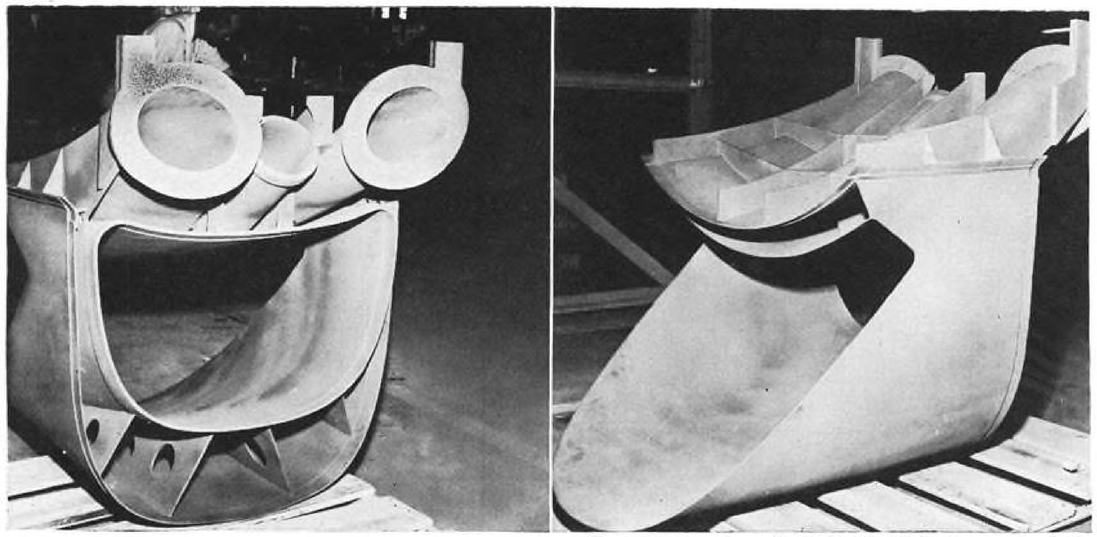

Engine air scoop casting made by R. H. Osbrink Mfg. Company, Los Angeles

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Huge thin-wall magnesium casting satisfies appetite for air

At supersonic speeds more than ten miles above the earth, Chance Vought Aircraft's Regulus II consumes enormous quantities of air through a 150 lb. magnesium casting.

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For more information about magnesium sand castings and their use in aircraft design, contact your nearest magnesium foundry or Dow sales office.

AVIATION CALENDAR

June 16-18—Second National Convention on Military Electronics, Sheraton Park Hotel, Washington, D. C.
June 19-21—Annual Meeting, Institute of Navigation, University of California Santa Barbara College, Goleta, Calif.
June 22-27—Golden Jubilee Meeting, American Institute of Chemical Engineers, Philadelphia, Pa.
June 22-27—61st Annual Meeting, American Society for Testing Materials, Hotel Statler, Boston, Mass.
June 22-27—Summer General Meeting and Air Transportation Conference, American Institute of Electrical Engineers, Statler Hotel, Buffalo, N. Y.
June 23-24—Summer Meeting, Western States Section, the Combustion Institute, Dwinelle Hall, University of California, Berkeley, Calif.
June 23-25—Annual Technical Session, Investment Casting Institute, Muskegon, Mich.
June 23-27—Vacuum Metallurgy Program, New York University. For details: Dr. Bunshah, NYU College of Engineering, University Hgts., Bronx 53, N. Y.
June 24-26—31st Meeting, Aviation Distributors and Manufacturers Assn., Mount Washington Hotel, Bretton Woods, N. H.
June 25-28—23rd Annual Meeting, the Drop Forging Assn., the Homestead, Hot Springs, Va.
June 27—First Water-Based Helicopter Symposium, sponsored by the Bureau of Aeronautics and Stevens Institute of Technology, Stevens Institute of Technology, Hoboken, N. J.
June 30-July 1—Industry Missile & Space Age Conference, sponsored by Aero Club of Michigan, Hotel Statler, Detroit, Mich.
July 4-6—Northeastern States Championship

(*Continued on page 6*)

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(Continued from page 5)

Soaring Contest, Harris Hill, Elmira, N. Y.

July 8-11—The Institute of the Aeronautical Sciences, National Summer Meeting, Ambassador Hotel, Los Angeles, Calif.

July 14-15—Triennial Inspection, National Advisory Committee for Aeronautics, Ames Aeronautical Laboratory, Moffett Field, Calif.

July 14-25—Physics of Infrared Radiation Program for research scientists and engineers, Massachusetts Institute of Technology, Cambridge, Mass.

July 24-25—Fifth Annual Symposium on Computers and Data Processing, Albany Hotel, Denver, Colo.

Aug. 5—Regional Technical Meeting on Space Exploration, sponsored by American Rocket Society and the Institute of the Aeronautical Sciences. For details: R. D. Linnell, General Chairman, Space Exploration Meeting, 3300 N. Harbor Drive, San Diego 1, Calif.

Aug. 6-8—Special Technical Conference on Non-Linear Magnetics and Magnetic Amplifiers, sponsored by the American Institute of Electrical Engineers, Hotel Statler, Los Angeles, Calif.

Aug. 13-15—Conference on Electronic Standards and Measurements, National Bureau of Standards, Boulder Laboratories, Boulder, Colo. Jointly sponsored by NBS, American Institute of Electrical Engineers and Institute of Radio Engineers.

Aug. 17-23—Missiles Operations Research, Engineering Seminar, Pennsylvania State University, University Park, Pa.

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

Aug. 25-30—Ninth Annual Congress, International Astronautical Federation, Amsterdam, Holland.

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

Sept. 3-5—1958 Cryogenic Engineering Conference, Massachusetts Institute of Technology, Cambridge, Mass.

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

Sept. 15-19—Annual Instrument-Automation Conference & Exhibit (International), Instrument Society of America, Philadelphia Convention Hall, Philadelphia, Pa.

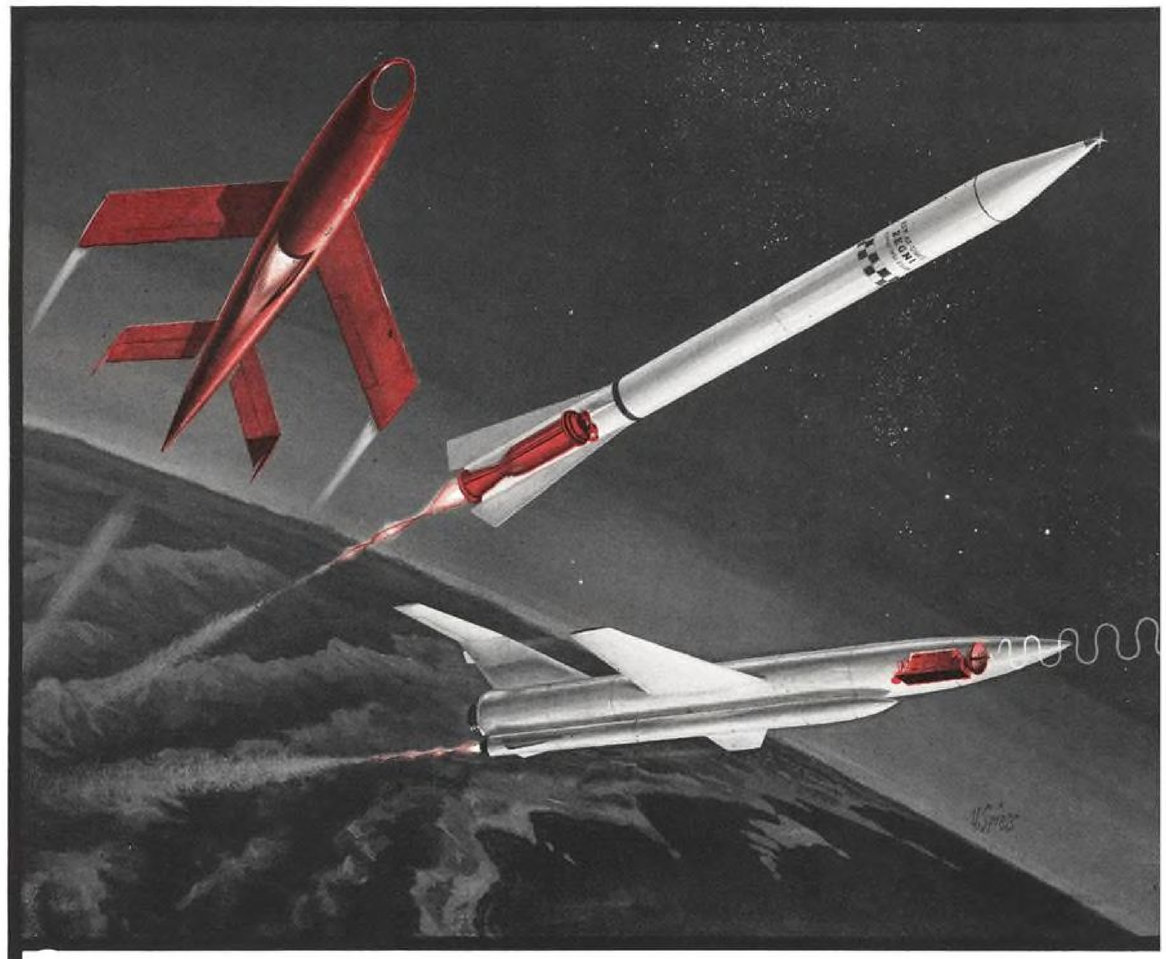
Sept. 22-24—1958 Meeting, Professional Group on Telemetry and Remote Control, Americana Hotel, Bal Harbor, Miami Beach, Fla.

Sept. 22-24—Seventh Annual Meeting, Standards Engineers Society, Benjamin Franklin Hotel, Philadelphia, Pa.

Sept. 29-Oct. 3—National Aeronautic Meeting, Society of Automotive Engineers, Inc., the Ambassador, Los Angeles, Calif.

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

Oct. 27-28—East Coast Conference on Aeronautical & Navigational Electronics, Institute of Radio Engineers, Lord Baltimore Hotel, Baltimore, Md.



RYAN HAS YEARS OF EXPERIENCE IN MISSILE DESIGN, GUIDANCE, PROPULSION

Modern missiles have not only changed the concepts of global strategy – but also the concepts of heat, speed and power. The incredible fuel consumptions, accelerations and temperatures of these man-made meteors have made manufacturing methods obsolete. Tiny imperfections can cause a missile to run amok through violent, unstable combustion or wildly erratic guidance. Ryan is skilled in meeting the demanding precision of missile fabrication because Ryan has years of experience in designing, guiding and powering missiles.

DESIGN – Complete development of the Firebee jet drone missile–aerodynamic and systems design, quantity manufacture, and field service. The Firebee is in volume production for use by the Air Force, Navy and RCAF. Ryan has also carried out extensive research on air-launched vehicles and is engaged on a new project for an advanced type nuclear weapon delivery system.

GUIDANCE—Development of advanced military radar systems for supersonic missile guidance; RANAV (Ryan Automatic Navigation) Doppler systems; and ground speed indicators and hovering devices for helicopters, airships, and VTOL aircraft. Ryan is a pioneer in continuous-wave radar techniques.

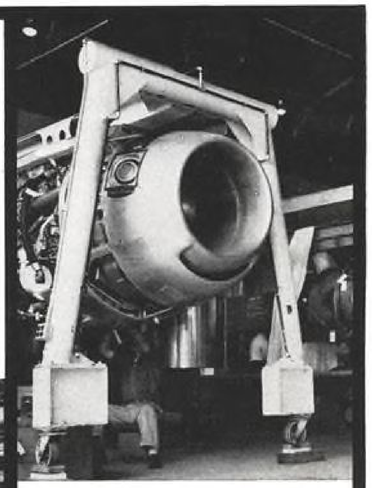
PROPULSION – Manufacture of powerful liquid rocket motors for surface-to-surface missiles; ramjet combustion chambers for ground-to-air missiles; and major high temperature components used by turbojet-powered missiles.

RYAN BUILDS ONE-HUNDREDTH BOEING JET TANKER AFT FUSELAGE

Huge aft fuselage sections for Boeing KC-135 jet tankers are now rolling off the Ryan production line at the rate of 15 a month.

Production of the giant airframe structures is well past the 100 mark, and ahead of schedule.

Ryan and Boeing have been in production partnership for more than 10 years. Ryan also built 888 fuselage sections and refueling pods, external wing fuel tanks and other components for the KC-135's predecessor, the piston-engined KC-97. The KC-97 production line met "on schedule" deliveries for seven years.



PACKAGED POWER FOR DOUGLAS DC-8s

Complete jet engine pods and supporting wing pylons for the new Douglas DC-8 Jetliners are now entering full production at Ryan. Ryan has been a major producer of equipment for military and commercial power plants since 1938.

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"Such vertical take-off jets can give us a tactical advantage never before realized," says a top expert on air power, "...as revolutionary a change in tactics and strategy as the jet engine itself."

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► Eight additional Douglas jet transports will be assigned to join in first flight test phase of development.

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COVER: McDonnell F4H-1 Navy fighter is carrying four Sparrow III air-to-air missiles—two under the wings and two under the forward fuselage. F4H, powered by two General Electric J79 engines rated at 10,000 lb. thrust each, is said to have the greatest range of any Navy jet fighter. See page 43 for story and other photos on the F4H.

PICTURE CREDITS

18, 19—Pratt & Whitney; 22, 24—Howard Levy; 25—Gloster Aircraft Co.; 28, 29—Douglas; 31—Royce Craig; 37, 41—U. S. Army; 38—USAF; 39—National Physical Laboratory; 40—Kaiser Industries; 43—McDonnell; 44—General Electric; 58, 59—Amphibious Aircraft; 60—Tusco; 65—Bethlehem Steel; 67—De Havilland; 68—Lockheed; 69—Convair.

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EDITORIAL

European Research Program

Some five years ago, the Air Research and Development Command established a European office in Brussels to organize a program enlisting the best technical brains of Europe in its basic research program. At this late date, it should not be necessary to emphasize the major scientific contributions made by European researchers, not only in basic work but also in many specific U.S. development programs such as atomic weapons, supersonic flight and avionics. Suffice to say, it has been substantial and ARDC was on sound ground in assuming the U.S. had no monopoly on technical brains. Nor can our own technology achieve maximum progress without actively enlisting the support of the best research ability wherever it can be found.

Recently, we spent a pleasant afternoon at ARDC's Brussels office with Col. Lee Gossick, now head of the European office, and his director of technical operations, Lt. Col. Raymond Nelson, to take a fresh reading on how this vital program is progressing. We were happy to find that one of the many beneficial effects the Soviet Sputniks had on U.S. support of research and development has been a marked acceleration of this effort to utilize European research specialists to cover gaps in resources and capabilities of USAF's basic research.

Operated by ARDC's Office of Scientific Research from a bare beginning of 15 contracts valued at $250,000 signed in Fiscal 1953, the operation had grown to a volume of 203 contracts valued at $3 million last year, with the program more than doubling since the first Sputnik began orbiting. It now arranges for the work of about 1,500 European researchers in 16 countries at a total cost in ARDC overhead of about $400,000. This low overhead cost is an outstanding feature of the ARDC European office which does the job with a total of only 44 people, of which half are simply clerical.

The European office had tough sledding in its early days. In the Wilson-Newbury era, basic research was a dirty word in the Pentagon. ARDC's entire effort in this field, both domestic and foreign, staggered along on a starvation diet from which the effects will be felt for a long time. European scientists, most of whom are in universities rather than the industrial complex, didn't relish the idea of working with the U.S. military for a variety of reasons, including the then-rampant McCarthyism. Gen. Thomas Power, then ARDC commander, gave the European effort a big boost as part of his campaign to reorient ARDC toward a big "R" for research and a smaller "d" for development but even as late as October, 1957, USAF's research programs were getting the sharp bite budget act.

Beeps of the Soviet Sputniks have had a major effect in stimulating relaxed purse strings for basic research programs, and fortunately the European program has not been neglected in this effort. Since last fall, when it had a backlog of 125 ARDC-approved proposals from European scientists sitting on the shelf for lack of funds, the European office has shifted into high gear. It now has a total of 242 active contracts totaling $5 million in value with 40 approved proposals totaling $637,000 in the procurement mill and with 82 more proposals planned for a $3 million expenditure under active study by the European office and ARDC's centers in the U.S.

Roughly, here's how the European office operates. It invites research project proposals from European scientists. Its 18 officers have ranged all over Europe, from Scandinavia to Turkey and Israel, dealing with specialists in particular fields that fit into gaps left by the domestic OSR program or in fields where the U.S. has limited capability. These proposals are sent to the appropriate U.S. ARDC center, mostly to OSR and Wright Air Development Center, for study in view of the over-all ARDC program plus a check on methods to be used if the proposal fits ARDC's program. Approval goes to the European office, which then writes a contract with the researcher and receives the finished product. Finished product is simply paper—technical reports, with the single exception of prototype development of carcinotron tubes in France. These programs do not call for any hardware development. The program operates in general fields interesting to USAF, including biosciences, chemistry, combustion, electronics, geophysics, mathematics, materials, mechanics, metallurgy, physics, propulsion and solid state sciences.

Here are some titles of finished reports selected at random: Meteor Trail Measurements by Radio Detection Means by Dr. Lovell, University of Manchester, England; Research Conditions Surrounding a Body Moving at High Speeds in Ionosphere by Dr. Devinenne, Mediterranean Research Laboratory in Thermodynamics, Nice, France; Research on Ring Airfoils by Dr. Weissinger, Karlsruhe Technical Institute, Germany; Research on Closed Cycle Gas Turbine by Dr. Keller and Professor Ackeret of Escher–Wyss Ltd., Zurich.

All technical reports are unclassified and available through the Armed Services Technical Information Agency in Washington. Authors are free to publish these reports in technical journals of their own choosing and many do. Researchers retain any proprietary rights to their work except where the U.S. government is concerned. However, many applications of this research disappear behind the security curtain when involved in specific hardware development programs.

It is always hard to pinpoint the value of any specific piece of basic research—a fact Congress has yet to learn. However, research in electromagnetic propagation done in Europe has supplemented limited U.S. capability in this field for the USAF Cambridge Research Center. Centripetal pump developed by Dr. Markus Reiner, of the Israel Institute of Technology, Haifa, as a research tool for his air viscosity studies for ARDC, is an exciting indication of a basic new approach to boundary layer control or a possible revision of the basic theories of aerodynamics.

Because of the European academic salary standards plus the fact that the European office adheres to them, the research dollar goes about four times farther than for similar work in the U.S. However, in addition to economy of operation plus technical results achieved, ARDC's basic research program in Europe has done a tremendous job in the establishment of ties of mutual respect between the European scientific community and the U.S.

—Robert Hotz

WHO'S WHERE

In the Front Office

Ronald Duckworth succeeds **Byron F. Sherrill** as assistant to the board chairman, Trans World Airlines, Inc. Mr. Sherrill is now general manager of La Nica, the Nicaraguan Airline.

Philip S. Fogg resumes the presidency and continues as board chairman, Consolidated Electrodynamics Corp., Pasadena, Calif. **Hugh F. Colvin** now senior vice president in charge of Pasadena divisions. Also: **Kennett W. Patrick**, vice president in charge of Monrovia divisions, and **Frank M. Jenner**, vice president-Rochester Div.

John W. Carrow, III, a vice president, Haveg Industries, Inc., Wilmington, Del.

Honors and Elections

Dr. Joseph C. Patrick, one of the founders of Thiokol Chemical Corp. and now a consultant to the company, will receive the 1958 Charles Goodyear Medal, the highest honor in rubber chemistry, at the national meeting of the American Chemical Society in September.

Capt. David R. Hull (USN, ret.), a vice president of Raytheon Manufacturing Co., has been elected president of the Electronic Industries Assn., Washington, D. C. Mr. Hull succeeds **Dr. W. R. G. Baker**, former vice president of General Electric.

Changes

Alfred B. Bowman, manager of flight-Eastern region, American Airlines, Inc.

W. S. Bobier, chief engineer, Detroit activity-Aero Hydraulics Division, Vickers, Inc., Detroit, Mich.

Wilson M. Alford, chief inspector, Hamilton Standard, division of United Aircraft Corp., Windsor Locks, Conn. Mr. Alford succeeds **Wilfred H. Shaw**, now assistant West Coast representative (Los Angeles) for Hamilton Standard aeronautical equipment, United Aircraft Service Corp.

Eugene J. Vigneron, manager-Needham, Mass., operations, Sylvania Electronic Systems, Sylvania Electric Products, Inc., Waltham, Mass.

Roger A. Merritt, manager, Cox Instruments Division, George L. Nankervis Co., Detroit, Mich.

L. R. Swift, special assistant to the manager-production and procurement, Aeronautical Division, Minneapolis-Honeywell Regulator Co., Minneapolis, Minn. **Ed Lund** succeeds Mr. Swift as director of production.

Dr. Joseph M. Denney has joined the nuclear electronics department of Hughes Aircraft Co., Culver City, Calif.

L. C. Wolcott, director of sales and engineering, Packard Electric Division, General Motors Corp., Warren, Ohio.

Jerome I. Davis, general manager, Aircraft Equipment Division, Consolidated Diesel Electric Corp., Stamford, Conn.

Edward J. Forisch, engineering assistant to the president, Aerol Associates, division of Cleveland Pneumatic Industries, Inc., Cleveland, Ohio.

Robert P. Thompson, assistant chief engineer, Airaterra, Glendale, Calif.

INDUSTRY OBSERVER

► Army reportedly will try to launch earth satellites without rocket boosters, using underground explosion forces, possibly from a nuclear bomb, to drive protectively encased satellite up a shaft in the earth which serves as a guidance "gun barrel." Program may be related to similar Advanced Research Projects Agency project designated "bomb-powered rocket." Army is asking that future satellite avionic equipment withstand 15,000Gs for 8 milliseconds, the same as its shock requirements for electronic prosimity fuzes used in field projectiles.

► **Life science studies are being pushed in Air Research and Development Command's bio-satellite project, designated Man-in-Space-Soonest, even though the program has not yet been funded, indicating ARDC's intention to meet projected schedules.**

► Russian hypersonic glider project similar to USAF's Dyna-Soar program already has entered the development stage. Effort is based upon the early work of German expert Eugen Saenger which has been expanded by Soviet scientists.

► **Raytheon's Sparrow III radar-homing guided missile developed for Navy's Bureau of Aeronautics has a pointed ceramic radome measuring about 22 in. in length and about 8 in. in diameter at the base. Companies supplying ceramics for various missile nose cone applications include Gladding, McBean & Co. and Corning Glass Works.**

► Air Force has requested $11 million for initiation of research and development on a dispersed site fighter for theater tactical operations in the Fiscal 1959 budget. It previously had $2.2 million for this fighter in the Fiscal 1958 budget.

► **Initial development on a single pump and a single gas generator for the Atlas ICBM engines has been completed. Atlas now uses a booster with two cylinders and one sustainer engine, and each has its own propellant pump and own generator.**

► U. S. officials were aware in February that the Soviets intended to place a satellite weighing more than 2,500 lb. (Sputnik III) into orbit in May.

► **First Jupiter intermediate range ballistic missile squadron to be used by USAF will precisely follow Army's plan, but subsequent units will have more launchers and reaction time will be reduced. Air Force did not make any changes in the first unit because it would have delayed introduction of the weapon.**

► Cost of an IRBM squadron plus a base built from scratch will cost Air Force an estimated $70 million. Once a base is established, cost of an additional squadron plus its necessary installation and equipment will be an estimated $43 million.

► **Approximately half of the first 603 B-52s ordered by Air Force have been delivered to operational units. Initial quantities of the model-improved B-52G will reach the inventory late this year.**

► Russia has built a dual-control trainer version of its two-place Ka-15 coaxial helicopter. Designation is UKa-15.

► **Ultimate flyaway cost of Convair's intercontinental ballistic missile is expected to be $1.6 million. Unit cost of the Thor IRBM in production is expected to be $735,000.**

► Navy is proposing a followup to the Vanguard satellite program incorporating Army's Jupiter topped by the upper two stages of Vanguard. Payload weight probably would include vehicles of 50 lb. to 300 lb.

► **General Electric is working with its subcontractors towards adaptation of its J85 small turbojet for flights of up to Mach 4.**

Washington Roundup

Reorganization Fight

President Eisenhower has reversed his position and decided to fight it out with the House Armed Services Committee headed by Rep. Carl Vinson (D.-Ga.) over the proposed reorganization of the Defense Department. The measure is slated for House action.

A few weeks ago, the President commended the compromise legislation unanimously approved by the House group, 32 to 0, raising only two objections to it in mild language (AW May 26, p. 25).

But as the hour for floor action approached, the President issued a strong blast against provisions of the measure at variance with his own plan which, he declared, would "continue to emphasize disunity and separatism with the Defense Department. They continue to imply Congressional approval of wasteful duplications, administrative delays and inter-service rivalries." The provisions would:

- **Require the Secretary of Defense to administer** the department through the three service secretaries. This, the President declared, "puts a premium on intransigeance by lower Pentagon levels." He said it would give "the color of legality" to "frictions, delays, duplications, . . ."
- **Require congressional review of any change** or abolition in "major" combatant functions. This, the President protested, "allows one military man to hold up defense improvements for many months and perhaps block them altogether."
- **Authorize the service secretaries** and chiefs of staff to present their individual views to Congress after first informing the Secretary of Defense. The President challenged that this "invites insubordination to the President and Secretary of Defense, endorses the idea of disunity and blocking of defense modernizations, suggests that Congress 'hopes' for disobedience and inter-service rivalries."

House Republican leader Joseph Martin (R.-Mass.) and Rep. Clarence Cannon (D.-Mo.), chairman of House Appropriations Committee, are backing the President.

Soviet 'Fishing'

Half-dozen Soviet "fishing ships" riding at anchor in international fishing waters 100 miles off Nova Scotia are suspected of reconnoitering new air defense and anti-missile radars undergoing test in vicinity of Boston, less than 500 miles away. Fact that number of ships seldom varies and that a departing ship is always replaced suggests that Soviet ships are seeking to learn characteristics of new radars for possible electronic countermeasures.

No Fixed Profits

Defense Department has assured House Appropriations Committee it will have a uniform set of cost principles to apply to military contracts by the end of the year. On profits, the Defense Department is firmly resisting some congressional pressure for a fixed profit limitation. Perkins McGuire, Assistant Secretary of Defense for Supply and Logistics, explained to the committee:

"We feel that policy guidance in the field of profit allowance must be stated in rather general terms since the factors affecting a reasonable rate of profit vary in each contract. Within the aircraft industry, for instance, there are wide variations in the factors which determine a reasonable rate of profit such as in the extent of government assistance, in the risks assumed by these contractors and in the efficiency with which contracts are performed. Accordingly, we do not feel that it would be appropriate to establish any specific profit range applicable to this or other industries. . . . The Congress has recognized in the Renegotiation Act the factors which determine a reasonable rate of profit. . . ."

Communications Compromise?

Compromise which might enable airlines to operate Doppler navigators at 8,800 mc. for the life of the equipment or some other reasonable period, providing they are willing to risk interference from military radars, may come out of an impromptu discussion by airlines, Defense Department and Federal Communications Commission representatives at last week's Armed Forces Communications and Electronics Assn. convention. Interested parties to the frequency allocation conflict, which threatens to block early airline use of Doppler radar (AW May 26, p. 33), may hold formal meeting soon to attempt to work out details.

Navarho Halted

Air Force has halted development of Navarho long-range navigation system and will use self-contained airborne Doppler and/or inertial systems for its combat aircraft. Air Force plans no further long-range ground-based navigation system developments for tactical use, Lt. Col. D. J. Freund told the Armed Forces Communications and Electronics Assn. convention. Freund, deputy chief, Nav-Aids Branch, USAF headquarters, flatly denied reports that Doppler auto-navigators might replace Tacan for short-range navigation, saying that Tacan would remain USAF's primary short-range system for at least the next decade.

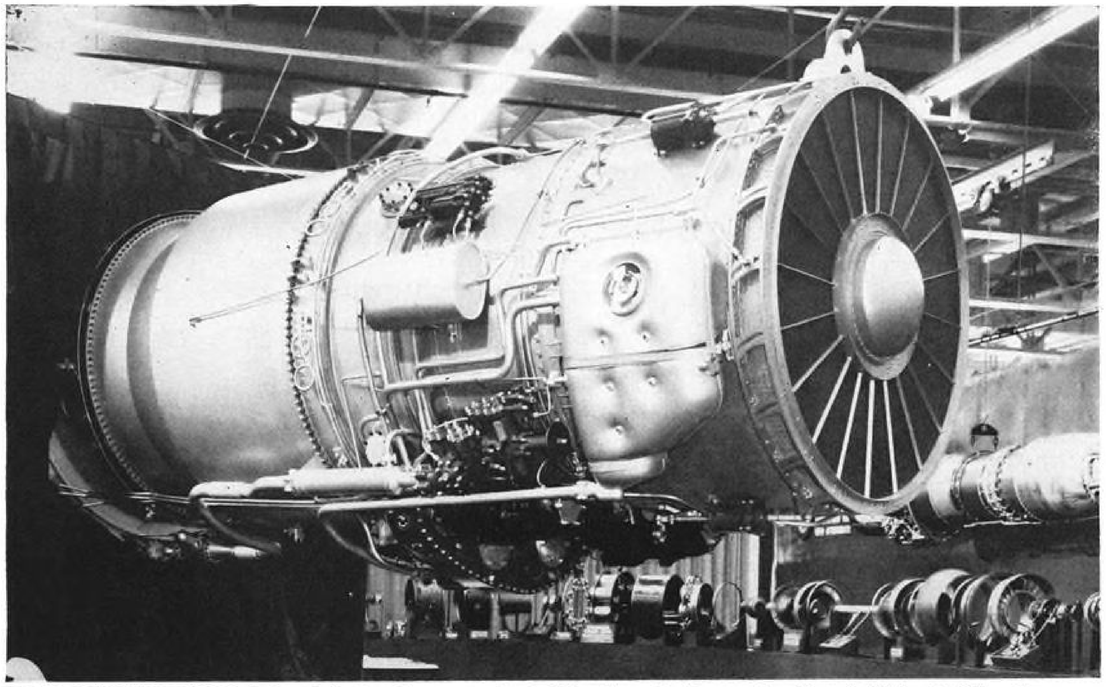
Durfee Warning

Civil Aeronautics Board Chairman James Durfee last week warned against the abandonment of existing air safety machinery in favor of "a shiny new agency that will somehow, magically, produce safety in the air." However, Durfee apparently was not voicing opposition to the proposed Federal Aviation Agency (see page 26). He was urging that air traffic progress attained thus far not be dropped because of high hopes for a complete panacea that will solve problems overnight.

Missed Opportunity

Nearly 400 members of the House missed an opportunity last week to participate in an event that may eventually change the nation's way of life. Less than 40 representatives were on hand when the House voted to create the National Aeronautics and Space Administration to lead the U.S. in the exploration of outer space. Although little fanfare was attached to the passage, Rep. Kenneth Keating (R.-N.Y.), a member of the House Space Committee, said: "Taking the long view, I am convinced that this bill may well be the most significant legislation to come out of the current Congress—or, indeed, to come from many Congresses. It has the word 'history' stamped all over it."

—Washington staff



PRATT & WHITNEY J58 Mach 3 turbojet is at least one and a half feet larger in diameter than Pratt & Whitney's J57 engine.

J58 Reflects Navy Development Changes

By J. S. Butz, Jr.

West Palm Beach, Fla.—Changing Navy philosophy of jet engine development is being reflected in Pratt & Whitney's J58 Mach 3 turbojet now running on the test stand.

New philosophy calls for a sharp increase in the number of running hours logged before an engine completes its 150 hour test and is accepted for production.

The move reflects Navy experience showing that the ultimate cost and operational success of an engine in fleet use is almost a direct function of the amount of testing performed during the development period.

In the past as few as eight experimental engines have been authorized for a complete development program, keeping test hours low and often resulting in long delays for repairs and rebuilding. Under the new policy, Pratt & Whitney will build approximately 30 test J58s in the experimental shop of its new Florida facility, which, to be completely accurate, should be termed a small factory. This shop, part of a $30 million Pratt & Whitney investment, contains $28 million worth of the largest and most modern machine tools supplied by the Navy.

Florida Test Facilities

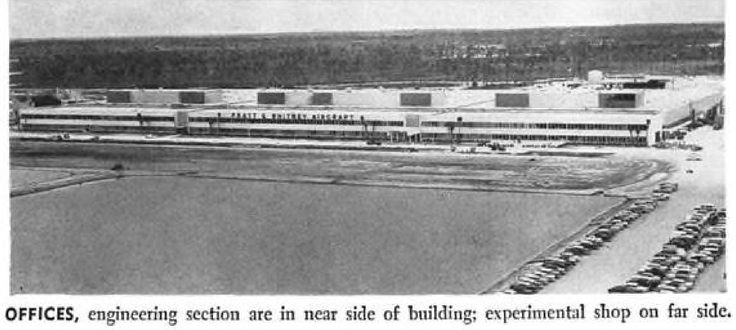
Testing facilities at the Florida site now consist of four open air jet engine test cells located a few miles from the engineering offices and shop so that they do not require soundproofing. Instrumentation of these cells and other test areas has been started with a $10 million authorization from the Air Force.

Altitude testing of the J58 will be conducted at Pratt & Whitney's Willgoos Laboratory at East Hartford, Conn., and in government facilities.

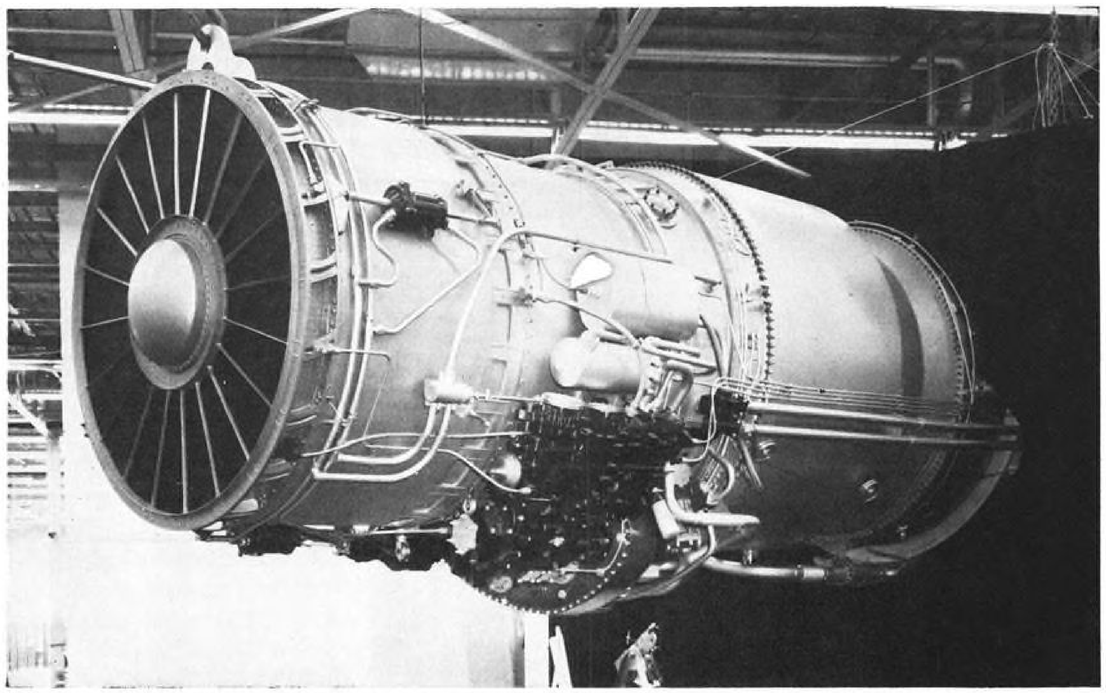
The J58 gives the U.S. a backup program and two turbojets in the Mach 3 class. The other engine is General Electric's J93 which already has been designated as the powerplant for two Mach 3-plus North American aircraft for the Air Force—the six-engine B-70 bomber and the twin-engine F-108 long-range interceptor.

Navy has not yet contracted for a Mach 3 airframe to be mated with the J58. Recent statements by Navy officials indicate that they believe that the engine development time will be much longer than that for the airframe. Therefore, an appropriate airframe and its exact mission would be determined after the powerplant's capabilities become much more definite.

Apparent reason for this approach is the serious difficulty the naval aircraft program suffered several years ago when the J40 engine failed to meet its original specifications. A major portion of the Navy's new aircraft designs



OFFICES, engineering section are in near side of building; experimental shop on far side.



CURTAIN at the rear of the J58 (right) conceals the afterburner. Pratt & Whitney will build 30 test J58s in Florida.

at the time had been predicated on these specifications.

Boron fuels are being used experimentally with both the J58 and J93. Proper use of the chemical fuel and its ultimate availability and attractiveness as to cost are apparently still somewhat uncertain.

To achieve the most efficient airframe design for a given mission, however, the decision to burn either chemical or petroleum fuel or some definite combination of the two must be made at the very beginning of the design.

The Pratt & Whitney facility in Florida is located on a 10 mile square tract which is over 10 miles from any populated area and about 18 miles from Palm Beach. Selection of this site on the edge of the Everglades for new engine development work was based on many factors but the primary considerations included obtaining maximum isolation with close proximity to a desirable living area to attract personnel.

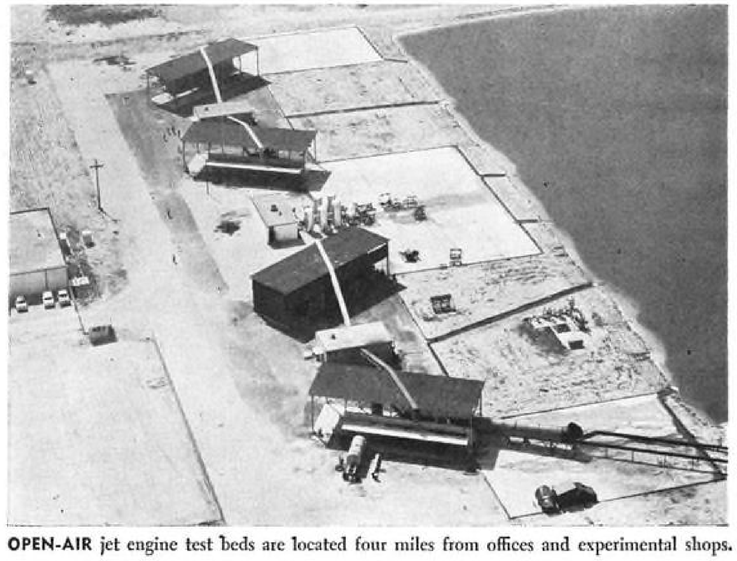
Isolation Required

Isolation was required to maintain good community relations while developing very large and very noisy rocket engines and other high speed powerplants that Pratt & Whitney has long been rumored to be working on. Confirmation of a portion of this program came at the dedication of the facility when Lt. Gen. Clarence S. Irvine, USAF, deputy chief of staff of materiel, indicated that Pratt & Whitney's activity included work with hydrogen fuel (AW June 2, p. 25).

Initial investment of $30 million in company money in the Florida plant follows a well-established United Aircraft policy of acquiring its own experimental facilities to speed development work without having to rely on outside laboratories. During the past 10 years, the corporation has spent more than $200 million in construction of new facilities.

H. M. Horner, chairman of United, announced at the dedication of the Florida plant that the board of directors had voted to spend another $50 million within 15 months, the major portion at the Florida facility.

In speaking at the dedication, both Gen. Irvine and Rear Adm. R. E. Dixon, chief of Navy's Bureau of Aeronautics, called for more investment of this type by industry as the best method of insuring its future.



OPEN-AIR jet engine test beds are located four miles from offices and experimental shops.

Mahon, Symington Hit New Complacency

By Katherine Johnsen

Washington—Two top Capitol Hill spokesmen on military matters attacked the backslide into complacency toward the defense program since last October's launching of Sputnik I in major speeches last week in the House and Senate:

• **Rep. George Mahon (D.-Tex.),** chairman of the House Appropriations Subcommittee on the Armed Services, said that "as a net proposition applied to defense effort, we will perhaps be spending less in Fiscal 1959 than in Fiscal 1958."

• **Sen. Stuart Symington (D.-Mo.)** charged that at the time of Sputnik I "our defense strength was greater vis-a-vis the Communists than it is today." He protested that virtually nothing has been done to implement any of the recommendations of the Senate Preparedness Subcommittee last January to strengthen the U.S. military position (AW Feb. 3, p. 33).

At the time, the recommendations were unanimously endorsed by Republican and Democratic members of the subcommittee headed by Sen. Lyndon Johnson (D.-Tex.).

Symington blamed the President and the Administration: "Through a policy of inaction, this Administration is handing military superiority over to the Communists; and the recent technological and diplomatic defeats of this policy, only serve to emphasize the growing peril."

Mahon made the blame general: "Now the hysteria is gone, the anger has cooled and the determination has been blunted. . . . Our emotions and resolves have run the whole gamut from the peak of awareness and urgency to the humdrum plane of complacency. We have slowed down our worries about survival and substituted the recession . . . as a focal point of interest. We are thinking more about how to keep up with the Joneses than how to keep up with the Russians in space technology and the cold war. We are wondering why . . . the people will not buy those big, beautiful, uncomfortable, expensive-to-operate automobiles that have been manufactured for them."

Although the $38.3 billion in new money carried in the Fiscal 1959 defense bill (AW June 2, p. 22) approved by the House last week is $4.5 billion more than provided in Fiscal 1958, Mahon pointed out that expenditures will be increased by only $1.2 billion. He explained the reasons behind the relatively-small increase this way:

• **Over $700 million will be absorbed** by recently-enacted pay raises.

• **$200 million is for increased** construction, leaving a net expenditures increase of $300 million for other defense activities.

"Experience shows that cost increases from inflation have accounted for about a 3% increase in defense spending each year," Mahon said. "This means, of course, that as a net proposition applied to defense effort, we will perhaps be spending less in Fiscal 1959 than in 1958."

Mahon said that the $38.3 billion Fiscal 1959 defense budget "does not represent a wild spending splurge for the unattainable. It is not an overly ambitious approach to our defense problems, yet it is not a timid approach."

He listed these highlights:

• **$96 million for the** North American B-70 bomber scheduled to succeed the Boeing B-52.

• **$950 million for the** intercontinental ballistic missile program—Atlas, Titan and Minuteman.

• **$758 million for the Convair B-58** bomber scheduled as the follow on to the Boeing B-47.

• **$1.3 billion for Navy's Polaris** fleet ballistic missile program. Combined with the previous program, this will provide funds for a total of nine Polaris submarines.

• **$2.7 billion for research** and development—An increase of $877 million over Fiscal 1958.

• **$152 million for reconnaissance** satellites.

• **$138 million for projects** to put man in space.

• **$72 million for lunar probes.**

• **$40 million for the** nuclear-powered aircraft program. Mahon said, "We will probably be beaten to the draw in this field because our government has elected to undertake to build a sophisticated and militarily significant atomic airplane rather than try to rush ahead with putting an atomic airplane in the air which would be of little commercial and military importance."

Mahon defended the Appropriations Committee's action in eliminating $35 million for long-lead items for a second nuclear-powered aircraft carrier:

These are the recommendations of Senate Preparedness Subcommittee of last January with Symington's comments on the progress that has been made to achieve them:

• **Modernize and strengthen SAC.** "There has been no acceleration whatever of aircraft production programs," Symington declared. "A few more long-range jet bombers and tankers were scheduled . . . less than one additional SAC wing—and that wing is not planned to be operational for three years."

• **Accelerate the dispersal** of SAC bases. "Solely in order to save money, SAC aircraft, defense missile facilities and other important military equipment are in some cases now actually being concentrated into more confined areas."

• **Increased effort in development of** an anti-missile missile system. "The organization to handle this problem is now worked out and current division of functions between the services can only cause increased waste and delay.

"Warning and communications rest largely in the Air Force, but the launching function remains in the Army. Both services receive constantly fluctuating financial assistance in their effort to carry out this vital mission—and that would appear to be one of the chief reasons why the entire program is characterized by disorganization and little sense of urgency."

• **Improve early warning system.** Construction of the distant early warning line against manned bombers "is proceeding slowly," Symington told the Senate, "due largely to arbitrarily established expenditure ceilings. . . .

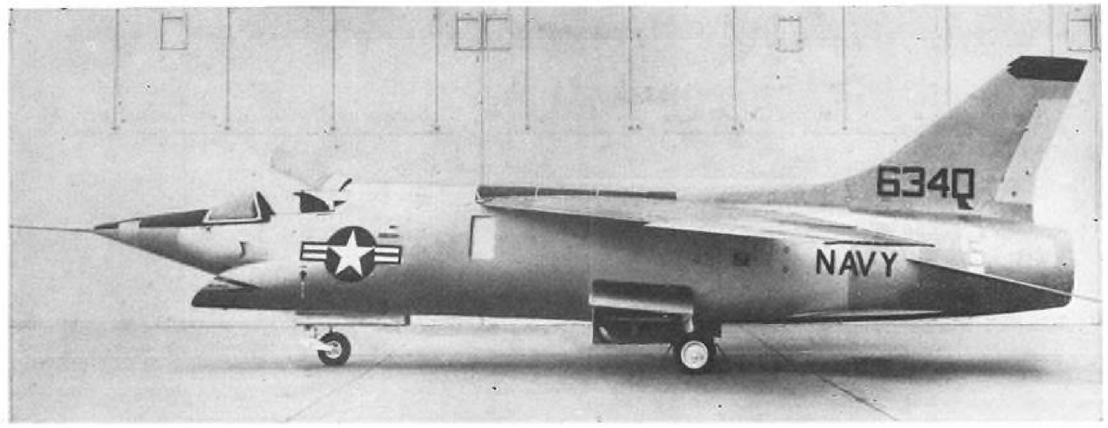
• **Provide adequate airlift** for ground troops. In a limited war, Symington said, "apparently we must hope for some miracle to be able to transport troops where needed."

• **Accelerate the production** schedules of Atlas, Thor, Jupiter and accelerate development of Titan. "There has been no acceleration of the Atlas, Thor or Jupiter programs," Symington protested. "Lack of a sense of urgency continues to dominate the long-range missile program."

• **Reduce lead-time in** weapons development by reducing the decision time and simplifying procurement procedures. This, Symington complained, is still "under study" by the Department of Defense.

• **Accelerate research and development** programs by long-term funding and improved administration. Although centralized control through the Advanced Projects Research Agency "should give better direction," Symington said, "the continuation of expenditure ceilings, plus the small appropriation requests for research and development do not leave any impression that this vitally important part of our national defense program is actually being accelerated."

• **Increased effort in development of** manned missiles. "There has been progress with the many-thousand-miles-an-hour X-15, and progress also in medical research for space flight," Symington said, "but over-all action is also handicapped by insufficient funds."



CHANCE VOUGHT F8U-3, Mach 2, all-weather interceptor is shown without its rocket engine. Primary powerplant is the Pratt & Whitney J75 turbojet of about 17,500 lb. thrust. Chin engine air inlet is modified Ferri supersonic type. Two ventral fins are folded to clear the ground. Retouched area under wing root probably is location of the missile armament.

F8U-3 Mach 2 Fighter Makes First Flight

Edwards AFB, Calif.—Chance Vought Aircraft's F8U-3 Crusader III, entrant in Navy's Mach 2, all-weather fighter competition with McDonnell's F4H made its first flight last week. (See p. 43 for F4H details.)

Crusader III is slightly larger than its predecessors, the F8U-1 and -2, but the wing and fuselage were generally scaled up and the planform and layout are nearly unchanged on the new aircraft. Major alterations required in increasing the Crusader's speed nearly one full Mach number were the incorporation of a modified Ferri type supersonic inlet with a swept forward lip, the addition of two large ventral fins, use of a sharper fuselage nose and a more submerged canopy.

F8U-3 is powered by a Pratt & Whitney J75 engine developing about 17,500 lb. thrust without afterburner and around 26,000 lb. with afterburner. Aircraft also is designed around use of a small rocket engine of several thousand pounds thrust.

This rocket engine seems to be the key to the Navy's eventual choice between the F4H and the F8U-3 for volume production and operational fleet use. The fact that both aircraft are still in the competition would seem to indicate that the primary difference between them is the powerplant arrangement, that neither fighter has had more than its share of stability or drag troubles and that they both have about the same percentage of total weight devoted to structure.

Rocket power would give the Crusader III a much greater ceiling than the F4H, and, to be of value, this altitude would have to be maintained for several minutes, probably at least five as usually specified for modern combat. The penalty for this altitude capability is the great amount of fuel consumed during combat by the rocket engine in comparison with the F4H's turbojets with afterburner.

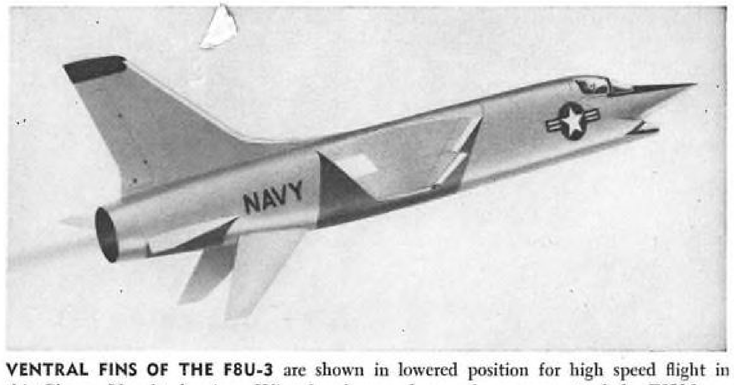
Advantages of the rocket installation would be greater rate of climb and a more rapid acceleration from cruise to combat speed. According to the Navy announcements concerning the first flights of the F4H and the F8U-3, they both are capable of more than Mach 2, and it is possible that at relatively low altitudes both aircraft are limited by skin temperatures.

Two ventral fins on the F8U-3 and the unusual anhedral arrangement of the F4H wing tips would seem to indicate that stability problems above Mach 2 are severe.

Crusader employs the two-position wing of the earlier F8U aircraft plus a boundary layer control system that blows air over the flaps for better lifting and control qualities during landing. Ventral fins are raised at the same time the flaps are lowered so that the tail will clear the ground during landing. Double screw jacks are used to raise the wing.

A primary feature of the F8U-3, although it was not used during the first flight, is the automatic nature of a large portion of its flight controls. These are simple push buttons which actuate equipment necessary to hold a Mach number for best climb, best range or greatest endurance and other types of flight which vary with weight, outside temperature and other variables. This system is presumably part of the Navy's new integrated flight instrument display and control ideas.

Armament of the F8U-3 will be all-missile, either Sparrow III or the Sidewinder or a combination of the two. It can be adapted to carry nuclear and other special weapons, electronic intelligence and countermeasures gear and photo reconnaissance equipment.



VENTRAL FINS OF THE F8U-3 are shown in lowered position for high speed flight in this Chance Vought drawing. Wingplan form and general arrangement of the F8U-3 are similar to earlier Crusaders, but the new aircraft is larger and heavier.

New Micro-Module Program Outlined by Army and RCA

By Philip J. Klass

Washington—Army's new Micro-Module program, which could have major impact on both electronic component and equipment manufacturers, was officially unveiled here last week before some 600 industry representatives by the Signal Corps and Radio Corp. of America. RCA is serving as the project's "leader contractor."

Air Force and Navy are now considering an Army request that they participate and support the new Micro-Module program. Army officials predict that joint service support will be forthcoming.

Size Reduction

New Micro-Module construction technique for fabricating individual components and joining them into functional circuits holds promise of 10-fold reduction in size, weight of military electronic equipment. (AW June 2, p. 65). Army and RCA officials also predict a comparable gain in reliability and maintainability. Defective Micro-Modules will be discarded in the field, with no attempt at repair.

Micro-Module consists of a suitably interconnected stack of 0.3 in. sq. ceramic wafers called "elements" on which one or more components have been fabricated. Individual ceramic wafers, as well as the complete module, bears some resemblance to earlier Navy Project Tinkertoy units but are considerably smaller in area.

Micro-Module design is based upon using transistors and other semiconductor active elements, rather than tubes, throughout. This will limit Micro-Modules, at least initially, to low-power level applications such as communications, computers, instrumentation and control.

Greatest impact at first will be felt by electronic component manufacturers who are being asked to abandon long-used form factors to design components to fit standard 0.3 in. sq. dimension of Micro-Module elements.

For many passive components such as resistors, certain sizes of capacitors and transistors there appear to be no major obstacles. Other types of components—inductors, potentiometers, relays, etc.—will be more difficult. RCA plans to eliminate relays wherever possible, use transistors instead for switching purposes.

Although existing component techniques will be used initially to speed the program, an RCA official acknowledged that the ultimate goal is to use radically different types of semiconductor devices which can perform complete circuit functions (AW June 2, p. 64).

RCA will subcontract most of the component development work to established firms with required competence. Companies wishing to be considered were advised to write to G. W. Fry, manager, Purchased Equipment, RCA Defense Electronic Products, Camden, N. J.

Program also will require the development of a new line of batteries that are dimensionally compatible with new Micro-Modules. Batteries are to have nominal voltage of 15 v., with taps for 1½, 3, 6, 9, and 12 v.

Initial design goal is for components capable of operating in ambient temperatures ranging between −55C and 85C, with subsequent plans to raise upper limit to 125C, eventually to 200C.

RCA Plans

During the next two years, RCA expects to develop a limited family of Micro-Module component elements to enable the company to fabricate experimental units capable of performing RF, IF and audio amplifier functions plus certain basic computer circuits. By 1962, RCA expects to deliver complete prototype equipments constructed almost entirely from the new Micro-Modules.

Other equipment manufacturers will be able to buy components in new form factors from suppliers, much as they now purchase conventional components, and combine them into their own circuit configuration, according to present plans.

An official of Sprague Electric, major component manufacturer, said that his company can now produce some of the component elements required for Micro-Modules as a result of previous company research along similar lines.

While expressing confidence that the required components could be developed by industry, he cautioned that component manufacturers are "being asked to invent all components over again in only four years and come up with far smaller, far more reliable devices than they have been able to develop during the past 30 years."

Inadequate Funds

The Sprague official warned that the $5 million which Army has set aside for the Micro-Module program "is far too little for a program of this magnitude." He also cautioned that experience indicates that reduction in component size usually increases its cost and expressed doubts about the manufacturing economies claimed.

Relatively few comments from other industry representatives present suggested a "wait and see" attitude. One industry observer privately speculated that the Micro-Module program might be a far bigger undertaking than now envisioned by the Army and RCA and that, unless the program quickly receives all-out joint service support and 10 to 20 times more funding to greatly accelerate the effort, it may not arrive in time to achieve widespread use.

How F-102 Mounts Falcon

Mounting of two different types of Hughes Falcon missiles is shown on a Convair F-102A. GAR-1 radar guided model is mounted at the forward stations and the infrared-guided GAR-2 is mounted aft. F-102A is shown carrying six Falcons. Apertures in doors show some of the tubes for mounting twenty-four 2.75 in. air-to-air rockets.

German Air Industry Promised $250 Million Licensed Production

Bonn—Defense Minister Franz Josef Strauss has promised the German aircraft industry military contracts for at least $250 million and probably double that sum between now and 1964.

He said that a minimum of 100 light strike fighters and a minimum of 200 interceptors would be built under license in West Germany. He estimated the cost of each light strike fighter at about $600,000 and the cost of each high-performance supersonic interceptor at $833,000 to $957,000. Neither price includes the cost of spares.

Strauss declared that the cost of guided missiles between now and 1964 would "at least equal" the quarter of a billion dollars, cost of the two categories of planes, but that discussions with industry would be necessary to determine when, how and to what extent German companies would participate in missile construction.

The light strike order is expected to go to a northern consortium consisting of Weser Flug A.G., Hamburger Flugzeugbau and Siebel ATG. The interceptor order to the southern group of Flugzeug Union Sued consisting of Messerschmitt, Heinkel, Boelkow and Junkers. Boelkow is the only company presently engaged in guided weapons activity. Strauss said the airframes would definitely be built in Germany and if possible the powerplants as well.

Speaking at a convention of the German Aircraft Industry Assn., and later to reporters, Strauss said 50 complete Fiat G.91s would be purchased from Italy as the basic lightstrike aircraft (AW June 2, p. 57). He indicated that the model to be built under license would be an advanced version of the G.91.

He said that a formal decision on the interceptor would be announced within the next four weeks. Re-testing of the Mirage 3-A has now been completed and the choice lies between the French plane and Lockheed's F-104 Starfighter. Strauss said only 50 to 100 complete planes would be purchased. The expected number is about 75. Since the decision, once taken within the defense ministry, will be referred to the defense committee of the Bundestag (lower house of Parliament), the choice will have to be made within Strauss' new deadline if it is to reach the deputies before they adjourn for the summer.

In his address, Strauss explained that the light strike fighter would fill a double role of troop ground support and army reconnaissance. He said that the interceptor would also be configured for two additional roles as a fighter bomber and air force photo-reconnaissance. He said that with the soaring cost of aircraft, it was necessary to reduce the five missions to two basic types, each of which would have the same fuselage and powerplant in its various configuration.

Strauss added that in his contract estimates to industry he did not include orders for transports and helicopters. The lightstrike fighter is due for incorporation in the Luftwaffe in 1960, the interceptor in 1960-61.

With regard to missiles, Strauss outlined five families for West German armed forces by 1964:

- **Anti-tank.**
- **One or two types** for close support bombardment with the range of the Honest John.
- **Ground-to-air** incorporating elements of the Nike, Hawk and Bloodhound.
- **Tactical bombardment** with a 600-mi. range or slightly better.
- **Air-to-air.**

Strauss said that at least three of these would be produced in conjunction with other members of the Western European union which includes France, Italy, Great Britain and the Benelux countries. He said the cost of research, development and production is so high that West Germany could not do the job alone or even in cooperation with just the United States. Discussions on this subject have already been initiated within the French-Italian-German arms pool which was formed at the beginning of this year.

Strauss said that for the period 1961-63, two thirds to three quarters of Germany's air force would consist of manned planes.

X-15 Instruments

Washington—Novel inertial flight instruments developed by Sperry Gyroscope Co. will be used by pilot of Air Force's X-15 hypersonic research vehicle for navigation and determination of safe trajectory for re-entering denser atmosphere from altitudes beyond 100 miles.

North American-designed X-15 will carry Sperry-developed flight instruments which display vehicle attitude, velocity, vertical rate and altitude, all obtained from inertial sensors. Conventional pressure operated altimeter and airspeed indicator are not usable at such altitudes because of near-vacuum conditions. System also gives pilot continuous indication of his position and deviation from prescribed course.

Heart of the new system is a small three-gyro stabilized platform, three force-feedback type integrating accelerometers and a small computer. System has been designed to withstand accelerations above 10-Gs. Sperry system is being turned over this summer to National Advisory Committee for Aeronautics for preliminary flight tests in an F-101 flying test bed.

SR.53 Crashes

Saunders Roe SR.53 rocket-turbojet powered fighter exploded on takeoff and crashed last week at Boscombe Down, England. Sqd. Ldr. John Booth, Saunders Roe chief test pilot, was killed. The aircraft was powered by a de Havilland Spectre rocket engine using kerosene and high test peroxide as propellant and an Armstrong Siddeley Viper turbojet.

Little Military Value Predicted for Space

Touting of space research as a defense project by respected technical leaders fearing lack of public support for a program based on purely scientific motives was criticized by Dr. Albert Hibbs of California Institute of Technology's Jet Propulsion Laboratory in a speech to a session of the Los Angeles Air Procurement District.

Hibbs said military applications of the space research product are uncertain and probably limited. He predicted that when this truth comes to light, public disillusionment will endanger realistic and useful research.

Hibbs said that the bill recently passed by the House creating a civilian space agency offers the competent civilian scientific direction which he feels the space program needs. However, the future of the program can still be jeopardized if the U.S. taxpayer is scared into putting more and more money in illogical and unnecessary military ventures, he added.

VTOL Rotodyne Makes Transitions

White Waltham, England—Fairey Rotodyne VTOL transport demonstrated transitions last week from helicopter and autogyro regimes without loss of altitude and little change of altitude.

Noise level was high but not objectionable in the helicopter regime, using rotor tip jets for propulsion. Noise suppressors will be fitted to the jets soon to reduce the noise further, however. In flight, the noise level of the two Napier Eland turboprop engines is less than that of a Vickers Viscount.

Civil Space Agency Bill Passes House

By Ford Eastman

Washington—Legislation to create a powerful national space agency under civilian control breezed through the House last week and went to the Senate without a dissenting vote.

The measure introduced by Rep. John W. McCormack (D.-Mass.) would establish a National Aeronautics and Space Administration with the National Advisory Committee for Aeronautics as its nucleus. It follows the basic recommendations made by the President in a message to Congress last April.

The Senate's Special Committee on Space and Astronautics, meanwhile, pushed for early action on its own version of a national space agency. The committee staff has completed a proposed draft of a bill, which reportedly follows the main principles recommended by the Administration. However, it is expected that a number of changes will be made in the language of the bill to strengthen or clarify the act as was done by the House.

House Amendments

Before passing the bill, the House adopted several amendments, all approved beforehand by the House Committee on Astronautics and Space Exploration. Most were of a technical nature to correct spelling or to make minor changes in wording. The most significant changes included:

• **Elimination of a section** that provided for a Joint Congressional Committee on Aeronautics and Outer Space.

• **Insertion of a clause** that would permit the administrator to establish the civil service entrance grade for scientific and engineering personnel without previous government service at a level up to two grades higher than that set by the Classification Act of 1949.

• **Changing the name of the act** from National Aeronautics and Outer Space Act of 1958 to "National Aeronautics and Astronautics Act of 1958."

Albert Resolution

McCormack, chairman of the House Space Committee, offered the motion to strike out the section establishing the joint committee after unanimous agreement by the space committee members.

The action took place after Rep. Carl Albert (D.-Okla.) introduced a resolution calling for a 25-man Committee on Science and Astronautics to be composed of members of all other House Committees interested in space projects.

McCormack said the Albert resolution would create a committee with a broader base than that of the joint committee and that it would be unnecessary to continue the provision for a joint group in the bill. He added that he hoped action on the Albert resolution would be taken before the end of the session, but that, in the meantime, the select committee would still be in existence.

An amendment to create higher, more equitable salaries for starting scientists and engineers was offered by Rep. B. F. Sisk (D.-Calif.), a member of the House Space Committee.

He said the present bill authorizes the administrator of the space agency to pay slightly higher compensation to a limited number of personnel than is now permitted by the Classification Act but that there is no comparable provision for the starting salaries of recent scientific and engineering graduates.

Sisk explained that the amendment would authorize the administrator, if necessary, to hire personnel of this type at a GS-7 rating rather than the usual GS-5. He said a GS-7 would be able to start at a salary of $4,980 while a GS-5 would receive $4,040.

Major Provisions

In addition to the amendments made on the floor, major provisions of the bill as passed by the House, include the following:

• **Activities of mankind in outer space** shall be devoted to peaceful purposes and the general welfare with adequate safeguards for the common defense and security of the U. S.

• **That such activities shall be directed** by a civilian agency which also shall act in cooperation with the Defense Department "insofar as such activities are peculiar to or primarily associated with weapons systems, military operations or the defense of the U. S."

• **That the agency shall act in cooperation** with the Atomic Energy Commission and other agencies "insofar as such space activities are associated with matters within their jurisdiction."

• **That management of NASA** be vested in an administrator and deputy administrator appointed by the President and confirmed by the Senate.

• **That a 17-man advisory committee** be created, of which nine members be designated from appropriate government departments or agencies, including at least three from the Defense Department, while the rest would be chosen from the fields of science, engineering, technology, education, administration, or public affairs.

• **Creation of a Military Liaison** Committee and an Atomic Energy Liaison Committee.

• **Creation of a Division of Military** Application and a Division on Nuclear Application in addition to others that may be determined necessary.

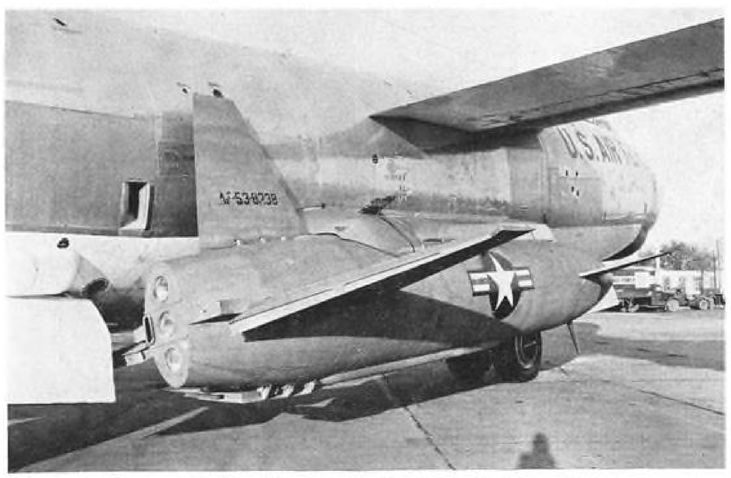
• **That information obtained or developed** by the administrator shall be made available for public inspection, except classified information necessary to protect national security or that authorized or required by law.

• **That all functions, real and personal property,** personnel, funds and records of NACA be transferred to the space agency.

• **That funds appropriated for** administration and operation of the agency must be expended on a one-year basis, while funds appropriated for construction of facilities, or for research and development activities shall remain available until expended.

The entire cost of an effective space program was estimated by the administration as running from $100 million to $200 million a year. The House Space Committee, however, estimated it would take about $500 million annually for the first several years and perhaps a billion dollars a year thereafter.

In urging passage of the bill, McCormack said every effort has been made in the legislation to define the functions and powers of the new agency in order to prevent possible conflict and wasteful duplication and at the same time make sure that the program will be coordinated and comprehensive.



External Rack on DB-47 Holds Rascal

Rack mounted on starboard side of Boeing DB-47 medium bomber fuselage holds Bell Rascal air-to-surface radar-command missile. B-47s modified to carry the GAM-63 Rascal are redesignated DB-47s. Missile is being delivered to SAC (AW April 14, p. 67).

Mk.8 Javelin Equipped with Afterburners

Gloster Mk.8 Javelin, British all-weather fighter, will enter Royal Air Force service later this year, replacing previous types. Aft configuration of the Mk.8 is changed by protruding afterburner nozzles on its two Armstrong-Siddeley Sapphire engines. Like the Mk.7, the Mk.8 is equipped to carry de Havilland Firestreak infrared-homing air-to-air missiles (AW March 31, p. 77). Aircraft is taking off from factory field at Brockworth. Note bortex generators just ahead of ailerons.

USAF Pressure Suit Tried in Space Cabin

San Antonio—An airman who spent two days living in a pressure suit in the Air Force School of Aviation Medicine's space cabin simulator found the experience extremely uncomfortable.

Staff Sergeant Marion L. Aydt lived and worked for two days in the same cabin in which Airman First Class Donald G. Farrell spent a week. But where Farrell had the pleasantest environment that could be provided, Aydt was clad in the pressure suit and fed a meager diet.

Significance of this latest experiment lies in the fact that man will have to depend heavily on his pressure suit when he ventures into space and thus it is important to find out how well he can tolerate it over long periods.

Aydt said that the first hours in the suit were tolerable, but "after that it was hell." He said he broke out in a sweat at the slightest effort and that the tight suit rubbed and chafed his skin. Aydt got some relief from the heat by using a blower which forced cabin air against his suit.

During the experiment, Aydt worked on a set 24 hour cycle. Schedule started with three four hour work periods with an hour of rest between them. After 14 hours of this, Aydt slept for three hours. After the sleep period there was an hour for breakfast and checking equipment, then three hours of work followed by three hours of rest, eating and checking gear. The second 24 hours followed the same pattern.

As with the Farrell experiment, Aydt was given a constant series of problems and projects to determine how well he maintained his proficiency under the stresses of the experiment.

While Farrell had a wide assortment of ordinary food available during his week in the chamber, Aydt's supply was severely limited. He had only baby food, hot tea and water.

Swiss Drop P.16

Geneva—Swiss government has canceled a development and production order for 100 FFA P.16 ground attack airplanes following an investigation of the crash of the third prototype into Lake Constance. It was the second P.16 to crash into Lake Constance (AW March 31, p. 29).

Official reason for the cancellation is that redesign of the hydraulic system would delay deliveries.

Observers believe this provided a convenient excuse for the Swiss to drop an unwanted airplane bought for political reasons. Purchase of the Grumman F11F-1F Supertiger becomes a possibility again.

Japanese Plant to Test Swiss Rocket Battery

Geneva—Contraves Oerlikon Type 58 Swiss anti-aircraft rocket battery is undergoing acceptance tests by the Japanese prior to shipment to Japan for trial operations and firings.

Japanese interest in a beam-riding missile with performance approximately in the Nike-Ajax category could result in an order for the Swiss company.

Boeing to Receive Hound Dog Mockup

Downey, Calif.—North American Aviation's Missile Development Division here will ship first model of the GAM-77 Hound Dog air-to-surface missile to Boeing Airplane Co. some time this month.

Model will accurately simulate the missile's mass, configuration, size, weight and center of gravity. It may be used for gathering aerodynamic data while mounted on a modified B-52 at Boeing's Seattle plant, or it may be sent to Wichita for use with the first B-52G, the airplane for which it was designed.

Missile will be carried on a special pylon containing monitoring and launch equipment.

Missile powerplant will be a Pratt & Whitney J52 turbojet engine. Missile speed has been described as "high supersonic," with a range of "hundreds of miles." Engine is podded and is carried suspended below the rear of the missile itself. The engine does not use the afterburner.

Hound Dog's configuration most probably is canard, with a high power-weight ratio utilized to achieve supersonic speeds in view of engine thrust.

Guidance and control equipment for Hound Dog is being developed by North American's Autonetics Division. First unit, designed to provide simulated barometric pressures for evaluating the GAM-77 flight control system, has been delivered to the Missile Development Division by Autonetics.

Federal Aviation Plan Gains Momentum

By L. L. Doty

Washington—Congressional action to create an all-powerful Federal Aviation Agency before the end of the summer was put into motion last week with strong White House support.

First positive move toward the immediate establishment of a long-awaited independent organization that can resolve the growing crisis of overcrowded airways was made when Sen. A. S. Mike Monroney (D.-Okla.) introduced a bill that would drastically revise the Civil Aeronautics Act of 1938 (AW June 2, p. 18).

The bill has drawn enthusiastic support from most segments of the aviation industry although some dissension exists on specific points of the proposed legislation. A similar bill has been introduced in the House by Rep. Oren Harris (D.-Ark.).

Final pattern of the new agency will become clearer when Senate hearings, which began last week, are concluded.

Pattern of Agency

However, most observers believe that:

• **Congress will pass the legislation** this session. Details of the proposed Monroney bill will be changed but its overall concept will remain substantially the same.

• **President Eisenhower will give** his support to the bill. However, he will ask for changes that will equip the proposed agency with more far-reaching powers than are now implicit in the bill. The President also will ask for stronger military participation in the agency's functions. He will encourage a make-up that will guarantee the agency the power to act on its own.

• **Civil Aeronautics Administration** will be the core of the new Federal Aviation Agency. The agency will absorb the Airways Modernization Board. Its structure will be patterned after existing CAA organizational plan. Air Coordinating Committee will continue to function as an advisory group, particularly on international affairs where close coordination with State Department is required.

• **James T. Pyle,** present CAA administrator, will be named administrator of the new agency.

• **Civil Aeronautics Board will retain** most of its present powers and will continue to function as in the past. Writing and amending of Civil Air Regulations, now a CAB responsibility, will be transferred to the Federal Aviation Agency. Any move to transfer CAB accident investigations to FAA is likely to be blocked.

The Federal Aviation Agency, as proposed in the Monroney bill, fits into the general concept of the single independent agency urged by Edward P. Curtis in his report last year to the President on aviation facilities planning (AW May 20, 1957, p. 26). But it falls short of the authority the Curtis group would have given the Federal Aviation Agency.

White House Program

In a recent address, Quesada stressed that his group is "trying to weld together an organization in which both authority and responsibility are pinpointed." Chief goal of the White House in lending its full support to the Monroney bill will be to eliminate any features that will delay the agency from performing its functions independently and with full authority in much the same way the Airways Modernization Board has operated since its inception (AW July 1, p. 30).

Essentially, the White House program has stressed that military representation should not be reduced to a "liaison" status but should be elevated to full joint participation with civil factions. Milton Arnold, Air Transport Assn. vice president, has urged that a military officer should be named deputy administrator under the administrator who will be a civilian.

The White House position on military participation was supported last week by ATA President Stuart G. Tipton who told the Senate Aviation Subcommittee that ". . . there must be the closest military-civil coordination as we progress toward positive control if military and civil interests are to be met."

Quesada's deadline for completion of the White House program is January, 1959 under instructions issued by Congress last year when the Airways Modernization Bill was passed. However, he has repeatedly stressed that "good legislation" which carries out the recommendations of the Curtis group should be supported.

Same Ultimate Goal

Last month, he told the Airport Operators' Council meeting in Puerto Rico (AW May 26, p. 44) that, "if good legislation can be drafted, publicly debated and passed prior to January, 1959, so much the better. It would appear that both the executive and legislative branches of the government are interested in the same ultimate goal."

Although industry groups continue to disagree on a number of minor points, indications are that a leading majority will drop their differences and support the various proposals for strengthening the bill.

Major point of contention among industry groups now lies in a provision of the new bill calling for a transfer of the issuance of safety regulations from the CAB to the new agency. Although the ATA strongly supported this phase of the bill during last week's Senate hearings, it opposed a provision for an appeal to the Board of decisions of the new agency on any regulation which would impose an economic hardship on the person appealing.

Tipton held that the latter provision again divides responsibility for safety in aviation. He charged that the arrangement "tends to perpetuate and even accentuate the present unsatisfactory situation."

Air Line Pilots Assn. urged that the right of appeal not only be retained but expanded to include "safety" as well as "economic" hardship as a basis for appeal.

Charles Parker, executive director of the National Aviation Trades Assn., urged that the administrator of the agency be required to consult appropriate aviation groups affected through advanced proposals in the form of draft releases. He added:

'Check and Balance'

"Also, while criticism has been heard of the present method of CAA formulating proposals and CAB taking final action on adoption of such proposals, the fact is that to us, it has served as a check and balance beyond any formal action provided under the act."

Generally, the Monroney bill proposes a series of amendments to the Civil Aeronautics Act of 1938 by introducing the Federal Aviation Act of 1958.

Prime purpose of the bill is to create an independent Federal Aviation Agency, create safer and more efficient use of airspace by civil and military operations and to provide for the regulation and promotion of civil aviation.

Here are the highlights of the proposed amendment:

• **Agency will be headed** by an administrator to be appointed by the President and confirmed by the Senate. He will be a civilian with past civil or military aviation experience, will be paid $20,500 annually.

• **Defense Secretary will appoint** a special military adviser to the administrator to advise on military needs relating to air traffic control, research and development, allocation of airspace and air traffic rules.

• **Administrator will develop** with Defense Department plans to transfer the agency "intact" to the Defense Department in the event of war. This provision has drawn bitter opposition from most segments of civil aviation.

• **Administrator is authorized** to place a total of 175 positions in the agency at the top civil service grades of 16, 17 and 18 in addition to the number of positions authorized by the Classification Act of 1949.

• **Unexpended balances** of appropriations made available to the CAA and AMB will be transferred to the FAA at dates specified by the President through executive order.

• **Administrator will develop** long-range plans and form policy on the use of airspace. He will "assign by rule, regulation or order the use of airspace under such terms, conditions and limitations as he may deem necessary in order to ensure the safety of aircraft in flight and the efficient utilization of such airspace."

• **Fuel research and development** powers are granted the administrator. If a question exists as to whether a matter is of primary concern to the military, the administrator is authorized "and directed" to decide whether he or the military agency shall have responsibility. Military agencies will be required to furnish the agency with any technical information concerning research and development projects that may have application to a common system.

U. S. Missile Lag Described by York

Washington—U.S. is more than a year behind the Soviet Union in the development of large rocket engines but, in the complete ICBM picture, the two nations are very nearly equal, Dr. Herbert F. York, chief scientist of the Advanced Research Projects Agency, said last week. In the overall picture, York said, the U.S. leads in guidance and some of the other systems necessary for an ICBM.

Dr. York told the first National Missile Industry Conference that the most serious consequence of the U.S. propulsion position was its limiting effect on the satellite program, and that it would be 12 to 18 months before we could place a payload in orbit equal to that of Sputnik III's 3,000 lb. payload.

Heartening aspect of the U.S. propulsion capability in Dr. York's estimation is its superior rate of progress. He believes that we were five years behind in 1952 and are rapidly closing the gap.

The National Missile Industry Conference was sponsored by the National Capital Section of the American Rocket Society and a local Washington organization, the National Rocket Club.

Activity at the conference centered principally around question-and-answer periods between panels of speakers. First panel session was intended to deal primarily with industry's problems in contracting and negotiations. The military contracts officer represented on the panel was Cmdr. E. E. Sack, head of Bureau of Aeronautics, Purchasing Branch, and the majority of questions were directed at him. Main points made by Sack concerning fundamental government policy included:

• **Too much time is now spent** on discussing the exact percentage of profit to be allowed a contractor instead of working more vigorously on lowering the total cost of a contract. He felt this would change in the future.

• **Attempts have been under way** for two years or more on revising the allowable costs on cost plus fixed fee contracts but divergent views among various industry groups and government groups had kept anything concrete from being accomplished.

RMI 'Flying Belt'

Denville, N. J.—Reaction Motors Inc. demonstrated a "flying belt" to the Army last week which it claims will enable an individual to run at superhuman speeds, jump great distances or scale large heights. Army officials reportedly like what they saw, and RMI plans to continue development of the unit which, in its present form, will not enable a person to actually fly.

The idea is to provide thrust equal to from 50% to 80% of an individual's weight, thereby subtracting this amount from his total weight and enabling him to use his muscles more efficiently. Reaction Motors says the device will be inexpensive and that delivery can begin within one year after receipt of a contract.

Iroquois Completes NACA Tunnel Tests

Toronto—Orenda Iroquois turbojet engine has completed more than 100 hr. of testing in the engine propulsion tunnel at National Advisory Committee for Aeronautics' Lewis Flight Propulsion Laboratory, Cleveland, Ohio.

During this test program, normal relights were made following induced flameouts up to 60,000 ft., the altitude capability of the tunnel. Relights were made at designed Mach numbers. Orenda Engines Ltd. says that the engine achieved probably the highest dry thrusts ever recorded by turbojets on the North American continent.

Developmental models of the Iroquois have undergone more than 5,000 hr. of bench running. Dimensions and performance specifications for the Iroquois are as follows:

Over-all length, including afterburner—approximately 19 ft. Over-all length, without alternator frame—approximately 17 ft. Intake diameter—about 42 in. Afterburner diameter—approximately 47 in. Thrust—approximately 23,000 lb. dry. Thrust to weight ratio—more than 5 to 1. Specific fuel consumption—under 1 for dry rating and under 2 with afterburner.

The Iroquois has a two-spool compressor, an annular, high-velocity vaporizing combustion system and a close-coupled afterburner.

Modifications Raise B-52G Range 25%

Ft. Worth—Modifications which reduced empty weight of the B-52G and provided the new Boeing heavy bomber with increased fuel capacity have given it a 25% increase in range over the B-52E.

Strategic Air Command has estimated that with one combat refueling, the B-52G will fly close to 14,000 statute mi. Gross weight of the bomber is more than 450,000 lb., and it is powered by Pratt & Whitney J57-P-43W engines.

First production B-52G will roll out in July. After flight test and evaluation programs are completed with the first production models, deliveries to SAC will begin early next year.

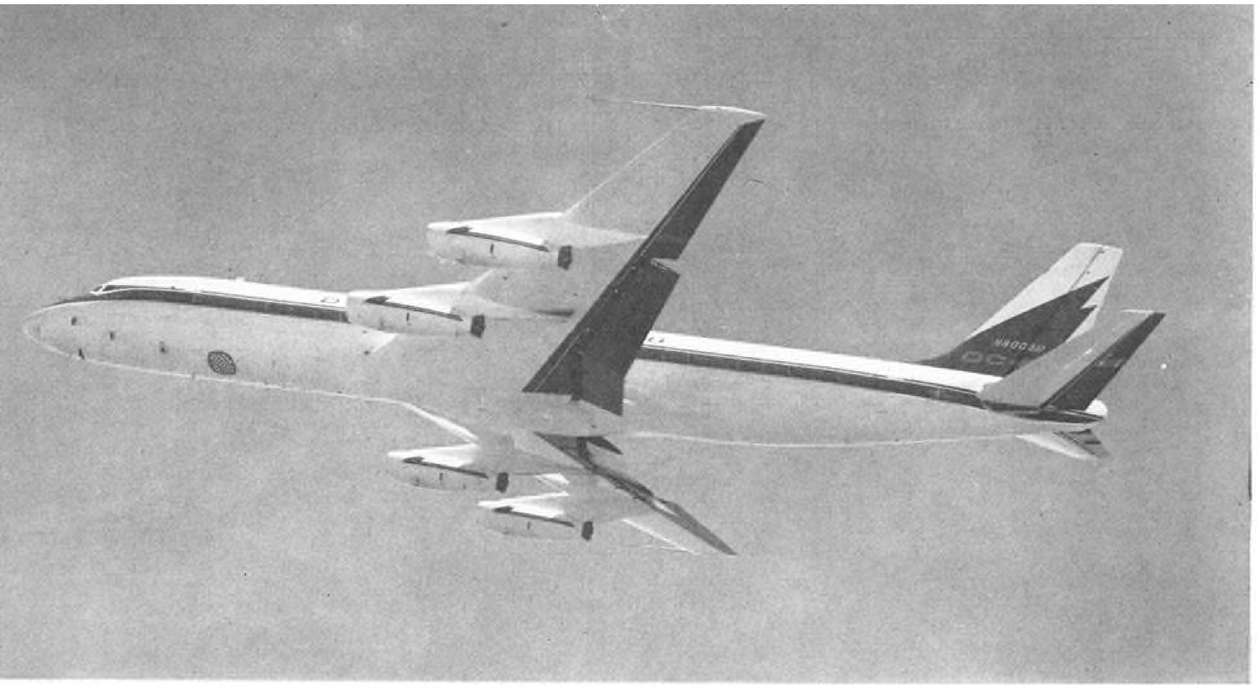
Besides its greater range, the B-52G has better climb performance and higher target altitude than the B-52E. Although it is considerably heavier, the B-52G takes off and lands in the same runway lengths as the B-52E.

Major structural changes in the bomber allow a reduction of empty weight and give the airplane a greater fuel carrying capacity. The G model has a redesigned wing which uses integral wing skin and stiffeners. Wing is used as a fuel area without fuel bags.

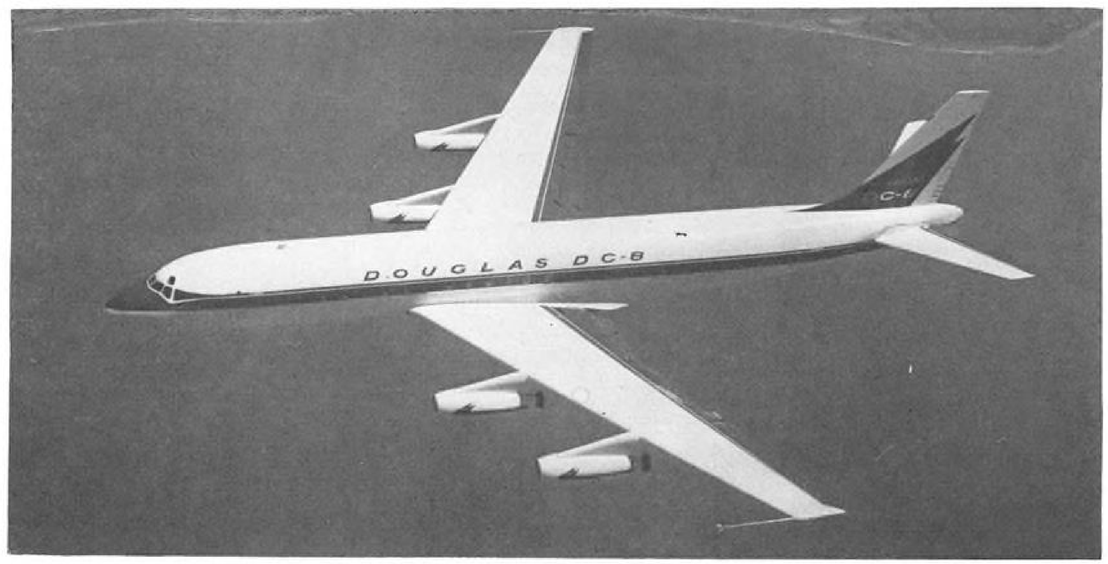
News Digest

Martin Co. plans to gain needed new financing through an issue of 20-year senior non-convertible debentures. The sale is expected to produce $20-25 million. Instead of depressing Wall Street, word that the issue would be non-convertible actually caused the price of Martin stock to rise over a point in trading early last week.

Doak Aircraft Co.'s Doak 16 vertical takeoff and landing vehicle developed for Army Transportation Corps has completed 50-hr. ground test two weeks ahead of schedule. Next step is to complete the plane by installing skin in preparation for flight test phase scheduled shortly.



DOUGLAS Aircraft Co.'s DC-8 jet transport, shown here on first flight, completed its second flight at Edwards AFB last week. Aircraft was in the air for 2 hr. and 5 min. during which it extended envelope of speed and altitude of first flight.



DOUGLAS DC-8 on first flight. Aircraft weighted 190,000 lb. and lifted off after 3,500 ft. run at speed of 110 kt.

DC-8 Moves Into Flight Test Program

Long Beach, Calif.—Douglas DC-8 moved into the flight test phase of its development with routine take-off on its Memorial Day first flight. The first DC-8 underwent two hours of condensed system and handling tests over the Pacific Ocean before recrossing the coast near Santa Barbara and landing at Edwards AFB.

Plane will operate exclusively from Edwards until about 10 hr. have been logged, after which it may return here briefly or land at other airports during flight tests. Eight more airplanes will be assigned to the test program and 28 will have been completed by the time the test program is ended.

Some will be delivered before certification to allow airlines time to train crews before commercial service becomes legal. First deliveries are scheduled for the summer of 1959. Domestic service should start by the end of that year and intercontinental service should start about 60 days later.

The DC-8 lifted off after a 3,500 ft. run at air speed of 110 kt. The airplane weighed only 190,000 lb. at lift-off—1,000 lb. more than maximum landing weight. Four JT3C-6 (J57) engines generated dense brown smoke as they developed a total of 50,000 lb. thrust with water injection at takeoff.

Observers near the runway reported comparatively low noise level from the engines which were equipped with an experimental multiport sound suppressor. Most objectionable noise at close range was compressor whine but more distant observers found this negligible.

Combination daisy petal-and-ejector suppressor intended for delivered airplane was not available.

Tests on first flight were carried out at altitudes up to 31,000 ft. The airplane was checked for general handling characteristics and hydraulic, electrical and air conditioning systems were tested out. Some of the right side window panels on the test airplane were replaced with emergency pressure relief valves to cope with possible failure of the regular pressure control valves.

Total of 138 DC-8s have been ordered to date with a total value of $700 million. Northwest Airlines is expected to sign an order for several more shortly. Douglas has invested about $225 million in the DC-8, so far.

First 50 airplanes will include domestic and overwater models, three different powerplant systems and nine different customer configurations. Dimensionally the overwater and domestic versions are identical, but overwater version has been given intercontinental range by providing additional 26,100 lb. of fuel and by increasing strength of wing and landing gear.

Most DC-8s now on order will be powered by the Pratt & Whitney JT4 (J75) and many overwater craft will be powered by the Rolls-Royce Conway. First airplane will fly with the proven Pratt & Whitney JT3 (J57). Second will have the (JT4). First JT4-powered DC-8 will be delivered to Pan American World Airways in December, 1959, and the first with Conways will be delivered in February, 1960.

Airplanes powered by the JT3 have four separate engine-driven powerplant water injection systems with four 190 gal. supply tanks. The tanks are pressurized to ensure a priming flow at starting. JT4 and Conway versions do not use water injection.

Western Strike Ends

Los Angeles—Pilots ended the long Western Air Lines strike by answering a return to work call by the company last week. Airline will resume operations to 28 cities on June 10 with 11 flights, mostly to areas completely deprived of air transportation.

Since approximately one-half of Western's fleet is stored in the Los Angeles area with most flights originating from there, first day's service also will include flights from Los Angeles to San Francisco, Seattle, Minneapolis and Salt Lake City.

In accordance with an agreement signed by company and union representatives, first flights will be operated by pilots with greatest seniority. Aircraft are being thoroughly cleaned, given 100-hour checks and completely flight-tested by supervisory pilots prior to returning to service (AW June 2, p. 32).

End to Transportation Excise Tax Urged in Senate by Smathers

By Ford Eastman

Washington—Sen. George Smathers (D.-Fla.) opened a determined drive on the Senate floor last week to eliminate the excise tax on transportation of persons and property originally imposed during World War II to discourage shipping and travel.

Smathers termed the tax as one no longer applicable and one which is operating directly against the best interests of the government.

He said that the tax money leaks out of the Treasury from the bottom in the form of subsidies and other ways as fast or faster than the money pours in at the top.

Advantages to be Gained

The Senator said these advantages would be gained from removal of the 3% freight tax and 10% passenger tax:

- ". . . **there would be only** an insignificant drop in tax revenues—perhaps even a gain."
- "**Removing the excise** would stimulate the entire transportation industry. It would encourage traffic in exactly the same fashion as the tax discouraged traffic."
- "**It would unquestionably lower prices** to the consumer—not only directly,—by cutting the cost of train and plane tickets, but indirectly in the goods and services on which tax costs are now pyramided."
- "**It would improve** the competitive position of small business by eliminating what is essentially a tax favoritism for big business."
- "**It would remove a regressive feature** from our present tax structure—something we can easily do without."
- "**It would give a shot in the arm** to the railroads, which are hurting pretty badly now. It would help all regulated motor carriers and might well save the inter-city bus transportation system. It also would greatly assist airlines who face mounting operating costs with little or no increase in traffic."
- "**It would be a direct and essential** contribution to the health of our economy which depends on huge capital expenditures from the entire transportation industry."

Smathers said 46 other members of the Senate earlier indicated they would support repeal of the transportation excise tax but that some may have changed their opinions following President Eisenhower's recent statement that he hoped to hold the line against tax reductions.

Humphrey's Interpretation

Sen. Hubert Humphrey (D.-Minn.) said he interpreted the President's declaration against a tax reduction to mean that he does not want a loss of revenue. "Therefore," he said, "I believe one can support the President's position as to revenue by the repeal of these two taxes, because they are reducing government revenues every day."

Various ways in which the excise tax on transportation would reduce government revenues was explained this way by its Senate supporters:

- **Tax imposed during the war** to discourage travel and shipping still accomplishes that purpose, resulting in a loss of revenue to the industry. Since certain segments of the industry operate at a loss, revenues brought into the Treasury at the top through the tax are drained off the bottom through subsidies.
- **Tax has not only discouraged** shipping and traveling on common carriers but has diverted a considerable portion of what there is to private carriers, resulting in a big loss in income tax collectible by the government.
- **While the amount of revenue received** through the tax has dropped since the war, the cost of collection has increased to further reduce government income.
- **Transportation tax also is deductible** from income as legitimate business expenses so the apparent gain for the Treasury is at least partially offset by this invisible loss.

Discrimination Charge

Senators backing the repeal movement said that the tax also is discriminatory to the consumer. For example, they said, shippers of large quantities have their own transportation systems and, therefore, pay no tax. If they do ship by common carrier, their rates are lower since the shipments are in big lots. Smaller shippers not only have to pay transportation tax on common carriers but must pay a higher rate because of the smaller shipments.

Another discriminatory feature of the tax, Smathers said, is the additional burden imposed on those who must ship their products long distances to markets and still compete in price with products shipped only short distances. The long distance shipper not only has to pay higher shipping costs but must pay a higher transportation tax than the short shipper.

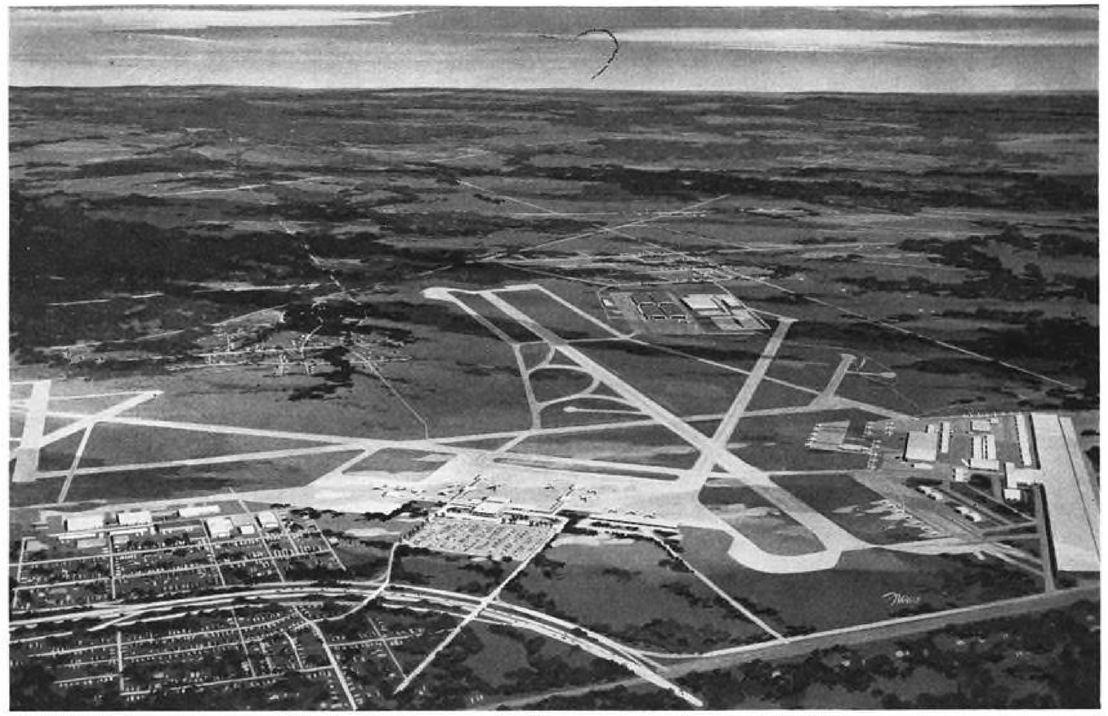
Vickers Assembles Continental's Viscount IIs

Viscount 810s (Viscount IIs) for Continental Air Lines are shown on Vickers-Armstrongs (Aircraft) Ltd. final assembly line. Continental has begun first class service with the 56-passenger turboprop transports between Chicago and Los Angeles (AW June 2, p. 30).

Los Angeles to Lengthen Runway for Jet Service

Los Angeles International Airport will lengthen its present runway 25L to 10,000 ft. from its present 8,500 ft. to provide better takeoff and landing facilities for jet aircraft.

Estimated to cost $480,000, the project, in addition to the extra 1,500 ft. of runway, will include holding apron, taxiways and lighting. The project has been approved and bids for contract are being invited. Completion date is set for Nov. 1 when first Boeing 707 is scheduled to go into operation by American Airlines. Runway 25L is designated the instrument runway, is southernmost of the dual runways now paralleling the terminal area.



ARTIST'S air view of new Tulsa airline terminal shows site it will occupy near south end of 10,000 ft. runway (lower center). At right is Douglas Aircraft Co. plant. American Airlines overhaul base, now undergoing $20 million expansion, is at north end of runway.

Tulsa Plans Second Terminal for Jet Age

By Craig Lewis

Tulsa—New airline terminal will be built here to accommodate traffic increases expected when jet transports go into service. Terminal project will be part of $33 million in construction scheduled for the Tulsa Municipal Airport complex over the next three years.

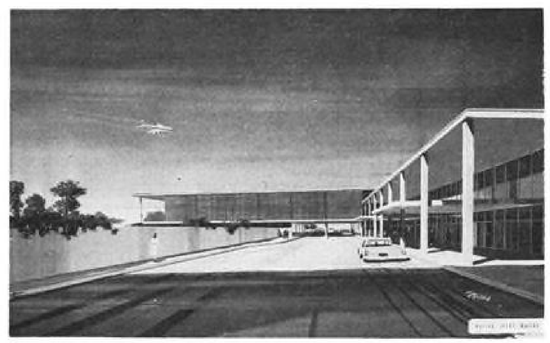
Tulsa voters recently approved a bond issue which permits the Tulsa Airport Authority to move ahead with its $8 million terminal project. It is scheduled for completion by 1961.

Across the field from the terminal, American Airlines already is at work on a $20 million expansion of its overhaul facility to accommodate turbine transports on order. And next to the American facility, the Air National Guard plans to start work on a new base.

New Tulsa terminal will allow the airport to be run as a dual operation. Terminal will be near the 10,000 ft. main runway which will accommodate all airline operations. About a mile west of the main runway is a pattern of shorter runways which can be used for business and private flying.

Present nine story control tower is a separate structure which stands between the old and new terminal sites, and it will continue to control the two operations.

New terminal will provide 16 loading positions, compared with eight at the



MAIN lobby on second level of new Tulsa terminal (left) will be reached by escalator. Drawing at right shows roadway entrance, with ticket offices on ground level.

present terminal. It will be a split-level design in which the passenger will enter from the roadway at ground level and go through the ticketing procedure. Main lobby will be on the upper level.

Passengers will descend to the fingers via escalators, and present plans call for eight gate lobbies. Airline operations centers and offices also will be located in the two fingers. Provisions will be made for second level loading from fingers if it proves feasible when jet operations are under way.

Since the present main runway is 10,000 ft. long, 200 ft. wide and built of 16 in. concrete, no new construction is planned for turbine operations. The runway is currently used by B-47s which are undergoing overhaul and modification at the Douglas Aircraft Co. plant on the east side of the field.

New taxiway will be built for the main runway to make it more accessible to the terminal. Runway will also have certain specified high speed turnoffs.

Civil Aeronautics Administration is installing a centerline, flashing strobe light approach system at Tulsa, and the field is supposed to get airport surveillance radar during the coming fiscal year. It is currently equipped with VORTAC, DME, ILS and low frequency facilities.

Should future traffic warrant it, there is enough land within present airport boundaries to accommodate a parallel 10,000 ft. runway. Airport also owns an 8,000 ft. strip a half mile wide off the south end of the instrument runway and ½ mi. clear zone off the north end, which is further protected by 2½ mi. of park area.

Cost of the project will be $8.4 million, with CAA paying for half of it. The balance will come from a $4.2 million bond issue, half of which is to be retired with revenues from airport operations. The Tulsa airport has been self supporting since opening in 1928; profits last year were $386,000.

Rate-of-Return Plan Opposed

By Robert H. Cook

Washington—Local service carriers are presenting a solid front of opposition to Civil Aeronautics Board's bureau counsel recommendations urging the CAB to adopt a 9.5% rate of return computed on the carriers' investment base.

Rebuttal exhibits in the Rate of Return for Local Service Carriers case term the proposal—designed to establish a rate calculated to attract financing—as a collection of "statistical errors and faulty assumptions." Attorneys for the Assn. of Local and Territorial Airlines say that, even if the proposal were accepted, "proper" application could result in a return of as high as 17.59%.

Heart of the carriers' stand is that their investment base as compared to capital turnover is so low that a percentage return would result in an almost negligible increase. They contend that their present financial condition will deteriorate still further since the shrinking values of their flight equipment, essentially DC-3, is slicing the investment base to where it is unable to attract new financing (AW May 12, p. 40).

In defense of its position, bureau counsel says it considers this situation a "temporary problem" already in the process of being solved by such measures as the 90% Guarantee Loan Act, Federal Reserve Board action in lowering discount rates, retention of capital gains by the carriers, pending legislation for equipment trust certificates and improvement within the framework of existing route structures. They contend that these actions will double the present investment base within two years as the carriers replace obsolete equipment. Objectors claim that such a philosophy is almost certain to defeat its own aim, with a resultant financial confusion that could postpone local carriers' freedom from subsidy far beyond the foreseeable future. The lines contend that an expansion of their investment base cannot provide a stable base for rates since new flight equipment will depreciate each year. Once fully depreciated, they say this equipment will have a residual value of only 15% of its original price, thus placing the carriers in much the same position as they are today with the DC-3. Where orders for new aircraft may have represented a doubling of the investment base, the depreciation scale of this equipment would largely nullify any increase in investment and the corresponding rate of return based upon it. While new equipment is desperately needed for economical operations, local service spokesmen say they fear the target of subsidy free operation may be unobtainable if the CAB adopts the bureau counsel's method of rate making.

Favored alternatives are:

- **Multi-element formula of 14%** on investment where commercial revenues exceed a ratio of 1.4 to investment or a combination allowing 10% on commercial revenues where the investment base is below the ratio.
- **Payment of one quarter to one third** of a cent per available seat plane mile.

The first proposal has been offered by the Conference of Local Airlines which includes Allegheny, Mohawk, North Central, Trans-Texas, Piedmont, Southern and Southwest.

Favoring the other proposal are Bonanza, Central, Frontier, Lake Central, Ozark and West Coast Airlines, all members of the Assn. of Local and Territorial Airlines.

Under CLA's rate plan, carriers with an investment base in excess of total annual commercial revenues would draw a straight 14% on investment. Those with a lower, or depressed investment, would draw the 14% figure plus an amount that would allow a combination return equal to 10% of commercial revenues. At present, Mohawk is the only member that does not have a depressed investment base. The plan is similar to that applied to surface transportation under Interstate Commerce Commission regulations.

ALTA's proposal would average six to eight cents per available plane mile for a typical DC-3 operation.

Both plans would increase annual subsidy payments by as much as $4 million, which would decrease as new equipment was retired, according to the two organizations.

Applied to local service revenues of $43 million for 1956, on an investment base of $17 million, the carriers would have realized a 25% return on investment as compared with the 9.5% recommended by bureau counsel. Under the 10% formula of CLA, the carriers netted $4.3 million in 1956 as compared with only $1.6 million under the counsel proposal.

Local service carriers have been operating with an unusually low capital which last year reached a deficit of $4.66 million as compared with the net working capital of $120 million included in the investment base of domestic trunk lines.

ALTA terms the failure of bureau counsel to allow a return on any portion of members' current liabilities a "distortion of investment base."

ALTA claims that low capital is the major reason why a normal profit margin would yield a high return on that capital but does not indicate the one third of a cent formula is unreasonable.

Attacking the bureau recommendation on a broad front, ALTA denies charges that its plan constitutes a "cost plus" formula since, it says, operational costs are calculated at five cents per seat mile with a profit element of only one third of a cent. The organization claims that with a "risk 15 times as great," it would not be practical to offer an unduly large volume of service.

The Guarantee Loan program should meet part, but not all, of the local-service carrier's loan needs since it is granted only for equipment and only in amounts up to $5 million per carrier. ALTA says a substantial amount of more costly loans will be needed to cover other equipment needs, expansion costs and sums in excess of the allowable $5 million.

Cargo Lines Report Executive Salaries

Washington—Following is a list of cargo airline executive and directors salaries, bonuses and indirect compensation, expenses and stock holdings as reported by the airlines to the Civil Aeronautics Board.

Cargo Airlines

THE FLYING TIGER AIR LINE INC.—**S. B. Mosher,** chairman, board of directors, $400 salary, 27,762 common shares and $18 shares of preferred stock; **R. W. Prescott,** president and director, $44,666.64 salary, 4,229 common shares, three preferred shares and $180,000 worth of debentures; **A. T. Chase,** director, $400 salary and 1,113 common shares of stock; **H. Rehrig,** director, $400 salary and 100 shares of common stock; **B. Gresov,** director, $100 salary and no stock; **R. Axe,** director, $100 salary and 600 shares of common stock; **A. Linkletter,** director, $100 salary and 200 shares of common stock; **C. Luckman,** director, $100 salary, 1,000 common shares and $5,000 worth of debentures; **J. Tyler,** director, $100 salary, 100 common shares and $5,000 worth of debentures; **F. Benninger,** vice president and treasurer, $27,833.34 salary and no stock; **W. Bartling,** vice president-research, $16,000 salary and 505 shares of common stock.

G. Cussen, vice president, $17,833.34 salary, 200 common shares and 33 shares of preferred stock; **L. Kimball,** vice president, $11,766.66 salary and 600 shares of common stock; **F. Lynott,** vice president-operations, $21,666.66 salary and 38 shares of common stock; **N. Berboth,** vice president, $13,880 salary and no stock; **V. Zimmerman,** vice president, $3,750 salary, 5,800 common shares and $17,000 worth of debentures; **J. Higgins,** assistant vice president, $15,163.71 salary and no stock.

O. R. Burghardt, secretary and assistant treasurer, $17,000 salary and 425 shares of common stock; **R. Stump,** assistant secretary, $11,400 salary and 100 shares of common stock; **N. Meyers,** assistant secretary and director, $400 salary, 3,152 common shares, eight preferred shares and $85,000 worth of debentures; **Arthur Anderson & Co.,** accounting services, $21,200; **Meyers and Batzell,** legal services, $60,000; **Hill, Farrer & Burrill,** legal services, $8,690; **Cloverdale & Colpitts,** consulting engineers, $45,830; **Hixson & Jorgensen,** advertising service, $31,615.

RIDDLE AIRLINES INC.—**J. P. Riddle,** president and director, $19,583.34 salary, 24,371 common shares held directly and 43,750 shares of common stock in name of others; **P. T. Craven,** senior vice president, treasurer and director, $16,645.83 salary and 3,000 shares of common stock; **J. B. Love,** secretary, $5,875 salary and 1,500 shares of common stock; **J. G. McKay Jr.,** assistant secretary and director, no salary and 2,000 shares of common stock in name of others; **C. L. Hood,** vice president-traffic and sales, $10,575 salary and 100 shares of common stock; **N. H. Golden,** vice president-engineering, $12,720 salary and no stock; **H. T. Weaver,** regional vice president-New York, $9,400 salary and 1,000 shares of common stock; **R. B. Cole,** director, no salary or stock; **W. K. deVeer,** director, no salary and 100 shares of common stock.

W. E. Dunwoody Jr., director, no salary and 100 shares of common stock; **H. B. Hibbitts,** director, no salary, 16,000 common shares directly held and 27,000 shares of common stock in name of others; **C. A. Hinsch,** director, no salary and 42,000 shares of common stock; **J. M. Sessions,** director, no salary and 50 shares of common stock; **R. W. King,** executive vice president (resigned 11/7/57), $18,000 salary with stock holdings unknown as of 12/31/57; **Dixon, DeJarnette, Bradford & Williams,** legal services, $18,679; **Bowen & Scoutt,** legal services, $19,808; **Leyshon Associates of Florida, Inc.,** public relations and consulting services, $21,573.

SEABOARD & WESTERN AIRLINES INC.—**R. A. Norden,** president and director, $35,000 salary, 38,676 common shares held directly and 17,687 shares of common stock in name of others; **A. V. Norden,** executive vice president and director, $35,000 salary, 33,427 common shares held directly and 28,683 shares of common stock in name of others; **C. D. Brell,** vice president-operations, $25,000 salary, 27,218 common shares directly held and 5,885 shares of common stock in name of others; **E. O. Schroeder,** vice president-maintenance, $25,000 salary and no stock; **W. P. Neth,** vice president-traffic, secretary and director, $22,500 salary, 22,948 common shares directly held and 7,865 shares of common stock in name of others; **D. M. Amann,** director, $4,200 salary and 6,600 shares of common stock.

C. B. Ripley, director, no salary, 23,591 common shares held directly and 2,412 shares of common stock in name of others; **W. H. Renninger,** vice president-engineering, $18,000 salary and 8,808 shares of common stock; **H. Montee,** vice president-Washington affairs, $17,500 salary, 10,807 common shares held directly and 2,995 shares of common stock in name of others; **A. Thomson,** vice president-commercial services, $15,000, salary and 313 shares of common stock; **J. H. Mahoney,** vice president-government affairs, $13,750 salary and 608 shares of common stock; **J. H. Rosenwald,** vice president-administration, $13,500 salary and 55,979 shares of common stock.

S. I. Fondiler, comptroller, $14,500 salary and 500 shares of common stock in name of others; **Mel Adams & Associates,** public relations, $31,200; **Braunstein & Chernin,** accounting and auditing services, $30,200; **Chapman, Walsh & O'Connell,** legal services, $18,304; **Lambert Dupong,** legal servies, $6,000; **Joel Fisher,** legal services, $11,596; **Bert Hassel,** operations consultant, $6,000; **Lowenstein, Pitcher, Spence, Hotchkiss, Amann & Parr,** legal services, $37,894; **Hardy McClay,** legal services, $21,249; **Paul Oberer,** Swiss commercial adviser, $6,133; **Arthur Young & Co.,** auditor, $18,000; **G. K. Griffin,** manager consultant, $19,125; **Dixon Speas,** operations engineering consultant, $26,715.

R. J. Norris, secretary and treasurer (until 11/13/57), $9,583.41 salary and 155 shares of common stock; **Pogue & Neal,** legal services, $13,016; **Williams & Kinnear,** legal services, $17,035; **William C. Wold Associates,** sales commissions, $22,500.

ALASKA COASTAL AIRLINES (a partnership)—**S. B. Simmons,** co-manager, $17,409.55 salary and $2,065.89 expenses; **O. F. Benecke,** co-manager, $17,400.87 salary and $2,005.96 expenses; **A. R. Seaton,** major overhaul N47M, $5,446.60; **Theodore I. Seamon,** legal retainer fee and expense, $7,484.59.

ELLIS AIR LINES—**G. A. Bodding,** vice president-operations, $14,798.52 salary and 8,302 shares of common stock; **R. E. Ellis,** president, $15,000.53 salary and 21,326 shares of common stock; **N. T. Gerde,** secretary and treasurer, $14,000.53 salary and 4,461 shares of common stock; **G. E. Lorenz,** director, $9,900.53 salary and 1,718 shares of common stock; **W. A. Nebel,** director, $13,473.86 salary and 2,697 shares of common stock; **J. L. Sherman,** vice president-maintenance, $12,050 salary and 8,075 shares of common stock.

Airline Transports on Order

PISTON-POWERED	TOTAL	U. S. FLAG	FOREIGN FLAG
Deux Ponts	4	—	4
Douglas DC-6A	20	7	13
Douglas DC-6B	25	11	14
Douglas DC-7	8	3	5
Douglas DC-7B	5	5	—
Douglas DC-7C	3	—	3
Lockheed Super Constellation 1049G	2	—	2
Lockheed Super Constellation 1049H	7	6	1
Noratlas	6	—	6
TOTAL	80	32	48
TURBOJET			
Boeing 720	11	11	—
Boeing 707	94	78	16
Boeing Intercontinental	59	17	42
Caravelle	28	2	26
Comet IV	31	—	31
Convair 880	57	49	8
Douglas DC-8	140	100	40
Vickers VC-10	35	—	35
TOTAL	455	257	198
TURBOPROP			
Bristol Britannia	27	5	22
Fairchild F-27	49	33	16
Fokker Friendship	29	—	29
Lockheed Electra	143	119	24
Vickers Vanguard	40	—	40
Vickers Viscount 700 Series	53	—	53
Vickers Viscount 800 Series	74	15	59
TOTAL	415	172	243
GRAND TOTAL	950	461	489

As Compiled by Air Transport Assn.

AIRLINE OBSERVER

► Industry controversy over the no-show control plan has been building rather than easing since a compromise agreement was adopted last month by the Air Traffic Conference following American Airlines opposition to the plan (AW May 26, p. 39). Possibility is now strong that a majority of trunklines will resist any effort to water down either the reconfirmation or minimum time limit on ticket pickup phases of the plan, although most airlines will be willing to let the $3 penalty plan drop from the picture. A sharp split will result with American supporting a more flexible plan, while Eastern will lead forces advocating the plan in its present form.

► **Hearings by Civil Aeronautics Board on the Las Vegas midair collision on April 21 may extend beyond the scope of normal accident investigations. CAB is hopeful of taking a deeper look into the relationship of civil to military traffic and wants a report on the case that will detail the over-all problems basic to the collision hazard.**

► Greenwich Meridian Time (GMT) will be standard time for all domestic operations effective June 15. All flight plans will be filed by GMT and all Civil Aeronautics Administration airways and navigation procedures will be conducted with GMT standards. Passenger schedules and published arrival and departure flight times will not be affected. Purpose of the action is to get a closer integration of international and domestic navigation procedures. Airlines have been preparing for the change-over since last October.

► **Aeroflot, Soviet-owned airline, is converting all its 18-seat, twin-engine Il-14P transports to accommodate 24 passengers, "thus producing many millions of rubles additional revenue annually." The modification, which requires strengthening the lower part of the fuselage, will give the Russian Il-14Ps the same seating capacity as the newer, longer Il-14Ms. East Germany began manufacturing 26-passenger Il-14Ps last year.**

► American Airlines has placed an order with Federal Telephone and Radio Co. for Tacan-compatible distance measuring equipment (DME-T) to be installed on the carrier's fleet of Boeing 707 jet transports, confirming an earlier prediction by AVIATION WEEK (AW May 12, p. 45).

► **Presidential fact-finding board completed its hearings in Washington last week on disputes between Eastern Air Lines and Air Line Pilots Assn. and Flight Engineers International Assn. Decision in the case which began in New York Feb. 10 is expected in about a month.**

► U. S. has won its fight for a cut in its annual contribution to the International Civil Aviation Organization, although the amount of the reduction is not as great as originally sought. As a result of U. S. position, entire issue of member assessments will be studied before further adjustments in contributions are made.

► **Rate of return of Class I railroads declined to 2.72% for the 12 months ending April 30 from 3.87% for the same period in 1957, according to an estimate by the American Assn. of Railroads. Net income for the group dropped to $121.5 million for the first four months of 1958 from $295.6 million reported for the first four months of 1957.**

► Air Coordinating Committee has scheduled an international symposium on "U. S. domestic short distance navigation system—Vortac—and its relationship to the international air navigation system." Invitations to aviation officials and agencies in foreign countries are being issued through the State Department. ICAO has scheduled a special meeting in February on short distance aids and their relationship to other elements of the air navigation system.

► **Northwest Airlines will defer implementation of its recently-granted Chicago-Miami route until after Oct. 1. When service begins, the airline will offer first class service with Boeing Stratocruisers, coach service with DC-6Bs and a combination first-class/coach service with DC-7Cs.**

SHORTLINES

► **Civil Aeronautics Administration** has published a booklet on regulations and procedures for administration of the labor and wage provisions of the Federal Aid Airport Program. The booklet, "Federal Aid Airport Program, Labor Standards and Enforcement Procedures," was prepared for guidance of airport project sponsors and contractors performing work under the program. Booklet can be obtained without charge from Civil Aeronautics Administration, Washington 25, D. C.

► **Eastern Air Lines** has taken delivery of its last piston-powered airliner under its $435 million expansion program. The Douglas DC-7B is the last piston airliner to be delivered before Lockheed delivers the first of Eastern's fleet of 40 Electra turboprop aircraft. First Electra delivery is scheduled for September.

► **Piedmont Aviation Inc.** in its financial report to stockholders, on the first quarter of 1958, says the airline expects first delivery of the Fairchild F-27 in June. The aircraft will be used for training purposes during July with three more F-27s scheduled for delivery in August. Four additional F-27s are scheduled for delivery in September and October.

► **Trans World Airlines** has filed formal notice with the Civil Aeronautics Board for temporary suspension of its service at Topeka, Kan. TWA says Central Airlines, a local carrier that will soon begin service between Kansas City, Topeka and Wichita, is in the best position to accommodate Topeka's traffic flow to both Kansas City and Wichita.

► **United Air Lines** has increased its weekly flight schedules from California to Hawaii by 36%, with 30 flights weekly in each direction. First class flights from Los Angeles to Hawaii have been increased from four to seven and coach service from seven to nine each week. San Francisco-Hawaii first class service is up from four weekly to five and coach from seven to nine.

► **U. S. Post Office Department's** new regular 7-cent air mail stamp will feature picture of a composite turbojet transport. The stamp will be available on Aug. 1 when the new postage rates go into effect.

► **Flying Tiger Line** air freight revenues during April totaled $936,226, the highest ever recorded for that month. Traffic showed a 14% gain over April, 1957, when revenues totaled $821,832.

Bomarc Checkout Unit Simulates Flight

Dallas—Missile exerciser developed for the Boeing Bomarc can provide an operational checkout of the interceptor missile's guidance system by simulating flight motions.

Built by Space Corp. from a Farnsworth Electronics Co. design, the Bomarc flight simulator can be used for periodic checkout of the missile when it goes into storage at operational bases. It can also be used for preflight checks.

Part of System

Simulator is part of a complete system for checking out Bomarc and its components being developed by Farnsworth.

Space Corp. has built three of the machines, and three others are being fabricated by Baldwin-Lima-Hamilton Corp.

Bomarc exercisers have been delivered to Cape Canaveral, Fla., and to Boeing Airplane Co., Seattle. They are used in the test program now, but they are designed for use as operational test equipment to keep Bomarc in peak condition in the field.

The machine has not yet been ordered in quantity.

Missile exerciser can simulate roll, pitch and yaw motions. Bomarc is clamped on the machine and put through a series of automatically programmed tests.

Program provides a readout on the instrumentation system from outputs designed into the missile to facilitate testing.

Exerciser is a 30,000 lb. complex of heavy steel frames and complicated linkage.

It is 26 ft. long and 10 ft. wide, and its H-beam base is bolted to a concrete pad.

Above the stationary main base are three separate frames. Yaw frame is attached to the base through a central bearing, and the pitch frame sits on the yaw frame and is attached to it. The roll cradle is suspended in the pitch frame, and the Bomarc is clamped in the roll cradle.

The 7,400 lb. dummy used to test the exerciser is loaded with an overhead crane, and presumably Bomarc will be loaded the same way.

Can be Tuned

Unique feature of the exerciser is the fact that it is a tuned system. Its frequency of motion is two cycles per second, and this rate is constant to all three motions. The machine is driven by a standard type of hydraulic system.

Torsion tubes are used to get and maintain frequency and amplitude. Spring effect is actuated by a boost from the hydraulic system, then the system automatically feeds impulses which are just strong enough to supplement the spring motion and maintain amplitude.

Yaw frame moves 4.5 in. from the center line in each direction for a total movement of 9 in., and other motions are on the same order. Missile goes through yaw, pitch and roll motions one at a time, and when one frame is in motion, the two quiet frames are locked. Testing can move from one motion to another in any sequence.

Hydraulic Locking

Quiet frames are locked by hydraulic cylinders which drive lock pins. Locking is automatic. The machine is additionally equipped with an over-amplitude switch which shuts it down when amplitude exceeds the operating rate.

Machine is driven by a variable displacement piston pump with booster. It takes 800 psi. to run the unit in all motions, but it is pressure tested up to 1,500 psi.

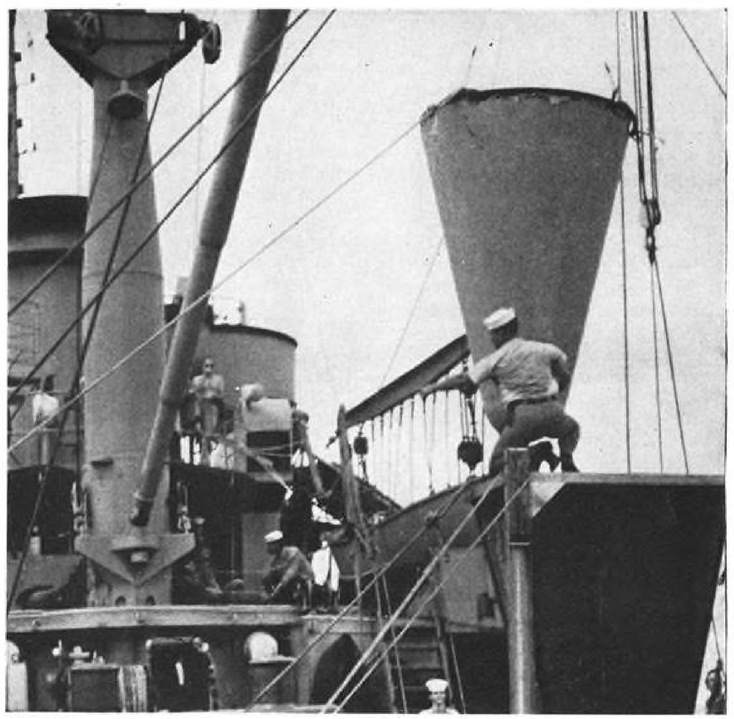
Bomarc is attached to the roll cradle with two large clamps. Cradle also has an elevating screw mechanism which presses against the missile's ramjet outriggers, giving added rigidity and a leveling effect.

Air Transportable

Missile exerciser is air transportable, along with the rest of the Farnsworth system.

Exerciser's portability is limited by the fact that it needs a concrete pad.

Farnsworth system has 40 pieces of test equipment for checking out the missile and its components, all of them of a go, no-go type. System is designed for use by ordinary airmen with no extensive technical training.



Jupiter Nose Cone Survives Re-entry

After successful 1,600 mi. flight from Cape Canaveral, Fla., Jupiter intermediate range ballistic missile nose cone is recovered and packed into steel shipping container for trip back to Army Ballistic Missile Agency. Ablation of cone surface, apparent near base, served to keep re-entry heat from penetrating shell and enabled cone to remain intact.

MAGNETIC tape drives behind control console of IBM 705 electronic data processing unit.

Norton AFB Will Process Data To Expedite Missile Logistics

San Bernardino, Calif.—Electronic data processing center for direct support of ballistic missile program was officially opened here at Norton AFB. Scheduled to be completely operational in July, the center will be managed by Directorate of Ballistic Missiles, just formed for this function in Air Materiel Command's San Bernardino Air Materiel Area, headquarters located at Norton.

Data processing system will be able, in a matter of minutes, to handle difficult logistics problems associated with the Atlas and Titan intercontinental ballistic missiles and Thor intermediate range ballistic missile, and to expedite management actions in connection with supply, maintenance, transportation, quality control and other factors. This operational capability will allow extremely fast liaison between AMC's Ballistic Missile Manager Maj. Gen. Ben I. Funk, ballistic missile operating squadrons, supporting AMC bases and missile contractors to institute vital action in minimum lapse of time. In some cases the system is expected to reduce stock supply requirements from 45 to 15 days.

Heart of data processing system is general-purpose digital computer, International Business Machines Corp.'s IBM 705. Computer will accept data from operational units, pass information to weapon system storage sites, depot or contractor, and set in motion the airlift responses. Transaction information will come over transceiver networks in and out of the control location, backed by teletype circuits. This communications system will connect the data processing center to the AMC transceiver network and with Air Force administrative teletype network, Aircomnet.

Number of transceivers the data processing center's installation can accommodate is limited only by space considerations.

IBM engineers, in conjunction with several other communications manufacturing companies, is studying specific ways of operating transceivers with microwaves.

In the area of inventory control, the center will:

- Permit worldwide accountability and control of assets, automatic resupply and precise up-to-date record data.
- Facilitate requirement and budget-buy computations.
- Enable ballistic missile manager to balance stock levels at optimum points.
- Minimize problems of disposal and obsolescence of equipment.
- Give accurate data for most economical use of transportation.
- Aid in cataloging and preplanning of maintenance schedules and workloads.

About 200 Air Force personnel will be on 24-hr. duty at the processing center.

Five full-time IBM technicians will be assigned there to handle the center's equipment maintenance.

IBM 705 computer, expanded greatly at Norton by the addition of many auxiliary components, will include 30 magnetic tape units, each capable of storing five million types of information. System is expected to ultimately require more than 5,000 reels of tape in its library.

Indications are that Air Force is also thinking of applying the electronic data processing system to aircraft logistics, because of the increasing complexity of weapon systems. In such a case the processing system would have to be keyed with initial projection of the weapon system.

Key personnel associated with the processing center at Norton are Maj. Gen. E. W. Anderson, commander of San Bernardino Air Materiel Area, Col. Philip B. Foote, heading the newly-created Directorate of Ballistic Missiles, and Col. Robert E. Kirby, who will direct technicians in the operation of the center.

MAGNETIC tape units at Norton AFB store data relating to ballistic missile logistics.

British Conducting Shock Tube Tests

Teddington, England—Nine months of shock-tube tests at the National Physical Laboratory here have convinced British scientists of two things:

- **Shock tubes** are useful tools for hypersonic and physical studies.
- **American data,** obtained in about a dozen shock tubes in half-a-dozen locations, is "quite accurate."

National Physical Laboratory's hypersonic shock tube, built as a development item for a planned tube, has a 3-in. dia. in the driver and a 15½-in. dia. working section. Mach numbers of approximately nine can be reached at a simulated altitude of 200,000 ft., with an upstream pressure of 200 atmospheres.

Bigger Tube Planned

The next tube will be double the diameter in the driving section, and will simulate Mach numbers up to 20 and altitudes down to about 80,000 ft., using upstream pressures of the order of 1,000 atmospheres.

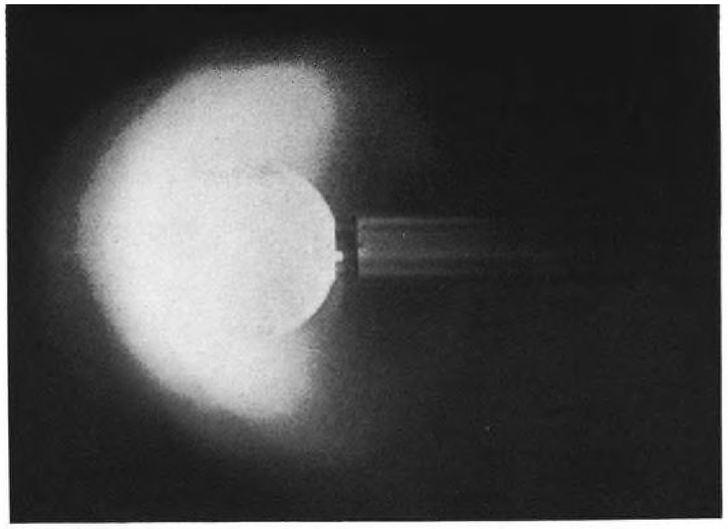
In addition, National Physical Laboratory scientists have designed a helium tunnel and is now operating a small water-cooled electric arc tunnel. If funds become available, they intend to build the helium tunnel and may possibly invest in a condenser bank for operation of the electric-arc tunnel similar to the "Hotshot" tunnels developed by engineers of the Air Research and Development Command's Arnold Engineering Development Center (AW Feb. 24, p. 34).

Scientists working on the shock tube tests acknowledge the leadership of the U.S. in this area of investigation, and envy the number and variety of these installations in America. "About all we've done so far," said one, "is to confirm that Avco turns out accurate and highly useful data."

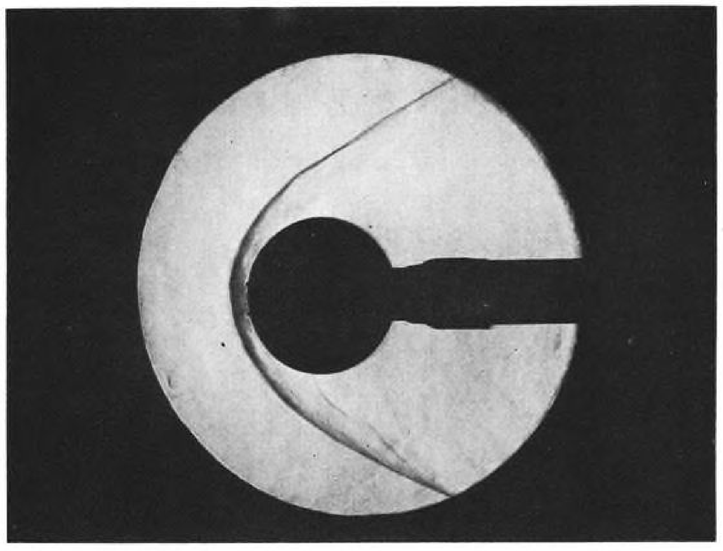
Photography Objective

A basic investigation in the National Physical Laboratory shock tunnel centers around the physical mechanism of starting. The whole problem is to get a time sequence of pictures as the shock wave passes the object in the tunnel, all in the interval of a fraction of a microsecond. A standard ballistic camera of the Cranz-Schardin type has been adapted by National Physical Laboratory technicians to do the job. The camera takes eight pictures in sequence at the rate of about three per microsecond. Hooked into the schlieren system, the camera supplies eight high-intensity pulses of light made by a spark gap.

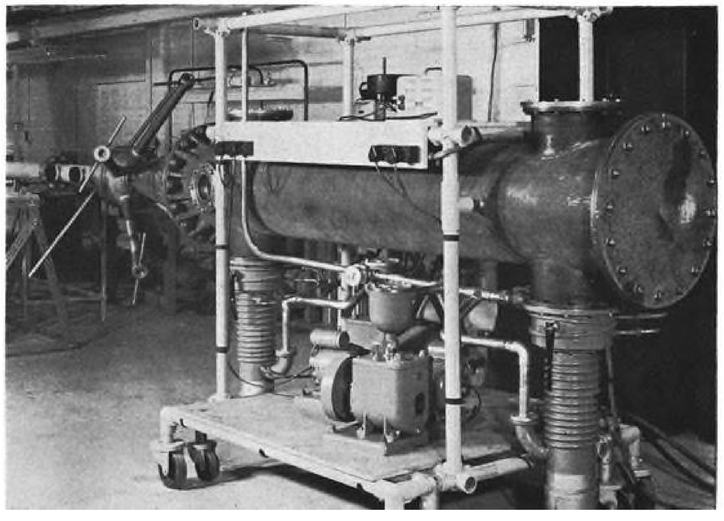
The light sources are spaced on a



SPHERE in British National Physical Laboratory hypersonic shock tube glows at speed of about Mach 9, simulated altitude of about 200,000 ft., stagnation temp. about 7,500K.

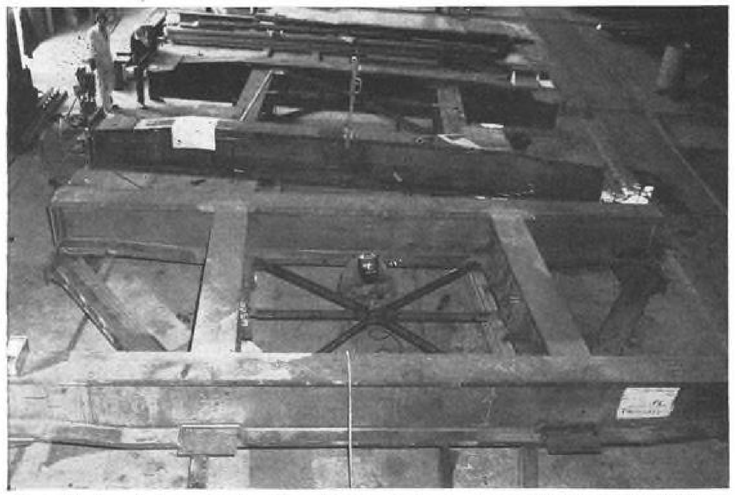


TWO bumps at head of shock wave above are resistance thermometers. Hypersonic aerodynamic studies are made in 16-in. working section of British development shock tube below.

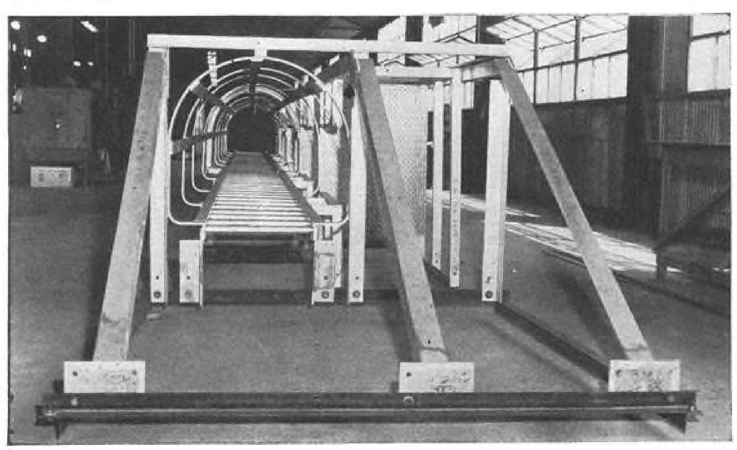


Erector towers for USAF's Titan intercontinental ballistic missile are being constructed at Kaiser Steel Corp.'s Steel Fabricating Plant at Montebello, Calif. Above, heavy steel section of basic tower structure is welded. The Martin Co. is prime contractor for Titan.

Titan Missile Ground Support Equipment Includes Steel, Aluminum Erector Tower



Over-all view of heavy steel section of tower is shown above. Bottom photo shows the aluminum manway and ladder which run vertically alongside the erector tower for the complete missile. Access platforms to different levels of the tower are at the right of the structure.



circle around the central lens of the schlieren system, and register the picture in mirror-images on a standard photographic plate.

In the physical-study shock tubes, three-centimeter microwave equipment is being used to study the electron density of a high-speed shock system. The importance of such a study is hinted at by knowledge of the high degree of ionization of air at the nose of a ballistic missile.

Tracking Telescopes Use Special Gears

Reduction drive of an 84-ft. dia. radio telescope for tracking missiles, satellites and stars has a maximum gear ratio of 1,440,000 to 1.

Final reduction of the drive is a 50 in. center distance double enveloping worm gearset. Stationary gear is cut into the outside diameter of the steel race of a large ball bearing which supports the paraboloid antenna. The bronze worm tracks around the gear at a rate of one revolution per day.

Gearset unit was fabricted by Cone-Drive Gears Division, Michigan Tool Co., Detroit, Mich. D. S. Kennedy & Co., Cohasset, Mass., is in the process of building six of the telescopes for installation in various parts of the world.

Bomarc Control Job Goes to Westinghouse

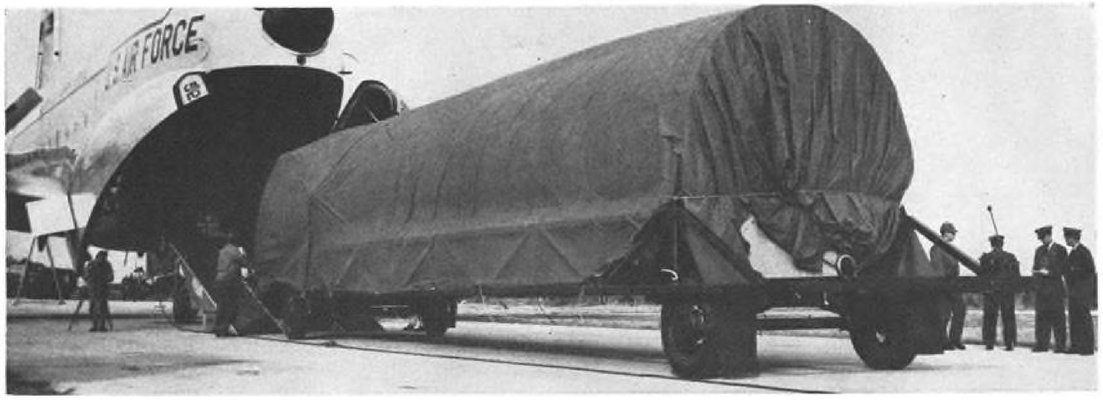
Westinghouse Electric Corp. will develop and test an advanced ground control system to guide the Bomarc air defense missile. Contract, approximating $10 million, will be undertaken by the company's Electronics Division, Baltimore, Md. Prime contractor for the project is Boeing Airplane Co.

Project, concurrent with Boeing's over-all advancement of Bomarc weapon system, calls for development of ground guidance of the missile to a point where Bomarc's built-in terminal guidance will take over and lock the missile on target.

Advancements called for include: control of the missile over longer ranges, ability to "trade" information automatically with other Bomarc ground systems, reduction of equipment size and the ability to track more targets simultaneously.

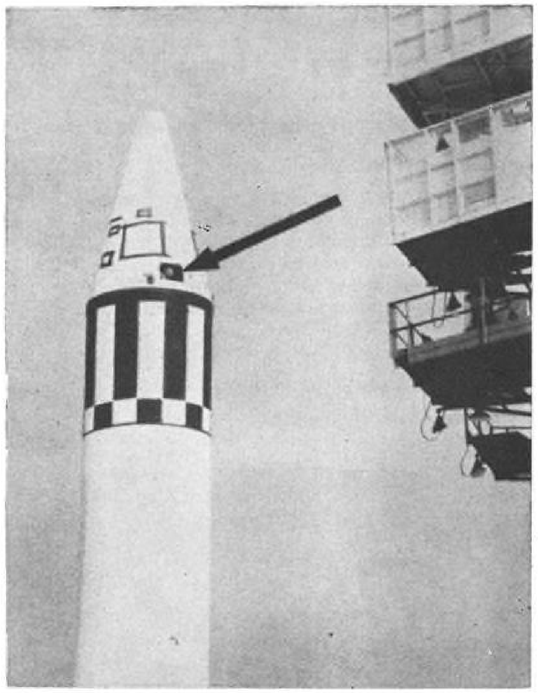
Lockheed Division Expands Navy Polaris Development

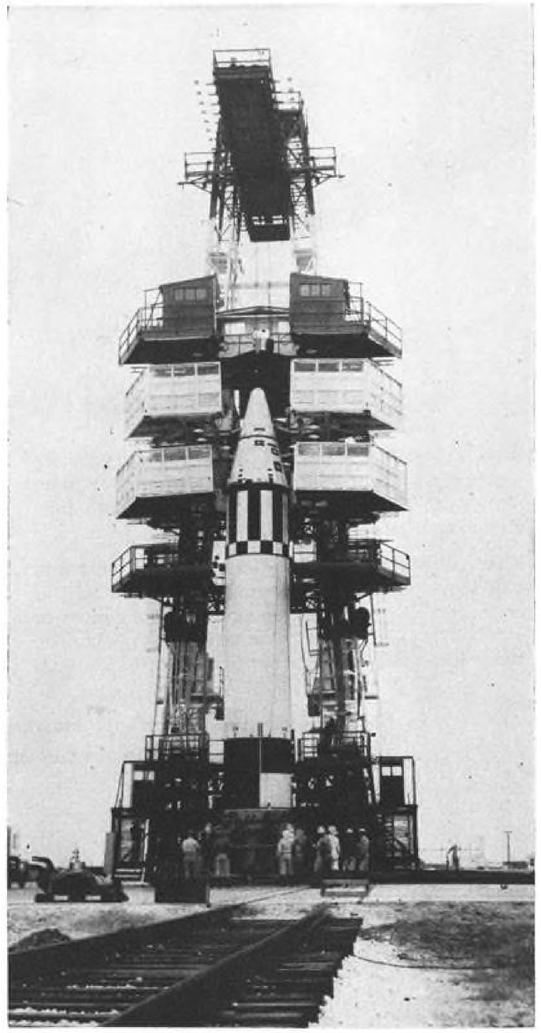
Lockheed Missile System Division will expand Navy-owned Polaris development facility at Sunnyvale, Calif. Officials said accelerated tempo of entire Polaris program has advanced second phase date originally set for next year.



Draped with heavy canvas protective cover, Jupiter intermediate range ballistic missile is loaded onto Douglas C-124 for shipment from Army Ballistic Missile Agency at Huntsville, Ala., to USAF Missile Test Center, Cape Canaveral, Fla. Jupiter is transportable by ground, sea or air. First full-scale IRBM nose cone to successfully survive re-entry into the earth's atmosphere was launched by an Army Jupiter from the USAF Missile Test Center, Cape Canaveral, Fla. (AW May 26, p. 38).

Jupiter Prepared For Launching Test





Missile technician works in nose section of Jupiter (arrow, left). He probably is adjusting avionics instrumentation. Portion of gantry crane is at right of picture. Photo at right shows entire missile and support complex, with gantry in position at the launch pad. Exhaustive tests are made on missile and its control equipment until just prior to the actual launching. Gantry moves to a safe distance some time before Jupiter is fired. Markings aid visual tracking.

FLIGHT view of McDonnell F4H-1 shows aircraft in traffic pattern, gear and flaps down. Note extended droop in horizontal tail.

F4H-1 Stresses Range in Navy Order Bid

Navy's new McDonnell F4H-1 jet fighter, which has just made its first flight, appears to be roughly comparable to competing Chance Vought F8U-3 at altitudes below 60,000 ft. since both aircraft have same speed limit above Mach 2.

Carrier Aircraft

Both aircraft are designed for Navy carrier service but apparently the choice will depend on actual mission capability. McDonnell F4H-1 reportedly has greater range and can perform traditional carrier mission of cruise to assigned sector, loiter while waiting for target, engage in combat for five minutes and cruise back to carrier. With one engine shut down, the F4H would gain additional range.

However, F8U-3 has greater altitude capability because of rocket engine. Maneuverability and turn performance of Chance Vought aircraft thus would be superior above the 60,000 ft. altitude, observers feel. Aircraft made its first flight last week.

The McDonnell fighter wings are swept back 45 deg. Aircraft carries pilot and radar observer (AW June 2, p. 21). Powerplants are two General Electric J79 engines producing 10,000 lb. thrust each; use titanium sheeting near twin tailpipes.

SPARROW III missile, geometry control inlet hinge can be seen in this F4H-1 runway view.

Engine inlets appear to be variable geometry type in which a hinged ramp adjusts diameter for maximum efficiency, similar to that used on Convair F-106 all-weather interceptor. F4H-1 also is equipped with drag chute to slow landing roll.

Anhedral Wingtips

Anhedral wingtips are said to improve stability and control by offsetting 23 deg. negative dihedral of horizontal tail, especially at high angles of attack. Unusual tip configuration also offsets any pitchup tendencies.

Plane can be equipped with four Sparrow III air-to-air missiles and also is capable of long-range delivery of conventional and nuclear bombs. Aircraft is said to have greatest range of any Navy jet fighter.

Refueling can be accomplished at supersonic speeds by probe and drogue or by buddy systems.

The aircraft is 56 ft. long, has a wing span of 38 ft. 5 in.

J. S. McDonnell, president of McDonnell Aircraft, said 4,202 employes now are working on the F4H-1 project. He said 6,800 man-hours were expended on the design and construction of the initial aircraft before its first flight.

Discussing the economics of McDonnell Aircraft's entry into the supersonic, carrier-based interceptor field, McDonnell said "stability of employment at the company would be dependent to a very considerable de-

gree on the Navy's acceptance of the plane for volume production."

F4H-1 Subcontractors

He stressed that approximately 1,500 subcontractors and suppliers from 28 states are involved in the F4H-1 project.

About 400 of those companies are located in the metropolitan St. Louis, Mo., area.

"The ability of our planes to destroy enemy aircraft is no longer dependent solely on speed, range or altitude capabilities," McDonnell contended. "To do the job today, our planes must be considered as part of a complete weapon system that also includes special radar, novel detection means and guided missiles."

He referred to the advantage of radar operators in missile firings and added:

"The fact that the (F4H-1) has two engines is certain to mean a higher survival rate in training and combat operations."

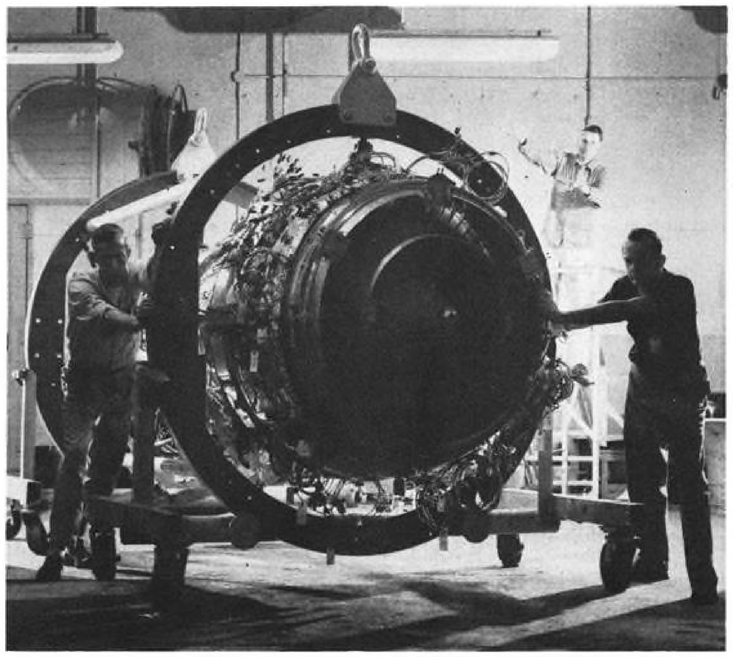
F4H-1, he continued, is designed with a "liberal allowance for growth potential."

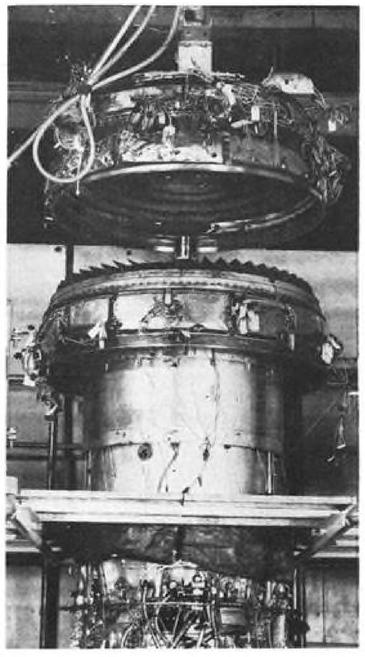
Kaman Laboratory Construction Starts

Bloomfield, Conn.—Kaman Aircraft Co. has broken ground for new engineering laboratory building which will be completed Sept. 1.

Laboratory, which contains 9,600 sq. ft of floor area, is located near 34,000 sq. ft. engineering and administration building now under construction.

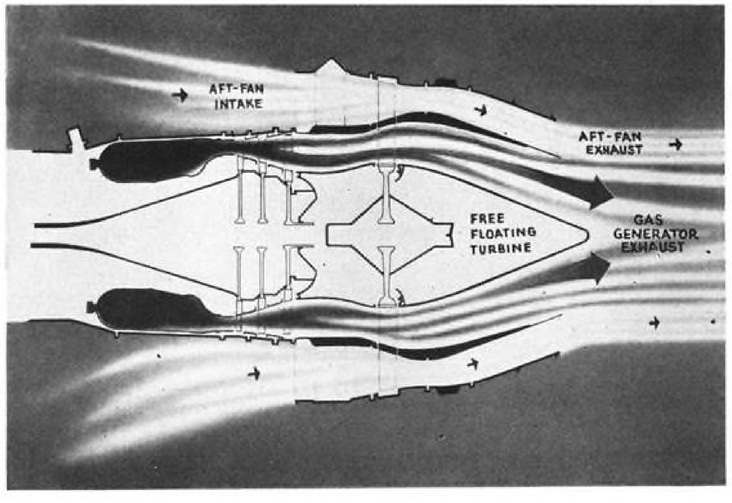
New laboratory is steel frame with masonry walls and two ribbed galvanized steel walls.

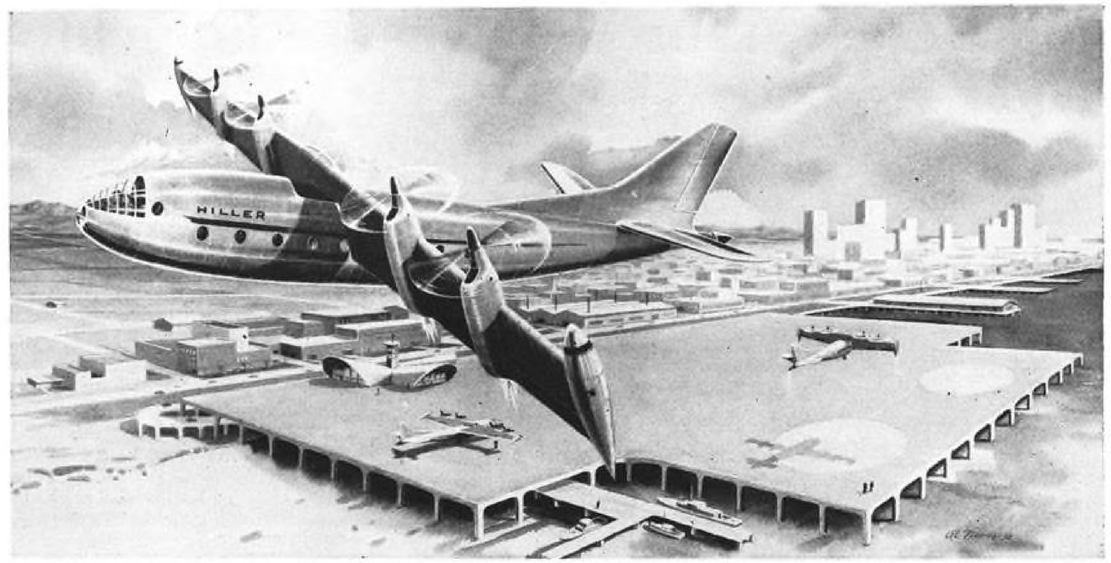




General Electric Tests Aft-Fan Turbojet Engine

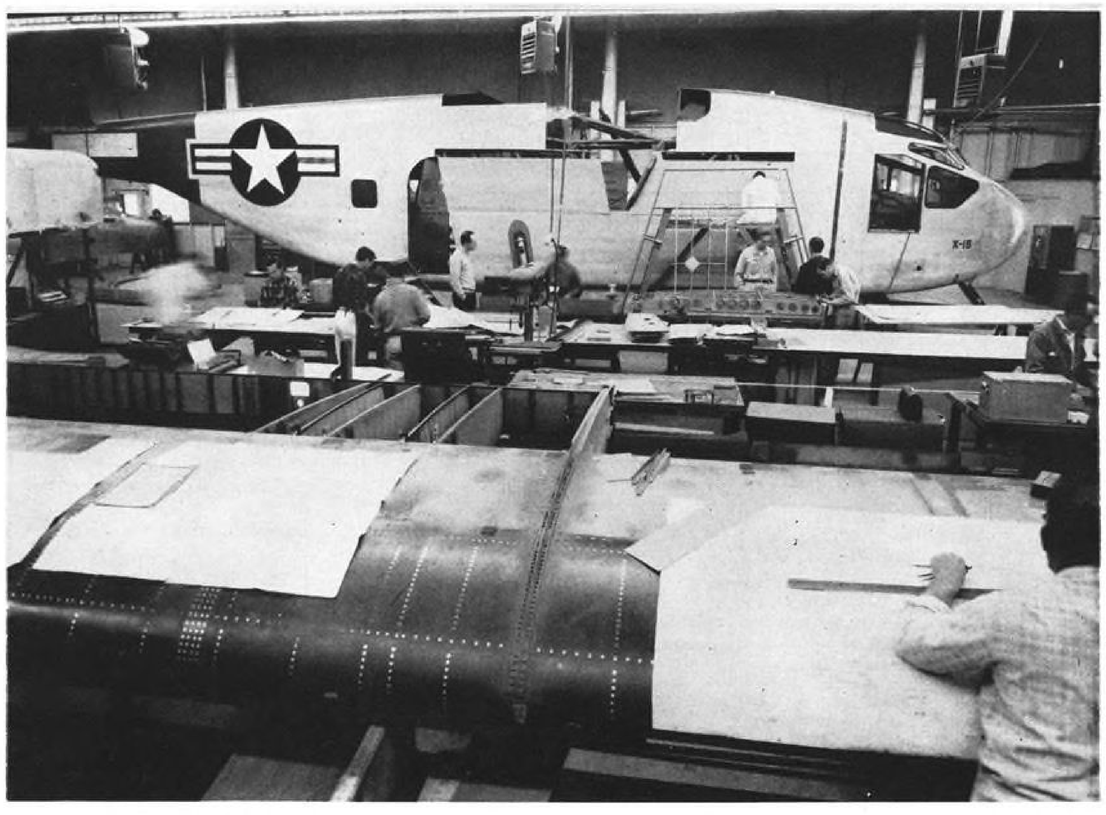
Military version of General Electric Co.'s CJ-805-21 aft-fan turbojet engine is shown above being wheeled into test room. Engine is being readied for flight test on USAF jet tankers. It has undergone several months of testing at General Electric's Evendale, Ohio, facility (AW May 26, p. 33). Aft-fan component (right, above), shown in final assembly stage, is added to basic gas generator in three sections. Test instrumentation is visible. Rear frame supports fan. Fan wheel is not mechanically coupled to CJ-805-21 engine turbine rotor. First cross-section of the engine (right) shows free-floating turbine which drives fan, with only aerodynamic connection between turbine and three turbine stages of the basic engine. Free-floating turbine is supported by a bearing at each end of the shaft. Power-turbine stages are supported by conical shaft.



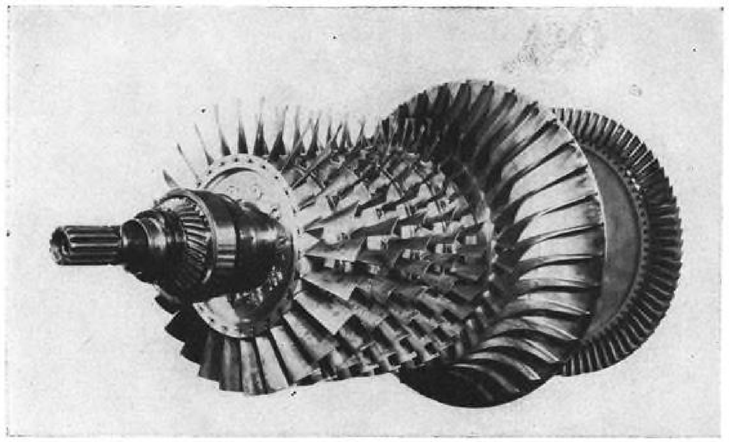


Hiller Assembling Prototype Tilt Wing X-18 for Air Force

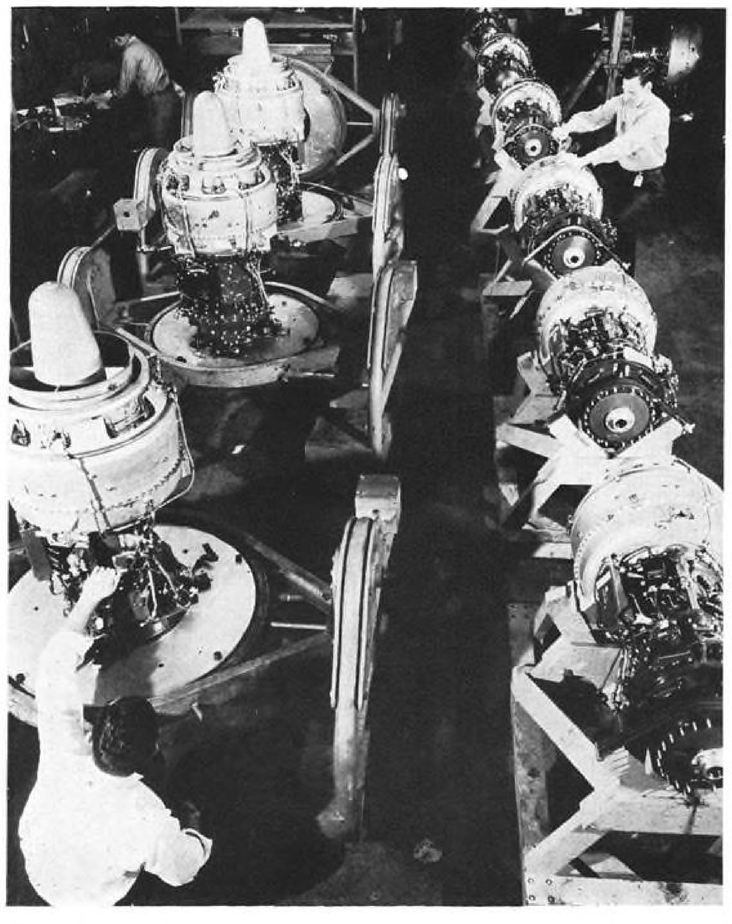
Hiller Helicopters artist's conception (above) of a tilt wing airline transport of the future indicates that the aircraft would be designed to operate from bases near metropolitan centers. Tilt wing's versatility would permit conventional takeoffs and landings from conventional runways with resultant fuel savings. Below, Hiller constructs Air Force X-18 tilt wing research transport at Palo Alto, Calif. Full span of the forward wing section is in the foreground. The wings will tilt at 90 degrees.



T53 Designed for Maintenance in Field



AXIAL-CENTRIFUGAL COMPRESSOR is designed to keep number of blade stages and engine length to a minimum. Turbine output shaft passes through the compressor's hollow shaft to permit placement of reduction gearing and power output at forward, cool area. Lycoming has plans to make centrifugal stage of titanium to reduce engine weight and acceleration time. Below, the pre-production engines are shown in their final assembly stage at Stratford plant.



By Erwin J. Bulban

Stratford, Conn.—Design of Lycoming's T53 860-shp. turboshaft engine is aimed toward ruggedness at the sacrifice of some weight saving in an attempt to provide reliability in the field where minimum of maintenance facilities and trained personnel may be available.

Primary consideration was given to the Army mission involving operations close to the battlefield.

These parameters resulted in the T53 having these basic features:

• **Compressor** of axial-flow configuration for the first five stages, plus a centrifugal impeller as the final stage. Reason for this, in addition to reducing the engine's length, was to avoid high number of axial stages and attendant multiplicity of small axial blades that Lycoming engineers felt would increase initial manufacturing costs and spares requirements and also be more susceptible to foreign object damage.

• **Combuster** of annular external configuration also houses the power turbine as part of the combuster assembly, providing short length. Quick removal provides easy access to all engine hot parts; reverse-flow design is aimed at even radial temperature distribution at the turbine inlet to increase life of turbine components.

• **Turbine output shaft** passes through the T53's hollow compressor shaft allowing reduction gearing and power output to be placed at the cool front area of the engine. Short engine length aided this placement of the shaft.

Market Potential

Like General Electric, which is planning a wide industrial market for its T58 (AW Mar. 17, p. 52), Lycoming is studying numerous applications of the T53 for civilian and military use including ground power generation and in marine vehicles. Like the T58, the Lycoming engine is also being studied for use in Navy's new class of hydrofoil-equipped high speed landing craft, on which several research contracts have been let.

Aviation applications thus far include firm production programs such as the Bell HU-1 (formerly H-40), Kaman H-43B, Vertol 107 and Grumman AO-1 Mohawk turboprop; other installations include the Doak X-16 ducted fan VTOL research aircraft, the Ryan Vertiplane vectored slipstream VTOL research plane and the Vertol 76 tilt-wing VTOL. Test-bed installations include the Kaman HOK-1 and Vertol 105 helicopters. Engine has compiled a total of some 1,000 hr. of operating time, with approximately 450 of these being flight time.

T53-L-1 recently passed its 150-hr. USAF qualification trials at 860-shp. rating, an improvement over the 825-shp. it was rated at prior to the test. This qualification trial was of considerable importance to the Stratford plant considering that USAF-Army had earlier given it a production contract totaling approximately $10 million calling for initial delivery of engines next January. Engines contracted for are scheduled for the Bell HU-1 and Kaman H-43B helicopters.

Lycoming production plans call for initial output of four or five T53s monthly; company expects to produce in excess of 500 engines by 1960 with production geared to approximately 50 T53s a month.

Cost Should Drop

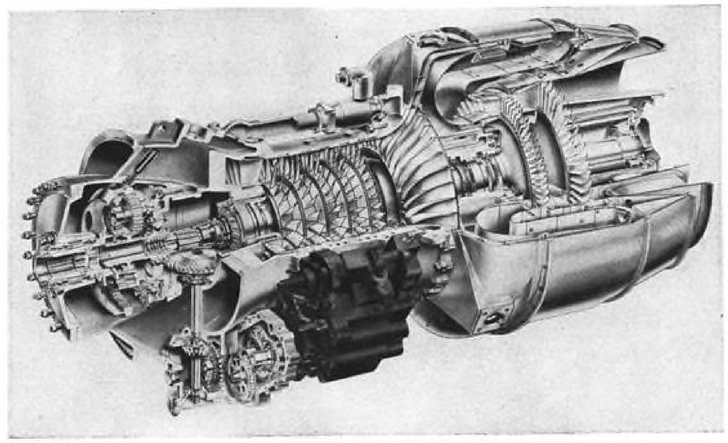
This production quantity may bring cost of the engine down to $65 per horsepower, further decreasing to approximately $35 per horsepower in 1962.

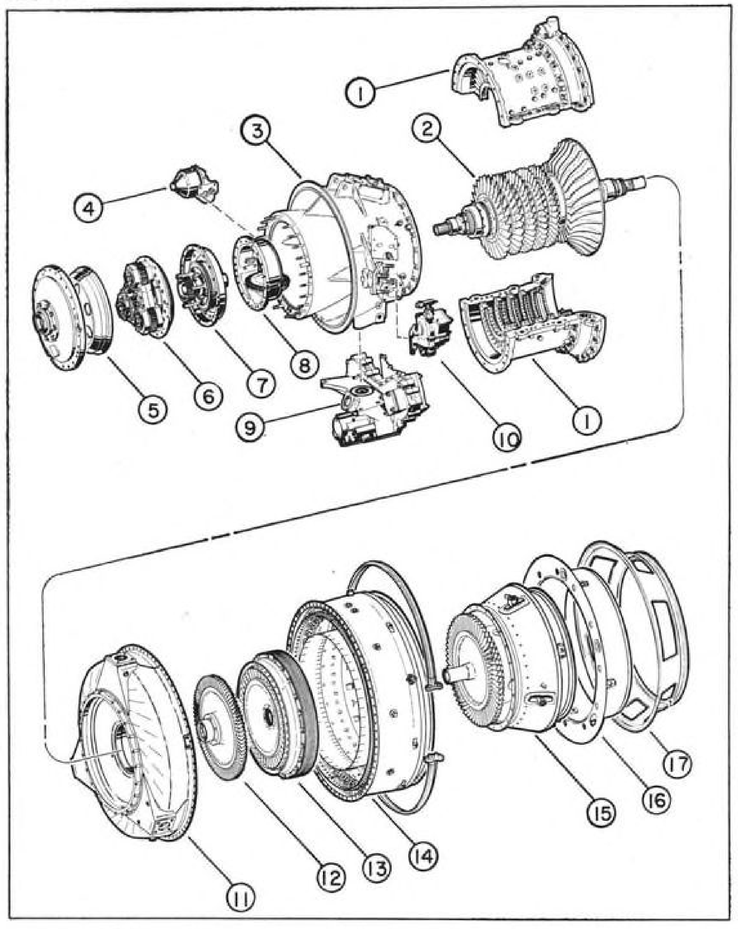
In addition to the T53-L-1 turboshaft, Lycoming is also counting on a market for the turboprop version, designated T53-L-3, slated to deliver a minimum military takeoff power of 960 shp. plus 113 lb. residual thrust for a total of 1,005 eshp. at 1,700 propeller shaft rpm. and providing specifical fuel consumption of .655 at takeoff power. Fuel specific is slightly improved over the T53-L-1, which is given as .673 lb./eshp./hr. at military power. Installations include single and dual configurations, the latter providing high takeoff power with advantage of being able to shut one engine down for optimum cruise characteristics for commercial or military missions.

Lycoming foresees developing the T53 turboshaft engine to more than 1,000 shp. by increasing operating temperature; it also plans to develop the turboprop T53-L-3 in stages. Current version, delivering 960 shp., could be boosted to 1,050 shp. using new gearing arrangement and further power gain made to 1,250 shp. by incorporating some transonic stages in compressor.

Also in the works is the larger T55-L-1 delivering 1,676 eshp. at takeoff at 1,320 propeller shaft rpm. and specific fuel consumption of .648 and a turboshaft version, the T55-L-3 with similar performance characteristics. T55 weight is about 600 lb. As yet Lycoming has not been able to develop sufficient military interest in programming these more powerful units. T55 is currently running on the test stand.

T53's axial-centrifugal compressor, designed to achieve pressure ratio of approximately 6:1, consists of five wheels holding stainless steel low-hardness-level non-chip blades for the initial stages fit-





BASIC MAKEUP of T53-L-1 is to use magnesium in forward, cold section; steel in hot section. Major components of powerplant include: 1. Split compressor housing and vane assemblies; 2. Compressor rotor assembly; 3. Air inlet housing; 4. Main oil filter; 5. Power output gear assembly; 6. Torquemeter carrier and gear assembly; 7. Planetary sun gear assembly, 8. Accessory drive carrier assembly, 9. Accessory drive gear box and oil pump assemblies, 10. Overspeed governor and tachometer drive assembly, 11. Diffusor and first-stage nozzle assembly, 12. First-stage turbine wheel, 13. Second-stage nozzle assembly, 14. Combustion chamber assembly, 15. Power turbine support assembly, 16. Fire shield assembly and 17. Support cone assembly.

INTERNATIONAL DELINQUENCY

Nuclear weapons ready to be delivered by jets and missiles are vital. But in cases of international delinquency, they would be like city police using tanks to prevent a rumble by juvenile delinquents.

United States Navy carrier groups, like cops on their beats, protect our citizens, make rescues, and keep the neighborhood quiet. If called on, they can restore law and order with a wide choice of weapons from a complete arsenal. Carrier groups are also our best protection against submarines capable of launching missiles, plus being a deterrent to all-out aggression.

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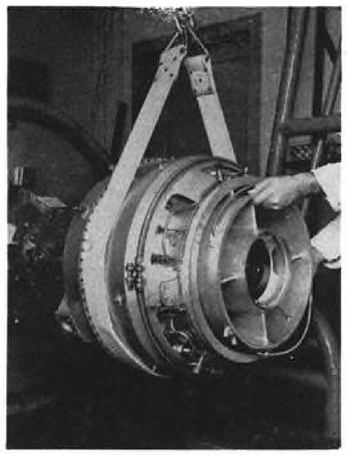


COMBUSTION CHAMBER with power turbine can be removed as a unit for ready access to engine hot parts without need for taking out entire engine.

ted together with five spacers. The axial compressor sections and the centrifugal rotor are tied together by a sleeve which is screwed into the compressor stub shaft.

First ring, forming a bearing support unit, is steel, other four rings are aluminum; spacers are steel.

Titanium Proposed

Centrifugal rotor on current production engines is steel, but Lycoming is planning to go to titanium for this wheel on a later model, cutting some 11 lb. from its weight and reducing acceleration time by 1 or 1½ sec.

Compressor blade retention utilizes small pins retained to pins in the blade dovetails. Blade dovetail has a slot extending only approximately halfway across it.

For mounting, blade is slid over a tab washer until the half slot hits the stop pin, then the portion of the tab washer jutting out is bent upwards, holding the blade in place.

No T53 compressor unit has been lost in operation, Lycoming reports; company notes that fabrication of the blades permits them to bend, rather than break, should they encounter foreign objects such as bolts. One engine swallowed a quarter-inch bolt that came free from another part of the aircraft; after the engine was shut down and inspected it was noted that compressor blades were bent and twisted but none of them had broken loose.

Compressor housing is a magnesium assembly split horizontally, bolted together for ease of disassembly. Stator blades are cut from 10-in. strips of rolled steel and are of constant airfoil shape. Production cost of these blades is estimated at 50 cents each.

Five rows of stators are furnace-brazed to inner and outer shrouds, three screws holding each stage on each upper and lower half of the housing.

Anti-icing provision uses a hot-air valve bleeding forward from the centrifugal compressor, taking 400-500 deg. air to the inlet housing to protect the inlet guide vanes on top and two horizontal struts.

Diffuser-Combustion Area

After leaving the centrifugal final compressor stage, the air is channeled into a radial diffuser section containing straightening vanes to eliminate the swirling and also reduce air velocity prior to combustion.

Engine diffuser section is also the main support area for the engine, providing three mounts, duplicating three mounting points on the inlet housing. Section also provides support for the engine's No. 2 bearing.

Combustion section is tied to the diffuser with a bolt circle that allows the combustor and power turbine to be removed easily from the engine for checking the combustor or for access to both turbines.

Engine's hot parts are designed for ease of accessibility. Power turbine is supported within the exhaust diffuser, which is part of the combustor assembly. Entire assembly, including combustor, can be removed from the engine without disturbing other rotating parts. Removal of this assembly provides access to combustor liner, fuel vaporizer, turbine wheels and stators.

Annular combustion system takes air from the diffuser, passes it between the liner and housing and then through holes and louvers into the combustion area, where it is mixed with fuel vapor. Openings in the liner pass diluted air into the combustion area. Burning gas is then passed through the first stage turbine nozzle and the first stage turbine wheel.

Turbines are single-stage units consisting of nozzle, wheel and shaft. Turbine nozzle consists of an outer ring to which vanes are welded to form the nozzle. Turbine wheels are made up of solid wheel disks with each blade held to the rim by a pin through the wheel rim and the blade root.

First-stage nozzle and first-stage turbine wheel, together with the axial-centrifugal compressor, diffuser and combustor, make up the gas producer section, the compressor rotor assembly being directly connected to the gas producer turbine wheel.

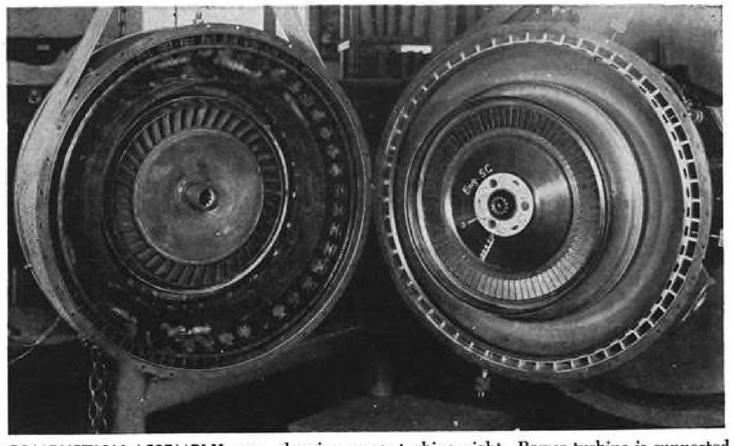
Power turbine assembly is composed of the second-stage nozzle, second-stage turbine wheel and interconnecting shaft and gears to the engine output shaft. Planetary gearing reduces power turbine speed 3.22:1. Reduction gearing is located forward, at the engine's "cold end," to provide greater reliability and life of gears and highspeed bearings. T53's makeup is such that rear drive installation, as well as power output at both ends, can be readily handled.

Connected to the producer section is the power takeoff for auxiliary drives, providing up to 30 hp.

Power Control

Fuel and power control unit is grouped in the wasp-waist section of the engine to maintain minimum diameter. Fuel flows from the control directly to the main fuel manifold, entering through eleven T-shaped injection nozzles. On activating ignition, fuel enters the starting manifold and into the combustion chamber via five starting fuel nozzles. Two of these starting nozzles work with the igniter in initiating combustion, other nozzles assist in flame propagation.

Engine power control is a simplified



COMBUSTION ASSEMBLY open, showing power turbine, right. Power turbine is supported within exhaust diffuser, which is part of T53-L-1's combustion chamber assembly.

single lever. Normally, free power turbine rotor speed is controlled by the power turbine speed governor; gas producer turbine speed governor prevents the engine from overloading or combustion blowout due to sudden changes in power selection. Power control lever covers these positions: 90-93 deg., military power; 25-30 deg., flight idle; 10-13 deg., ground idle and 0-3 deg., off.

Minister Adds Details On Swallow Project

London—Further details of Vickers Swallow project have been given by a government spokesman in the House of Commons.

Supply Minister Aubrey Jones said research on the variable geometry aircraft had been underway 10 years when it was decided last year to move beyond fundamental research to the construction of an actual research aircraft (AW May 19, p. 34).

Vickers Armstrongs was invited to submit a proposal based on the Barnes Wallis research.

"The proposals were for the construction of a research aircraft which might prove the foundation for a bomber to succeed the supersonic bomber," Jones said. "In other words, it was a research aircraft which might be the foundation for a post-supersonic bomber."

The supersonic bomber, however, was canceled following the 1957 Defense White Paper.

"Accordingly, I informed Vickers that the proposal in the form in which they had counched it could no longer rank high on the list of priorities," Jones said.

"But I added that the Ministry of Supply was still extremely interested in the whole principle of variable geometry and invited the company to submit alternative proposals, proposals which would apply the principle in a different form, a form different from that of the supersonic bomber."

The minister said that since then, certain alternative proposals have been received from Vickers. These are being examined by British and U.S. Air Force officials.

Vickers reportedly is continuing the Swallow project at its own expense. Until government support was withdrawn, Ministry of Supply has provided 80% of Swallow funds, with company putting up the remainder.

Jones was challenged by a Member of Parliament who declared: "If as a result of false advice or false economy, Dr. Barnes Wallis is driven out of this country, I shall do my best for the rest of my life to find out who was responsible and expose him in the public eye." He said some 775,000 experiments on the project have been carried out by Wallis.

Wallis, he said, was almost in despair last September because he believed he was on the brink of one of the most important discoveries of his life at the moment the axe came down on defense. It was for this reason the U.S. was brought into the picture, it was said.

The government listed for the House three new aircraft requirements which it considers "clearly essential":

- **Replacement for Beverley** freighter. A spokesman said it is planned to continue using the Beverley as a heavy freighter until the mid-1960s. It is for the following period that a successor is being sought.
- **Replacement for Canberra** bomber. Although the Blackburn NAA. 39 (AW May 12, p. 29) still is being considered, it may be necessary to obtain a tactical strike aircraft which is supersonic, it was stated.
- **Replacement for Venom.** Trials for this aircraft are to be held in the Aden protectorate this summer, with the Folland Gnat as a leading contender.

COAXIAL Kamov Ka-15 helicopter is powered by 255 hp. engine, has top speed of 93 mph.

Coaxial Ka-15 Designed for Utility

Russia has disclosed rotor system design details and operating characteristics of its two-place Kamov Ka-15 coaxial helicopter, which it calls "the pioneer craft of its type in actual use."

Together with the larger, four-place Ka-18 "flying automobile," the Ka-15 is hailed by the Soviet press as another example of Russian supremacy in aeronautical engineering. The USSR claims that "not withstanding many attempts to bring coaxial helicopters to the point of practical utilization in foreign countries, nobody (there) has yet succeeded in doing it."

Designer N. I. Kamov, who helped build the first Soviet autogiro—the KASKR-1—in 1928, started planning his first small coaxial helicopter in 1945. His single-place Ka-10m "aerial motorcycle" was publicly demonstrated in 1952.

The Ka-15 is powered by a 255-hp. engine, has a top speed of 93 mph. and a cruising speed of 78 mph. (AW Nov. 25, p. 80). Range is 2½ to 4 hr., and ceiling is 10,000 ft.

Special attachments permit using the

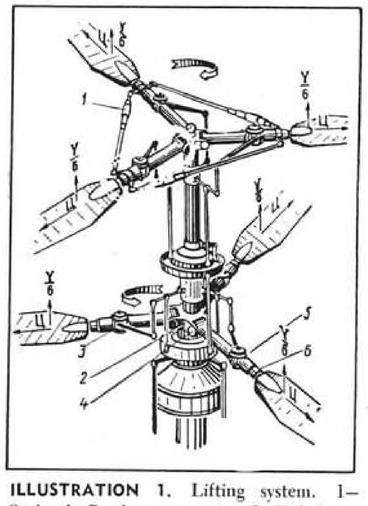
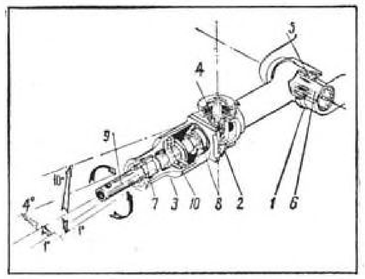
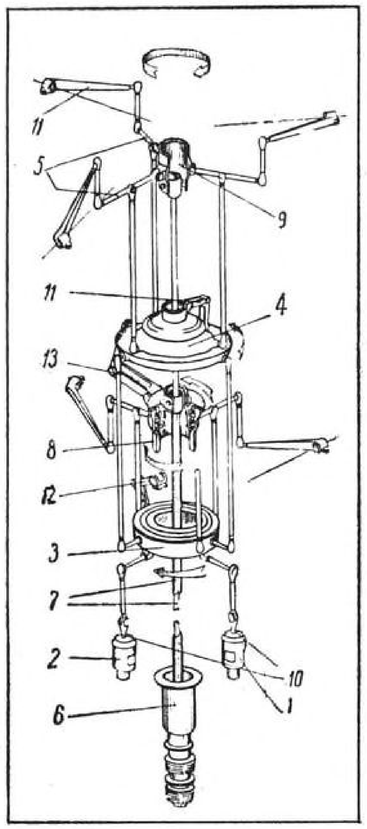


ILLUSTRATION 1. Lifting system. 1—Spring buffer for upper rotor; 2—Hub housing; 3—Hub sleeve; 4—Horizontal hinge; 5—Vertical hinge; 6—Axial hinge; μ—Centrifugal force; Υ—thrust developed by one blade; —Arrows indicate direction of rotors' turning.



HUB sleeve: 1—horizontal hinge; 2—vertical hinge; 3—axial hinge; 4—friction damper; 5—needles for horizontal hinge bearing; 6—pin for horizontal hinge; 7—needle bearing for axial hinge; 8—ball bearing for axial hinge; 9—blade pin; 10—thrust bearing for axial hinge.



CONTROL system on column: 1—spool for longitudinal control; 2—spool for lateral control; 3—lower automatic swash plate; 4—upper automatic swash plate; 5—rocker; 6—machanism for collective and differential pitch; 7—coaxial shaft; 8—lower slider; 9—upper slider; 10—worm for control spool; 11—guide for blade pin; 12—lower slot-hinge; 13—middle slot-hinge. —Arrows show directions of rotation of rings of automatic devices and sliders.

Ka-15 for agricultural, mosquito control and rescue work.

According to Kamov, coaxial helicopters have better handling qualities and are more economical than single-rotor designs. He adds that the coaxial craft can be built smaller and more symmetrically.

Pilot Training

Soviet helicopter engineer V. Biryulin points out that coaxial helicopters such as the Ka-15 have important advantages in pilot training, "since the operation of their controls is closer to that of an airplane."

The Ka-15's lifting system consists of two identical rotors located one above the other on a single geometric axis.

Turning in opposite directions, the three-bladed rotors are fastened to concentric shafts.

Power from the engine crankshaft is transmitted through an intermediate reducer to a distributing reduction gear. Two shafts come from the distributing reducing gear—a short, outer one for the lower rotor and a long, inner one for the upper rotor. The distributing reduction gear divides the power between the two rotors and produces their contra-rotation.

The Ka-15's tail assembly, featuring twin fins and rudders, is similar to that of an airplane.

In general, Kamov favors four-wheel landing gear for his coaxial craft to provide better stability while moving along the ground.

Control is Simple

According to Biryulin, control of a coaxial helicopter such as the Ka-15 is simpler than for a single-rotor helicopter.

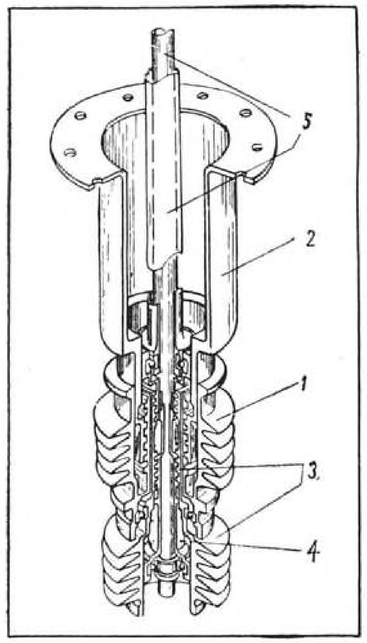
Main difference, he says, is in course (directional) control.

"Longitudinal-lateral control (by cyclic pitch) for coaxial and single-rotor helicopters is similar. The only difference is that with coaxial helicopters, when the stick is moved in any direction there is an approximately parallel tilt in the same direction by both rotor disks.

"Collective pitch control on the Ka-15 affects all the blades of the upper and lower rotor simultaneously and to the same degree. The collective pitch and throttle mechanism operates exactly the same as on a single-rotor helicopter.

"Course (directional) control with a coaxial helicopter such as the Ka-15 is achieved (through pedal operation) by two methods: by differential change of the rotors' collective pitch and by the rudders. . . .

"Operation of all three control devices—cyclic pitch stick, collective pitch lever and pedals—is entirely independent. Piloting a coaxial helicopter is particularly simplified near the ground when there is a limited landing area containing obstacles. Thus, for example, it is considerably easier to land on a ship's deck or to fly between trees.



COLLECTIVE and differential pitch mechanism: 1—collective pitch drums; 2—fixed sleeve with inner band thread; 3—drum and sleeve for differential pitch; 4—intermediate threaded sleeves; 5—long coaxial shafts.

Biryulin says "the reaction lag to stick operation in the Kamov coaxial helicopters is less than for Soviet single-rotor helicopters, and the control effectiveness is greater. Therefore, stick movement must be relatively less, and its return after movement in any direction must be quicker."

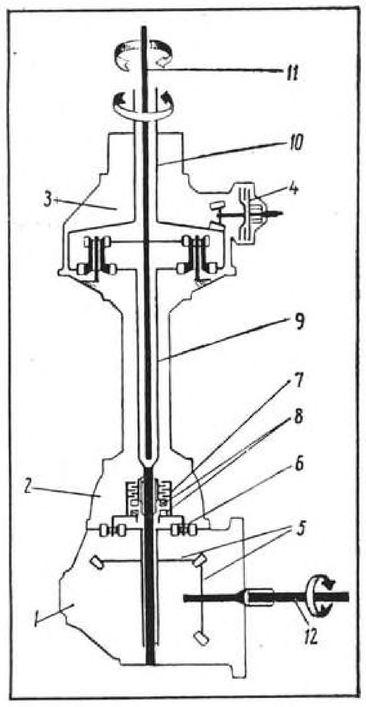
Range Increase

"The coaxial lifting system has other advantages. Because of the smaller loading on the disk of each rotor, when other conditions are equal an increase of about 15% in range and 20% in endurance is achieved.

"Getting into turbulence or in vortex ring state is also less dangerous with a coaxial helicopter."

Biryulin conceded that elimination of vibration is still a major problem on the Ka-15 and similar craft.

"The upper rotor is carried a long distance from the support on a comparatively thin and flexible shaft. It is very susceptible to manufacturing discrepencies and variations which show up during the craft's operation. Adjustment of the coaxial rotor system



TRANSMISSION arrangement: 1—Motor reducing gear; 2—Combination clutch; 3—Distributing reducer; 4—Rotor brake; 5—Bevel gears; 6—Planetary reducer; 7—Friction clutch; 8—Ratchet clutch; 9—Drive shaft; 10—Lower rotor shaft; 11—Upper rotor shaft; 12—Engine crank shaft.

is more complicated than is the case with a single-rotor system."

Biryulin also admitted that placing rotors one above the other "creates a danger that their blades will strike when they are turning at slow speeds or when they are hit by gusty winds while stopped."

This problem, he declared, can be minimized by close observation of operating instructions.

Thor IRBM School Opens at Tucson

Tucson—Douglas Aircraft's Tucson Municipal Airport facility has been formally opened as a Thor intermediate range ballistic missile school for USAF and Britain's Royal Air Force personnel.

Program represents a consolidation, in the interests of economy, of training activity which has been under way for some time at manufacturing facilities and other locations.

Entire program is under contract to Douglas from USAF's Air Training Command.

Approximately 90% of enrollment will be RAF personnel. Both officers and enlisted men will comprise classes which will average 100 trainees. Upon completion of course, trainees will be integrated with missilemen trained at facilities provided by associate Thor contractors—General Motors' AC Spark Plug Division, Rocketdyne, and General Electric Co.

Science Conference Draws 480 Students

Los Angeles—West Coast Student Conference of the Institute of the Aeronautical Sciences held here recently drew some 480 registrants from colleges and universities, more than double the number of earlier years.

Eight undergraduate and two graduate papers were presented at the conference with Tom Vincent of Oregon State College winning in the undergraduate category for his paper on "An Experimental Verification of Static Stability Predicted by Nonlinear Column Theory."

Malcolm Lock, graduate student at California Institute of Technology won the graduate division for his paper on "Panel Flutter."

Conference included plant tours and banquet at which awards were made.

Wright Replacing Cap On Turbo-Compound

Heat resistant alloy steel cooling cap on the power recovery unit of the Wright R3350 Turbo-Compound engine has replaced the nickel alloy cap formerly used.

Purpose of the change is to extend the service life of the cap, which serves to discharge cooling air from the turbine section.

Power recovery section is a source of overheat problems on the engine (AW April 21, p. 39).

Constructed of N-155 alloy steel, new cap is expected to withstand the 1,250F exhaust gas temperatures for over 4,000 hr. of service.

Caps are fabricated from N-155 alloy tubing produced by the Alloy Tube Division of Carpenter Steel Co., Union, N. J.

Reprints Available

Reprints of Aviation Week's special report on magnetohydrodynamics at the following rates:

1-10 copies: 40 cents each.
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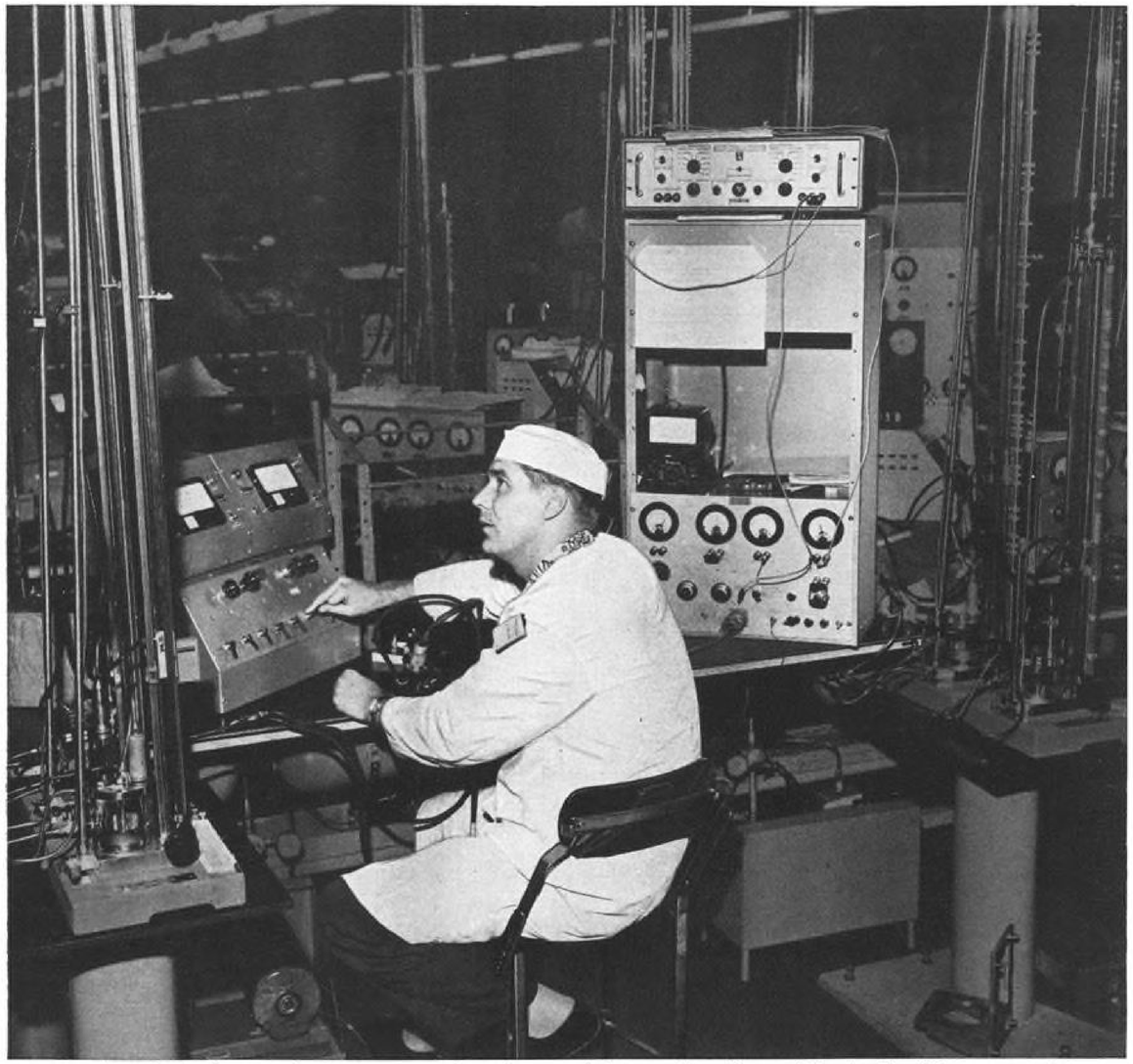

Honeywell's production department has 65 manometer stations using equipment of laboratory accuracy on a production basis. Hospital-clean assembly and calibration rooms and exclusive production techniques, such as Honeywell-developed welding processes for bellows manufacture, have made Honeywell's transducer facilities the finest in the industry.

They offer greater accuracy at less weight—they can be custom-engineered to your exact needs

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- Transistor or magnetic amplifiers.
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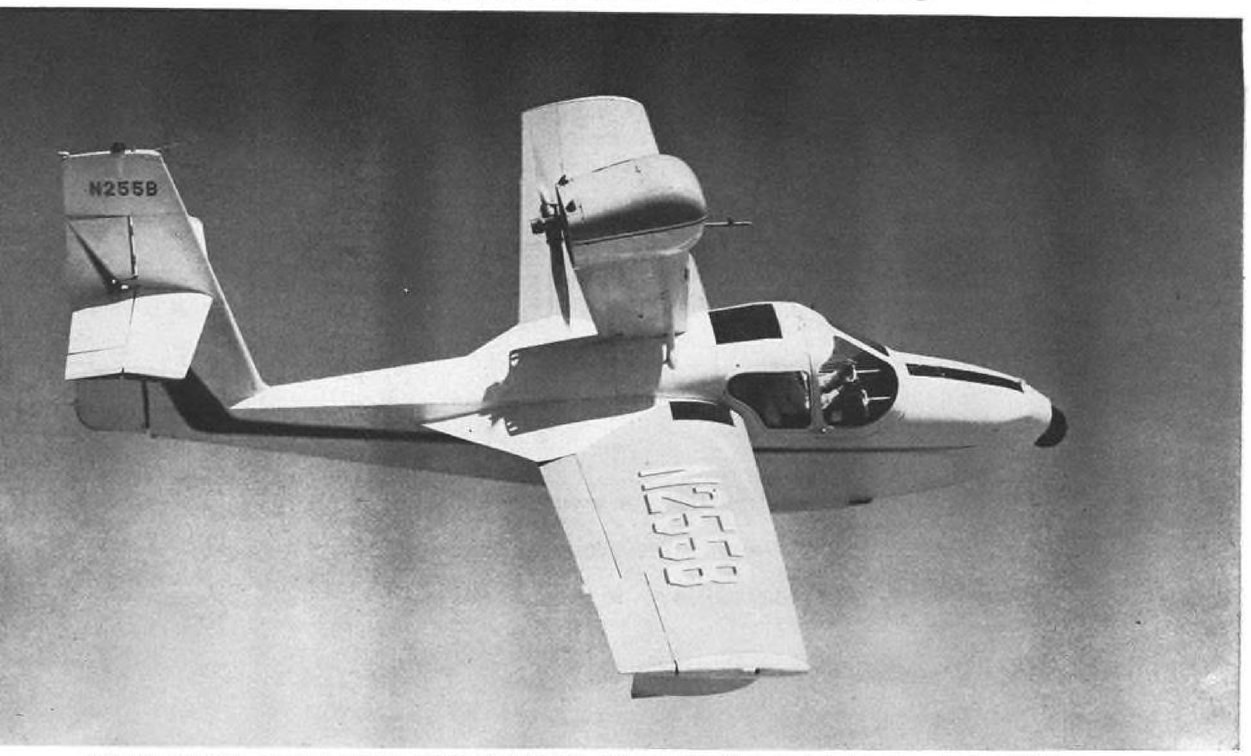
- No outside cooling required.

Honeywell currently has pressure transducer equipment flying in such aircraft as the F-89, F-100, F-101A, F-101B, B-36, B-50, B-66, CF-100, CF-105, KC-135, B-52, B-58 and various missiles and target drones.

For complete information on Honeywell Pressure Transducers write Honeywell, Military Products Group, 2600 Ridgway Road, Minneapolis 13, Minnesota.

Honeywell

Military Products Group



SKIMMER IV cabin, ahead of midwing, affords good visibility. Wing area is 157 sq. ft., including triangular-shaped fillets.

Aviation Week Pilot Report

Water-Stable Skimmer Lands 'Hands Off'

By Robert I. Stanfield

Teterboro, N. J.—Excellent short-field capabilities, along with extreme stability during water operation, are key features of Colonial Aircraft's new four-place C-2 Skimmer IV.

All-metal amphibian is powered by Lycoming O360-A1A engine generating 180 hp. at 2,700 rpm. at takeoff. Engine compression ratio is 8.5 to 1. Fuel grade is 91/96 octane. Pusher propeller is Hartzell forged dural, constant speed. Governor is Woodward.

Trim Difference

Engine location—above and behind leading edge of wing—results in trim change with application of power which is opposite to that encountered in conventional single-engine installation.

Performance characteristics evidenced during flight evaluation by AVIATION WEEK embraced:

• **Hands-off landings.** Water landings are a cinch, providing pilot doesn't try too hard. Actually, he must learn to do nothing. Amphibian requires no abrupt back pressure. Nose won't dig and airplane can ride on nose without tripping. Skimmer was landed "hands off" twice, did a fine job all by itself.

• **Water stability.** Despite gusty winds ranging from 20 to 40 kt., airplane maneuvered in river like a boat. There were no weathercocking tendencies. Ski-bottom floats add to cross-wind taxi capabilities; airplane won't tip in turns.

• **Short-field performance.** One-position slotted flaps, with area of 24.5 sq. ft., extend 80% of the span of the wings. Result: good lift, plus cushioning effect on landing. Airplane flew off hard-surface runway in slightly less than 300 ft.; was brought to stop—into 30 kt. wind—in slightly over 100 ft.

Skimmer is keyed to operation in low-water areas. Optimum cruise altitude—for best speed and fuel consumption—is 6,000 ft. Water operation is not recommended above this altitude because of power loss.

Trim looking amphibian is rather deceptive sitting on the ramp, appearing smaller than its actual size. Side of fuselage (chine) is but 17.5 in. from ground. Wide gear tread is 11 ft. 2 in. Gear, with long oleo travel, is a weldment of 4130 steel.

Powerplant is face mounted with steel weldment providing rigidity. Pylon provides fore-and-aft shear strength and torsional stiffness. External side braces provide for lateral loading.

Hull breaks down into four separate water-resistant compartment (with drain plugs), two of these being in nose. Midwing floats are sealed at top. Airplane's float bumpers and wing tips are plastic. Gas tank, in fuselage aft of passenger compartment, can also be classified as flotation device when empty or partially empty.

Airplane flown was N255B, first production model Skimmer IV which rolled out last September. Aboard was Jack Strayer, president of Amphibious Aircraft Corp., Teterboro, marketing organization for Colonial Aircraft Co.

With two aboard, plus instrumentation and navigation equipment, and 20 gal. of gasoline, airplane grossed out at about 2,084 lb. Maximum allowable gross is 2,350 lb.

Airplane was entered through windshield "door." Windshield is hinged in center. Either half can be raised up and over until it lays on other half. With cabin open, one can stand straight up in cockpit and, if necessary, step to bow of airplane during water exit.

Cabin is roomy and comfortable. Floor-to-ceiling height is 47 in. at rear, 43 in. in front. Width is 44.5 in. Length is 62.5 in. From back of rear seat to back of movable front seats, length is 30 in. Trunk at the rear of back seat will hold 30 lb. Entire cabin length could be increased to 82.5 in. by removing rear seat.

Accessories in bow can be easily reached. These include anchor and docking line, battery, and hydraulic reservoir, all in separate compartments.

Instrumentation and Controls

Skimmer's engine controls—throttle, pitch, mixture and carburetor heat—are located overhead, center, and are accessible from both seats. Flight instruments are located in front of pilot. Radio is center. Engine instruments are mounted to right.

Switches for lights, pitot and cabin heat, hydraulic pressure, generator, battery and anchor light are set in fuselage to pilot's left, along with control for mechanically activated water rudder. Circuit breakers run beneath switches. In addition to engine driven pump, electric fuel pump switch is available for starting, takeoff and landing.

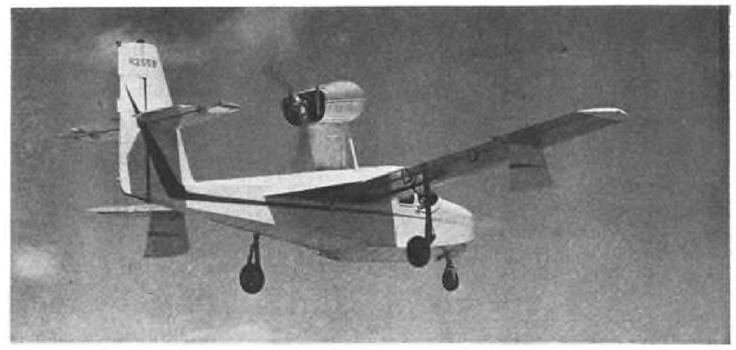
Also center mounted just below instrument panel are gear and flap handles, telescoping emergency hydraulic pump, and gear-flap indicator lights.

Spring-loaded hydraulic trim surface control handle, which springs back to neutral after trim application, is located on floor between pilot's seats, as is parking brake lock.

Engine started up quickly and the airplane was taxied out. Turns were a bit rough until I adjusted to a forceful and positive braking action. Brakes are on pilot's side; copilot's rudder pedals are for directional control only and can be folded down flush to floor for additional leg room.

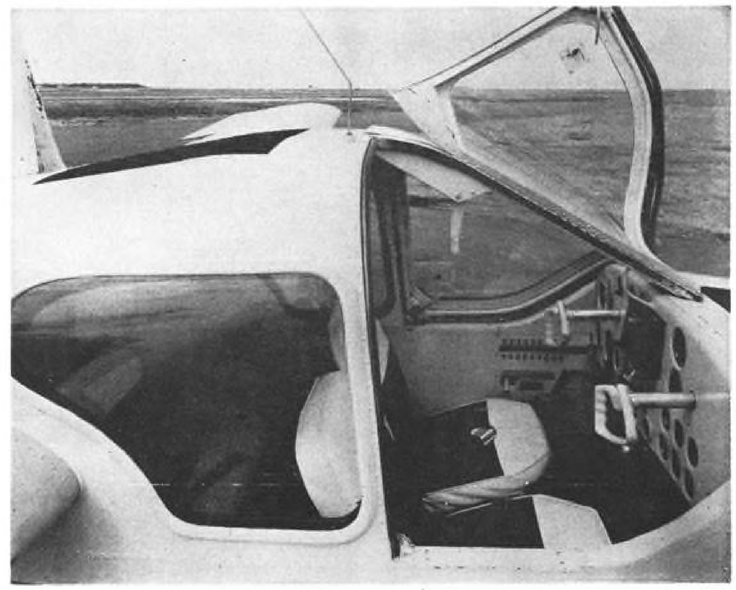
Lycoming engine has a tendency to ice up during taxi, and full carburetor heat was needed. There is no prop blast, due to pusher configuration, and at low taxi speeds air filter does not supply sufficient air.

Magnetos were checked and props run through at 1,800 rpm. Full flaps were dropped (there is only one position), carburetor heat was moved to cold, and airplane was ready to go. Wind was from the northwest at 20



C-2 gear, with long oleo travel, is weldment of 4130 steel; tread is 11 ft. 2 in.

AMPHIBIAN'S float bumpers and wing tips are plastic; nosewheel acts as buffer.



HINGED and watertight windshield folds over from either side; bow accessories are within easy reach. Cabin is 47 in. high, 44.5 in. wide and 62.5 in. long.

Colonial C-2 Skimmer IV Specifications

Engine	Lycoming 0360-A1A
Hp. and rpm	180 at 2,700
Propeller	Hartzell forged dural, constant speed
Gross weight (lb.)	2,350
Empty weight (lb.)	1,525
Useful load (lb.)	825
Wing span (ft.)	34
Wing area (sq. ft. including fillets.)	157
Length (ft.)	23′ 6″
Height (ft.)	8′ 10″
Wing loading (lb. sq. ft.)	15
Power loading (lb./hp.)	13.1
Flap area (sq. ft.)	24.5
Fin area (sq. ft.)	17.33
Stabilizer area (sq. ft.)	15.73
Elevator area (sq. ft.)	8.75
Rudder area (sq. ft.)	5.42
Trim surface area (sq. ft.)	3.75
Fuel capacity (gal., 91/96 octane)	40
Baggage capacity (lb.)	30

Skimmer Performance

Max. cruise speed (mph.)	130
Normal cruise speed, 75% power (mph.)	125
Stalling speed (mph.)	52
Rate of climb speed, flaps down (mph.)	75
Rate of climb speed, flaps up (mph.)	90
Rate of climb (fpm.)	800
Cruising range (mi.)	500
Fuel consumption (75% power, gph.)	9
Optimum cruise altitude (ft.)	6,000
Service ceiling (ft.)	14,000

kt., with gusts up to 40. Sea level pressure was 30.06 in. Outside air temperature was 66F.

Once Skimmer started to roll it had immediate directional control; no braking was necessary. Airplane picked up speed quickly and was airborne, with slight back pressure, at 65 mph. Takeoff run was less than 400 ft. pulling 27 in. manifold pressure and 2,700 rpm.

With gear up, power was reduced to 26 in. and 2,600 rpm. Amphibian was held to initial climb speed of 75 mph. Flaps were raised with no appreciable sink, and airplane climbed out at 90 mph. Rate of climb was 1,000 fpm.

During climb Skimmer was deliberately pulled nose high. Steepness presents no hazard and it wouldn't be easy to stall after takeoff. With buffeting and early warning sound of Safe Flight stall indicator, nose was eased forward and climb-out continued.

Cabin sits well ahead of the wing, and big windshield area makes for good vision ahead, to the side and down, and aft. Turning around I could observe movement of horizontal trim surface.

Stability was good during climb and the airplane responded quickly to light control pressure. Skimmer requires minimum amount of elevator control.

With engine high and to the rear of cockpit, easy conversation was possible; noise level was moderate.

Airplane was leveled off at 2,000 ft. and headed for nearby Hackensack River. At this altitude, with 75% power—24.5 in. and 2,400 rpm.—indicated air speed was 125 mph. Approaching the river, engine-out procedure was simulated.

Power was cut back, full carburetor heat applied, and full flaps dropped. Lowering nose, trim was set and Skimmer spiraled down at 85-90 mph. Approach wasn't too steep and control was good. Airspeed was held on high side because of strong gusts.

Airplane was held off over water until ready to stall in. Controls were released and I simply sat back. Skimmer, with big flap area, seemed to hover slightly before dropping in. Water was somewhat choppy and windshield caught a bit of spray, but there was no digging of hull nor was there any bounce tendency. No back pressure is necessary.

Propeller sits high enough to be immune from water spray, as well as gravel, stones, etc., picked up on runway. Height, plus protection of wing, also shields prop and engine from salt spray.

Maneuvering with water rudder down is easy, as the amphibian won't tip running crosswind. Boat hull holds well in water and wing floats have good balancing effect. Skimmer has been flown off in circular turn, but with heavy gusts and chance of catching a wing at pull-off, the maneuver was postponed.

Additional safety feature in water operation is nose wheel, which with tire running ahead of nose (in up position) acts as buffer. Gear was designed to take abuse. It is lowered in the water for run to and up shore when necessary. Corrision, which is a salt-water problem, is offset by extensive grease fittings.

With but slight back pressure, Skimmer flies itself off water. Elevator control provides good longitudinal control at low hump speed on water. Amphibian will usually get off at 65 mph. With a little backstick to hold nose out, then forward, the airplane went off at 70 mph. after a short run. Again, because of gusts, speed was held higher than normal.

About six water landings were shot, all with good results. Skimmer has even been landed in water with gear down. Airplane didn't turn over because of main gear's backward position, plus location of flotation area (forebody) ahead of wheels.

Stall Characteristics

Skimmer was stalled power on and power off, with gear and flaps down. With the engine pulling 24.75 in. and 2,400 rpm., the nose was up fairly high before pre-stall buffeting and stall warning occurred.

Stall came at about 50 mph. but

Converted Navion Cruises at 185 Mph.

Navion conversion developed by Tusco Corp., Houston, Tex., features 240-hp. Continental engine, McCauley constant-speed propeller, 34-gal. tip tanks, wing-to-fuselage fairings, flush riveted wings. Tusco reports that its new Model D Navion has continuous cruise speed of 185 mph. and climbs at 1,010 fpm. at 3,150-lb. gross weight. Gross weight service ceiling is given as 17,400 ft. CAA-certificated Model D also provides entrance to cockpit over wing trailing edge, a step being provided in the wing flap. Plane has cabin arranged to seat five people.

ICBM:
An artist's conception

in missiles...

among scientific, military, government and industry men . . .

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In the rapid-paced, dynamic field of space technology, missiles have captured the imagination and attention of the world. And because Aviation Week editors were on the scene when the first missiles were developed, they know what efforts in research, development and engineering work lie behind the missiles now on the way up. This perspective, this ability to correlate, this awareness of a great industry behind the biggest headlines and smallest component account for Aviation Week's accurate reporting of current events and deep insight into the future.

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there was no clear break and fall-away; rather a combination of buffeting-hovering which ceased when nose was lowered and speed increased. Altitude loss was nil, lateral control good.

Power-off stall, according to specifications, could result in loss of 250 ft. With flaps and gear down, stall again was preceded by buffeting and stall warning which preceded break by 7 to 10 mph. Break was smooth at 50 mph. and altitude loss was negligible. Low stalling speed is attributed to large, slotted flaps.

Stability and control of Skimmer were excellent during all flight phases. Elevator control is sensitive at flight speeds; airplane, because of powerful trim requirements, employs separate set of longitudinal control surfaces.

Control system motions are transmitted entirely by push rods with the exception of a short length of chain and cable in the aileron system at the control wheels. Longitudinal trim surfaces are hydraulically controlled. Trim surface—3.75 sq. ft. in area—limits amount of control surface on elevator and prevents over-controlling.

Skimmer was next flown through several hard-surface landings, with time out for additional gasoline.

Fuel Consumption

Amphibian averages 9 gal. per hr. fuel consumption. With 40 gal. of fuel, this would allow 4 hr. of cruise and reserve of about 26 min. Range, at normal cruise of 125 mph., would approximate 500 mi. plus reserve.

Airplane is redlined at 146 mph. Gear and flap speed is 125 mph. With gear and flaps down, and holding 90 mph. on approach, rate of descent can be fairly steep with power off. Getting into a tight area wouldn't be hard.

Four landings were shot. Airplane sits low, and there is a tendency to level off too high. Amphibian will cushion itself down after roundout, and it used no more than 400 ft. of runway.

Short-field landing, as mentioned earlier, was made in about 100 ft. into 30 kt. wind, with prop in flat pitch. Strayer demonstrated this one. Descent was steep enough to override normal obstacles, and airplane settled quickly after flare-out. Only moderate braking was necessary.

Skimmer's hydraulic system is based on desire to keep hydraulic fluid out of engine compartment. Accumulator provides rapid actuation of gear. Electric pump charges accumulator up to 1,100 psi., at which point the electric motor is stopped by pressure switch. When gear, flaps or longitudinal trim surfaces (also hydraulically controlled) are operated and pressure drops below 750 psi., the electric pump automatically starts and recharges the accumulator.

Electrical system is a straightforward 12v. system, circuit breaker protected.

Hull structure consists essentially of upper and lower longerons and keel with transverse frames and outside platings. Aluminum alloy (24 ST) is used almost exclusively for spars, ribs, frames and external covering. Hull skin is .051 gage. Corrosion protection is via alodine treatment and zinc chromate priming of all aluminum parts prior to assembly.

Wing lift bending is carried by a single spar at the 25% chord point. Inner portion of the beam is built up with 14 ST extruded spar caps and 24 ST web. Outer portion is a 24 ST built up channel system.

Two jack points, one under each wing, are keyed to main wing spar. Chordwise bending strength is provided by an additional spar along the trailing edge of the wing. Control surfaces consist of a beam to provide bending strength, with metal outer skin providing required torsional rigidity.

Large triangular-shaped wing-fuselage fillets add to Skimmer's trim appear-

Bethlehem Steel Convairs Get Longer Range

Bethlehem Steel Corp.'s two Convair 440 executive transports have been reworked by Pacific Airmotive Corp. to provide transcontinental range. Standard Convair integral wing tanks were extended to a point halfway between the furthest outboard wing rib and the wing tip, providing increase in fuel capacity from 1,730 gal. to 2,080 gal. Standard oil tanks were increased by 6 gal. each to 36 gal. Planes arrived at Pacific Airmotive bare except for cockpits. Pacific Airmotive applied Lockfoam styrofoam soundproofing, building plywood molds to contain the liquid until it hardened. Lockfoam was forced under pressure through holes drilled in plywood molds. Quarter-inch padding was cemented to entire inner cabin. Modification company says tests reveal average sound reduction of 20 decibels compared with standard Convair soundproofing. Floor structure was modified to take special swivel chairs and divans. Bethlehem's 440s can seat up to 20 persons each. Planes are fitted with Bendix RDR-1B-1 X-band weather radar.

ance. Fillets are necessitated because of negative pressure condition induced by propeller inflow.

Basic price of Skimmer is $21,780. Standard equipment includes stall warning indicators; basic flight instruments plus manifold pressure gage, sensitive altimeter and rate of climb; towbar, paddle and anchor; and four air vents for each of the cabin windows.

Optional equipment embraces dual controls, specialized instruments, radio equipment, heater, twin landing lights and electrically heated pitot. Instrumentation package deal is in the works, as an average sale includes about $2,000 worth of accessory equipment.

Colonial figures that with five-year depreciation, insurance, hangar rent, direct operating costs and set-aside funds for anticipated maintenance plus engine and propeller overhaul, Skimmer IV can be operated for less than $17 per hour if utilized 600 hours per year. Operating costs, for two persons, are estimated at 7¢ per passenger mile.

C-2 was certified by the CAA on Dec. 18, 1957. Orders were taken in January and the third and fourth airplanes were delivered last month. Firm orders total 16, with next delivery scheduled for mid-September. Company is working against permanent three-month backlog of 10-12 airplanes.

By November of 1961 the firm hopes to be turning out 17 aircraft a month—roughly 200 a year. Skimmer dealers in the U.S. now number eight. Amphibious Aircraft plans to add seven more for a total of 15. Top markets for the amphibian are low-altitude water areas in the U.S., Central and South America. In addition to sportsman and executive use, Amphibious Aircraft is not discounting airplane's applicability for off-shore oil operations.

Earlier three-place C-1 Skimmer, of which 25 aircraft were sold between September, 1956, and August, 1957, probably will be discontinued in favor of the C-2 Skimmer IV.

PRIVATE LINES

Robbins Aviation Corp. has been formed as result of reorganization of former Executive Aircraft Corp., Pontiac, Mich. Firm holds Lycoming and Aero Commander distributorships. New offices and fully-equipped radio repair facility are being built.

Junior Jato unit, developed by Aerojet-General, delivering 250 lb. thrust for additional takeoff power, has been issued an aircraft engine type certificate by Civil Aeronautics Administration. Unit, designed for single or multiple installations in aircraft of up to 10,000 lb. gross weight, delivers equivalent of 100 hp. for 15 sec. duration, weighs about 50 lb. installed.

Beech Aircraft Corp. has been awarded a $2 million contract from USAF for additional T-33A trainer wing assemblies, extending this production through spring of 1959.

Wrap-around shop installation, built by Remmert-Werner, Inc., reduces time on 100-hr. inspection for DC-3 to one day, firm reports. Designed on basis of motion and time studies, units put most of needed shop facilities close to the job, have been installed at its St. Louis, Toledo and Pompano Beach bases.

Number of airports in New York State increased by 10 in 1957 for a total of 275 landing facilities, Department of Commerce reports. Latest list shows 46 municipal fields, 174 private and commercial fields (up 13 over previous year), 11 military air bases, 37 seaplane bases and seven heliports (three less than in 1956).

Bureau of Reclamation of Department of Interior has taken delivery of its Aero Commander, a Model 680 Super, which is fitted for aerial photo work. Based in Denver, Colo., the plane will be operated from short fields, adjacent to dam and power plants.

De Havilland DHC-3 Otter serves as a flying testbed for a model of the de Havilland DHC-4 Caribou utility aircraft.

Twin-Engine Caribou Undergoes Testing

First prototype of the DHC-4 Caribou twin-engine utility aircraft is shown being fabricated by de Havilland Aircraft of Canada Ltd. at Downsview, Ontario (below). Second prototype is expected to be rolled out by next month. Five orders have been placed by the U. S. Army for the Caribou. Model at right is painted in Army olive drab. Model at right, below, is painted in white and a luminescent red, a color combination the Army is using on aircraft flown in Arctic or tropical regions. U. S. Army Caribous will have Pratt & Whitney R2000-4 engines producing 1,450 hp. at 2,700 rpm. for takeoff. Payload will be between 6,000 and 7,320 lb.

Industry Team Bids on USAF Project

By Craig Lewis

Dallas—Weapon system group has been formed by Temco Aircraft Corp. and six other companies here to prepare a bid on a unique weather reconnaissance system planned by the Air Force. Formation of the group points up some changes in the technical and management setup in the aircraft industry.

Temco group is the latest sign in a trend toward group efforts on weapon systems first observed in AVIATION WEEK a year ago (May 6, 1957, p. 69). And it's a trend that has strong support from the Air Force.

For the companies involved, these team efforts mean a chance to participate in contracts for military systems too big and complex for them to handle themselves. Benefits aren't confined to the smaller companies. Groupings of aircraft industry giants bidding on the Dyna-Soar project show that for the Air Force, these teams mean more economical use of industry facilities and capabilities and less money spent on building new facilities and developing new technical skills when these skills already exist.

With this group effort, any combination of skills needed can be brought together when the team is being formed. This cuts into the former practice of developing needed new skills at USAF cost in single companies working on complex systems.

USAF has supported this in various ways. One was a letter to Aircraft Industries Assn. from Maj. Gen. William T. Thurman, Deputy Director of Procurement and Production. In this letter, which was distributed in the industry, Thurman observed that growing complexity of weapon systems will increasingly require proposals from system manager and subcontractor combinations from the airframe, propulsion, electronics and allied industries.

General Thurman said that "it would appear that such prime contractor-subcontractor combinations could offer the possibility of developing superior products with a more economical use of existing industrial and engineering resources. Particularly, this should reduce requirements for establishing new facilities and developing engineering capabilities which duplicate existing resources in other companies."

Thurman also laid down a management challenge. He pointed out that one of the big problems with these industry combinations lies in the integration of management efforts in a way which gains all the advantages of the team approach, yet retains the essential single point of responsibility of the weapon system manager.

"The development of management concepts and procedures which will achieve these objectives should be a major challenge to the aircraft and allied industries," he said.

Navy's Anti-Submarine Version of Electra

Model shows configuration of Navy anti-submarine warfare version of the Lockheed Electra turboprop. Bulge under fuselage is for radar installation. Plastic tail cone would house magnetic airborne detector (MAD). Aircraft would carry crew of ten. Lockheed has a $2 million contract for research and development prior to production of the aircraft.

It appears certain that the management capabilities of bidding groups will be increasingly important factors in the awarding of contracts for major systems. Not only will companies have to propose the best technical solution to a weapon system problem, but they will have to show that they have the plans and skills to make a success of managing the weapon system program once they get it.

To prepare a bid for the new USAF weather reconnaissance system in this climate, Temco has formed a weapon system group with Northam Electronics Inc.; Radiation Inc.; Electronic Communications Inc.; American Institute for Research; Goodyear Aircraft Corp. and Aerophysics Development Corp.

The system this group is working on represents a more sophisticated approach to weather forecasting and research than anything now used. It is "a gross extension of the state of the art" in the words of I. Nevin Palley, senior vice president of Temco.

System will operate in a large transonic jet of a current type, one that will fly at speeds to Mach .95 and altitudes to 50,000 ft. No airplane is specified, but it is obviously in the Boeing 707 or Douglas DC-8 class. The system is to be ready in the 1963-70 period and has to be compatible with other states of the art in those years.

Data Transmission

Operations will involve such functions as meteorology, geophysical measurement, use of radar for searching clouds and storm centers, microwave capability and data gathering, storing and processing. Also involved are the problems of the transmission of data from high speed aircraft over long distances and the logistics of operating such a reconnaissance system.

Weather reconnaissance system must be designed for operation under all conditions by technically unsophisticated airmen. It involves ground stations as well as a flying system, and it may involve the whole cycle of overhaul and modification so that improvements could be made by the people who designed and built the system.

The system will be used in a worldwide weather reconnaissance operation operating on a patrol principle. Information is to be transmitted to ground stations all over the world. United Nations currently sponsors a group—World Meteorological Organization—which provides for exchange of weather data, and this USAF system would be compatible with the international system.

Convair Assembles F-106 All-Weather Interceptors

Convair Division of General Dynamics Corp. assembles F-106 supersonic interceptors for USAF's Air Defense Command, San Diego, Calif. Aircraft above are single-seat F-106As. Two-seat F-106B recently made first flight at Edwards AFB, Calif. (AW April 21, p. 33).

In contrast to present techniques of merely measuring what happens to weather, the reconnaissance system would feed its information to computers to find out something about it—to get a broader, more basic picture. The system could do basic weather research at high altitudes along with simple forecasting.

This orientation back toward the basic sciences in weather reconnaissance is made possible by advances in computer art in recent years.

Unlike such projects as missile systems, the technical envelope for this weather system can't be very strictly defined.

This fact gives the contractor more flexibility and more responsibility in his design and development work.

In many ways, the weapon system group Temco and its associates have devised is similar to the current weapon system manager concept, but it carries the team idea a step further by having the team work together from the start rather than forming it after the prime contractor-weapon system manager is awarded a contract.

This approach gives Temco the benefit of industry-wide skills and a broader view of the situation. It also provides the technical competence and background Temco will need as the central agent bidding for the systems contract without the need for expanding into new areas. And the advantages are not all technical. The financial resources of such parent firms as Goodyear, Curtiss-Wright (Aerophysics Development Corp.) and Norris Thermador Corp. (Northam Electronics) add to the stature and stability of the group.

Advantages in the arrangement to Temco's associates are varied, but an important one is the chance to participate in systems work it couldn't get on its own. Electronic Communications, for instance, had been looking for a program like the weapon system group. It is attractive because it allows ECI to broaden the scope of its operations and get into business it couldn't otherwise touch.

Another advantage lies in the fact that each company is participating in the design from the start. This means the system will have the benefit of the latest knowledge in each special field, and each company can draw on the specialized skills of its partners. When a specialized company is in on the design phase, it doesn't get saddled as a subcontractor with components which suffer from the inexperience of a prime contractor.

The associates draw a financial advantage from participating in the original design job. They get a share of the system from the beginning and aren't confined to bidding on a cost basis for parts of the system the prime contractor subcontracts after he has quite naturally kept the most profitable components and subsystems for himself.

Palley points out that one of the major advantages of the group to the Air Force would be the fact that it avoids duplication of scientific staffs and facilities and cuts recruiting and training costs. Design work now is being done at Temco, and if the contract is awarded, components will be built at each associate's home facility and integrated at Temco.

Palley also says that use of a group of smaller companies avoids the inertia

of large company structures and gives USAF an organization that can move quickly, yet has the resources of large company magnitude.

These arguments coincide with Air Force thinking as cited in the Thurman letter and elsewhere. Different manifestations of this can be seen in USAF efforts to blend skills in the root engine field, rather than creating new ones. AVIATION WEEK has noted the recent trend to mergers in this field, including such moves as the formation of a new company, Astrodyne, by North American Aviation and Phillips Petroleum (AW April 14, p. 55).

The process of forming a combine like the Temco group involves considerable intercompany investigation and analysis. Discussing their appraisals of the firms involved, members of the group said "we probed their souls bare." Complete knowledge and understanding of each other was essential in the decision to choose each company best qualified in its area.

After eliminating a number of firms in the process, here are the companies the Temco group wound up with and the functions they will perform:

- **Goodyear provides** radar capability for reconnaissance of clouds and storm centers. Company has capability in a specialized field of radar that applies to the weather system.
- **Radiation Inc.,** is in the field of digital computers and recorders and provides capability in information theory and data processing for airborne systems.
- **Aerophysics Development** will work on the flexible, automatic test and checkout gear which will be needed to make in-flight checks of system components and to make automatic decisions on the equipment tested.
- **Northam Electronics** specializes in sensors and measurement instruments and will provide capability for measuring meteorological and geophysical conditions.
- **Electronic Communications** will work on the problem of data transmission to a ground readout which will provide data in a usable form for weather observers.
- **American Institute for Research** will handle the human factors problems involved in the operation of a complex system.

Group members have had to subvert competitive instincts in many areas. In the case where capabilities overlap, one company does the job, and the other firms are limited to backup support.

Group has been working together at Temco since April under terms of an interim agreement. The agreement specifies that Temco is responsible for preparing and submitting the group bid and that the associates are responsible for developing their selected areas of the proposal and for providing Temco with management, technical and cost data related to these areas. Each company is paying its own expenses in the group effort, and costs largely are salaries of the people involved. Provision is made for Temco to pay Northam and American Institute for Research for special help in connection with Temco's share of bid responsibility.

Agreement calls for free exchange of proprietary information, but limits use of such information to the current project. If a patentable idea is developed to a practical degree during the bid proposal program, it remains the property of the participating inventor, but other members of the group get non-assignable, non-exclusive license to use the invention on a royalty basis.

A Policy and Progress Committee has been established with Palley as chairman and includes one management representative from each associate. Committee oversees the bid effort and can make recommendations to Temco in Temco's preparation of the proposal and negotiations with USAF.

Veto Power

Palley has veto power on any suggestion made by the committee to Temco, but a dissatisfied associate can have the chairman's decisions reviewed by two officers of Temco other than Palley.

Provision is made for withdrawal of an associate in extreme circumstances. If one of the companies wants to leave the group, it can present its case. Then if Temco top management and two thirds of the associates concur, the firm can withdraw under terms defined by Temco. These terms are not to include any form of payment of consequential damages.

The group can also eliminate one of its members under the agreement. After full decision of the circumstances among Temco, the committee and the associate, the decision rests with Temco. No claim for damages is allowed unless the termination can be proved capricious and in bad faith.

If an associate leaves voluntarily or involuntarily while the Temco bid is still in competition, the associate cannot join a competing group or divulge any information concerning the Temco proposal. Temco decides who will do the job left by a withdrawing associate, and provision is made for acquiring new associates.

The interim agreement covers the period of joint bid activity and negotiation with USAF until a decision is made. If the Temco group gets the contract, the arrangement moves toward a more conventional weapon system manager concept.

If a contract is awarded, Temco will be the central agent which has dealt with the Air Force and will be the prime contractor. At that point, each associate will negotiate a subcontract with Temco covering its own area of the reconnaissance system. Harmony in the joint efforts among the associates then becomes the result of moral ties between them, rather than a responsibility set down as it is in the interim agreement.

The Policy and Progress Committee will continue throughout the duration of such a prime contract, although provision is made for any modification warranted by new circumstances.

Formation of the weapon system group for the weather reconnaissance system reflects Temco's orientation toward the aerial reconnaissance field as an area of specialization. The company has produced an airborne reconnaissance system for the Navy and has built up a quick reaction capability in its aircraft modification program.

This quick reaction capability involves doing a fast job of putting electronic systems into modified aircraft and turning them around quickly. In connection with this, Temco built an antenna laboratory and developed a capability in that field. All these moves headed Temco in the direction of airborne reconnaissance skills and the current competition.

Temco has also been intensely involved in building an engineering management organization. In 1954, the firm started to build up a weapon system engineering setup. This organization won the TT-1, XKDT-1 and Corvus contracts for Temco, proving itself as an effective vehicle for obtaining contracts.

A more sophisticated organization was needed for managing the contracts after they had been won, so the engineering department was reorganized along program management lines, and Gen. Robert E. Galer USMC (Ret.), was brought in to manage Corvus and other programs. General Galer had been Director of the Guided Missiles Division of the Navy Bureau of Aeronautics.

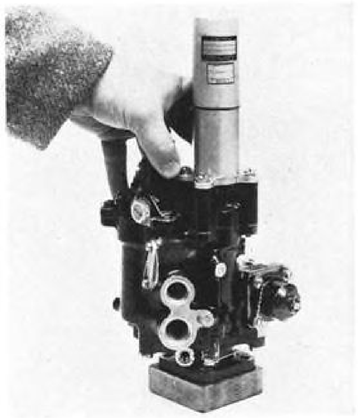
In May, Temco took a further step in this direction when it promoted Palley from vice president, engineering to senior vice president and named General Galer to the engineering vice presidency.

Correction

American Machine & Foundry Co. is producer of the launcher for Bomarc, Boeing's surface-to-air missile. On page 95 in the May 26 issue of AVIATION WEEK, American Car & Foundry was incorrectly named builder of the Bomarc launcher.

American Machine & Foundry, in addition to the Bomarc launcher, also makes the launcher for the Talos, Navy surface-to-air missile.

NEW AVIATION PRODUCTS

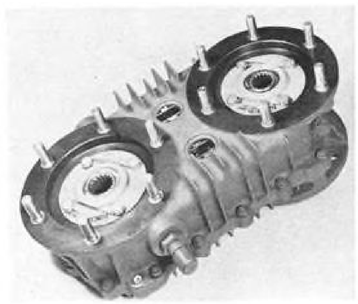


Fuel Control Unit

Fuel control for use on small gas turbine powered aircraft, missiles and target drones incorporates a pneumatic speed governor for constant speed from sea level to 60,000 ft.

Control is a unitized fuel system with a positive displacement gear pump, metering valve and by-pass valve. Several versions are available in weights of from 7 to 10 lb.

Chandler-Evans, West Hartford 1, Conn.



Accessory Gear Box

Universal type aircraft accessory gear box operates in a horizontal position, on either side of the engine.

Model 1126 gear box is said to operate at a maximum altitude of 35,000 ft. Design life is 1,000 hr. with environmental temperatures to 260F. Unit incorporates a self-contained lubrication system with sight level glasses for left or right hand operation. Input pad conforms to MIL and 10262 Type XII J. Output pad conforms to MIL and 20002 Type XII J. Designed for use of MIL-L-7808-C lubricant, unit has a lubrication service interval of 250 hr. Weight is 13.25 lb.

Western Gear Corp., P.O. Box 182, Lynwood, Calif.

Helicopter Spark Plug

Helicopter spark plug now available for commercial use has been in operation with USAF for the past year. Plug was specifically developed for Franklin aircooled engines used in Bell, Hiller and Omega helicopters.

The REL38B plug follows massive electrode design adopted by USAF. Approved for commercial use by the manufacturers of Franklin aircooled engines and the CAA, it is available through dealers.

Champion Spark Plug Co., Toledo 1, Ohio.

Scratch Microscope

Scratch investigation microscope is used for checking surfaces on missile surfaces, aircraft canopies, propeller blades and wing skins.

Portable instrument measures scratches up to .025 in. deep on flat or curved surfaces, to an accuracy of

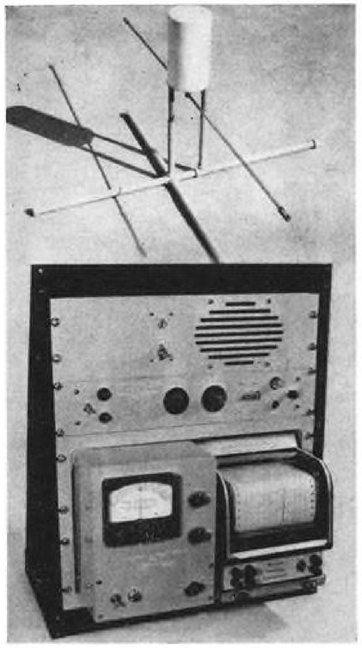
.001 in. Camera attachment is available which permits the making of photographic records on 35 mm. film.

Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill.

Lightning Warning System

Lightning forecasting system warns missile and aircraft flight testers and other lightning endangered workers of potential lightning danger.

System interprets atmospheric potential gradient according to a few objective rules. Gradient unit shows buildup of charges within 20 mi., and indicates lightning discharges. Unit consists of an all-weather radioactive probe for picking up air voltage, a stable electrometer-amplifier with semilogarithmic scale, and a recorder. System also includes a "sferics" (radio static type) lightning indicator and



counter which detects lightning at greater distances (60 mi.) but does not show charge buildup. Unit is available in several versions.

Meteorological Research, Inc., 939 E. Union St., Pasadena, Calif.

Air Duct Drain Valve

Valve automatically allows condensate to drain from pressurized air ducts. Valve is placed in duct system wherever condensate tends to collect. When system is pressurized the valve is automatically closed; unpressurized, valve opens allowing accumulated condensate

to drain out. Spring-loaded tungsten carbide ball remains closed under normal active duct pressure and opens when duct pressure is reduced to from 2 to 10 psi. Valve body is made of stainless steel.

Barber-Coleman Co., Aircraft Controls Division, Rockford, Ill.

British Accident Investigation Report:

Flap Bolt Failure Caused Viscount Crash

Early in the afternoon of March 14, 1957, the Vickers Viscount aircraft G-ALWE (generally known as "W.E." or "Whisky Echo") crashed while approaching to land at Ringway Airport, Manchester. The aircraft was owned and operated by British European Airways and was reaching the end of a scheduled passenger-carrying flight from Schiphol Airport, Amsterdam, with a crew of five and 15 passengers. As a result of the accident all the crew and passengers and two other persons were killed.

Until the aircraft was roughly a mile from the threshold of the runway it was apparently making a perfectly normal approach, then it made a banked turn to starboard and continued to descend until the starboard wing tip struck the ground. With the starboard wing furrowing the earth and breaking up, the aircraft, obviously completely out of control, went on until it struck some houses, demolishing two of them (in one of which a woman and her infant son were killed).

The aircraft came to rest in the ruins of the houses and immediately caught fire and set fire to the houses. The position of the final crash was about 900 yd. short of the runway and 200 yd. to the right of its extended center line.

The weather was fine and the visibility good. The aircraft had been properly maintained and the load carried was comparatively light and was correctly balanced. The captain and first officer were experienced and highly competent pilots. Although there were no survivors from the aircraft, it is clear from the evidence of eye-witnesses and from the communications which took place between the aircraft and the ground that all was apparently normal until, at the most, half a minute before the crash.

An eye-witness of the accident noticed a deformation of the flaps of the starboard wing just before the aircraft began its banked turn. Careful examination of the wreckage has revealed that a bolt and a fitting which constituted part of the support of these flaps had broken before impact. An elaborate technical investigation was subsequently undertaken and has shown conclusively that a structural failure occurred and that the probable effect of this would be to cause the aircraft to make a banked turn to starboard.

I had to consider whether there was anything that the pilot or copilot could have done to keep the aircraft under control. At no stage of the inquiry was it suggested by the Crown or any of the parties that the pilots were in any way at fault. The reasons why they were in all probability prevented from doing anything to save the aircraft depend on the detailed evidence which will be dealt with later in this report, but I desire to make it clear at the outset that I am satisfied that there was no error of any kind on their part.

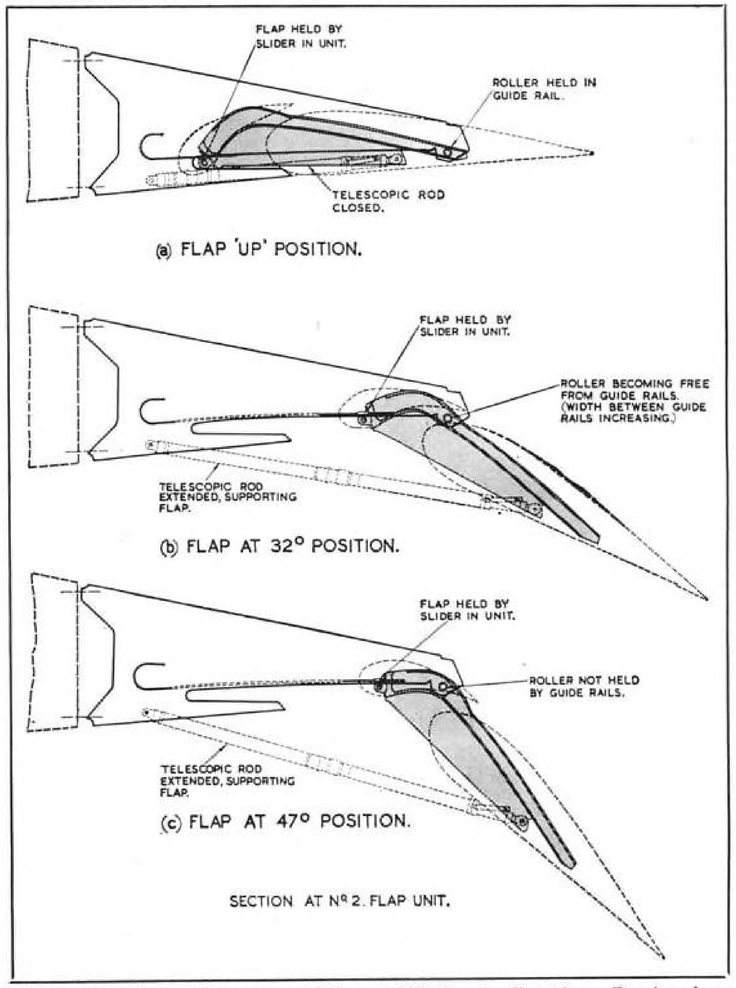
The fire and rescue services arrived at the scene with the utmost promptitude but because of the fierceness of the fire there was no possibility of saving any lives, even if any of the occupants of the aircraft were not killed immediately on impact.

The most difficult part of this inquiry has been to ascertain the precise cause or causes of the structural failure. On this matter certainty cannot be achieved but with the guidance of my assessors I have been able to form a definite opinion as to the probable course of events. There were several circumstances so unusual that a combination of similar factors is most unlikely to occur again. But lessons have been learnt from this accident which have resulted in additional precautions being taken in several directions.

Because it was apparent soon after the accident that a structural failure might be involved, measures were taken to ensure that all Viscount aircraft then in operation should, within a certain time, be submitted to certain examinations. I have had to consider whether these steps were sufficiently prompt and vigorous.

Once it was decided where the weakness lay, a modification was introduced which, as was accepted by all parties at the inquiry, was sufficient to ensure that a failure at the same point would not occur again.

W.E. was a Viscount 701 type aircraft manufactured by Vickers-Armstrongs (Aircraft) Ltd., in 1952 and delivered to British European Airways Corp. Jan. 3, 1953. A Certificate of Airworthiness was granted on Nov. 20, 1952, and was annually renewed and was in force at the date of the accident. The aircraft was maintained according to maintenance schedules approved by the Air Registration Board.



TELESCOPIC rod extends to support Viscount 701 flap in all settings. Drawing shows flap operation from full up position to 47 deg. down at No. 2 flap unit.

This maintenance involves a pre-departure inspection prior to each flight; a Check A within 24 hr.; Check 1, after a period not exceeding 135 flying hours; Check 2, not exceeding 520 flying hours; Check 3, not exceeding 1,040 flying hours; Check 4, not exceeding 1,500 flying hours. Each of the Checks 2-4 is more rigorous than the preceding check and includes all the matters included in the previons check and some additional ones. After each Check 1, 2, 3 or 4 another check has to be made after not more than 135 flying hours. After a Check 4 the rotation begins again. Following each Check 1, 2, 3 and 4 a Certificate of Maintenance is issued. On Aug: 8, 1957, following a Check 2, a Certificate of Maintenance of W.E. was issued (signed by a currently licensed engineer) which by its terms was valid for 31 days or 115 flying hours. The 115 was a clerical error for 135 but this is unimportant because the accident occurred only six days after the check and the hours flown since the check were only 23½.

The pre-departure inspection includes a visual check of the control surfaces and flaps to see that they are free from damage. Check A includes the same matters and also a check of flap operating mechanism for flap extension at the 40 deg. position.

Checks 1, 2, 3 and 4 include examination of all flap falsework and fairings for satisfactory condition and security, examination of flaps and operation mechanism for satisfactory condition, correct synchronization, snug fitting, no fouling, adequate clearance between flaps and falsework and condition of guide channels and examination of inner plane structures internally and externally for satisfactory condition and security of components and pipe lines.

The first Viscount aircraft to be manufactured was a prototype 700. Certain modifications were then introduced and the type of aircraft so modified was called 701. W.E. was the first 701 type Viscount to be manufactured and was used by Vickers for flight tests and after delivery to B.E.A. was used to a considerable extent for the training of pilots—that is to say for teaching experienced pilots how to handle aircraft of this new type.

For this reason W.E. had had by March 14, 1957, more flying hours than any other Viscount except one and more landings than any other Viscount except another one, i.e. 6,902 flying hours and 4,553 landings as compared with 6,948 flying hours and 4,951 landings which were the highest figures among other Viscounts. The highest figures among other Viscounts in the B.E.A. fleet were 6,948 flying hours and 3,937 landings.

Last Flight

On its last flight the captain of W.E. was Capt. Thomas R. Breheny. He was in possession of a valid license entitling him to fly Viscount aircraft on scheduled passenger services. He was 39 years of age. He joined the Royal Australian Air Force in 1940 and flew mostly transport aircraft, retiring with the rank of flight lieutenant.

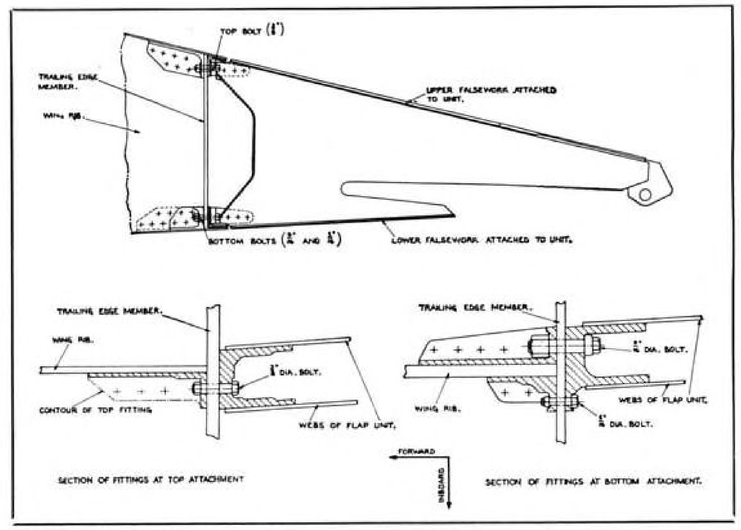
He joined B.E.A. in August, 1946, as a captain and in May, 1955, he completed a conversion course for Viscounts. He had flown with B.E.A. 6,951 hr., 1,051 of which were on Viscounts.

The first officer was Douglas Palin. He too was in possession of a valid license entitling him to fly Viscount aircraft on scheduled passenger services. He was 35 years of age. He joined the Royal Air Force in 1941 as a pilot on transport aircraft. He was awarded the A.F.C., and retired as a flight lieutenant.

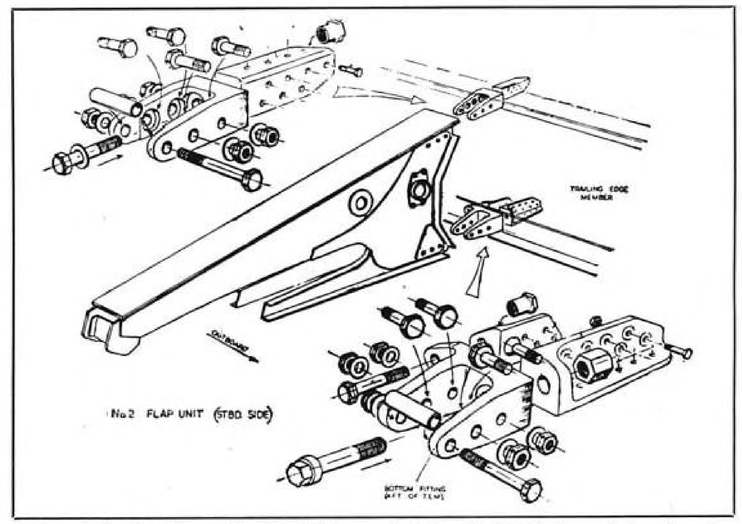
He joined B.E.A. in December, 1946, left in April, 1946, and flew as a captain for charter companies until 1951, then rejoined B.E.A. In January, 1957, he completed a conversion course for Viscounts. He had flown with B.E.A. 7,314 hr., 132 of which were on Viscounts.

Both the captain and the first officer were regarded by B.E.A. as very reliable pilots. They had carried out their duties excellently and all their training had been completed to a high standard. On the day of the accident both had been on duty for about 7¼ hr. (having flown from London to Manchester, from there to Amsterdam and then back to Manchester), and on the previous day 5 hr. 10 min. The two preceding days both had been off duty. It is not possible to say which of them was actually piloting the aircraft at the time of the accident.

The radio officer was D. J. Denman. He held a valid license and had flown with B.E.A. 4,968 hr., 1,967 of which were on



ACCIDENT occurred when trailing edge member bolt broke from fatigue at a position on starboard wing No. 2 flap unit. Bolt position is detailed in drawing above.



FLAP unit involved in accident is rigidly mounted directly behind inner starboard engine. Aileron became locked when flap unit moved away from trailing edge member.

Viscounts. The other members of the crew were D. J. Harries, steward, and Miss D. W. Newman, stewardess.

There were 15 passengers on board together with their luggage and a small quantity of cargo. The aircraft was loaded and trimmed within the specified limits set out in the Certificate of Airworthiness.

DESCRIPTION OF ACCIDENT

At about 13.34 hr. on March 14, 1957, the aircraft on its way to Ringway Airport passed into the control of the Manchester approach controller. At 13.36 the approach controller received a call from the pilot and asked him to report passing Oldham Beacon and reaching 3,500 ft.

The approach controller then gave him the latest weather observations—wind 250 deg., 23 kt., visibility 10 naut. mi., cloud 5ths at 3,000 ft. and 8/8th at 10,000 ft. He also gave the airport pressure. At 13.41 the aircraft reported at Oldham Beacon still over 3,500 ft. (According to normal practice the pilot would start his pre-landing drills after passing Oldham Beacon and this would include lowering the flaps).

The approach controller asked the pilot if he wanted an instrument let-down. The pilot said he would like GCA to give him a cloud break. This meant that he wished for the system of Ground Control Approach to be used so as to ensure a clear descent path, leaving him to make a visual approach after he had broken through the lowest cloud.

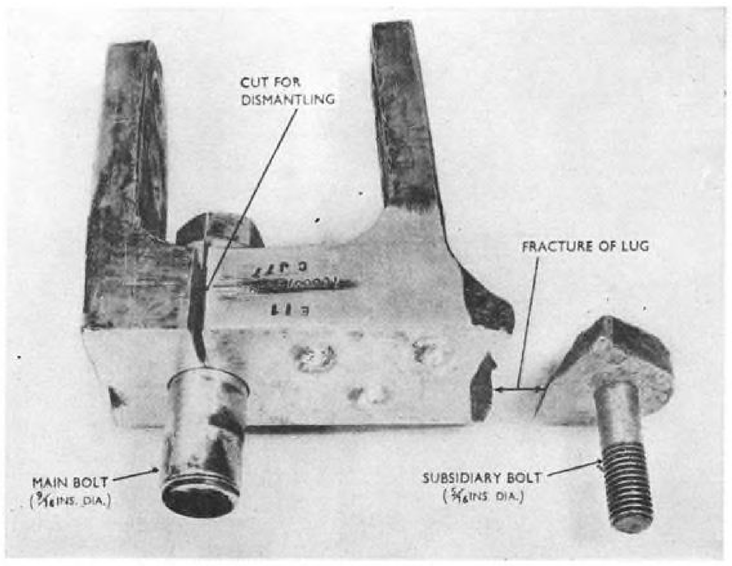
He was accordingly handed to the GCA director until he came below cloud and had the airfield in sight, when he asked to be transferred to the airport controller. The pilot then gave a call meaning "finals," i.e. that he was in line of approach to the runway in a position from which a landing would be made on his then present heading. The airport controller told him he was clear to land and gave him the surface wind.

The airport controller sighted the aircraft when it was 4½ to 5 mi. from the runway and the approach controller at 3 to 4 mi. Both watched it approach (though neither was watching it continuously) and neither saw anything unusual until it was, they thought, about one mile or a little more from the end of the runway.

Then both saw it take a gradual turn (one of them described it as a "shallow diving turn") to the right, which looked like an intentional maneuver, perhaps to get into line with the runway, but very soon the turn tightened up and the angle of the bank increased so that both these witnesses realized that something was wrong and each separately gave the crash alarm. Neither saw the actual crash because their view was obscured by buildings.

The time of the crash was 13.46. The time between the steep banking turn and the crash was estimated at something between 10 seconds and half a minute. The airspeed at the critical time is estimated at 115 to 120 kt.

There were five eye-witnesses apart from the two control officers. All of them lived or worked in the neighborhood and were familiar with the sight and sounds of aircraft coming in to land. Two of them in particular (one of whom, Mr. Stanford, had been a pilot in the R.A.F. from 1939 to 1946, and the other, Mr. Pettigrew, had



BOTTOM fitting of No. 2 flap unit is shown in this photograph. Investigators said Viscount crashed after lug broke (right) and 9/16th in. bolt broke because of fatigue.

had experience in the A.T.C. and as an observer at Farnborough and held a gliding license), gave remarkably detailed accounts of what they observed.

The evidence of the five witnesses did not exactly tally in all respects but there was general agreement that the aircraft was approaching normally (though perhaps rather lower than usual and perhaps on a heading which would have brought it rather to the left of the runway), until it reached a point about a mile from the threshold. It then banked to the right and maintained this bank for a few seconds.

Mr. Stanford thought it side-slipped and looked as if it was getting into difficulties but then put on full left rudder and got on to an even keel. No other witness observed this. If there was any recovery it must have been only momentary because to other witnesses the aircraft appeared to pass straight from what might have been a controlled banked turn into a steep and uncontrolled turn. (One witness, but only one, said that the engine noise increased in loudness and rose in pitch).

The ultimate angle of bank was variously estimated at from 45 deg. to 80 deg. and then two of the witnesses saw the starboard wing tip touch the ground. From marks afterwards found on the ground and from pieces of wreckage collected, it can be stated positively that the starboard wing tip touched the ground about half a mile from the threshold and 150 yd. to the right of the extended center line of the runway. From that point a furrow in the earth made by the starboard wing went nearly straight (at an angle of about 45 deg. with the extended center line) but curving very slightly to the right for a distance of about 25 yd. and then, after a break of about 10 yd., for about another 35 yd.

During this time about half the starboard wing broke up and parts of it were found scattered to right and left of the furrow. The final crash into the houses was about 85 yd. from where the wing tip first touched the ground.

A most important piece of evidence was given by Mr. Pettigrew. He said that when the aircraft was over a point which is rather less than a mile from the threshold and was perhaps 500 to 600 ft. high, he could see it from directly astern and observed that the two inboard starboard flaps appeared to rise above the wing. It appeared to him that the center joint between these flaps had come adrift from the wing.

One moment the flaps were normal and the next they were bent. The angle of the flaps made it appear that they had risen above the trailing edge of the wing giving "a sort of roof effect." The port flaps remained normal. It was immediately after the movement of the starboard flaps that the aircraft first banked to the right. He looked to see if the ailerons moved but could not see any movement.

I am satisfied that Mr. Pettigrew's observation of the movement of the flaps was accurate and, although it cannot be certain that he would have noticed any movement of the ailerons if they had moved (because they are much smaller than the flaps), it can at least be said that there is no evidence from any eye-witness that the ailerons were operated at all after the first turning and banking movement began.

Mr. Pettigrew estimated the time interval between the bending of the flaps and the final impact with the ground at only about five or six seconds. From the evidence of other witnesses I think that this is an underestimate and that the period was probably about 20 sec.

As will appear later in this report, a movement of the flaps such as was described by Mr. Pettigrew would tend to cause the aircraft to make a banked turn to the right but not to such an extent that the movement could not be easily controlled by the ailerons if they were working normally. Witnesses with experience in the control of

aircraft all agreed that a competent and experienced pilot would automatically use his ailerons in such circumstances and I am advised by my assessor, Capt. White, that this movement would come so naturally to a pilot that it is unthinkable that he would not make it.

This at once creates an impression that for some reason the ailerons must have been incapable of movement. If this was so then as appears from the evidence and the advice of my assessors the only possible hope of getting the aircraft righted was by use of left rudder and increased power from the starboard engines.

There is as indicated above some evidence that the rudder was put to port and that there was some increase of engine speed. If these actions were taken in the very short time available then the pilot acted with great skill and promptitude but in all probability the bank was too steep and the aircraft too near the ground for these measures to be effective. Capt. Gordon-Burge, a senior inspector of the Accidents Investigation Branch, expressed the opinion that there was nothing the pilot could have done to avoid the accident and I am satisfied that this is correct.

As already mentioned, the crash alarm was given by the two air traffic control officers independently before the aircraft struck the ground. Indeed, the airport fire appliances were on the move before the crash occurred. Five fire appliances, two foam tenders, two water tender/pumps and a Vauxhall tender were turned out. At about the same time two Fairey Aviation appliances, a pump tender and a Land Rover set out from the nearby Fairey Aviation Works fire brigade. All the above-mentioned appliances reached the scene by 13.50. At 13.48 a call was made by direct telephone line to Altrincham fire station and within a short time 24 appliances were dispatched from this and other stations. Also at 13.48 Manchester ambulance headquarters was telephoned and 16 ambulances and two shooting brakes were sent out. Further ambulances were called from other centers a little later.

The Manchester city police were called at 13.51 and 50 Manchester police officers attended, also officers of the Cheshire county police. Eight ministers of religion attended. Others who came quickly to the scene were hospital services (five doctors, one nursing sister, five nurses), airport technicians, civil defense (rescue), gas, water and electricity undertakings, representatives of the Manchester city surveyor's department and two morticians. There were also a number of civilian volunteers.

Houses Struck

The aircraft had crashed into Nos. 23 and 25 Shadow Moss Road, Wythenshawe. It had apparently struck the houses below roof level, the wings had folded inward, the fuselage collapsed and accordioned and the wreckage buried itself beneath the roof debris of the houses. House No. 21 had also been severely damaged. The aircraft was upside down. Fire broke out in about 20 places.

Seven pump jets were got to work while the airport fire officer searched house No. 21 for survivors. More pump jets arrived and were got to work, followed by waterspread jets. Service and civilian helpers helped to remove debris and searched for passengers and crew and any residents in the houses.

Between 15.20 and 19.10 22 bodies were found, corresponding with the five crew and 15 passengers known to have been in the aircraft and two residents ascertained by police enquiries to be unaccounted for in the houses. The operations were substantially complete by 19.44 but smouldering debris was still being dealt with up to 23.21.

It is clear that mobilization of all necessary services in adequate numbers was carried out with promptitude. Attendance of fire appliances and equipment was in fact in excess of requirements, primarily because the Cheshire fire brigade and the Manchester fire control each assumed that the incident was in its own area.

All necessary equipment was provided except that heavy caliber mechanical rescue equipment was not readily available in the quantity called for in such a case. It was not suggested that this deficiency had any serious results in this case.

The total number of rescue workers and technical personnel who attended was about 300 and it was estimated that about an equal number of civilians were intent on rendering help in every possible way. Unfortunately, these public-spirited willing workers tended to hamper rather than assist the operation. There was no single control over the various services.

The rapid mobilization of so many vehicles inevitably caused traffic congestion. Such conditions are not surprising, following a terrible accident of this kind. The way in which the operation was carried out is to the credit of all concerned and there was no way in which any lives could have been saved or the material damage reduced.

TECHNICAL INVESTIGATION

A senior inspector of the Accidents Investigation Branch of the Ministry arrived at Ringway about 2¼ hr. after the accident. He saw Mr. Pettigrew the same evening and, having heard what he had to say about the starboard flaps, had a search made during the night among the rubble, and by the following morning recovered most of the starboard flaps and also recovered No. 2 starboard flap unit and its fittings. These were sent to Farnborough by air for examination at the Royal Aircraft Establishment. Later the whole of the wreckage was sent to Farnborough and, as far as possible, assembled there.

In order to make this part of the report as clear as possible to the non-technical reader, I will give a brief description of the flaps, flap units and ailerons. At the rear or trailing edge of each wing there are three flaps numbered 1 to 3 from inboard to outboard. Except when taking off or landing the flaps are within a kind of housing formed by the upper and lower falsework structures which are fixed to the trailing edge member of the wing, and are a continuation of its upper and lower surfaces.

There is a quite elaborate mechanism, involving a chain drive and a telescopic arm, by which the flaps can be lowered, i.e. made to move outwards toward the rear of the aircraft and downward. There are five positions for the flaps: up; 20 deg.; 32 deg.; 40 deg.; and 47 deg. (down). The flaps on both wings all move together, being operated by a single control, and the effect of lowering them is that the pressure upon them of the air as the aircraft goes forward has a retarding and lifting action.

Each flap consists of two separate parts, a main flap and a fore flap. There is a slot between the fore flap and the upper falsework and another between the fore flap and the main flap. The slots remain open when the flaps are lowered and closure of either of the slots would substantially lessen the effectiveness of the flap.

After the accident the flaps were found to be in the 32 deg. position, which would be normal for the stage reached by the pilot immediately before the banked turn occurred.

The three flaps on each wing are supported by four structures called flap units which are attached to the trailing edge of the wing and protrude toward the rear within the falsework. No. 1 flap unit supports the inboard edge of flap No. 1; No. 2 flap unit, the outboard edge of flap No. 1 and the inboard edge of flap No. 2; No. 3 flap unit, the outboard edge of flap No. 2 and the inboard edge of flap No. 3; and No. 4 flap unit, the outboard edge of flap No. 3.

Aileron Operation

There is an aileron (consisting of two parts, inner and outer) on each wing, situated at the trailing edge of the wing and outboard of the flaps. The ailerons are hinged to the trailing edge and are controlled by a single control in such a way that when the starboard aileron moves up the port aileron moves down and vice versa. The effect of moving the starboard aileron down is to tend to raise the starboard wing and so to make a banked turn to port, or to overcome any tendency to make such a turn to starboard.

In order to prevent damage to the ailerons when the aircraft is on the ground, they can be locked in the neutral position by a control lever in the cockpit. The same control lever operates to lock all the control surfaces (i.e. rudder, elevators and ailerons) simultaneously. This lever should, of course, never be operated in flight. It could not be operated accidentally because it requires a considerable pull to move it.

No experienced and competent pilot would ever think of locking his control surfaces while approaching to land—if he did so, his aircraft would be completely uncontrollable. When the lever is moved to lock the controls it pulls a wire which pulls seven separate wires, each of which operates one lock, there being two locks on each aileron and one lock each on the elevators and the rudder.

The manner of locking is that a movable arm becomes engaged between jaws fixed to the control surface. Although no particular clearance between the arm in its disengaged position and the jaws had been specified for Viscounts generally, B.E.A. had required that this clearance should be at least 0.1 in. In practice it was usually more.

Each flap unit is attached to the trailing edge member of the wing in this way: to the top and bottom of the trailing edge member are bolted fittings; (these are called "forward fittings"). To the top and bottom of the front edge of the flap unit are bolted fittings; (these are called "aft fittings"). The fittings are of aluminium alloy.

A bolt passes from aft forward through

the top aft fitting, the trailing edge member, and the top forward fitting, and is secured by a nut. On flap units 1, 3 and 4 a bolt passes from aft forward through the bottom aft fitting, the trailing edge member, and the bottom forward fitting, and is secured by a nut.

On No. 2 flap unit the bottom aft fitting has a small lug and there is one bolt passing through the main part of the aft fitting, the trailing edge member and a forward fitting, and a smaller bolt passing through the lug, the trailing edge member and a subsidiary forward fitting. (The reason for the subsidiary bolt is that the position of No. 2 flap unit in relation to the wing rib was such that the main bolt could not be placed centrally in the fitting).

In every case the bolt is secured by a nut at its forward end. The bolts in different positions are of different sizes. They are of high tensile steel as also are the nuts.

From the point of view of this report the important flap unit is starboard flap unit No. 2. The important fitting is the aft lower fitting of that unit and the important bolt is the larger bolt through that fitting. This was a $\frac{7}{8}$ in. diameter bolt and the smaller bolt at the same fitting was $\frac{3}{4}$ in. In the wreckage were found the flap unit and the main part of the aft bottom fitting with the head and part of the shank of the $\frac{7}{8}$ in. bolt (broken off so as to leave only one thread), while the lug of the fitting was still attached to the trailing edge member by the $\frac{7}{8}$ in. bolt.

The remainder of the $\frac{7}{8}$ in. bolt together with its nut was never found, despite diligent search. The surface of the break in the $\frac{7}{8}$ in. bolt showed on examination an appearance which left no doubt in the mind of an expert (and my assessor Prof. Redshaw is quite satisfied about this), that the bolt had been subject to fatigue: about 20% of the area appeared to have had a fatigue crack spreading slowly across it, about another 70% showed a more rapid progress of fatigue, and the final 10% had suffered a sudden tension fracture.

The break of the lug from the remainder of the fitting cannot be described with particularity because fire had so affected the broken surfaces as to destroy evidence of the metallurgical character of the fracture. When found, the flap unit was completely detached from the wing but the indications were that the top fitting had broken after the lower part of the unit had been detached from the wing and it seems probable that the top fitting broke only in the course of the final break-up of the aircraft.

At this point it is possible to draw prima facie conclusions as to how this accident may have happened. The $\frac{7}{8}$ in. bolt was badly fatigued and the ultimate breaking of it may have been the first step in the chain of causation leading immediately to the accident. If it did break the stress on the lug and the $\frac{3}{4}$ in. bolt holding it would be considerable, and it was the lug that broke.

Alternatively the lug may for some reason have broken first and the stress so imposed on the $\frac{3}{4}$ in. bolt would then have been more than in its fatigued condition it could bear. In one or other of these ways the lower part of the flap unit became detached from the wing. The air pressure on the lowered flaps caused them to lift the No. 2 unit so that it pivoted about its top fitting.

Matters now to be considered are: is there any ascertainable cause of the fatigue in the $\frac{7}{8}$ in. bolt? Was there any reason (unless the bolt broke first) why the lug should break? Were the ailerons put out of action in any way?

Fatigue in a piece of metal is caused by numerous alternations of stress in it. It is most liable to occur at a place of high stress concentration such as a sharp re-entrant corner, e.g. the bottom of a thread in a bolt. All the main bolts supporting flap units were subject to certain alternations of stress but it had not been supposed up to the time of this accident that stresses of sufficient magnitude could occur a sufficient number of times to bring about fatigue within the period in which this happened to this particular bolt. The question arose —might such fatigue be of wide occurrence in main bolts supporting the lower fittings of flap units in Viscount aircraft?

To obtain an answer to this question an examination was undertaken by R.A.E. of most of the bolts from lower fittings of flap units in 100 Viscounts (out of 189 then operating). This involved the examination of 845 bolts. As a result it was found that: (a) in W.E. four bolts besides the one which had broken showed signs of fatigue—the fatigue being substantial in the $\frac{7}{8}$ in. bolt from the lower fitting of the No. 2 port flap unit and slight in the other three bolts, (No. 2 starboard $\frac{7}{8}$ in.; No. 3 starboard; No. 2 port $\frac{7}{8}$ in.); (b) including those from W.E. a total of 33 bolts showed signs of fatigue.

This was considered a significant proportion but it is right to say that none of the bolts, except the two in W.E. that had substantial fatigue, were more than slightly affected, the largest of the other cracks not being more than 2% of the area of cross-section of the bolt.

All the fatigued bolts came either from No. 2 or from No. 3 flap unit. No explanation of why these were affected while the bolts from Nos. 1 and 4 were free has been definitely established. The incidence in bolts from No. 3 was slightly greater than in those from No. 2 (6.7% as against 5.4% and 4.9%); but see the end of the next paragraph.

The incidence tended, as was to be expected, to be greater in aircraft which had had more landings. (Where a bolt had been changed the relevant number of landings was of course the number since the new bolt was put in). Among the No. 2 bolts a striking difference was apparent between aircraft which had been modified in a certain way in certain conditions, and those which had had the modification introduced in other conditions. It is necessary to explain this modification, known as Mod. 799, in some detail. It was applied to W.E. in March, 1955, since when W.E. had flown 3,639 hr. and had made 2,973 landings.

According to the original design the larger bolt for the lower fitting of No. 2 flap unit was a $\frac{1}{2}$ in. bolt. Now with the earlier Viscounts some trouble was experienced with the flaps. The defects were not of a serious nature. They were such minor defects as are usually experienced with a new type of aircraft.

W.E. itself had some of these flap troubles but not to an exceptional extent and there is no reason to suppose that any extra stresses on the supports of the flap units were caused by them. However, one thing that happened in a number of Viscounts was that the chain broke in the No. 2 flap unit and it was decided to strengthen this chain.

For valid technical reasons it was considered that the chain ought to be the weakest part of the unit (because a break in the chain was less likely to have serious results than a break in the structure), and so when the chain was strengthened it was decided to strengthen various parts of the unit, including the main bolt holding the lower fitting.

After calculations as exact as the nature of the problem permitted, the decision was to increase the diameter of the bolt to $\frac{7}{8}$ in. The calculation involved assessing the load expected to be carried by the bolt, and applying a factor of 1.5 to arrive at the "fully factored load" and then applying another factor to give a further reserve of strength; for flap attachment bolts in Viscounts this second factor was at least 1.6 but for this particular bolt it was about 2.4, that is to say the fully factored load was about six tons and the strength of the bolt was sufficient for a static load of about 14 tons.

The name of Mod. 799 was given to the whole modification including the provision of a stronger chain and a larger bolt with the associated work. In Viscounts which were in course of manufacture and which had not yet reached the stage at which this part was completed, the modification was introduced before assembly; when the examination was made after the accident none of these bolts were found to be fatigued.

In Viscounts which were in course of manufacture but had had this part completed, the modification was made in the factory; one of these bolts was fatigued out of 35 examined. In Viscounts which were already in operation (which included W.E.) the modification was made elsewhere than in the original factory; 10 of these bolts were fatigued out of 52 examined. It seems clear that modification after delivery tended to increase the incidence of fatigue in No. 2 bolts.

This modification cannot, however, be regarded as the cause of all the fatigue found since the No. 3 bolts had not been modified at all and yet had a significant incidence of fatigue. (Comparison of the actual percentage incidence between No. 2 and No. 3 cannot usefully be made since the No. 3 bolts were on the average a considerably older population).

Of all the Viscounts to which Mod. 799 was applied after delivery to operators, one was modified by Vickers, four by Aer Lingus and 17 (including W.E.) by Marshalls Flying School Ltd., of Cambridge. This last mentioned company, despite its name, carries on an extensive business in work in connection with the repair and modification of aircraft and has a high reputation in that connection.

While five fatigued bolts were found in the 17 aircraft modified by Marshalls, one was found in the aircraft modified by Vickers and four (two in one aircraft and one each in two others) in those modified by Aer Lingus.

Examination of the fitting concerned on W.E. after the accident revealed certain

unusual features as follows:—

• **Marks of the bolt heads** and nuts (both the original ½ in. one and the later $\frac{9}{16}$ in. one) on the fittings were uneven i.e. were more pronounced at one side than the other, indicating that either the bolt or the hole was out of true; and consequently the loading on the bolt would not have been truly axial; the position of the deepest impression of the nut of the $\frac{9}{16}$ in. bolt corresponded approximately to the fatigue origin on the bolt; (something similar, and even more pronounced, was found in the corresponding position on the port wing and, on the assumption that in each case the shaft of the ½ in. bolt was true to its head, it appeared in each case that the $\frac{9}{16}$ in. hole was not concentric with the ½ in. hole and that the axes of the original and the new hole were not parallel).

• **Front face of the fitting** had been milled down by about 0.1 in.—one effect of this being that the lug was 0.1 in. thinner than as designed;

• **Because the part** of the trailing edge member of the wing against which the fitting had to rest had three snap rivet heads projecting from it three small depressions had been made in the face of the fitting; but the edge of two of these depressions had fouled their rivet heads so that the face of the fitting had not been lying true against the trailing edge member.

The wings of W.E. (apart from the flaps) were manufactured by contractors, Saunders-Roe, a company of high reputation with long experience in the aircraft manufacturing industry. As to the parts relevant to this inquiry, Saunders-Roe manufactured the trailing edge member, the forward fitting and the after fitting and reamed holes for the ½ in. bolt.

The holes in the trailing edge member and the forward fitting were originally left at $\frac{7}{16}$ in. and were reamed to ½ in. on final assembly. After delivery of the wing to Vickers, for some reason a replacement for the forward fitting was asked for by Vickers, and was delivered separately by Saunders-Roe. This replacement was delivered with a $\frac{7}{16}$ in. hole which was reamed by Vickers to ½ in.

Because of the modification which later took place it is impossible to tell whether it was the ½ in. hole or its bolt which was out of true. It appears from the evidence that it is quite possible that in the course of the successive reamings some mal-alignment of the hole came about. However, for the purposes of this report any mal-alignment of the ½ in. hole is irrelevant unless it led to the mal-alignment of the $\frac{9}{16}$ in. hole.

Modification Procedure

Mod. 799 as already explained was performed on W.E. by Marshalls. They reamed a $\frac{9}{16}$ in. hole which may not have been co-axial with the original ½ in. hole. The reaming of this hole on an assembled wing was an awkward job. Vickers provided three reamers graded in size and Marshalls supplied a socket to fit over the head of the reamer and a series of extensions to bring the operating point clear of the flap unit.

The reamer was operated by a ratchet attached to the outermost extension. This extension was supported by passing it through a hole in a steadying pad. The mechanic operating the ratchet would be unable to see the reamer. When the hole had in this way been enlarged to $\frac{9}{16}$ in. it was cleared of swarf and checked with a dummy bolt and then a $\frac{9}{16}$ in. bolt coated with a jointing compound was inserted.

Owing to the obstruction of other parts of the structure the means of tightening the nut on the bolt was unusual: one man inside a tank compartment in the wing had to fit the nut on to the bolt and hold it with a spanner, while another man turned the bolt head from outside.

Tightness was checked by an inspector and the nut was locked by popping. (At that time there was no requirement for torque loading; since the accident a requirement has been introduced for the tightness of such bolts to be checked by a torque loading figure of 350 lb. in. However it does not appear that the tightness of the nut was a critical factor in relation to the development of fatigue).

Subsequent experiments go to show that when a hole is enlarged in the way described the original hole normally tends to keep the reamer in true alignment. Nevertheless in the result the axis of the $\frac{9}{16}$ in. hole was not true. How this came about remains uncertain. At the time when W.E. was modified Marshalls had already applied Mod. 799 to about 10 Viscounts.

Before any of this work was done Marshalls' inspectors and the operatives concerned spent some time at Vickers' factory to study the operation; moreover when the first three or four modifications were done by Marshalls an inspector from Vickers was present.

It appears that at the time when this work was done people highly experienced in this type of work would never have supposed that a reamer carefully operated in the manner described would "wander" appreciably. I am satisfied that inspection on W.E. was carried out as fully as was practicable by Marshalls' inspector: the design of the fittings made it impossible to examine the seating of the nut and only about 40% of the seating of the head could be seen and that not accurately. The jointing compound squeezes out and makes it still more difficult to observe the seating.

It was suggested on behalf of the British Airline Pilots' Assn. that Marshalls' records were not as full as they should have been. The records showed the work done, the inspector and the gang of men responsible. In my opinion it would be unreasonable to ask for more. To record the exact part played by each operative in doing a job would involve an amount of clerical work that would not be justified.

The machining of the face of the aft fitting was done in Vickers' workshops. There should have been a concession note for this work but it has not been possible to find one and probably none was issued.

I was assured, and accept the assurance, that the work would not have been done without obtaining the oral consent of the design department and that those responsible for the design believed and still believe that the fitting was still of adequate strength with this amount of metal removed. (A similar fitting on the prototype 700 was treated in the same way and on that occasion a calculation was made to ensure that the strength was not reduced too much and a note was made that a concession had been granted).

The reason for the alteration was probably that on assembly the flaps were found to be very slightly out of alignment and that the machining was done to get them properly aligned. The only materiality of the matter is that the lug might not have broken if it had been of the original thickness.

Wrong Rivets Used

It was by an oversight in the original detailed drawings that snap head rivets and not counter-sunk rivets were indicated. Only W.E. and one other aircraft had been fitted with these rivets when the error was discovered. Thereafter the rivets were counter-sunk but on W.E. it was considered unnecessary to remove perfectly good rivets which were already in place and the procedure adopted was to make depressions to accommodate the rivet heads.

When the 0.1 in. of metal was removed the depressions remaining in the surface of the fitting would obviously be too small and would have to be enlarged. Again this work should have been covered by a concession note but apparently was not. However, it was obviously necessary to do it.

For some reason which is unexplained, two of the depressions were not exactly in the right position and instead of completely enclosing their rivet heads the edge of each of these two rested on the edge of the rivet head. This meant that the forward face of the fitting was not in close contact with the trailing edge member. (Certain calculations suggest that the maximum distance between them was about 0.03 in. but this figure is not definitely established).

Two possible consequences would be (1) that when the two bolts were tightened up the fitting would be under stress which may have caused the lug to break off. (If this stress had directly caused such a fracture it would probably have happened at once, but it is possible that a minute crack was caused which led in time to some degree of corrosion followed eventually by fracture). (2) That when the original ½ in. bolt was removed for Mod. 799, the fitting still held by the $\frac{9}{16}$ in. bolt would slightly spring away at the other end of its face (though the attachments of the fitting to the flap unit would tend to reduce any such springing) so that it would be in a slightly different position when the reaming operation was performed from the position it would take up when the $\frac{9}{16}$ in. bolt was inserted and the nut tightened.

This, therefore, is a possible cause or contributory cause of the faulty seating of that bolt. It must, however, be remembered that the seating of the corresponding bolt on the port wing was also faulty, although the fitting was there lying snugly against the trailing edge member.

A careful experimental investigation has been made by R.A.E. into the question of whether faulty seating of the bolt head or the nut had any effect on the incidence of fatigue. The results establish that an inclination of a few degrees may drastically reduce the fatigue life of the bolt.

Unless the inclination was so small that the bolt head or nut could bed down on the fitting the effect on fatigue life was not related to the angle of inclination Broadly speaking the investigation showed that a bolt accurately seated could withstand about twice the alternating load of a bolt with inclined seating.

But the effect of inclined seating on

fatigue life in certain ranges of alternating load was found to be of a high order. The findings may be summarized as follows: with loads up to four tons to the square inch both well-seated and badly-seated bolts still had an indefinitely long life; between four and eight tons to the square inch, well-seated bolts still had an indefinitely long life but badly-seated bolts had a limited life; from eight to 12 tons to the square inch both had a limited life but the life of a well-seated bolt, expressed in alternations of load, was about 50 times that of a badly-seated one.

Up to the time of these investigations it was not known even to experienced aeronautical engineers that the seating of a bolt could have such an important bearing on fatigue life; the matter had apparently never been studied before except for one series of experiments in the United States, the results of which had been published in 1955 but were not widely known.

It is now clear that the mal-alignment of both ⅜ in. bolts in W.E. is an important factor to be considered in relation to the high degree of fatigue which had developed in both of them. On the other hand it cannot be said that no fatigue would have occurred if the bolts had been accurately seated: for among the 28 bolts from other Viscounts found to be cracked were at least two which had cracks to the extent of about 2% of the cross-sectional area and which showed no signs of mal-alignment.

Flap Deformation

Other experiments were made by R.A.E. and Vickers to discover what deformation of the flaps would be likely to result from the failure of the connection at No. 2 unit bottom fitting and what effect on the flight of the aircraft this would have.

The conclusions reached were that in all probability the top fitting held and the unit pivoted about this point until the bottom of it came away to a distance of about six inches from the trailing edge member.

The distortion of the starboard flap system which resulted (involving the closing of the slot between the fore flap and the upper falsework) would introduce sufficient asymmetry to cause the roll and turn which was observed, provided no corrective action was taken by the use of the ailerons.

The rolling tendency would, however, be well within the corrective power of the ailerons. This matter was investigated by both Vickers and R.A.E. Vickers made a mechanical test on a wing, simulating the conditions believed to have affected W.E. and obtained a certain deformation of the flaps. They then calculated the aileron angle necessary to hold the resulting roll and concluded that it was probably 2.4 deg. or at most 3.8 deg.

R.A.E. made flight tests and simulator tests and concluded that the deformation might have brought about a somewhat greater loss of lift than was found by Vickers and that to cause the roll described by witnesses flap damage equivalent to about 4 deg. of aileron would be needed. Ailerons, if working normally, could turn through an angle many times as great as this. (Simulator tests, checked by full-scale flights, showed that control by the use of rudder alone, with the ailerons locked, would have been marginal and almost certainly impossible in practice under the conditions existing at the time). This leads to a consideration of whether the ailerons were locked in some way.

The wire controlling the locking devices of the starboard aileron passed through a fair-lead on No. 2 flap unit. Just inboard of the unit it passed in front of a fuel pipe. Geometrically it is clear that a movement of the unit such as has been described above would tend to pull on the wire (the extent of this pull being much magnified by the proximity of the fuel pipe) and so to lock the aileron. This would cause the port aileron also to be immovable.

Tests which were made indicate that while the degree of movement obviously depends on the exact position of the wire (which cannot be ascertained), it would have been possible for the ailerons to be locked in this way, assuming a position for the wire within ¼ in. of the fuel pipe which, though unusual (as shown by examination of a number of other Viscounts), does occur in a small proportion of cases. There are several indications in the wreckage that the ailerons were in fact locked.

Elevators Examined

There was also some indication in the wreckage that the elevators were locked or partially locked and the rudder was locked. These could not have been locked by any such means as are described in the preceding paragraph. It appears that the control lever which operated all the locks was not at the time of impact in the off position but was at least a quarter of the way toward the lock position. That would probably be sufficient just to cause the locks to begin to engage.

This leads to the question—did the pilot operate the locking lever and if so, why? The most probable answer, supported by the views of competent witnesses and confirmed by the advice of my assessors, is this: the movement of the flap unit locked the ailerons; the pilot, when the roll began, at once tried to move his ailerons and found that they were locked; in desperation he (or the copilot on his instructions) seized the locking lever to see if he could free the ailerons and (it being at that time in the unlocked position) pulled it towards the locked position. This probably happened at a time when the aircraft was, in fact, irretrievably out of control. The locks would not necessarily engage immediately but would do so on any control surface which reached the neutral position while the lever was being pulled. An alternative possibility is that in the break-up of the aircraft something caught the main locking wire and pulled it; but no evidence of this having happened could be found in the wreckage.

The question arises of whether B.E.A. could have discovered before the accident that bolts in W.E. and in some other Viscounts were affected by fatigue. None of the ordinary checks would have revealed this because such checks do not involve the extraction of such bolts.

In about 1955 B.E.A. decided to apply to Viscounts a "10% sampling check" system which had been worked out in cooperation with Air Registration Board and the manufacturers for another type of aircraft. This check was to be carried out on the first Viscount in the fleet to reach 6,000 hr. flying, then on the first to reach 12,000 hr. and so on.

At any one check 10% of the aircraft's bolts falling within certain descriptions were to be removed for the purpose of inspecting the holes for corrosion. (The check was never intended as a safeguard against fatigue of bolts. Examination of such a small proportion of bolts at such long intervals would be of little use for that purpose).

From time to time additional items were added to the list. In August, 1956, bolts attaching flap units to the trailing edge member were added. Before the accident the first of the B.E.A. Viscounts to reach 6,000 hr. (which was not W.E. but O.G.) had been subjected to this 10% sampling check. This was on Nov. 14, 1956.

One of the bolts removed happened to be the ⅜ in. bolt from one of the No. 2 flap units. Although the check was primarily a check of holes and not of bolts, bolts were examined by a magna-flux test and in other ways and then sent to the manufacturers for further examination. No cracks were then found in any of these bolts. At a later date after the accident the ⅜ in. bolt from O.G. was submitted to a very stringent examination and was found to have a minute crack.

TECHNICAL DISCUSSION

This section deals with a number of technical matters relating to the material, construction and assembly of the bolt and fitting which failed, to the forces involved and the probable cause of the fractures. The opinions expressed are those of my assessors, Prof. Thom and Prof. Redshaw, which I fully accept.

The fitting was machined from a high strength aluminium alloy extrusion to specification D.T.D. 363, the grain of the material running fore and aft. This was considered by the designer, and quite correctly, as being the most advantageous direction for the grain, but as a result the direction of the grain for the projecting lug provided for the ⅜ in. bolt was in an unfavorable direction; nevertheless, the thickness of the lug as designed, and its method of attachment, would not have caused any undue anxiety on this score.

We know that the thickness of the lug had been reduced from 0.4 in. to 0.3 in. and that the fitting was assembled with its face clear of the trailing edge member; it would therefore have been scarcely surprising if the lug had been cracked by the tightening up of the bolts either initially or subsequently during the incorporation of Mod. 799.

The elongation of aluminium alloy D.T.D. 363 in the transverse grain direction would not be more than 2%-3%, and therefore it is reasonable to assume that after assembly, as far as stress was concerned, this lug was in a critical condition and it may well be that a small tension crack had already started in the very sharp corner of the spot face.

A visual examination of the lug fracture showed that the failure was in bending with some shear and that the failure commenced at the sharp corner of the spot face. The corner between the lug face and the main part of the fitting was rounded; the spot face impinged on the curved portion of the surface, causing a sharp re-entrant corner there). As the fitting had been softened by fire, it would not be possible to say whether the failure of the lug was caused by fatigue,

by stress corrosion or by any other cause.

Both the $\frac{7}{8}$ in. and $\frac{3}{4}$ in. diameter bolts were manufactured from high tensile steel, to specification S.99, which calls for an ultimate strength of not less than 80 tons/in.^{2}; the limits on the bolts, and the holes through which they passed, conform to good engineering practice. The bolts were threaded to BESA limits and the threads were run out to mitigate the effect of stress concentration. Finally, the bolts were given the standard cadmium coating protection.

Fretting Observed

In addition to the evidence of fatigue cracks, fretting was observed on the shanks of various bolts including the $\frac{7}{8}$ in. bolt under discussion. In this connection it is to be noted that it is very unlikely that any of these bolts were ever tightened sufficiently to prevent movement of the bolt in its hole.

In the case of Whisky Echo, this effect might have been augmented by a definite slackening of the bolts caused by creep deformation of the heavily-loaded rivet heads under the fitting. These combined probably explain the fretting marks.

Fretting is, however, only in the very early stages and is not indicative of any appreciable movement along the axis of the bolt (since the edges of the marks are fairly sharp and correspond to the three thicknesses of metal which the bolt passed through). The fretting could not be considered as contributing to the failure of the bolt but it does indicate a degree of movement at this point which is relevant to the question of whether a bolt in tension should be used in such a situation.

It is necessary to consider the forces which would be operating on the bolt and fitting. As the flap unit is rigidly bolted to the wing trailing edge member, the reactions at the attachment are statically indeterminate. We have at the lower attachment a tension, an indeterminate shear force and an indeterminate moment.

The exact values of these quantities depend on the elasticity and deformation of the structure, and are almost impossible to calculate. Considering the bottom attachment, as the loads on the flap unit with the flap in operation are predominantly upward, the two attachment bolts would be subjected to a tension, an upward indeterminate shear force, and the indeterminate moment which would be transmitted to the structure as an additional tension in the bolt and a pressure on the trailing edge member from the edge of the fitting.

It is necessary to explain how the bolt could have been subjected to oscillatory stresses of such a magnitude as to produce a fatigue failure. The bolt would be stressed due to tightening when initially assembled and it would be subjected to direct and shear stresses caused by the transmission of loads from the flap. Vickers made careful calculations at the time when Mod. 799 was introduced and these are substantially correct.

The question of indeterminancy nevertheless remains, and as mentioned previously it is impossible to include everything. At some points in the calculation estimates of loads have to be made, and it is here that uncertainties are introduced. It is, however, to be noted that these calculations are for the design case, that is the worst case which the airplane is ever expected to encounter.

Since the accident Vickers has made a series of flight load measurements on the Viscount flap support structures. These showed that the over-all loads were in good agreement with calculated values. The conclusion was reached that high frequency oscillating loads occurring when the undercarriage was extended were unlikely by themselves to be critical from the fatigue point of view.

No. 2 flap unit is situated to the rear of the rib which carries the main undercarriage leg, and therefore shocks transmitted by the leg on touchdown and subsequent taxiing would cause oscillatory stresses in the bolt itself. Furthermore, the unit is in the proximity of the inner engine and therefore any buffeting of the flap from the propeller slipstream, and indeed from the undercarriage leg when in the down position, would cause additional oscillatory stresses on the bolt and fitting. The measured value of these oscillatory stresses was ± 3 tons/in.^{2}, or possibly 20% greater.

It is possible that during the life of the bolt there might have been a million such stress repetitions. Reference to a graph which summarized the results of experiments made by R.A.E. with a number of bolts shows that this is perilously near the failing load for bolts whose heads and nuts are not properly seated.

It should be noted that No. 2 fitting is almost directly behind the inner starboard engine. There is little evidence as to the magnitude of the disturbances which might be thus produced. In this connection, it is to be noted that no fatigued bolts were found in Nos. 1 and 4 flap units (which are not in the vicinity of the engines) in any of the aircraft which were examined.

Apart from the high frequency oscillatory loads it is necessary to remember the much greater alternating loads occurring in certain conditions on landing and at takeoff. These, as appears from flight tests and from Vickers' original calculations for Mod. 799 were of the order of ± 11 tons to the square inch.

As the bolt was in tension the stress concentration factor could vary considerably from bolt to bolt, depending as it does on the surface finish at the root of the thread. The bolt was manufactured from a high tensile steel which is very notch-sensitive, its Izod value being 25 ft. lb. as compared with, for example, 40 ft. lb. for a much lower strength high tensile steel of specification S.96.

Therefore the surface finish of any portion of the bolt subjected to stress was of the highest importance. From the evidence given, we know that the threads were cut but not ground or polished and it was stated that grinding or polishing might possibly have done more harm than good which is probably quite correct. The point is that a very notch-sensitive steel was used and it was subjected to a concentration of stress which is inevitably associated with a threaded bolt under tension.

It could be argued that the R.A.E. tests took account of the fact that the bolt was improperly seated, as indeed they did, but these tests were made under ideal laboratory conditions which might quite well be more favorable than the actual conditions obtaining on the assembled fitting. It is necessary to have in mind here the unknown applied moment and shear force which almost certainly vary from aircraft to aircraft.

Having regard to all the matters referred to in the last three paragraphs, it is possible to account for the occurrence of such alternating loads as would, taken together, be sufficient to cause fatigue in the bolt in question and other bolts in similar situations supporting flap units in Viscounts.

During the hearing, frequent reference was made to the advisability of using bolts in tension and it was stated that this was general engineering practice, and that a multiplicity of bolts in tension would not necessarily provide an additional safeguard. This is true, but it must be remembered that the bolt in question and its nut were of very high tensile steel. In most cases tension bolts are made from a low tensile ductile steel which would allow some imperfection in bolt head and nut seating to be accommodated; in addition, a low tensile steel would not be so notch-sensitive and therefore not so liable to the development of a fatigue crack from any small surface imperfection.

The stress at the bottom of a thread is very much larger than the mean stress across the section, larger by the so-called "stress concentration factor" which could be of the order 3 or 4. If, instead of using the bolt in tension, the fitting had been so designed that the load was taken by a bolt in shear, then the stress conditions would have been entirely different.

For one thing, the degree of redundancy in the attachment reactions would have been reduced as no fixing moment would have been present, but of more importance would be the fact that the threaded portion of the bolt would not have been subjected to stress and therefore it would never have been in danger of fatigue at this point.

As to the consequence of failure, it is clear that a fatigue crack in the bolt must have been present before the lug failed. If we assume that the fatigue of the bolt had reached such a stage that it finally failed in tension, then the failure of the lug must have been almost immediate. The loading conditions on the lug would be those of bend, shear and torsion but an examination of the fracture shows that the failure was in bending with some shear and that it commenced at the sharp corner of the spot face, a type of failure hardly consistent with the assumption of the prior failure of the bolt.

Theory Supported

The kind of failure which would occur if the $\frac{7}{8}$ in. bolt failed first was shown in a photograph produced at the hearing of a fitting deliberately broken as a test. This is quite different from the failure on Whisky Echo and so gives support to the theory that the lug failed first. In all probability, however, it failed very shortly before the accident. If the $\frac{7}{8}$ in. bolt in its severely fatigued condition had been bearing the whole load at this point it would probably have failed before the flaps reached the 32 deg. position.

It is conceivable that the fatigue crack in the bolt had progressed only to 20% of the area of its cross-section before the already over-stressed lug failed due to the operation of the flaps, or the lug may

possibly even have failed due to stress corrosion or fatigue at this stage.

The surface of the fatigue crack in the bolt, after the well-defined initial stage, is such as to indicate a more rapid advance of the crack and it is just possible that this next stage could have taken place during the portion of the flight with the flaps retracted, when the loads would be small but of an oscillatory nature. The operation of the flaps prior to landing could then cause the final failure of the bolt.

Although it may well be that the lug failed first, nevertheless the failure of the fatigued bolt was inevitable. Even if the lug had remained intact the bolt would have failed before long, though its failure might have been preceded by the failure of the bolt on the port wing.

STEPS FOLLOWING ACCIDENT

Immediately after the accident information of it was sent to Vickers, the Chief Inspector of Accidents, R.A.E. and A.R.B. Discussion of the causes of the accident and of precautionary measures to be taken at once began between all these and B.E.A. The measures that were taken were the result of agreement reached day by day as the investigations developed.

On March 14, Vickers sent telegrams to all licensed operators of Viscounts informing them of the accident. On March 15 the broken bolt was identified and on the evening of that day it was sent to Vickers and by them to R.A.E. On March 16 the conclusion was reached that the breaking of this bolt had something to do with the cause of the accident. On March 16 and 17 the corresponding bolts on all Viscounts in the B.E.A. fleet were checked for tightness where they were except for two aircraft which, for special reasons, were flown home (one from Amsterdam to London Airport and one from Glasgow to Wisley) without passengers and without the use of flaps on landing.

At a meeting late in the evening of March 17 it was decided that certain precautions should be taken, especially with regard to Viscounts which had exceeded 1,500 landings. At that time particular attention was being paid to checking bolts for tightness and instructions about this, dated March 17, were issued by Vickers to all operators; aircraft which had not exceeded 1,500 landings were merely to have bolts tightened but aircraft which had exceeded 1,500 landings were to have bolts replaced if found to be loose, or in any case within a further 100 landings. There was at that time no instruction for immediate return to base or for special precaution in the use of flaps. On March 18 Vickers sent fresh instructions to all operators, to the following effect: (1) on aircraft which had not yet reached 1,500 landings all bolts from bottom fittings of flap units should be inspected for tightness at the next check nearest to 100 flying hours; loose bolts to be tightened and re-locked; (2) on aircraft which had exceeded 1,500 but not exceeded 2,500 landings not more than 20 deg. of flap should be used and aircraft should return to base for immediate replacement of bolts at flap units 2 and 3; (3) aircraft with over 2,500 landings should immediately return to base using not more than 20 deg. of flap and fit new bolts on all four units.

B.E.A. followed these instructions. Viscounts which had exceeded 1,500 landings were brought home empty and without the use of flaps; in fact, all their Viscounts were brought in rather ahead of schedule and had all the bolts from bottom fittings of flap units changed. This was completed by March 29.

On March 19 Vickers sent to Viscount operators a request for return of bolts with instructions for identification. It may be mentioned that no cracks were found in bolts from any aircraft which had had less than 1,500 landings but a small crack was found in a ⅞ in. bolt from an aircraft which had had only 1,462 landings since Mod. 799. On March 22 Vickers began drawings for a modification to strengthen the support of all the flap units (Mod. D 2175). On March 23 Vickers sent to Viscount operators directions for the inspection of fittings (because although there was no evidence of fatigue in the fittings, it was known that the lug had fractured from a fitting in W.E.). By March 27 the first sets of parts for Mod. D 2175 were ready and sets for this modification were sent out for all Viscounts by about May 1. B.E.A. incorporated this modification in all their Viscounts between April 8 and June 1.

Vickers' Modification

Mod. D 2175 may be briefly described as follows: The lower part of the flap unit had reinforcing gussets and angle plates added to it. A fishplate was added on the outside of the wing surface so that there is now an additional and redundant structure for carrying the loads. These additional parts are designed to carry the full load as if the fittings and bolts were not there.

In addition the designers worked to low stresses to ensure a good fatigue life. The fishplate reduces loads in the bolts to about half their original value. It is believed that this would extend the fatigue life of the bolts at least 10 times. In addition, however, the bolts are to be examined periodically and replaced after specified periods. The examination is made in the laboratory and includes a development of the magnaflux test which development provides a very delicate test for small cracks. As a further safeguard the clearance of the locking lever has been increased so that even if the unit did become detached in the same way as on W.E. (which is considered to be practically impossible) the ailerons would not lock.

Vickers has also introduced for itself and its subcontractors the practice of checking by a blueing test (which is a test for accurate seating) any bolts in an aircraft that take tension loads and any bolts in holes reamed out on assembly.

No criticism was made at the hearing of the remedial measures adopted but it was suggested on behalf of the British Airline Pilots Assn. that in addition it would be desirable that the aileron control cable should not pass through any guide on a flap unit, so that if this unit did become detached, there would be no possibility of the aileron becoming locked.

I am satisfied that the modifications made as indicated in the last paragraph are sufficient for this purpose and there is no practical reason for altering the position of the fairlead. However, it appeared from the evidence that there would be no difficulty in having the fairlead on the main structure of the wing rather than on the flap unit, and it would be worth while to make the alteration if it would give pilots a sense of greater security.

Another submission made on behalf of the B.A.L.P.A. was that it would have been desirable to cancel all flights or at least all passenger flights of Viscounts immediately if there was reason to believe that a structural fault had caused the accident, until a judgment could be formed as to where the fault lay and whether it was something peculiar to W.E. or not.

Such a decision must always be a difficult one to make and I am not prepared to say that those responsible were in error in allowing flights to continue during the first few days of the investigations. It is accepted that from March 18 onward all necessary precausions were taken.

CONCLUSIONS AND RECOMMENDATIONS

I concluded that this accident happened because:

- **Lug broke;**
- **9/16 in. bolt broke** because it was badly fatigued;
- **Aileron became locked** when the flap unit moved away from the trailing edge member.

I am satisfied that this was the probable order of events, though it is not certain that the lug broke before the bolt.

The breaking of the lug was probably an indirect result of the fitting having been machined down to the extent of 0.1 in. and of the fitting not having been seated close against the trailing edge member. It was unfortunate that the 0.1 in. of metal was removed. The faulty seating of the fitting was a serious defect of workmanship. This was not discovered on inspection and it may well be that because of the absence of a concession note for the work done on the fitting attention was not directed to checking the accuracy of the seating. All these matters concern Vickers alone and have nothing to do with Saunders-Roe or with Marshalls.

The view I have formed about the severe fatigue of the ⅞ in. bolt is that it was the result of a number of factors. I think the magnitude and number of alterations of stress to be expected at the bottom attachment of Nos. 2 and 3 flap units were under-estimated by the designers. This is the only way in which the significant incidence of fatigue in bolts from both these units can be accounted for.

Secondly, I am satisfied that the method of effecting Mod. 799 after delivery made it impossible to do the work with as much precision as when the modification was made in the course of manufacture. This would explain the substantial incidence of fatigue in main bolts from bottom fittings from units so modified by each of three highly reputable organizations.

Thirdly, I have no doubt that the larger number of landings performed by W.E. than by nearly all other Viscounts is one reason why there were bolts in it more severely cracked than in any of the others.

Additional factors which may have operated in this connection are that as this was the first machine of its type, the manufacturing difficulties would be greater than for later models and (though this cannot affect the ⅞ in. bolts) that the use of this aircraft for the specialized training of pilots may have involved some additional stress. Lastly, I am satisfied that the faulty seating of the head and nut of this particular bolt brought about the advance state of fatigue that was present in it.

Because the corresponding bolt on the port wing is also out of alignment I do not feel that the mal-alignment of the bolt in question can with any confidence be attributed to the faulty seating of the fitting. It is, however, possible that the fitting sprang slightly when the bolt was removed for enlarging the hole and that this led to the hole being reamed out of true.

Whether this was so or not, it is fair to say that the state of knowledge of these matters at the time when the reaming was done was not such that those responsible could have been expected to know that a small error in the alignment could lead to a great acceleration of fatigue. If this had been realized the seating could have been submitted to a test known as a "blueing test" which would have disclosed the error; the normal practice did not require such a test.

Whatever mistakes may have been made in connection with any of the matters discussed in this paragraph, I do not consider that any of them could properly be described as a wrongful act or default or negligence.

As to the locking of the ailerons, nobody could have been expected to foresee this and neither the placing of the control wire nor the provision of a fairlead attached to the unit could, in my opinion, be called a fault in design.

Final Conclusion

In coming to a final conclusion about the cause of this accident, I consider that the fatigue of the bolt was really the effective cause. It was this bolt that was designed to carry most of the load and, even if the lug broke first, there is nothing to show that a major structural failure would have occurred if the bolt had not been severely fatigued.

It was, in fact, in such a condition that it was bound to break sooner or later, and if when it broke the lug was still attached by the smaller bolt to the trailing edge member the lug and the small bolt had imposed on them a load which (although according to the evidence they were both deemed strong enough to carry it) it was not their function to bear.

The locking of the ailerons is to be regarded rather as something which made it impossible to prevent an accident than as something which caused it. In answering the formal questions, I consider it sufficient to specify the effective proximate cause of the accident.

The questions put to the court were as follows:

- **What was the cause** of the accident?
- **Was the accident due** to or contributed to by the act or default or negligence of any party or any person in the employ of that party?

The answers of the court are as follows:

- **Cause of the accident** was the fracture of the ⅞ in. bolt holding the bottom of the No. 2 starboard flap unit. The fracture was due to fatigue.
- **No.**

I have considered very carefully with my assessors the question of whether recommendations for the future can usefully be made. Different opinions were expressed at the hearing by highly qualified witnesses as to the general question of the use of bolts in tension for supporting important structures. No absolute rules can be laid down as applicable on all occasions and future practice must take account of future developments in knowledge and experience.

I am, however, impressed with the difficulty of calculating the magnitude of the alternating stresses on such a bolt and how often they will occur, and I am satisfied that until this accident happened it was not realized that the precise alignment of such bolts might be of great importance. I have considered whether to recommend a periodical laboratory examination for fatigue but it appears that once there is any sign of fatigue its development may be so rapid that an effective system of checking would hardly be possible and would in any case impose an undue burden on operators. For that reason I consider that recommendations should be directed to the avoidance of fatigue rather than to detection and remedial action.

I therefore recommend:

- **That reliance on a single bolt** in tension for the support of a primary structure should be avoided if possible.
- **That where such bolts are used** an ample margin of strength should be allowed (having regard to the material of which the bolt is made) so as to ensure that fatigue will not develop at any time in the life of the bolt.
- **That where such bolts are used** the seating of the bolt and nut should be carefully checked.

David Cairns
R. N. White
S. C. Redshaw
A. Thom

AMC Contracts

Wright-Patterson AFB, Ohio—Following is a list of unclassified contracts for $25,000 and over as released by the Air Materiel Command:

Lear, Inc., Grand Rapids, Mich., Gyroscope, type MD-1, indicator, type MM-3 and MM-4 and shock mount for F8U-2, A4D-2 and F11F-1 aircraft; (MIPR-R58-1072-62-NOas), $4,890,610.

Sperry Gyroscope Co. Division Sperry Rand Corp., Great Neck, N. Y., components for the DSCE-80 system plus spares for the QF-80 aircraft; (PR-MA-8-05F-307 and 308), $768,000.

Aerosonic Corp., Clearwater, Fla., type MA-1 pressure altimeters for B-57 aircraft; (PR's MA-8-05C-101, MA-8-05C-105, MA-8-05C-106 and MA-8-05C-2833), $163,023.

General Tire and Rubber Co., Akron, Ohio, nose wheel assemblies for KC-135A aircraft; (PR-PE-1-03B-4600), $47,954.

Aerosonic Corp., Clearwater, Fla., type MA-1 altimeters for KB-50 aircraft; (PR-MA-8-05C-102 and OC-8-05C-2095), $74,875.

Courter Products, Model Engineering and Manufacturing, Inc., Boyne, Mich., MT-1 indicators, aircraft usage for F-106A, B, T-38A, B-52D, E and G, F-105B and C aircraft; (PR-PE-8-05G-3264 and 3264-1), $58,354.

AC Spark Plug Division, General Motors Corp., Flint, Mich., sighting, set-gun, bomb rocket, type AN/AJQ-1 for F-100F aircraft; (PR-PE-7-11B-4704), $84,634.

Montrose Division, Bendix Aviation Corp., South Montrose, Pa., transmitter, fuel pres-

sure, type E-1; (PR-MA-6500-1, -2 and -3), $49,766.

Philharmonic Radio and Television Corp., New Brunswick, N. J., AN/ARN-32, marker beacon receiving set, spare parts and data for T-33A, F-101C, F-104A, KC-135, B-52, F-100F and C-130A aircraft; (PR-PE-7-16A-4876, amendment No. 1, 2, and 3, R-02-890216-SC-01-23 and amendment No. 1), $454,041.

B. F. Goodrich Aviation Products, B. F. Goodrich Co., Dayton, Ohio, spare wheels for B-47 aircraft; (PR-00-8-03B-1106 and 00-8-03B-1111), $808,000.

Chatham Electronics Division, Tung-Sol, Inc., Livingston, N. J., power supplies, metallic rectification, type G-1, spare parts, ground support equipment and data for B-52 and KC-135 aircraft; (PR-PE-8-03C-3257), $90,750.

CAA Contracts

Washington—Following is a list of contracts as released by the Civil Aeronautics Administration:

General Radio Co., Cambridge, Mass., $18,283.89 for 42 slotted line assembly units and spare parts.

Sierra Electronic Corp., Menlo Park, Calif., $17,813.50 for 25, wave analyzers.

Northern Radio Co., New York, N. Y., $17,660.33 for 10 twinplex combiners and spare parts.

Sterling Radio Products, Inc., Houston, Texas, $15,472.11 for 60 monitor units.

Rauland Corp., Chicago, Ill., $15,360 for 26 cathode ray tubes.

Bendix Radio, Baltimore, Md., $15,167.40 for transformers and related parts.

Arcs Industries, Inc., Bellmore, L. I., N. Y., $14,902.24 for 132 receiver selectors and spare parts.

Topp Manufacturing Co., Inglewood, Calif., $14,865.99 for 51 portable antenna masts.

Tektronix, Inc., Towson, Md., $14,851.20 for 26 oscilloscopes.

Army Contracts

Washington—Following is a list of unclassified contracts for $25,000 and over as released by Army Contracting Agencies:

DEPARTMENT OF THE ARMY, Chicago Ordnance District, 209 W. Jackson Bldg., Chicago 6, Ill.

American Machine & Foundry Co., Chicago, supply contract, thruster, 250 ea., $59,910.

A. O. Smith Corp., Chicago, supply contract, nitrogen receivers, 35 cu. ft., 15 ea., $80,850.

REDSTONE ARSENAL, USA, Redstone Arsenal, Ala.

Continental Technical Service, Inc., Dayton 2, Ohio, 4,200 additional man hours of engineering services, (PR: CS-273-57) supplemental agreement No. 5, $31,000.

CORPS OF ENGINEERS, USA, Office of the District Engineer, St. Paul District, 1217 U. S. Post Office and Custom House, St. Paul 1, Minn.

Toltz, King, Duvall, Anderson and Associates, Inc., St. Paul, preparation of contract plans and specifications for four (4) Nike installations, River Falls, Wis., Farmington, Minn., St. Bonifacius, Minn., and Bethel, Minn., $80,800.

CORPS OF ENGINEERS, USA, Office of the District Engineer, San Francisco District, 180 Montgomery St., San Francisco, Calif.

Carl Daniels, Monterey, Calif., ammunition storage facilities, ADC type, Castle AFB, Merced Co., Calif., (IFB ENG-04-263-57-616), contract No. DA04-203-ENG-5181, $460,536.

U. S. Army Engineer Division, New England, Corps of Engineers, Portland, Me.

Bridge Construction Corp., Augusta, Me., construction of alterations and additions for Nike batteries for Loring AFB Defense Area, (DA-19-016-ENG-5802), IFB ENG-19-016-58-63), $166,720.

Harper & Lynch, Inc., Ft. Fairfield, Me., construction of aircraft fueling facilities, Loring AFB, Limestone, Me., (DA-19-016-ENG-5806), IFB ENG-19-016-58-85, $111,-211.

Westinghouse Electric Corp., Mobile, Ala., transformers, oil circuit breakers, for Eglin AFB, Fla., Contract No: DA-01-076-ENG-4173, (IFB-ENG-01-076-58-54), $151,265.

Moloney Electric Co., St. Louis, Mo., voltage regulators for Eglin AFB, Fla., $43,971

Whaley Co., Inc., Birmingham, Ala., construction of operations squadron bldg., at Columbus AFB, Miss., $103,567.

Federal Pacific Electric Co., Newark, N. J., transformers for Eglin AFB, Fla., $103,180.

ESCO Manufacturing Co., Greenville, Texas, transformers for Eglin AFB, Fla., $33,782.

Laidlaw Construction Co., Mobile, Ala., construction of ditch closure at Brookley AFB, Ala., $74,687.

LOS ANGELES ORDNANCE DISTRICT, USA, 55 S. Grand St., Pasadena, Calif.

Reynolds Industries, Inc., Santa Monica, Calif., technical equipment, $30,949.

Douglas Aircraft Co., Inc., Santa Monica, Calif., Honest John improvement program, (1) $242,834, (2) $51,687.

Gillfillan Bros., Inc., Los Angeles, emergency and Blue Streak requirements of spare parts for Corporal missile system, $44,557.

Topp Industries, Inc., Los Angeles, angle of attack transducers, $135,739.

Lear, Inc., Santa Monica, Calif., gyroscope, $146,136.

CORPS OF ENGINEERS, USA, Office of the District Engineer, St. Paul District, 1217 U.S. Post Office and Custom House, St. Paul, Minn.

Louis Nicholas, Grand Rapids, Minn., construction of recreational facilities, multipurpose building at AFS, Grand Rapids, Minn., (IFB ENG-21-018-57-23), $122,455.

Ashbach Construction Co., St. Paul, Minn., construction of east-west runway extension at Duluth AFB, Duluth, Minn., (IFB ENG-21-018-58-9), $910,612.

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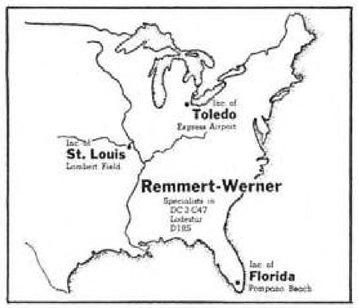

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LETTERS

French Aerobats

Knowing your desire for accuracy, I would like to submit this correction to the article by David A. Anderton entitled, "Italian Team Pioneers in Formation Landings," (AW May 19, p. 81).

On Armed Forces Day in 1956 at Evreux/Fauville Air Base, France, I and several other U.S. pilots were somewhat shaken when the French Air Force Acrobatic Team, flying Ouragans, not only landed but took off in their four-plane show formation. In other words, the slot man was in the slot position from the time they taxied onto the runway for takeoff until they taxied off upon landing, except for their bomb-burst maneuver.

The leader of our own USAFE acrobatic team from the Statue of Liberty Wing at Chaumont commented that this French team flew the tightest, most precise and daring formations he had ever seen. Incidentally, this team was made up of two lieutenants and two sergeant-pilots.

LT. COL. EDWARD O. WILLEFORD,
Professor of Air Science
Washburn University of Topeka
Topeka, Kan.

Rescue Beacons

We have noted that considerable interest in air-sea-rescue radio devices has been in evidence in many aviation periodicals. Comments have appeared both in the editorial material and in "Letters to the Editor."

Of particular interest to us has been the statements made with regard to the SARAH success and the intelligent query as to why it is not used in the United States.

Our experience in this area has indicated that air-sea-rescue radio beacons are not universally used in the U.S. This is not the case, however, in other parts of the world. Most NATO countries use SARAH beacons for air-sea-rescue purposes; the U.S. does not.

In those few instances that beacons are carried by American planes, no protection is afforded while flying over European, Canadian, and other regions for the U.S. equipment is not compatible with SARAH receivers. The converse of this is also true where a SARAH beacon will not activate the American search receivers.

The SARAH beacon uses one vacuum tube, has over 20 hours' life, and approximate range of 100 miles. American beacon contains four or more vacuum tubes, has short life, and lower range capabilities. The cost difference is obvious.

Exercising our license rights with the British manufacturer of SARAH, we are currently developing a beacon called LOCAR which will function equally well on both sides of an international border with complete compatibility. This we feel, will result in greater safety by cutting across preferences of various countries to different technical philosophies.

It may be of interest for you to know that many beacons of the SARAH type have been supplied for the recovery of missile nose cones. SARAH, because of its long range and high accuracy, has been selected over other systems to recover an expensive piece of hardware. We feel that it is a tragedy that flight personnel are not given the same opportunity for rapid and economical recovery.

CHARLES URBAN
Administrative Engineer
Simmonds Aerocessories Inc.
Tarrytown, N. Y.

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

No Time

Statements before the Unpreparedness Committee, editorials and letters to the editor combine to give me the impression that our dependable old axiom "Necessity is the Mother of Invention" is not adaptable to the current big problem. It may still suffice for everyday civilian requirements (aside from medical), but in future warfare necessity will leave no time for invention. Unlimited production capacity is worthless without something useful to produce. More basic research, under unified and competent supervision to prevent waste and duplication, is imperative. For every new war machine devised, there will logically be many incidental benefits to humanity (possibly even a good five cent cigar).

K. B. RUHLE
Annette, Alaska

Unfunny Sandwich

Your article "IATA Sets Sandwich Configuration" (AW April 28, p. 39) was very amusing, yet it points up a state of affairs which is not at all funny. Here is the spectacle of two American corporations (TWA and PAA), from the last stronghold of free enterprise, complaining to the grievance committee of an international cartel (the IATA Breaches Commission) because the competition's service is too good!

However, the real fault does not lie with the airlines, but with the regulatory system under which they are forced to operate. The entire concept of air transport regulation is based on the assumption that airlines are not fundamentally different from railroads or public utilities. Since it would be uneconomical for several companies to duplicate each others' tracks or power lines, one or two must have a monopoly of service in their areas or on their routes. Government regulation is necessary to prevent unreasonable exploitation of this monopoly. No such monopoly is available to airlines except by government decree, since an airplane can be used on any route to which its range and takeoff/landing characteristics are suited. Of course, along with monopoly come government price-fixing and the obligation to fly low-density, unprofitable routes.

The present difficulties in which the airlines find themselves (re-equipment finance scarcity, dwindling profits, etc.), are entirely due to the fact that they are prohibited from charging realistic fares and flying realistic schedules, except insofar as a very slow moving government agency permits.

I believe that the following program would result in sound airline economics and at the same time improve the over-all level of services provided:

1. Permit any carrier to fly any routes and schedules he chooses, to change them at will, restricted only as to safety.
2. Permit the carrier to provide any quality of service and to charge fares he sees fit.

The possible objections which may be raised are:

1. The airlines will engage in "cutthroat" competition and go broke.
2. The airlines will charge outrageous fares and the traveler will be "taken to the cleaners."
3. Small town, low-density routes will get unsatisfactory service, or none at all.

The first two objections are contradictory. One or the other situation may exist for short periods over a few routes, but the airlines with highest cost and poorest service will soon move elsewhere if the profits are too low, and the overcharging airlines will soon be faced with competitors eager to share the bonanza of high priced routes. The third can be disposed of by observing that if an airline is forced to operate an uneconomical route but is given a profitable one to make up for it, the passengers on the first route are being given service at the expense of those on the latter. Where services are needed, passengers will be willing to pay enough to get it. If not, they are at liberty to ride the bus.

Free enterprise is what has made America rich and strong. Let's try it in air travel!

FRANKLYN J. DAVENPORT
Seattle, Wash.

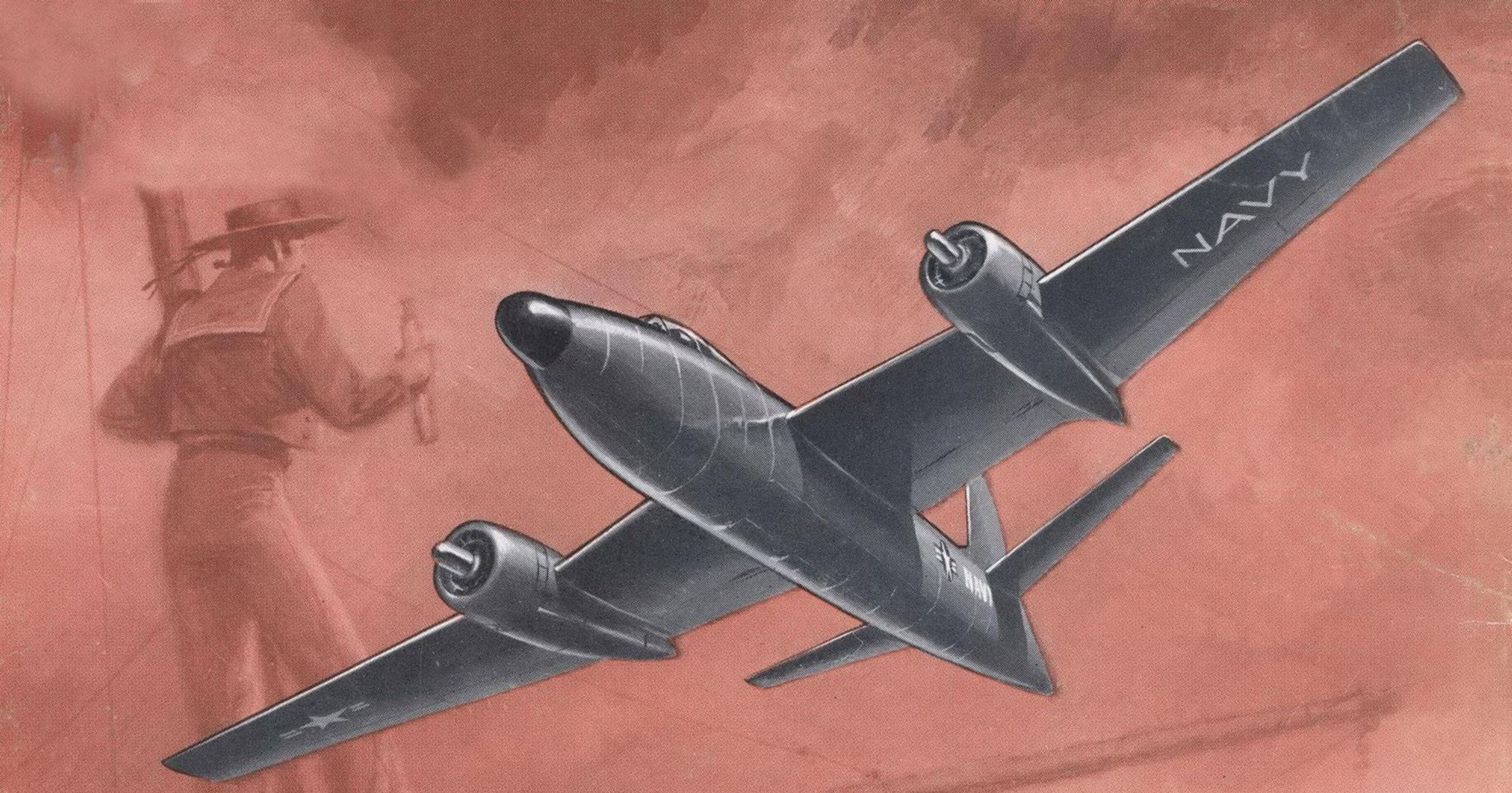
Barrier Saves F-84

On Monday, May 12, an Air National Guard F-84 lost power on takeoff and engaged the barricade assembly at Lambert Field in St. Louis, Mo. The engagement speed was set at 150 knots.

This barricade assembly is one of a set we manufactured for McDonnell Aircraft at Lambert Field. It is designed to catch the F-101. It was so successful in arresting the aircraft, the only apparent damage was small damage to the tail.

We felt you would be interested in this occurrence. This barricade is an air actuated "fence" of nylon webbing. It is not a Davis Barrier. It may prove to be the answer for high speed airports in populous areas. Wold-Chamberlain in Minneapolis, O'Hare in Chicago, and many others, as well as St. Louis, need a solution.

JIM BOYT
Boyt Harness Co.
Des Moines, Iowa



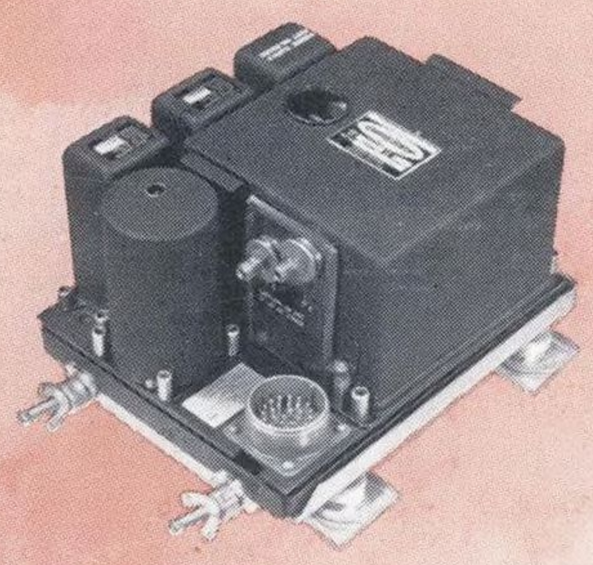
"LOOKOUT" 1958

The modern-day lookout's masthead is the U. S. Navy's long-range Anti-Submarine aircraft. His eyes, electronic. His quarry, unfriendly submarines.

This mission requires constant and complete patrolling of all vital areas in accordance with the pre-planned patrol pattern. Pinpoint navigation and precise positioning of the aircraft at all times is essential. To maximize the navigational capabilities of the Navy's "flying patrol," highly accurate True Airspeed Computers, designed and produced by Servomechanisms, Inc., are now being installed. Utilizing a force balance transducer, designed by SMI, the computer has an exceptional accuracy...within 2 knots in range of from 100 to 250 knots.

This computer is only one of a whole series of True Airspeed Computers produced by SMI. Completely transistorized True Airspeed Computer designs for use on aircraft assigned to various missions, are also available. These computers, which operate over a wide range of speeds, exhibit the same high degree of performance, accuracy and reliability.

The computers are another example of Servomechanisms' Mechatronic Design Philosophy, wherein each major function is accomplished in a separate, functionally packaged module. The plug-in, pull-out design reduces down time to a minimum and enables semi-skilled personnel to maintain this equipment by simple substitution of the plug-in modules.



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The products of SMI are available in Canada and throughout the world through Servomechanisms (Canada) Limited, Toronto 15, Ontario.