Aviation Week

Including Space Technology

75 Cents

A McGraw-Hill Publication

May 11, 1959

How Soviets May Land Man on Moon

USAF-Martin Titan A-1

You'll wonder where the metal went!

(Voi-Shan engineered a weight saving averaging 23% on their **weight/master** *anchor nut)*

Voi-Shan's introduction of **weight/master** anchor nuts to the fastening field is the result of a new design concept that meets the requirements of the industry while providing the utmost in saving.

weight/master (tm)

weight/master's Balanced Design has a readily recognized trim shape. Excessive metal has been removed without sacrificing full performance.

Voi-Shan has the **weight/master** readily available in the single lug, two lug, and corner type anchor nuts in five sizes: 4-40 through ¼-28.

The chart shows Voi-Shan **weight/master** part numbers with the applicable NAS numbers.

For information on these and other **weight/master** nuts, write to:

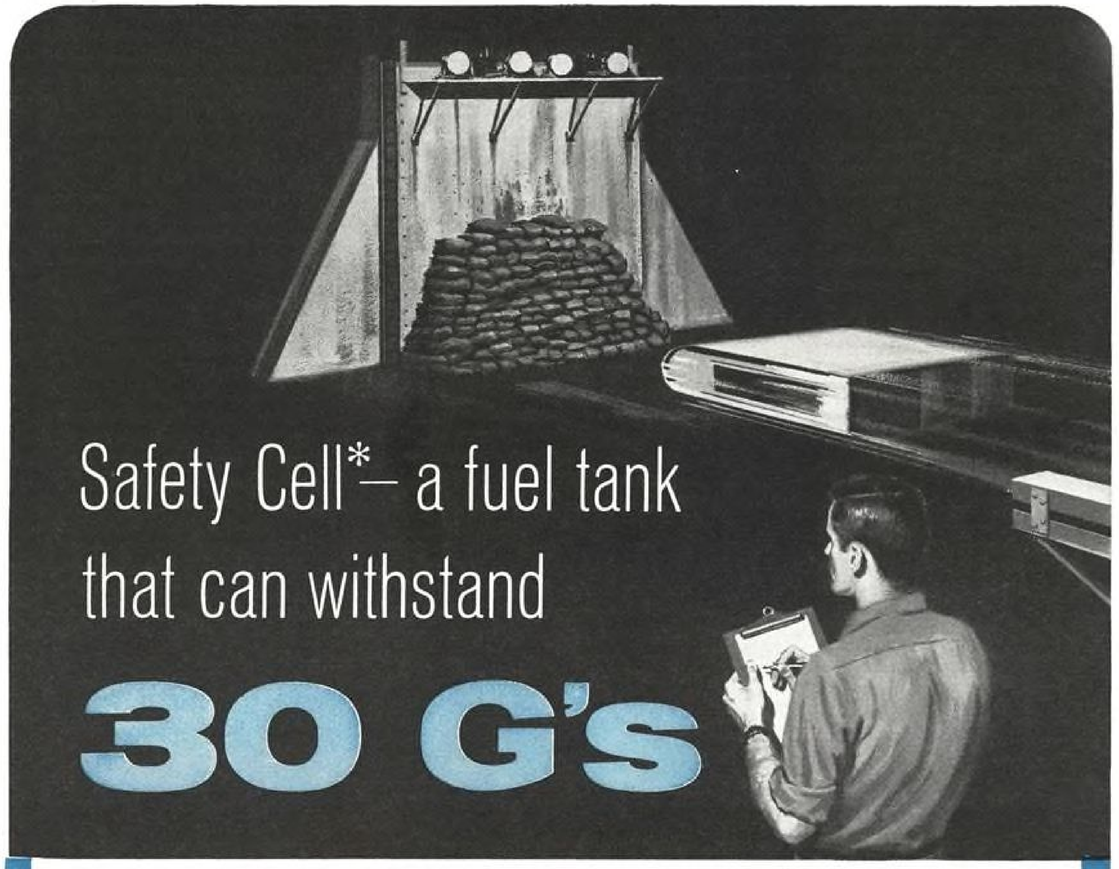
VS PART #'s	AN and NAS PART #'s
VN 101	NAS 682 NAS 1025
VN 102	NAS 680 NAS 1023 AN 362 AN 366
VN 103	NAS 684 NAS 1027

VOI-SHAN

VOI-SHAN MANUFACTURING COMPANY

8463 Higuera Street **Culver City, California**

Another "First" from Goodyear Aviation Research



Safety Cell*– a fuel tank that can withstand 30 G's

THE PROBLEM: how to control aviation fuel during high-impact conditions so that instantaneous vaporized combustion can be prevented.

THE GOODYEAR ANSWER: Safety Cell, a high-strength, low-weight fuel tank made of super-tough rubberized fabric. Under exhaustive testing, in cooperation with the Federal Aviation Agency, these tanks have successfully withstood impacts exceeding 30 G's—maximum level of human tolerance. This means that the danger of vaporized combustion at impact is substantially reduced. Thus, the opportunity for survival is materially increased. A number of these tanks are already in use.

THE SIGNIFICANCE: personnel and property protection against full vapor combustion far beyond any type previously obtainable.

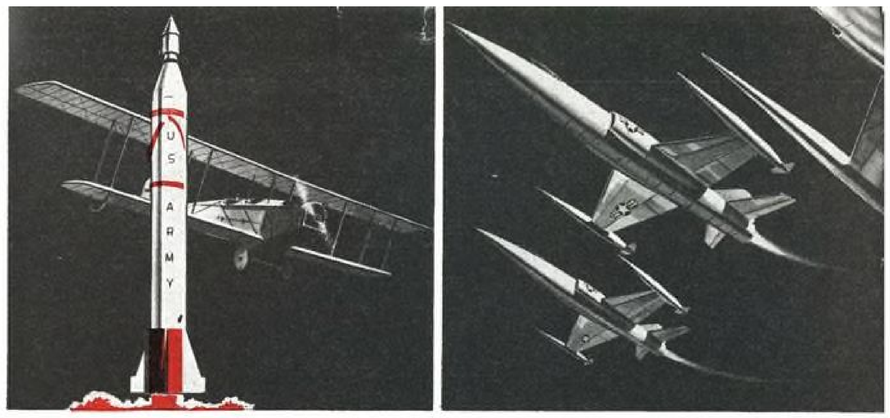
More information on Safety Cell, the revolutionary new fuel cell, is yours for the asking. Simply write Goodyear, Aviation Products Division, Akron 16, Ohio.

AVIATION PRODUCTS BY **GOODYEAR**

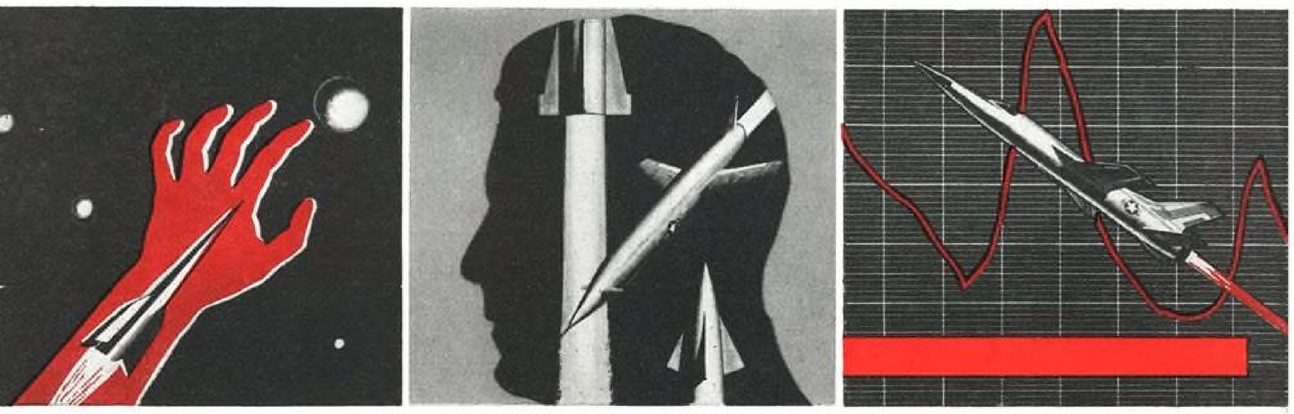
*Safety Cell—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

MORE AIRCRAFT LAND ON GOODYEAR TIRES, WHEELS AND BRAKES THAN ON ANY OTHER KIND

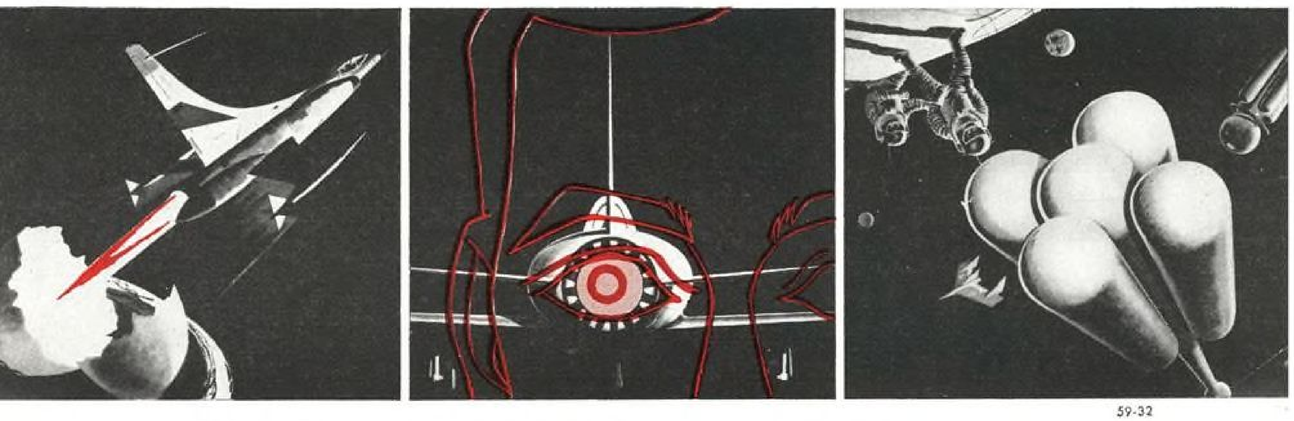
Idea sessions on going places in the sky often put



the future as near as the next thought. When talk of



ability turns to availability, think of Ex-Cell-O for the



59-32

pre-requisite to performance...precision.

EX-CELL-O FOR PRECISION XLO

EX-CELL-O CORPORATION DETROIT 32, MICHIGAN Aircraft Division

MAN AND MISSILES FLY HIGHER, FASTER AND SAFER WITH PARTS AND ASSEMBLIES BY EX-CELL-O AND ITS SUBSIDIARIES: BRYANT CHUCKING GRINDER CO., CADILLAC GAGE CO., MICHIGAN TOOL CO., SMITH BEARING DIV.

AVIATION CALENDAR

May 18—Symposium on Space Medicine Electronics, Franklin Institute, Philadelphia, Pa.

May 18-21—18th Annual National Conference, Society of Aeronautical Weight Engineers, Hotel Henry Grady, Atlanta, Ga.

May 19-21—Middle Eastern District Meeting, American Institute of Electrical Engineers, Lord Baltimore Hotel, Baltimore.

May 20-22—National Spring Meeting & Exhibition, Society for Experimental Stress Analysis, Sheraton Park Hotel, Washington, D. C.

May 20-22—Second Jet Age Airport Conference, American Society of Civil Engineers, Shamrock-Hilton Hotel, Houston, Tex.

May 21-22—1959 Ohio Valley Instrument and Automation Exhibit and Symposium, Cincinnati Section, Instrument Society of America, Music Hall, Cincinnati, Ohio.

May 24-June 5—Federation Aeronautique Internationale Annual Meeting, Moscow, USSR.

May 25-27—1959 National Telemetering Conference on Investigation of Space, Brown Palace and Cosmopolitan Hotel, Denver, Colo. Sponsors: American Rocket Society, Institute of the Aeronautical Sciences, American Institute of Electrical Engineers and Instrument Society of America.

May 25-27—All Industry Production and Quality Control Exposition and Convention, American Society for Quality Control, Cleveland Public Hall and Hotel Sheraton, Cleveland, Ohio.

May 25-28—Design Engineering Show and Conference, American Society of Mechanical Engineers, Convention Hall, Philadelphia, Pa.

May 26-28—Supersonic Transport Meeting, San Diego Section, Institute of the Aeronautical Sciences, San Diego, Calif.

May 29-31—Soaring Society of America's

(Continued on page 6)

AVIATION WEEK Including Space Technology

May 11, 1959

Vol. 70, No. 19

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How to buy RELIABILITY* In A Precision Potentiometer

Answer: SPECIFY ALL THESE RELIABILITY FEATURES

1. Welded terminal and taps. A positive electrical and mechanical bond to withstand high temperatures, shock and vibration.
2. Machined metal case for retention of accuracy, especially under high temperature and/or humidity.
3. Metal inserts in molded wiper hubs for positive wiper positioning, for accuracy under shock, vibration, acceleration.
4. Precious metal resistance wires where needed for extremely low noise values, especially in corrosive atmospheres and for long storage life.
5. Precious metal contacts for low noise and high temperature.
6. One piece wiper construction for life, accuracy, low noise and low torque.
7. Stainless steel clamp bands capable of withstanding high torque, and the stresses and strains of shock, vibration and acceleration.
8. Precision stainless steel ball bearings — for low torque, high temperature, high vibration and shock characteristics.

PLUS 100% inspection AND a separate Quality Control program which puts 1 out of every 100 production units through complete environmental torture tests.

Since the ultimate price of a potentiometer is directly related to the reliability built into it . . . you only get what you pay for in a "pot".

Only Fairchild Linear and Non-Linear High Reliability Pots incorporate *all* of the above features. This High Reliability group can be had in ⅞" to 2" diameters, single and multi-turn, in standard and high temp versions and with accuracies as high as .009%.

For more information write Dept. 11Y.

*Fairchild's Built-in SAFETY FACTORS Beyond the Specs for Reliability in Performance.

RELIABILITY INSIDE THE BLACK BOX

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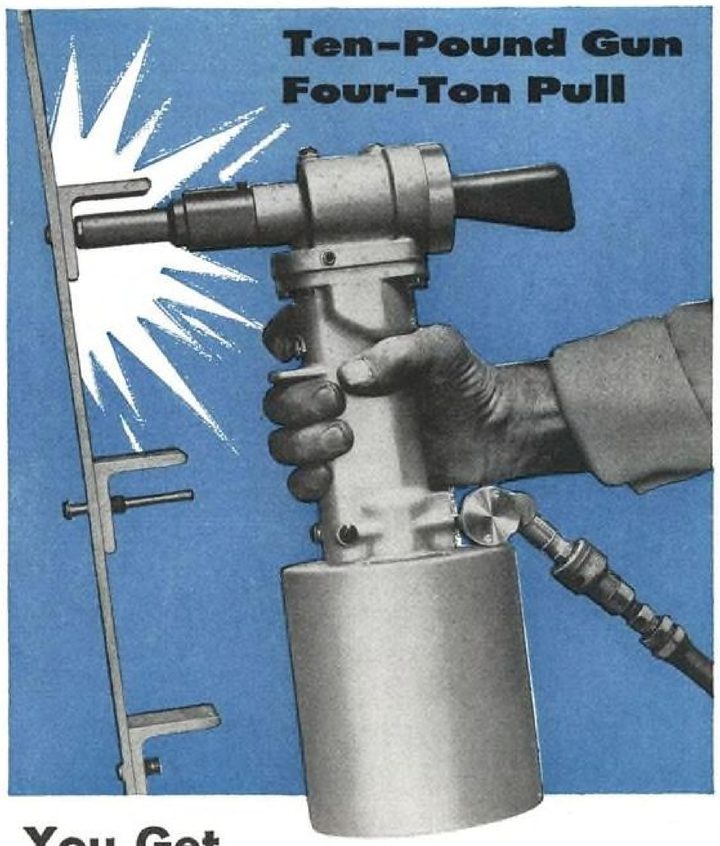

You Get MORE POWER—Less Weight with the *New* CHERRY G-85 Lockbolt Gun

The new Cherry G-85 lockbolt gun is designed to give you maximum pulling power with less weight. Its simplified rugged construction assures low maintenance costs. The gun weighs only 10.5 pounds, which reduces operator fatigue.

No special air supply is required with this lightweight gun, because it develops this high capacity at normal line pressure.

As the leader in the field of special aircraft fasteners, Cherry Research and Development department has produced this new lightweight, high capacity gun to increase the efficiency of installing lockbolts.* The G-85 gun may be adapted for setting stainless steel, monel, aluminum and carbon steel Cherry blind rivets.

For information on the new Cherry G-85 gun write Townsend Company, Cherry Rivet Division, Post Office Box 2157-N, Santa Ana, California.

*Licensed under Huck patents RE22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

CHERRY RIVET DIVISION

SANTA ANA, CALIFORNIA

Townsend Company

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AVIATION CALENDAR

(*Continued from page 5*)

Northeastern Soaring Meet, Dutchess County Airport, Poughkeepsie, N. Y.

June 1-3—Third Annual Summer Conference on Vacuum Metallurgy, New York University's College of Engineering, University Heights, Bronx, N. Y.

June 1-3—National Symposium, Institute of Radio Engineers' Professional Groups on Microwave Theory & Techniques, Harvard University, Cambridge, Mass.

June 4-5—Third National Conference, Institute of Radio Engineers' Professional Group on Production Techniques, Villa Hotel, San Mateo, Calif.

June 5-6—Annual Meeting of the Army Aviation Assn. of America, Shoreham Hotel, Washington, D. C.

June 5-6—10th Annual Maintenance & Operations Meeting, Reading Aviation Service, Inc., Municipal Airport, Reading, Pa.

June 8-9—Industry Missile and Space Conference, Sheraton-Cadillac Hotel, Detroit, Mich. Sponsor: Aero Club of Michigan.

June 8-11—Semiannual Meeting and Astronautical Exhibition, American Rocket Society, El Cortez Hotel, San Diego, Calif.

June 12-21—23rd French International Air Show, Le Bourget, Paris, France.

June 14-18—Semiannual Meeting, American Society of Mechanical Engineers, Chase-Park Plaza Hotel, St. Louis, Mo.

June 16-19—National Summer Meeting, Institute of the Aeronautical Sciences, Ambassador Hotel, Los Angeles, Calif.

June 21-26—Summer-Pacific General Meeting and Air Transportation Conference, American Institute of Electrical Engineers, Olympia Hotel, Seattle, Wash.

June 23-25—33rd Meeting, Aviation Distributors and Manufacturers Assn., St. Francis Hotel, San Francisco, Calif.

June 24-26—Second National Symposium, Nuclear Industry Division, Instrument Society of America, Idaho Falls, Idaho.

June 29-July 1—Third National Convention on Military Electronics, Sheraton-Park Hotel, Washington, D. C. Sponsor: Institute of Radio Engineers' Professional Group on Military Electronics.

June 29-July 3—Summer seminar on Plastics—Its Mechanical Properties, Design and Applications, Pennsylvania State University, University, Park, Pa.

July 1-10—U. S. National Soaring Competition, Harris Hill, Elmira, N. Y.

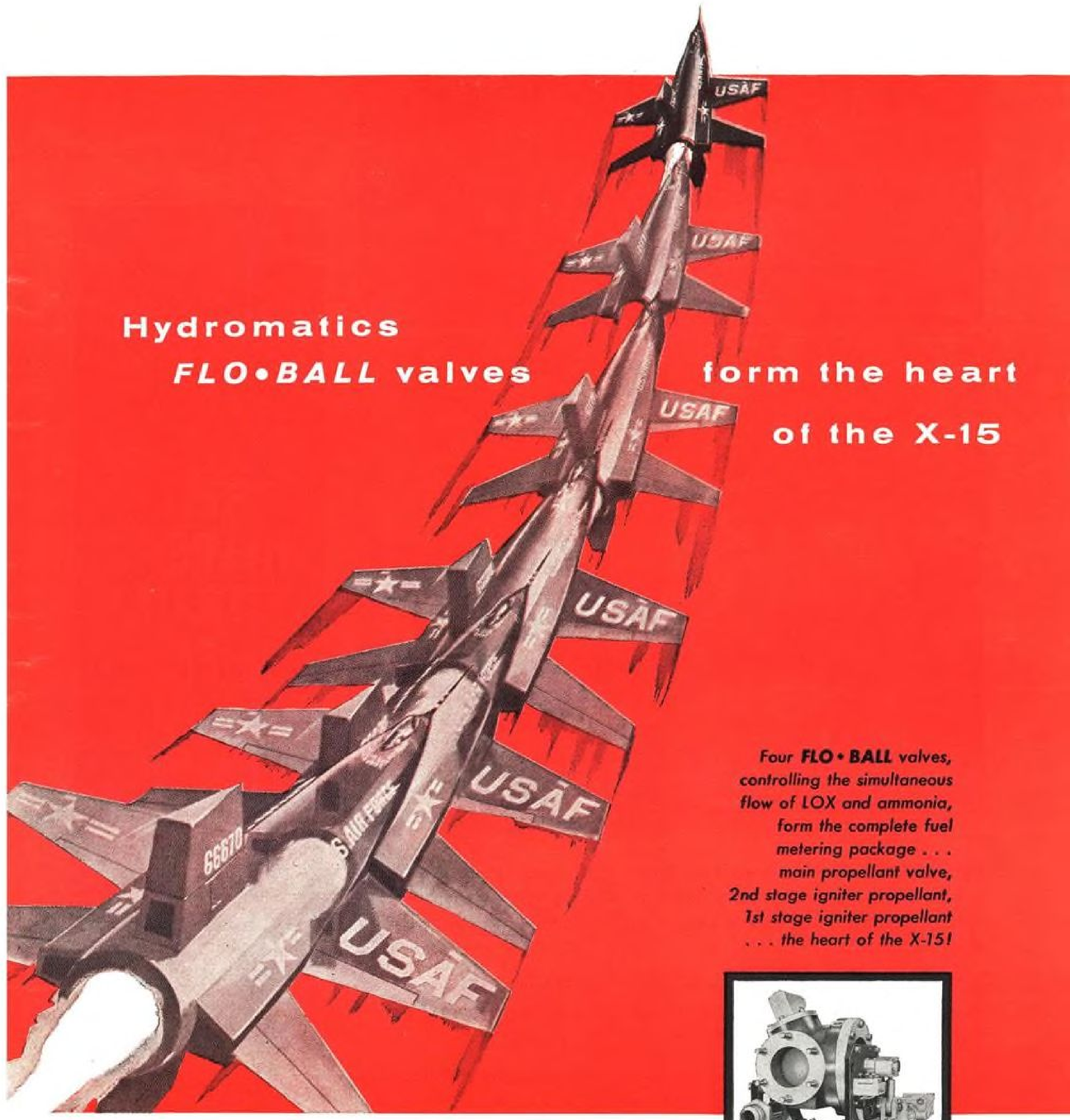
July 4-8—All-Woman Transcontinental Air Race from Lawrence, Mass., to Spokane, Wash. For information: All-Woman Transcontinental Air Race, Inc., 2611 East Spring St., Long Beach 6, Calif.

July 30-31—Sixth Annual Symposium on Computers and Data Processing, Denver Research Institute, Stanley Hotel, Estes Park, Colo.

Aug. 31-Sept. 5—10th Annual Congress, International Astronautical Federation, Church House, Westminster, London.

Sept. 7-13—1959 Farnborough Flying Display and Exhibition, Society of British Aircraft Constructors, Farnborough, England.

Oct. 12-16—15th General Convention of the International Air Transport Assn., Tokyo, Japan.



Four **FLO • BALL** *valves, controlling the simultaneous flow of LOX and ammonia, form the complete fuel metering package . . . main propellant valve, 2nd stage igniter propellant, 1st stage igniter propellant . . . the heart of the X-15!*

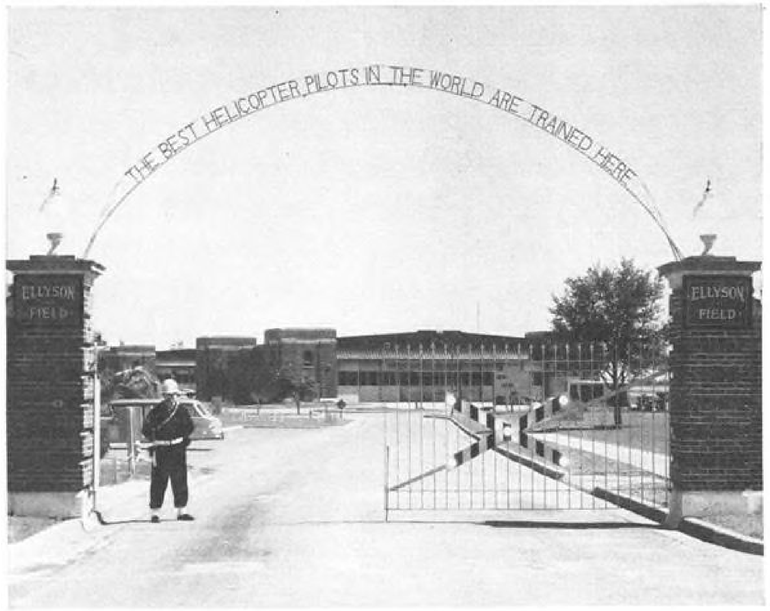
Only these space-age valves . . . could form the life-or-death heart of the X-15 . . . carrying America's first man into outer space!

Write for complete information on Hydromatics **FLO • BALL** valves... excelling in every major missile, aircraft, and ground support system.

Hydromatics, Inc.

Livingston, N. J.

The Bell HTL-7,
Latest Navy Trainer



BELL HELPS TRAIN THEM ALL!

Backstopping the Navy's striking power in the air are its helicopters and their pilots who perform missions ranging from plane guard to defense against the threat of enemy subs — and Bell is the helicopter that trains them *all*.

At Ellyson Field, the Navy's helicopter training center, Bells are used exclusively for primary training through solo flight by each of the more than 600 pilots graduated every year.

Regular trainees receive a standard 56-day course — pilots of flag rank get an intensive course lasting three weeks. And every last man-jack leaves Ellyson Field's HTG with a keen sense of pride in his newly-acquired "whirlybird" wings.

Bell, too, is proud — for in contributing to the strength and versatility of the Navy, Bell is helping contribute to America's position as "guardian of the peace."

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INFRARED FINGERPRINTS

for reconnaissance, interpretation and prediction

Aerial reconnaissance systems of the future will depend on infrared detectors and scanners for operation around the clock. Each surveillance target or object of military or geophysical significance will have its own characteristic fingerprint in the infrared spectrum.

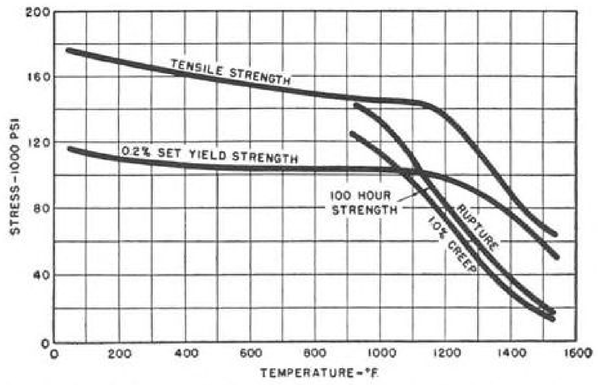
Infrared scientists at Bendix Systems Division, backed by years of experience in these techniques, are developing important new approaches to the interpretation and prediction of infrared reconnaissance data.

Extensive flight test data are being analyzed and catalogued to provide the guide to infrared interpretation. Also, test results are being correlated with laboratory techniques to predict the response of sensors and synthesize the infrared pictures they will produce. Thus, it will be possible to plan missions exactly as they will appear to the infrared observer.

Other infrared work includes target and background radiometric studies, detector studies, and infrared instrumentation for geophysical satellites, seekers, search, track, fire control, early warning, aerial intercept, collision warning, communication, mapping, horizon sensing, and infrared augmentation for target drones. Progress in infrared research and development exemplifies Bendix leadership in "the systems of tomorrow." Major Programs include the AN/AMQ-15 Weather Reconnaissance System and the Eagle air-to-air missile system. Inquiries are invited with respect to positions for better engineers and scientists.

Bendix Systems Division
ANN ARBOR, MICHIGAN

Bendix
AVIATION CORPORATION



Graph shows high tensile, creep and rupture strength Incoloy "901" provides at 1000°-1400°F.

New standard alloy... "super" alloy properties!

In the 1000°-1400°F range, Incoloy "901"* iron-nickel-chromium alloy has properties which match those of "super" alloys.

Its nominal composition is 40% nickel, 13% chromium, 2.40% titanium, 6.00% molybdenum. The balance: iron.

Incoloy "901" alloy was especially developed for rocket and gas turbine components. This alloy provides high tensile, creep and rupture strength (see graph), good oxidation resistance and favorable expansion characteristics at elevated temperatures.

Solution treatment extends time-to-rupture

In bar stock, time-to-rupture for a given stress and temperature can be extended by a high temperature solution treatment before aging. Sheet is best formed in the annealed condition and aged by a short time (2 hr) treatment at 1400°F.

Other new high temperature alloys developed by Inco

In addition to Incoloy "901", Inco has developed four other high temperature alloys which deserve attention in missile design. They are: Inconel "713 C"* nickel-chromium alloy, Inconel "700"* age-hardenable nickel-cobalt-chromium alloy and Inconel "702"* aluminum-containing nickel-chromium alloy. For basic data on all five, write to the address below.

*Registered trademark

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street — New York 5, N. Y.

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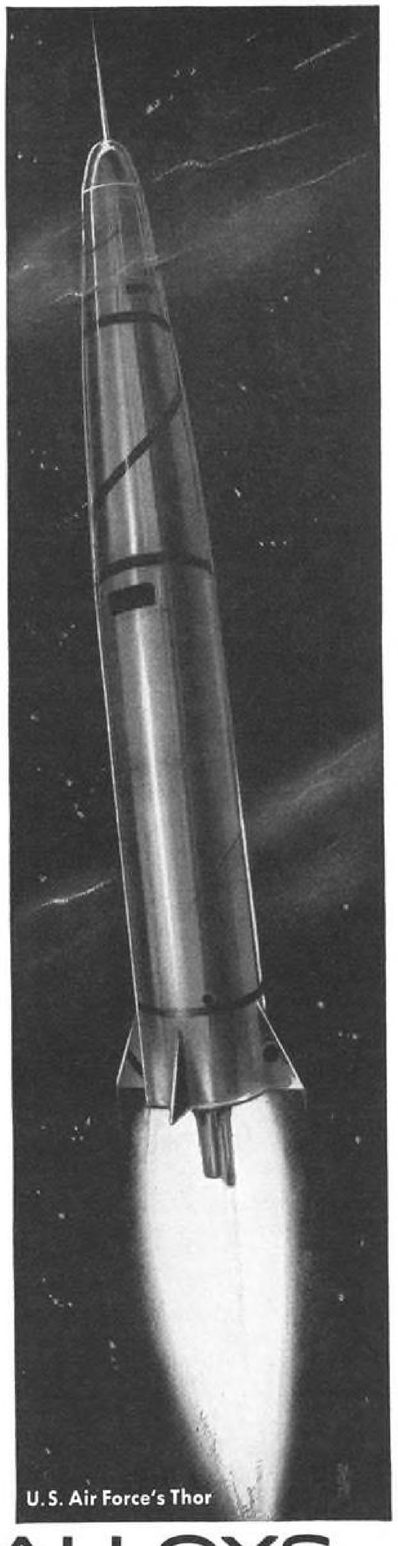
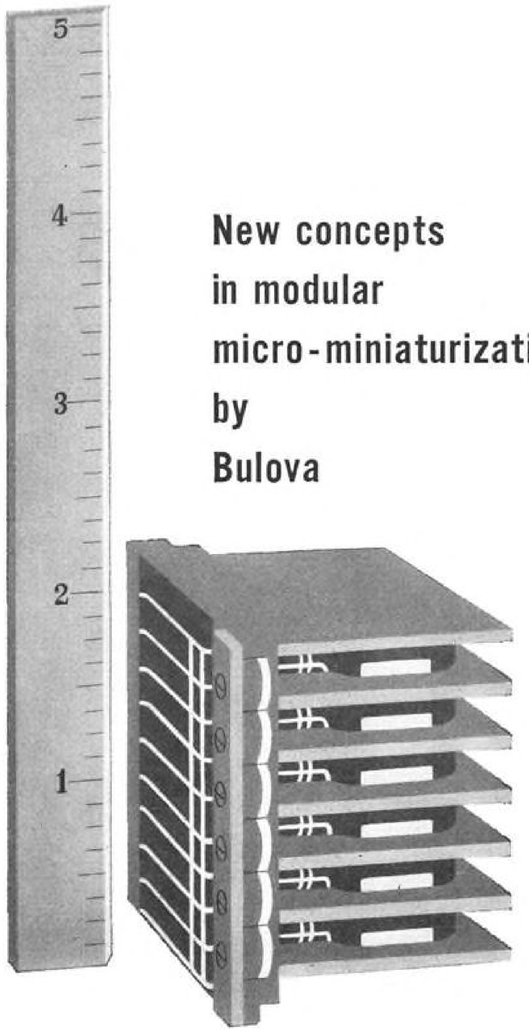


U.S. Air Force's Thor

INCO NICKEL ALLOYS

NICKEL ALLOYS PERFORM BETTER LONGER



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in modular
micro-miniaturization...
by
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Put Bulova capability behind your program

Bulova is implementing and shaping new concepts in micro-miniaturization, high-density packaging and micro-modular construction.

Bulova craftsmen, toolmaking and production facilities are geared to mass production with tolerances of less than .0003". Watch gaging and quality control techniques provide definite savings in precision assembly.

Experience in precision design, in precision manufacture, is the Bulova capability. Has been for over 80 years. For more information write —

Industrial & Defense Sales, Bulova, 62-10 Woodside Ave., Woodside 77, N.Y.

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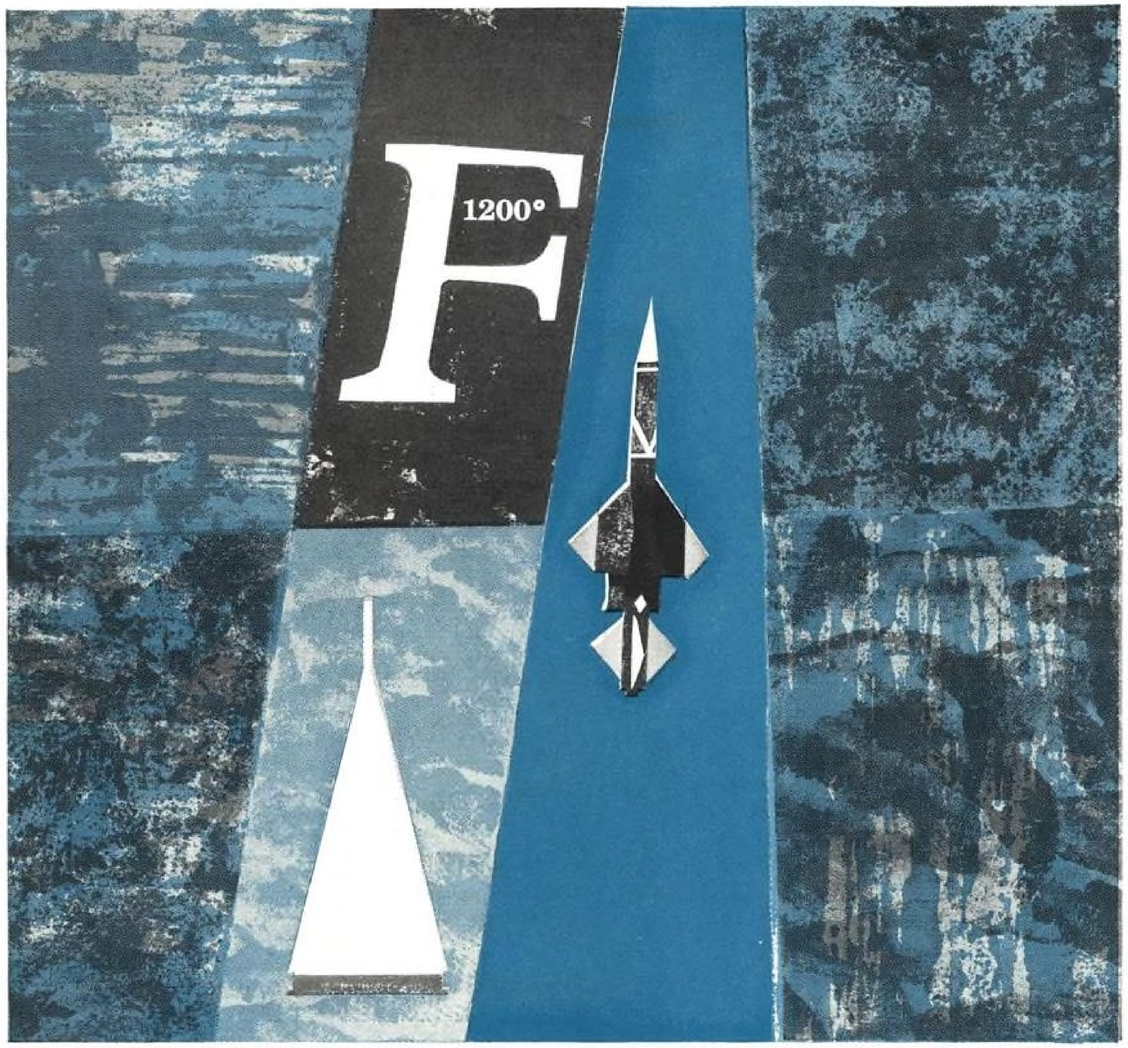


BRUNSWICK "SHOOTS" THE RADOME RANGE TO 1200°F

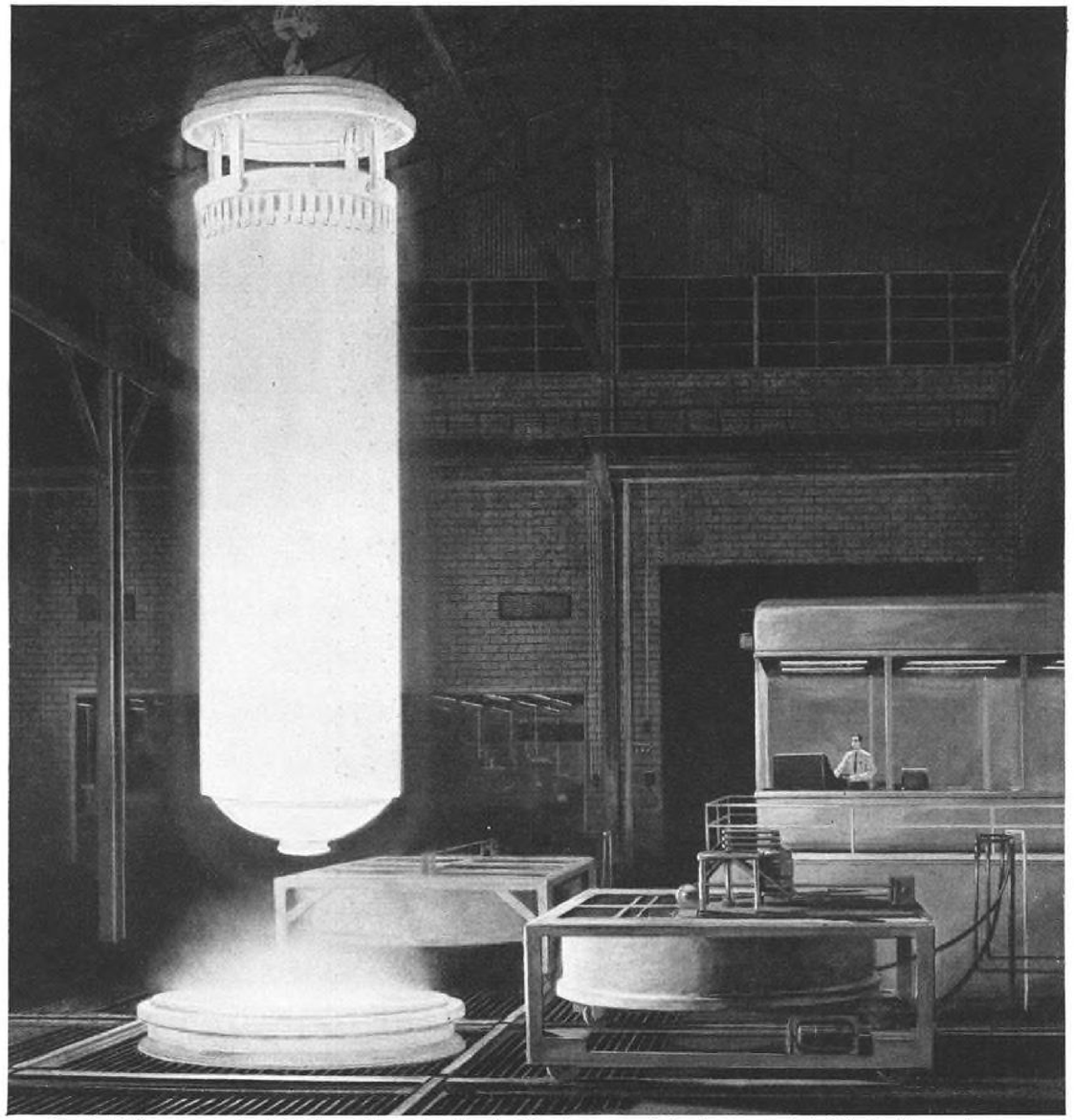
Brunswick makes a new breach in the thermal barrier with newly developed non-metallic materials that boost the temperature tolerance of radomes and nose cones to 1000-1200°F for limited exposure periods — almost twice the previous limit. This new advance in Brunswick's Strickland 'B' Process of filament winding opens a new chapter in aircraft and missile designing.

New "SBP" filament winding results in the highest strength-to-weight ratios ever obtained in radomes and nose cones with significant weight savings over conventional structures. With unmatched electrical uniformity, Brunswick builds them to meet the tightest tolerances for dielectric constants and compound configurations. Brunswick offers full electronic testing facilities.

Brunswick radomes and nose cones now slice skyward on such supersonic aircraft as the advanced Convair F-106; on such missiles as the Boeing Bomarc and Lockheed Q5. For details on Brunswick's leadership in research, development and testing, write: The Brunswick-Balke-Collender Company, Defense Products Division, 1700 Messler St., Muskegon, Mich.

BRUNSWICK

MAKES YOUR IDEAS *WORK*



Giant missile components—including rocket motors for the Minuteman—are being heat-treated by Solar in this new furnace.

New Solar capability for giant space age components

THE LARGEST CONTROLLED atmosphere pit furnace in the nation is in operation at Solar. Capable of heat-treating and brazing assemblies of 9 ft in diameter by 30 ft in length, this furnace represents an important addition to Solar's advanced weapon systems capability. With years of active experience in producing aircraft and missile components *—and as an industry leader in high-temperature technology*—Solar is particularly qualified to help solve difficult design and fabrication problems. Write to Dept.G-115, Solar Aircraft Company, San Diego 12, California.

SOLAR AIRCRAFT COMPANY — SAN DIEGO, DES MOINES

ENGINEERS WANTED! *Challenging projects, unlimited opportunities with Solar. Write today!*

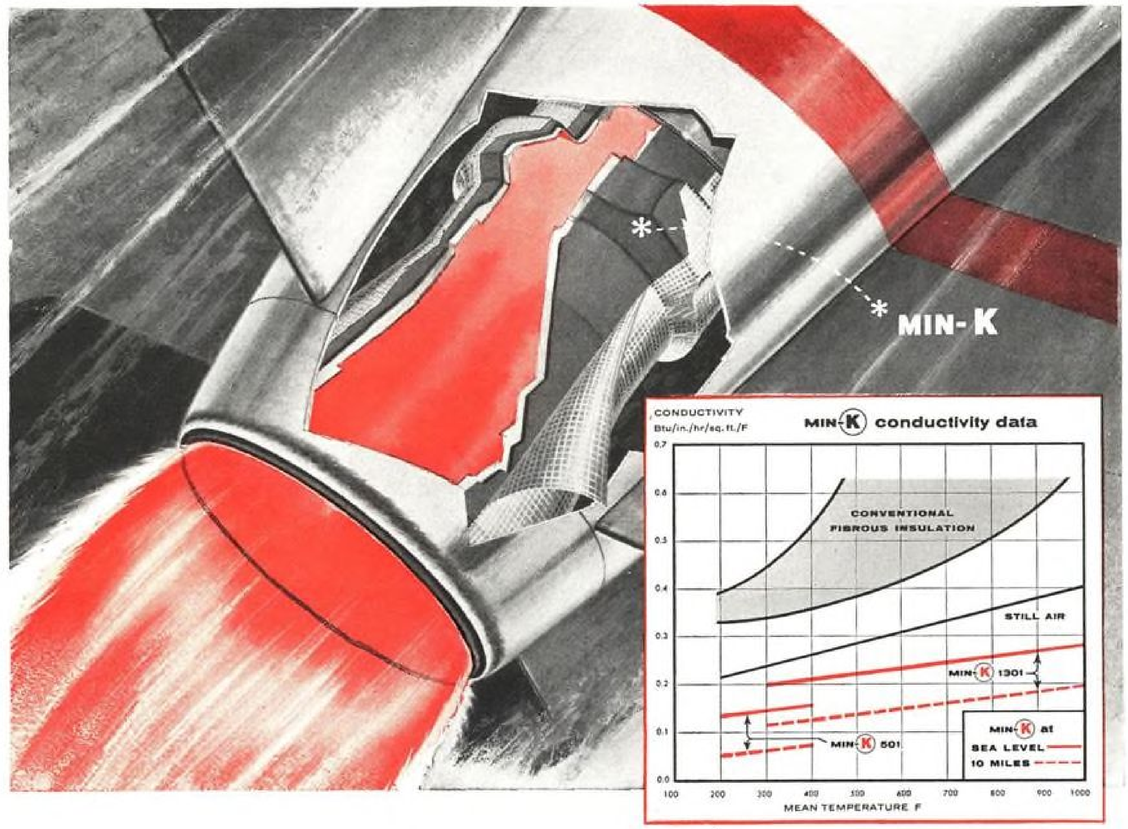


Chart compares Min-K's thermal conductivity with conventional fibrous insulations and still air. Note that Min-K's conductivity decreases with altitude.

Johns-Manville announces . . .

A scientific break-through in missile insulation!

New MIN-K has lower conductivity than still air—performs better the higher it flies

- **Saves missile space to boost fuel capacity and range**
- **Protects instrumentation more effectively to increase accuracy**
- **Offers lower thermal conductivity than any known insulating material**
- **Now performing successfully in operational U.S. missiles**

Min-K is in every meaning of the term —a scientific break-through!

For in Min-K, Johns-Manville research scientists have developed an insulating material entirely new in concept, an insulation so effective that its thermal conductivity is actually below what was long called the ultimate—the molecular conductivity of still air.

Increases accuracy and range

With this new low in thermal conductivity (less than half that of the best fibrous insulations), Min-K contributes to greater accuracy by providing more effective protection of temperature-sensitive instrumentation . . . increases range by conserving space for greater fuel storage.

Insulates better the higher it flies

Unique with Min-K is improved performance at altitude, for its thermal conductivity drops appreciably as atmospheric pressure decreases. At an altitude of 10 miles, for example, Min-K's thermal conductivity is decreased by as much as 40%, and further decreases at higher altitudes!

Manufactured by J-M as integral parts—Min-K insulations are precision molded to any shape you specify . . . encased in high-temperature metal foils or laminated to reinforced plastics. Min-K insulations include a wide variety of strengths, densities and temperature resistances.

For detailed information about Min-K, write Johns-Manville, Box 14, New York 16, N. Y. (Ask, too, for aviation insulation brochure IN-185A.) In Canada, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

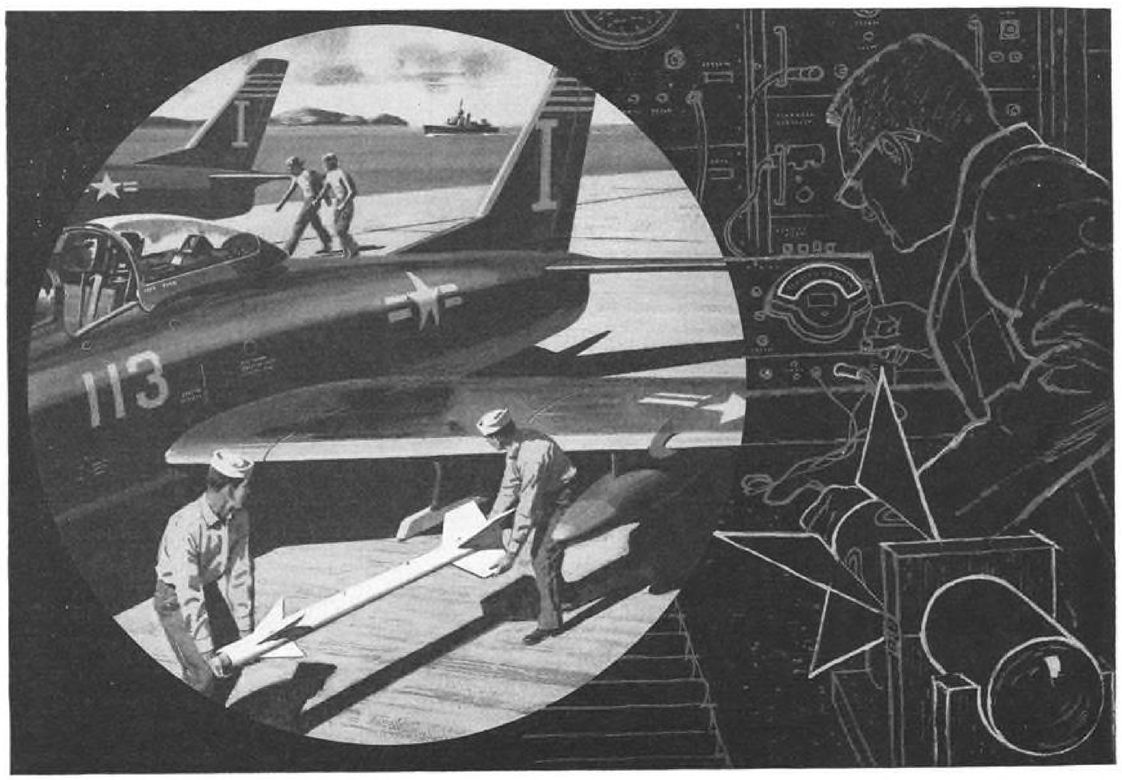
PHILCO IS **PEOPLE**

From advanced research and development to mass production, installation and servicing of countless electronic products and systems, Philco is people. Here is a closely integrated organization of scientists, engineers, installation and service specialists, ready to meet any challenge for creation of military, industrial and consumer electronics systems.

PHILCO IS **FACILITIES**

To assist this outstanding organization of skilled and dedicated people, Philco has amassed millions of dollars worth of intricate equipment in plants and laboratories from coast to coast. Philco facilities include: the world's most advanced research labs; environmental test facilities; specially equipped design and engineering labs, plus prototype and model shops; and the most advanced mass production facilities.

PHILCO IS **CAPACITY**



At Philco the world of tomorrow is *NOW!* Here are human resources, plus ultra-modern facilities, plus tremendous accumulated experience in research and development. Here too, are unlimited career opportunities in the fields of missiles and guidance, weapons systems, All-Transistor computers, infra-red, advanced radar techniques and communications systems. At Philco, versatility is the key to tremendous capacity in advanced technology. Make Philco your prime source for prime contracts from development to delivery.

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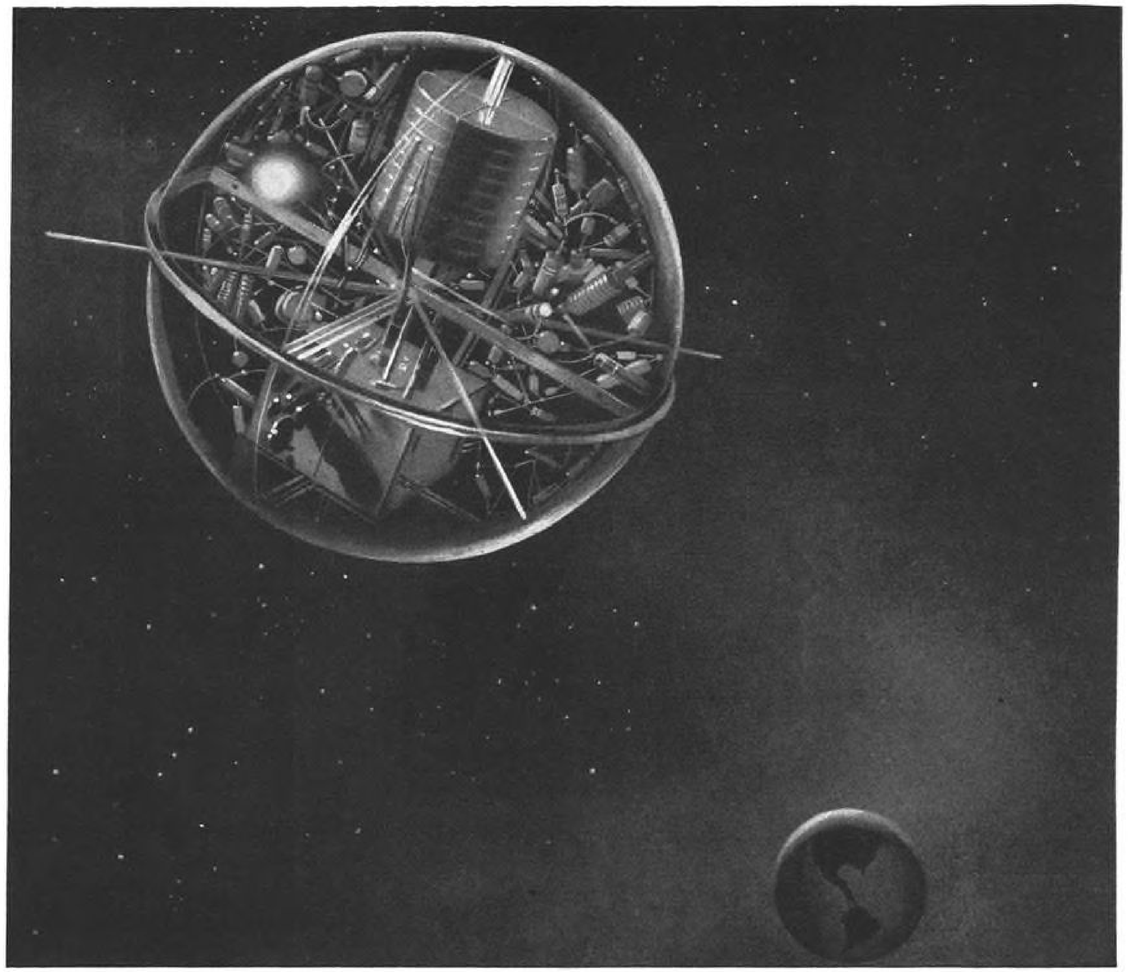

Meet temperature demands of the satellite age with the latest CDF laminates and tapes

Many new flame-retardant and high-temperature-resistant grades of CDF laminated plastics were developed specifically for the exacting service of missile and satellite operation. Here are a few:

High-temperature structural parts. New CDF felted-asbestos phenolic laminates have successfully resisted exposure to temperatures of 3500°F for 6 to 10 seconds, 2500°F for 60 seconds, intermittent operation at 900°F, and continuous operation at 500°F, without loss of mechanical properties. Negligible dimensional and mechanical changes have been observed in dry or wet heat after prolonged exposure at 300° to 350°F.

Flame-retardant glass-base laminates. Immediate self-extinguishing properties characterize new CDF glass-base epoxy laminates for high-temperature printed-circuit and other electronic applications. Typical properties: CDF Grade GB-28EFR, which meets MIL-P-18177B, type GEB, exhibits insulation resistance of 100,000 megohms, arc-resistance of 180 seconds.

Flexible printed-circuit sheeting. CDF has developed special *flexible* grades of Di-Clad® printed-circuit base, made with glass-supported duPont TEFLON TFE fluorocarbon resin, clad on one or both sides with electrodeposited copper.

Full CDF line. These heat-resistant specialties are only a few of the complete CDF line of electrical insulations, which includes Dilecto® Laminated Plastics/Di-Clad® printed-circuit laminates/Celoron® molded products/Micabond® mica products/flexible tapes of Teflon, Micabond, and Silicone-rubber/Diamond® Vulcanized Fibre/Vulcoid® resin-impregnated fibre.

Enjoy the complete plastics-fabrication facilities of CDF.

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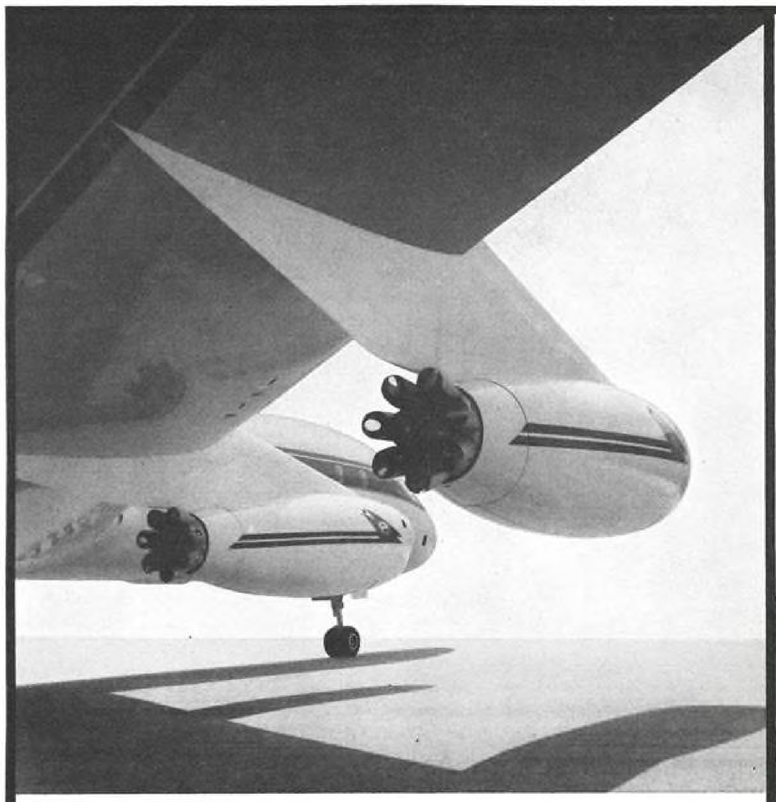

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May 11, 1959

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COVER: Martin Titan A-1 intercontinental ballistic test missile provides the most complete ground checkout the missile gets early in the series. Test missile is shown on one of four stands at Martin's Denver, Colo., facility. Test involves checkout of electrical and hydraulic systems, plus static firing. In addition, each flight missile is static-fired at Denver and all but one have been static-fired at Cape Canaveral, Fla., before actual flight.

PICTURE CREDITS

Cover—Martin Co.; 27—General Electric; 28, 29—Avco; 32—Piasecki; 43—Sud Aviation; 49—Port of New York Authority; 52—Lockheed; 57—Chance Vought; 72, 73, 75, 76—Boeing; 81—Martin Co.; 85, 113—USAF; 86, 87—Convair; 93—Kamerabild; 97, 98, 99—(top) Royal Swedish Air Force; 99 (bottom)—D. A. Anderton; 102—Missouri Research Labs.; 104—U. S. Navy; 115, 116—McKinnon; 120—Cessna; 139—Flight Refueling.

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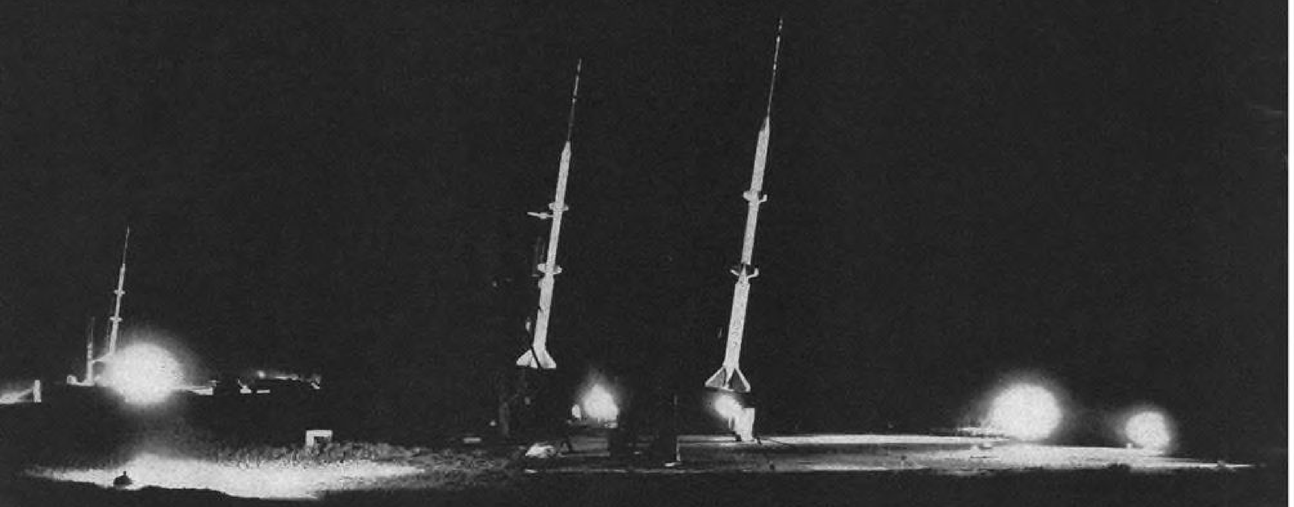

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EDITORIAL

Mixed Force Concept

(The following statement on the mixed force concept for the strategic deterrent of the future was delivered by Lee Atwood, president of North American Aviation, Inc., before a subcommittee of the House Armed Services Committee. Aviation Week *is presenting significant excerpts from Mr. Atwood's testimony as a contribution to better understanding of the mixed force concept—R. B. H.)*

It is incumbent on us in the conduct of our business to analyze all manner of air weapons—their use and their associated technologies. Drawing upon this fund of data, as well as upon my long experience in air weaponry, I would like to make certain observations regarding United States military strategy in the atomic and space age. In this way I hope to be able to make some contribution to the nation's over-all defense thinking:

• **The expressed intent** of the potential enemy, coupled with the awesome destructive capability provided by modern technology, forces the free world to try to provide a complete deterrence to all-out war.

• **Maximum military deterrence** to all-out war requires that we convince the enemy of our determination to insure and provide certain retaliation if attacked; back it up with an inventory of weapons capable of certain retaliation; and ensure that the inventory includes the capability of ferreting out and destroying every remaining vestige of enemy nuclear offensive potential.

In any exchange of intercontinental ballistic missiles with nuclear warheads, terrible and widespread damage will be inflicted. But by the nature of such devices, being purely mechanical and therefore imperfect, some substantial residual atomic war-making capability is a mathematical certainty.

First, the technical and operational probabilities possible for such missiles in the foreseeable future make it economically unfeasible to launch sufficient missiles at all known targets to insure the probability of absolute military destruction.

Second, we do not have the assurance that we can provide the three-dimensional target information of the required accuracy to guarantee the destruction by missiles of all enemy nuclear delivery capability. In this regard, a potential enemy finds it much less difficult to identify accurately the targets in our system.

Third, the regimentation characteristic of the potential enemy enables them to take much more effective passive defense measures in the dispersal and under ground protection of personnel and facilities.

Fourth, missile systems are incapable of informing us of missed or new targets where remaining enemy strike capability may exist.

Under such circumstances, there exists a calculated probability of substantial residual enemy capability. If the calculation looked favorable to the enemy, they might well start the conflict with the mathematical certainty of ending with a favorable balance of power, and being subsequently free to impose their will over the entire world.

The only way to recognize missed, new or mobile targets and to ferret out the last elements of enemy power is to put men in the immediate enemy area with the best extension of their faculties that we can technically provide. These men can use the advanced equipment provided to identify new or poorly located targets or targets not yet completely destroyed; take action and simultaneously feed back the information to allow us to direct or divert remaining weapons so as to be most effective. The high accuracy-yield combinations provided in our manned systems insures the capacity to destroy hardened targets which might remain.

These factors indicate the indefinite continuation of the "mixed force concept" for the USAF weapons inventory. It has never been, nor likely to be, prudent or practical to depend entirely on one type of system in a weapon inventory. The advent of the atomic bomb and the missile potentials demonstrated by the German V-1s and V-2s, motivated the USAF to start, in 1946, the programs for Snark, Navaho and Atlas. These systems were to complement the manned bomber force and raise its potential in the face of improving defense potential. In operating from the present version of the "mixed force concept," the intercontinental ballistic missiles will be programed to strike known targets and enable us to apply our manned weapons for destruction of the missed and other critical targets that will spell final victory, if it can so be called. The missiles will undoubtedly disrupt large portions of the enemy defense structure and thus raise the effectiveness of our manned weapons. Our possession of a manned air weapon of the most advanced technical capability will assure the potential enemy of our ability to complete the total destruction of their strategic capability if they attack us, thus completing our deterrence to all-out war.

Assuming that enemy planners similarly assess the situation, we must have a manned interceptor of long range and high rate of sweep, in order to counter the enemy's manned threat in the event that our own fixed air defense structure is partially disrupted by initial missile attacks. We can be assured that the enemy will provide a similar capability to attempt to stop our manned systems that can provide the conclusive destruction of all their strategic power.

This is strong, inhumane talk; yet if we are to preserve our security, we must face the possibility of attack, must work out a deterrent strategy, and must provide ourselves with the visible force to carry out that strategy. In the interest of humanity, we must talk out these awful possibilities, and come to sound conclusions.

There is, essentially, no such thing as an unmanned weapon system. Man designs, programs, maintains and makes the decisions to use all weapon systems. It is rational to use inanimate vehicles wherever they can fully satisfy the mission requirement. But the vagaries of warfare, including the much-used element of surprise and the improbability of ever being able to determine accurately in advance all possible targets and other factors involved, has brought us to the conclusion that the judgment of man will always be required in some fashion in the immediate battle area.

The fact that missile systems are not recallable, once well launched, presents us with the necessity of making an irrevocable decision at the time of launching the first missile. The difficulty of making such a decision lengthens the system reaction time of the missile. A man located in the air vehicle provides positive control in flight; thus a manned system can be launched on less than certain information, with corresponding gain in system reaction time. In the air defense role, a manned vehicle is needed to verify early information by providing positive identification, as well as for ultimate defense.

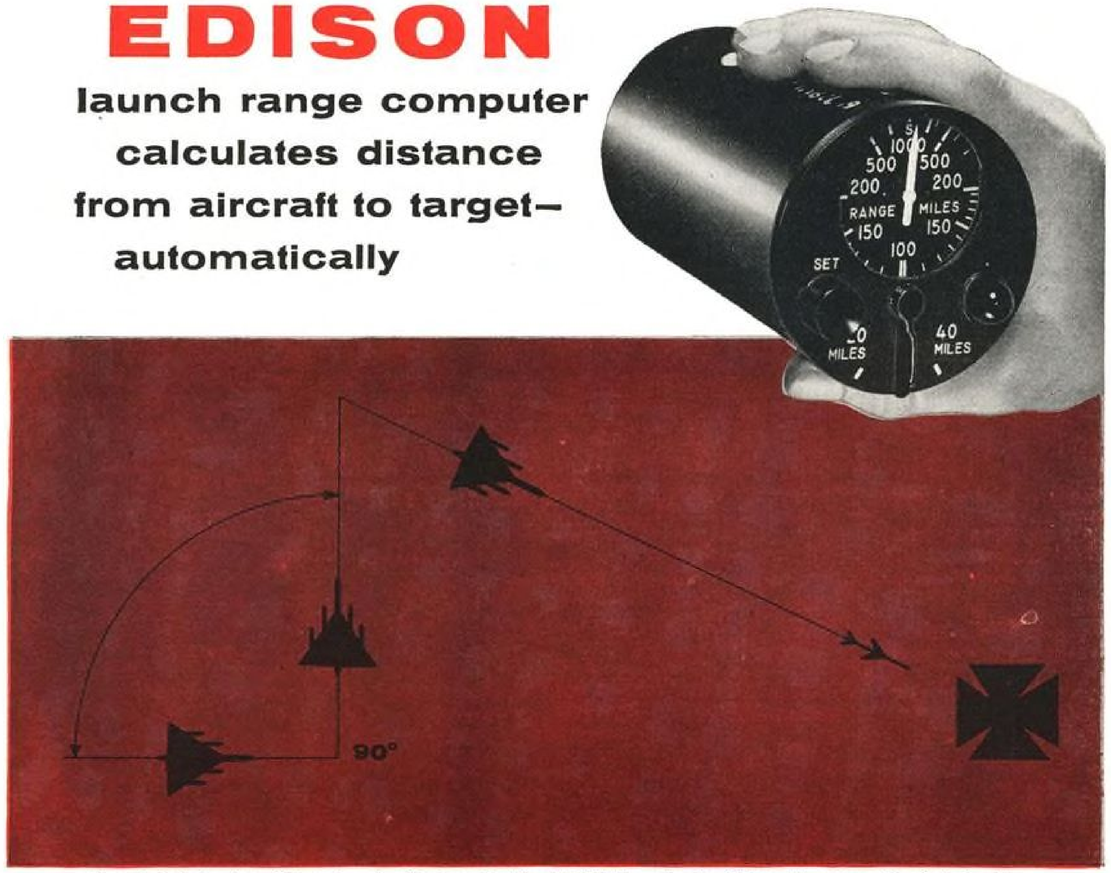
Moreover, manned air vehicles incorporating the most advanced technology provide a physically demonstrable presence, with its undoubted strengthening of our allies and its corresponding deterrent effect on the enemy. From the viewpoint of the enemy, the present USAF capability with manned systems is already proven to a high degree.

Certainly our missile force must be powerful and reliable. But when we complement it with highly advanced, flexible, manned air weapons—with their high accuracy-yield potential—we will have assured the enemy of conclusive action and provided a maximum deterrent to all-out war.

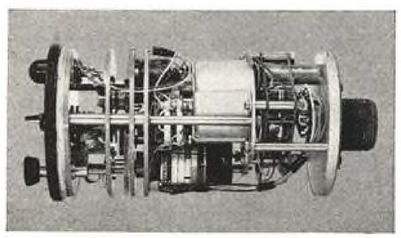
THOMAS A.

EDISON

launch range computer calculates distance from aircraft to target— automatically



Computer indicator shows distance from aircraft to target in miles. Light indicates when aircraft is too close to target for missile launching.



Edison computer contains two control transformers, servo motor, transistor-magnetic amplifier, gear train with slip clutch and integrally lighted indicator with pushbutton reset, all in a compact package weighing only 44 ounces.

New Edison range computer is a tactical instrument used in air to ground release of guided missiles. Unit computes automatically the distance from the aircraft to a ground target. Pilots formerly had to perform this problem manually.

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WHO'S WHERE

In the Front Office

Donald W. Douglas, Jr., a director, General Aniline and Film Corp., New York, N. Y.

Emerson S. Ronk, a director, Rheem Manufacturing Co., Downey, Calif.

J. Turner Moore, a director, Airwork Corp., Millville, N. J.

Hugh S. Ferguson, president, National Research Corp., Cambridge, Mass. Mr. Ferguson succeeds **Richard S. Morse**, now Director of Research and Development for the U. S. Army, Washington, D. C.

Marvin G. Whitney, a vice president, Semiconductor Division, Hoffman Electronics Corp., and manager of the Division's new West Coast plant, El Monte, Calif.

Dr. E. C. Creutz, vice president-research, General Atomic Division of General Dynamics Corp., San Diego, Calif. Also appointed vice presidents: **H. B. Fry** and **C. A. Rolander, Jr.**

J. Douglas Darby, vice president and assistant to the president, United States Steel Corp., Pittsburgh, Pa.

George Ustin, vice president-engineering, Buchanan Electrical Products Corp., Hillside, N. J., subsidiary of Elastic Stop Nut Corporation of America.

Myron P. Roebuck, vice president-special products engineering, Canoga Division, Underwood Corp., Van Nuys, Calif.

Joe Foss, vice president, Raven Industries, Inc., Sioux Falls, S. D.

Otto Struve has been appointed the first director of the National Radio Astronomy Observatory, Green Bank, W. Va.

Carl F. Schmidt, engineering director, Flight Safety Foundation, Inc., New York, N. Y.

Dr. Julius A. Stratton will be inaugurated as the 11th president of the Massachusetts Institute of Technology, Cambridge, Mass., on June 15.

Honors and Elections

Dr. C. S. Draper, head of Massachusetts Institute of Technology's Department of Aeronautics and Astronautics, has been appointed chairman of the National Inventors Council, Washington, D. C.

K. F. Mundt, vice president-manufacturing of Aerojet-General Corp., has been elected chairman of the Manufacturing Committee of the Aircraft Industries Assn. **M. F. McCammon**, assistant general manager of the Eclipse-Pioneer Division of Bendix Aviation, was elected vice chairman.

Changes

Dr. Robert Bromberg, director, and **Arthur F. Grant**, assistant director, Propulsion Laboratory, Research and Development Division, Space Technology Laboratories, Inc., Los Angeles, Calif. Also: **Dr. Richard D. De Lauer**, director, and **Harold Hirsch**, associate director, Vehicle Development Laboratory of the Research and Development Division.

(Continued on page 143)

INDUSTRY OBSERVER

► **Four industrial teams have just submitted bids to Air Force for its new ground-based electronic intelligence data gathering and processing system known as 466L, which calls for expansion and integration of USAF's far-flung network for obtaining electronic intelligence. Bidders include teams headed by General Electric, Hoffman Electronics, Radio Corp. of America and Thompson Ramo Wooldridge.**

► Flight control and guidance system suitable for soft landing of an instrument payload on the moon is the objective of a design study contract recently awarded to Sperry Gyroscope Co. by Wright Air Development Center.

► **Shipboard inertial navigation system (SINS) for five of the Navy's new Polaris carrying submarines will be built by North American Aviation's Autonetics Division; two other Polaris submarines will use SINS built by Sperry Gyroscope. The two companies are bidding for subsequent Polaris submarine inertial guidance business.**

► General Electric and a team consisting of Convair and Raytheon are the two top contenders for selection by Army to develop its Mauler tactical air defense missile system if the Army is able to find sufficient funds to finance the program. Decision is expected before the end of the month.

► **Elimination of the full length longitudinal welded seam on large solid rocket cases is being obtained by General Electric at Evendale (Aircraft Gas Turbine Division) through a technique of hydrospinning them out of tool steel. GE has a development contract for Minuteman cases using this process. The technique still hasn't reached the stage where GE can spin the whole case, so sections must be welded laterally. GE, however, hopes to reach the point where a complete, seamless case can be spun.**

► International Business Machines Corp. has won competition to supply airborne digital computer for new inertial guidance system to be used on Titan intercontinental ballistic missile. Computer will work with gyro-stabilized platform to be supplied by AC Spark Plug Division of General Motors (AW April 20, p. 34), using basic design developed by Massachusetts Institute of Technology's Instrumentation Laboratory. USAF's Ballistic Missile Division and Space Technology Laboratories overruled recommendation by M.I.T.'s Dr. C. S. Draper that Titan guidance use a small digital computer which M.I.T. had developed for that purpose.

► **General Electric's rocket engine section of the Aircraft Gas Turbine Division has a new laboratory process that in the laboratory increases yield strength of steel 100,000 psi. That is it can raise present yield strengths of 200,000-240,000 psi. to 300,000-340,000 psi. The trade name of the process is Aus-forming. Navy Bureau of Ordnance has supported the initial research.**

► Martin Co. is doing research and development work on storable liquid propellants for possible use in advanced USAF Titan intercontinental missiles and space vehicles and for the Navy Bullpup air-to-surface missile.

► **Hughes Tool Co., Culver City, Calif., is pushing studies in both liquid and solid exotic fuels.**

► Operations and maintenance costs of USAF's SAGE aircraft detection system will reach an estimated $129.5 million for Fiscal 1960, according to Defense Comptroller W. J. McNeil. SAGE system operations and maintenance costs totaled $46 million in Fiscal 1958. Level-off of annual costs is anticipated by Fiscal 1963 and probably will be in the area of $306 million.

► **Fiscal 1960 defense budget requests for an additional 70 Boeing B-52H intercontinental jet bombers, powered by Pratt & Whitney J57 turbofan engines, bring total orders and requests for the B52 to 712.**

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Washington Roundup

Nuclear Plane Reversal? . . .

Watch for Defense Department to reverse its long-standing opposition to faster development of a nuclear-powered aircraft in a political move to try and cut the ground from under those who have criticized it for its delay.

First public hearings ever held on the aircraft nuclear program are scheduled to begin on Thursday before the research and development subcommittee of the Joint Atomic Energy Committee headed by Rep. Melvin Price (D.-Ill.). Unless Defense had finally agreed to Air Force proposals for a greatly increased program, the hearings were expected to force a showdown. As a consequence, Defense is now expected not only to approve the program but to announce its intention before the hearings begin. Chief opponent of faster development has been Deputy Defense Secretary Donald A. Quarles.

. . . Backing from McCone

Support for the concept of rapid development of nuclear aircraft powerplants also came last week from Atomic Energy Commission Chairman John A. McCone. Asked if he foresaw application of nuclear power to commercial flight, he said he did not. But, he added that development of atomic powerplants for aircraft should "go forward as rapidly" as technology permits, regardless of applications because uses always have become apparent as soon as technical advances have been made. Whether the USAF plan to power a bomber with atomic energy is "correct" will depend largely on "timing," McCone said.

NASA Budget

House Science and Astronautics Committee last week approved a Fiscal 1960 $485 million authorization for National Aeronautics and Space Administration. This compares with $404 million NASA had for the current fiscal 1959 year.

The committee cut $4.7 million for an undesignated site to test high-energy solid and liquid rocket fuels. However, a $5 million "cushion" included in the measure could be used by NASA for this purpose. The total includes over $333 million for research and development as compared with $205 million in Fiscal 1959. The authorized funds must still be implemented with appropriations.

More Atlas Squadrons Asked

Air Force proposal to boost the number of Convair Atlas intercontinental ballistic missile squadrons from the presently-planned nine to a total of 16 or 17 is now before Defense Secretary Neil H. McElroy for approval.

Air Force Secretary James Douglas told the Senate Appropriations Committee late last week that the additional squadrons would require an added $278 million in the Fiscal 1960 budget and an extra $500 million in Fiscal 1961. A single Atlas, he said, costs approximately $2 million as compared with $7 million for a Boeing B-52 jet bomber.

Secretary Douglas also told the committee that Air Force had hoped to keep alive the now-canceled Fairchild Goose ground-launched diversionary missile program. Its request for $133 million in Fiscal 1960 to support the program was trimmed from the budget after its submission to the Defense Department, Douglas said.

Other cuts made in Air Force budget requests detailed by Douglas included $204 million from the Convair B-58 bomber program and $108 million from the Republic F-105 fighter-bomber requests.

Soviets View Mars . . .

Life on Mars, a subject of speculation for several centuries, came in for most unusual speculation in Soviet Russia last week. It included:

• **Artificial satellites.** Physicist I. Shklovskiy, writing in Komsomolskaya Pravda and quoted by Moscow Radio, said he believes Phobos and Diemos, the very small moons circling close to the planet Mars, are artificial space stations weighing possibly 100 million tons and put into orbit as much as two to three billion years ago by intelligent beings who had "achieved a high level of culture." "Within a period of only a few decades," he said, Phobos "has gone two and a half degrees farther ahead in its orbit than if its speed had been constant," indicating it may now be spiraling into the planet. Phobos is known to circle Mars in less time than it takes Mars to turn on its own axis. It is the only one of the 31 known satellites in the solar system to do so.

• **Underground Martians.** Prof. Aleksander Kazancew was quoted by the newspaper Zycie Warsawy as saying in Moscow that intelligent Martians may have developed artificial oxygen eons ago and moved underground. Recently-developed theories, he said, include these: A great explosion in Siberia 50 years ago was caused by the crash and disintegration of a nuclear space ship, possibly from Mars; an atomic explosion was sighted on Mars two years ago; Mars' moons are artificial satellites launched centuries ago. This presumably referred to Shklovskiy's beliefs.

. . . U. S., the Sun

Meanwhile, Dr. William M. Sinston told the American Geophysical Union that the sun has become 2% brighter over the past five years. The sun's heat output has been thought to be constant. The increase in brightness, presumably accompanied by an increase in heat, coincided with an increase in sun spot activity to the peak of the sun's 11-year cycle. Studies are continuing to see whether the sun cools as sunspot activity decreases. Work reported by Dr. Sinston—and in more detail by H. L. Johnson and Braulio Iriarte in the Observatory Bulletin—was done at Lowell Observatory and sponsored by Air Force. The same meeting was told by Dr. Roger Gallet of the Bureau of Standards' Boulder, Colo., laboratory that Jupiter may have an ionosphere.

Russell Plan

Sen. Richard Russell (D.-Ga.), chairman of the Senate Armed Services Committee, may push a plan that would give Congress a greater role in the selection of weapons through an advance review of proposed programs. The military services would be required to obtain authorization for their procurement programs each year from House and Senate Armed Services Committees before seeking funds to implement them from the Appropriations Committees. Russell pointed out last week that military construction programs, which total less than $2 billion a year, are now gone over by the two armed services committees, project by project, while the weapon procurement programs which total over $15 billion a year are not.

—Washington staff

McElroy Predicts Limited Use for Nike

Increasing reliance upon F-108, Bomarc foreseen; Nike Hercules cuts invited at Senate hearings.

By Katherine Johnsen

Washington—Defense Secretary Neil McElroy invited Congress last week to cut funds requested for Army's Nike Hercules surface-to-air missiles and related facilities from the Fiscal 1960 defense budget.

At hearings of the Senate Appropriations Committee, McElroy said that as the threat of attack shifts to bombers equipped with "Hound Dog-type" standoff air-to-ground missiles and then to intercontinental missiles, the U.S. will "count less and less" on Nike point defense and turn increasingly to the USAF-North American F-108 Mach 3 long-range interceptor backed by area defense Boeing Bomarc interceptor missiles. He told the committee:

"The F-108 gives the furthest reach-out. Then, for missile purposes, it looks very much as if Bomarc with its, we hope, about 400-to-500 mi. range in the new version will have the greatest backup to the interceptor because it does have the ability to reach out.

"We push the interceptor as far as we can north and to the east. We then have a Bomarc capability down from the interceptor zone where we can have peripheral protection that would be supplied to some degree by Canadian (based) Bomarcs. A relatively small number of additional high priority target areas will be considered as further Nike sites."

Nine months ago, Congress tried to force Defense Department to make a choice on the proper mixture of defensive missiles and aircraft (AW Aug. 11, p. 21). Congress cut 20% from combined Bomarc and Nike construction funds and directed McElroy "to determine with respect to each defended area, which missile or combination of missiles will be employed in that area."

The controversy actually dates back even further and initially involved the entire question of air defense roles and missions. Former Defense Secretary Charles E. Wilson attempted to settle a part of this dispute in November of 1956 by assigning the "point" defense role to the Army and the broader "area" defense mission to USAF.

At one time last year, it appeared that Air Force might have to give up its air defense efforts to Army and concentrate on offense; put all-out support behind the Bomarc at the risk of helping to kill off manned interceptors, or hope for a mix of manned and unmanned interceptors. McElroy's testimony indicates he favors the latter.

'Difficult' Decision

The lingering Nike-versus-Bomarc controversy within the Defense Department, McElroy said, "has been the most difficult matter we have had to deal with." He added:

"We have not done very well in making a decision," he told the committee. "As far as I am concerned, it would not bother me if you held our feet to the fire and forced us in connection with this budget."

The Defense Secretary also said that high-altitude nuclear bursts (see p. 31) have shown "that there would be a complication in the use of a defensive system like Nike Zeus" anti-missile missile.

Total of $300 million already has been invested in the Nike Zeus development program in Fiscal 1958 and 1959, and an additional $300 million is earmarked for it in the Fiscal 1960 budget. In addition, McElroy said, the Fiscal 1960 budget includes $130 million "for research work on still more advanced concepts for missile defense." The initial test of Nike Zeus, he said will be from the Pacific Missile Range, Pt. Mugu, Calif.

McElroy said there is "considerable expectation of success" in the development of a system of satellites which would be capable of detecting the firing of long-range missiles at the time of firing. One of the systems, he said, is the infrared-instrumented Midas (AW Dec. 8, p. 31). "A number of such satellites circling the earth would be able to detect the great blast of heat emitted by a missile when taking off," McElroy said. This would approximately double the amount of warning time available from the Ballistic Missile Early Warning System radars.

By the time the U.S. believes that the Soviets will be capable of launching a full-scale intercontinental ballistic missile attack, McElroy said, "the BMEWS system is expected to be able to provide that critical margin of warning which would enable our strategic forces to get off on their retaliatory mission." Other McElroy testimony:

- **Boeing B-52H** equipped with Pratt & Whitney J57 turbofan engines "will have a 10 to 15% greater range than the B-52G which itself was a great improvement over the earlier models."
- **First North American Hound Dog** air-to-ground missiles to be carried by the B-52G are scheduled to be in the hands of Strategic Air Command before the end of Fiscal 1960.
- **"The B-47s still can be counted upon** to carry a large part of the retaliatory mission."

McElroy opposed the suggestion of Sen. Henry Dworshak (R.-Idaho) that the Air Force aircraft nuclear propulsion program be abandoned. "We cannot fail to proceed," McElroy said. He added, however, that "it would be ill-advised to proceed at any great hectic pace because this does not look as though it is anything that can compress time very much with simply an excess of funds. . . .

"I believe that if you would put up a nuclear propelled aircraft which was really not a practical, feasible instrument for performing some sort of military or civilian mission, that it would be very clearly pointed out . . . by the various aeronautic scientists, and I do not think that such a country would do anything more than become some sort of laughing stock. . . . We are not unaware of the psychological advantages which might accrue to the nation which first flies a true nuclear powered aircraft. . . ."

In testimony late last week, Air Force Secretary James Douglas told the committee that an ad-hoc panel headed by Dr. Clifford C. Furnas, chancellor of Buffalo University and former Assistant Secretary of Defense for Research and Development, has recommended that development and deployment of the Bomarc be expedited.

The panel, formed on the request of Deputy Defense Secretary Donald A. Quarles in December, issued its report two weeks ago. Secretary Douglas said the report was "emphatic in its recommendation that the initial deployment of the Bomarc B should not be held up but, in fact, expedited. . ."

Douglas, who told the committee the Air Force had no hand in calling for formation of the ad-hoc panel, said USAF's Fiscal 1960 budget requests now under consideration call for approximately $447 million for 19 Bomarc sites. Original Air Force request submitted to the Defense Department, he said, was about $200 million higher than the final figure submitted to Congress.

Mercury Contracts

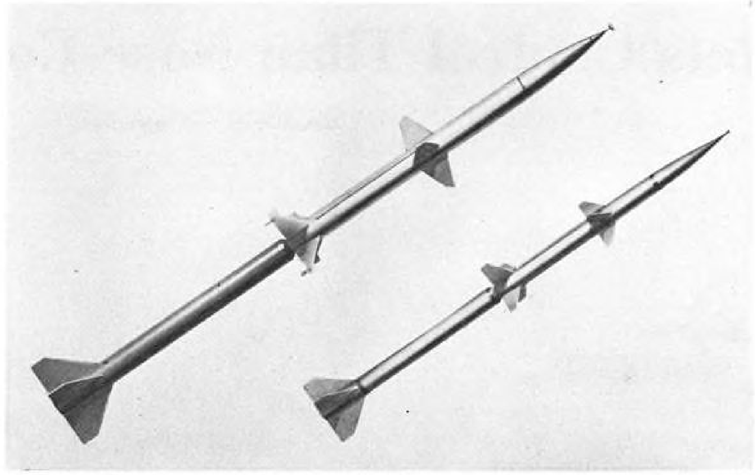
Washington—Space Electronics Corp. of Glendale, Calif., has received a $46,356 design study contract for a control center for the orbiting phase of the Mercury manned space flight project. Negotiated contract was awarded by National Aeronautics and Space Administration in mid-April. Control center will be located at the Goddard Space Flight Center near here.

NASA also is considering bids from Aeronutronic Systems, Inc., Vidya, Inc. and Space Technology Laboratories, Inc. for a study contract for real time data analysis for Mercury orbits. Contract will be for about $30,000.

Kwajalein Test Units

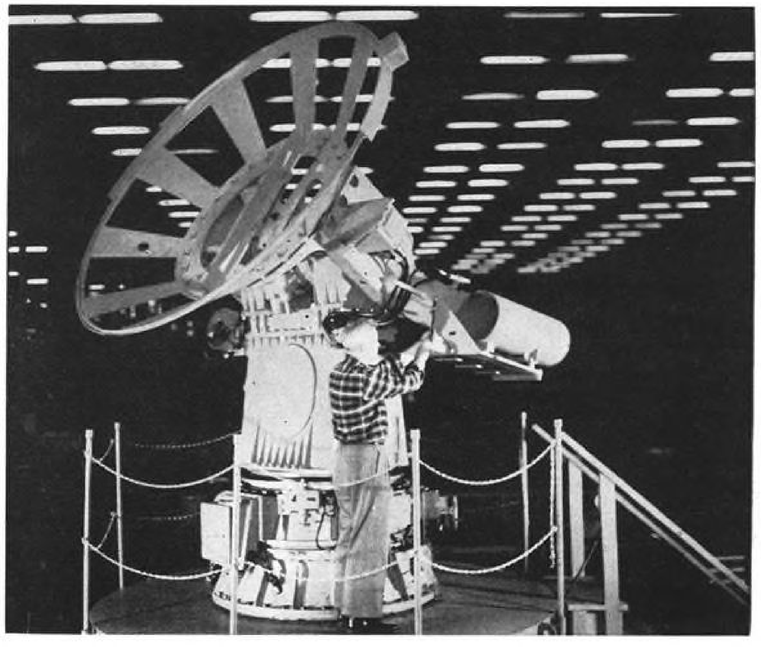
Washington—Army Corps of Engineers expects to advertise for bids late this week for construction of Nike Zeus anti-missile missile research and test facilities on Kwajalein atoll in the Pacific Ocean. Experimental missiles and support equipment for the test program already have been procured.

Missiles will be fired at targets launched from the Pacific Missile Range in California. Construction at Kwajalein will be done on part of a Navy station that has been declared in excess of current needs. Contract will be administered by the Engineers' Pacific Ocean Division at Honolulu. Initial complement on the atoll is expected to be about 1,000 men, including some 40 military personnel.



First Drawing of Tartar Shows Comparative Size

First drawing of Navy Bureau of Ordnance Tartar surface-to-air missile shows size in comparison with Terrier (left, above). Convair Division of General Dynamics Corp. and Applied Physics Laboratory are Tartar prime contractors. Tartar is a solid propellant, dual-thrust rocket with 10-mi. range designed for use aboard destroyers and cruisers. The larger Terrier is about 15 ft. long and weighs 1.5 tons. Tartar MK73 fire control director below is being prepared for testing at General Electric Ordnance Department. The unit is designed to track supersonic targets.



Boeing and Lockheed Report Earnings Drop

Write-offs on commercial airliners continued to loom as a factor in lower first quarter earnings reported by Boeing Airplane Co. and Lockheed Aircraft Corp., but changeover in military programs also was important to Boeing, which showed the sharpest decline.

Its earnings, on sales of $316,206,413, were $1,539,275 or 21 cents a share. This was a drop from earnings of $9,499,190 to $1.29 a share on sales of $411,057,648 for the first quarter of 1958.

Boeing had earlier predicted these declines, resulting also from transition to fixed price contracts on the B-52G and Bomarc programs. Commercial write-offs for the 707 jet transport program totaled $12,600,000. This compares with $17 million written off by Douglas in the same period for its DC-8 program. Boeing's backlog declined from $2,445 million as of Mar. 31, 1958, to $2,329 million; of that figure $820 million is commercial.

Lockheed's sales rose 17% to $278,604,000 in the first quarter, but earnings of $4,112,000 or 65 cents a share were down from $5,076,000 or 86 cents a share a year ago.

Backlog fell from $1,252 million to $956 million.

Other financial reports:

- **Thompson Ramo Wooldridge Inc.** reported first quarter sales increased 5% to $91,281,091 with earnings of $2,236,704 or 71 cents a share. This was an increase from last year's quarterly figure of $2,028,283 or 65 cents a share.

The company still is actively studying separation of ownership of its subsidiary, Space Technology Laboratories.

- **Pan American World Airways,** reacting to rising prices of airline stocks, (AW May 4, p. 26), asked stockholders to approve issuance of $50 million in convertible debentures to finance further jet aircraft acquisition.

Jets Control Titan Nose Cone's Attitude

TITAN intercontinental ballistic missile heat sink nose cone reflects hoisting mechanism in highly polished forward surface, which is stainless steel coated with nickel. Nose cone has just completed its final vibrational testing prior to shipment from Avco Research Corp. plant. Waffle structure around after portion of nose cone is part of the packing container used during movement within the plant for handling ease and to prevent damage. Instrumentation leads for vibration tests are still installed. Avco now is studying ablation type re-entry bodies in a more advanced nose cone program.

First type of Avco Research Corp. heat sink re-entry nose cone to be delivered to the Air Force is shown here during its laboratory test program at Avco. Specially designed for use with the Air Force-Martin Titan intercontinental ballistic missile, the nose cone is equipped with an attitude control device called DARAC (Damped Aerodynamic Righting Attitude Control).

The DARAC system does not operate until the nose cone reaches about 300,000 ft. during its re-entry.

At this altitude, where the air density is large enough for normal aerodynamic force to begin to act on the vehicle, DARAC is actuated to stop any tumbling or unstable movements of large magnitude. Sensing mechanisms in DARAC primarily determine angular accelerations, and the attitude control system operated by these sensors consists of four gas jets. The jets are located 90 deg. apart on the after end of the nose cone.

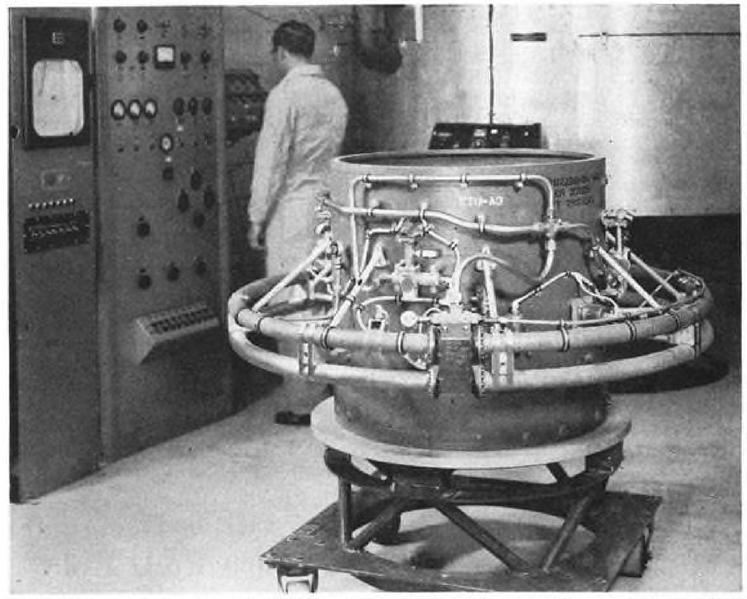
Avco's portion of the test program for this heat sink warhead has been completed, and the company is now engaged in more advanced nose work. Ablation type re-entry bodies are being studied in this program. Avco also has participated in the Air Force re-entry test programs using the Thor-Able rocket as a test vehicle.

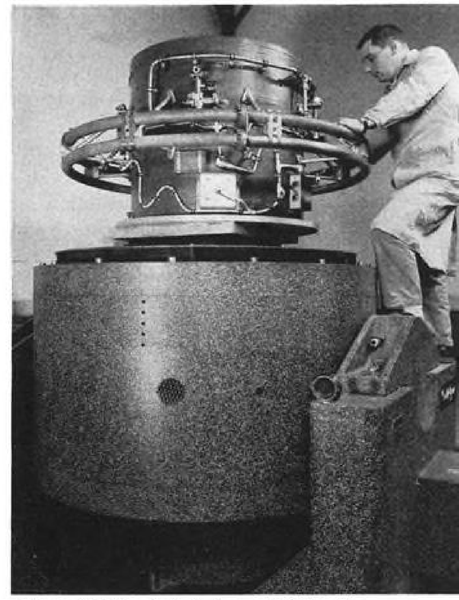
Full-scale flight tests of this nose cone and others planned for the Titan probably will not be made for some time. Titan tests at the Air Force Ballistic Missile Test Center, Cape Canaveral, Fla., have just passed through the A series. This series was originally intended to test structural integrity, first stage powerplant and the autopilot.

Separation tests also were pushed into the first phase after the initial shots proved more successful than predicted. The separation procedure employed in these tests consisted of explosive bolts and two Grand Central JATO bottles on the 37 ft. dummy second stage. The JATO rockets pushed the second stage forward rather than having retrorockets push the first stage backward as has been done on most U.S. multistage missiles. It has not yet been decided whether to use this procedure on the operational missile.

Instrumentation during separation included a series of wires inside the missile which were played out as the two stages moved apart. As the reels of wire began to move, they actuated telemetry circuits which then gave a picture to the ground of the rate of separation and several other parameters.

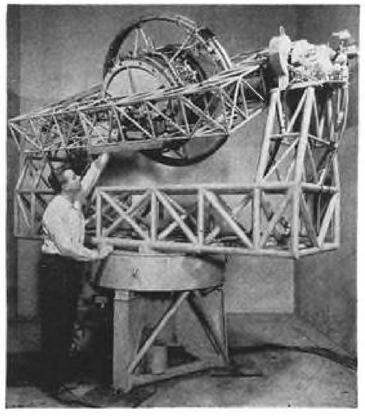
New phase of the test program, the B series, is now under way, with the first firing scheduled within a month.

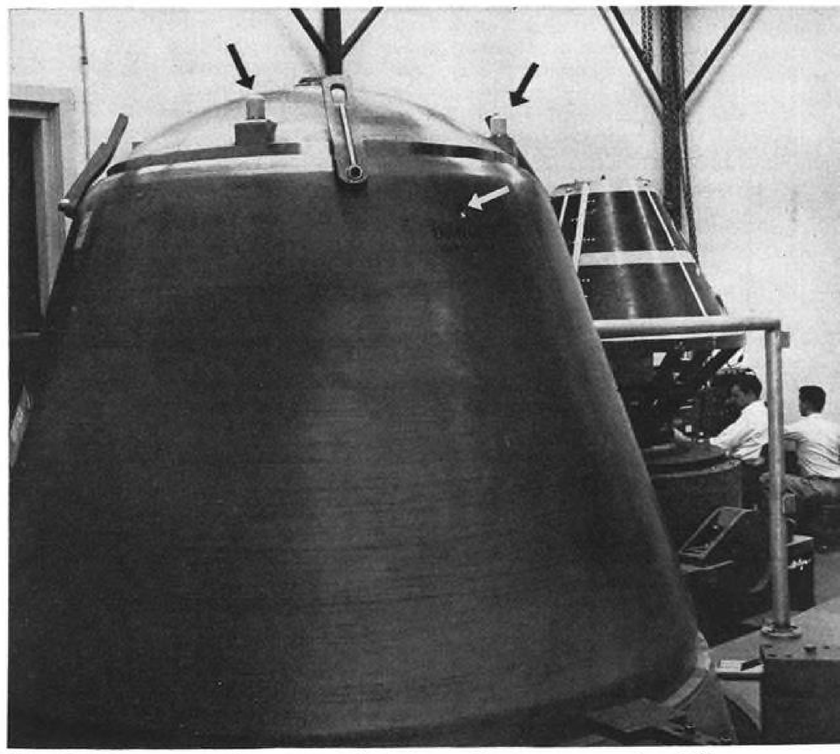




DARAC (Damped Aerodynamic Righting Attitude Control) system is mounted on a Calidyne shaker (right) and is instrumented for the test program (left). DARAC mechanism is mounted on the outside of the large cylinder and a thermonuclear weapon would be located inside. Large diameter tubes encircling the complete assembly are feed lines for the gas jets which are actuated by DARAC. Small rate switches which measure angular velocity are the principal sensors used by DARAC to keep the nose cone at the proper attitude.

LOW TEMPERATURE tests of DARAC unit are started in Avco laboratory. Performance tests of the complete unit are conducted in the gimbaled rig below. Actual re-entry motions of the nose cone can be simulated.





NOSE CONE rests on small transport dolly before undergoing tests on the Calidyne shaker in the background. Stub antennas of the vehicle's telemetry system are indicated by the black arrows, although operational model would not have this system. One of the four gas jets used for attitude control is shown by the white arrow. Three removable handling lugs are attached to after end of the nose cone.

Maintenance Budget Forces Cuts

Washington—Fiscal 1960 budget of $10.5 billion for operation and maintenance will provide for only a minimum of what the military services require to perform assigned tasks, witnesses have told the House Defense Appropriations Subcommittee.

Although the 1960 figure represents an increase of $206 million over Fiscal 1959, including supplemental requests, increased costs of operation and maintenance will force cutbacks in programs in order to fund high priority projects.

Of the total amount, Air Force obligations in operation and maintenance are estimated at $4.2 billion, an increase over 1959; Army $3.058 billion, a decrease from 1959, and Navy $2.8 billion, an increase.

Witnesses for all three services said they believed the amount budgeted would permit them to remain in a state of combat readiness, but to do this however it will require that operations be conducted on a highly selective basis.

Testimony Highlights

Highlights of other testimony given before the subcommittee are:

• **Flying hours program** for both Air Force and Navy will decrease in Fiscal 1960 from the last fiscal year, as well as aircraft inventories. However, Army flying hours and inventory will increase. The Air Force active inventory of 22,578 aircraft in 1958 will decline to 19,982 (operating aircraft 18,500) by the end of 1960. Flying hours will decline during the same period from 7.7 million to 6.8 million. The Navy active aircraft inventory of 10,533 in 1958 will decline to 9,117 (operating aircraft 7,200), while flying hours will drop from 3.9 million to 3.2 million. The Army aircraft inventory will increase from 5,027 in 1958 to 5,363 in 1960 with a higher concentration of helicopters. Flying hours program will increase from 1.3 million to 1.9 million.

• **Air Force, in 1960** estimates a combined total of in house and contract aircraft and related equipment overhaul program of about $725 million, $27 million less than the 1959 program. The Navy overhaul program for aircraft and related equipment for 1960 will be $235 million, about the same as in 1959.

• **Army has a backlog** of overhaul work on unserviceable but economically repairable equipment of $1,161 million at end of Fiscal 1958, $1,220 million at end of Fiscal 1959 and by the end of Fiscal 1960 it will be $1,320 million.

• **Maintenance work** at installations which field commanders feel should be undertaken, but which will not have been started by the end of the fiscal year will total more than $500 million for all services.

• **Air Force** said that even with six or seven hours warning of an attack some of the bombers would have to remain on the ground because of insufficient refueling capability at the present time.

• **In the day-to-day** operation of high performance jet aircraft, the Air Force found that blast and the sound from jet exhaust caused sonic fatigue of airframe structures. Structural failure begins when sound pressures reach 146db.

• **Over-all crew combat readiness** of the Air Force will have been increased by 20% by the end of Fiscal 1959, and the force standing on continuous alert will have been doubled.

• **Reorganization of Air Rescue** Service has resulted in shifting the local rescue mission responsibility, which previously had been performed by tactical rescue units, to individual air bases. Helicopters assigned to this task are now on 24-hr. standby alert to perform rescue missions within 100 naut. mi. of the airbase instead of flying regular patrols.

• **Commercial contract support** will normally be required for peculiar missile items and ground support equipment until the missile program stabilizes and the Air Force gains additional experience. As an example of the increased workload in missiles, the Air Force said Fiscal 1959 requirements for ballistic missile depot maintenance amounted to $5.7 million for Thor, Atlas and Jupiter. For Fiscal 1960, it will jump $11.1 million to $16.8 million.

• **To date, 18% of Air Force** aircraft have been equipped with Tacan navigation equipment. As of July 1 of this year, 32% will be equipped and, as of July 1, 1960, a total of 64% will be equipped. Present policy is to have all Air Force aircraft completely equipped with Tacan by 1963.

• **Lack of spare parts** is keeping about 8% of the Navy's aircraft grounded. A Navy spokesman said the problem was more one of distribution and proper provisioning than lack of funds.

• **Navy ruled out the necessity** of a continuous airborne alert to protect its sea forces. Instead, it said sustained combat readiness and maximum ability to survive can be most effectively maintained by continuing to adhere to its sea alert concept—maintaining about one-half of its fleet at sea at all times.

Rocket Test Shift

Edwards AFB, Calif.—In a move to centralize rocket engine development and test work, Air Research and Development Command is transferring the rocket engine applied research activity from Wright Air Development Center, Wright-Patterson AFB, Calif., to the Air Force Flight Test Center's missile captive test facility here. Transfer, to be completed by end of this year, will cover about 200 persons.

The move will put the applied research work closer to West Coast industry, the Ballistic Missile Division of ARDC at Inglewood, center of USAF ballistic systems management.

In a related move, National Aeronautics and Space Administration will establish a small group at the captive missile test site at Edwards to coordinate testing of Rocketdyne's 1.5 million lb. thrust single-chamber rocket engine and other engines for NASA systems. Engine will be tested on stand 1-A. This and other very-high-thrust engines will be tested on stands 1-A, 1-B and 2-A in a separate complex from test stands used for smaller engines.

Navy Office Designed To Boost R&D Role

Washington—Navy last week formally established the office of Deputy Chief of Naval Operations for Development with wide authority over research, development, test and evaluation activities to succeed the lesser-ranking post of Assistant Chief of Naval Operations for Research and Development.

The new office, which will shepherd Navy weapon systems from their inception through the evaluation stages, is under the command of Vice Adm. J. T. Hayward, who also headed the abolished office but with the lesser rank of rear admiral.

Establishment of the new post was one of the major recommendations made by a seven-man committee headed by Under Secretary William B. Franke which called for a major reorganization of Navy's management structure (AW Mar. 30, p. 40).

As of late last week, however, the over-all report, which also proposed the merger of the Bureau of Aeronautics and Bureau of Ordnance into a new Bureau of Naval Weapons, had not been formally approved by outgoing Navy Secretary Thomas S. Gates, Jr. Gates, who originally had been scheduled to act on the proposals by May 1, will be succeeded in the near future by Under Secretary Franke, primary author of the reorganization report.

AMC Awards J93 Follow-on Contract

New York—Follow-on contracts totaling $29.3 million have been awarded General Electric Co. by Air Materiel Command for further development of the J93 turbojet, scheduled to power the North American B-70 and F-108.

Pioneer IV Data Alters Van Allen Theory

Washington—Pioneer IV—this country's successful solar satellite launched last Mar. 3—showed a vastly different picture of the two natural belts of radiation that surround the earth than was obtained from Pioneer III or Explorer IV, according to Dr. James Van Allen, the scientist for whom the belts were named.

Pioneer IV passed through the outer radiation belt about six days after a major solar disturbance. At that time the belt was found to extend more than 50,000 mi. into space, almost 20,000 mi. farther from the earth's surface than the upper limit measured by Pioneer III on Dec. 6.

Speaking before a symposium on "Problems in Space Exploration," Dr. Van Allen said that he tentatively surmised that charged particles emitted by the sun during such disturbances replenished and increased the total number of charged particles trapped in the outer radiation belt. He is head of the department of physics of the State University of Iowa, and has been responsible for the collection and analysis of radiation data from U. S. satellites and space probes.

The symposium was held under the joint sponsorship of the National Academy of Sciences, the National Aeronautics and Space Administration, and the American Physical Society.

Results of a preliminary analysis of the radiation data gathered by Pioneer IV are:

• **Radiation belts.** The existence of the two radiation belts around the earth as shown by Pioneer III and Explorer IV was confirmed by Pioneer IV.

• **Distances.** The outer radiation zone extended to 52,250 mi. from the surface of the earth—18,750 mi. farther than was indicated by Pioneer III on Dec. 6. The measured total number of trapped particles was more than three times that found in December.

• **Solar disturbance.** The flight of Pioneer IV was preceeded on Feb. 25 by the occurrence of a major M-region disturbance on the sun that, it is assumed, replenished and increased the total number of trapped particles in the outer radiation belt.

• **Inner belt.** A shielded radiation counter in Pioneer IV showed that the inner radiation zone contained predominantly highly penetrating radiation. Relatively little radiation was absorbed by lead shielding 0.16 in. thick.

• **Outer belt.** Radiation in the outer radiation zone was almost completely absorbed by the shielding, tentatively indicating that the two zones are quite different.

Dr. Van Allen suggested that this supports the hypothesis that the radiation in the inner belt consists primarily of decay products of neutrons emerging from the earth's atmosphere, and that radiation in the outer zone is predominantly due to solar gas that is of much lower average energy. Other findings:

• **Cosmic rays.** Good measurements of the intensity of interplanetary cosmic radiation were received out to 396,000 mi. from the earth's surface.

• **Lunar pass.** Pioneer IV came within about 37,500 mi. of the moon and showed no change in the intensity of radiation being measured at that distance. The magnetic influence of the moon, however, is not expected to reach this far from the lunar surface.

• **Interplanetary measurements.** Beyond 52,250 mi. and during about 25 hr. of observation, no fluctuations in radiation intensity were measured that were beyond statistical expectations.

The statistical characteristics of the two Van Allen radiation belts as presently determined are:

• **Inner belt.** The inner belt begins at an altitude of about 1,300 mi. and extends to 3,000 mi., and is about 4,000 mi. wide from north to south.

• **Outer belt.** The outer radiation belt begins at an altitude of about 8,000 mi. and extends to approximately 52,250 mi., and is about 20,000 mi. wide from north to south.

Highlights of other papers presented at the joint meeting, and at separate meetings of the two scientific societies, included:

• **Project Argus.** Scientific findings of the Project Argus experiment where three low-yield nuclear bombs were exploded at an altitude of about 300 mi. over the South Atlantic Ocean were described (see p. 63).

• **Earth environment.** Observations on the geomagnetic field at great distances recorded by Pioneer I and analyzed by scientists of Space Technology Laboratories, Inc., indicated a highly irregular structure. At a distance of 50,000 mi., both the magnitude and direction of the field varied in a disordered manner. This is believed to be the result of the collision of ionized gases originating in the sun with the geomagnetic field. Data obtained from 16,000 to 28,000 mi. indicated that on the day of flight the magnetic field did not decrease in the predicted manner.

Other members of the same laboratory group described the radiation measured by Pioneers I and II. Pioneer I reached an altitude of more than 70,000 mi. and provided the first experimental evidence that the inner radiation belt discovered by Van Allen was geomagnetically trapped. Pioneer II only reached a maximum altitude of 963 mi. before impacting in Central Africa but had the advantage of providing data along a relatively flat trajectory at the lower edges of the inner radiation belt as it approached the equator, making it possible to observe the increase in radiation at a constant altitude with decreasing latitude.

• **Planetary observations.** Astronomers from Harvard College Observatory reported on recent data on planetary bodies. The discovery of absorption bands characteristic of heavy organic molecules in the infrared spectrum of the dark regions of Mars by Dr. W. M. Sinton was reported. These regions vary in shape and especially in intensity in synchronism with the seasons on Mars, strengthening the belief that a form of plant life exists there.

Princeton University scientists discussed the unexplained difference between the theoretically predicted and the observed positions of the planet Jupiter. The displacement—up to a maximum of 600 mi. ahead or behind of the predicted position—goes through a complete cycle every 12.4 years. The cycle is slightly longer than the time it takes Jupiter to complete an orbit of the sun (11.9 years) which raises the possibility that the error may be due to a steady but gradual change in the shape and orientation of Jupiter's orbit. There is, however, no explanation of why such a change should take place.

Manned Space Tests

Washington—Flights in six manned space vehicles have been simulated by pilots in human centrifuge research work to be described at the first annual Space Medicine Electronics Symposium to be sponsored by the Franklin Institute in Philadelphia on May 18.

Vehicles include the X-15, Dyna-Soar, Mercury manned capsule, an Ames Research Center capsule, a Langley Research Center winged vehicle and an Edwards' vehicle. Flights have been made in exit and re-entry acceleration tests in the 4,000 hp. centrifuge at Naval Air Development Center in Johnsville, Pa. Tests already have led to modifications in seats, restraints, instruments and flight dynamics of vehicles investigated.

One-day symposium is an attempt to bring together medical and engineering disciplines to further development of electronic equipment applicable to space medicine. Speakers will include Vice Adm. John T. Hayward, Deputy Chief of Naval Operations for Development, and speakers from Advanced Research Projects Agency and NASA.

Official Asks Study of Deterrent Satellites

By Philip J. Klass

Boston—The U.S. must study the feasibility of deterrent satellite weapon carriers, armed orbiting satellites which could be directed on command out of orbit against aggressor targets, an Advanced Research Projects Agency official told a recent American Rocket Society conference here on controllable satellites.

Although many feasibility questions about this weapon concept must first be answered, including such things as accuracy, reliability, availability and safe recovery, if deterrent satellites prove to have unique advantages, the U.S. must develop this capability, ARPA's George Brady said.

Pointing up one of the problems involved, the altering of satellite orbit, Brady said that approximately 2,000 lb. of propellant would be required to quickly change the inclination of the orbit of a 5,000 lb. satellite by only 10 deg.

Brady also said it may be possible to employ manned space stations equipped with maneuverable missiles as an active defense against enemy ballistic missile attack.

Use of a small ion propulsion system offers significant weight saving over chemical or gas-jet propellants for satellite attitude stabilization and/or orbit changing, Harold Brown, of General Electric's Flight Propulsion Laboratory, reported in a paper co-authored by Russell N. Edwards.

For example, he said, a small ion propulsion system could shift the orbit of a 1,500 lb. satellite by 10 deg. in approximately 370 to 700 hr. with consumption of only 60 to 80 lb. of cesium or other ion engine propellant, Brown said.

Small Rockets

Based on tests now under way at General Electric on a 3,000 watt cesium ion rocket, Brown predicted that small ion rockets could be ready for use in satellites by 1961-62. Although internal erosion would limit useful life of these early models to several hundred hours, Brown said that larger, longer-lived models could be in orbit by 1964-65.

The 3 kw. ion rocket now under test employs cesium vapor generated under controlled pressure. Vapor passes through a large heated rectangular duct, diffuses through curved screened incandescent emitter surface where it is ionized. Ions are extracted by electric field, and the beam is guided by focusing electrodes. Electrons emitted by incandescent grid are mixed with an ion beam to yield a neutral (uncharged) plasma.

Using present design concepts, Brown said it is possible to produce a 300-watt ion rocket with about 0.001 lb. thrust, a specific impulse of 10,000 sec. and an efficiency of 70 to 80%. (Efficiency is ratio of exhaust jet power to total electric power supplied.) Device would consume approximately 3 lb. of propellant during a year's operation. At lower specific impulse, efficiencies would be somewhat lower.

A 35 kw. ion rocket capable of producing approximately 0.1 lb. thrust could provide specific impulse of about 10,000 sec. with propellant consumption of approximately one pound per day.

Preliminary experiments with arc propulsion devices using helium gas have produced specific impulses up to 1,150 sec. with thrust chamber efficiencies greater than 50%, M. C. Adams and Morton Camac of Avco Research Laboratory reported, and theory suggests that even higher specific impulses are obtainable. Efficiencies of 65% were obtained at specific impulse values of around 600. By altering arc chamber geometry, it should be possible to obtain the same efficiency at higher specific impulse, the Avco scientists said.

Major Effects

Three major effects which may limit range of efficient operation of neutral plasma devices of this type, according to Adams and Camac, are:

- **Frozen-flow losses in nozzle:** When gas is heated above about 3,000K, some of that heat energy goes into dissociation of molecules into atoms or into breaking electrons away from atoms. When gas is cooled as it expands through a nozzle, this energy is lost and does not appear as kinetic energy—unless recombination occurs before gas leaves the nozzle.
- **Heat losses to chamber walls:** This limitation arises because of aerodynamic heat losses to the walls, reducing the over-all efficiency.
- **Electrode surface losses:** As specific impulse increases, the higher gas temperature results in sharply increased electrical conductivity of the gas, producing increased anode heating. The electrical power consumed in anode heating reduces over-all efficiency.

Other areas which require further investigation include anode and cathode erosion rates, arc instabilities, transpiration cooling and over-all cooling system design and deviations from frozen expansion in the nozzle which would reduce energy lost in ionization and increase range of efficient operation.

New standard atmosphere, known as the 1959 ARDC Model Atmosphere, based upon recent data obtained from satellites and sounding rockets was proposed by Dr. R. A. Minzner, Geophysics Corporation of America. Minzner formerly was on the staff of Air Force's Cambridge Research Center's Geophysics Directorate.

Greater Density

In the new model, pressure and density values are approximately half those of the 1956 ARDC Model Atmosphere at 105 to 110 km., and the 1959 values are about 18 times greater (density) than the old model at altitudes of 500 km., Minzner reported.

Molecular scale temperatures in the new model are 34K lower than the 1956 values in the 80 to 90 km. region, but the temperature gradient between 105 and 160 km. is 20K per km., almost double the value used in the 1956 model. The molecular scale temperatures of the new model are almost twice those of the 1956 model in the 200 to 300 km. region, Minzner reported.

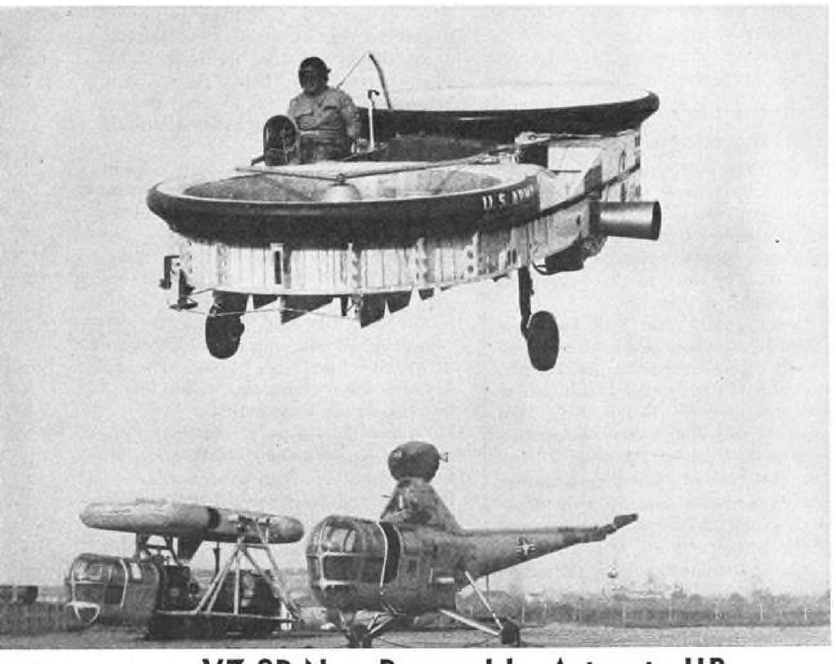
Molecular weights used in the 1956 model may be "considerably in error," particularly between 90 and 200 km., Minzner said, based upon data obtained from recent sounding rockets.

Use of aerodynamic stabilization of satellite attitude for orbit altitudes of less than 300 mi. appears feasible, despite the near-vacuum conditions, according to a study reported by John K. Wall of Douglas Aircraft Co. Aerodynamic stabilization moments could be produced by dragging a thin aluminum coated plastic sphere attached behind the satellite, or by dragging a device resembling a huge box kite.

Oscillation Periods

Wall conceded that the aerodynamic stabilization moments produced are exceedingly small and would result in oscillation periods of several hundred seconds, but this may not prove objectionable in terms of the normal satellite orbit period of several hours.

For a 500 lb. satellite orbiting at 200-300 mi. altitude, a 20 ft. diameter balloon would provide attitude stabilization with an oscillation period of about 500 sec., Wall estimated. A box kite type stabilizer measuring approximately 10 ft. by 20 ft. on a side would provide similar performance. If these oscillation periods prove too long, viscous damping mechanisms could be employed to couple the balloon or box kite to the satellite, according to the speaker.



VZ-8P Now Powered by Artouste IIB

Piasecki VZ-8P vertical takeoff and landing aircraft is checked out after installation of a single Turbomeca Artouste IIB gas turbine rated at 425 eshp. The VZ-8P formerly was powered by two Lycoming O360s rated at 180 hp. each. The VTOL has attained an altitude of about 25 ft. (AW Mar. 30, p. 74).

Structural Modifications on B-47 Boost Active Life by 3,000 hr.

By J. S. Butz, Jr.

Washington—All operational Boeing B-47 bombers have had their useful life extended for approximately 3,000 hr., or between six and 10 years in normal service with the Strategic Air Command.

This Air Force estimate is based upon structural modifications made after the aircraft was subjected to exhaustive tests to determine its fatique life. The need for modifications to the B-47 were clear long before the fatigue tests were completed and the exact benefit of the modifications could be determined. During congressional testimony early in March, Maj. Gen. A. G. Hewitt, then Air Force director of maintenance engineering, reported only that modifications were being made. Information received since the time of his testimony has established that the increase in service life allowed by the modifications is approximately 3,000 hr. Modifications consisted primarily of:

- **Wing strengthening largely** by adding doubler plates near the wing root. The fatique tests confirmed operational information indicating impending failure in this case (AW Dec. 15, p. 71).
- **Strengthening forward longerons** which failed catastrophically during fatigue tests. Experience had not yet shown that this was a trouble area.
- **Rework of the large milk bottle** fittings which held the wings to the fuselage. Stress corrosion had appeared in this area. These fittings were bushed and their pins replated.

Dynamic structural test program used to establish aircraft fatigue life are relatively new in the Air Force, and the B-47 was the first to be tested. This program duplicates in a comparatively few hours the repeated loadings that the aircraft would experience during years of use. Loading during takeoff, landing, rough weather flying, maximum performance bombing runs, etc., are all duplicated in a logical sequence.

The B-47 fatigue program began a little over a year ago, and the Boeing B-52 and the Convair B-58 are now undergoing dynamic tests. Future tests of this nature will include the North American F-108 and B-70 Mach 3 aircraft.

Value of the tests extends beyond the discovery of catastrophic type failures which probably will occur during some period in the aircraft's life such as the longeron failure on the B-47. The tests also aid in orderly maintenance planning and spare parts purchase. This has benefited the B-52 program because the equivalent of 12,000 flying hours will have been logged during the dynamic tests before any operational aircraft has reached 1,000 hr. Another major benefit of the tests is the check they give on structural design specifications for long fatigue life. Considerable revision of the specifications has resulted from the B-47 tests.

Validity and repeatability of the dynamic loading tests was illustrated by the fact that three separate groups tested the B-47 and all three came up with essentially the same results. Boeing, Douglas and the National Aeronautics and Space Administration were each given a high-time aircraft by the Air Force. Each of these aircraft had the wing attachment fitting modification incorporated. The test was then begun to determine exactly how long the modified aircraft would hold together.

The group at Boeing-Wichita was slightly ahead of the other test groups, and its aircraft experienced the first major failure. The aircraft actually fell into two pieces when one of its major longitudinal members failed. A fix was then designed to prevent this type failure. The modification was then applied to the aircraft under test at Douglas and the NASA as well as the damaged aircraft at Wichita. After the delay required to make the modification, all of the tests were resumed, and on the basis of the data gathered since that time the Air Force, after applying suitable safety factors, estimates that all of its modified B-47s will last at least 3,000 hr. longer than previously. Low-time B-47s, which were among the last off the line when production ceased two years ago, have considerably more than 3,000 hr. of useful life ahead.

Congressional testimony on the B-47 structural difficulties brought out the fact that the aircraft no longer use the LABS maneuver to deliver bombs at low level. This required the bomber to approach a target at low level and at near maximum speed and then execute an Immelmann turn. The bomb was released some time during the turn.

Gen. Hewitt said that the use of this LABS maneuver for which the B-47 was not specifically designed was a major contributing factor in the fatigue failures on the aircraft. Maj. Gen. M. A. Preston, USAF director of operations in the office of the Deputy Chief of Staff, Operations, said that, while the LABS maneuver has been discarded on the B-47, other effective means of delivering bomb loads at low level have been devised.

Utility Jet Testing

USAF this week begins evaluation flight testing of both the Lockheed JetStar CL-329 and the McDonnell 119 utility jet transports at Edwards AFB, Calif. Air Force decision on orders is expected by July 1.

First production non-certificated JetStar will go to Pratt & Whitney Aircraft in September, 1960. Pratt & Whitney will furnish its own JT12 advanced engines and will utilize the 600-mph. jet plane as a testbed. Following test work the aircraft will return to Lockheed's Marietta, Ga., plant for conversion to a Pratt & Whitney corporate airplane.

First delivery of a four-engine certificated JetStar will be to Continental Can in January, 1961. Latest order for the CL-329 was placed last week by James A. Ryder, president of Ryder System, Inc., of Miami, Fla. The Department of Transport of Canada may purchase up to 10 of the Lockheed jets.

USAF Awards Douglas ALBM Design Contract

Washington—Air Force last week awarded Douglas Aircraft Co. a design study contract as a first step in the development of an intermediate-range, air-launched ballistic missile system. Avionic subsystem manager in the proposal submitted in the competition by Douglas is General Electric's Light Military Electronics Department, Utica, N. Y.

Under the contract, Douglas will develop specific performance and cost data "upon which further cost and effectiveness studies can be based." Air Force said the initial study period should require approximately six months.

Thus far, General Electric apparently is the only firm associated with Douglas on the project. No commitments have yet been made on the propulsion system or other subcontract work.

The Douglas approach incorporates use of reaction control jets in the nose similar to those on the North American X-15 research aircraft rather than a gimbaling thrust chamber (see p. 83).

Convair Gets Contract For Vega Space Units

Washington—Contract for $33.5 million for eight Vega space vehicles for orbital, lunar and planetary missions was awarded last week to Convair's Astronautics Division by the National Aeronautics and Space Administration. Flight tests are expected by late 1960.

About half of the initial order of eight vehicles, which are to be delivered by the end of 1961, will be three-stage Vegas. Both two and three-stage versions will use the USAF-Convair Atlas intercontinental ballistic missile as a booster. Cost of the Atlases is not included in the contract.

Convair will handle design, construction, tests and launchings. NASA's Jet Propulsion Laboratory will handle technical supervision and planning of planetary payloads.

Two-stage version will use a 34,000 lb. thrust improved version of General Electric's Vanguard engine, with autopilot guidance in the second stage. It will put a two-ton capsule carrying several men into a 300-mi. orbit. General Electric has been awarded $4.12 million for development.

Three-stage version will add a 6,000 lb. storable nitrogen tetroxide and hydrazine engine now being developed by Jet Propulsion Laboratory under a $6.4 million contract. Third stage will carry inertial guidance and control jets.

Missions for the three-stage version will include sending a 1,000 lb. payload to the vicinity of the moon, soft-landing several hundred pounds on the moon and sending 750-lb. payloads on planetary missions.

News Digest

Canadair, Ltd., subsidiary of General Dynamics Corp., has begun shipping Bomarc wings and ailerons on schedule to Boeing Airplane Co. The missile components, built under $1.7 million Boeing subcontract (AW Feb. 23, p. 25), were shipped from Montreal to Seattle and will be used in Bomarcs delivered to USAF for armament of forces within the United States. Contract was generally regarded as a test of Canadian production facilities.

British aviation exports have marked up a three-months-period record with sales of more than $123 million, according to Society of British Aircraft Constructors. However, Edward Bowyer, director, said that despite the showing, the British industry must expect a "substantial drop" in exports.

India is expected to order a "considerable number" of Hawker Siddeley Avro 748 turboprop transport, according to Sir Roy Dobson, managing director. Aircraft carries up to 40 passengers, will cost about $4.75 million each.

Sylvania Electronic Systems, Waltham, Mass., has received a $4,340,000 Department of Defense contract for production of a new military communications system. Details not revealed.

Advanced shipboard radar systems will be built for U. S. Navy by Westinghouse Electric Corp.'s Electronics Division, under an $8 million follow-on contract. Contract includes production of long range air and surface radar search equipment.

U. S. Venus probes, once planned for early June, and an earlier launching of a 30,000 mi. satellite on which equipment for the Venus probes was to have been tested, have been postponed indefinitely because of engineering difficulties in both boosters and payloads, National Aeronautics and Space Administration said last week. Satellite shot was Thor Able III and Venus shots were Thor-Able IV and Atlas-Able IV. New missions will be assigned to the vehicles.

Boeing B-52G jet bomber has made a record nonstop flight of more than 9,000 mi. without refueling, the Air Force announced last week. Aircraft, which made the flight on Dec. 15, remained in the air for 18 hr. flying a 500 mph. criss-cross course over the U. S.

Gen. Lawrence S. Kuter, commander in chief of the Pacific Air Forces, was named by President Eisenhower last week to succeed the retiring Gen. Earle E. Partridge as commander of the North American Air Defense Command. Appointment becomes effective on July 31, date of Gen. Partridge's retirement.

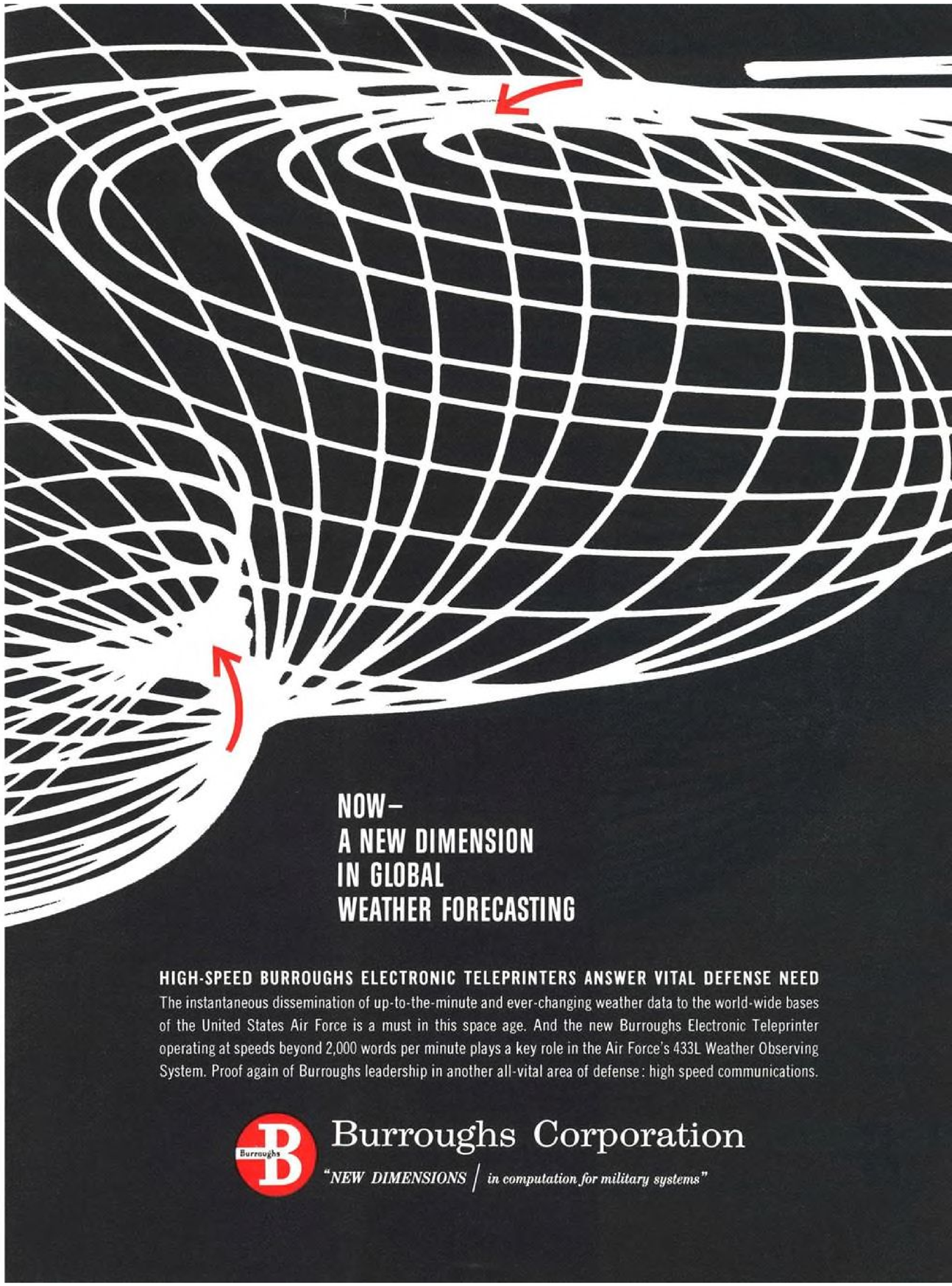
Civil Aeronautics Board last week reaffirmed its policy on "off-peak" coach fares and dismissed complaints from four trunklines—Delta, Eastern, Northeast and Northwest—against National Airlines' new coach rate between Boston and Miami. Eastern and Northeast filed similar tariffs, emphasizing that the step was taken "defensively" to compete with National. Braniff, Delta and Northwest plan to use the low fares on routes competitive to those covered by the National fare adjustment.

Guidance Shift

Washington — Formal announcement of use of an American Bosch Arma developed inertial guidance system in the Air Force-Convair Atlas ICBM is expected within the near future.

System was originally developed for the Martin Titan, then redirected to the Atlas when it reached a development stage that permitted the switch to Atlas.

Massachusetts Institute of Technology developed a further refined inertial system for Titan. Production contract for the system has been awarded AC Spark Plug Division of General Motors.



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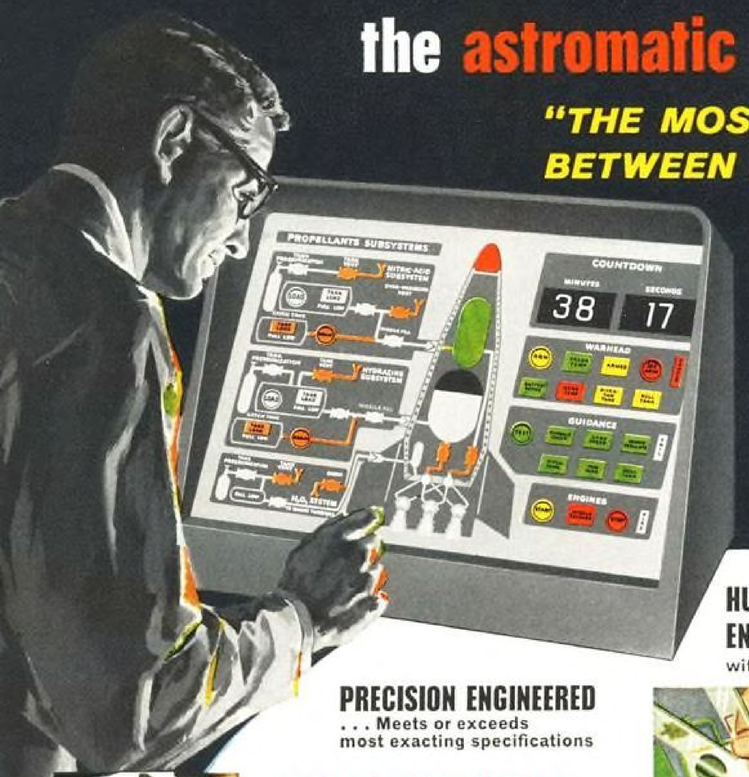

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Eastern Maps Plan to Regain Traffic Lead

Greater schedule reliability termed a key factor in bid to attract passengers, boost position.

By L. L. Doty

Miami Beach—Eastern Air Lines last week called for greater schedule reliability as a key factor in restoring the carrier's position as a leader in the number of passengers carried.

Eastern, which moved more passengers than any domestic or international airline in 1957, lost its enviable position last year, due principally to the effects of the 39-day labor strike late in the year.

The call for consistent on-time performance keynoted opening remarks by the company president, Thomas A. Armstrong, at the spring semiannual advisory and junior board of directors meeting here.

The unique six-day, give-and-take conference, which has been a standard Eastern procedure since 1947, was attended by close to 400 supervisory and top-level management personnel. Capt. E. V. Rickenbacker, who normally quarterbacks the entire program, was in Houston during the first three days of the meeting attending Civil Aeronautics Board hearings on the Southern Transcontinental Route Case.

Slow Recovery

Armstrong told the group that recovery from the slack created by the strike had been slow and warned that sales must be accelerated if Eastern is to keep pace competitively in the jet picture. In this connection, he noted that "Eastern would be in a tough spot were it not for the Lockheed Electra."

He said the Electra turboprop transport, which now serves 19 cities on Eastern's routes, had carried 140,700 passengers during the first quarter of the year and had grossed $8.4 million in revenues. However, he pointed to depreciation expense and interest on loans as cost factors resulting from the conversion to turbine equipment which will continue to grow and which must be offset by heavier traffic.

Expanding costs resulting from introduction of jet equipment in establishing adequate airport facilities were stressed by Maurice Lethbridge, assistant to the president. He said turbojet aircraft will make Chicago's Midway Airport completely obsolete and that amortization and maintenance expense of the larger O'Hare Field will result in an annual airport operating cost of $825,000 for Eastern in 1962 as compared with its current Chicago airport costs of $200,000 yearly.

Lethbridge added that roughly $30 million will be spent by seven airlines in making the move from Willow Run Airport to Metropolitan Airport in Detroit.

Increased Landing Fees

Landing fees will also climb, Lethbridge said. For example, current landing fees at New York's LaGuardia Airport of $165,000 a year will reach $425,000 by 1962. He said the airline's hangar at Newark, N. J., is inadequate and must be replaced by a new $4 million hangar.

To stress the inflationary factor, he said the original estimated cost of the company's new hangar at New York International Airport of $15.2 million had already jumped to $19 million.

Rising payroll costs to the company also were set forth during the meeting. The company is anticipating a 5% increase in personnel complement this year which will hike the $96 million wage level set in 1958 to $105 million this year.

Hidden payroll costs such as the retirement plan, social security and unemployment compensation will boost wage costs another 11% during the year.

Schedule Pattern

Armstrong said that the airline has established the best schedule pattern in the company's history. He warned, however, that the 11% increase in the number of available seats which became effective this spring will be cut quickly by management if load factors are not sustained at a high level.

On this point, he told the group that Eastern, during the month of March, was still lagging in its drive to match traffic growths experienced by its competitors. Eastern showed a 1.9 point gain in load factors during the month as compared with a 7.3 point gain for National, 4 for American and 3.7 for Northwest.

United's reported decline of 2.36 points in load factors was attributed by Armstrong to competition from American's Boeing 707 jet transport flights.

Under its present schedule, Eastern has placed 213 passenger aircraft into service to provide a total capacity of 13,580 seats daily. Each day the company will operate 511 flights representing 1,509 departures. Because the period between 4 p.m. and 6 p.m. covers the most attractive departure time

Comet Sales Future Unpromising

London—Despite a concentrated sales effort, de Havilland Aircraft Co., Ltd. has not received enough orders to make the Comet 4 project remunerative. And in the U. S. it seems unlikely that any non-American company can sell to airline operators there, according to de Havilland Chairman W. E. Nixon.

De Havilland has sold 33 Comet 4s to date and the company is making additional aircraft in hopes of meeting any delivery dates specified by new buyers, Nixon revealed.

No orders for the Comet have been forthcoming from the U. S., which, he said, represents more than 70% of the world market for airliners of that size.

"It appears unlikely," he said, "under present circumstances, that a non-American company can achieve any substantial success in selling to operators in the U.S."

Additionally, there is "fierce" competition coming not only from the U. S. but France, and soon from Russia, Nixon said, and he took the government to task for not providing a new policy for the aircraft industry.

Development, tooling, and preparation of the Comet 4 for flight cost de Havilland "many millions of pounds," the chairman said. And although the government made a contribution, it amounted to "only a small fraction of the cost."

Manufacturers in the U. S., France and Russia, he said, are materially assisted by orders from their governments.

But despite disappointment in Comet 4 sales, the company is going ahead with the design and construction of the Airco 121 jet airliner for British European Airways. This aircraft is scheduled to enter service in 1963.

for the great majority of passengers, the airline will have 187 aircraft of its total fleet in actual operation during this period.

A major problem facing the carrier in obtaining on-time schedules with so high a daily number of flights has to do with airport acceptance rates. In addition, the severity of the gate-space shortage at many airports was strongly emphasized as a leading problem.

For example, at the Washington National Airport, where gate shortage is especially acute, the carrier has been allocated but six gate positions to accommodate a total of 107 daily departures. Atlanta provides 24 gate positions for the same number of flights.

Armstrong said Eastern established a new company record last November when 65% of the flights scheduled were operated on time and 18.5% departed in less than 15 min. of the scheduled departure time. In January, this on-time rate tumbled to 55% for on-time operations but rose slightly to 19.1% for flights departing within 15 min. of scheduled time. By March, on-time figures stood at 58% and 18.3% respectively.

William L. Morrisette, Jr., vice president-traffic and sales, warned that the industry was no longer "on the threshold of the jet age but in it." He added, however, that the company will continue to operate a fleet of 187 piston-engine aircraft for "some time to come" and warned "we cannot allow ourselves to be sold out . . . by low load factors on this fleet."

Travel Agent Role

Morrisette called for closer cooperation with travel agents and said, "travel agents will become more and more important in sales because of the increased competition on Eastern's routes that has developed over the last three years."

He noted that sales during the first quarter dipped more sharply in the Midwest—11%—than elsewhere on the system. He attributed this decline to two new competitors in this market—Trans World and Northwest—who had the strong advantage of building up advance bookings for the heavy Florida season while Eastern was grounded by strike.

A similar advantage was lost to Eastern on the New York-Miami route, he said, and added that the airline ran more newspaper advertising lineage during the first quarter in the New York area than any other airline, in a move to regain its position in this market.

During the course of the advisory and board meeting, every member of the airline present is required to give a report on activities in his department or station during the past six months. Remarks made by reporting individuals are frequently challenged during these sessions; others are taken as operating programs which must be adopted at all stations as means of improving the airline's service patterns.

CAB Opens Southern Long-Haul Hearings

By Craig Lewis

Houston—Latest round in the long and bitter battle over trunk airline routes in the southern tier of states opened here last week when the Civil Aeronautics Board launched its hearings in the Southern Transcontinental Service Case.

Airlines and communities asking for new service across the southern tier crowded a spacious hearing room here as the CAB opened hearings in the most important route case now in the mill. Hearings will move from Houston to Los Angeles and Miami before returning to Washington in July for airline testimony, and the case is expected to be the center of a vigorous battle for the routes involved in the 18 months to two years it will take the CAB to reach a final decision.

Communities Testify

Houston, Los Angeles and Miami hearings are concerned only with the testimony of the communities affected by the case, but airline executives and attorneys showed up in force when Houston led with 27 witnesses, followed by Dallas with 32. Testimony will be taken from 23 cities in Texas, Louisiana and Mississippi before the hearings move to Los Angeles next week.

Generally, the case involves long-haul routes across an area south of a boundary running from Jacksonville to Atlanta, Birmingham, Dallas and Ft. Worth, Albuquerque, Las Vegas and San Francisco. Some shorter range services will be involved, but local service and such issues as turnaround and local service between Dallas and Houston are excluded.

When the final decision is made, the nation could easily wind up with one or two more transcontinental carriers. If the Board wants to avoid the prospect of another transcontinental carrier, the solution may lie in continuing interchanges and certificating regional carriers which would connect in Texas, although such a patchwork solution seems unlikely.

A number of restrictions have been applied in advance against any new route awards in an attempt to limit the case to long haul issues and to limit the new services a carrier might be able to offer in connecting a new route to its present route structure in areas beyond the limits of the case. Possible need for any further restrictions is also an issue in the case.

Such restrictions are designed, for instance, to keep a carrier now serving New York from operating New York-Los Angeles nonstop with the addition of a southern transcontinental route. But restrictions like this have had a way of being dropped over the years, and restricted services authorized in the present case may well have broader impact than that envisioned in the CAB's Southern Transcontinental Case decision.

Under the restrictions the CAB currently contemplates, a carrier could operate through-plane service from points outside the area to points on a new southern route, but a stop would be required at a border point such as Atlanta or Dallas.

Flights coming from outside the area would also have to serve a point in each of any two of these states: Florida, Georgia, Texas, Louisiana and California.

In sorting out the areas involved for purposes of turnaround restrictions, the CAB has lumped Florida and Georgia in an eastern region, Texas and Louisiana in a south central region, and California in a western region. Turnaround service between these regions will be permitted, as will turnaround service between Nevada and Arizona points and Dallas and points east and between Mississippi and Alabama points and points west of Dallas.

Three General Routes

New service is being considered along three general routes. One stretches west from Houston to San Diego, Long Beach, Los Angeles and San Francisco/Oakland via San Antonio, El Paso, Albuquerque, Tucson, Phoenix and Las Vegas. A second stretches across from Miami, Ft. Lauderdale, Orlando, Jacksonville, Tampa/St. Petersburg-Clearwater, Pensacola and Mobile to San Diego, Long Beach, Los Angeles and San Francisco/Oakland via New Orleans, Houston, San Antonio, El Paso, Dallas, Ft. Worth, Lubbock, Albuquerque, Tucson, Phoenix and Las Vegas.

A third route would involve Miami, Jacksonville, Atlanta, Birmingham, Jackson, and Shreveport in the southeast and run through New Orleans, Houston, San Antonio, El Paso, Dallas, Ft. Worth, Lubbock, Albuquerque, Tucson, Phoenix and Las Vegas to San Diego, Los Angeles and San Francisco/Oakland.

The Southern Transcontinental Service Case is the latest chapter in a chain of airline battles over the route which stretches back more than a decade. Hearings were conducted in Houston 10 years ago this month on the same issue. In the celebrated and acrimonious Southern Service to the West Case, Eastern Air Lines was recommended by an examiner for a southern transcontinental route, but the CAB chose to set up a network of interchanges instead.

These involved interchanges included American Airlines, Eastern, Delta Air Lines, Braniff Airways, Continental Airlines, National Airlines and Trans World Airlines in various combinations. After a court battle and numerous reconsiderations and alterations by the CAB, the present interchange pattern emerged with American and Delta operating between Atlanta and the West Coast, Continental and American flying between Houston and the West Coast and American, National and Delta operating between Miami and California via New Orleans and Dallas/Ft. Worth.

Continuance Questioned

The question of whether these interchanges should be continued is an issue in the current case. In view of the demonstrated superiority of single carrier service over interchanges, it doesn't seem likely that the interchange approach to air service in the area will survive this case.

Much of the drive behind the current proceedings has come from two rival Texas cities, Houston and Dallas.

Dallas has long been unhappy with the service afforded by American over its monopoly route to the West Coast, and the city asked the CAB to put in competitive service. The result of this move was the Dallas-to-the-West Case. Hearings were held in Dallas two years ago (AW July 1, 1957, p. 38) and the case moved forward over the objections of Houston, National and Eastern.

Houston and the two airlines argued that award of a new route to California would prejudice later efforts to get a southern transcontinental route and to improve service at Houston. They said it would be more logical to expand the case to cover southern transcontinental service. The CAB brushed these arguments aside at the time and proceeded with the case.

In March, 1958, the CAB decided to look into Houston's request and launched a Southern Transcontinental Service Case. After the Dallas-to-the-West Case had reached its final stages later in the year, the Board reversed its earlier position, awarded some regional routes to Continental and consolidated the long-haul aspects of the Dallas-to-the-West Case into the Southern Transcontinental Service Case.

This move caused considerable chagrin in Dallas and Ft. Worth because it meant a delay of more than two years before they would get competitive service to the West Coast. It also threw Dallas and Houston into a competition of sorts, since each city is now working to make sure it will be on the transcontinental route pattern that emerges from this case.

Eastern has been after the southern route across the country for well over a decade. The carrier is applying for routes which would cover all three of the segments involved in the case, and the addition of a transcontinental route would probably make Eastern the biggest airline in the country.

An indication of the effort Eastern will be putting behind this latest try to get the route can be seen in the appearance of Board Chairman E. V. Rickenbacker to head the Eastern forces at the hearings, even though no airline testimony was heard. Rickenbacker made a strong pitch for the route at a press conference and elsewhere, pointing out that his company had been trying to get it since the World War II era, and arguing that Eastern can offer more and better service than any other carrier.

American is also making a strong effort to move into this new area, relying on its interchange experience and offering its substantial jet re-equipment program as evidence that it can provide the best service. Apparently American also intends to use its very active all-cargo operations as another argument that it can provide the kind of service the area needs.

Since American is bound to have competition on its present Texas-California route, the carrier is trying to offset this by moving into another transcontinental service area. Such a route will also probably give American the Los Angeles-San Francisco route it has been after.

Delta is also an applicant and, like Eastern, could offer strong competition on the transcontinental route because of the backup traffic it could channel from its routes in the East and Southeast, traffic that is now going into the interchanges. Withdrawal of this backup support will also hurt American if the interchanges are canceled.

National is asking for a route across the country from Miami to California via New Orleans, and the carrier's current authority across the Gulf from Florida to Houston is also an issue in the case. A transcontinental route would represent a major expansion for National, and this factor may work in the airline's favor if the CAB follows its policy in recent years of trying to build up the smaller carriers. National is the only carrier which hasn't reaped any substantial rewards from the series of route decisions which started in 1955.

Like American, TWA would strengthen its present transcontinental pattern if it got the southern route requested through Dallas, Houston, New Orleans and Tampa to Miami. TWA has the advantage of having been recently certificated to serve Miami from St. Louis and thus being able to fly between California and Florida via that junction point.

Braniff is asking for the southern transcontinental route via New Orleans, but not including Atlanta.

Continental and Western Air Lines are sticking to their traditional Western areas of operation and are asking only for routes to the West from Houston and Dallas/Ft. Worth. Since it was an applicant for a Dallas-California route in the Dallas-to-the-West Case, California Eastern Aviation is also automatically included in the present case.

Capital Airlines has entered a modest proposal to extend its present routes to San Antonio via Dallas and Ft. Worth and via Houston. Such service would not solve southern transcontinental problems, and Capital will rely heavily on the benefits of services from these points to northern points on its present routes as its argument for the new routes.

By the time the CAB reaches a decision in the case, current turbine equipment orders will be largely delivered, and any carrier needing new aircraft to handle a new route probably wouldn't have to wait long before getting them.

Financing them might be a harsher problem, however, and the larger carriers are arguing that their greater financial strength will make them better able to offer the service with turbine equipment called for by a new southern transcontinental route.

Airport Elections

Washington—John R. Wiley, director of aviation for the Port of New York Authority, has been elected president of the Airport Operators Council for a one-year term.

First vice president for 1959 is George Dement, of Chicago, with Byron R. Dickey, of Cincinnati, second vice president. Council members elected to the board of directors included Louis Couhe, of Paris; Emery L. Cox, Wichita; Herbert C. Godfrey, Tampa; R. Alan Mils, Portland, Ore.; Clyde G. Sharrer, San Antonio, and Dudley W. Frost, Oakland, Calif.

E. Thomas Burnard, of Washington, continues as executive vice president and Leander I. Shelley, of New York, as general counsel.

Carriers Study Plan to Boost Subsidies

By Robert H. Cook

Washington—Subsidy payments to local service carriers could be increased by as much as 20% upon adoption of one of nine modified versions of a Civil Aeronautics Board revised rate-making procedure now under study by the carriers. Procedure was formulated by a private research firm employed by the airlines and based upon a suggested CAB plan.

Although initial payments would be significantly higher than collected under the current subsidy formula, the Board's basic plan (AW Nov. 10 p. 45) and modifications recommended to the airlines by economists of United Research, Inc. are considered by local-service spokesmen as the first practical methods evolved to meet the individual needs of the carriers and eventually free them from dependence on government financial support.

Retains CAB Concepts

While the airlines have not yet publicly expressed a preference, each of the modifications is tailored to retain the basic concepts formed by the CAB. Both the Board and the airlines are in tentative agreement on the new rate-making concepts since they should eliminate time-consuming and costly temporary and final mail rate hearings; settle the controversial question of a proper rate of return; afford better control of subsidy payments by CAB through means of fixed amounts paid for specific operations; reward carriers for progress made with a profit sharing arrangement, and give the airlines greater management freedom based on knowledge of predetermined subsidy payments.

Framework of the CAB proposal, upon which the modifications have been designed, is built around a class rate formula, under which each carrier's many route divisions would be subsidized monthly at a per-route-mile rate determined by the frequency with which it received service and a formula setting forth assumed passenger loads which increase with frequency.

Any increases in service beyond the CAB established formulas would decrease the amount of subsidy paid, with each route division held to an absolute limitation on subsidy. Carriers also would be allowed a reasonable profit as part of subsidy payments and those realizing a 10% profit (after taxes) on their investment, would retain the full amount. Profits between 10 and 20% would be split evenly between the airline and the government.

While the United Research modifications follow the general pattern laid out by the Board, they are much more extensive. To the Board's base "mileage subsidy," the company has recommended adding a "station subsidy" plus an allowance of 10% of operating revenue (exclusive of subsidy) to be deducted from the sums of station and mileage subsidy.

Nine modifications were submitted for carrier study, but the company considered the three most similar to the CAB proposal as failing to provide either adequate subsidies or incentive to furnish adequate air service to the public. The firm said the five remaining formulas analyzed provided proper subsidy but failed to meet the need of expanded future service.

The favored plan calls for subsidy payments based on the first six daily round-trip flights on the basis of assumed loads of five, seven, nine, 11, 13 and 15 passengers per flight. United feels this should be expanded to include subsidy on the seventh through twelfth trips on the basis of loads of 15 passengers to provide good frequency. Upon this base the CAB mileage subsidy plus station subsidy of $1,833 per station served per month and the deduction of 10% of operating revenue would be applied.

In addition this method includes the following provisions:

- **"Experience adjustment"** similar to CAB's profit sharing plan by which the future subsidy of carriers with high past profits is reduced. Major difference from the Board's plan would be a quarterly—as opposed to an annual—revision of cost and revenue standards.
- **Adjusted miles definition** to provide a greater rate per mile subsidy for short flights and short route divisions.
- **Translation of flights performed** with such non-DC-3 equipment as the Martins, Convairs and Fairchild F-27s into comparable DC-3 equivalents for operating cost figures.

Had this plan been implemented during 1958, in which the 13 local service carriers collected $32.5 million, it would have boosted their total subsidy payments to an estimated $40.5 million, the United analysis indicates. Average subsidy payments of $2.5 million would have increased to approximately $3 million per airline.

Frequency Rule

Basic step on CAB's suggested plan concerns the selection of routes to be subsidized based upon a minimal frequency rule having the effect of eliminating all duplicating route divisions. As an alternative to provide adequate frequency, while avoiding the possibility of subsidizing every route segment independently, the research firm suggested that on any route division serviced by several segments, the number of flights subsidized be multiplied by the number of such segments. Segments with intermediate points which could be connected with their terminal points by interchanges with other segments would not be counted.

The Board's proposal also envisions a mileage subsidy based upon rates reflecting total operations costs. The United Research plan would limit mileage subsidy rates to those of only direct aircraft operating cost. Part of indirect costs at station operations would be subsidized directly on the basis of the number of airports operated by each airline. Modified formula suggested by the researchers would pay subsidy at a standard rate of $1,833 per station a month with mileage subsidy paid at rates based upon direct operating cost plus 41 cents per DC-3 mile.

With the DC-3 standard operating cost figured at $1.09 per mile by United, based upon an average 80 mi. stage length, the economists have expanded the CAB plan to include plane mile costs of $1.82 for Convairs and Martins and $1.73 for the Fairchild F-27 based upon a DC-3 equivalence factor to encourage airlines to use equipment, which attracts the most passengers.

Actual subsidy paid would vary with the load standard of each trip. For example, under the recommended plan, a flight departing with five passengers would earn subsidy of $1.09 (DC-3 cost) minus 5 x 5.22 cents (yield per passenger mile) or 83 cents per aircraft mile. An F-27 flight under the same formula and load factor would earn $1.47 per aircraft mile.

To compensate for many short-haul routes, the recommended proposal also suggests that mileage subsidy be determined by an adjustment to make about half of the mileage subsidy based on the number of subsidized routes and frequency, with the other half determined as the total subsidized mileage. This would be accomplished by a formula of a fixed amount of 40 mi. per route division plus one half the actual route mileage or flight distance. An actual route of 50 mi. would thus be adjusted to 65 mi. for subsidy purposes, thus providing route segments with closely spaced stops with a greater subsidy per mile flown and a greater number of subsidized flights.

A standard rate of return of 10% on investment, after taxes, but not less than 2¼ cents per aircraft mile, also has been built into the formula, with United Research pointing out that the percentage return is equivalent to before tax earnings of 19% of stockholder equity plus 10% of long-term debt.

Subsidy Payment Squeeze

Washington—Civil Aeronautics Board is being forced to trim subsidy payments to local service carriers because of a congressional delay in approving a supplemental appropriations bill. Cutbacks have placed several of the carriers in critical financial positions.

A spokesman for the local service industry said the CAB notified the local carriers in March that it could pay only 40 cents on every dollar of subsidy requested pending approval of the supplemental appropriations bill. He added that, unless action is taken in the near future, the carriers will not be able to meet their payrolls, since they subsist largely on a month-to-month basis on their subsidy payments, and have little or no cash reserve.

Funds requested by the CAB for subsidy payments amounted to $18 million and were considered in the second supplemental appropriations bill for Fiscal 1959. The House approved only $12 million for this purpose, but the Senate increased it to $16.1 million and named Senate conferees to work out differences with the House. As of late last week, however, the House had not named its conferees.

Western Plans Lease Of Allison Turboprops

Washington—Western Air Lines asked Civil Aeronautics Board approval last week of an engine leasing plan with the Allison Division of General Motors Corp., a move first reported by AVIATION WEEK on April 20 (p. 49).

Terms of the lease, expected to save the airline an estimated $4 million in the initial cost of acquiring a fleet of nine Lockheed Electra turboprop transports, cover the rental of 45 Allison 501 engines amortized at five years each from the Al-West Leasing Corp., a wholly owned subsidiary of General Motors. Delivery of the first engine, costing $88,905, was scheduled last week, according to Western.

Similar to American Airlines' engine-lease agreement with Allison, the Western lease also provides for an option to purchase the engines outright at any time by payment of 10% of the engine cost or balance of the unamortized cost due, which ever is greater.

FAA Studies Computer System To Forecast Air Traffic Growth

Washington—Instant prediction of any phase of air traffic for the next 20 years by the Federal Aviation Agency is expected to be available within the next six months.

Statisticians for Booze-Allen and Hamilton, which began formulating a special FAA traffic forecasting project last July, reported last week that major segments of the study have been completed, including assimilation by automatic computer of 80,000 military, general and scheduled flight results collected last January and February from 536 general and military aviation fields plus every major point served by scheduled airlines. The data obtained has been used to provide information on air activity at its lowest seasonal point, they said.

A second field survey to reveal the demands of peak seasonal air traffic is planned for a four-week period beginning July 9 and will involve studies of 119,500 flights throughout the country. In total, the two surveys will cover 825 of the nation's civil airfields; 52% of the 63,000 general aircraft; 100% of the airline aircraft; 100% of the nation's military air bases and planes, and 44 of the 50 states, including data from Alaska and Hawaii, the firm reported. Scope of the data being collected for storage and processing by an IBM 709 computer is designed to provide information on a broad range of subjects such as:

- **Variations due to aircraft** and pilot characteristics.
- **Variations due to different** weather conditions.
- **Variations due to time** of day and time of week.
- **Variations across time** (summer highs and winter lows).
- **Terrain effects upon flight** activity; altitudes and aircraft usage.
- **Effect of economic conditions** in various sections of the country on air traffic flow.

Researchers say completion of the summer survey, along with an intensive weather study being conducted in conjunction with several hundred weather bureau stations and covering 920 separate areas, will form the basis for determination of a correct formula to predict air traffic flow by automation up to 1980. Final selection of the proper formula also would be flexible to allow the insertion of new survey studies in the future to ensure the planned accuracy of the method, they said.

End results of the current project will be the development of approximately 150 mathematical equations, each of which will be capable of forecasting some specific phase of aviation activity for the present and over the next 20 years. Direct outputs are expected to cover more than 15,000 specific air traffic indicators which FAA will use in future traffic control planning.

Philosophy behind the study seeks to establish a general mathematical formula for future prediction of air traffic, along with allied information, by means of studying current air activity and merging this information in the computer with data compiled on 1959 aeronautical and economic environment. Application of the mathematical technique of multivariate regression analysis is expected to establish relationships between the environmental factors, such as numbers and locations of airfields, populations and income levels and the observed flight activity.

Field survey work has been conducted through personal interviews and questionnaires which will eventually cover more than 100,000 pilots. Military survey is being conducted by the Air Force, Navy and Army, while the general aviation effort is being handled by the Civil Air Patrol. Independent checks of the survey validity have been built into the procedure.

Data submitted to the electronic computer provides the raw material for three major tasks performed by the IBM 709:

- **Simulation of an expected** total of 200,000 flights with simultaneous classification and tally of required data.
- **Additional information needed** in further analyses, such as purpose of flight; IFR-VFR traffic mixtures and altitudes.
- **Expansion of sample flight activity** information to estimates of the total activity taking place over the U.S.

Time savings thus available to FAA in determining future traffic, placing of facilities and expected lead times for programing and installations are expected to be a major advantage since the computer can recreate an estimated 36,000 flights per hour, according to agency spokesmen.

Detailed breakdown of information scheduled to be readily available on IBM cards splits aircraft and users into six separate categories, covering local and cross country flights involving more than 200 airports plus information on international terminals and flights, traffic density figures for local flights over 67 given areas and 920 points for cross country flights, traffic flow between 220 major air terminals and detailed study of landings and takeoffs.

USAF Studies Off-the-Shelf Cargo Jets

By Russell Hawkes

U. S. Air Force, citing time and money to build a tailored jet cargo transport, will make an off-the-shelf purchase of a civil jet with such modifications as are practical, according to Col. Earl C. Hedlund, of the Directorate of Transport, USAF Headquarters.

USAF is reported working closely with Pan American World Airways in its study.

Hedlund emphasized that USAF will insist on straight-in loading; kneeling landing gear configuration proposed as a means of lowering the floor has been turned down because of complexity and weight.

U. S. manufacturers currently are proposing swing tail versions of civil jets to comply with the straight-in loading demand. USAF has stipulated that the cargo jet must offer a 50,000 lb. payload at 3,500 naut. mi. with a limit load factor at takeoff of 2.5 and tradeoff of payload for fuel to extend range to 5,000 naut. mi. with a 20,000 or 30,000 lb. payload (AW Feb. 23, p. 41).

The off-the-shelf purchase is necessary, Hedlund said, because the aircraft is needed for the period from 1961 to 1970 and at present there is neither time nor money to obtain a plane exactly tailored to USAF needs.

Jet Integration

Hedlund said the requirement for cargo jets grows out of a need to integrate the transport function with tactical functions. It will then be possible to share critical skills across the board in an all-jet Air Force. Hedlund said it will then be possible to deploy strategic offensive and other combat forces overseas swiftly and recover strategic bombers without delay when they land at advanced bases after completing a mission. Delay in getting a recovery team and spare parts out to the returning airplane leaves it in an exposed and vulnerable position. It would also be used for emergency aero-medical evacuation.

USAF also is looking for a long range high-speed troop and light cargo aircraft. Officers concede that the demand for this must be balanced against the need for a workhorse heavy cargo carrier. Hedlund said that proposals on a replacement for the Douglas C-124 now are being studied. Meanwhile, the first generation of cargo jets will stress convertibility since it must be used to fight a war on enemy terms which cannot be accurately predicted. Requiring versatility cuts productivity but results in over-all fleet economy, because the Air Force cannot afford complete specialized fleets, Hedlund said.

Rapid progress in the fields of propulsion and aerodynamics complicates the question of when it becomes economical to re-equip a transport fleet. USAF apparently has decided that a re-equipment program at the present time can increase the service's capability while cutting manpower and organizational requirements.

Loading Study

At the invitation of Boeing Airplane Co., USAF ran a loading study on the Boeing 707 fuselage mockup at the Renton, Wash., plant. Final conclusions of the study which were embodied in the general operating requirement called for:

- **Swing-tail cabin entry** for straight-in loading of bulky cargo.
- **Cargo floor** to hold at least 200 psf. distributed load.
- **Ability to withstand** wheel and axle loads of an Army 6 x 6 truck or a Bomarc interceptor missile on its transporter.
- **Cargo tiedown** and handling system.
- **Accommodations** for at least 150 troops and their equipment.
- **Provisions** to handle a load of air evacuation patients with 40% on litters.
- **Austere feeding** provisions.
- **Belly compartment** bins to speed loading of sensitive equipment and protect it.

USAF says the cargo jet will have a productivity of 11,500 ton-knots. Pressurization and low noise level it offers are desirable for the troop-carrying function. High speed makes weather forecasts more reliable.

Threat of submarine-launched missiles to U. S. island bases in the Pacific makes the long-range jet cargo carrier a necessity there, according to Hedlund. Military Air Transport Service must now plan on servicing bases in the Orient with nonstop flights. This eliminates the Douglas C-133, according to arguments of the cargo-jet proponents, because it was designed for Atlantic runs and its range is limited to 3,500 naut. mi. Seattle-Tokyo run is 4,100 naut. mi. along the great circle route which passes within a few miles of Soviet territory. East-west crossing encounters headwinds averaging 70 kt. at cruise altitude.

Lt. Col. M. E. Peterson, Chief of Materials Handling Project Office at Wright Air Development Center, outlined General Operating Requirement 157, a complete technological and physical system for the handling of air cargo.

The end product will include design specifications for equipment. The requirement was issued in March, 1957, after discussions by an ad hoc committee headed by Brig. Gen. R. L. Winn, USAF Director of Transportation.

Industry was invited to bid in a design competition involving a nine-month study contract on Jan. 1, 1959. Peterson admits the time allowed is extremely tight, considering the fact that USAF estimates the study will require a 30-man-year effort.

The response to GOR 157 is known as Project 463L in Air Research and Development Command. End product of 463L is called a "Materials Handling Support System." Douglas Aircraft Co. won this design competition and subcontractors during the study phase will include Arthur D. Little Co. and International Business Machines Corp.

Subjects covered in the study will include:

- **Aircraft cargo loading.**
- **Cargo handling from** terminal to aircraft.
- **Cargo handling in terminal.**
- **Air freight terminal** design.
- **Data processing,** communication and control of air logistics.
- **Documentation** of system functioning.
- **Marking and labeling** of air cargo.
- **Packaging of air cargo.**
- **Determination of optimum** size lots in which to handle small cargo.
- **Cargo traffic analysis.**
- **System simulation.**

Systems Analyses

Douglas will make operational systems analyses of all these facets. After completion of the study phase in January or February, 1960, a one-year service test will be run on the recommended system with a minimum amount of prototype equipment and on a carefully selected route segment. The actual service test would be preceded by analog simulation of the system operating against all known variables.

Service test will be followed by implementation of the final system. Douglas end-product will include procurement data in the form of performance specifications expressing requirement in output, function of subsystems, etc. Design, fabrication and internal workings of equipment will be left to the winner of production contracts.

Douglas will, of course, be bidding on these.

Peterson said that WADC regrets that the program is strictly Air Force-sponsored and suggested that the Department of Defense and substantial parts of industry should be involved. He also said aviation could learn much about cargo handling from marine shipping, noting that trucking cargo from warehouse to the airplane is comparable to "stream loading" of sea-going vessels from shore to ship lighters. This is scarcely ever done because of the greater efficiency of bringing the ship to a pier which can be stocked in proper sequence with cargo that can be loaded quickly.

The result is a maximum utilization of facilities and a minimum turnaround time.

Peterson pointed out that there is little point in building a supersonic transport if the time in the air is negligible compared with the total time from point of origin to user.

Sud Aviation Unveils Triple-Turbine Helicopter

Sud Aviation's triple-turbine Model 3200 heavy helicopter now is undergoing ground tests. Prototype is powered by three Turbomeca Turmo 3 turbine engines, rated at 786 eshp. each. Main four-bladed rotor is 49 ft. 1½ in. in diameter; tail rotor diameter is 8 ft. 2½ in. Helicopter will carry more than 20 passengers (AW Dec. 29, p. 25). Testing of second prototype will start soon.

U.S. Carriers Ask Caravelle Price

New York—Sud Aviation's renewed drive to sell the twin-jet Caravelle transport in the U. S. has resulted in requests from three carriers for firm price quotations.

The French manufacturer's optimism about U. S. sales possibilities was reflected by President and General Director Georges Hereil, who said here last week that the Caravelle is sure to be operated by U. S. airlines before the end of next year.

The Caravelle is now "fully available," Hereil said, and production will run at least four airplanes a month by mid-1960. Breakeven production total is 150 aircraft, according to Hereil, and markets outside the U. S. should account for at least that figure. He split the potential Caravelle market at 80 in Europe, 30 in South America, and 40 in other parts of the world but not including North America. Since the U. S. market would then be all profit, Sud would be prepared to establish an elaborate spares setup in the U. S. to help sales here.

Breakeven load factor of the Caravelle in a typical U. S. market over a stage length of 500 stat. mi. would be about 45%, according to Sud. Seat mile cost would be 6.5 cents per mile. At full gross weight, the Caravelle, with a wing loading of 60 lb. per sq. ft., was said to be capable of operating at about 200 U. S. airports.

Hereil said the U. S. public's reaction to jet transportation indicates passengers aren't going to accept "flying behind propellers" much longer, and jets will have to go to stage lengths of 200 to 2,000 mi. He said the Caravelle has no competition in its class and will not have for several years, whereas in the case of the Boeing 707, "the bonanza will last only a few months" until competitive equipment goes into service.

Sud is addressing its U. S. sales pitch most strongly to prospects among the carriers still not committed for short or medium range turbine equipment. United Air Lines President W. A. Patterson recently told stockholders his airline is considering short and medium range jets such as the Boeing 727 and Douglas DC-9.

Hereil said the French Air Force is "not yet" interested in the Caravelle, although various versions of a Caravelle transport for the military are under study.

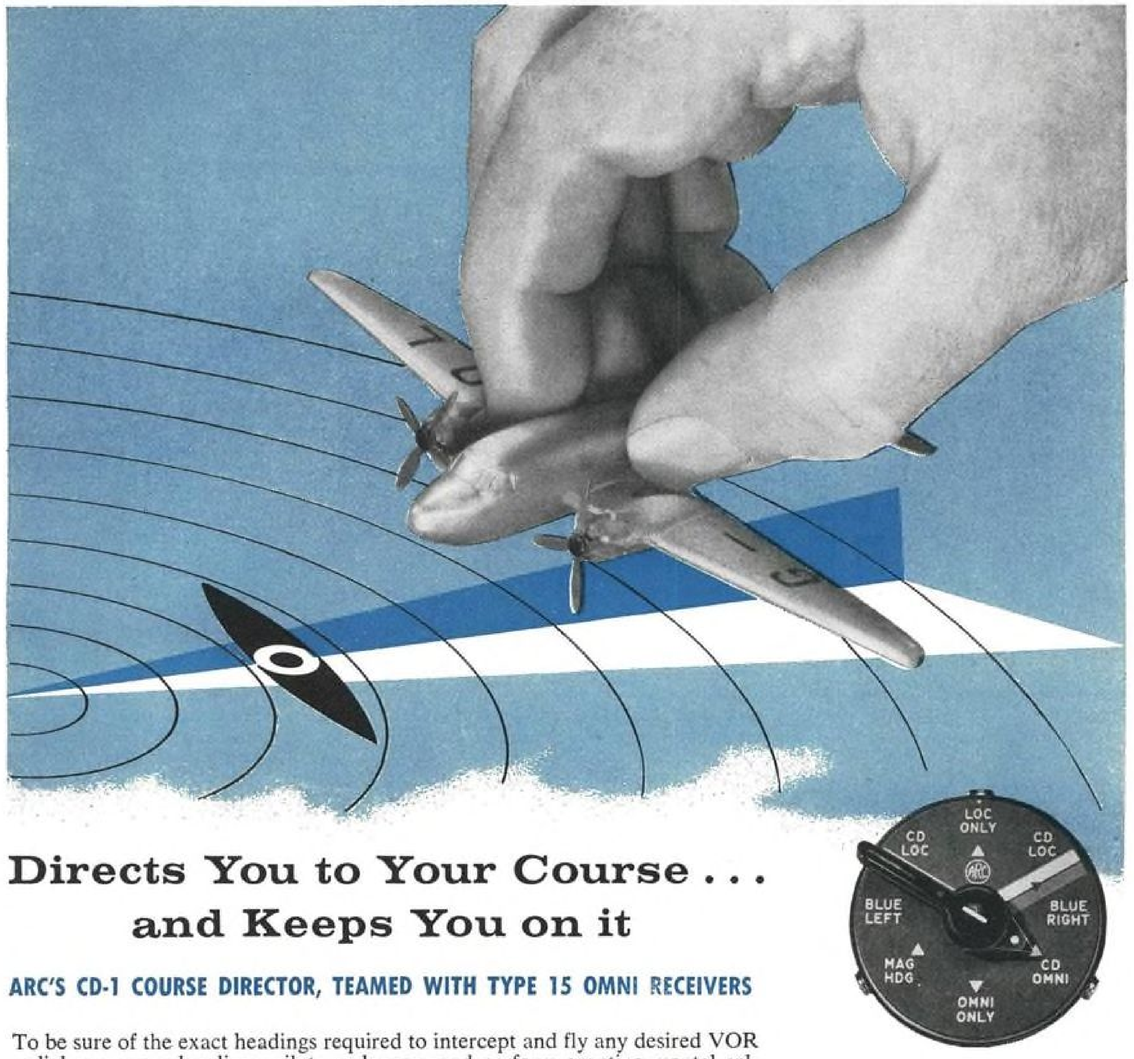
The Caravelle recently went into scheduled service with Scandinavian Airlines System. Air France plans to begin service with the jet tomorrow. Sales total now stands at 50 firm, 16 options.

United to Supply Crews To Japan Air Lines

Chicago—United Air Lines last week agreed to furnish Japan Air Lines with flight crews for transpacific flights between the U. S. and Tokyo.

Personnel involved in the agreement will include captains, copilots and flight engineers and may total as many as 20 persons.

United crews, which will be based at Los Angeles, San Francisco and Seattle, will supplement Japan's personnel complement now being expanded to cover new services between Los Angeles and Tokyo that began May 1 and between Tokyo and Seattle on the Great Circle Route which is expected to start June 27.



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SHORTLINES

► **Allegheny Airlines** reports that it flew 43,460 passengers 7,301,000 revenue passenger miles during April for an 11% gain over the same month of 1958 and a new company record. Combined air express and air freight shipments posted a 51% gain over April of last year at 587,460 lb., with freight figures alone up 66%.

► **British Overseas Airways Corp.** will accelerate de Havilland Comet 4 flights on its London-Hong Kong-London route from four to eight flights each week beginning Aug. 4. Westbound flights are expected to take 22 hr., 50 min. Certain scheduling of the westbound route will permit departures at 8:00 a. m. from Hong Kong, arriving London at 9:50 p. m. the same day. All times are local.

► **Continental Airlines** plans to spend an additional $630,000 to expand its Los Angeles maintenance base in preparation for Boeing 707 jet transport flights beginning June 1. The addition will raise Continental's investment at Los Angeles to $1.9 million.

► **Eastern Air Lines** has signed a $1 million contract with The Gibson Refrigerator Co., of Greenville, Mich., for nonstop flights from 39 points in the U. S. to San Juan, Puerto Rico. Operation involves an anticipated 5,000 Gibson dealers, salesmen and their wives to be flown on 63 round-trip flights.

► **Sabena Belgian World Airlines** has had installed a 5,660-mi. high-speed communications system connecting 19 of its 27 offices in the U. S. with New York, enabling them to make and confirm reservations on all of Sabena's flights across the Atlantic and throughout the carrier's entire network. Network was installed by the Long Lines Department of American Telephone and Telegraph Corp.

► **United Air Lines'** board of directors has declared a quarterly dividend of 12½ cents per share of common stock payable on June 15 to stockholders of record as of May 15, plus a 3% stock dividend payable at the same date.

► **William C. Wold Associates** has sold two Douglas DC-4 aircraft. One to Overseas National Airways of Baltimore has been delivered; the other goes to Twentieth Century Aircraft Co., of Los Angeles. Latter aircraft is now being refitted at the company's shops in preparation for delivery. Prices involved in sales were not disclosed.

AIRLINE OBSERVER

► Reported move by the White House to pick a nationally-known name to fill the next Civil Aeronautics Board vacancy could create strong industry reaction. Purpose of the step apparently stems from a desire to add to the prestige of the CAB, but most industry leaders would prefer to see ability outweigh reputation as a determining factor in the final selection of a new Board member. Harmar D. Denny's term expires at the end of the year and Chairman James Durfee, whose term expires in December, 1960, is still expected to be named to the judgeship of the Federal Court of Claims as first reported by AVIATION WEEK (AW Mar. 16, p. 35). Recommendation of Elwood Quesada, Federal Aviation Agency Administrator, will play a major part in President Eisenhower's final choice of the two appointees.

► **Serious consideration of a Mach 7 "pickaback" transport for operation at 130,000 to 145,000 ft. has been asked by R. D. Jamison, an assistant chief engineer of Bristol Siddeley Engines, Ltd. Dr. Jamison, head of the British company's ramjet department, admits a design study of such an aircraft would be somewhat "speculative" but believes the plane would have enough capabilities to justify the study (AW May 4, p. 55). Idea calls for a 240,000 lb. launcher aircraft with short runway capability, which would take the hypersonic transport to Mach 4 at 90,000 ft. Launch plane would then return to its airport, while the 130-passenger transport would accelerate to Mach 7, flying London to Vancouver in 75 min.**

► Group in USAF's Air Research and Development Command favors establishment of a USAF requirement for a supersonic transport. North American Aviation with the B-70 Mach 3 bomber and General Electric with the J93 powerplant for the B-70 are regarded by other manufacturers as in a strong position in such a case, and an effort is being made by them to create competitive designs.

► **Aeroflot claims that its passenger traffic broke all records during the first quarter of 1959, rising 100% above the same period of last year.**

► Russia has inaugurated its second scheduled helicopter passenger service with 10-passenger Mil Mi-4s. Newest routes are along the Caucasus coast of the Black Sea from Adler northward to Sochi and Tuapse and southward to Gagra. Like Aeroflot's Crimean helicopter service begun late last year between Simferopol and Yalta, the Adler flights are primarily for vacationers. This summer, the Mi-4s also will make sightseeing flights to Caucasus mountain villages.

► **Aeroflot, the Soviet-owned airline, plans to extend its recently-inaugurated Il-18 turboprop passenger service to "a series of additional cities" by summer. New routes will include Moscow-Mineralnye Vody (northern Caucasus), Moscow-Simferopol (Crimea) and Moscow-Tashkent (central Asia). First scheduled Il-18 passenger flights from Moscow to Adler and Alma-Ata began April 20.**

► International Civil Aviation Organization is warning that increased expenditures over those now planned by the nations of the world for air traffic control and navigation facilities will be essential for the safe and economical conduct of commercial turbojet flights.

► **Continental Airlines expects that 80% of its seat miles will be operated by Boeing 707 turbojets and Vickers Viscount turboprops by this October.**

► Delta Air Lines will inaugurate a 2 hr. 15 min. nonstop Detroit-Miami schedule in October with the first of its fleet of Douglas DC-8 turbojet transports. The airline will operate 14 round trips weekly.

► **Pan American World Airways will route its peak summer Paris and Rome jet schedules, which will begin June 1, through Boston. Stop not only will provide Boston with transatlantic jet service but also should ease Pan American's hot-weather runway and noise problems at New York International Airport.**

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Airline Income and Expenses — February, 1959

(IN DOLLARS)

	Passenger Revenue	U. S. Mail	Express	Freight	Charter	Total Operating Revenues	Total Operating Expenses	Net Income Before Taxes
DOMESTIC TRUNK								
American	21,129,582	564,666	2,022,322#	.....	.....	23,839,074	24,991,803	−610,695
Braniff	4,435,798	133,368	58,157	148,095	2,963	4,842,468	4,629,853	166,173
Capital	7,304,657	166,678	82,416	87,918	9,217	7,748,183	8,627,810	−879,627‡
Continental	1,937,803	39,922	13,604	44,802	630	2,150,829	2,359,775	−208,945‡
Delta	7,044,000	149,000	78,000	282,000	.....	7,681,000	7,558,000	78,000
Eastern	19,673,353	338,746	806,624#	.....	55,453	21,055,322	19,505,836	1,275,135
National	6,109,792	99,970	25,360	154,362	7,562	6,633,280	5,915,893	699,122
Northeast	2,380,511	36,886	12,653	33,626	.....	2,519,900	2,775,846	255,946‡
Northwest	4,953,838	172,354	447,929#	.....	195	5,585,721	6,281,801	−696,079‡
Trans World	14,885,080	397,184	854,907#	.....	62,728	16,347,576	17,579,646	−1,210,264
United	18,410,419	857,996	1,681,067#	.....	97,430	21,251,218	22,519,946	−1,306,822
Western	3,537,308	81,610	34,000	86,247	22,981	3,817,908	3,297,293	454,695
INTERNATIONAL								
American	614,165	3,700	61,310#	.....	.....	704,199	614,211	89,497
Braniff	493,556	9,342	.....	45,219	.....	592,857	636,522	−47,676
Caribbean-Atlantic	245,065	2,343	9,815#	.....	1,397	260,497	171,519	88,570
Delta	336,000	4,000	.....	12,000	.....	368,000	410,000	−44,000
Eastern	1,950,759	26,216	71,906#	.....	.....	2,055,994	1,692,383	341,949
Mackey	152,049	.....	432	1,854	.....	163,297	147,854	15,443‡
National	290,623	2,619	1,040	9,313	.....	313,085	293,064	19,712
Northwest	1,377,559	620,292	370,610#	.....	.....	2,484,570	2,235,746	248,824‡
Pan American								
Alaska	126,000	10,000	25,000#	.....	.....	177,000	372,000	−194,000
Atlantic	6,168,000	614,000	826,000#	.....	108,000	8,114,000	9,947,000	−1,746,000
Latin America	5,809,000	167,000	1,083,000#	.....	46,000	7,499,000	7,947,000	−446,000
Pacific	3,791,000	564,000	727,000#	.....	572,000	5,852,000	6,286,000	−127,000
Panagra	1,164,000	41,000	.....	153,000	2,000	1,490,000	1,534,000	−40,000
Resort	.....	.....	.....	.....	591,929§	591,939	531,746	60,193‡
Trans World	2,007,552	451,222	309,158#	.....	1,084,801	4,020,731	6,037,808	−2,069,797
UMCA	5,027	.....	646	.....	.....	5,673	11,626	−5,953
United	934,122	43,259	18,949#	.....	.....	999,278	955,155	33,714
Western	194,362	4,467	.....	3,916	.....	337,192	325,217	4,999
LOCAL SERVICE								
Allegheny	361,748	12,134	8,544	12,874	404§	582,199	795,096	−212,897‡
Bonanza	253,690	3,737	1,765	3,735	773	406,060	397,173	6,878
Central	158,109	6,245	1,621	6,160	.....	384,445	429,450	45,005‡
Frontier*	.....	.....	.....	.....	.....	.....	.....	.....
Lake Central	162,274	3,699	6,977#	.....	1,795	312,437	319,142	−6,705‡
Mohawk	515,450	6,865	4,913	7,478	12,976	703,432	781,562	−78,130‡
North Central	605,815	21,025	12,000	.....	31,295§§	913,543	1,201,942	−297,478
Ozark	363,041	211,092●	5,771	11,442	17,939	615,754	717,263	−107,676
Pacific*	.....	.....	.....	.....	.....	.....	.....	.....
Piedmont	456,971	8,660	4,286	6,815	5,765§	922,023	893,947	210
Southern	208,289	7,556	5,333	5,621	.....	411,128	458,291	−47,470
Trans-Texas	282,625	13,360	3,035	10,083	2,318	538,251	544,687	−6,754
West Coast	279,297	3,644	715	3,757	3,388	421,748	608,371	−186,623‡
HAWAIIAN								
Aloha Airlines	159,006	527	.....	4,198	.....	166,097	198,457	−32,360‡
Hawaiian	378,326	3,400	.....	49,976	392	472,927	510,687	−52,389
CARGO LINES								
AAXICO	.....	3,928	5,291	50,890	401,722	541,314	504,105	37,409†
Aerovias Sud Americana	.....	.....	.....	89,383	7,435	98,887	115,605	−18,342
Flying Tiger	.....	11,152	971,583#	.....	966,587	1,940,762	2,061,705	−171,986
Riddle	.....	3,300	532,700#	.....	271,411	815,335	969,752	−154,417‡
Seaboard & Western*	.....	.....	.....	.....	.....	.....	.....	.....
Slick*	.....	.....	.....	.....	.....	.....	.....	.....
HELICOPTER LINES								
Chicago Helicopter	48,513	94,749●	.....	.....	.....	143,388	166,388	−27,044
Los Angeles Airways	13,459	10,281	7,290	.....	.....	102,437	98,924	3,513‡
New York Airways	48,392	3,372	2,782	2,709	.....	237,455	243,738	10,609
ALASKA LINES								
Alaska Airlines	137,207	50,069	32,231	.....	67,086	411,119	526,237	−91,365
Alaska Coastal	42,546	9,486	.....	6,903	989	90,868	135,568	−44,700‡
Cordova	7,785	7,095	.....	3,082	18,314	77,319	78,123	−2,607
Ellis	31,462	4,250	.....	3,591	2,141	83,513	74,737	8,777‡
Northern Consolidated*	.....	.....	.....	.....	.....	.....	.....	.....
Pacific Northern	344,698	.....	54,698	.....	620	713,376	734,684	−33,183
Reeve Aleutian*	.....	.....	.....	.....	.....	.....	.....	.....
Wien Alaska	34,727	40,663	.....	18,506	109,725	336,497	360,835	−24,338‡

* Not available. † Net profit/loss. ‡ Net operating profit/loss. # Property figure.
§ "Non scheduled transportation." ● Includes federal subsidy.
Compiled by AVIATION WEEK from airline reports to the Civil Aeronautics Board.

Chief Engineer Askin's records show outstanding performance of AC Spark Plugs.

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AC SPARKED 'COPTERS CONQUER CANADIAN WILDS! Cracking the ground barrier . . . flying men and material into heretofore inaccessible places . . . leaves no margin for error! That's why Okanagan—largest helicopter operation on the continent—counts on AC *aircraft* Spark Plugs for top performance.

Here's what Chief Engineer R. G. Askin has to say about AC-SR83P *platinum electrode* Spark Plugs, "Everyone knows that 'copters demand the ultimate in spark plug performance, but Okanagan's operations are even more severe because of the wide range of altitudes, temperatures, terrains and restricted landing area. We have found ACs to be lead free and to eliminate premature plug removals. They deliver dependable sparking over a longer service life!"

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International Jet Flights Increase

International Arrivals Building at Idlewild is the scene of increasing international jet activity. Above, extreme left, Pan American Boeing 707-120 at gate; extreme right, BOAC Comet 4 is readied for loading. PanAm increased its New York-London jet flights last month to two daily, will step up Paris flights in June to 10 weekly. Aerolineas Argentinas has scheduled its first Buenos Aires-New York service May 30.

Airlines List Officers' Salaries, Bonuses

Washington—Following is a list of airline officers' salaries, bonuses and indirect compensations, expenses and stock holdings for the year ending Dec. 31, 1958, as reported to the Civil Aeronautics Board.

Eastern Air Lines, Inc.—E. V. Rickenbacker, chairman of the board of directors, general manager and director, $47,396 salary; $1,000 bonus and indirect compensation and 44,307 shares of common stock; **T. F. Armstrong,** president and director, $34,089 salary, $1,000 bonus and indirect compensation, 10,620 shares of direct common stock and 1,061 common shares in name of others; **S. L. Shannon,** senior vice president and director, $29,219 salary, $1,000 bonus and indirect compensation and 5,636 shares of common stock; **T. E. Creighton,** treasurer and director, $17,045 salary, $1,000 bonus and indirect compensation and 5,370 shares of common stock; **L. P. Arnold,** vice president, $21,915 salary and 4,883 shares of common stock.

M. M. Frost, vice president, $26,784 salary and 2,229 shares of common stock; **W. Van Dusen,** vice president, $24,349 salary and 2,703 shares of common stock; **C. Froesch,** vice president, $18,334 salary and 2,546 shares of common stock; **J. H. Brock,** vice president, $19,480 salary and 1,046 shares of common stock; **R. Ramspeck,** vice president, $19,480 salary and 739 shares of common stock; **W. L. Morrisette, Jr.,** vice president, $18,334 salary and 212 shares of common stock; **J. H. Hallburton,** vice president, $15,314.85 salary and 472 shares of common stock; **B. T. Dykes,** vice president, $28,830 salary and 687 shares of common stock.

G. A. Smith, second vice president, $19,480 salary and 17 shares of common stock; **R. S. Lipp,** secretary, $9,591 salary and 128 shares of common stock; **M. Lethbridge,** assistant vice president, $8,178.46 salary and no stock; **M. B. Westphal,** assistant vice president, $9,095.46 salary and 315 shares of common stock; **F. Sharpe,** assistant vice president, $9,325.15 salary and three shares of common stock; **A. L. Chabot,** assistant vice president, $11,510.63 salary and 1,020 shares of common stock; **D. C. McRae,** assistant vice president, $6,840.31 salary and 711 shares of common stock.

F. E. Williams, assistant vice president, $6,578.23 salary and 202 shares of common stock; **M. O. Byrd,** assistant vice president, $6,848.39 salary and 107 shares of common stock; **G. Hall,** assistant vice president, $4,046.61 salary and eight shares of common stock; **E. L. Williams,** assistant vice president, $5,803.84 salary and 27 shares of common stock; **D. L. Sinkler,** assistant vice president, $6,578.23 salary and 340 shares of common stock; **H. W. Cutshall,** assistant vice president, $5,803.84 salary and 22 shares of common stock; **A. F. Tirrell,** assistant vice president, $5,819.39 salary and 117 shares of common stock.

J. E. Reinke, assistant vice president, $8,125.77 salary and 34 shares of common stock; **H. C. Dobbs,** assistant vice president, $6,694.93 salary, 282 shares of direct common stock and 194 common shares in name of others; **F. A. Bennett,** assistant vice president, $4,419.23 salary and no stock; **R. E. Baskind,** assistant vice president, $4,022.85 salary and two shares of common stock; **G. W. Channell,** assistant vice president, $12,537 salary and 189 shares of common stock; **C. A. Glover,** assistant vice president, $6,063.58 salary and 235 shares of common stock; **B. Griffith,** assistant vice president, $4,046.61 salary and 510 shares of common stock; **J. A. Hamill,** assistant vice president, $5,358.77 salary and 160 shares of common stock; **H. Knapp,** assistant vice president, $8,069.85 salary and 234 shares of common stock.

W. T. Raymond, assistant vice president, $8,706.16 salary and 108 shares of common stock; **T. A. Sundem,** assistant vice president, $4,624.35 salary and 55 shares of common stock; **E. E. Hahn,** assistant treasurer, $10,104.00 salary and 190 shares of common stock; **C. J. Simmons,** assistant treasurer, $9,811.00 salary, 322 shares of direct common stock and 54 common shares in name of others; **J. C. Warlick,** assistant secretary, $9,740.00 salary and 471 shares of common stock; **C. A. Wallen,** assistant secretary, $9,591.00 salary and 494 shares of common stock.

Following directors were not paid salaries: **P. H. Brattain,** $13,000 bonus and indirect compensation and 12,004 shares of common stock; **E. R. Cook,** $200 bonus and indirect compensation and 1,383 shares of common stock; **P. M. Davis,** $600 bonus and indirect compensation and 2,972 shares of common stock; **G. B. Howell,** $700 bonus and indirect compensation and 1,592 shares of common stock; **H. Knowlton,** $600 bonus and indirect compensation and 514 common shares in name of others; **S. Peabody, Jr.,** $600 bonus and indirect compensation and 315 shares of common stock; **P. E. Reinhold,** $900 bonus and indirect compensation, 1,592 shares of direct common stock and 6,159 common shares in name of others; **L. S. Rockefeller,** $800 bonus and indirect compensation, 90,311 shares of direct common stock and 3,686 common shares in name of others; **McG. Smith,** $700 bonus and indirect compensation and 531 shares of common stock; **F. J. Turner,** $900 bonus and indirect compensation and 313 shares of common stock.

Following firms and persons were paid for services rendered during 1958: **Gambrell, Harlan, Russell, Moye and Richardson,** legal, $193,107; **C. Moon,** consulting services, $6,000; **Price Waterhouse & Co.,** auditing, $47,362; **Wyatt, Grafton & Grafton,** legal, $12,713; **Stryker, Tams & Horner,** legal, $19,202; **Smith Barney & Co.,** consulting services, $62,500.

Northwest Airlines, Inc.—**D. W. Nyrop,** president and director, $67,333 and 20,000 shares of common stock; **M. S. Mackay,** executive vice president and director, $30,000 salary, 1,000 5¼% preferred stock and 3,000 shares of common stock; **F. C. Judd,** vice president-operations and engineering, $28,958 salary and 2,005 shares of common stock; **G. M. Bain,** vice president-sales, $28,958 salary and 200 shares of common stock; **L. C. Glotzbach,** vice president-personnel, $23,000 salary and 2,005 shares of common stock; **A. E. Floan,** vice president and secretary, $22,000 salary and 1,005 shares of common stock; **W. J. Eiden,** treasurer, $23,958 salary and 2,004 shares of common stock; **A. D. Piepgras,** assistant comptroller, $12,583 salary and 1,000 shares of common stock; **D. H. Hardesty,** assistant treasurer, $12,875 salary and 310 shares of common stock.

D. Merrick, assistant vice president-properties, $13,583 salary and 1,000 shares of common stock; **C. L. Stewart,** vice president-plans, $17,375 salary and 1,000 shares of common stock; **P. L. Benscoter,** vice president-Orient Region, $18,575 and 50 shares of common stock; **C. Hunter,** chairman of the board of directors, $35,417 salary, 1,500 5¼% preferred shares and 5,000 shares of common stock; **F. J. Scott,** assistant secretary, $11,417 salary and no stock; **P. T. Drotning,** vice president-public relations, $18,875 salary and no stock; **W. Stern,** director, $10,800 salary, 500 5¼% preferred shares and 1,500 shares of common stock.

J. H. Binger, director, $900 salary and 2,926 shares of common stock; **M. H. Fry,**

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4 PRINCIPAL REASONS

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The Convairs are the most popular choice of businessmen throughout the world for large executive or corporate aircraft and have long measured up to the exacting standards set for them in this type of flying.

The Canadair-Convair '540' is powered by Napier engines and is the latest model, and the jet-prop successor to this very popular series of aircraft and provides even higher standards of all-around performance.

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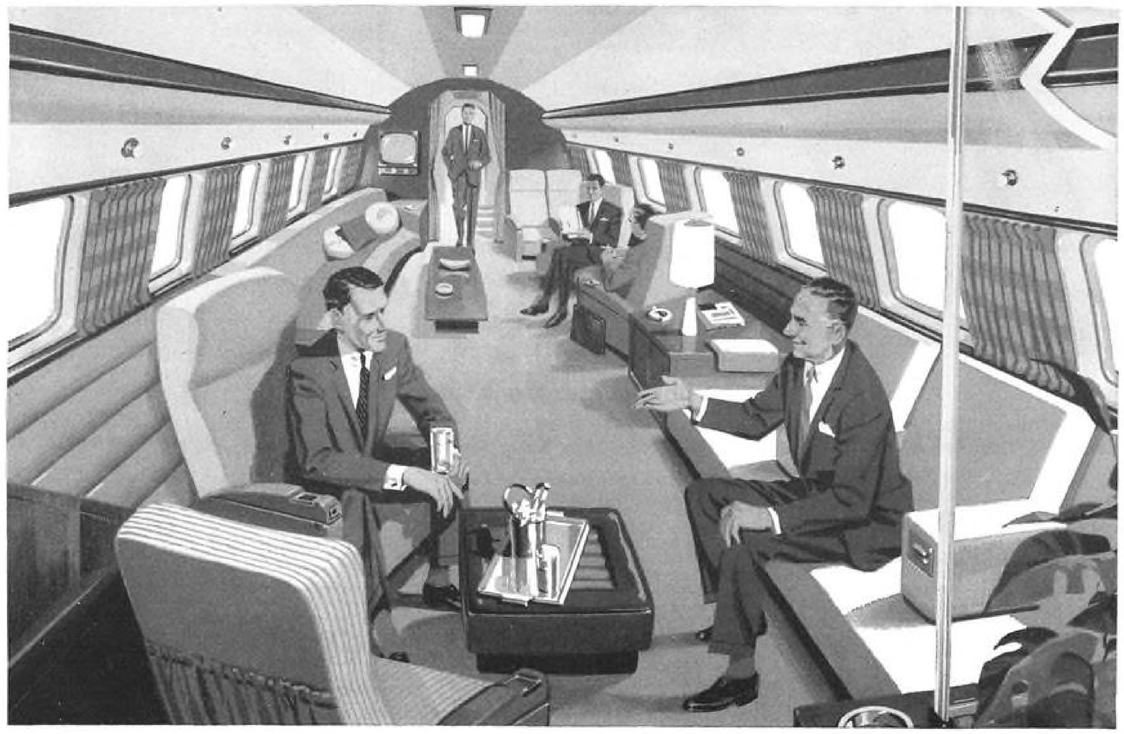
The '540' is a product of Canadair which, as a member of the General Dynamics family of companies, is associated with the following corporate divisions that constitute this important enterprise and represent it in its many exciting fields of activity: Convair, for the Atlas satellite and missile programme; Electric Boat, for atomic-powered submarines; Stromberg-Carlson, for nuclear instrumentation; General Atomics, for Triga research reactors; Liquid Carbonic, for production of industrial and medical gasses; and Electro-Dynamics, for the production of electro-mechanical control equipment.



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You and your pilots will appreciate the airliner performance characteristics of the '540': take-off from most airports . . . rate of climb is 20,000 feet in 16 minutes . . . speeds up to 340 miles per hour . . . altitudes are anywhere above the weather up to 20,000 feet in fully pressurized comfort . . . and range is up to 1600 miles, such as Chicago to 'Frisco, New York to Houston, or Seattle to St. Louis, without refuelling. With extra fuel tanks the range can be extended to 2500 miles at long cruise power.

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Cathay Pacific Airways, Ltd., Hong Kong airline, has ordered two Lockheed Electra turboprop transports, the first of which is shown during flight test. Cathay Pacific operates five flights weekly between Hong Kong, Bangkok and Singapore with Douglas DC4s and DC-6s.

director, $1,300 salary, 5,700 5¼% preferred shares and 17,000 shares of common stock; **J. T. Johnson,** $1,300 salary and 1,000 shares of common stock; **A. Petteys,** director, $900 salary, 7,000 5¼% preferred shares and 21,000 shares of common stock; **C. F. Reavis,** director, $600 salary, 1,167 5¼% preferred shares and 3,500 shares of common stock; **A. G. Redpath,** director, $1,100 salary, and 1,000 shares of common stocks; **L. E. Wakefield, Jr.,** director, $1,100 salary, 335 5¼% preferred shares and 1,000 shares of common stock; **A. J. Weatherhead, Jr.,** director, $600 salary, 1,000 5¼% preferred shares and 4,050 shares of common stock; **H. Case,** director, $900 salary, 24,000 5¼% preferred shares and 40,000 shares of common stock; **T. R. Gamble,** director, $500 salary and no stock; **C. B. Morgan,** director, $1,100 salary and no stock.

Following firms and persons were paid for services rendered in 1958: **H. L. Cummings,** public relations, $8,864; **Dorsey, Owen, Barker, Scott and Barber,** legal $5,834; **Ernst & Ernst,** accounting, $27,087; **Hodges, Reavis, McGrath and Downey,** legal and financial, $32,024; **Koteen and Burt,** legal, $12,865; **C. Edward Leasure,** legal, $45,000; **Mayo Clinic,** medical, $11,148; **Northwestern Hospital,** medical $7,077; **Harold R. Harris,** payment to former president under termination agreement of Mar. 4, 1954, $10,000; **Claude J. Jasper,** legal, $6,479; **Leasure & Scheurer,** legal, $9,877.

United Air Lines, Inc.—W. A. Patterson, president, $100,000 salary, 10,351 direct common shares and 264 common shares in names of others; **R. E. Johnson,** senior vice president-sales and public relations, $50,000 salary and 4,076 shares of common stock; **J. A. Herlihy,** senior vice president-engineering and maintenance, $50,000 salary and 886 shares of common stock; **D. F. Magarrell,** senior vice president-transportation services, $50,000 salary and 2,168 shares of common stock; **D. R. Petty,** senior vice president-flight operations, $48,000 salary and 1,824 shares of common stock; **C. Barkes,** senior vice president-finance and properties, $50,000 salary and 2,060 shares of common stock; **R. F. Ahrens,** senior vice president-personnel, $39,000 salary, 5,499 direct common shares and 55 shares of common stock in name of others; **H. E. Nourse,** senior vice president-economic controls, $32,000 salary and 2,949 shares of common stock.

C. F. McErlean, vice president and assistant to the president, $32,000 salary and 379 shares of common stock; **S. P. Martin,** secretary and assistant to the president, $20,000 salary and 1,844 shares of common stock; **R. E. Bruno,** comptroller and assistant secretary, $24,000 salary, 357 direct common shares and 20 shares of common stock in name of others; **A. M. DeYoursney,** vice president and treasurer, $25,000 salary and 545 shares of common stock; **R. M. Ruddick,** vice president and assistant to the president, $17,600 salary and 51 shares of common stock.

J. E. Moore, vice president and assistant to the president, $24,000 salary and 1,000 shares of common stock; **W. C. Mentzer,** vice president and assistant to the president, $30,500 salary and 1,021 shares of common stock; **W. P. Hoare,** vice president-maintenance, $26,000 salary and 263 shares of common stock; **O. T. Larson,** vice president-ground services, $28,000 salary, 372 direct common shares and 257 shares of common stock in name of others; **O. C. Enge,** vice president-passenger services, $24,000 salary, 482 direct common shares and 268 shares of common stock in name of others; **I. E. Sommermeyer,** vice president-flying, $28,000 salary, 292 direct common shares and 225 shares of common stock in name of others.

J. M. Hodgson, vice president-flight administration, $25,900 salary and 645 shares of common stock; **B. B. Gragg,** vice president-marketing, $27,400 salary, 901 direct common shares and 264 shares of common stock in name of others; **H. J. Merchant,** vice president-sales manager, $24,000 salary, 25 direct common shares and 273 shares of common stock in name of others; **D. V. O'Leary,** vice president-purchasing and stores, $24,000 salary and 534 shares of common stock; **D. C. Meenan,** vice president-facilities and properties, $19,000 salary and 163 shares of common stock; **C. M. Mason,** vice president-employe relations, $23,600 salary and 133 shares of common stock; **T. Lee, Jr.,** vice president-education and training, $15,500 salary and 358 shares of common stock; **L. F. Hampel,** vice president-business research, $19,200 salary and 28 shares of common stock.

W. E. Alberts, vice president-industrial engineering, $18,500 salary and 123 shares of common stock; **M. C. Ansorge,** director, $1,900 salary and 790 shares of common stock; **P. A. Bissinger,** director, $2,000 salary, 1,700 direct common shares and 113 shares of common stock in name of others; **H. T. Brown,** director, $2,000 salary and 332 shares of common stock; **G. Cowles,** director, $1,600 salary and 1,136 shares of common stock; **J. W. Dart,** director, $1,700 salary and 13,067 shares of common stock; **T. F. Gleed,** director, $2,000 salary, 153 direct common shares and 1,907 shares of common stock in name of others; **P. G. Hoffman,** director, $1,700 salary and 186 shares of common stock; **E. A. Johnston,** director, $1,700 salary and 2,272 shares of common stock; **J. J. Mitchell,** director, $1,800, salary and 4,775 shares of common stock; **A. Nielson,** director, $1,900 salary and 744 shares of common stock; **V. Stouffer,** director, $1,800 salary and 1,049 shares of common stock.

Following persons and firms were paid for services rendered in 1958: **Arthur Anderson & Co.,** audit services, $29,716; **Barrington Associates, Inc.,** research consultant, $52,114; **Brobeck, Phelger & Harrison,** legal, $12,139; **B. M. Doolin,** airport consulting service, $11,932; **S. V. Bull,** management consultant, $17,700; **Hardin, Hess & Eder,** legal, $10,636; **Harriman, Ripley & Co.,** financial consulting service, $16,480; **David A. Kosh Associates,** public utility consultant, $14,500.

Raymond Loewy Associates, Inc., designing service, $231,958; **Mayer, Friedlich, Spiess, Tierney, Brown and Platt,** legal, $294,899; **George H. Miehla,** architect and engineering services, $102,520; **Regnar Benson, Inc.,** engineering services, $15,793; **James Francis Reilly,** legal, $33,767; **Elmo Roper & Associates,** research consultants, $30,000; **Stanford Research Institute,** research consultants, $47,133; **John R. Stealman,** economic consultant, $13,000; **Stryker, Tams & Horner,** legal, $10,300; **Trippet, Yoakum, Stearnes & Ballentyne,** legal, $10,392; **Wallace Clark & Co., Inc.,** management consultants, $10,824; **John C. Bowers,** property management services, $18,750; **H. J. Brunnier,** engineering services, $5,315; **Burns, Bear, McNeil & Schneider,** architect services, $6,524.

Height, Gardner, Paar & Havens, legal, $11,935; **Holman, Mickelwait, Marion, Black & Perkins,** legal, $8,315; **Morris, Nichols, Arsht & Tunnell,** legal, $5,140; **Skidmore, Owens & Merrill,** architect and engineering services, $57,781; **Young, Richardson & Carleton,** architect and engineering services, $6,377; **Millard Sheets, Designer,** designing services, $7,210.

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Through precise manufacturing techniques, Hughes PNP fused-junction silicon transistors give you extreme uniformity of parameters by type. Result: circuit interchangeability no longer is a problem.

Designed for switching and amplifying applications at low and medium current levels, these Hughes transistors offer you a number of advantages:

- useful Beta at extremely low collector currents
- BV_{EBO} and BV_{CBO} are similar
- high punch-thru voltage (BV_{CEO} in excess of 100 volts in types 2N1244 and 2N1234)
- low saturation resistance

These E.I.A. registered devices, now available in production quantities, are housed in TO-5 (single ended) and coaxial packages (double ended). Engineered for extreme reliability, several types meet MIL-T-19500A specifications.

Coaxial Package Type:	2N1238	2N1239	2N1240	2N1241	2N1242	2N1243	2N1244
TO-5 (formerly JETEC-30) Package Type:	2N1228	2N1229	2N1230	2N1231	2N1232	2N1233	2N1234
Collector to Emitter Voltage (BV_{CEO}) (I_{CEO} = 100μA)	15V	15V	35V	35V	65V	65V	110V
Collector to Base Voltage (BV_{CBO}) (I_{CBO} = 100μA)	15V	15V	35V	35V	65V	65V	110V
Emitter to Base Voltage (BV_{EBO}) (I_{EBO} = 100μA)	15V	15V	35V	35V	65V	65V	110V

Coaxial Package: Power dissipation . . . 1 watt in free air (derate 7.4 mw/°C)
5 watts with heat sink (derate 37 mw/°C)
TO-5 Package: Power dissipation . . . 250 mw (derate 1.8 mw/°C)
Collector current limited by power dissipation. Operating and storage temperature range −65°C to +160°C

Your inquiry regarding these transistors will be given prompt attention. Just write or call the Hughes sales office nearest you. They are located in Boston (phone WO 2-4824), Newark (phone MA 3-3520), San Francisco (phone DA 6-7780), Syracuse (phone GR 1-0163), Philadelphia (phone MO 4-8365), Chicago (phone NA 2-0283), and Los Angeles (phone OR 8-6125). Or write Marketing Department,

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53

How Soviets May Land Man on Moon

By Boardman Rising*

Shortly after the Russians launched their cosmic rocket on Jan. 2, they announced their intention to put a man on the moon and bring him safely back this year. How can they accomplish this, and what are the chances of success?

It appears that most of the major technological advances necessary for a manned lunar expedition have already been made. The Jan. 2 launching demonstrated the necessary advancement in propulsion. Placing the dog Laika in orbit in 1957 indicated a reasonable knowledge of the techniques required to sustain life in space. The selection of personnel to make the trip should present no problem; there would undoubtedly be more volunteers than could possibly be used. If we can believe the reports, the training program is already well under way.

The guidance accuracy required to intercept the moon is somewhat more difficult to obtain. Undoubtedly, some terminal correction will be necessary to arrive at the correct velocity for interception. A variation of some 40 feet per second, or about one-tenth of one per cent variation in the initial velocity, is the maximum allowable for a lunar landing. This would be well within reach of presently available guidance equipment if it were not for the requirement of landing not one but several payloads within short distances of each other and within short distances of some preselected location on the moon's surface (AW May 4, p. 33).

The use of initial launch guidance will be inadequate for such accuracies. It will be necessary to carry aboard the vehicle either auxiliary vernier rockets or a means of firing the main landing rocket motor momentarily, in order to adjust both the course and the velocity when well inside the lunar gravitational field. In addition it will be necessary to carry some sort of lunar surface scanning equipment, at least in the unmanned vehicles, to provide a reference for computing the amount and direction of the trajectory adjustment. Both the vernier thrust system and surface scanner are well within the present state of the art.

Let us now speculate on a possible means of accomplishing a manned lunar expedition. In order to send even one man to the moon and get him back again with any sort of scientific data worth mentioning, the weight of equipment and return fuel would be considerably above that of the largest payload the Russians have thus far demonstrated. We can then assume that either a much larger launch vehicle than the Jan. 2 cosmic rocket is being developed at the present moment, or that multiple launchings must be resorted to. The former assumption is unlikely since the "cosmic" vehicle, designed apparently for lunar uses, has already been built and tested.

Theoretical Mission

If multiple launchings are assumed, the expedition then might appear somewhat as follows:

First an unmanned instrument carrier and lunar surface exploratory unit would be sent up. This would conform in size to the largest presently available payload. It would carry terminal guidance equipment, telemetry, retrograde propellant and rocket motor to provide soft landing, remotely-controlled scientific instruments, a television scanning system, and a means of locomotion on the lunar surface. The Russians have even sent us a short animated film depicting an artist's conception of the vehicle's configuration and operation. The television would be used both for surface exploration and as a means of visual reference for terminal guidance. The propulsion would consist of a separate low-thrust motor, or fourth stage, for vernier and retrograde thrust. The third stage tankage and motor would be dropped at burnout to conserve retrograde propellant, leaving enough to maneuver near the lunar surface, and also to allow use of a smaller, more easily controlled motor operating at optimum efficiency.

The surface locomotion system, if we believe the publicity, would consist of a small, lightweight, radio-controlled, tractor-type vehicle contained in the nose of the payload. Upon landing, the fairing structure would be jettisoned and the tank lowered to the ground to begin crawling on its own treads. The route is watched on a TV screen back on earth, and radio control signals are sent up to alter the speed and direction of the tractor. Information obtained from the scientific instruments aboard the tractor is telemetered back to earth. When the tractor runs out of fuel it stops moving, but enough electric power can be obtained from solar cells to operate the beacon and, periodically, the telemetry, thus providing continuing information and a radio guidance aid for homing subsequent vehicles. Following is a tentative weight breakdown for a typical lunar landing vehicle:

- **Vehicle:**

Gross weight	3,245 lb.
Diameter	68 in.
Length	20 ft.
Weight, retrograde propellant	1,850 lb.
Propellant; liquid oxygen-borohydride	332 Isp.
Tankage and rocket motor (from third stage)	440 lb.
(Separate at final burnout)	
Electronics and navigation	35 lb.
Equipment and batteries	51 lb.
Retro motor and its equipment	40 lb.
Structure and miscellaneous	35 lb.
Total jettisoned weight	601 lb.
Payload weight	794 lb.

- **Payload capsule:**

Payload capsule total	794 lb.
Structure and landing gear	27 lb.
Guidance and attitude control	120 lb.
Homing equipment	25 lb.
Miscellaneous equipment	30 lb.
Total jettisoned weight	220 lb.
Actual payload	592 lb.

Refueling Vehicles Launched

Second, a series of three refueling vehicles would be sent up. Each is similar to the instrument carrier except that the payload consists of rocket propellant instead of instruments and an exploring unit. Television may now be replaced by radio homing equipment in the refueling vehicles in order to conserve power and increase reliability.

Each refueling vehicle is soft-landed as near the instrument carrier as possible, using the radio beacon on the instrument carrier as a homing aid. The distance over which a fuel tank must be carried by a man must be kept as small as possible, probably not over half a mile. All the refueling units should be within the range of vision of the TV aboard the instrument carrier so that their landings and ultimate positions can be monitored. Since it may take some time to accomplish the

*Boardman Rising is a design engineer in the Research Spacecraft Department of Lockheed Aircraft Corp.'s Missiles and Space Division, Sunnyvale, Calif.

EQUIPMENT LIST AND WEIGHT BREAKDOWN

Manned Payload

Total available payload weight	592 lb.
One man and clothing and incidentals	155 lb.
Space suit and controls	20 lb.
Food and water and containers	40 lb.
Oxygen supply and tankage	24 lb.
Nitrogen supply and tankage	20 lb.
Air conditioning and heating system	24 lb.
Monitors and controls	8 lb.
Cameras and recorders	6 lb.
Batteries and electrical system	60 lb.
Electronics and radio	22 lb.
Re-entry heat shield and aerodynamic surfaces	160 lb.
Recovery parachute	40 lb.
Miscellaneous equipment	13 lb.

Propellant Payload

Total payload weight available	592 lb.
Tankage	12 lb.
Valves and plumbing	5 lb.
Propellant	575 lb.

Instrument Payload

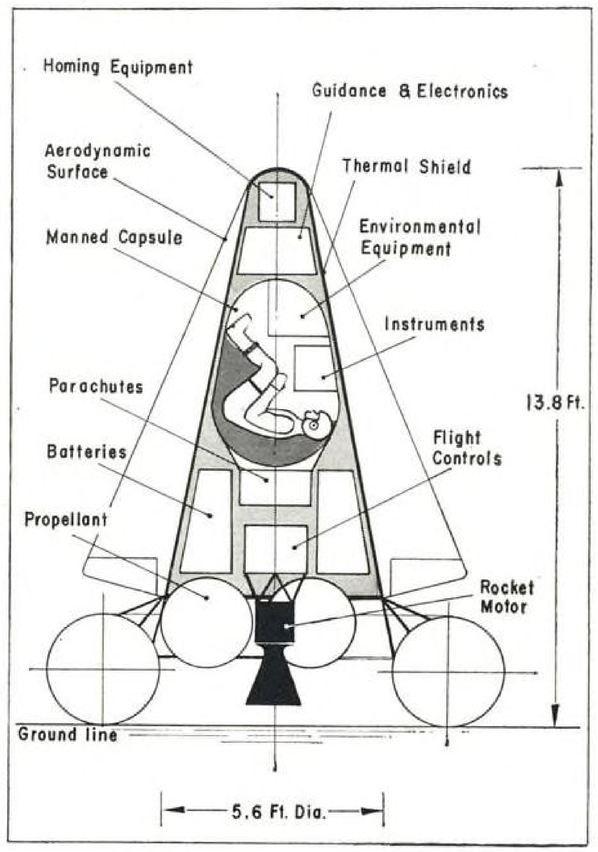
Total available payload weight	592 lb.
Mobile instrument carrier structure	70 lb.
Locomotion motor and controls	16 lb.
Locomotion fuel and oxidizer, and tankage	120 lb.
Batteries and electrical system	100 lb.
Solar cells and battery charging unit	40 lb.
Television viewing system, total	16 lb.
Thermal control system	14 lb.
Recording and telemetry	21 lb.
Miscellaneous electronics and equipment	20 lb.
Scientific instruments, total	175 lb.

Return Vehicle, Complete

Man and remaining incidentals	150 lb.
Space suit and controls	20 lb.
Remaining food and water	10 lb.
Remaining oxygen and tankage	8 lb.
Remaining nitrogen and tankage	12 lb.
Air conditioning and heating equipment	24 lb.
Controls and monitoring equipment	8 lb.
Films, samples, and records	6 lb.
Electrical system and batteries	50 lb.
Electronics and radio	22 lb.
Re-entry shield	160 lb.
Parachutes	40 lb.
Rocket motor (as used for vernier and retro)	40 lb.
Structure and plumbing	160 lb.
Navigation aid and computer	35 lb.
Homing equipment	25 lb.
Guidance and attitude control	120 lb.
Propellant tankage	36 lb.
Propellant (three payloads)	1,725 lb.
Miscellaneous	30 lb.
Total weight of return vehicle	2,681 lb.

Scientific Instruments

Total weight available	175 lb.
Lunar crust sampler	38 lb.
Mass spectograph and controls	35 lb.
Radiation intensity meter	6 lb.
Molecular gas analyzer	16 lb.
Ion gage	1 lb.
Solar bolometer	2 lb.
Gravitational field accelerometer	4 lb.
Cloud chamber and controls	14 lb.
Instrument camera and film and controls	12 lb.
Lunar terrain camera and controls	9 lb.
Micrometeorite detector and counter	8 lb.
Lunar surface temperature recorder	2 lb.
Recording magnetometer	3 lb.
Shock wave geophysical prospecting equipment	18 lb.
Miscellaneous instruments	7 lb.



MANNED LUNAR VEHICLE proposal would be designed to send a man to the moon and bring him back after obtaining scientific data about the moon that could not be gotten without making the trip. Flight in both directions would be controlled automatically with the pilot acting as a monitor. On the return trip, midcourse and terminal thrust corrections would bring vehicle to atmosphere where hypersonic flight phase of mission begins. Capsule separates, parachutes to ground.

ESTIMATED PERFORMANCE FIGURES FOR A LUNAR EXPEDITION

Burnout velocity	36,850 fps.
Velocity at 500 mi. altitude	34,340 fps.
Velocity decrement required at lunar surface	9,090 fps.
Time of flight	30.5 hr.
Hyperbolic excess velocity	1,220 fps.
Retrograde thrust	7,000 lb.
Maximum time on moon	5 days
Maximum acceleration on pilot during retro	5 earth g
Gross weight of return vehicle	2,681 lb.
Weight of return fuel (three payloads)	1,725 lb.
Type of fuel RFNA and hydrazine	290 Isp.
Return thrust	7,000 lb.
Burned out weight of return vehicle	996 lb.
Weight of parachute recovery capsule, including parachutes	410 lb.
Return burnout velocity	9,000 fps.
Hyperbolic excess velocity on return	1,220 fps.
Velocity at top of sensible atmosphere	36,930 fps.
Time of return trip	33 hr.
Fuel available for return vernier	40 lb.
Maximum acceleration on pilot during lunar launch	7 earth g

STEPS IN THE RACE TO OUTER SPACE

Nuclear Rocketship

Despite the sky-high transportation costs, Lunar manufacturing should prove economically viable. With unlimited Solar power, controlled atmospheres and advanced automation, a considerable commerce could be realized in delicate instruments, rare minerals, reactor cores and other items that might be more efficiently processed or produced in the Moon's perfect vacuum.

To supply the Moon colonists, and to carry their production back to Earth, special rocketships will be developed. Nuclear energy is the most promising source of propellant power. The ship shown here utilizes nuclear fission for heat and hydrogen gas as a working fuel. From pressurized tanks, the gas is fed through a heat exchanger, expanded, and expelled for the motive thrust.

When the craft leaves Earth, it carries only enough gas for a one-way trip. For, by extracting hydrogen and oxygen from Lunar rocks, Moon settlers will be able to refuel the rocketship for the return voyage. This will permit smaller fuel tanks on the craft and larger payloads.

Inertial navigation systems will play an increasing role in the exploration of outer space. ***ARMA*** is actively supporting the Air Force's program in long range missiles and is in the vanguard of the race to outer space. ***ARMA***, Garden City, N. Y. A Division of American Bosch Arma Corp.

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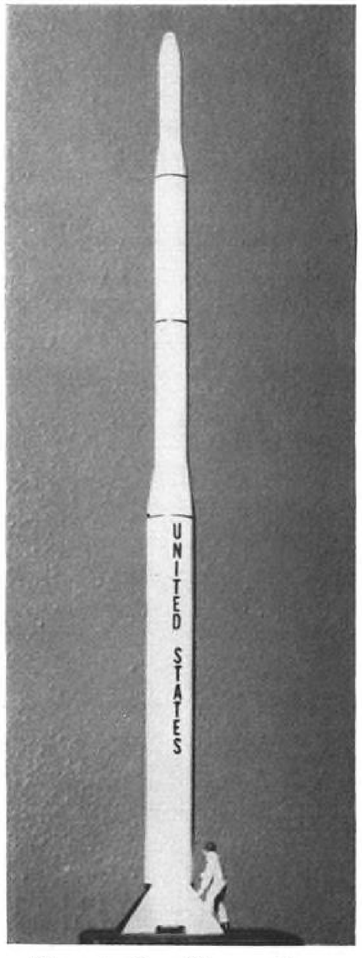
entire mission, storable fuels and oxidizers (liquids at normal temperatures, rather than liquefied gases) are a necessity.

After enough return fuel is safely landed on the moon, the final, manned vehicle is launched. This vehicle is identical to the refueling units, except that the payload is a manned capsule, and the fairing is of a thermal material for use as a radiating heat shield during re-entry into the earth's atmosphere on the return trip. The fairing shape may be made so that the vehicle becomes a entire mission, storable fuels and oxi- hypersonic glider. With this configuration the entire return mission velocity can be dissipated at re-entry, and it will not be necessary to expend rocket fuel to arrive at close-in orbit before initiating the re-entry trajectory.



Scout Configuration

Chance Vought Aircraft, Inc., model shows configuration of National Aeronautics and Space Administration's solid propellant rocket (AW April 13, p. 27).

The only maneuver required will be that necessary to establish about the earth a highly eccentric orbit with a perigee velocity just short of the characteristic one-way mission velocity. If the perigee of this orbit can be made to enter the sensible atmosphere, then aerodynamic forces can be used to alter the trajectory in such a manner that the rate of frictional heating of the vehicle equals the rate of heat radiation at a temperature well below the melting point of the materials. This method uses far less return rocket fuel than the method of establishing a close-in orbit as a basis for re-entry.

Landing of the manned vehicle is accomplished in the same manner as for the previous unmanned vehicles. The landing spot should be partially in shadow for the duration of the mission to avoid extremes of temperature. Any lowlands thickly covered with dust should also be avoided. The flight in both directions will be controlled automatically, with the pilot monitoring the operation. Until more is known about man's ability to function under long periods of zero gravity it would be unwise to entrust the mission to manual control except in emergency.

Moon's Surface

Once on the moon's surface, however, the pilot will be working in a positive field of about one-sixth earth gravity. With adequate precautions, it should be possible for him to spend short periods outside his capsule in a space suit collecting his fuel. Carrying the fuel tanks should be easy in reduced gravity. Every item of equipment, unless absolutely necessary for the return flight, shall be left on the moon. Once the return vehicle is refueled and checked out, the remainder of the time may be spent taking photographs, making scientific measurements, collecting samples of dust, lunar crust, and reporting findings to earth.

It is very important to maintain adequate two-way radio communication between earth and moon at all times. Distance should prove no barrier even for voice communication, if a radar signal can be reflected from Venus. The large tracking antennas on earth should make up for the shortage of power at the lunar transmitter. When the pilot has obtained his data he gets in the return vehicle and blasts off. Midcourse and terminal thrust corrections bring his vehicle to the edge of the earth's sensitive atmosphere where the hypersonic aerodynamic flight phase of the mission begins.

At a low altitude and a greatly reduced velocity the manned capsule is separated, and recovery is made by parachute.

Now that a possible manned lunar expedition has been outlined, we may

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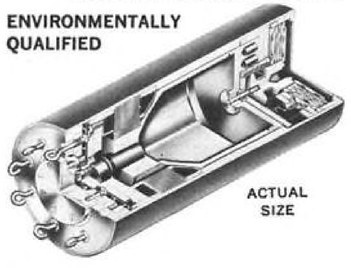

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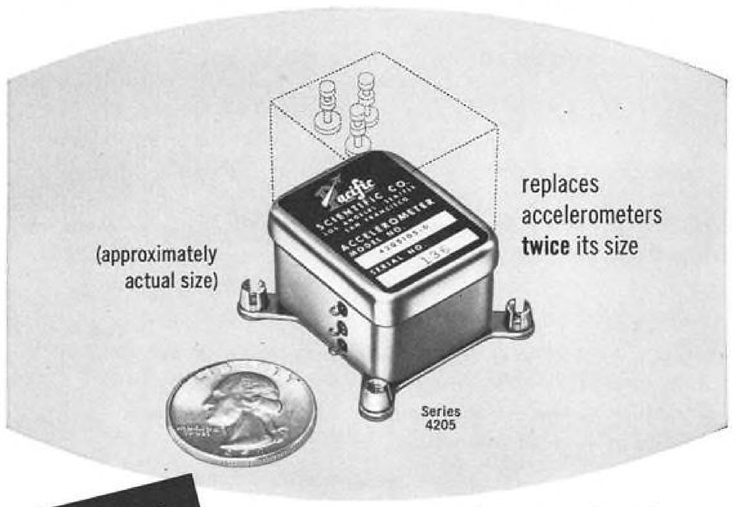

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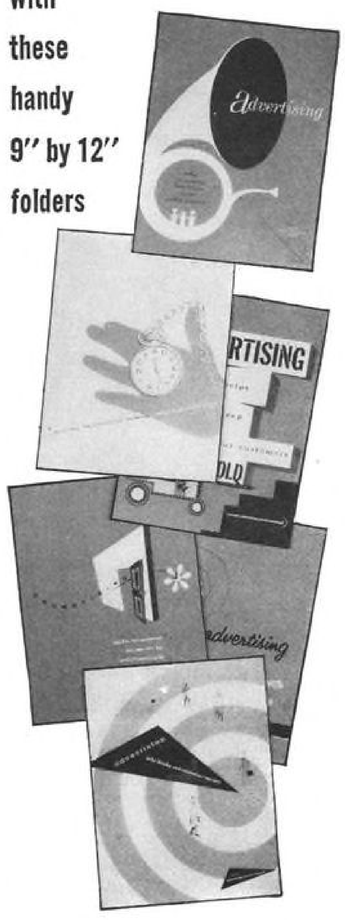

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ask the second question posed in the introduction, "what are the chances of success?" What would the reliability of such a mission be? As for getting information, the chances of success are fairly high during the unmanned part of the mission, since as many instrument carriers as necessary may be launched until one is safely landed and performs as desired.

Low Reliability

As for getting a man safely on the moon and back, the reliability of any individual launching is probably low. The complexity of the system, the time element and the number of hazards still unknown, make any one pilot's chance of survival poor. This low reliability of any individual flight is a greater deterrent to a similar lunar expedition by the United States than is our technological lag.

By allowing volunteers to attempt such flights, Russia can not only get to the moon first, but can increase the reliability of the over-all mission by increasing the number of flights of the manned vehicle as required for 100% success. By scaling down the payload weight we would be in as good a position as Russia at present to launch a manned lunar expedition. However, our philosophy of the primacy of the individual at the possible expense of the mission, makes it unlikely that we shall attempt such a venture for some time.

It may be asked what the over-all purpose of the manned lunar mission really is. One obvious answer is the collection of scientific data about the moon that we cannot get except by going there. Another is the propaganda value of demonstrating to the world the advanced state of a nation's technology. There are other scientific purposes such as paving the way for the establishment of a permanent manned lunar station, an extra terrestrial, low gravity launch point for space vehicles, etc.

Reason for Project

But, we may still ask, why must a human being be placed on the moon now? It is technically possible to put automatically controlled instrumentation in unmanned vehicles to obtain any scientific lunar data which a man can get, and at less cost. However, placing a man on the moon is more than a propaganda stunt; it is an expression of the destiny of a nation. The Russians have announced to the world that they will put a man on the moon and bring him safely back this year. They wish to continue calling their shots. They also wish to continue their reputation for achieving scientific "firsts." To impress the world, then, and above all, their own people, they have no choice but to make good.

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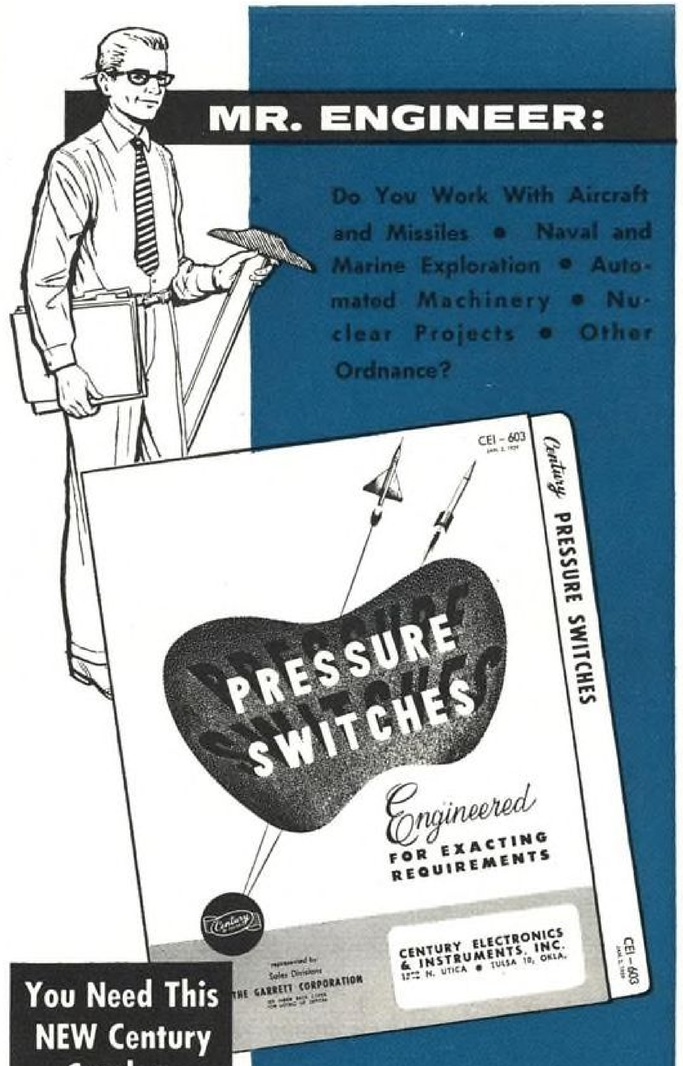

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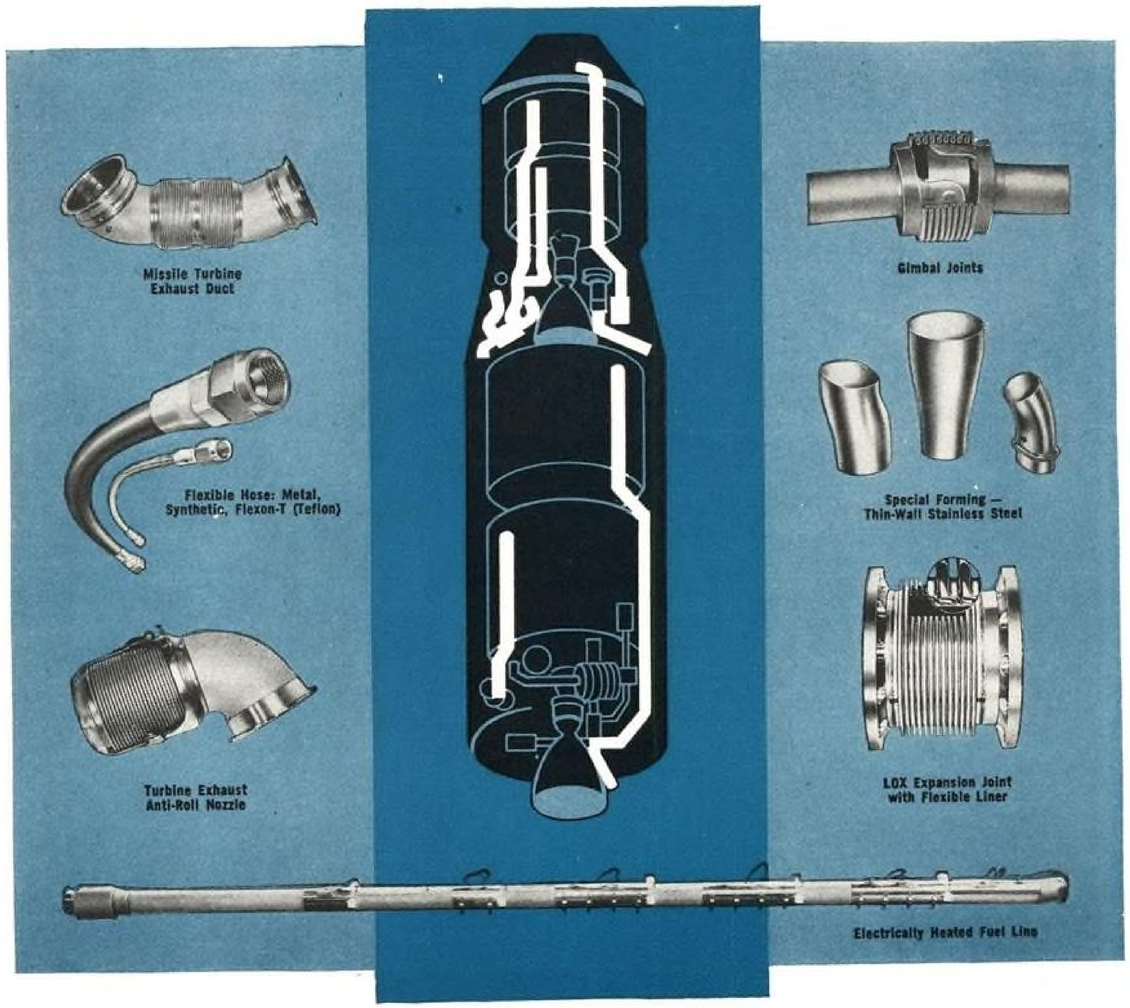

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Military Application of Argus Doubted

By James A. Fusca

Washington—Doubt has been raised as to the military usefulness of effects created by high altitude nuclear blasts such as the three Project Argus explosions over the South Atlantic Ocean last summer. Details of the Argus effects were presented to scientists here last week at the 96th annual meeting of the National Academy of Sciences.

One of the potential uses claimed for Argus-type explosions is the total blackout of radio and radar at the geomagnetic conjugate point (AW April 6, p. 31) as a method of disrupting the reaction capability of a nation under attack. Radio measurements made close to the conjugate points of the Argus blasts—near the Azores Islands—failed to detect any effect on frequencies in the range between 30 and 120 mc. and only moderate reductions in signal level at very low frequencies.

Scientists presenting the Project Argus data, however, cautioned that the results of megaton explosions at very high altitudes may be considerably different than the effects of the low yield Argus shots. All three of the Argus explosions had yields of between one and two kilotons.

Possible Threat

One possible threat of megaton explosions of this type, according to the man who proposed the Argus experiment, the self-taught Greek nuclear physicist Nicholas Christofilos, would be the creation of shells of intense radiation that would be a threat to space travelers. One megaton bomb exploded in the proper location in outer space, he said, would deliver to a man in a satellite a lethal dose of 400 roentgens in less than three hours.

The symposium, titled "Scientific Effects of Artificially Introduced Radiation at High Altitudes," featured papers by a panel of experts that included Christofilos, of the Lawrence Radiation Laboratories of the University of California, Dr. James Van Allen of the State University of Iowa, and scientists from the Air Force Special Weapons Center, Kirtland AFB, Air Force Cambridge Research Center, and Stanford Research Institute.

The main purpose of the Argus experiments was to test the proposal made by Christofilos in an unpublished memorandum in October, 1957, that the electrons resulting from the radioactive decay of fission fragments and neutrons produced in the detonation of a nuclear bomb in the tenuous upper atmosphere would be temporarily trapped in the geomagnetic field and form a shell of radiation around the earth.

While the proposal was under study, the discovery of the existence of natural belts of trapped radiation provided over-all validation in that it showed that charged particles could be trapped in the geomagnetic field. It became clear that the artificial injection of known charged particles along a known magnetic line of force at a known time would be a powerful technique for uncovering many of the unknown aspects of the dynamics of geomagnetic trapping.

The project was carried out last summer under the direction of the Advanced Research Projects Agency. To determine the effects of the explosions, a group of about 800 scientists participated in taking measurements and observations at the firing location in the South Atlantic, at the conjugate point near the Azores, and at stations of the International Geophysical Year throughout the world.

Argus Effects

Electrons and positively charged ions produced by the Argus explosions and trapped in the earth's magnetic field spiraled along the path of the magnetic lines of force from the site of the blast in the South Atlantic into space a distance of about 4,000 mi. to the geomagnetic conjugate point in the northern hemisphere. Those electrons not absorbed were reflected back and forth along the field lines, forming a banana-shaped tube of radiation.

At the same time, these electrons tended to drift to the east because of centrifugal force as they bounced back and forth between the mirror points and because of the decrease in the magnetic field with altitude. This drift rate of the electrons is a function of

Data on Argus Explosions

	Argus I	Argus II	Argus III
Nominal Altitude	290 mi.	290 mi.	290 mi.
Nominal Yield	1 to 2 Kilotons	1 to 2 Kilotons	1 to 2 Kilotons
Approximate Time Of Burst	0230 GMT. Aug. 27, 1958	0320 GMT. Aug. 30, 1958	2210 GMT. Sept. 6, 1958
Approximate Geographical Coordinates	38 Deg. S. 12 Deg. W.	50 Deg. S. 8 Deg. W.	50 Deg. S. 10 Deg. W.

Time to Drift Around the World Versus Energy

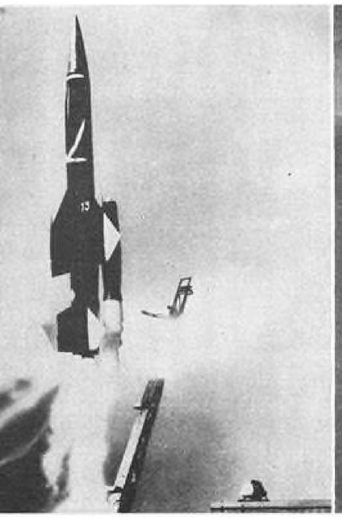
Electron Energy (Mev)	Average Time (minutes/revolution)
0.5	57
1.0	33
2.0	18
3.0	12.5
4.0	9.7
6.0	6.6
8.0	5.2

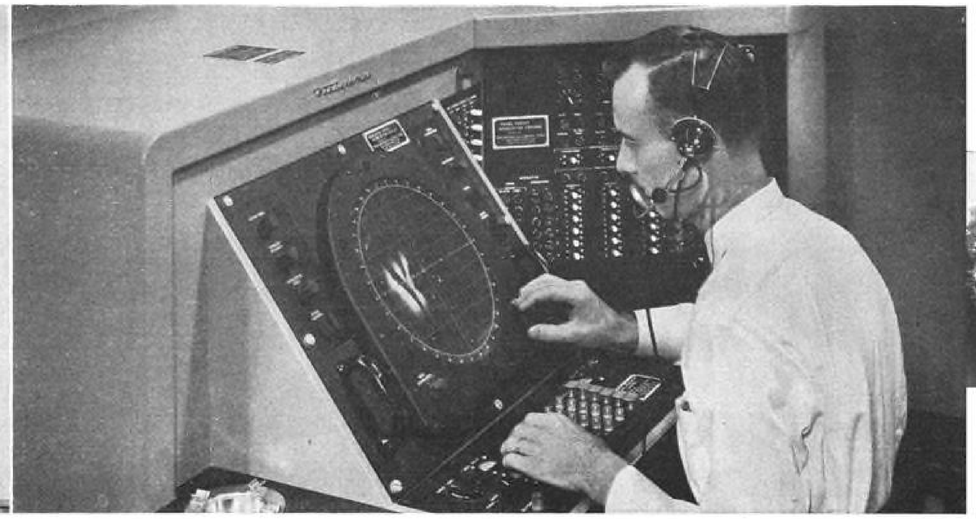
Summary of Observed Intersections by Explorer IV Giving Significant Data

Shot	Number in Northern Hemisphere	Number in Southern Hemisphere	Period of Observations
Argus I	28	9	Aug. 27—Sept. 6 1958
Argus II	27	12	Aug. 30—Sept. 6 1958
Argus III	61	27	Sept. 6—Sept. 19 1958
Totals	116	48	

CAPABILITIES FOR DEFENSE

10,904 graduate engineers and scientists with over 133,000 years of experience perform vital tasks at Westinghouse

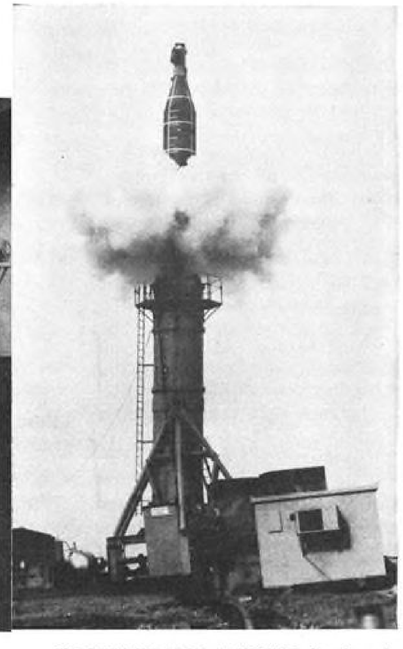




MISSILE GUIDANCE SYSTEMS. Both ground guidance and terminal guidance systems are designed, developed and produced at Westinghouse. More advanced guidance systems are now being developed to replace those in production and in actual operation. The latest techniques in radar, infrared, and data processing and display are being applied to all phases of missile guidance by Westinghouse engineers with many years of experience in this field. ***Air Arm and Electronics Divisions***

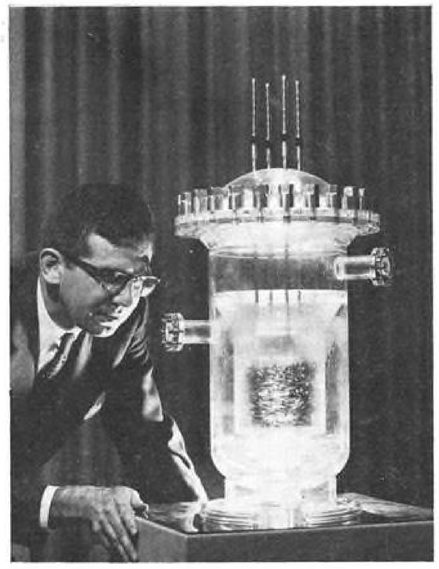
EXPERIENCED FIELD ENGINEERS are an important adjunct to Westinghouse engineering capabilities. Located at key locations abroad, in this country, and afloat—wherever Westinghouse equipment is in use—these field engineers supply the experience and information needed to fully utilize new equipment, help indoctrinate new personnel, and provide technical liaison with the manufacturing plants of the Defense Products Group.

HUMAN ENGINEERING—mating man and the machine—is important in electronic equipment design. Continuing scientific study and research at Westinghouse facilitate advantageous application of this concept—from missile analysis to maintenance design—in developing better avionic systems. ***Air Arm Division***



UNDERWATER IRBM LAUNCHER for the submarine-based Polaris missile, shown here during early test launching with dummy missile, was designed and built by Westinghouse. Design features developed for this system appear applicable for use in other solid fueled missile launching systems.

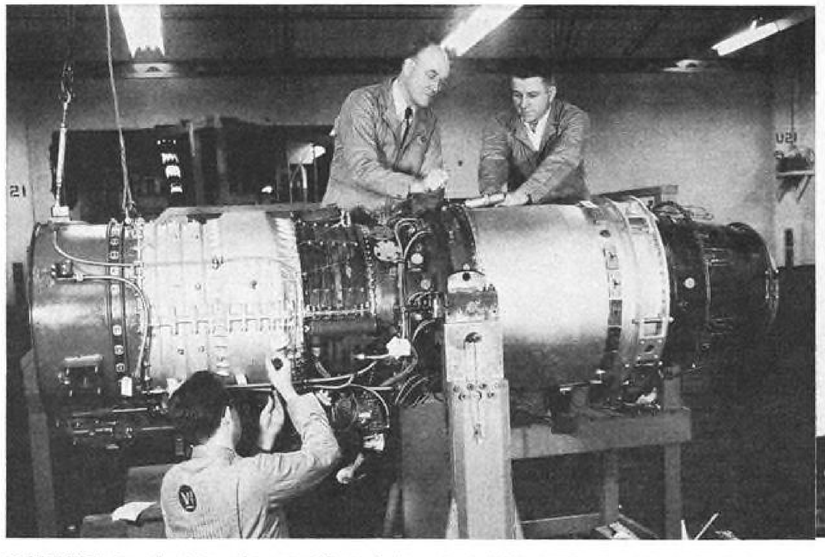
AIRCRAFT ELECTRICAL SYSTEMS. From Jenny to jet, Westinghouse has been producing aircraft electrical equipment representing the day's most advanced state-of-the-art. Systems for today's finest aircraft—including the Boeing 707 jetliner, Convair B-58 bomber, and North American A3J-1 twin-jet fighter—are Westinghouse designed and developed. These systems include the entire a-c power system, control and protective devices, and feature the world's first brushless generator . . . result of pioneering experience dating back to the first airborne, strut-mounted a-c generator built by Westinghouse in 1917. ***Aircraft Equipment Department***



NUCLEAR ENGINEERING experience is still exceedingly uncommon, but Westinghouse probably has more knowledge in this very specialized area than any other company in the world. Westinghouse has designed and developed more nuclear power reactors than anyone else. Its engineers have worked in almost every field related to atomic energy. Five different commercial reactor designs are now under active development.

UNDERWATER WEAPONS SYSTEMS. Westinghouse engineers designed the Navy's first all-electric torpedo in 1942. Since then, Westinghouse engineers have continued work on new and improved underwater systems, to include high resolution sonar and a high speed, long range antisubmarine torpedo. Technologies involved include hydrodynamics, acoustic systems, servo mechanisms, and guidance control. ***Ordnance Department***

AIRBORNE ELECTRONIC SYSTEMS for weapons control, terrain avoidance, bombing and navigation, antisubmarine warfare, missile guidance, bomber defense and other applications are designed and manufactured by Westinghouse. Aero 13 Armament Control System, shown above, for the Navy's F4D Douglas Skyray fleet interceptor, is a recent example. *Air Arm Division*



PROPULSION. From the design of America's first turbojet engine in 1941—by 14 pioneering engineers at Westinghouse—to present-day engines for high-speed aircraft, Westinghouse has kept pace with the aviation industry's constant demand for increases in engine power and efficiency. Current applications include the use of new metals and advanced design features to attain maximum thrust-to-weight ratio, higher speed and higher altitude performance. Jet propulsion engineering reached a new high when a recently developed Westinghouse engine met design goals just 11½ months after these goals were set. *Aviation Gas Turbine Division*

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electron energy which varies over a considerable range for electrons created by a nuclear explosion, so the tube of electrons produced by the Argus blast spread eastward around the earth to create a shell of radiation which lasted until the electrons "leaked" back into the atmosphere and were absorbed.

The three nuclear warheads detonated in the Argus tests were carried aloft to a height of about 290 mi. by modified, three-stage USAF-Lockheed X-17 rockets fired from the deck of the USS Norton Sound from a location in the South Atlantic. The reasons for picking this area for the firings were:

• **Safety.** An isolated firing area was necessary for safety reasons.

• **Intermediate latitude.** For the trapped particles to have a lifetime of at least a few days, it was necessary to choose an intermediate geomagnetic latitude. At low latitudes the trapped particles spend a larger fraction of their paths in denser air. At high latitudes, the corresponding magnetic lines of force go farther from the earth in the geomagnetic equatorial plane and a reduction in the lifetime of the trapped particles probably would be caused by perturbations in the outer reaches of the geomagnetic field.

• **Satellite interception.** The shells of radiation produced by the tests had to be located so that they could be intercepted by a low-altitude satellite in an orbit inclined at not more than 51 deg. to the equatorial plane—the highest inclination which was practical with existing U.S. satellite launching facilities at that time. An intermediate latitude also meant that the satellite orbit would intercept the shell at a less oblique angle.

• **Background radiation.** From the observations of Explorers I and III, it was known that the intensity of the natural radiation diminished rapidly, at a given altitude, in both directions from the geomagnetic equator. Therefore, the background radiation would be less than an intermediate latitude.

• **Geomagnetic anomaly.** In the South Atlantic the scalar magnitude of the geomagnetic field is less than at any other point on the earth at an intermediate latitude. Therefore, for a given altitude of injection, the trapped lifetime of the charged particles would be the longest with the firings in this area.

• **Conjugate point.** To observe the effects of the explosions at the conjugate, it was desirable that there be an island there to act as an observation site. The Azores were selected for this purpose.

The earth's magnetic field closely resembles that of a bar magnet located not quite in the center of the earth. The magnetic lines of force follow the familiar pattern made by iron filings scattered near a bar magnet, with the field strength falling off rapidly with altitude.

One of the characteristics of a magnetic field of this configuration is that it has the property of reflecting charged particles. Charged particles in a magnetic field perform helical orbits spiraling around magnetic lines of force.

If the path of an electron spiraling about one line of force takes it into an area where the lines of force are denser —such as when a line of force approaches the earth—a point will be reached where the electron will be reflected. For electrons with different energies the reflection point will be different but for every charged particle there is a critical field strength or mirror point beyond which it cannot penetrate. Therefore, these electrons are confined within the magnetic field, oscillating back and forth between two regions of stronger magnetic field.

Electron Approach

An electron will approach the earth in one hemisphere, bounce back at its mirror point along the line of magnetic force to its mirror point in the opposite hemisphere, at the same time drifting to the East. This drift will carry a typical fission product electron around the earth in less than half an hour.

The earth's atmosphere decreases rapidly with altitude but never entirely disappears—eventually merging into the small but finite density of solar gases present at the distance of the earth's orbit from the sun. The electrons trapped in the magnetic field occasionally scatter off an atom of this tenuous atmosphere, which almost always results in a lower mirror point for the electron and, therefore, a higher average density at each mirror point. The higher density of the atmosphere increases the scattering, further lowering the mirror point, until the electron is eventually lost in the atmosphere. The low altitude edge of the shell will decay first and then particles at higher altitudes will eventually scatter enough to be lost.

An important consideration is that the altitude—and, therefore, the air density—of a particle's mirror point varies considerably as it drifts around the earth. This is because of irregularities or anomalies of the earth's magnetic field. Mirror points are so low over the South Atlantic that almost all of the scattering loss occurs there.

One of the efforts related to the Argus experiments was a project to determine what the effects of the explosions would be, especially in the area of the conjugate point. This program was carried out as a part of Project Midas—a missile defense alarm study under the direction of the Advanced Research Projects Agency.

These measurements and observations were made jointly by Air Force Cambridge Research Center and Stanford Research Institute. To gather all possible types of data, observation stations were set up near the conjugate point in the Azores, in Spain, and aboard the Navy seaplane tender USS Albemarle, stationed a few hundred miles south of the Azores. Observers were also stationed with the task force that launched the Argus rockets to determine the effects there.

Equipment at these stations included special radars (backscatter sounders), riometers, ionosondes, all-sky cameras, photometers, magnetic field measuring devices, and a microlock station in Spain to interrogate Explorer IV. At the Azores site, two USAF C-97s were equipped to take measurements at upper altitudes.

The highest concentration of electrons penetrating the atmosphere was expected at the Azores at the end of the initial trajectories, before the eastward spreading had begun. Some of the effects that were expected were auroral displays, changes in magnetic field strength, and increased absorption of radio energy by the ionosphere. The aurorae would be the result of excitation of nitrogen and oxygen in the atmosphere, both of which emit characteristic light as they return to their normal state.

No aurorae were seen from the ground at the Azores on the first two Argus explosions, although a navigator of one of the C-97s may have seen a weak auroral display from the first shot. Twenty-three minutes after Argus III, a vivid multi-colored aurora was seen at the conjugate point. The aurora was surmounted by an unusual red crown, associated in natural aurora with streams of protons from the sun. Aurorae were seen after all three shots by observers with the task force.

To obtain maximum detection sensitivity for aurorae with relatively simple equipment, two special radars (backscatter sounders) were constructed to operate on 27 mc. One was aboard the USS Albemarle and the other aboard a ship of the task force.

Auroral radar echoes were obtained on all three explosions by the radar near the launch point, and on the first and third shots at the conjugate point. The lack of an echo on the second shot may have resulted from the ship being in the wrong position. The ship was positioned about 400 mi. south of the calculated conjugate point so that the radar energy would impinge on the aurora at right angles. At other angles, there may be no return.

The echoes appeared within seconds after the explosions at the launch radar and later, though less than a minute, at the conjugate radar. The longest displays observed were 1 hr. 15 min. at the conjugate point and 5 hr. at the launch point.

During the Argus experiments, very low frequency radio measurements were made in the launch region and at a number of locations near the conjugate region, and at Stanford University. Signals observed in the conjugate area were from station GBZ in England on a frequency of 19.6 kc. Recordings of signals from this station taken at the Azores and in Spain showed abrupt decreases in signal strength following Argus II and III which were from 6 to 12 db. At Stanford, the signals from NPG in Seattle and NDT in Japan were analyzed and showed slight increases in signal strength following Argus II and III.

Also, as part of the Argus experiments, three riometers were operated in the conjugate area. The riometer is a sensitive, self-balancing, noise measuring equipment designed for measurement of ionospheric absorption by monitoring the power level of cosmic noise which has propagated through the ionosphere. The sets were operated on 30, 60 and 120 mc. during the tests.

The results were negative in that no significant absorption increases were recorded following the three shots. The measurements demonstrated that although there was sufficient perturbation of the ionosphere by the Argus blasts to produce reduced signal strength or absorption of very low frequency signals, the perturbations were either not large enough or widespread enough to be detectable on equipment sensitive to absorption in the high frequency range.

Two reasons have been suggested for moving the location of the Argus blasts. One confirmed by scientists taking part in the program was that it was desired to establish the radiation shells at different altitudes so that measurements of shell size and intensity would not be corrupted by residual particles from previous tests. They refused, however, to confirm that an attempt was being made to place the conjugate point as close as possible to the observing station in the Azores, but admitted that calculation of the conjugate point proved accurate only to within a few hundred miles.

Air Force Special Weapons Center participated in the Argus experiments with a program called Project Jason (AW Mar. 30, p. 27) which involved the launching of 19 high altitude sounding rockets. Thirteen of the firings were successful in that they carried a 50 lb. payload in altitudes averaging 550 mi. The rockets were launched from three sites—Wallops Island, Va., Cape Canaveral, Fla., and Ramey, AFB., Puerto Rico—separated in latitude to improve the chances of intercepting the electron shells.

The earliest Jason flight was prior to the first Argus explosion and was less than three days after the very high yield, high altitude shots at Johnston Island in the Pacific fired as part of Project Hardtack.

Comparing the results of this flight with later flights, it appears that trapped electrons were observed which originated from the beta decay in flight of neutrons that were propelled to high altitudes in the Pacific negotiations.

Intercept the Electron

The attempt to intercept the electron shell produced by Argus I was not successful, although some data was obtained on radiation levels in the vicinity of the shell. Following the Argus II explosion, a total of 10 rockets were successfully fired—six successful flights from the three stations within four hours after burst—and valuable data was obtained. Because of the relatively northern position of the shell, only rockets fired from Wallops Island were able to intercept it, but contributory data was obtained with the other launchings.

At the altitudes that the Wallops Island rockets intercepted the shell, between 200 and 300 mi., it appeared to be about 12 mi. thick and to have an initial counting rate about 100,000 times normal. Both the width and location of the shell remained constant over the next 100 hr. within ±5 mi.

The intensity of the shell was observed in these measurements to decay approximately inversely from the time of burst, which is consistent with the theory that the electrons are lost predominantly through scattering in the atmosphere near the mirror points.

Much important data on the Argus shells appears to have been gathered by radiation detection instruments placed in Explorer IV (Satellite 1958 Epsilon) by the group at the State University of Iowa. A total of 164 satellite intersections of the three Argus shells yielded significant data.

Although analysis of the satellite data is not complete, preliminary results show that at satellite altitudes the observed thickness of the shells was in the range of 42 to 132 mi., measured perpendicular to the shell boundaries.

It appears probable that a trace of Argus electrons was also detected near the geomagnetic equator by Pioneer III on Dec. 6, but no observable radiation intensity remained on Mar. 3 when Pioneer IV was launched.

During the month that preceded the first Argus explosion, extensive data was collected by Explorer IV to establish the detailed spatial dependence of the natural trapped radiation and many of its properties in terms of the characteristics of the four detectors which had been devised for the program.

The geometric relationships between the orbit of the satellite and the radiation shells are such that in the favorable case the orbit intersects a given shell four times during each revolution around the earth. In practice the number of observed intersections from which significant data were obtained was less than four per orbit because:

• **Many intersections** were at such low altitudes that the intensity of Argus electrons was immeasurably small.

• **Fewer than four** intersections occurred due to distortion and tilt of the chosen magnetic shell.

• **Many intersections** occurred beyond radio-telemetry range of receiving stations.

• **Some intersections** occurred at points where the artificially injected radiation was unobservedly small relative to the natural radiation.

In each set of observations, the outputs of each of the detectors in the satellite were converted either to true counting rate or to absolute directional energy flux using preflight calibration data. From the corrected plots the following qualities were estimated:

• **Net intensity** above background of observed Argus electrons, obtained by subtraction of the interpolated background values.

• **Time width** of the Argus peak at half-maximum intensity.

• **Time width** of the Argus peak at one-tenth maximum intensity.

• **Local maximum** and minimum values of intensity near the center of the peak.

• **Time at which** the center of the peak occurred.

Then, from the satellite ephemeris:

• **Geographical location** in latitude, longitude, and altitude of the center of observed peak.

• **Geometric thickness** of the shell at half-maximum intensity, measured perpendicular to the shell.

Capetown Anomaly

Gap of several hundred miles between the inner and outer belts of natural radiation that surround the earth, called the Van Allen belts, may be the result of the area of very weak magnetic field strength in the South Atlantic that is known as the Capetown Anomaly.

Radiation level in this gap is about 30 times less than within the belts themselves and, according to this hypothesis, results from the loss of charged particles in this area by atmospheric absorption resulting from the lowered mirror points. The Capetown Anomaly measures approximately 1,000 mi. long by 300 mi. wide, and extends over the South Atlantic near the southern tip of Africa.

The theory was presented to a recent meeting of the American Geophysical Union by Dr. A. J. Dessler, Lockheed Missiles and Space Division.

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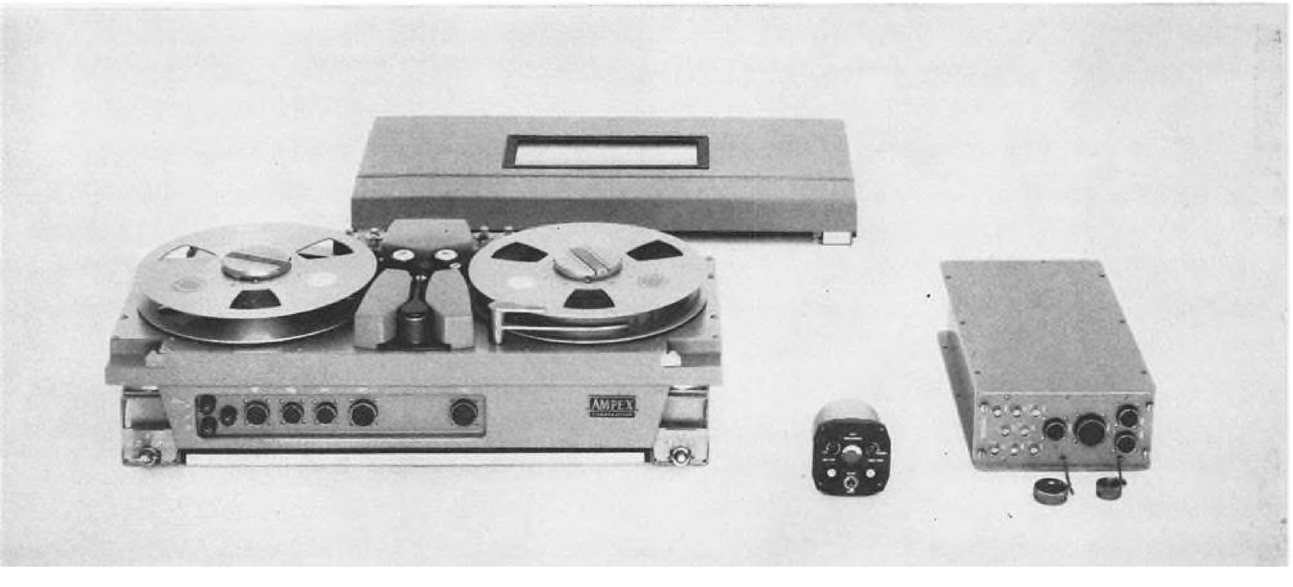

Measuring Whole-Body Radiation Determines Effect on X-15 Pilots

Los Angeles—Effects of cosmic radiation on X-15 pilots can be determined by measuring whole-body radiation.

The investigative tool in measuring this radiation is a gamma counter which determines the amount of radioactive potassium in the striated muscle tissue. Preflight radioactive potassium amounts will be compared with the radioactive level of the potassium in a postflight examination.

Lt. Col. Burt Rowen, USAF (MC), discussed human factors support of the X-15 program at a meeting of the Aerospace Medical Assn., formerly the Aero Medical Assn. Formal name-changing ceremonies were conducted during a business meeting at the Aero-medical convention here. Increasing emphasis on the physiology of space travel prompted the name change.

Radiation Counter

A whole-body radiation counter is operated by the University of California at the Los Alamos Scientific Laboratory. The device, shielded by 20 tons of lead, uses a gamma counter and is similar in appearance to an iron lung. The examination takes only about three minutes. Half-life or radioactive potassium, however, is 12.8 hr. an da pilot's postflight radioactivity would return to normal in about three days.

Air Research and Development Command plans to obtain the use of a whole-body radiation counter for installation at or near Edwards AFB to determine induced radioactivity immediately following each X-15 flight.

Isolation and confinement studies involving subject groups of five men, as well as single volunteers, indicate that psychological examination can offer clues to the kind of men who can acquit themselves well in space missions. Stress and fatigue studies, conducted by Captains G. E. Ruff, E. Z. Levy and V. H. Thaler of the Biophysics Branch of Wright Air Development Center's Aero Medical Laboratory, showed that selection was more important in the single man venture than in a crew of five.

Five men crew studies, involving five days' confinement in a compartment measuring 17 x 7 x 6 ft. revealed that the ordeal was no more than "moderately stressful." Unusual interest in the preparation and eating of food was noted in each of the three groups participating in the tests. This was explained as an outlet for gratifying drives which would normally have been satisfied by other means of expression.

Isolation studies, ranging in duration from three hours to seven days, showed a wide variation in tolerance among the more than 100 individuals tested. In some experiments, subjects were kept in total darkness and silence. Others were subjected to continuous white noise and could see only a homogeneous field of light admitted through frosted goggles. Physical activity was restricted to varying degrees in the experiments.

Capacity to withstand the experiments depends directly on the integrity of the individual's personality. Individuals with a minimum of emotional problems adapt most easily to the unstructured environment of isolation.

A naval aviator-flight surgeon was exposed to 48 hr. 3 min. at space equivalent altitudes (above 50,000 ft.) in the Navy's Mark III Model II full pressure suit. Results of the prolonged exposure indicated no harmful effects, according to a paper by Cmdr. Arthur L. Hall, MSC, USN, and Cmdr. Richard J. Martin, MC, USN.

Findings indicated man can tolerate 100% oxygen at altitudes of 35,000 ft. for 72 hr., that the Navy suit is tolerable at extremely high altitudes for extended time intervals and that man could function adequately with negligible physiological or psychological deterioration.

Oxygen Caused Dehydration

Dryness of oxygen produced some dehydration in the test subject, Lt. Cmdr. Richard H. Tabor, MC, USN, leading to an indication that some moisture in oxygen would alleviate the problem.

At extreme altitudes (140,000 ft.), subject could walk, move his hands, arms and head, although his fine finger movements were restricted under this maximum pressurization situation.

Optimum cabin pressure differential value would be 3.4 psi., since breathing pure oxygen under this pressure altitude produced no harmful effects over long exposures, and this differential also reduced cabin structural requirements. Subject would be able to keep his faceplate open since pure oxygen and pressure combination produced life sustaining value of oxygen tension in the blood.

Bodily functions were presumed to become a problem after a four-day flight, with the recommended procedure being to have two crewmen aboard, so that one could either repair an unexpected pressure leak while the other was engaged in bodily function, or else being able to re-suit the person so engaged in case of a complete pressure loss, before a fatality occurred.

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by
Arthur A. Nichols

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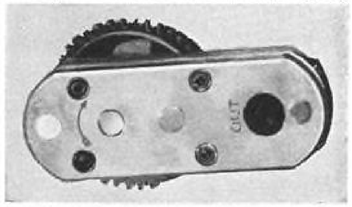

Fig. 1. Metering pump, designed and produced by Nichols.

Other materials now handled by Nichols pumps include: beverages in vending machines; molten lead in production equipment; lubricants for engines and gear boxes in helicopters and other aircraft; fluids for ship-borne and airborne hydraulic servo systems and coolants for high-flying electronic equipment. *(Fig. 2.)*

Fig. 2. Electronic equipment coolant pump.

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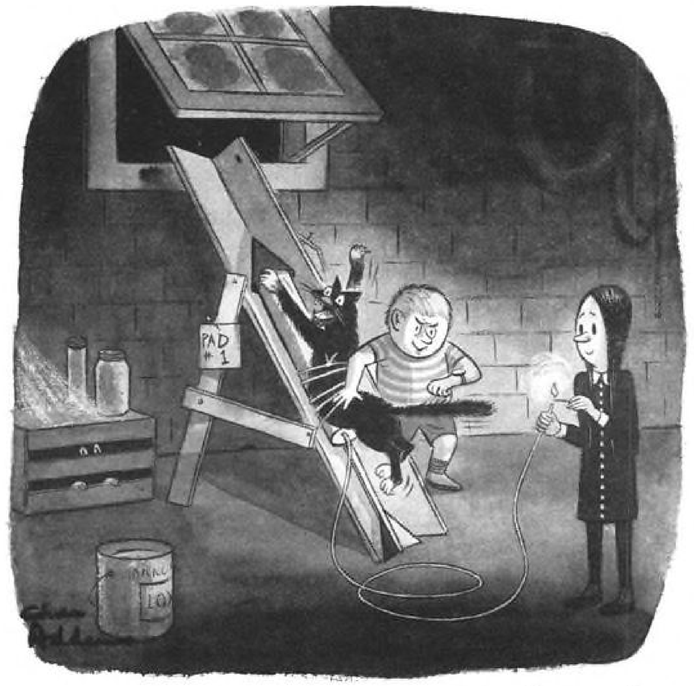

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The Killer Camel

(Continued from Inside Back Cover)

began firing as soon as he was within range—and the treacherous Camel claimed another victim. When this stubby fighter was first introduced in 1917, it took more lives of Royal Flying Corps pilots than the Germans did. As the war progressed, the Camel chalked up an astounding record of enemy kills: 1,634 confirmed victories, including 99 balloons and a Zeppelin.

Although the plane became the supreme Allied dogfighter of the war, only one Victoria Cross was won by a Camel pilot. The Camel was the favorite plane of many unsung British heroes. One of them was Captain H. W. Woollett, D.S.O., M.C. On April 12, 1918, Captain Woollett shot down three enemy aircraft before lunch, then scored victories over a Pfalz D III, a 2-seater reconnaissance plane, and a Fokker Triplane—a feat seldom equalled and never surpassed.

The Camel demanded courage and intelligence of its pilots. For high maneuverability, its main weight was concentrated in a short forward fuselage. Its biplane wings spanned only 28 feet; the upper wing was mounted flat and the bottom wing had a high degree of dihedral.

The Sopwith Camel flew for 15 months with the Royal Flying Corps and the Royal Naval Air Service. The plane derived its name (at first unofficially) from the humping of the panels which faired the breeches of its twin Vickers guns. The prototype had a 110-hp. Clerget engine. Production machines had a more powerful 130-hp. version, and some had a 110-hp. Le Rhone. Although the plane has been described as "too slow to catch anything or to run away," it had more speed than the Fokker Triplane.

Its rotary engine had the effect of a 381-pound gyroscope. Pilots encountered their first problem with the Camel just after take-off: correct setting of the fine adjustment with the

CAPTAIN ROY BROWN
...his victim: Germany's greatest ace

(*Advertisement*)

throttle. If the mixture was not right, the engine would cut out at about 200 feet and the plane would head into a spin.

The Sopwith Camel saw extensive service against ground installations and troops. It was equipped to carry four 25-pound fragmentation bombs, and more venturesome pilots also added a lapful of grenades to increase the plane's armament. Some pilots removed the fairing strips from the brace wires between the wings to add a scream to the normal whine of the engine during strafing operations. The Camel was among the first planes used on Royal Navy carriers and also was used extensively in night flying operations.

The British built 5,490 Sopwith Camels. All were treacherous to handle and full of idiosyncrasies—but their unmatched maneuverability and lightning-fast turns contributed importantly to aerial supremacy.

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The overwhelming number of requests from readers interested in obtaining reprints of "Heritage of the Air" paintings makes it impossible for Leach Corporation to continue offering free lithographed prints, scale drawings and specifications of the aircraft in this series. Leach thanks the thousands of Aviation Week readers who already have reserved their reprints and regrets that the free offer cannot be extended.

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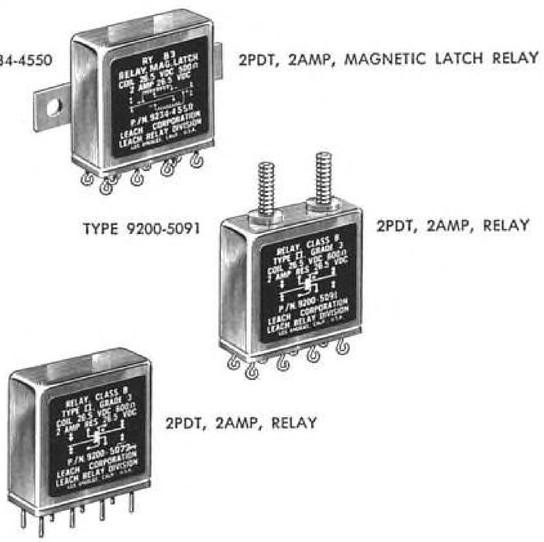

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EXPERIMENTAL final assembly line for Bomarc interceptor as it looked prior to moving production to a new missile plant in Seattle.

Bomarc to Be Combat-Ready at Year End

By Russell Hawkes

Los Angeles—USAF's Boeing IM-99A Bomarc interceptor missile will be "on-site" in September and a combat-ready weapon later in the fall. By late 1960, its successor, IM-99B, with doubled range, better performance, much improved guidance and a much longer maintenance cycle, will begin to supersede it.

Canada will receive two squadrons of Bomarc B at about the same time USAF begins getting it. Canadian engineers are helping to develop the new model at Boeing and subcontractor plants and are taking part in the test program which has just begun at Cape Canaveral, Fla.

Area Defense

Unlike other surface-to-air missiles, Bomarc has no single launch-to-target guidance system and firing command is not ordinarily issued at the launch site. It is remotely launched by a SAGE Direction Center and vectored toward the target much like a manned interceptor. Self-contained terminal guidance target seeker radar only controls the missile during the final run on the target.

Bomarc is an area defense weapon similar to a manned fighter but since its mission is a one-way trip, some of its characteristics differ. Lack of a human pilot means somewhat less versatility in the combat zone, demanding a higher quality information about the enemy before launch and inevitably results in loss of the interceptor regardless of whether its mission is accomplished. Boeing says the missile is necessarily based upon the assumption of a short, all-out war. No small war capability is claimed.

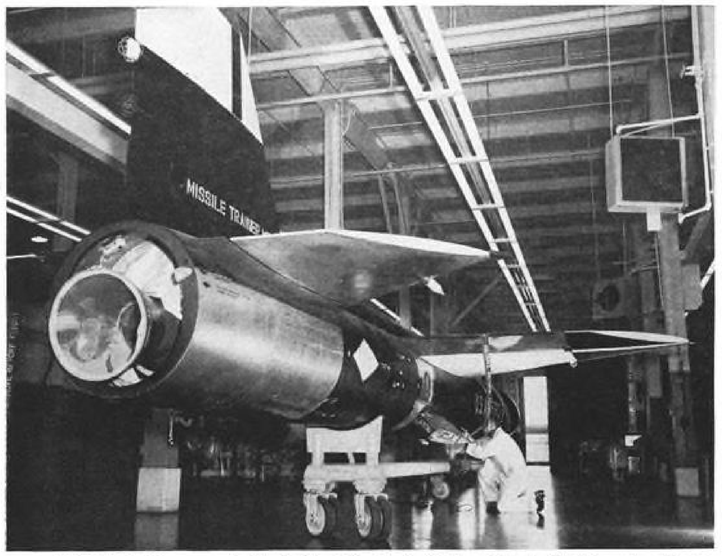
Absence of Pilot

Some cost and performance advantages are derived from leaving the pilot behind. His absence eliminates the weight and cost of all the systems needed to accommodate him plus fuel and equipment needed for the return flight. Since Bomarc will make no controlled landing, its designers could concentrate on producing a high speed airplane without compromising aerodynamics and structures to get low speed performance.

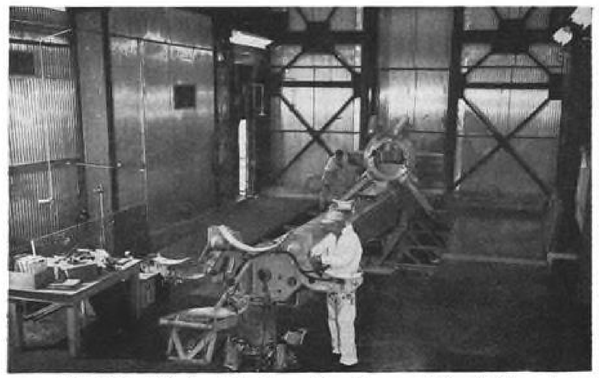
USAF and Boeing proponents of the Bomarc concept claim it will outmaneuver a manned fighter because load factor limits are set by structural rather than human limitations. They concede this is probably not too important a factor

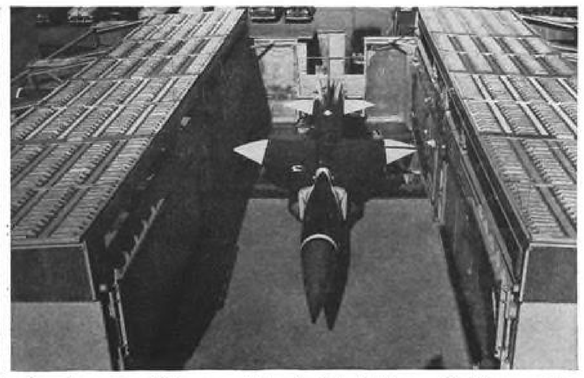
FUELING of IM-99A shows crews loading red fuming nitric acid which acts as an oxidizer for the liquid rocket engine booster unit. Missile can be stored fueled for long periods.

MISSILE ENGINEERING

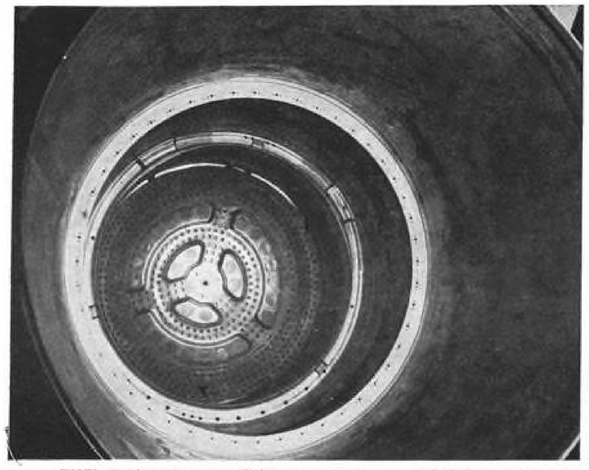


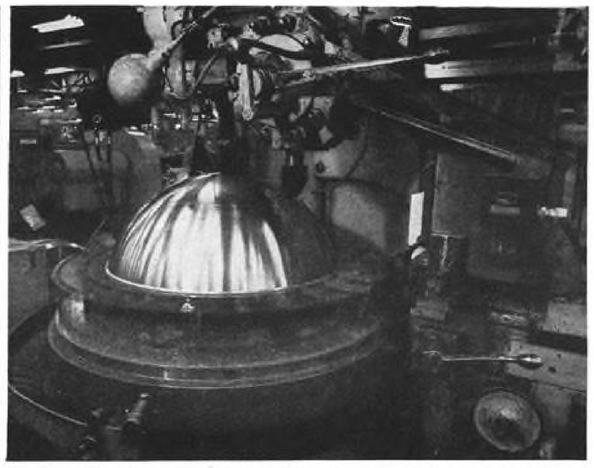
TRAINER Bomarc missile (left) at Boeing's Harbor Island, Seattle, school is shown with Aerojet-General booster unit in tail fully gimbaled. Nozzle is uncooled, ceramic-lined. Production Bomarcs (right) move down final assembly at new Seattle plant.





SCHOOL at Harbor Island provides Bomarc shelter (left) and erector-launcher permitting complete simulated firings. Prototype operational shelter (right), with lead ingots on roof to simulate heavy snow load, is fitted with IM-99 solid-rocket boosted Bomarc.





FUEL TANK interior (left), tank ends are milled from titanium. Boeing is experimenting with explosive forming for tank ends.

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for missions as brief as those flown by Bomarc. Despite the high load factors which can be accepted, turn rate is so low at Bomarc speeds and altitudes that fuel consumption per degree of turn is considerable and a 180 deg. turn would take a large bite out of the small total flight duration possible.

Because of the cost reduction made by eliminating the pilot and the return trip, Bomarc can be delivered to its base, less warhead, for about $400,000. This is less than 10% of the price of a manned fighter capable of surpassing Bomarc's Mach 2.75 cruise.

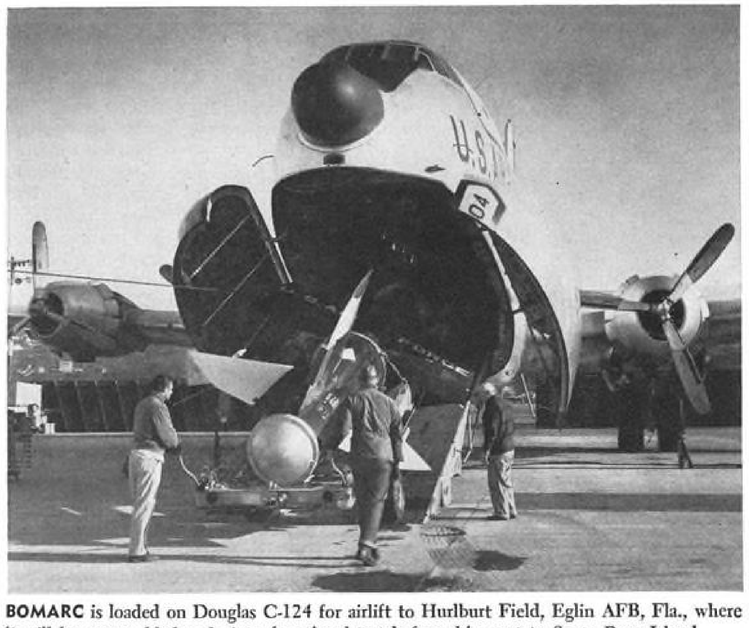
Timing of the Bomarc program was fortunate from standpoint of mating it to SAGE, for the team of Boeing and Michigan Aeronautical Research Center, whose initials make up the designation Bomarc, began work on the missile only shortly before Massachusetts Institute of Technology's Lincoln Laboratory started development of SAGE.

Completion date for development and demonstration of Bomarc A (IM-99A) was to have been Jan. 1, 1959, but it was reached five months early and range and altitude figures exceeded those specified. First of 17 announced tactical launch sites in U.S. is now being finished at McGuire AFB, N. J., and will be ready in September. Service Evaluation (Category II) Tests are being run by 4751 Air Defense Squadron (Missile) at Eglin AFB, Fla., and Field No. 9 on Santa Rosa Island off the Florida Gulf Coast. Training of Bomarc crewmen has been going on at Boeing's Harbor Island school installation in Seattle for a year. Unit training has just begun at Eglin. More than 150 copies of Bomarc A are known to have been ordered since the missile went into full production in 1957.

Bomarc B (IM-99B) will go to the ninth USAF base to be activated in late 1960 and all succeeding ones including the two announced Royal Canadian Air Force bases. Canada estimates its two bases will cost $164 million. A $300 million order for the B version has already been placed in the U.S. and some contractors have rosy visions of total Bomarc production eventually reaching 100,000 with a total value of $10 billion.

This thinking ignores the present unpopularity of air defense weapons in Congress, compared with the powerful deterrents and small war weapons. Air Force and Boeing hopes are far more restrained. USAF is asking $92 million for Bomarc site construction in Fiscal 1960, rather than the $122 million planned earlier. Senate Armed Services Committee has lumped it in with the Army request for Nike, reduced the sum by 20% and assigned to Department of Defense the authority to decide how it should be spent.

Bomarc A is basically a 15,000 lb. gross weight radio-controlled airplane which is launched vertically by an Aerojet-General LR59-AG-13 fully gimbaled liquid propellant booster and is powered in cruise by two 28-in. diameter Marquardt RJ43-MA-3 ramjets which are said to develop about 10,000 lb. thrust in the cruise phase of the mission. The booster system is an integral part of the fuselage tail section



BOMARC is loaded on Douglas C-124 for airlift to Hurlburt Field, Eglin AFB, Fla., where it will be reassembled and given functional test before shipment to Santa Rosa Island.

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and is not jettisoned after burn-out. It has one of the earliest fully-gimballing chambers with an uncooled, ceramic lined nozzle, which can be used because of the brief burning time.

Propellant combination is inhibited red fuming nitric acid oxidant and JP-X, a mixture of JP-4 middle-cut gasoline and unsymmetrical dimethyl hydrazine. Propellants are fed by helium stored under 4,300 psi. Booster ignition is provided by filling the fuel line between tank and chamber with a starting slug of aniline furfuryl alcohol separated from the JP-X by a burstable diaphragm. Nitric acid and the aniline-furfuryl are an exceedingly hypergolic combination.

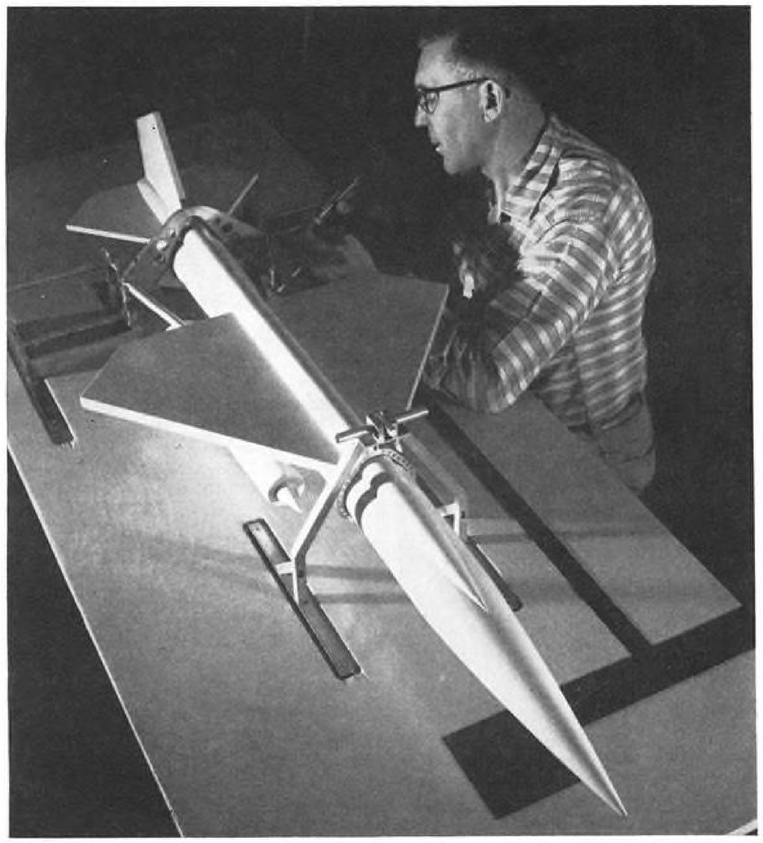
Aerojet Booster

The Aerojet liquid propellant booster is also used without the gimballing arrangement and with a slightly beefed-up chamber and nozzle to propel sleds on the Project SMART and SNORT high speed test tracks.

Marquardt RJ43 ramjets used in Bomarc A for cruise propulsion burn 80 octane gasoline and are started by inexpensive magnesium fusees or flares in the combustion sections. Starting flares are automatically ignited about five seconds before lift-off. The ramjets start at subsonic Mach numbers; RJ43 uses no variable geometry in the inlet duct and maintains shock position by fuel flow control. Bomarc reaches its maximum speed of perhaps Mach 3 at booster burnout while it is still going straight up. Longitudinal center of gravity range is obviously of very little importance during the vertical phase of flight so booster propellants are stored in the fuselage tail section far aft of the normal cruise center of gravity and the missile does not begin to program over into level flight until booster propellants are expended and CG will be in acceptable range.

Bomarc fuselage has a high fineness ratio—about 16:1. Long, pointed radome nose cone is of spun glass but Boeing engineers say that aerodynamic heating is not a problem. Propellant tank walls are also fuselage skin. There is no internal stiffening in the tanks. Tank ends are milled titanium hemispheres. Boeing now is experimenting with explosive forming of the tank ends. Wiring and plumbing run along the top of the fuselage in a magnesium fairing. Warhead section skin is also magnesium. Avionics compartments are pressurized to control dielectric values and temperature conditioned by a small ammonia refrigerator.

Bomarc B, now entering the flight test phase of its development at Cape Canaveral, has been given a Thiokol solid propellant booster, which, like its liquid propellant predecessor, remains a part of the fuselage after burn-out. Control and stability during the first seconds of flight will be provided by a jetavator annular vane like those used in Lockheed Polaris and Northrop SM-62 Snark boosters. Mid-course propulsion for Bomarc B will be delivered by a pair of improved Marquardt RJ43-MA-7 ramjets. Better ramjet design and more internal space for fuel made available by use of solid propellant booster will increase the range from 250 naut. mi. to about 450 naut. mi. The modified RJ-43 will also increase speed and altitude figures. In the Lockheed X-7, the RJ-43 has flown to Mach 4 and more than 100,000 ft. Ramjet fuel is JP-4 rather than 80 octane. It simplifies logistics slightly, since it is more plentiful at USAF bases.



BOMARC IM-99B will be harnessed to the ground for firing tests at Larson AFB, Moses Lake, Wash., as shown with model. Harness was designed by Boeing Pilotless Aircraft Div.

Readiness Status

Bomarc IM-99A is designed to be kept on two minute readiness indefinitely and can be brought up to within 30 sec. of launch and canceled repeatedly without requiring any manual repreparation. The launch can be canceled right up to the moment of booster ignition. Two minute readiness is better than can be had from manned fighters and Boeing officials claim that essentially all the missiles can be held on this status continuously.

The case made for area defense weapons such as Bomarc and manned interceptors is founded upon the ability to use their longer range to intercept attackers farther from the target than can point defense anti-aircraft weapons. Longer range also means a defensive zone of given size can be protected by a smaller force and there is some time for battle assessment between launch and intercept in which to make last minute adjustments in tactical plans. Industry and USAF proponents of area defense estimate that for an equal probability of survival, a target complex can be protected with interceptors for as little as 25% as much as it would cost to use point defenses.

Kill Probability

Boeing officials claim Bomarc offers a higher kill probability and better availability rate for less money than manned fighters. An estimated kill probability of 82% has been published for a Bomarc test series. Manned fighter kill probability is usually estimated at something over 35%. Any unmanned mis-

GENERAL ELECTRIC

T58

The T58, now in production, delivers more power per pound of engine, consumes less fuel per hp-hr than any other turboshaft flying today. Guaranteed at 1050 shp, 0.64 SFC, this 271-pound G-E helicopter powerplant has flight-proven its high performance, ruggedness, and reliability. Now on test is the 1250 shp first-step growth version.

T64

General Electric's T64 is a turboprop/turboshaft engine in the 2600-hp class. It is a compact, versatile power package for rotary-wing or fixed-wing aircraft, or as a power source for radically new airborne applications. Now on test, General Electric's T64 engine is confirming its exceptional performance advantages.

J85

G.E.'s powerful, lightweight J85 turbojet is a 2000-lb-thrust class engine, designed to provide significant dollar savings and performance advantages for missiles, drones, small and medium sized aircraft. The J85 is being flight tested in McDonnell's "Quail" decoy missile and North American's T39 utility trainer.

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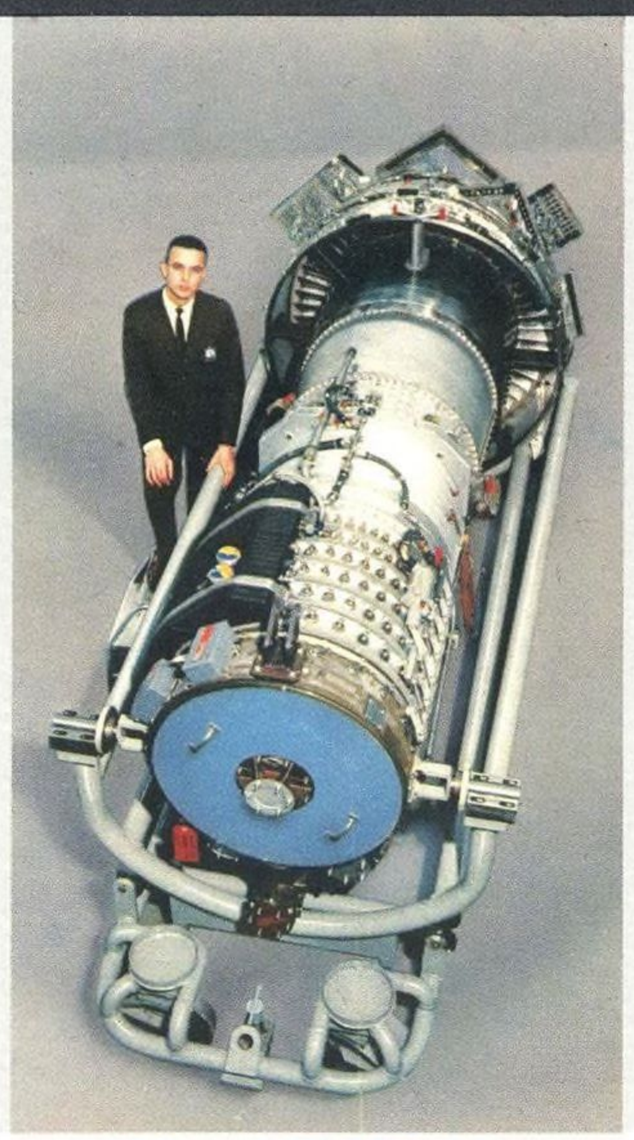
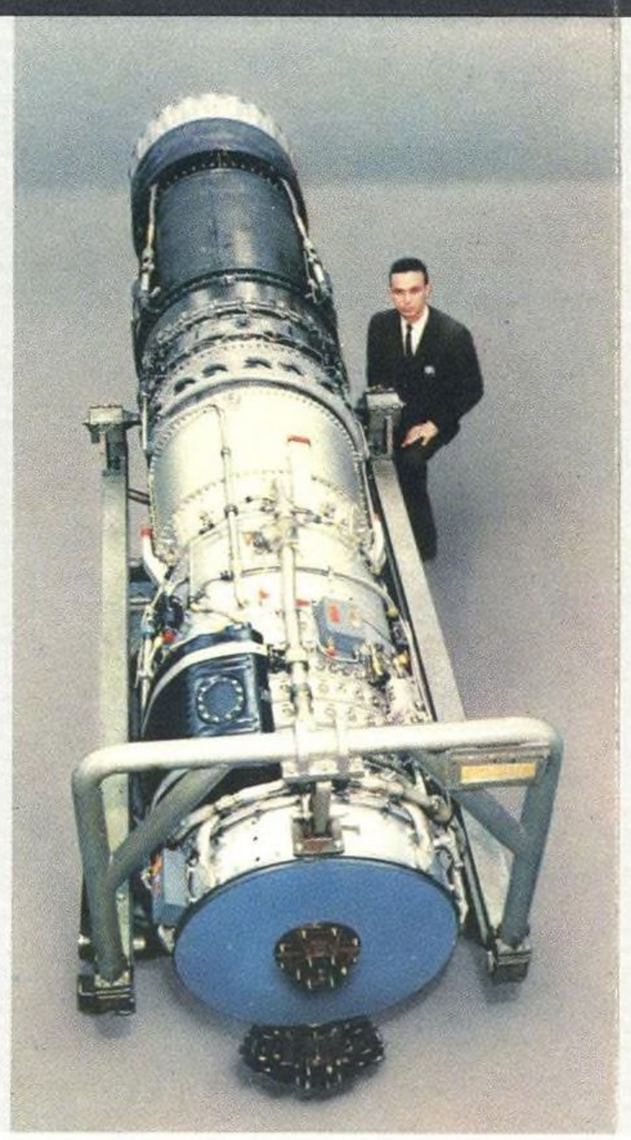
CJ-805-3

G.E.'s commercial counterpart of the military J79. Rated in the 10,000-lb-thrust class, it provides a 4:1 thrust-to-weight ratio. Now being proved in extensive flight test programs, the -3 will power Convair's 880 jetliner. General Electric-built engine reverser-suppressors on the -3 produce optimum results with minimum losses.



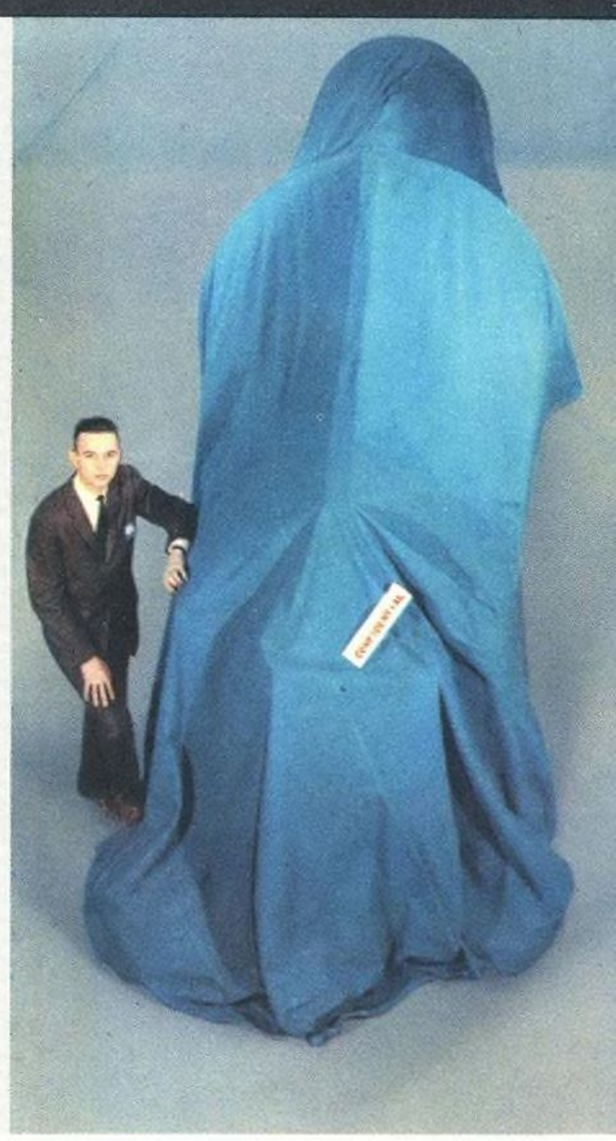
X220 and CJ-805-23

The first successful U.S. turbofan engine. Designed for near-sonic military aircraft, the X220 combines the proved J79 gas generator with an aft-fan, provides higher thrust at lower SFC. Its commercial version, the CJ-805-23, will power Convair's 600 luxury jetliner. New turbofan growth models being developed assure long service utilization.



J79

The 15,000-lb-thrust class J79 powers six Mach 2 air weapons, including the USAF F-104 Starfighter, world's record holder for speed, altitude, and time-to-climb. Other applications: USAF's B-58, Navy's F4H, A3J, F11F-1F, and Regulus II. With over 90% of U.S. Mach 2 flight time, the J79 has demonstrated its ruggedness and reliability.



J93

General Electric's J93 Mach 3 turbojet — still highly classified — will power North American Aviation's F-108 long-range interceptor and B-70 intercontinental bomber. Along with other advanced turbojet engines currently under development. the J93 typifies General Electric flight propulsion progress. 233-21

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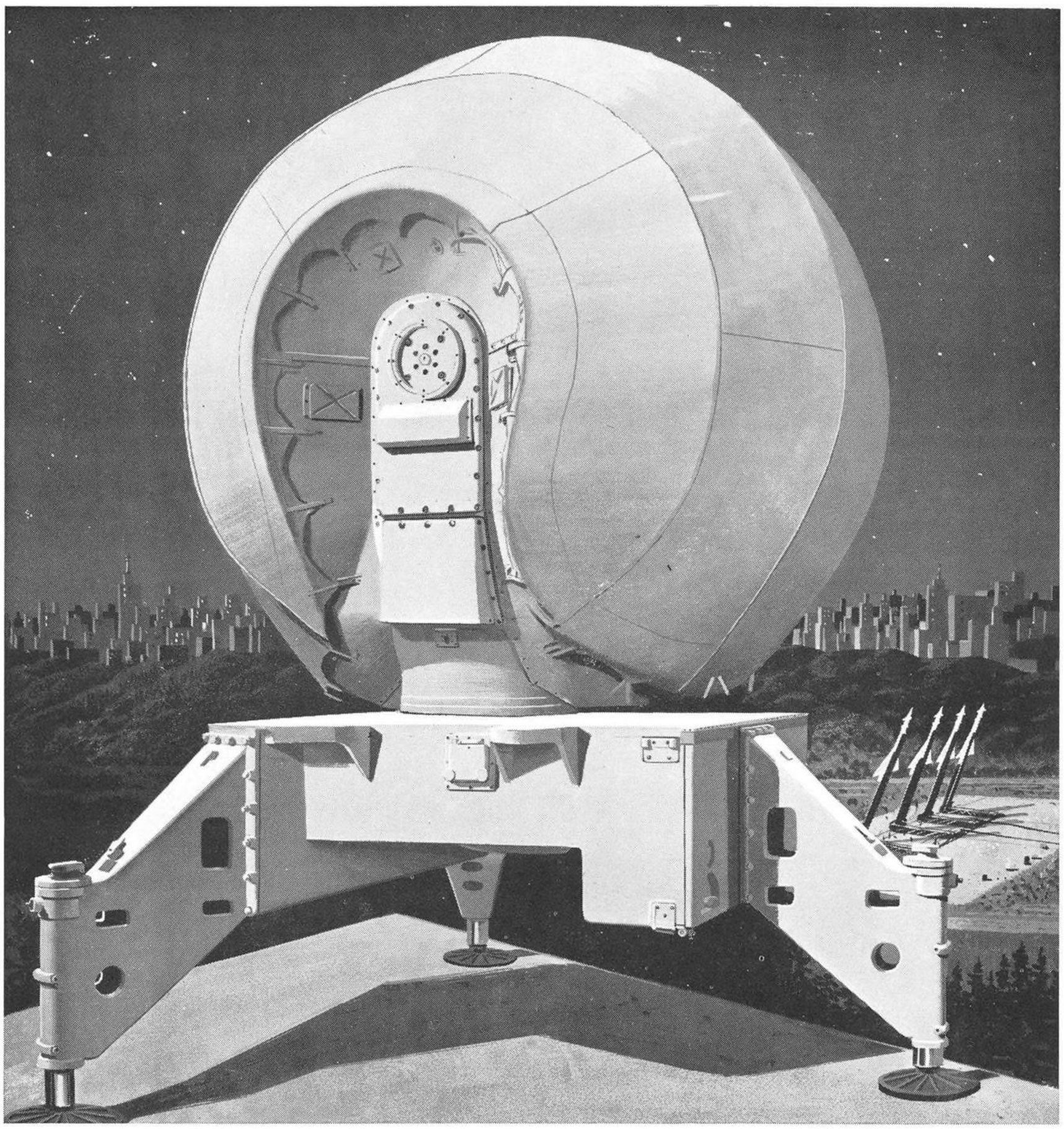
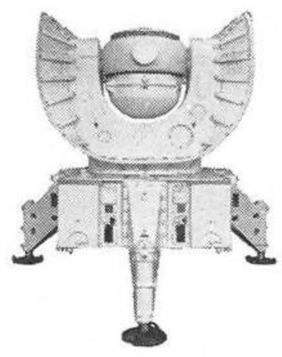


big ears of Nike Hercules

Mounts for radar antennae used by the U. S. Army's Nike Hercules to track aerial intruders and guide the deadly Nike missiles that strike them from the sky are products of the integrated manufacturing and engineering skills of Kelsey-Hayes, working in close cooperation with Western Electric. Capabilities range from prototyping to final production. The manufacturing facilities of Kelsey-Hayes Company in Springfield, Ohio, are devoted solely to the production of aircraft and missile components. Kelsey-Hayes Company, General Offices: Detroit 32, Michigan.



Nike Antenna Mount manufactured by Kelsey-Hayes requires over 2,000 individual parts, many of which are machined to a tolerance of less than two ten-thousandths of an inch.

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Master Flight Reference

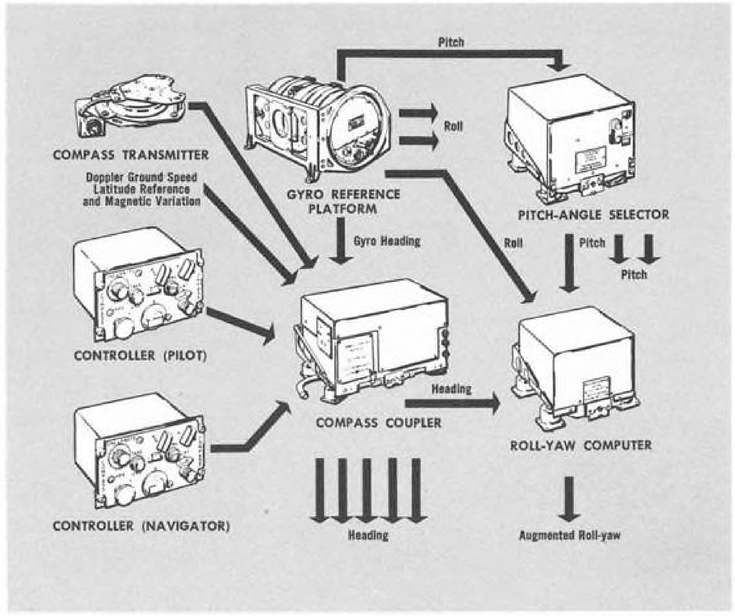
New General Electric Master Flight Reference System integrates direction and attitude changes; guides supersonic aircraft through intricate maneuvers such as over-the-shoulder and toss bombing

A new navigational sub-system, designed to help solve the problem of integrating the various elements of flight control at supersonic speeds, has been developed by the General Electric Instrument Department. Designated the SR-1 Master Flight Reference System, this electronic "brain" is already being used to guide some of our fastest jets in intricate maneuvers such as over-the-shoulder and toss bombing, Immelman turns, and cuban-eights.

Basically a direction and attitude reference sub-system, the General Electric SR-1 (Navy designation AN/ASN-26) accurately senses roll, pitch, and yaw change signals by means of three single-axis gyros. These changes are then converted into multiple signals and automatically relayed to aircraft radar, autopilot, dead-reckoning and navigational computers, bombing equipment, and all-attitude indicators.

General Electric engineers have designed the Master Flight Reference System around six basic components:

1. A three-gyro, four-gimbal, all-attitude stable platform from which flight reference information is transmitted.
2. A small remote compass transmitter which furnishes an accurate heading signal and is used in conjunction with the directional gyro platform to provide a stabilized heading direction.
3. A coupler device which receives the azimuth signal from the platform, plus any necessary correcting signals from the pilot, Doppler radar and the magnetic compass combining them to provide an accurate azimuth signal with sufficient outputs for the operation of the system.
4. A control panel located in the pilot's compartment for his use in setting in necessary information concerning mode of operation, aircraft ground speed, latitude, and synchronization of directional gyro and compass. An identical control panel may be installed for a navigator if required.
5. A servo adapter for platform pitch output which repeats platform-pitch signals for other aircraft components needing attitude information and capable of initiating the operation of any given function at a preset pitch angle.
6. A servo circuit which translates earth coordinates to aircraft coordinates during special maneuvers. It also provides true aircraft roll information for the autopilot and all-attitude indicator.



The Master Flight Reference System is just one of General Electric's many contributions to aircraft instrumentation. Other G-E aircraft instruments are used in systems that measure and indicate mass fuel-flow, engine speed, electric-quantities, temperature, and position. For information on any of these instrument systems, contact your nearest General Electric Apparatus Sales Office; or write direct to General Electric Co., Section 596-501, Schenectady 5, New York.

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If you would like to work on intriguing projects such as the Master Flight Reference System, there may be an unusual opportunity for you with the General Electric Instrument Department. For complete details, write or phone for an appointment with:

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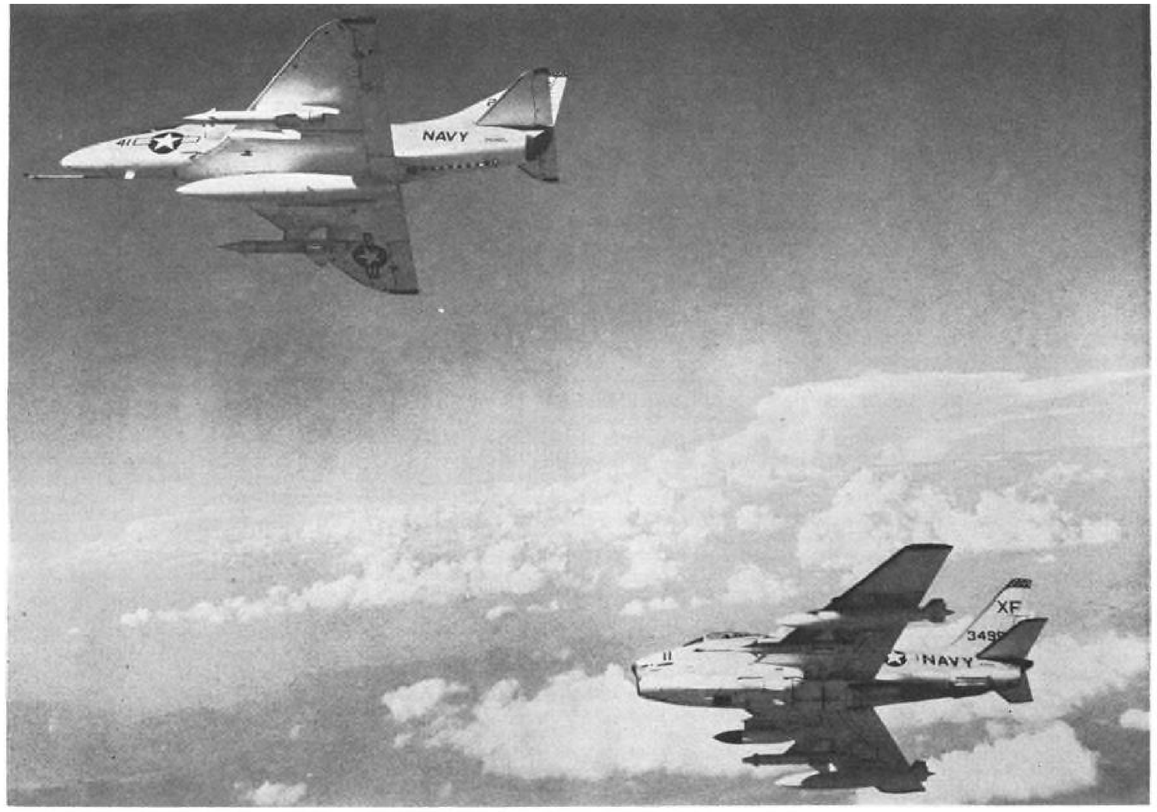

A4D, FJ-4B Modified to Carry Bullpup

Navy Douglas A4D Skyhawk (top) and North American FJ-4B are carrying Martin Bullpup ASM-N-7 air-to-surface supersonic missiles. Bullpup is powered by an Aerojet-General solid propellant rocket. Weapon, designed for close tactical support, has command guidance.

sile has the advantage of being able to get along without range-to-target data. A perfect collision course can be flown merely by holding the target on a constant relative bearing.

On the other hand, a fighter needs more data because the pilot must know when the target is within range and when he is getting dangerously close to the burst zone of his own nuclear armament. Short range of air-to-air missiles, large burst radii of nuclear warheads and low turning rate of high performance fighters combine to give the pilot a very brief time in which to fire and maneuver to escape the blast.

This ability to hit the target with cruder data also pays off with somewhat greater security against enemy electronic countermeasures, Boeing claims. It is not sufficient for the enemy to disrupt only the missile's range information presentation.

Bomarcs are assigned to 28-missile flights, each of which has its own maintenance and assembly area. Squadrons probably will be composed of two flights. Main responsibility of the squadron personnel will be maintenance. Each flight will have two spare missiles so that all the missiles can be periodically cycled through the maintenance and checkout system without reducing effective squadron strength.

To maintain the close integration of SAGE Bomarc weapon system despite the maintenance cycling, the crews must ensure that the missile being rotated into a shelter is identical in some respects to that being rotated out. Command subchannel, missile address, beacon identity code and warhead type must be always the same to avoid confusing the International Business Machines AN/FSQ-7 computer which is the heart of SAGE.

Correct subchannel filters and address plugs are installed in the assembly and maintenance shop and the right beacon code is set. Warhead is installed at the shelter and must be of the type specified by SAGE. Because of these requirements it will be necessary to code missiles to shelters after the assembly and maintenance period as they will not return to the same shelters they left.

A SAGE/Bomarc mission will begin with detection of an unidentified aircraft by one of the powerful surveillance radars in a system of overlapping zones covering the approaches to North America. This effective radar system does not yet exist but responsible officials say that it will by the time Bomarc is on the line.

A coordinate transmitter at the radar will convert the target position into computer terms and transmit it to the FSQ-7 computer at SAGE Direction Center which may be a few hundred miles away. There, it will be stored in the computer's memory system and a blip will be painted upon the SAGE operator's PPI scope. As subsequent radar returns come in they will be used by the computer to establish the "merit" or validity of the track.

Track Identity

Information about friendly aircraft which might be causing the radar return is taken from the computer's memory and the track is established as hostile or friendly. If hostile, a reference number will be assigned to the target and displayed on the operator's scope along with letters identifying it as hostile and indicating the merit of the track. Height finder radars send target altitude to the Direction Center where the FSQ-7 continues to grind out course predictions at split second intervals.

The Direction Center then checks with the Bomarc squadron duty supervisor to make sure that a selected missile has been brought through 90 sec. warmup to stand by condition, is holding at launch time minus 30 sec. and

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is ready to fire. When the squadron confirms that a missile is on standby status, the fact is shown on a digital display before the operator's console at the Direction Center. The operator then asks the FSQ-7 for an "Engagement Prediction Point." This is the modern terminology for the intercept point calculated with the information available at the moment.

Information available will include present range, heading, altitude and speed of the target along with the flight profile of Bomarc for existing atmospheric conditions. As time passes and the situation changes the engagement prediction point will vary. When the operator at the Direction Center pushes the "fire" button, the program timer and electrical launch equipment begins the automatic 30-sec. "fire-up" stage preparatory to launch. The missile goes on internal power, starts its subsystem and completes final checks. The shelter roof slides back, the launcher-erector raises the missile to vertical and retracts empty as the ramjet flares are ignited. Perhaps five seconds later, red fuming nitric acid and aniline-furfuryl alcohol mingle in the rocket chamber to start the booster. As Bomarc rises vertically from its shelter, it rolls to present its top surface toward the enemy and as it reaches cruise altitude, pulls over in an Immelmann turn to roll out headed toward its target.

If the target maneuvers, command control signals generated by FSQ-7 will turn Bomarc onto a new intercept heading. Identity coded radar beacons enable SAGE to direct many interceptors in a comparatively small area without confusing their respective target assignment. Cruise altitude is probably about 80,000 ft. When the missile is near its target, FSQ-7 will command it to pitch over and dive upon a target lower than itself or zoom to reach a higher one. After the Westinghouse Target Seeker terminal guidance locks on, Bomarc will reject further commands from FSQ-7 and will be written off the board at Direction Center.

SAGE Bomarc has killed drones ranging from the Boeing QB-17 bomber

WS-138A Review

Washington–Douglas Aircraft Co., Inc., has been recommended by a USAF source selection board as prime contractor for the WS-138A air-launched ballistic missile. Recommendation was under review by top USAF officials late last week. Douglas, teamed with General Electric Co., was one of 14 contenders (AW April 20, p. 23). Missile would arm the North American B-70, Convair B-58 and Boeing B-52. Contract is believed to be about $500 million.

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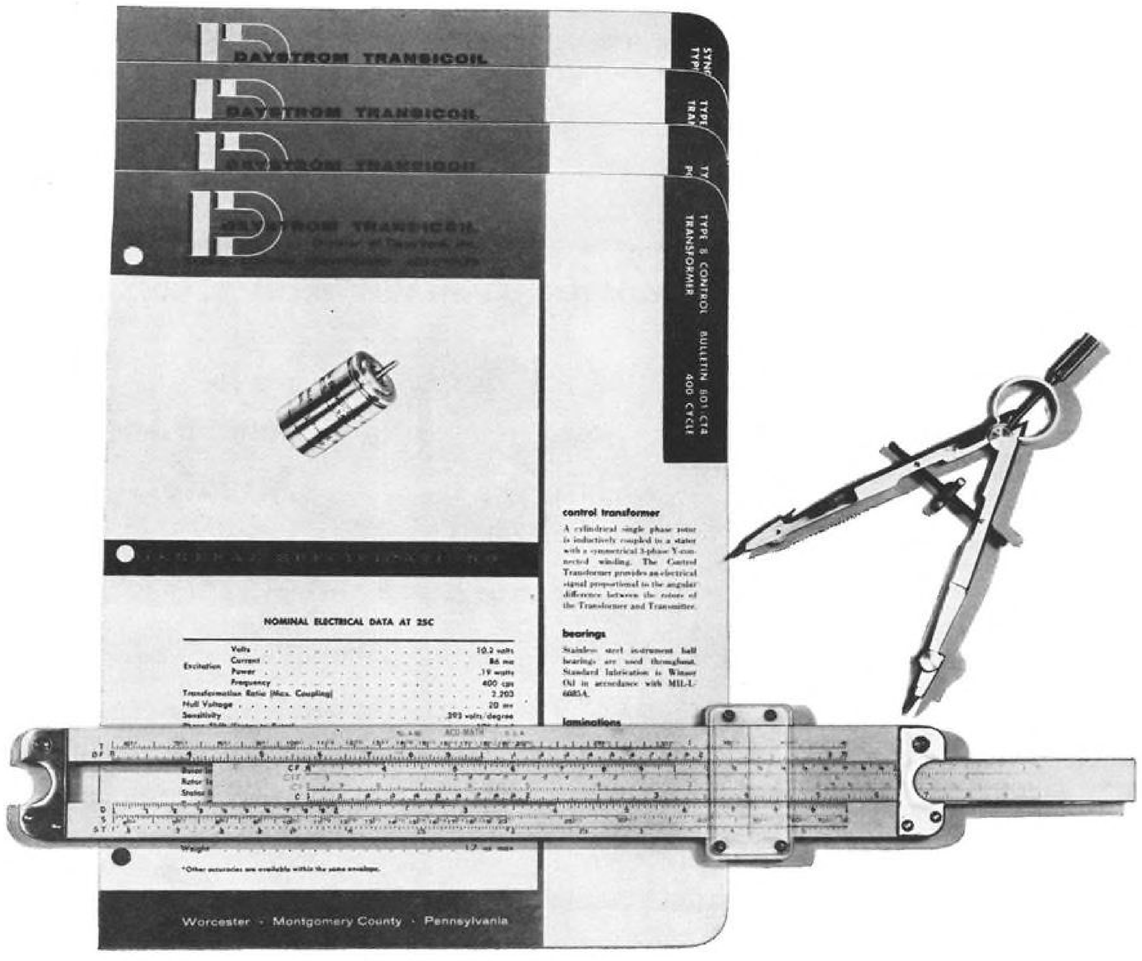

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Ion Thrust Project

New York—B. F. Goodrich Co. has joined with High Voltage Engineering Co. to form Goodrich-High Voltage Astronautics, Inc. for work on ion propulsion devices.

Development of a laboratory ion thrust unit is now under way at High Voltage's Burlington, Mass., plant. New firm will be headquartered at Burlington.

P. W. Perdriau, general manager of B. F. Goodrich's Aviation Products Division, has been named chairman of the board. A. John Gale, vice president and director of applied physics for High Voltage, has been named president.

Officials said Goodrich-High Voltage Astronautics also will work in the field of power generation from nuclear and solar sources.

to the ramjet-powered X-10 test vehicle. Ten feet is a fairly representative miss distance which indicates that a conventional warhead would be completely feasible, though the standard missile will be equipped with the nuclear warhead. Bomarc A has two mission profiles with different cruise altitudes depending upon target altitude. Its capability against low flying targets is definitely limited by inadequate structural strength in the fuselage and inability of the target seeker radar to pick out targets in the midst of ground clutter.

Bomarc B will be improved for use against low targets by a structural beef-up and installation of some type of moving target discriminator in the target seeker to eliminate clutter. A more realistic view has been taken of enemy talent for electronic countermeasures in Bomarc B. On the assumption that it may be difficult or impossible to get a good track on the target, Bomarc B has been given the ability to sweep a corridor with its improved target seeker and strike any target it finds there.

This means that with minimum information it would be possible for a controller to destroy everything airborne in a given area if he concludes that there is an enemy there on the basis of a poor or incomplete track. It would also be possible to lay a ring of Bomarc swept corridors around the last known enemy position and knock down anything flying out of the boxed area.

Severest test to date for Bomarc A was a simulated operational launch against North American X-10 test vehicle from the Navaho cruise missile program. Bomarc was controlled by Kingston, N. Y., SAGE center 1,500 mi. away from the Cape Canaveral launch site. The X-10 was launched from the Cape, flew out over the Atlantic and turned back for a mock attack on the missile base at a speed of 1,000 mph. (Mach 1.6) and altitude of 48,000 ft. Bomarc made its attack from a higher altitude. Elapsed time from launch to intercept was five and a half minutes. If the intercept had been at a extreme range of 300 mi., the mission duration would have been about 12 min.

Since it may be desirable to use Bomarc from overseas bases where there is no equivalent to SAGE, the weapon system includes a Westinghouse GPA-35 controller computer to substitute for the FSQ-7. If computing capability was reduced from maximum to minimum, the number of kills probably would not be reduced 50%.

Present Bomarc bases are soft since they are considered an unlikely target for enemy strategic forces, but there is some indication that this opinion may be revised as USAF is running cost effectivenes studies on the advantages of hardening or dispersing Bomarc shelters. Great disadvantage of dispersal is that it reduces extent to which support equipment, personnel and facilities can be shared among the missiles.

On soft Bomarc bases, the housekeeping and support area is immediately adjacent to orderly ranks of missile shelters. It includes an assembly and maintenance shop, heat and power building, compressor building and propellant storage facility. Assembly and maintenance building is the heart of the support area. Missiles are received and assembled there when the squadron is established and most of the periodic checkout and maintenance are done there. The Squadron Operations Center, where the supervisor controls warmup of the missiles in the shelters and reports availability to SAGE is also located in the A & M shop.

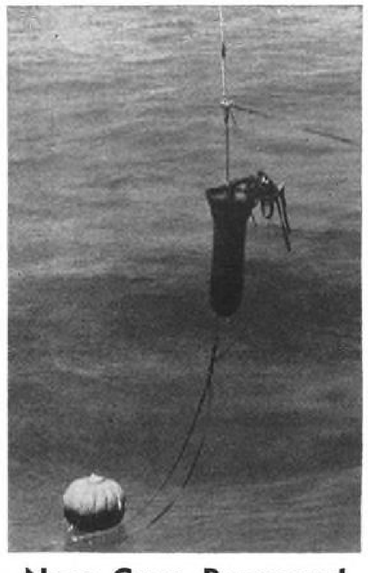
Standard remove-and-repair modular maintenance philosophy used in Bomarc is based upon a stable of automatic, self-checking Operational Test Equipment. Some of the checkout and maintenance functions are performed in the shelters but most of the heavy and complex equipment remains fixed in the A & M shop. A mobile inspection equipment van and radar target truck are used to carry out the 30-day "confidence" checks upon the missiles in the shelters. In Bomarc B, the confidence check cycle will be extended to 90 days.

Maintenance recycling of a missile through the A & M shop will occur every six months for Bomarc A and every two years for Bomarc B. Confidence checks and maintenance cycles can be stretched in the improved missile mainly because of the use of a solid propellant booster. There is no need to purge and check tanks and propellant lines which suffer somewhat from the corrosive fluids.

The van houses a functional checkout set and a launching equipment checkout set which automatically sequence functional tests of shelter mechanisms, missile and launching equipment. The launching equipment checkout set performs a self-check sequence of 590 tests and then performs another 590 tests upon the launching equipment.

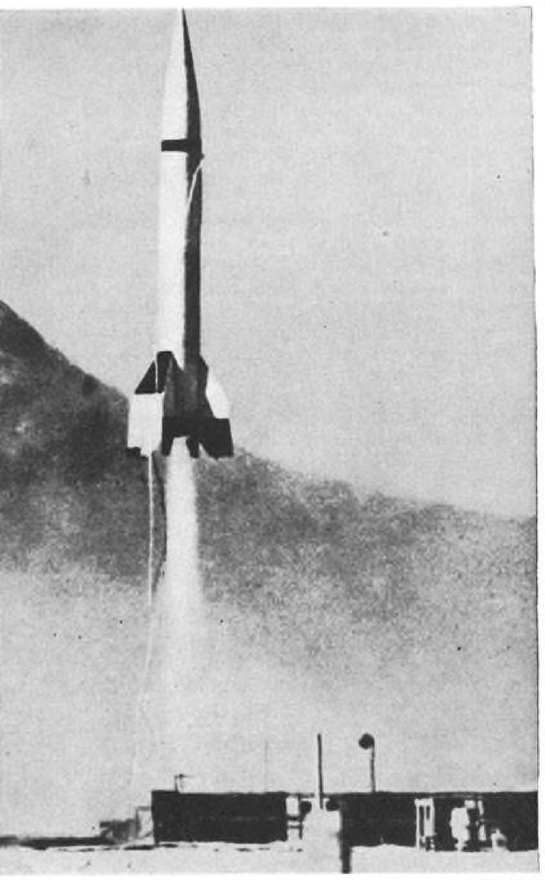
The entire performance requires about 20 min.

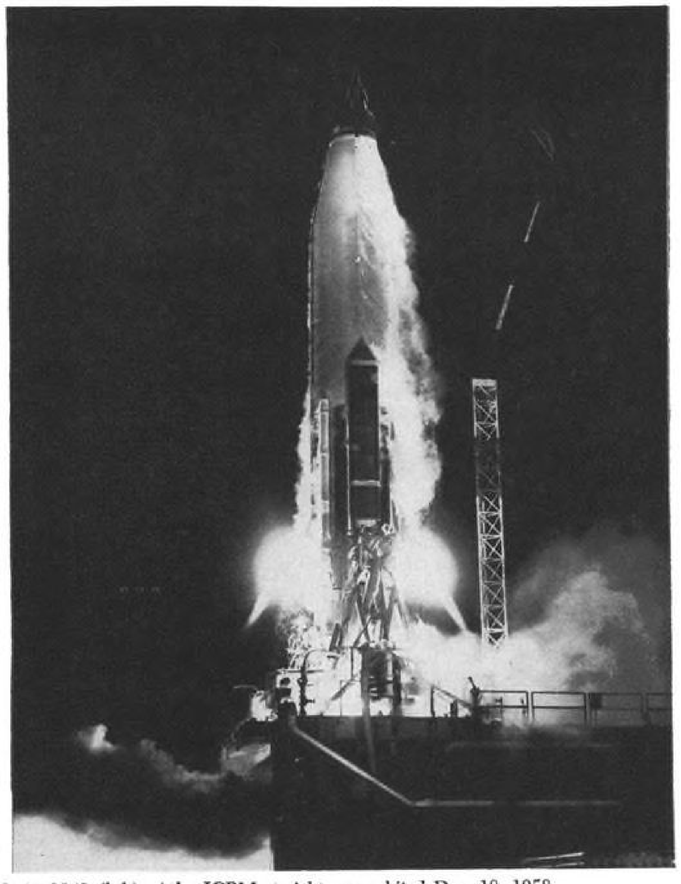
The six-month recycling is carried out on a six-position line along which the missile progresses in its most thorough field maintenance operation. Six positions are: missile entry bay, two disassembly and minor maintenance servicing stations, a propulsion test station, hydraulic test and assembly station and a functional test station at which the missile is placed upon an exerciser tied to a functional checkout set which can simulate an entire mission including control surface responses to radio command signals, warhead deterioration, etc. There is a separate ramjet test room in which the fuel control system can be checked. Missiles are moved from station to station in the A & M shop by an overhead crane. The number of stations will be reduced to two for Bomarc B.



Nose Cone Recovered

Thor-Able nose cone is recovered by USAF ocean range vessel near Ascension Island in the South Atlantic. This was the first nose cone recovered by USAF after re-entry into the atmosphere. Missile had been launched from Cape Canaveral, Fla., and impacted 5,000 mi. down range. Flotation bag is in water; nose cone was suspended from it 30 ft. below water's surface. Nose cone was returned to Avco for analysis of effects of heating during 15,000 mph. re-entry.





MX-774 test vehicle is launched at White Sands, N. M., in 1948 (left). Atlas ICBM at right was orbited Dec. 18, 1958.

Atlas to Play Major Space Booster Role

By Richard Sweeney

San Diego—Convair Atlas intercontinental ballistic missile—designed on concepts considered radical 13 years ago—is nearing operational status and will continue to play a major space booster role for some time to come.

These new missile design philosophies introduced by Atlas include:

- **Thin wall integral tank structure** where pressurization is the key to required structural strength.
- **Gimbaling engines** to control flight path of aerodynamically unstable vehicle.
- **Separating nose** to carry payload through re-entry stresses, eliminating need to worry about the airframe proper.

As a strategic deterrent type of weapon, today's Atlas can carry a thermonuclear payload over ranges up to 7,500 naut. mi., sufficient to hit any target in the USSR from any location in the United States.

But advances in propulsion and materials fabricating techniques, which have come along as functions of travel down the learning curve have pushed the missile's inherent capabilities to where a payload twice the weight of the design standard could be fired to the remotest possible point on earth for the retaliatory mission. Additional growth potential exists in the missile, obtainable through propulsion and other systems refinements. Atlas has been cast for these space work roles:

- **Centaur,** a package consisting of Atlas plus a high energy upper stage using liquid hydrogen and oxygen. This, incorporated back into missile application, would enable Atlas to carry more than 10,000 lb. payload to any point on earth, i.e., range of at least 12,500 mi. Centaur also could boost a substantial payload into orbit (the word orbit used alone refers generally to a distance above the earth of 300 naut. mi.). In addition, Centaur's potential is as a useful deep space probe, carrying instrument payloads millions of miles, as contrasted with near space travel, such as to the moon.
- **Vega,** which is Atlas with a Vanguard first stage engine on top. Later, addition of a 6,000 lb. thrust storable liquid engine may further boost this combination's potential. Advantage of Vega is that it can be available by the fall of 1960, also would use much of the same basic tooling as the later Centaur to facilitate production changeover. Vega is a near-space probe and will not handle the payloads Centaur can.
- **Mercury,** National Aeronautics and Space Administration man-in-space project, in which Atlas alone will power the manned flight article into its orbit trajectory. Here, the Vega early combination may be used in preliminary test work, that is Atlas with a Vanguard first stage on top. NASA is to build the first four instrumented test vehicles before McDonnell capsules are launched.
- **Dyna-Soar.** Centaur package is the booster for Boeing Dyna-Soar proposal, after a changeover from the original solid propellant propulsion system envisioned. Additionally, Bell-Martin Dyna-Soar team is keeping a close check on Atlas for possible incorporation into its proposal, although the original plan was use of Titan. In Dyna-Soar, Centaur would be topped by the manned last stage.
- **Sentry,** or WS-117L, the reconnaissance satellite, for which Atlas will be the booster vehicle.
- **Midas,** a family of satellites which will accomplish global reconnaissance and surveillance, with Atlas again the primary booster vehicle.

More Atlas uses, which are included in NASA's general space plan (AW Mar. 2, p. 19), include Atlas with Bell Hustler on top and Atlas-Able, Atlas with the Vanguard second stage and Allegany Ballistic Laboratory's solid propellant third stage of Vanguard.

Convair Studies

Convair has made additional studies with Atlas, using many combinations, to fully exploit the missile's potential.

Included in these have been studies which indicate, according to Convair, that a cluster of three Atlases would be very close in performance to the Juno V, the Army Ballistic Missile Agency cluster of North American Aviation Rocketdyne thrust chambers of the Atlas booster chamber thrust class, which is being designed as a million pound thrust engine.

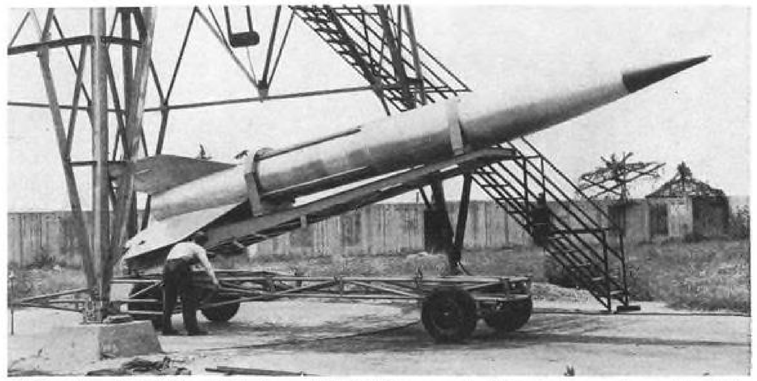
An extension of this is a cluster of three Atlases, and a cluster of the high energy upper stages of Centaur on top, with a single Centaur high energy stage on top of this. This should be useful for significant space travel efforts. Still another combination is the ABMA million-pound-plus cluster, topped by a Centaur (Atlas and high energy stage).

Convair also is not neglecting applications for work further down the line. In these studies, high energy upper stages with up to 140,000 lb. thrust and using propellants such as fluorine-hydrogen and fluorine-hydrazine are being considered. For this, Atlas as a booster would have its thrust value for launch raised to some 600,000 lb. by modifications such as replacing the sustainer chamber with a booster chamber, all three chambers with a thrust level approximating 200,000 lb. each. Booster chamber could replace sustainer since over-all envelope sizes of both happen to be very close despite the difference in the combustion chamber size, and expansion ratio.

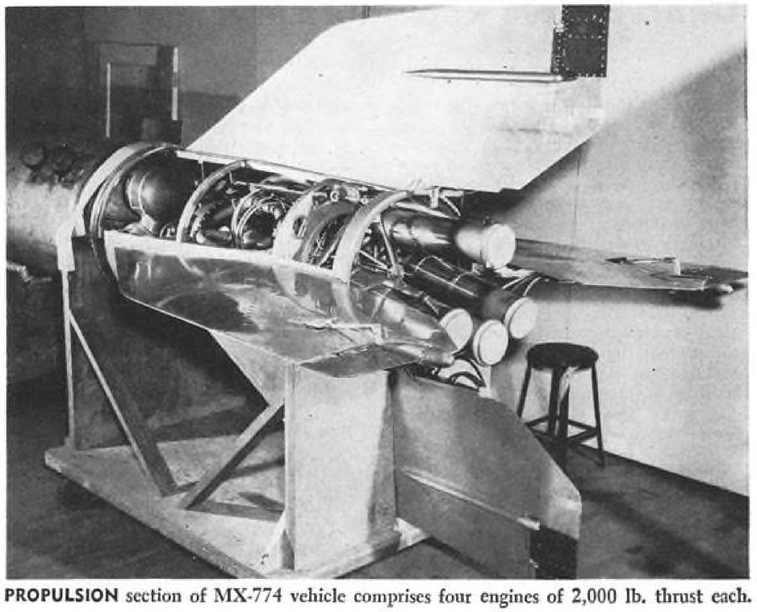
Indicative of variations possible with staging, Convair studies showed that an Atlas topped by a Thor, and with a Centaur high energy stage on top of this, was about equal to a Centaur combination alone. At firing of the high

Atlas Milestones

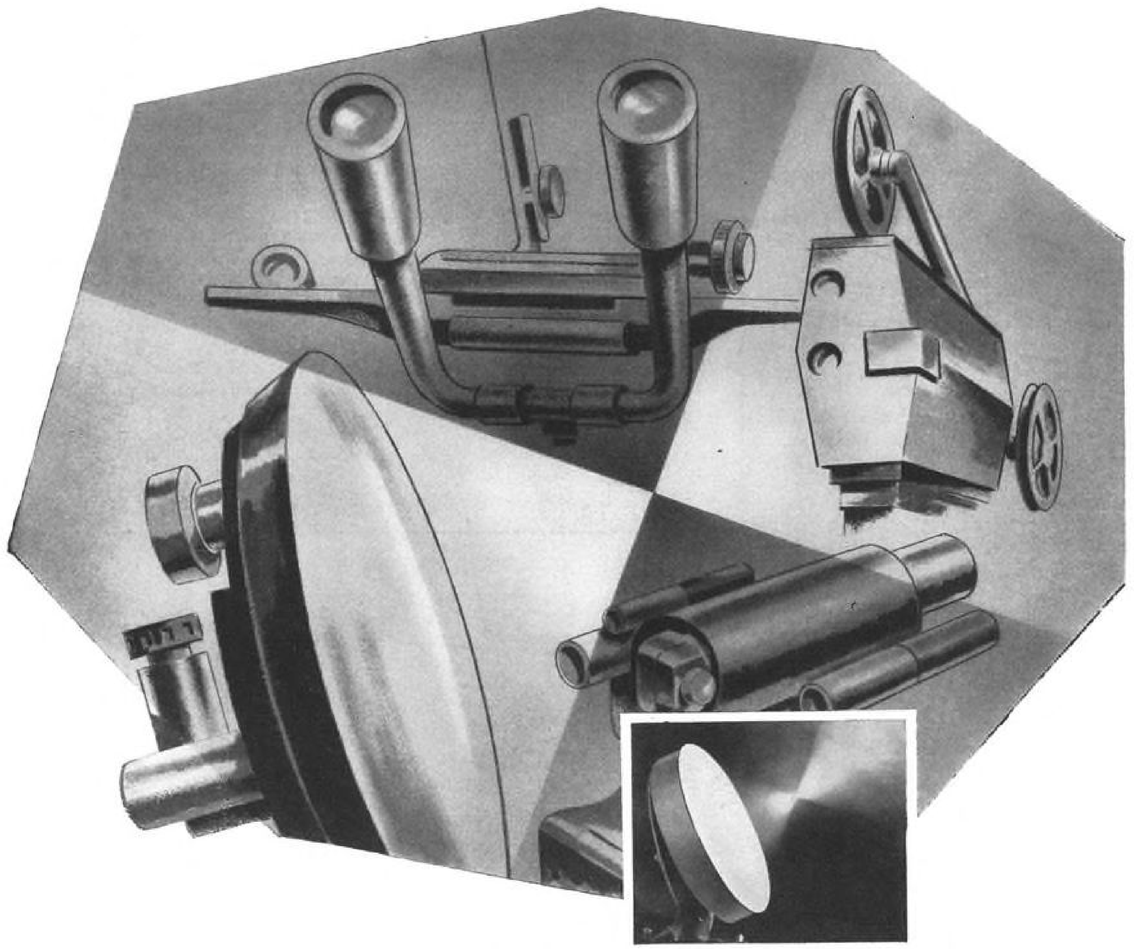
- MX774 Project, contract awarded Convair in April, 1946, first vehicle static tested in November, 1947, and first flight on July 13, 1948. Incorporated thin wall, integral tank structure, swiveling engines for control, separating nose cone.
- MX1593 Project, contract awarded in January, 1951, for over-all systems study and component design "leading to" an intercontinental ballistic missile. One stainless steel thin wall tank, 12 ft. in diameter, was fabricated according to Convair specifications by Solar Aircraft, was used for several years in static test of Atlas, even after the missile diameter became 10 ft., when the tank became in effect, a 1.2 scale model.
- WS107A, the Atlas contract signed in January, 1955, for the missile as it basically is today. First Atlas flight, June 4, 1957, missile 4A flew for 23 sec. before a malfunction occurred, and attained 90% of test objectives prior to destruction.
- First complete Atlas flew in September, 1958, incorporating all elements of the missile except the warhead. Carried significant weight of instrumentation. First full range Atlas flight, Nov. 28, 1958, when missile traveled its programed trajectory toward Ascension Island after launch from Cape Canaveral, Fla.
- Project SCORE, when Atlas 10B was placed into orbit carrying an Army-developed communications package, on Dec. 18, 1958.



ONE of three MX-774 vehicles is erected. Vehicles were built to test concepts used in Atlas.



PROPULSION section of MX-774 vehicle comprises four engines of 2,000 lb. thrust each.



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energy upper stage in both cases, velocity is very close. In the three stage vehicle, Thor weight reduces takeoff performance to a point where the firing of the Thor barely recaptures the velocity lost by its weight in the launch vehicle.

During its development-flight test cycle, Atlas has progressed through several letter-model designations:

• **Atlas A.** First Atlas launched was No. 4 missile of the A configuration, which had booster engines only and a heavy load of instrumentation. Atlas 4A flew for 23 sec. before being destroyed by the range safety officer, achieved 90% of the flight's objectives. Flight occurred June 11, 1957.

• **Atlas B configuration** had everything aboard which the operational missile would carry, with substitutions in weight where instrumentation replaced such things as the warhead. This model also carried extensive instrumentation, and was termed the operational prototype missile.

• **Atlas C** was a refined missile, its propellants were more densely packed, it was somewhat heavier at takeoff than the earlier models and had a slightly lower takeoff acceleration. The C model carried instrumentation, but to a lesser degree than the A and B models. In addition, this missile could travel approximately the design range, enabling it to be used in connection with the far downrange stations such as at Ascension Island. First full-range shot with Atlas took place last December, from Cape Canaveral, Fla., launching site for all Atlas flights up to now.

• **Atlas D** is the operational type missile, first of which was fired Mar. 18 from Cape Canaveral. Since it will be delivered to Vandenberg AFB, Calif., and be used in the training mission, Atlas D still carries some instrumentation, essentially that required to relay back information to the firing troops of how well their effort has gone. This instrumentation is about one-third that of the original load. However, for D model Atlases delivered to purely operational sites such as Francis Warren AFB, Wyo., even this instrumentation will be removed. Additionally, instrumentation carried aboard training models of Atlas D does not inhibit performance of the operational mission, which can be accomplished from Vandenberg in addition to the training mission. Although D model Atlases have the General Electric radio-inertial guidance combination, later D models will incorporate the all-inertial guidance system of American Bosch Arma.

• **Atlas E** will be the totally operational model. It will have much repackaging of the missile's equipment in the interests of better maintenance. It will carry all-inertial guidance from the start. Base requirements for Atlas E will differ from those of the D model, due to guidance systems, among other things, and it is possible that D model bases may be retrofitted to use the E models. In the normal course of events, D models will be used up by wear in training, maintenance, as well as training firings, which could result in all operational sites being equipped with E models eventually.

Atlas started as one half of a proposal that Consolidated-Vultee Aircraft made to U. S. Army Air Forces in 1945 for two pilotless weapons capable of traveling 5,000 mi. One was the ballistic missile, the other a subsonic turbojet-powered missile.

The proposal became a contract, awarded in April, 1946, for Project MX774. This called for a three-phase program, the final phase being an intercontinental ballistic missile.

Starting point of missile designs of that day was the German V-2, but basic elements of its design were unacceptable for the intercontinental mission, for at least two primary reasons:

• **Entire missile** was re-entered to protect the payload. Possible with the short range of the V-2, this was clearly impossible for a 5,000 mi. missile which would have to go much higher and faster.

• **Aerodynamically stable** in the atmosphere, the V-2 rocket engine control was provided by movable vanes in the exhaust. Their inherent efficiency was questionable, and it definitely was known they significantly lowered rocket engine's efficiency.

First phases in Convair's program called for design and flight test of two types of vehicles. One was a vehicle capable of Mach 5, the second was to be capable of Mach 18.

Mach 5 Vehicle

Detail design of the Mach 5 vehicle in program started in June, 1946, and it was as detail design was started that Karel J. Bossart conceived the idea of the thin wall integral tank. Bossart's reasoning was that since pressure had to be maintained on propellants to provide a pump head and prevent cavitation, then allow this pressure to go higher and support the structure. By making pressure the predominant load felt by the tank, the material all was stressed for tension and the over-all combination could be lighter weight than a conventional structure.

At approximately the same time, Bossart and F. B. Wozniak conceived using moving thrust chambers for control, rather than the jet vanes. During the first year total missile staff was about 60 persons, of whom 75% were in the electronic phase of the effort.

The separating nose cone idea also

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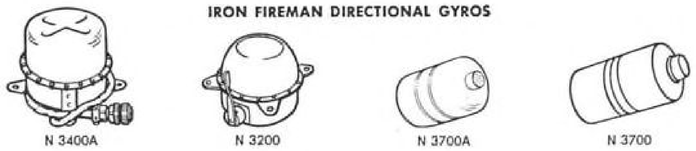

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came into being at this time, as the most logical means of getting the payload back through the atmosphere.

These features were combined into the Mach 5 vehicle design, and the machine had its first static test Nov. 14, 1947. This vehicle was 34 ft. long, 2.5 ft. in diameter and used 51S aluminum alloy for its welded thin wall tank structure as the best strength-weldability compromise. Its gross weight at takeoff was 4,000 lb.

Power was supplied by four Reaction Motors X-1 rocket engines, which basically developed 1,000 lb. thrust each and used a pressurized fuel system. Design improvements raised the thrust level to 2,000 lb. per chamber to give the missile 8,000 lb. total thrust, and a pump-fed fuel system was incorporated. Takeoff acceleration was 2g.

This missile had aerodynamic fins, but also used movable engines. The four thrust chambers were operated in pairs perpendicular to each other, and each pair swiveled in two axes.

This vehicle was intended to prove the principles of a thin wall integral tank structure, with movable engines controlled by autopilot.

There were to be 10 of these vehicles in this phase.

In July, 1947, the MX774 program was terminated in effect, when there was no ballistic missile money contained in the Fiscal 1948 budget.

However, funds on hand already carried through the construction and flight test of three Mach 5 vehicles, which became known as the MX774. When the three flights were completed, Convair has proved the thin wall pressurized integral tank, movable engines and separating nose cone ideas and had obtained in-flight aerodynamic load data as well.

When MX774 was cut, the second vehicle in the family was in detail design. It was to have had two stages, the first using five thrust chambers of 20,000 lb. thrust each, the second stage using one 20,000 lb. thrust engine. The rocket was to be used in re-entry studies, since its design velocity was to be Mach 18. At this time, nose cone decelerations were to be absolutely minimized, since payloads of that date were sensitive in this aspect, resulting in fantastic re-entry speeds being specified.

At the end of the MX774 program, USAF asked Convair which part of the radio control-inertial guidance system planned for the ICBM, was the most difficult. Convair said it was the element which tracked the missile to gain the data which was fed to the computer, and formed the base on which calculations were made of missile path and necessary corrections to keep it on proper trajectory. Correction orders based on data from the tracker were radioed to missile's autopilot, in the radio-controlled portion of the flight.

This tracking element, which became AZUSA impact predictor system (AW Feb. 9, p. 65), was funded and supported by USAF through the period 1948 to 1951 when ICBMs were revived. During this period, Convair kept theoretical studies of ICBM problems going, with its own funds. Missiles used in studies had "rubber" engines, i.e. the engine required to do the job was assumed as available when needed.

In the studies of this period, Convair proved mathematically that ICBMs were feasible economically, but the Circular Error Probability (CEP) dictated by warheads available was rather small, even by today's standards.

Since very high Mach numbers still were indicated for re-entry, nose cone studies embraced very sharp cones, such as 5 deg. half angles. Heat inputs in this regime were in the order of 50 to 60 million Btu./sq.ft./hr., an almost insoluble condition.

First Verniers

During the 1949 studies, the idea of using small rocket engines for fine attitude control of ballistic missiles appeared, the first use of vernier engines. These small rockets also were gimbaled in design concept, which was proved out on Atlas later.

In January, 1951, Wright Air Development Center awarded Convair a contract for Project MX1593, which was for the study of over-all systems and development of components "leading to" the design of an intercontinental ballistic missile. Working under the contract, Convair developed components which proved the study principles but also were producible, looking to the day when the company expected a new ICBM contract.

While studies made during the 1948-50 period utilized rubber engines, in the fall of 1951 a design was completed which was predicated on use of seven existing thrust chambers and a relatively heavy payload. Missile was to be 12 ft. in diameter.

The engines were those developed by North American Aviation for the Navaho program, with a basic chamber capable of about 120,000 lb. thrust at that time. The decision was agreed on all around that it was best to go ahead with what was available rather than develop new engines.

New Configuration

In January, 1952, a new configuration was officially established, using five chambers of the Navaho type, a 12-ft. diameter tank and with an official payload the same as before. Chamber thrust levels for this configuration officially remained 120,000 lb. each.

In this design, a switch in material was made from aluminum alloy, which posed problems in fabricating techniques to attain desired efficiencies, to stainless steel. This switch, which picked up some weight, also had the effect of giving the design a factor of safety in the far parts of the trajectory, where aluminum design was marginal in the time at an elevated temperature condition.

Hardware was fabricated for this configuration, a tank was put together by Solar Aircraft Co. working to Convair design. This tank was used extensively over the years in static tests at Convair's Pt. Loma facility, where it was used in investigations of vibrations, loads, autopilot control system.

At this same time, deceleration limits for the payload were eliminated, allowing a reduction in re-entry Mach number. However, the new speed remained in the regimes today considered hypersonic, and produced heat inputs on the order of 20 million Btu/sq.ft./hr. But since laboratory simulation had reached values of 16 to 18 million Btu/sq.ft./hr. inputs, the problem was judged solvable but extremely difficult.

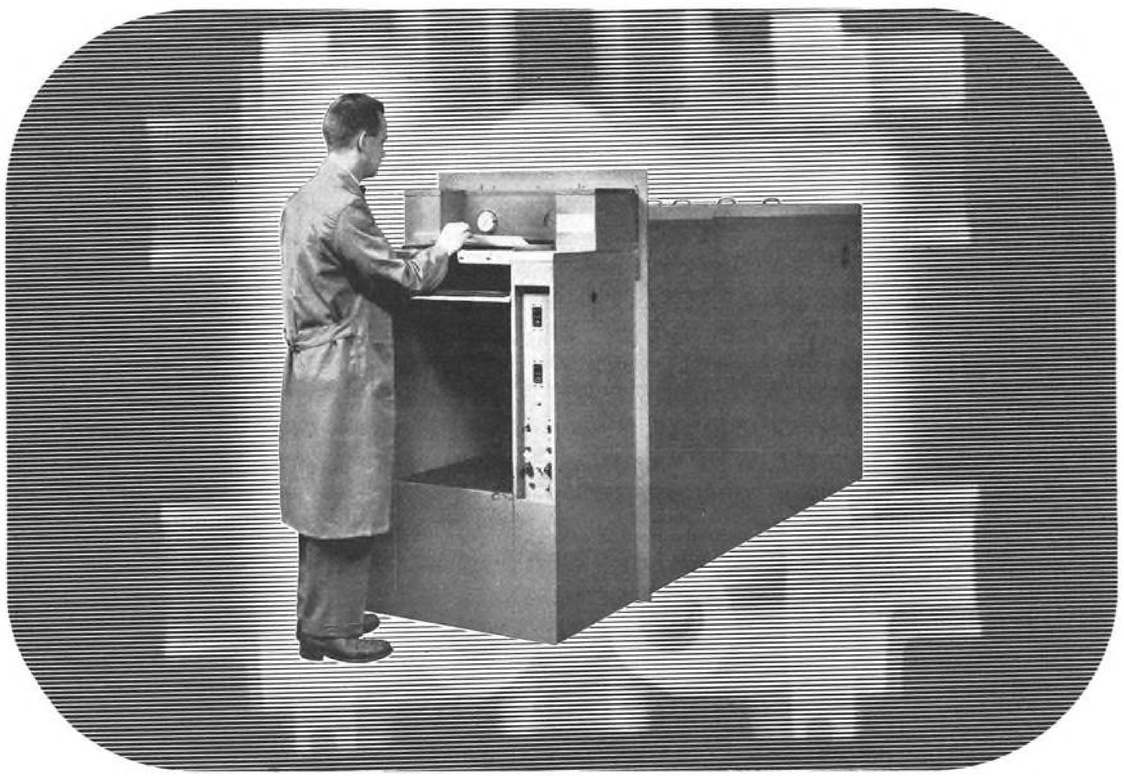
Convair nose cone design for these requirements approximated a 12½ deg. half angle, with work centering on both transpiration cooling and ablating material techniques to protect the payload.

These design parameters and Convair's approaches remained firm contractually for quite some time. First official redirection toward today's Atlas configuration did not come until August, 1954.

Studies Continued

Although configuration of the ballistic missile under Project MX1593 was firm, Convair continued its studies. In the period 1951-53, an area receiving heavy emphasis was staging with many schemes and configurations receiving attention. Included were tandem staging, parallel staging and combination of the two known as tandel. Rubber engines were used in these studies. One vital consideration in

USAF-CONVAIR Atlas intercontinental ballistic missile is equipped with an ablation-type nose cone designed to survive re-entry after launching from Cape Canaveral, Fla.



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staging studies was altitude ignition for second stage. It was desired to stay away from this if possible.

An approach to the staging problem which looked promising at first was an annular configuration, with the outer section being the booster and having the horizontal cross section of a doughnut, with the final stage carried in the doughnut's opening. However, problems of friction in separation, or bending and binding, heat inputs to the booster as the sustainer slid out, caused it to be dropped.

As the company worked on over-all ICBM problems during the 1951-1953 period, Convair came to some conclusions, and in June, 1953, recommended changes in requirements which were:

- **Impact Mach number** be reduced to subsonic, and heat sink technique be used to protect the payload. Heat sink was known to be within the state of the art.
- **Allowable CEP** be extended to twice the existing limit, to speed guidance development.
- **Payload weight** be cut about in half.

Convair, realizing these changes coarsened the weapon system's capabilities, urged that they be adopted in the interests of getting an ICBM faster, and that they should be compensated for where possible and losses accepted where unavoidable.

Changes Incorporated

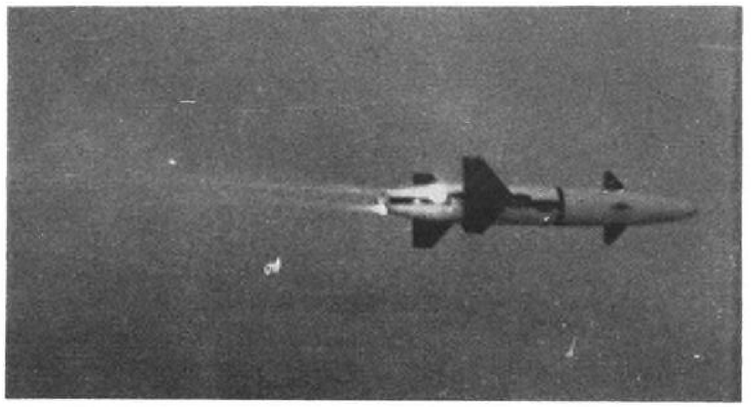
These recommendations were later incorporated into official changes of direction of the program.

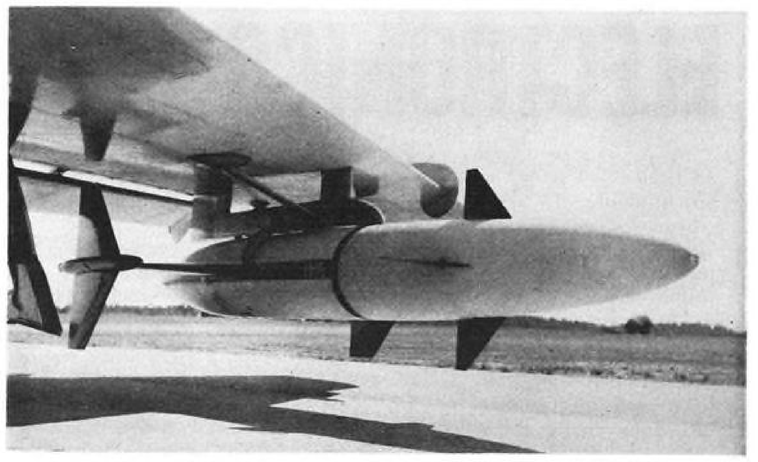
During 1952 and 1953, two particular events which significantly affected the Atlas program occurred.

Although ballistic missiles were still officially being designed around nuclear warheads into 1954, one of the most vital factors in missile technology started undergoing a tremendous change when a thermonuclear device was triggered in the Pacific in November, 1952. This indicated design of smaller size, lower weight but much higher yield warheads for ballistic missiles was possible. This was proved when the first thermonuclear weapon was fired Mar. 11, 1954.

Second occurrence was the establishment in 1953 of the Air Force Strategic Missiles Evaluation Committee under Dr. John von Neumann. This group urged acceleration of Atlas program and endorsed Convair's design approaches, but recommended a sweeping change in management concept of the program to achieve an operational ballistic missile earlier than had been planned.

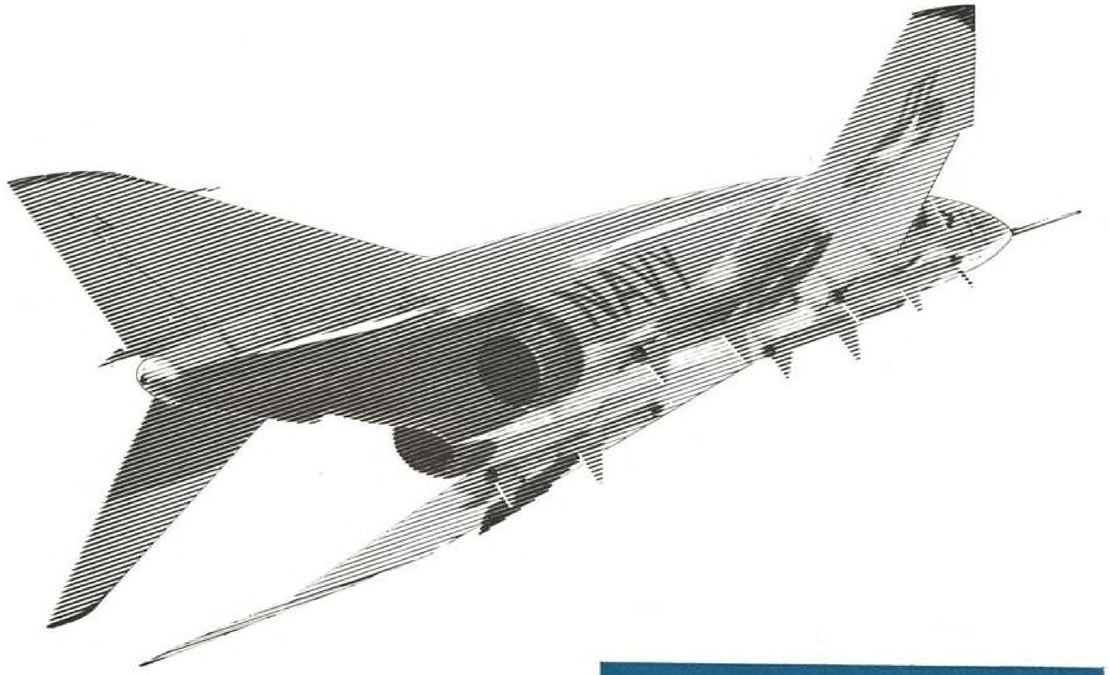
Air Force approved the von Neumann committee recommendations in May, 1954, and moved to align the Atlas program along the guide lines set forth. At approximately this same time, mid-1954, Convair recommendations of 1953 concerning ICBM design require-





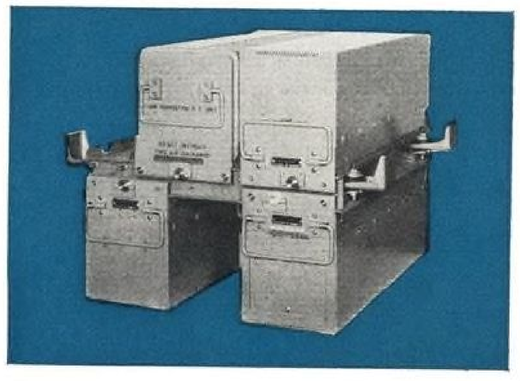
Swedish Test Air-to-Surface Missile

Swedish Type 304 air-to-surface missile was developed as one of many alternate armament installations on the Saab Lansen A-32A attack aircraft. In top photo, port tracking flare on missile has ignited and starboard flare is smoking. No exhaust can be seen from central sustainer nozzle. In middle photo, both tracking flares are lit and Type 304 streaks toward target. Bottom photo shows cylindrical configuration with ogival nose and tail sections. Geometry is canard, with delta wing aft fitted with vertical fins for directional stability. Forward trapezoidal surfaces are for pitch and yaw control. Speed is about Mach 1.2. Over-all length is 15 ft., wingspan 6.5 ft. Range is 2-3 mi. Missile, in quantity production for Royal Swedish Air Force, was developed by government scientists in cooperation with industry.



ABOARD THE NAVY'S F4H

COLLINS ELECTRONICS



McDonnell's F4H-1, Navy's first supersonic, twin-jet, all-weather fighter, adds a new dimension to the Navy's striking power. For the vital functions of communication, navigation and radar identification, this potent new Weapon System employs the Collins-developed AN/ASQ-19(XN-1).

First system of its type to employ the modular design concept advanced by the Avionics Division, Bureau of Aeronautics, the AN/ASQ-19(XN-1) has proven the capability of this concept to meet the requirements of supersonic Weapon Systems yet retain the many advantages of standardized production and field support.

Paving the way to the smooth integration of the AN/ASQ-19(XN-1) with the F4H-1 airframe were: close teamwork of Collins and McDonnell engineers . . . delivery of prototype models well in advance of requirements . . . thorough laboratory testing of the entire integrated CNI system from antennas to indicators.

Extensive testing in an F3H test vehicle and successful completion of the F4H-1's initial flight test program have proven the capability of the AN/ASQ-19(XN-1) to provide interference-free operation, high performance and reliability — a major step forward in Weapon System electronics.

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ments were acknowledged, and changes started to become official.

In August, 1954, Western Development Division of Air Research and Development Command was organized to manage the ballistic missile program.

As Western Development started its management of the ICBM program, the concept was Air Force as weapon system manager while industry contractors worked on various parts of the weapon system under associate contractor relationship. For the technical staff of Western Development, USAF contracted with the firm of Ramo-Wooldridge for technical services, a role which later was expanded to have the company provide technical direction and systems engineering for the ballistic missiles program.

During the late fall of 1954, the Atlas program generally looked like this:

• **Missile itself was changing** from the five-engine, 12-ft. dia. configuration and gross weight of more than 400,000 lb., to the three chamber stage-and-a-half, 10 ft. dia. missile which weighed considerably less.

• **Payload weight**, which Convair had urged cutting in half a year earlier, was reduced to less than what Convair had recommended. Officially, the payload weight had remained fixed for several years past, although in the interim an unofficial acknowledgement had been made of weight reductions and warhead yields which had been taken into consideration in calculations. What had been verbal agreements on payloads obtainable with thermonuclear technology advances were firmed and action accelerated to attain desired design values of weight and yield.

• **Various portions** of the missile development were to be given to a new lineup of associate contractors under new management concept, and last of the contracts was signed in early 1955.

North American Aviation's rocket engine division, Rocketdyne, was awarded the associate contract for the Atlas propulsion system in August, 1954. Basic booster now was to be two thrust chambers of the Navaho type, but using JP4 liquid oxygen propellants instead of alcohol-liquid oxygen, with a design thrust level of 135,000 lb. each. By December, 1954, the design thrust level for booster chambers had been raised to 150,000 lb. each. Development time was to be required for the new 60,000 lb. sustainer chamber, but it was judged that the new engine would be ready when the missile was. From 1952 until this time, North American was working on development of the five chamber engine as a subcontractor to Convair.

After new competitions for guidance and nose cone, in both of which Convair participated, contracts were awarded to General Electric for the now-official subsonic re-entry, heat sink nose cone and a second contract was given the same firm for development of radio-inertial guidance system.

Convair, which retained the airframe contract, had received official notice of redirection of Atlas design starting in August of 1954, when the CEP was enlarged and subsonic re-entry was firmed.

Receiving its contract in January, 1955, for airframe and flight test work, Convair saw its first Atlas, Missile No. 4A fly for 23 sec. June 4, 1957, a first flight in which 90% of the test objectives were achieved. Flight date was just 6 weeks behind objective established when contract was signed 2½ years earlier.

C-130 Transport Modified To Launch Firebee Drone

Aerial launching system for the Ryan Firebee jet target drone, utilizing Lockheed C-130 Hercules turbojet transport, is under development by Ryan Aeronautical Co. and Lockheed Aircraft Corp. Hercules modified to carry four Firebees has made its first flight from Dobbins AFB, near Marietta, Ga., with the drones mounted under the wing. Two more C-130s are being modified for sequence testing at Eglin AFB, Fla.

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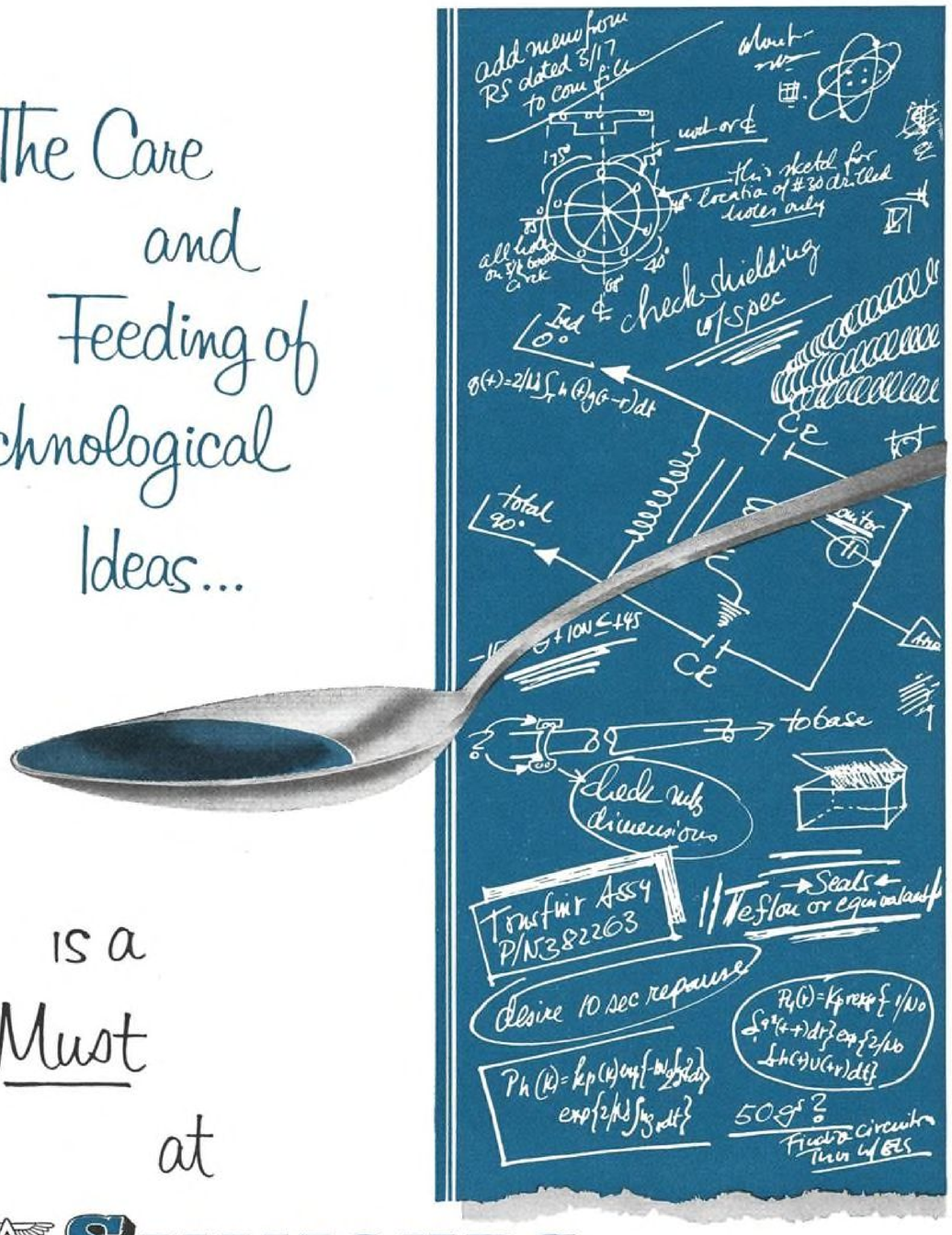

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SAAB DRAKEN receives winter testing at Lulea, Swedish air base 60 mi. south of Arctic circle. Routine includes operational missions.

Swedish Air Defense, Part III:

Sweden Operates Air Base Near Arctic

By David A. Anderton

Lulea, Sweden—Eight months a year, 24 hours a day, the Royal Swedish Air Force fights the winter weather at this base 60 mi. south of the Arctic circle.

From October to May, snowplows and snowblowers are on the go around the clock, keeping runways and taxiways cleared, plowing out and smoothing belly-landing strips, opening roads and apron areas.

On the flight line, technicians work in their wolf-fur trimmed parkas on planes tethered to the apron with steel cables because brakes don't hold on ice.

Operational flights take off and land on slippery runways, sometimes on glare ice, with the runway barrier net waiting at the end of the overshoot area.

This base is headquarters for Sweden's winter test establishment, where new aircraft and equipment are sent for thorough testing on simulated operational missions.

Lulea also is the center of a complex of bases fanning out to the north, where fighters stand on high alert, their engines running and their pilots strapped in, ready to roll on word from the control center.

Finally, Lulea is home base for a photo-reconnaissance squadron and a winter station for transit squadrons coming north for a refresher course in cold-weather operations.

Snow Problem

From October to May, Lulea is subject to snow. A typical storm could leave two to three feet of light, powder snow on the field. This amount never accumulates because of the continuous snowplow patrol maintained at the base.

A single runway, 6,560 ft. x 164 ft., plus its taxi strips, will account for about two million square feet of surface. Covered with the average snowfall, this means about six million cubic feet of snow that has to be removed as it is piling up.

Weight of snow varies, but averages out at a specific weight between 0.2 and 0.3, which corresponds to between 12 and 19 lb. per cubic foot. Total weight of the snow to be removed from the runway and its taxi strips then is on the order of 50,000 tons.

Add to this a second runway, if there is one, or aprons, and possibly an emergency belly-landing strip parallel to the runway and over the frozen subsoil, and the magnitude of the snow-removal job is clear.

Swedish experts in snow clearance have developed a standard type of attack on a snowy field. Using plows, blowers and rollers, they tackle the snowfall shortly after it begins and work continuously until the snow has stopped and the areas are cleared.

Plows are of two basic types: either a standard Caterpillar tractor pushing a diagonal plow, or a loaded truck pushing a V-plow with a wing. The truck is driven at top speed to move the heavier or wetter snows in the south of Sweden, but light powder snows can't be handled in this way.

Behind the plow come the snowblowers, huge units with paired screw feeds passing the snow into the center of a centrifugal blower. Biggest of these units, the 250-hp. Scania-Vabis blower, can toss 10 tons of snow per minute a distance of 75 to 100 ft.

Finally the blowers are followed by

ROYAL SWEDISH AIR FORCE Saab J29C from the 13th Day Fighter Wing at Noorkoping is warmed on the line at Lulea from external power source. Squadrons of the Swedish air force move to Lulea once a year for wintertime operations. Snow removal is a major operational problem from October to May, and aircraft sometimes take off and land on glare ice.

CLOSER view of the same external power source being used to warm a Saab J29C is shown above. Below, a Royal Swedish Air Force pilot puts on one of the sheet aluminum-alloy snowshoes packed as part of his survival kit. Standard one-man life raft serves as bed and shelter; parachute on ground behind pilot provides additional covering. Survival pack (left) is opened, contents spread out near pilot. Second snowshoe is in center foreground.

huge compacting rollers towed by a tractor. This rolling technique, used over a century ago for compacting snow on roads, is applied in a different way to runways. The rollers are towed through the piled-up bank of snow at the edge of the runway, breaking down the sharp lines into a smooth contour. This has three basic advantages; it prevents drifting of the snow back across the runway, it lessens or eliminates damage to an aircraft that runs or skids off the runway, and it camouflages the runway by eliminating the shadow from the sharp edge.

One of the problems which rose out of snow removal was the monotony of the job. Drivers made pass after pass along the runway at low speeds, for long periods of time, in heavy snow, and often at night. There was no scenery to provide relaxation of vision, there was no change of contour, no change of job: just the wearying drive up and down the field, surrounded by snow.

But morale got a boost and the drivers' attitudes changed when they were told simply and truthfully that they were the men on whom the air force depended. If the runways were clear, the planes could operate. Otherwise, they were a grounded air force. The approach worked, and a casual chat with any of the plow or blower drivers gives the observer the immediate impression that they take pride in their work.

What About Ice?

Ice is a completely different menace. At one field we slid helplessly across the slick apron hoping to avoid the refueling truck which was skidding slowly, majestically and sideways toward us.

This underlined the problem. On glare ice, there is nothing that can be done.

Mechanics and ground crew wear grippers on their boots, and have some measure of traction. Some of the road vehicles have tire chains, and also have traction. But chains are risky on the apron, where planes are fueled and there is a chance of spilled fuel. Stray sparks from the chains' impacts with dry patches of concrete make for a big fire risk, which is not worth taking.

The use of chemicals for melting the ice means a tremendous expense, because of the area to be covered and the fact that their use would have to be almost continual. Most of the ice-removing chemicals are salts which corrode metal, and the damage to brakes, wheels, and the underbodies of aircraft would be prohibitive.

For similar reasons, runway and taxiway sanding is difficult. The risk of jet engine damage due to ingestion of the sand or crushed gravel is too great.

Some experimental temporary sanding techniques have been tried, in which the last 1,600 ft. of the downwind end of the runway are sanded on the left hand side only. If the pilot sees that he won't be able to make a normal stop in the usual distance, he steers for the left, hits the sanded area at reduced speed with engine idling to minimize ingestion.

Sanding the apron is out, not only for ingestion reasons, but because of the blast damage that would result from engine runup and planes taxiing.

There is another line problem: engine runup. Brakes don't hold on glare ice, so the airplanes are tethered with steel cables to rings set into the concrete aprons and thus held back during ground runs.

Some inroads have been made against ice on the ramps and aprons by using an ice crusher. This gadget was borrowed from farming, and resembles an ordinary disk harrow. In use, it is towed behind a tractor and breaks the ice surface into small chunks that give much improved traction for men and vehicles. This technique doesn't lend itself to runway applications, because the crushed ice freezes again eventually and its sharp edges would quickly tear tires to ribbons.

When all else fails, there is always the runway barrier. These nets, installed at the upwind end of the strips, have saved many airplanes and pilots. Standard equipment with the Royal Swedish Air Force and 11 other air forces, these Befab overrun barriers were designed by the Royal Swedish Air Board and are manufactured by Borgs Fabriks AB of Norrköping.

The barriers were up at all the runways we used, and there were a couple of times when the sight of the big net waiting there was a relief. One landing made on a slick runway went most of the distance on the icy surface and for a while it looked as if we too would join the lengthening list of crews and aircraft saved by the net.

"You only need to save a couple of overruns to pay for the installation," said one engineering officer.

Personal Equipment

Working on the flight line in Arctic weather is tough duty, obviously. Machines freeze, men freeze, and men freeze to machines. There are no bare hands, regardless of how fine the work, because skin will freeze solidly to cold metal in the north, and the separation is painful. If the work to be done can't be done with gloved hands, the plane goes inside a sheltered area. But the mechanics we observed had developed a surprising dexterity even though they wore gloves, and were able to handle small tools better than we could with bare hands.

Their personal clothing is not elaborate. Over standard underclothing and outer coveralls, they wear lightweight trousers and parkas made of waterproof white cloth and filled with glass fiber insulation. The parka hood can be pulled over the head and covers most of the face. Edges of the hood surrounding the face are trimmed with wolf fur, the only material currently known on which the breath will not condense and freeze to ice.

Boots are standard issue of the Swedish Air Force and have a rubber base and felt top. The design resembles somewhat the Eskimo sealskin boots, which have heavy soles and flexible uppers.

Beards are not worn and mustaches are very rare, in spite of the close ties between the Royal Swedish Air Force and the British Royal Air Force. Shaving is done at night, never in the morning. The reason is that shaving washes off the natural oils secreted by the glands in the skin. Those oils add insulation to the skin and help prevent frostbite.

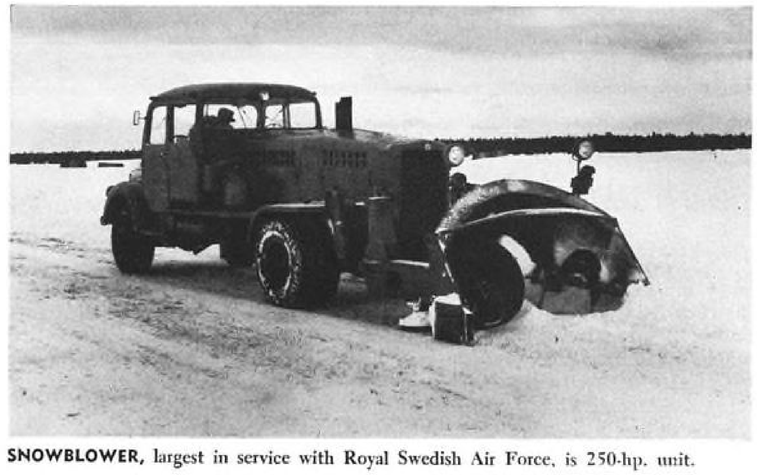
By shaving at night, there is time for replacement oil to be exuded and by morning the face skin is protected once again.

Survival Kits

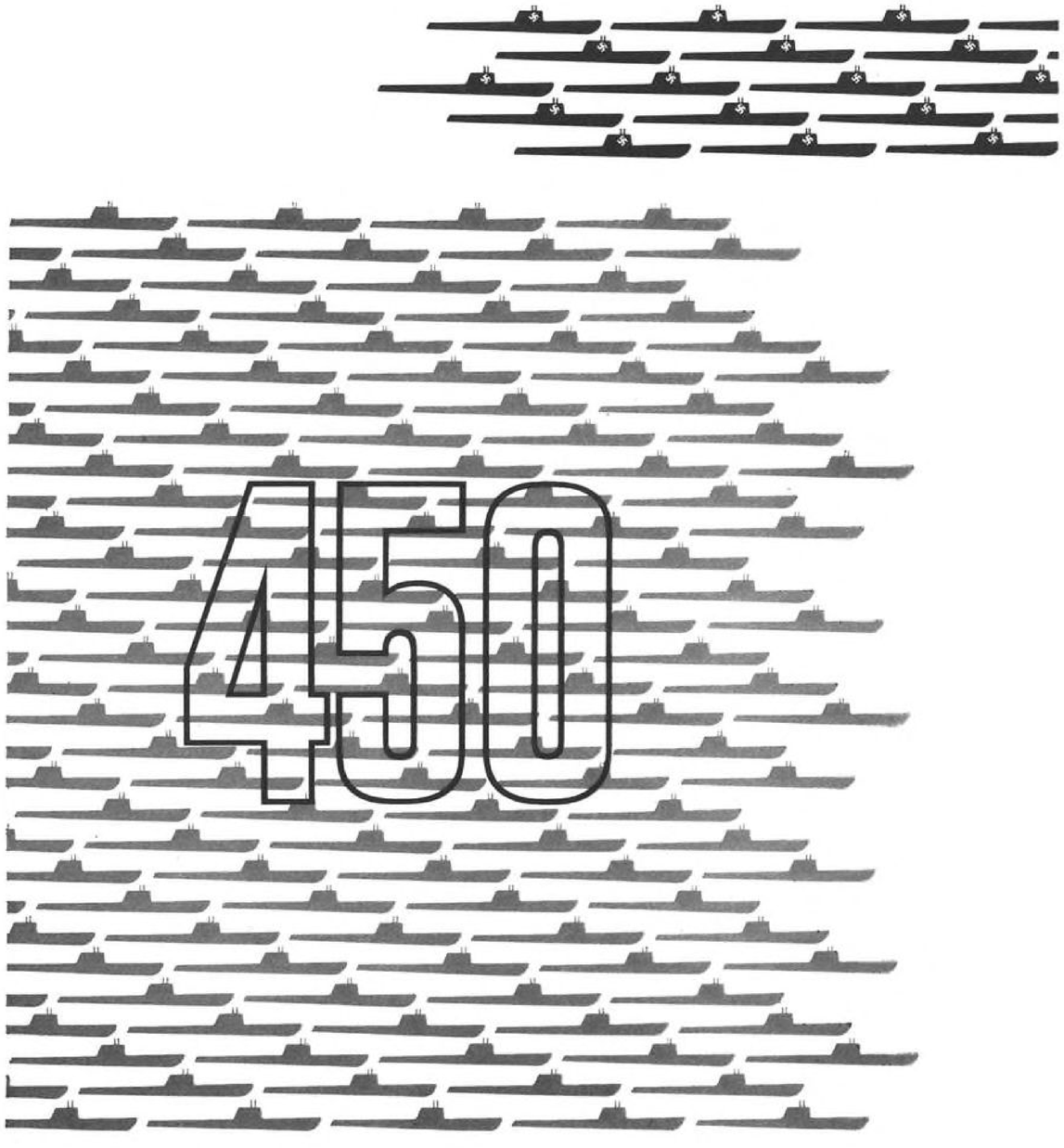
Personal equipment for survival is checked as carefully as a parachute. Packed into a seat cushion under pilot and observer, the standard Swedish Air Force survival kit contains concentrated rations, first-aid kit, fishing gear and a pair of snowshoes.

The shoes are modern adaptations of the classic "bear-paw" snowshoes used in northern countries in many forms for years. They are pressed out of aluminum sheet, curved slightly and grooved in the direction of motion. A handhold has been pressed into the rear portion, and one edge of the shoe has been sharpened and is normally pro-

FOUR snowblowers clear runway area at Lulea as part of round-the-clock fight against weather. Constant snow clearing is the rule for eight months of the year.



SNOWBLOWER, largest in service with Royal Swedish Air Force, is 250-hp. unit.



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Fifty-seven submarines came close to strangling world commerce and knocking the Allies out of World War II. This was Hitler's U-boat strength at the start of the war. Today it's the sobering fact behind estimates of what 450 subs might do. For this is the threat the U. S. now faces. Today's sub is far more powerful than before . . . a more deadly menace to American overseas commerce, 99.85% of which still comes and goes by ship. And today there's the additional menace of sub-launched nuclear missiles, which open our inland cities to possible devastation. If the Free World is to survive, the submarine threat must be solved. Primary fighters in this urgent contest are the men and ships of the Navy.

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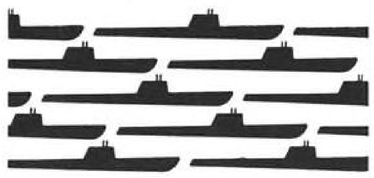

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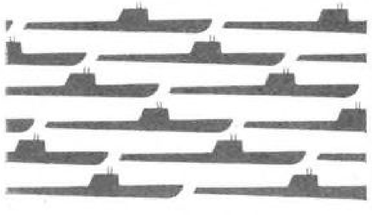
Vought's antisub specialists are analyzing the whole problem. Solutions will require improved devices and methods for detecting and classifying undersea craft. Development of new aircraft, missiles, and control methods is under intensive study.

In whatever direction these studies lead, Vought's antisubmarine warfare task force has the specialists and experience to analyze, design, and produce.



Antisubmarine warfare is just one in the broad spectrum of Chance Vought fields of activity. Other areas include: design and production of high performance aircraft, astronautics, electronics, advanced weapons, range systems management, commercial process control systems.

CHANCE VOUGHT DALLAS, TEXAS

tected with a strip of adhesive tape.

The handhold makes it possible to use the shoe as a snow shovel, and the sharpened edge makes a fairly efficient snow knife for cutting blocks of heavy snow for shelter or igloo building.

Rations for three weeks consist largely of supplementary tablets to maintain proper concentration of blood sugar. "Gourmet" meals of small game or fish must be provided by the downed crewmen himself, which gives him something to do during his isolation, provides some exercise to maintain circulation and helps his morale when he does catch something.

Standard pilots' coveralls carry some of the survival and escape gear. Whistle, compass, knife, smoke flares are part of the coverall, and are on the suit at all times. Over this is worn the standard life jacket, and a parachute back pack, with the parachute made of alternate gores of red and white material for maximum visibility summer and winter. Flying boots are also standard issue.

Tied to the pilot with lanyards are his life raft and survival pack, so that if he has to eject, everything goes with him.

Survival training follows the standard patterns adapted by USAF, the Royal Canadian Air Force and other forces operating in Arctic areas. There is a considerable interchange of information among the nations with cold weather bases, and Canada and the United States have benefited from Swedish experience and vice versa.

One a year, each pilot and crewman of the Swedish air force goes through a survival training course, in which he is sent into the frozen and wild terrain and told to get along. He has his parachute, life raft and survival pack. The parachute and the life raft provide shelter and sleeping accommodations the survival pack gives him the bare necessities for a maximum period of three weeks.

Considerable Difference

Naturally there is considerable difference between such a course—when the subject knows somebody will come to get him in a few days—and the real thing, when the downed pilot has no idea when rescue will come. But the rigors of simply living in sub-zero cold, and collecting food, firewood and water to maintain that life, are enough to train crewmen in a most realistic fashion.

Snow is an enemy almost all the way. How do you mark runways when the snow is deep and there is no visual contrast between the runway and the ground either side of it? Or when the compacted edges give no shadow for visual reference? Or when the wind is blowing and drifting the snow along the edges of the strip?

One way is a temporary set of markers, made of cloth flags suspended in a light metal frame. These frames are driven into the snow, one at each side of both ends of the runway. They carry three flags—the outer two are bright red and the center one is blue—which are free to blow in the wind and therefore never get obscured by snow.

Taxiways are marked with cut evergreen trees jammed into the snowy surface of the border, just as in USAF and other forces.

Taxiway Markings

But the snow and winter weather is not all bad. There are times when the uniform white landscape hides runways and hangars and makes most effective camouflage.

There are also times when, in retrospect, the snow outside didn't seem too bad. It was cold at Lulea when we arrived—not bitter cold, as it had been, but enough to make you notice it. First on the agenda after landing was a trip to the "bastu," the blistering-hot Swedish adaptation of the Finnish sauna bath.

We soaked out the stiffness caused from the Vampire's cramped cockpit and then stood warm and relaxed, drinking from the nearby ample stock of Swedish beer.

Right then, we didn't know—but couldn't have cared—if there were 10 ft. of snow outside instead of 10 in.

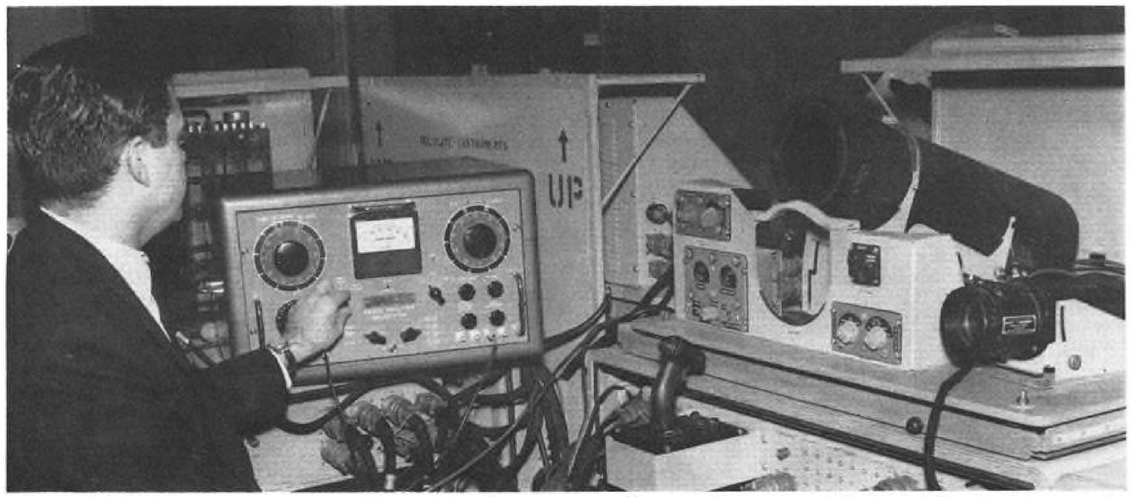
Bell Aircraft Plans German Affiliation

Bonn—Bell Aircraft Corp. and the German machine building company Henschel-Werke GmbH., Kassel, are negotiating a working agreement under which the companies will cooperate in several technical development and manufacturing fields.

The first specific steps under the agreement will be marketing by Bell in the United States of products manufactured partly by Henschel in Germany and partly by one of Bell's U. S. subsidiaries.

Henschel also is to undertake some developmental work for Bell; this work will be related to both defense and civil products to be manufactured in the United States.

Henschel has also reached an agreement with E. W. Bliss Co., Canton, Ohio, calling for establishment of a joint subsidiary, Bliss-Henschel, in Dusseldorf. Bliss-Henschel will build and sell Bliss rolling mills, mechanic-hydraulic presses, special machines and other equipment. Negotiations were mediated by the Norca Machinery Corp., New York, which is Henschel's U. S. representative and Bliss's export representative.



ANTI-ELECTRONIC countermeasures capabilities of radar fire control or guidance systems can be quickly checked in a laboratory or on the flight line on an operational basis, using new test equipment developed by Missouri Research Laboratories, Inc.

Checkout Device Tests ECM Capability

By Philip J. Klass

New York—Recent investigations indicate that many military radars are vulnerable to enemy electronic countermeasures (ECM) because of inadequate design, installation and/or maintenance, Richard W. Hanford told the Institute of Radio Engineers convention.

Hanford described new checkout equipment, recently purchased by Navy and Air Force, which is designed to quickly test the anti-jam capabilities of radar under a variety of different possible countermeasures. Hanford is technical director of Missouri Research Laboratories, Inc., which developed the new testers.

The checkout equipment can be used both in the laboratory to evaluate the effectiveness of basic anti-jam techniques in a new radar, and on the flight line to evaluate operational readiness of anti-jam circuits.

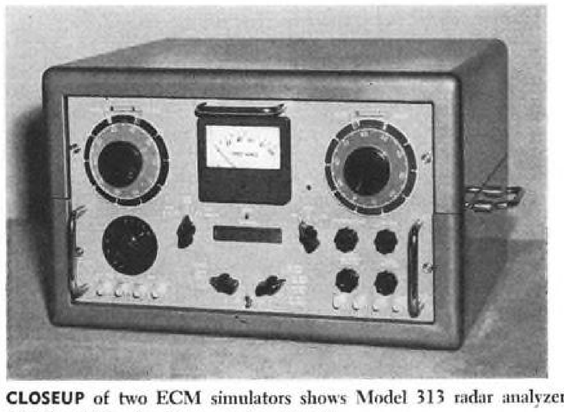
Use of such testers can greatly extend the useful life and reliability of radar fire control and guidance systems by slashing the time required for operational checkout during installation and on the flight line, Hanford said.

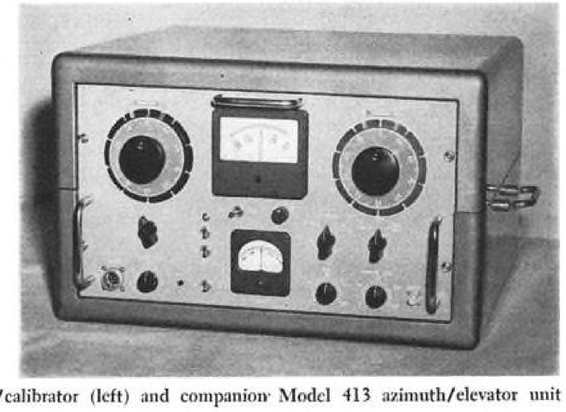
Alarming Condition

Using the testers to evaluate radars now under development and in use, under Defense Department sponsorship, Hanford reported that "features designed-in for a countermeasures environment were found to be produced-out, installed-out, modified-out and/or maintained-out—all unwittingly. Radar test procedures in general ignored the fact that anti-jam features were present in the radar and their disappearance would not normally have been discovered until after the outbreak of war.

"We also found," Hanford said, "that many of the designed-in anti-jam features operated against one another to nullify anti-ECM capability."

A survey of radar manufacturers, aircraft/missile manufacturers who install the radars and users, reported by Hanford, revealed serious voids in testing for anti-jam capability. Although all those surveyed agreed that such tests were "necessary," Hanford said, only this percentage employed such tests:





CLOSEUP of two ECM simulators shows Model 313 radar analyzer/calibrator (left) and companion Model 413 azimuth/elevator unit (right) which simulates moving targets.

• 33%: Rejection of dumped chaff by velocity differential.
• 11%: Rejection of dumped chaff by deceleration technique.
• 44%: Ability to resist range-gate stealing.
• 33%: Ability to track maneuvering targets.
• 22%: Tolerance to self-noise.

Basic Decision

It is necessary to make a basic decision early in the design of a radar whether to attempt to track the target through enemy jamming or whether to shut down and depend upon a built-in memory of past target position, heading and speed to predict future position until the jammer goes away, Hanford said.

But in many instances this basic decision is not made and the system ends up with mutually self-defeating anti-jam features, Hanford said.

For example, a tight range-gage usually is employed to improve signal-to-noise ratio in a radar, in combination with instantaneous automatic gain control (IAGC). However, the IAGC normally optimizes the radar receiver for the jamming signal rather than the target signal when the jammer is within the range-gate. And the tight range-gate increases the radar's susceptibility to being unlocked from the true target, Hanford pointed out.

ECM, Anti-ECM Techniques

Hanford cited a number of different electronic countermeasures and some of the widely known techniques which can be used to counter them:

• **Fortuitous jamming radar:** Pulse repetition frequency jitter, velocity gate, tight range-gate, narrow bandwidth or acceleration-gate.
• **Dumped chaff:** Acceleration-gate, leading edge-trailing edge lock-on with tight range-gate, or velocity differential.
• **Forward-shot chaff:** Automatic frequency track, velocity gate, tight range-gate, or acceleration-gate.
• **Decoys:** Acceleration-gate or trajectory examination.
• **Range-gate stealing:** Velocity-gate, tight range-gate, tight automatic frequency track or acceleration-gate.
• **Rail jamming:** Pulse repetition frequency jitter, velocity gate, tight range-gate or acceleration-gate.
• **Noise jamming:** Closed-loop rate memory for correlation, tight range-gate for improved signal-to-noise ratio or instantaneous automatic gain control.
• **Antenna slewing or inverse** modulation: Use of monopulse radar.

Analysis of the effectiveness of various anti-jam techniques, Hanford said, shows that a velocity-gate is the equivalent, or slightly superior to, an automatic frequency tracking system. Even better is an acceleration-gate, equivalent to a rate-limited frequency tracking system.

However, use of these new discrimination techniques demands a good closed-loop memory and a reacquisition region about the range-gate, Hanford said. It requires that designer consider not only the upper limit tolerances for anti-ECM effectiveness but also the lower limits so that noise or voltage anomalies with the radar itself will not cause the radar to break track.

Similarly, automatic frequency tracking demands tight limits on the rate of frequency excursion so as to accommodate maneuvers of the target but not radical departures which indicate a jammer or decoy. This type system also requires a reacquisition technique to target frequency when subject to noise or jammer perturbation, Hanford pointed out.

Hanford cautioned that any anti-jam technique, if improperly applied or adjusted, can degrade radar performance against legitimate targets. The radar designer must therefore be very selective in choosing anti-jam features to be incorporated.

Missouri Research Laboratories has developed two testers which can be used to check the vulnerability of a radar to electronic countermeasures under actual operational conditions:

• **Radar analyzer-calibrator,** Model 313, provides a simulated radar pulse echo whose range, range-rate, range-acceleration and pulse repetition frequency can be accurately selected and easily controlled.
• **Radar analyzer azimuth-elevation** unit, Model 413, in combination with a Model 313, makes it possible to simulate a target at any azimuth and/or elevation angle, moving at any desired angular velocity or constant acceleration. The difference between target and antenna position, which is system tracking error, is indicated directly on a meter.

Over-all anti-jam capability and performance of the radar can be determined in a matter of minutes using one or more of the Model 313 and 413 in suitable combinations, Hanford said. Test signals can be introduced as RF or video. Here are some of the anti-ECM capabilities which can be determined using the new testers:

• **Maximum** opening and closing rates.
• **Tolerance to self-noise,** by tracking at small velocity differential.
• **Break-track** on large velocity differential to establish whether range-gate can be stolen by fortuitous jamming, rail jamming or repeater jamming and whether it will track forward-shot chaff.
• **Small acceleration accommodation** to evaluate ability to track maneuvering targets.
• **Large acceleration rejection** to evalu-

Possible Counter-Countermeasures*

Type of Countermeasure	PRF Jitter	Tight Range-Gate	Velocity-Gate	Acceleration Gate	Automatic Frequency Track	Other
Fortuitous Jamming Radar	X	X	X	X		Narrow bandwidth
Dumped Chaff			X	X		Leading-edge/trailing edge lock-on with tight range-gate
Forward-Shot Chaff		X	X	X	X	
Decoys				X		Trajectory examination
Range-Gate Stealing		X	X	X	X	
Rail Jamming	X	X	X	X		
Noise Jamming		X				Instantaneous automatic gain control. Closed-loop rate memory for correlation.
Antenna Slewing or Reverse Modulation						Use of monopulse radar.

* Based on paper by Richard W. Hanford, Missouri Research Laboratories

ate whether system will track dumped chaff and certain types of decoys.

- **Rate-memory circuit** time constant measurement.
- **Acceleration tolerance measurement** while in rate-memory.
- **Susceptibility to glint** or other range anomalies.
- **Ability to track** in presence of noise, using auxiliary noise generator.
- **Velocity tolerances** as function of RF levels to determine effects of various jammers or modes of forward-shot chaff.
- **Acceleration tolerances** as function of RF levels to determine effects of dumped chaff.
- **Calibration of range** and range-rate voltage.
- **Optimization of AGC** characteristics, range-gate width and video levels.

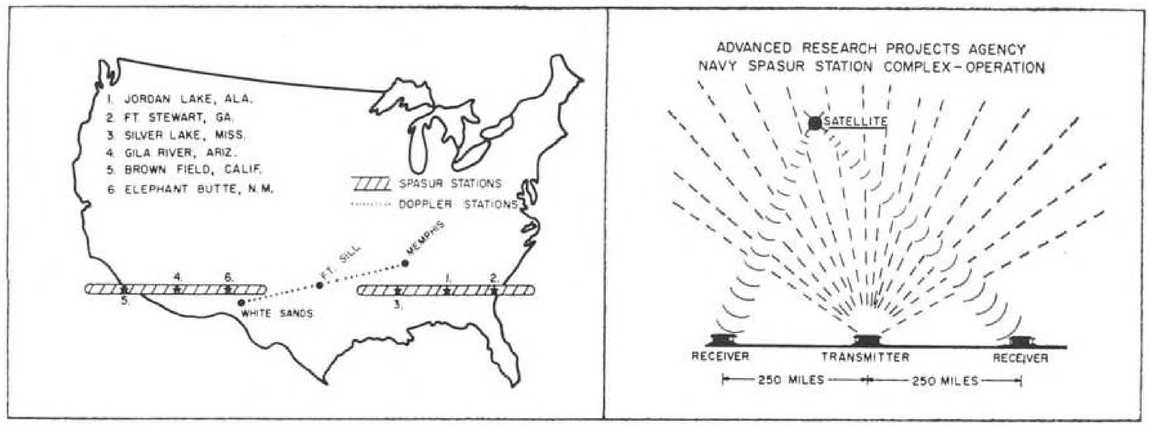
Detailed performance specifications on new electronic countermeasures capability testers can be obtained by writing Missouri Research Laboratories, Inc., 2109 Locust St., St. Louis, Mo.

Expansions, Changes In Avionics Industry

Applied Technology, Inc., is the name of a new firm in Palo Alto, Calif., which will specialize in very broadband microwave systems using traveling-wave and similar beam-type tubes for electronic countermeasures, radio astronomy and reconnaissance systems. Company is headed by Dr. William E. Ayer, president, and Peter D. Strum, vice president, both formerly with Granger Associates.

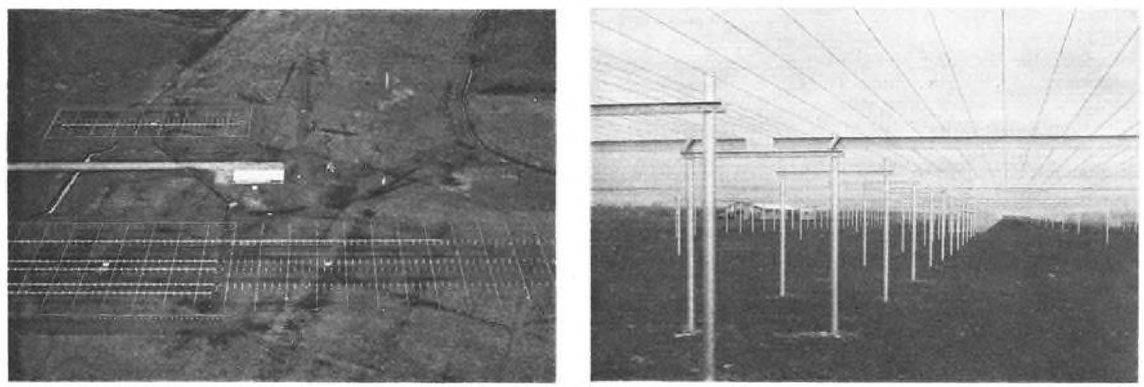
Other recent changes and expansions in the avionics field include the following:

- **Aeronutronic Systems, Inc.,** will build a $20 million research center at Newport Beach, Calif. When this and other new facilities under construction are completed in July, 1960, the company will have a total of 540,000 sq. ft., with another half million square feet planned for final completion by the end of 1961.
- **IMC Magnetics Corp.** is the new name of the former **Induction Motors Corp.,** Westbury, N. Y. Company also reports the acquisition of **Gray & Kuhn, Inc.,** Roselyn Heights, N. Y., which manufactures delay lines, transformers and filters.
- **Texas Instruments** has formed a Geo-Sciences and Instrument Division, to be headed by Fred J. Agnich, vice president.
- **CBS Electronics** is new name of former CBS-Hytron Division of Columbia Broadcasting System. Division, which manufactures tubes, transistors and components, will build a new 160,000 sq. ft. semiconductor plant in Lowell, Mass.
- **Melpar, Inc.,** has opened a new 60,000 sq. ft. plant in the Shirley Industrial Area south of Washington, D. C., bringing the company total to approximately 800,000 sq. ft.
- **Underwood Corporation's** Canoga Division will erect a 20,000 sq. ft. plant near Ft. Walton, Fla., for development and manufacture of telemetry, radar, and instrumentation, much of it for use at USAF's nearby Air Proving Ground at Eglin AFB.
- **Bell Telephone Laboratories** will build a new $20 million laboratory at Holmdel, N. J., for research in advanced communications. BTL currently has a research facility at Holmdel.
- **Stavid Engineering Inc.,** Plainfield, N. J., has purchased the pulse transformer and inductor business of **The Bostick Laboratory,** Tyngsboro, Mass., which has been transferred to Stavid's New Jersey facilities.
- **Kearfott Co.** has started construction of new million dollar, 100,000 sq. ft. facility across from present company headquarters in West Paterson, N. J.

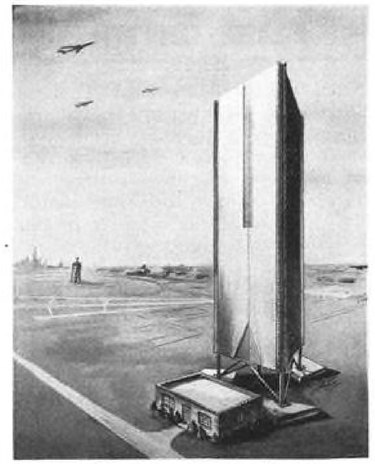


Satellite Tracking Net Established in Southern U. S.

Network of nine stations for tracking satellites without active radio transmitters now stretches across southern portion of the U.S. On each flank are three "SpaSur" (Space Surveillance) stations, developed by Office of Naval Research, which use interferometer techniques, while three center stations developed by Army Ballistics Research Laboratories employ Doppler tracking techniques. Each SpaSur station consists of a radio transmitter which produces a fan-shaped beam to illuminate satellites, and two adjoining stations, located 250 mi. on either side, to receive energy reflected off the satellite. Relative phase of reflected energy is used to establish satellite's position in space.



Elaborate antenna array required for SpaSur station is shown in aerial view (left) and ground view (right). First SpaSur station, at Jordan Lake, Ala., was completed last July; the last station at Elephant Butte, N. M. was finished in January. Data from stations are relayed directly to Washington, D. C., for analysis and evaluation. The silent satellite detection network is under the over-all direction of ARPA.



Height-Finding Radar

W. L. Maxson Corp., New York, N. Y., will develop a height-finding radar system for the Federal Aviation Agency at its Atlantic City, N. J., experimental center under $1.7 million contract. Air Height Surveillance Radar (AHSR-1), employing a fixed three-sided 150-ft. high antenna, will be designed to provide height information on aircraft up to a range of 50 mi. Completion of the prototype system is scheduled for October, 1960.

Robertshaw CAPTIVE SEAL® PRESSURE SWITCHES*

New bulkhead-mounting Robertshaw Pressure Switches represent true miniaturization for your rocket, missile and aircraft applications. Ruggedly built to withstand vibration up to 2000 cps ±35 G's in any direction. Piston actuator is insensitive to vibration fatigue, rapid temperature cycling and extremes of overpressure. These compact Pressure Switches can be grouped on 1.09" centers . . . and even the heaviest one weighs less than 4 oz. Actual sizes are shown above.

• 50 to 600 psi pressure settings • 3000 psi proof pressure (piston bottomed against mechanical stop) • —65° to +300° F ambient temperature range • Vibration: 0-2000 cps ±35 G's in any direction • Handles combustion gases, fuel, oil, H_2O_2, helium, etc. • Switch heads encapsulated in epoxy resin • 20,000 cycles minimum life • Weight: .240 lbs., .170 lbs., .150 lbs. (top to bottom above)

Other Robertshaw Pressure Switches are available to meet your specific requirements on mounting, electrical connections and for pressure ranges from 10 psi to 3,000 psi. Write for Data Sheet J-205.

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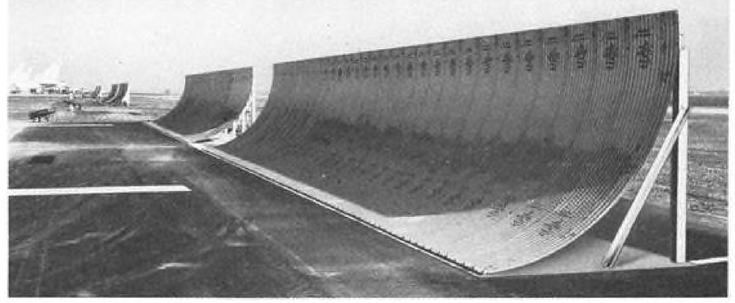
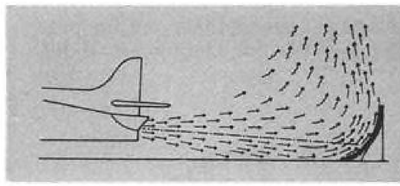


In a relatively short length of time Vinnell-Lynnco Air Curtain Blast Fence has gained widespread acceptance by Government Air Bases and commercial airports. Currently 28 Air Bases throughout the U. S. and territories are being equipped with this modern advancement.

***WHY?* Because Vinnell-Lynnco Blast Fence combines these important advantages...**

1. Unique "Air Curtain" design converts horizontal prop wash and jet blasts into a **vertical** curtain of air that blocks off both low and high-level horizontal blasts!
2. Vinnell-Lynnco Blast Fence is simple — no vanes or louvers to vibrate loose.
3. Scoop effect withstands maximum thrust from largest jet engines.
4. Vertical "air curtain" combines maximum effective height with low silhouette for wide-field visibility!
5. Installation is simple. Standardized parts bolt together — no welding or specialized operations required!
6. Completely galvanized finish requires no painting or other upkeep!
7. Approved for military and commercial applications!



THE "AIR CURTAIN" PRINCIPLE IN A NUTSHELL

Horizontal blast is converted into a vertical air curtain, blocking off both low and high-level blasts.

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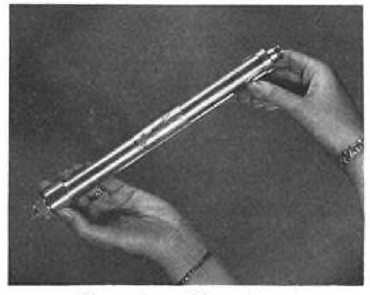
► **Space Vehicle Power Goals**—Current objectives of Army Signal Corps development of secondary power sources for satellites and space vehicles call for availability of a long-life 10-watt power source within a year, a 100-watt source within two years, and a source in the kilowatt range by 1961.

► **New Space Cell Configuration**—Army Signal Corps is experimenting with a new configuration for mounting silicon solar cells to increase available exposed area and generated power. Solar cells will be mounted on surfaces of a bellows configuration which will be compressed during launch to conserve space, subsequently be ejected and allowed to expand once the vehicle is in orbit.

► **Reducing Tube Replacement Costs**—Scientific approach to planned tube replacement in airline avionic equipment, developed by Arinc Research Corp., is expected to reduce in-flight failures and save airlines up to 40% of the cost of in-service failures and maintenance involved in replacing failed tubes. The procedure does not involve complex record-keeping. Highlights are described in AEEC Letter No. 59-1-28, available from Aeronautical Radio, Inc., 1700 "K" St. N.W., Washington, D. C.

► **Private DME-T**—Prior to selecting National Aeronautical Corp. to develop new low-cost DME-T equipment for general aviation, (AW April 20, p. 34), Federal Aviation Agency's Bureau of Research and Development analyzed proposed designs, circuit by circuit, to provide maximum assurance that the device could be produced and sold for less than $1,500, an agency spokesman says. A total of 11 companies submitted bids. Narco is slated to deliver 20 prototype units, starting in 11 months, under terms of its $291,000 contract.



Ferrite Device

New ferrite devices, using internal magnets, slash size and weight to a fraction of former figures, according to Sperry Microwave Electronics Co., which developed the technique. One L-band ferrite isolator is only $\frac{1}{10}$th as large and $\frac{1}{4}$th the weight of predecessors, Sperry says. The technique is being applied over a frequency band of 400 to 11,000 mc. Internal magnet also provides a more effective control field than older external magnets, manufacturer stated.

Infrared Dome

Infrared dome, called the largest IRdome ever produced in one piece, has been delivered to Servo Corporation of America to Naval Air Development Center for use in experimental equipment which will make comparative ground and airborne studies on the effectiveness of different infrared detectors. IRdome is made of arsenic trisulfide which passes infrared radiation out to wavelengths of 12 microns, the company says.

► **Signed on the Dotted Line**—Major contract awards recently announced by avionics manufacturers include the following:

- **Bendix Radio,** contract for more than $350,000 from Navy Bureau of Aeronautics for VHF communications systems.
- **Radio Corp. of America** reports a multi-million dollar contract from Navy Bureau of Ships for study and development of new communications system for Polaris program, presumably to permit long-range communications to Polaris-carrying subs.
- **Sperry Gyroscope Co.,** $877,430 contract from Air Force for 60,000 type 2K25 klystron tubes.
- **General Atronics** reports contract from Lincoln Laboratories to investigate new communication technique for coding and decoding several channels of voice or teletype under adverse propagation conditions. System concept is designated as "Kathleen."
- **National Co.,** Malden, Mass., $5.5 million contract from Navy for an undisclosed quantity of "no drift" radio receivers.

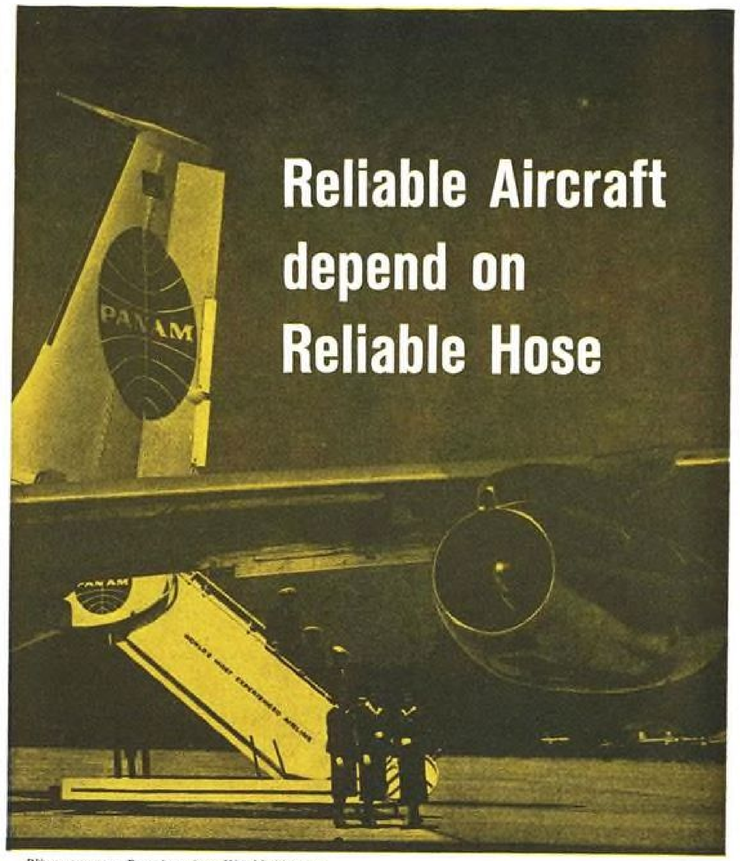


Photo courtesy Pan American World Airways.

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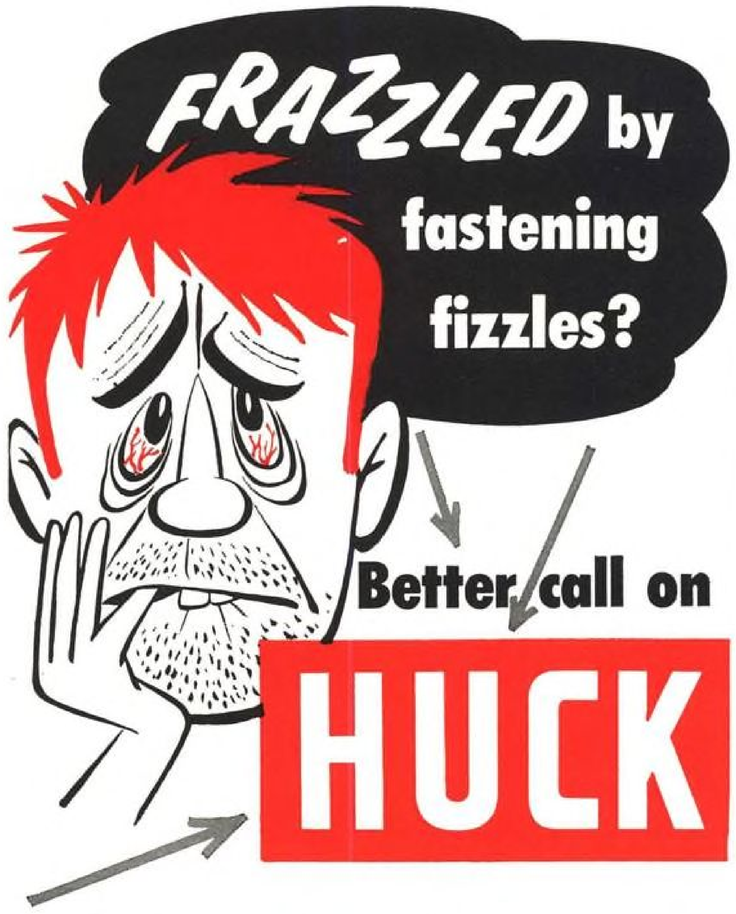

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Navy Contracts

Following is a list of unclassified contracts of $25,000 and over as released by Navy Contracting Offices:

AVIATION SUPPLY OFFICE, 700 Robbins Avenue, Philadelphia 11, Pa.

Parker Aircraft Co., Los Angeles, Calif., valves: fuel, for F11F-1 aircraft, N383-57296A(383/214290/59), $47,786.

Air Arm Division, Westinghouse Electric Corp., Baltimore, Md., transformers: to support radar equipment, N383-58427A-(383/233188/59), 273 ea., $28,938.

Redco Tools Division, Red Lion Cabinet Co., Red Lion, Pa., gages: oil pressure and temperature for various aircraft, N383-58921A(383/262078/59), $88,174.

Lear, Inc., Grand Rapids, Mich., actuators: power unit assemblies, for P5M-1 and -2, and Z5G-4 aircraft, N383-57932A(383/211019/59), $106,737.

Sundstrand Aviation Division, Sundstrand Machine Tool Co., Rockford, Ill., shaft assemblies: to support pumps on various aircraft engines, N383-57425A(383/256013/59), $936,856.

Hydraulic Research and Manufacturing Co., Burbank, Calif., valves: air, used in pneumatic systems on various aircraft, N383-58776A(383/212244/59), 881 ea., $93,-853.

Stratos Division, Fairchild Engine and Aircraft Corp., Bay Shore, N. Y., turbine assemblies: to spuport F4D-1 aircraft, N383-58626A(383/212239/59 and 383/212157/59), $1,785,370.

James G. Biddle Co., Philadelphia, Pa., testers: ohmmeter with self-contained hand generators, N383-59053A(JD-IFB-383-569-59), 209 ea., $28,999.

Whittaker Controls Division, Telecomputing Corp., Los Angeles, Calif., valves: solenoid, hydraulic, for various aircraft, N383-58758A(383/214184/59), $49,251.

Fuel Cell Department, United States Rubber Co., Providence, R. I., floats: right and left hand, to support HUS-1A aircraft, N383-58528A)383/212201/59), $29,235.

Pioneer-Central Division, Bendix Aviation Corp., Davenport, Iowa, preamplifier assemblies: used on converters for F9F-8T and F4D-1 aircraft, N383-58926A(383/211311/59), $29,324.

Army Contracts

Following is a list of unclassified contracts for $25,000 and over as released by U. S. Army contracting offices:

U. S. ARMY ENGINEER DISTRICT, Corps of Engineers, 2301 Grant Street, Mobile, Ala.

Perusisi Construction Co., Birmingham, Ala., construction of hardstands opposite Class and Laboratory buildings at Redstone Arsenal, Huntsville, Ala., contract DA-01-076-ENG-4484 (IFB ENG-01-076-59-69), $85,954.

Chavis Construction Co., Inc., Pensacola, Fla., construction of missile facilities at Eglin AFB, Fla., contract DA-01-0760 ENG-4485 (IFB ENG-01-076-59-62), $477,-883.

Butler & Cobbs, Montgomery, Ala., construction of compressed air facilities at Redstone Arsenal, Huntsville, Ala., contract DA-01-076-ENG-4486 (IFB ENG-01-076-59-65), $67,735.

SAVANNAH DISTRICT, Corps of Engineers, 200 East St. Julian Street, Savannah, Ga.

Hewitt Contracting Co., Columbus, Ga., construction of fiscal 1959 airfield facilities, Fort Benning, Ga., (IFB ENG-09-133-59-6), $989,310.

Williams Construction Co., Columbus, Ga., construction of hangar with shops for airfield facilities Fiscal 1959, Lawson Field, Fort Benning, Ga., (IFB ENG-09-133-59-6), $371,000.

DISTRICT ENGINEER, U. S. Army Engineer District, P. O. Box 61, Tulsa, Okla.

Standard Industries, Inc., Tulsa, Okla., depot maintenance apron, Tinker AFB, Okla., DA-34-066-ENG-5695 (IFB ENG-34-066-5942), $2,030,604.

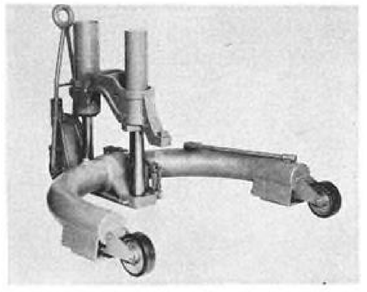
NEW AVIATION PRODUCTS

Oxygen Regulator

Miniature oxygen regulator which fits to pilot's face-mask requires no conscious breathing effort

Regulator weighs 2.7 oz. and is 1.7 in. in diameter and 0.8 in. thick. Currently being produced for the Navy, the regulator is said to have the lowest suction-flow characteristic of any regulator on the market.

Aeronautical and Instrument Division, Robertshaw-Fulton Controls Co., Richmond 19, Va.



Aircraft Jack

Hydraulic jack designed for military fighter aircraft can be placed under jack points 2½ in. above the ground.

Model 2956, Crocodile jack, is available in 10, 17 and 25 ton capacities with minimum jacking heights of 2½ and 3½ in. and hydraulic lifts of 15 and 21 in.

Automatic safety bypass valve prevents lifting of loads which exceed the jack's capacity.

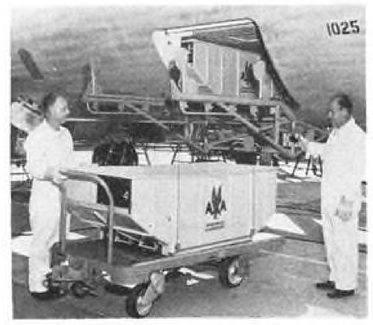
Regent Jack Mfg. Co., Inc., 11905 Regentview Ave., Downey, Calif.

Fuel Heater

Heater, utilizing compressor bleed air, raises fuel temperature to prevent the formation of ice in the fuel systems of jet aircraft. The 18 lb. unit is being installed on commercial jet transports and military jet aircraft.

The heater receives fuel at −60F and heats it to +35 or 45F. Compressor bleed air enters the plate and fin heat exchanger at +450F, exiting at 90F. Air is bled from the engine compressor section as required in order to maintain engine efficiency.

AiResearch Mfg. Division, 9851 Sepulveda Blvd., Los Angeles, Calif.



Airline Baggage Loader

Baggage loader is designed to expedite loading and unloading of passenger luggage on American Airlines' Lockheed Electra aircraft.

System includes glass fiber bins which may carry 400 lb. of luggage and an electrically powered hoist to lift the bins into the aircraft's cargo compartment. Hoist is powered by the aircraft's electrical system. Bins permit luggage to be separated according to destination.

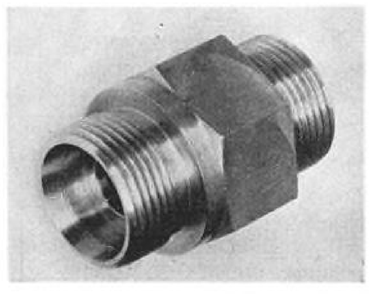
Sancor Corp., El Segundo, Calif.

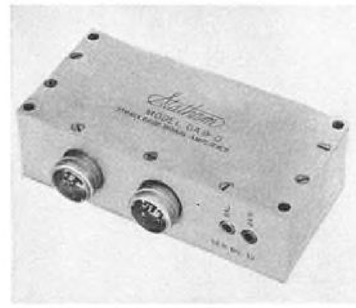
Hydraulic Check Valves

Miniature hydraulic check valves for aircraft and missile applications offer ports for both flared and flareless type tubing connections.

Valves are sized to fit envelopes of proposed specifications MS 24424 and MS 24423. Sizes 4 through 16, in both stainless steel and aluminum, are qualified for Type II System use. Stainless steel valves in each port configuration are suitable for Type III System use.

Hydraulic Division, Parker Aircraft Co., 5827 W. Century Blvd., Los Angeles 45, Calif.





Strain Gage Amplifier

Strain gage signal amplifier is intended to reduce system complexity in airborne applications.

Model GA9 amplifier operates from 28 vdc. input. The single package combines both power source for excitation and the signal amplifier, with self-contained balance and gain controls, delivering 0-5 vdc. output. Frequency response is from 0 to 2,000 cps. Environmental characteristics: ambient temperature range −65 to +165F; operates during 35g vibration and 100g shock. Dimensions are 3.87 x 1.87 x 1.16 in.

Statham Instruments, Inc., 12401 W. Olympic Blvd., Los Angeles 64.

Crash Position Indicator

Radio transmitter will transmit homing signals to search and rescue aircraft in the event of a crash. Transmitter is embedded in foam plastic and designed to be automatically ejected from the aircraft upon crash impact.

The battery-powered transmitter is buoyant and will send a continuous signal for 100 hr. that can be received at a range of 70 mi. under favorable conditions. Dimensions are 27½ x27½ x 6 in.; weight is 11½ lb.

Ultra Electric Ltd., Western Ave., London W. 3, England.

Pressure Regulator

Pneumatic high pressure regulator for missile application is used on Jupiter IRBM. Component handles oxygen, nitrogen, or helium.

Series 16000 regulators are available

missile connectors & assemblies

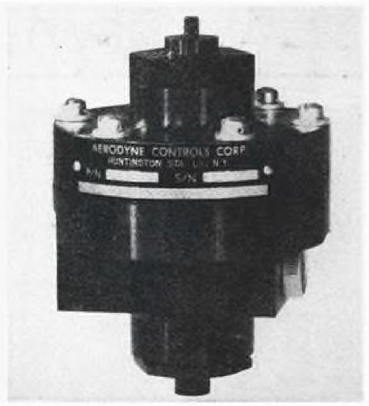
Skill in application engineering, production facilities and experience geared to short or long runs, a proved reputation for reliability—these are AMPHENOL's special capabilities in missile components. The assembly illustrated above reflects these capabilities.

This assembly has four AN/MS "E" connectors wired into a 83 contact shear-type connector and is being supplied in quantity for a production missile. Electrical connection between missile and ground support equipment is provided until the instant of launch when a 3500 pound maximum shear force shears all 83 contacts. All connectors are potted for optimum reliability.

Interstage connectors, umbilical breakaways, internal components and connectors for ground support equipment are now being manufactured for many missile projects. Inquiries on AMPHENOL's special capabilities in this field are invited.

AMPHENOL CONNECTOR DIVISION

Amphenol-Borg Electronics Corporation CHICAGO 50, ILLINOIS



with either internal or remote pressure sensing. Specifications include: Ambient temperature range is from −100 to +300F. Supply air pressure range is from 100 to 3,000 psig. at temperature from −100 to +300F. Air flow capacity of the 1.25 lb. unit is from 0.5 to 100 scfm.

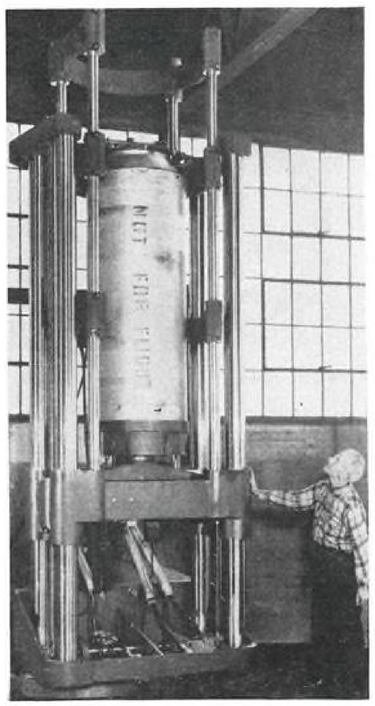
Regulated pressure setting is from 10 to 200 psig.

Aerodyne Controls Corp., 1783 New York Ave., Huntington Station, N. Y.

Rocket Engine Handler

Hydraulically actuated machine, designed for the Thiokol Chemical Corp., permits radiological inspection of solid propellant rocket engines.

Rocket engine is lowered into the machine, moved to the viewing location and indexed and positioned so that all portions of the engine may be viewed. Dimensions of the machine permit the inspection of 6,000 lb. engines, 5 to 10 ft. long and 36 in. in diameter.



Barnes & Reinecke, Inc., 230 E. Ohio St., Chicago 11, Ill.

WHAT'S NEW

Publications Received:

Flying Jet Winds—by C. L. Chandler, P.O. Box 252, Babylon, L. I., N. Y. 46, N. Y. $1.50; 46 pp. (Paper-bound) Drawings and everyday language show the pilot, flight dispatcher, operations officer and others connected with flight operations, the structure of the jet stream and how to fly it. A bill-fold card is included with the book showing the vertical cross section typical jet stream.

Bonded Aircraft Structures—Pub. Ciba (A. R. L.) Ltd., Duxford, Cambridge, England. $7.50; 177 pp.

Everyday Meteorology—by Austin Miller & M. Parry. Pub. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. $7.50; 270 pp. A detailed explanation of the science of weather.

The Aeroplane Directory of British Aviation—Temple Press, Ltd., Bowling Green Lane, London, E. C. 1. 30s net ($4.20); 610 pp.

This directory is an annual reference work which covers aeronautical activity, military and civil, in the United Kingdom and throughout the British Commonwealth, including a biographical section of more than 1,650 entries.

Civil Air Regulations and Flight Standards for Pilots—Aero Publishers, Inc., 2162 Sunset Blvd., Los Angeles 26, Calif. $2.50. Recent government changes in flight rules have been added to this new edition. A sample written test of the type a student pilot must pass to obtain a private pilot certificate is included along with Air Defense requirements, Airport Traffic Control, and instructions on how to read weather reports. Color illustrations are included. The necessary government sectional chart for the examination is provided.

Aviation Directory of Canada—1959 Edition—Published by Aircraft, 341 Church St., Toronto 2, Canada. $5.00; 194 pp. The contents of this directory include Canada's air transport industry; military aviation; civil government departments & organizations; aircraft industry; aviation organizations and sources of supply and services.

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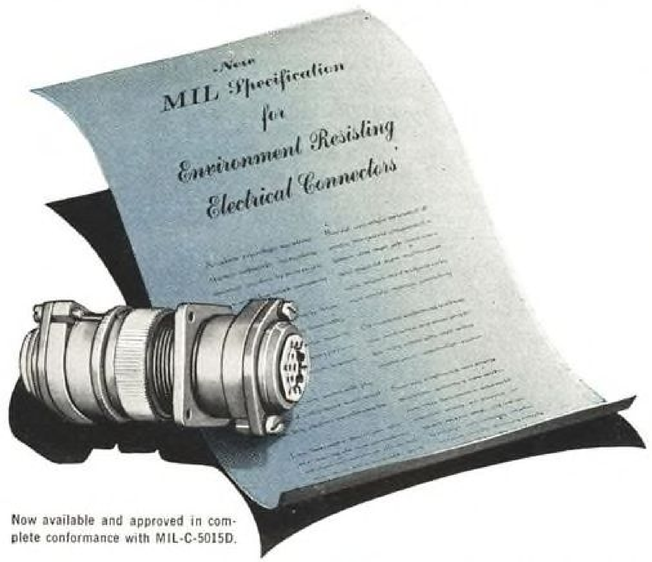
NEW BENDIX MS-R ENVIRONMENT RESISTING ELECTRICAL CONNECTOR



Now available and approved in complete conformance with MIL-C-5015D.

This new connector answers the demand from the aircraft industry for a shorter, lighter and more reliable environment resisting connector. This connector will inactivate practically all other MS types and the Military has assigned a new class letter R to insure incorporation of this better connector in all new designs.

An important reliability feature of the new MS-R connector is an "O" ring at the main coupling joint which provides for the best possible sealing and more positive inter-facial compression and assures complete performance compatibility among all approved MS-R connectors. Establishment of the MS-R connector as the "universal" military connector is testimony to the record of previous MS environmental resistant connectors using resilient inserts as pioneered by this Division. In the Bendix* connector, wire sealing is accomplished by an exclusive slippery rubber grommet which permits convenient wire threading and grommet travel over wire bundles.

Write for more complete information on this latest addition to the ever-growing family of Bendix electrical connectors.

*TRADEMARK

Bendix SCINTILLA DIVISION SIDNEY, NEW YORK Bendix AVIATION CORPORATION

Export Sales and Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y. Canadian Affiliate: Aviation Electric Ltd., 200 Laurentien Blvd., Montreal 9, Quebec.

FACTORY BRANCH OFFICES: Burbank, Calif.; Orlando, Florida; Chicago, Ill.; Teaneck, New Jersey; Dallas, Texas; Seattle, Washington; Washington, D. C.

TRUE PORTABILITY

is why one man can service aircraft or missiles in minutes with Cornelius ground support air compressors

Model 3790109
7 SCFM — 150 psi

Model 3260101
3.5 SCFM — 2000 psi

Model 3750303
3.5 SCFM — 3000 psi

Model 130R1409
2 SCFM — 3000 psi

Model 3800100
4 SCFM — 3000 psi

Model 130R3500
2 SCFM — 3000 psi

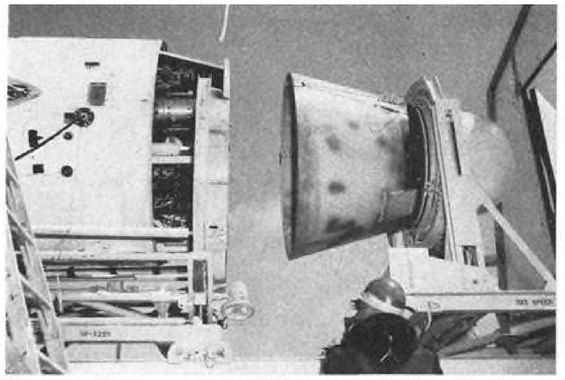
Cornelius ground support air compressors are light enough to be handled by one man but don't let their small size deceive you! When it comes to performance they provide pressures up to 3000 psi and air delivery up to 4 SCFM. Cornelius compressors can often be wheeled into service and complete jobs faster and easier than motorized equipment. They are ideal for "retriever" service because they are easily and economically flown to stranded aircraft.

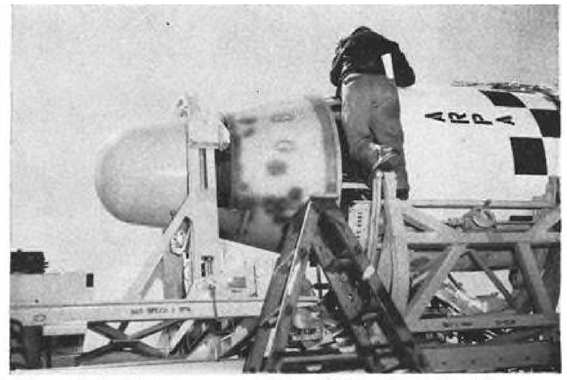
A complete Cornelius ground support service system includes compressor, moisture separator, oil filter, inlet filter, relief valve, pressure gauge and high pressure hose. Pressure reservoirs, back pressure valve, pressure regulators and chemical driers are optional. Gasoline engine drive, hydraulic or electric motor drive as well as turbine drive can be used to power Cornelius equipment. All U. S. military services use Cornelius compressors. Aircraft, missile, flame thrower and underwater demolition support are a few of their current applications.

Cornelius also manufactures compressors only, for mounting on your own multi-purpose ground support carts. In addition, a complete line of small industrial compressors (up to 3000 psi discharge pressure) for OEM, lab work, production test work and maintenance are available.

For true portability, one man operation and reliability in a small, compact, low cost ground support compressor, talk with a Cornelius sales engineer or write today for more information.

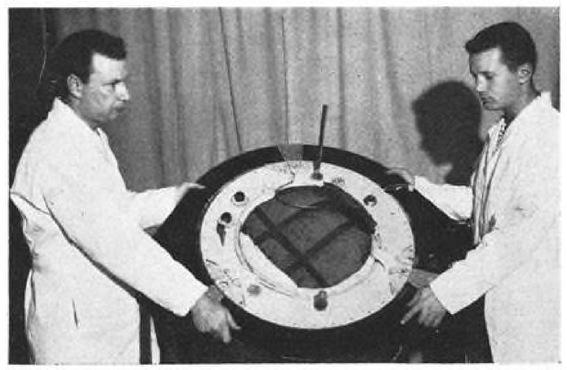
THE Cornelius COMPANY
AERO DIVISION
554 - 39th Avenue N. E. • Minneapolis 21, Minnesota
Pioneers in pneumatic systems for aircraft.



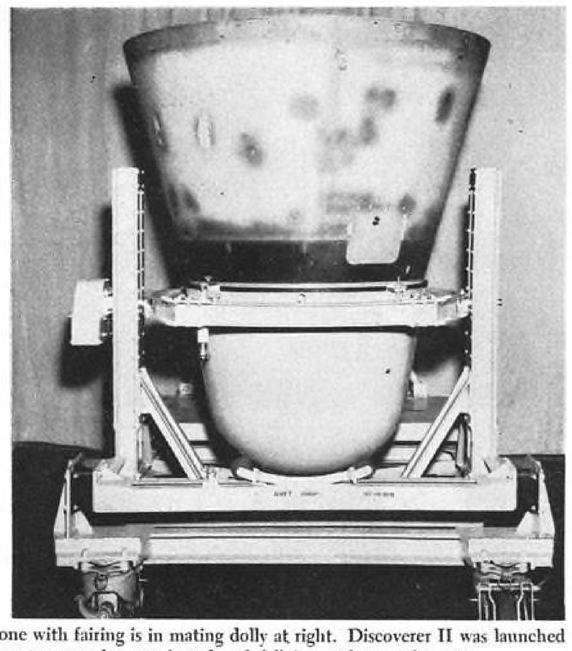


Discoverer II nose cone and fairing are attached to the Advanced Research Projects Agency satellite vehicle's afterbody. Nose cone includes an environmental package within a recovery capsule, an afterstructure supporting a retrorocket, and the fairing assembly.

Lockheed Assembles Discoverer II Nose Cone Unit



Environmental capsule (left) is placed in recovery capsule which contains parachute and beacons when fully assembled (right). Lockheed designed and fabricated second stage, which carries the recovery capsule. Booster is a modified USAF-Douglas Thor IRBM.



Retrorocket is attached (left) to afterstructure. Fully assembled nose cone with fairing is in mating dolly at right. Discoverer II was launched April 13 from Vandenberg AFB, Calif. (AW April 20, p. 26). Re-entry capsule was ejected and fell in northern polar area.

H. J. Bürchel

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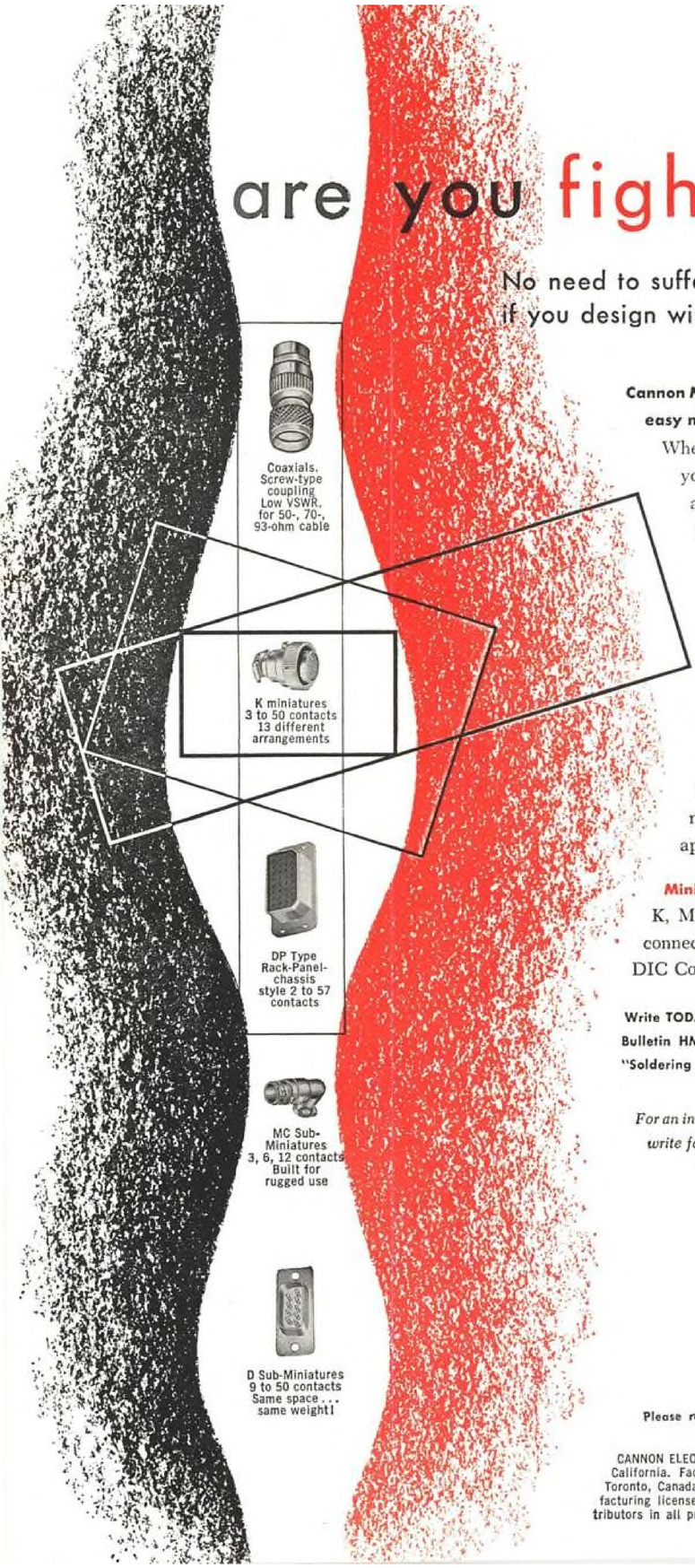
No need to suffer from engineering claustrophobia, if you design with **CANNON PLUGS** in mind!



Cannon Miniature and Sub-Miniature Plugs are rugged, easy mating, unusually versatile, neat and compact.

When you design with Cannon Miniatures in mind you'll get complete electrical circuit dependability in a very small space. Up to 50 contacts in ½ or ⅓ the area taken by standard multi-contact connectors!

Rectangular and circular types. Hermetically sealed, vibration and moisture resistant, and general purpose designs. Contacts for 5, 10, 15, 25 amps . . . and miniature coaxial connectors. Practically all five ampere contacts are gold plated. High dielectric insulation in phenolics, resilient materials, glass seals, Zytel, Diallyl Phthalate and Melamine. Aluminum alloy or steel shells, depending upon application.

Miniature lines include: DPA, DPX, DPM, DPG, K, MM, MR and Diamond MB and SM Coaxial connectors. **Sub-miniatures:** D, MC, and Diamond DIC Coaxial connectors.

Write TODAY for new 32-page 2-color Miniatures Bulletin HMC-2. Also, write for Bulletin SM-1, "Soldering Small Contacts."

For an interesting discussion of the broad subject of "Reliability," write for Cannon Bulletin R-1.

CANNON PLUGS

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Please refer to Dept. 110

CANNON ELECTRIC CO., 3208 Humboldt Street, Los Angeles 31, California. Factories in Los Angeles; Salem, Massachusetts; Toronto, Canada; Melbourne, Australia; London, England. Manufacturing licensees in Paris and Tokyo. Representatives and distributors in all principal cities. See your Telephone Yellow Book.

CANNON ELECTRIC

McKINNON G-21C demonstrator takes off. The Grumman Goose amphibian conversion can take off from 2,000 ft. of runway or water.

McKinnon Delivers First G-21C Goose

By Craig Lewis

Las Vegas—McKinnon Enterprises has its four-engine G-21C conversion of the Grumman Goose amphibian in production and the first airplane off the line has gone to the Everbright Sign Co. Future production will be scheduled on the basis of firm orders. McKinnon estimates two months for the conversion job at its plant near Portland, Ore.

Based on the two-engine G-21A Goose hull and wing, the G-21C has four Lycoming engines replacing the two 450-hp. Pratt & Whitney radial powerplants and individually retractable floats (AW Feb. 17, 1958, p. 101). Gross weight is increased from 8,000 lb. to 12,499 lb., and top cruising speed is 240 mph. The McKinnon amphibian will cruise at 200 mph. at 10,000 ft. with 60% power, and it will cruise at 175 mph. on three engines and at 135 mph. on any two engines.

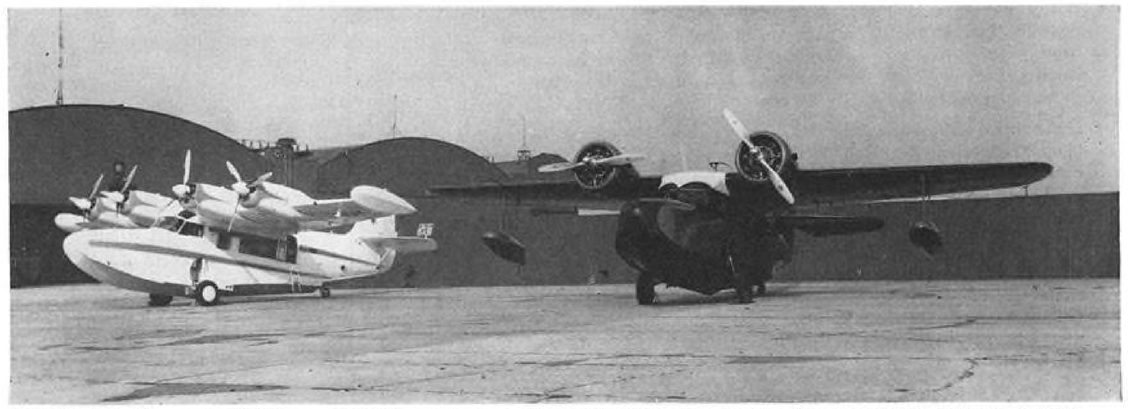
G-21C Performance

Rate of climb for the G-21C is listed at 2,000 fpm., and ceiling is 25,000 ft. Range is 1,500 mi., and fuel consumption for economy cruise is 56 gph. McKinnon says the amphibian will operate out of 2,000 ft. of runway or water, and time off the water is 8-16 sec.

The G-21C represents McKinnon's second amphibian conversion program. The company has been turning out the Super Widgeon for seven years. Work has been in progress on the G-21C for over two years, and first flight was made in January, 1958. After 10 months of testing, a Federal Aviation Agency Type Certificate was issued on the converted Goose.

The G-21C demonstrator is priced at $295,000, but prices on production jobs will vary with the equipment ordered. McKinnon says it would cost a large manufacturer $450,000 to produce an amphibian with comparable performance and features.

A complete standard conversion costs $175,000. This price does not include the airplane, airplane overhaul, radio,



FLOATS of the four-engine McKinnon G-21C demonstrator (left) are retracted to the wingtips. **Grumman G-21A Goose is at right.**

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INTERIOR of the G-21C demonstrator was designed by Horton and Horton of Ft. Worth, Tex. View toward the cockpit shows four passenger seats in the forward cabin, plus a three-place couch along the right cabin wall at the rear. Plane can be equipped with radar.

interior or paint. It calls for four Lycoming 340 hp. supercharged GSO-480-B2D6 engines and four Hartzell three-blade, full-feathering, reversible, constant-speed propellers. The aircraft also has a propeller anti-ice system with a 16 gal. capacity.

McKinnon points out that the four reversible propellers make maneuvering on water easy and permit the pilot to compensate for currents and wind. The individually retractable floats allow the amphibian to taxi alongside a float to unload passengers and cargo.

Dorsal fin has been installed to improve stability.

Nose of the G-21C has been extended 13½ in. and streamlined, and it has a glass fiber nose to accommodate radar. A spray rail is installed along the hull in the nose area to keep spray away from the windshield and propellers. G-21C has a curved, one-piece ¾ in. windshield and has two picture windows in the passenger cabin.

Amphibian's landing gear has Goodyear wheels and hydraulic brakes. Main gear retracts into the hull, and the tail wheel is also retractable. Fuel capacity includes two 175 gal. main tanks and an 80 gal. auxiliary. Fuel valves, oil valves, landing gear, all-metal flaps and floats are all electrically operated.

Conversion includes complete dual instrumentation, with dual vacuum pumps, dual electrical power source and alternate static source. Fire prevention is accomplished with fire detection tell-tale and engine smothering systems.

Augmentor tubes have been packed with glass fiber instead of steel wool to decrease engine noise and to increase the life of the augmentors.

Aircraft is structurally beefed to handle 12,500 lb. gross weight, and it has a new floor structure and metallized wings.

Janitrol Heater

It is heated by a Janitrol 100,000 Btu. heater. A number of smaller items complete the conversion.

Cost of conversion can be varied from the $175,000 list price by eliminating a number of these items. For instance, a customer can save $11,000 by choosing 295 hp. Lycoming normally aspirated engines instead of the 340 hp. supercharged powerplants. Or the center section auxiliary gas tank can be eliminated to shave $3,000 off the price. Reductions in other areas are also possible.

In the future, McKinnon will offer Goodrich de-icer boots and a Collins Radio autopilot with the G-21C. Engineering for these items is being done now.

McKinnon G-21C Specifications

Cruise speed, 60% power, 10,000 ft.	200 mph.
Climb	2,000 fpm.
Range	1,500 mi.
Wing span (floats retracted)	50 ft. 10 in.
Length	39 ft. 7 in.
Height (to prop tips)	14 ft. 6 in.
Empty weight	8,500 lb.
Gross weight	12,499 lb. land and water takeoff, 12,000 lb. landing on land
Engines	4 Lycoming supercharged GSO480-B2D6. 340 hp. ea.
Propellers	Hartzell three-blade, full feathering, reversing, 93 in.—constant speed, hydraulically controlled.

USAF Utilizes U-3A At $12.44 per Hour

Wichita, Kan.—Hourly operating costs for the Cessna U-3A military off-the-shelf counter-part of the 310B business plane, based on up-to-date actual overhaul charge cost data, indicate that these airplanes are being operated for $12.44 per hour—$3.54 less than initial analysis anticipated (AW Sept. 29, 1958, p. 81).

The difference in the earlier cost figure of $15.98 per hour and most recent data is attributable to the fact that earlier overhaul figures were based on maximum allowable contract charges for reparable items, lacking sufficient actual overhaul charges at the time, and the current figure is based on actual overhaul costs, indicating that the initial data was conservatively programed.

Air Force commands are currently issued and 21 private pilots' ratings earned. Eight airline pilots and a number of executive plane pilots went through the school last year, the company reports. It notes that growing interest in motorless flight in this country is indicated by the fact that membership in the Soaring Society of America has doubled in the last two years.

Schweizer Expands Soaring School

Increased interest in motorless flight instruction has prompted Schweizer Aircraft Corp., Elmira, N. Y., to expand its soaring school curriculum for 1959, adding a new advanced soaring course which permits rated glider pilots to qualify for Silver "C" rating.

Three of the four courses offered by the soaring-aircraft manufacturer are planned for pilots with powered aircraft experience; the fourth is for beginners. Prices for the various courses: $95 for professional power pilots, leading to a commercial glider pilot rating, which may be accomplished in two or three days; $135 for other qualified power pilots; $195 for the advanced soaring course and $375 for the complete private glider pilot course.

More than 100 students enrolled in Schweizer's glider school last year, 44 commercial glider pilot ratings being

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without E-W cooling units, electronic gear in this hut would burn out in minutes!

The Ellis and Watts Model A-9 Unit that keeps this critical electronic gear cool has a cooling capacity of 9000 BTU's per hour. Without this vital cooling capacity the electronic equipment would burn itself out in a matter of minutes! Wherever electronic gear is used, it creates heat problems. And, in compact airborne huts these problems are especially serious.

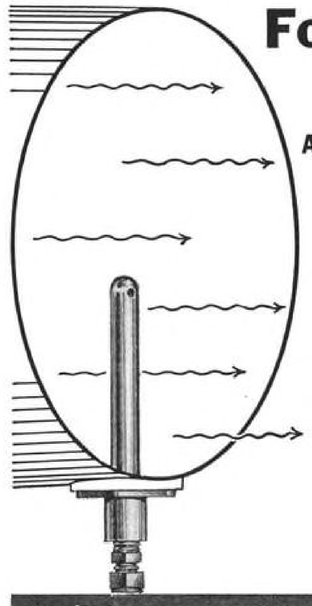
Designing and building specialized units to keep electronic gear cool is our business at Ellis and Watts. Units of any capacity, configuration, control requirements or functions can be designed and built to any applicable military or commercial specifications. E-W Units will function perfectly in any climate conditions on earth.

For additional information on Ellis and Watts Model A-9 Unit for cooling electronic gear in airborne huts or similar installations, write for Bulletin #130-A.

EW

ELLIS AND WATTS PRODUCTS, INC.
P. O. Box 33-A, Cincinnati 36, Ohio

Non-Cooled Thermocouple For High Velocity Gas Streams



At Temperatures Up To 3600°F.

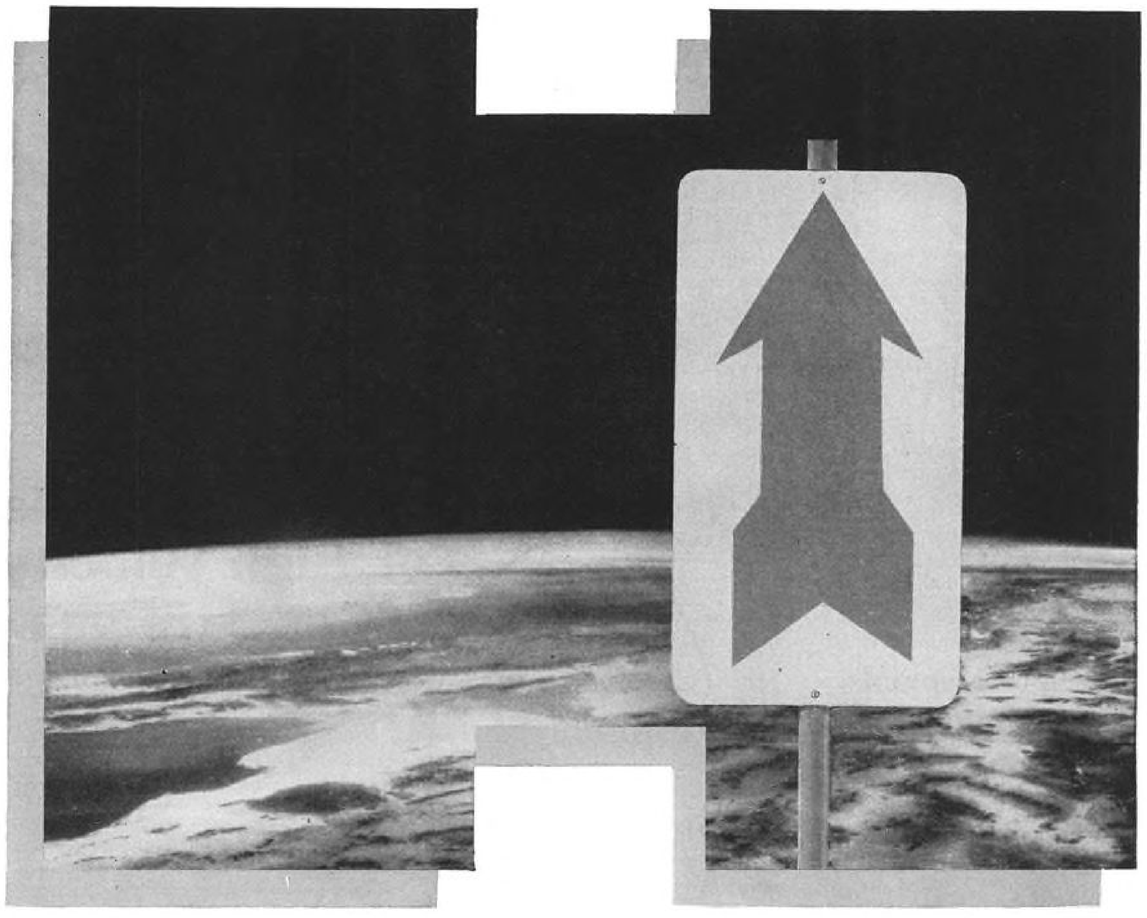
This new thermocouple can be used without water or air cooling in the high velocity gas streams of jet engine afterburners and ramjet and rocket exhausts. It includes a cermet radiation shield and support tube. Conduction errors from cooling are eliminated and installation is simplified. Radiation losses are reduced about 60%. In a typical application this probe endured temperature cycling from 1500 to 3000°F. at a 1500 ft./sec. velocity for 20 hours with no failure. Temperature changes of 2000°F./sec. have created no adverse effects. Conductors used are Platinum 30% Rhodium/Platinum 6% Rhodium to 3000°F., and Iridium Rhodium/Iridium to 3600°F. Contact Thermo Electric for adaptation of this thermocouple to your needs.

Write For EDS-36-C.

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada:
THERMO ELECTRIC (Canada) LTD.,
Brampton, Ont.

Sign of the times



Southern California and Arizona from 143 miles up, *photographed from a Navy Viking 12 rocket, fired from White Sands, N.M. Dark patch at lower left is the Gulf of California.*

Going up... and out into space... this is one of the assignments of engineers in the laboratories at Hughes.

To meet the demands of the Space Age, a wide variety of new projects is being initiated. Here are just a few examples:

Space Ferry Systems—To provide the initial apparatus for space station assembly.

Communications Satellites—Unique packages for space satellite applications.

ALIRBM—Air launched intermediate range ballistic missiles.

Global Surveillance Satellite Systems—To keep the world under surveillance.

Satellite Interception Systems—To destroy hostile satellites.

Meteor Communications—Scattering electromagnetic energy off meteors to establish long-range communications.

Futuristic Instrumentation Displays—Instrumentation displays for satellites and hypersonic vehicles.

Other Hughes activities are also participating in advanced Research and Development. Engineers at Hughes in Fullerton are developing new types of radar antennas which scan by electronic rather than mechanical means. Hughes Engineers in El Segundo develop test equipment which is as advanced as the equipment being tested. At Hughes Products, the commercial activity of Hughes, new ways have been found to *cast* silicon into desired configurations... and storage tubes with 21" diameters have been developed.

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Newly instituted programs at Hughes have created immediate openings for engineers experienced in the following areas:

Field Engineering	Systems Analysis
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Industrial Dynamics	Circuit Design
Digital Computers	Electron Tubes
Microwave Engineering	Industrial Systems
Semiconductors	Development Engineering

Write in confidence, to Mr. R. A. Martin, Hughes General Offices, Bldg. 6-A5, Culver City, California.

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Advanced Falcon guided missiles *are manufactured by the Hughes facility in Tucson... the largest electronics facility in all of Arizona!*

Maintaining liaison *with Air Force Personnel and airframe manufacturers, Hughes Field Engineers give instruction in the over-all systems operation of advanced Hughes equipment.*

Cessna U-3A Bond Room Item Repair

Comparison of New Cost to Repair Cost

	New Price	Air Force Not-to-Exceed Ceiling Price to Repair	Average Cost to Repair
Engine	$3,018.40	$1,961.96	$1,353.42
Magneto	66.62	43.30	36.59
Carburetor	311.58	202.53	85.30
Gyro-directional	147.29	95.74	32.72
Gyro-horizon	169.95	110.47	37.96
Governor, propeller	169.95	110.47	37.02
Vacuum pump	81.51	52.98	18.93
Receiver	351.84	228.70	16.12
Converter	356.77	231.90	22.54
Dynamotor	69.89	45.43	8.02
ARC T-11B transmitter	172.89	112.38	No reparables
Receiver	158.88	103.27	48.92
Indicator	441.52	286.99	68.47
Amplifier	84.87	55.17	47.13
Receiver	793.10	515.52	23.04
Indicator	134.17	87.12	No reparables
Control unit	130.65	84.92	No reparables
Loop	292.36	190.03	No reparables
Receiver	930.53	604.84	35.24
Power unit	204.21	132.74	39.72
Transceiver	1,747.09	1,135.61	36.90
Heater assembly	194.54	126.45	50.87
Propeller	503.05	326.98	213.57
Tach. generator	50.99	33.14	28.50
Pump	165.08	107.30	71.62
Starter	32.04	20.83	20.55
Generator 50 amp	238.84	155.25	39.51
Control panel	133.43	86.73	43.63
Control panel	155.95	101.37	No reparables
Pump fuel	95.74	62.23	35.30
Starter adapter	199.41	129.62	41.33
Titan fuel pump	56.78	36.91	No reparables

flying 158 U-3As—two of the original 160 delivered have been expended. Since initial delivery in May, 1957, U-3As have logged a total of 98,561 flying hours and are averaging 67.69 hr. monthly; Bolling AFB, Washington, D. C., which has 21 airplanes assigned to it, has been averaging 79.4 hr. monthly on its U-3As.

Under the logistical system developed for the airplane, four types of contracts are provided for maintenance, inspection and replacement overhaul of aircraft parts through the Cessna dealer organization (Sept. 29, 1958, p. 81). The number of distributor-dealers working on these contracts has been increased from 16 to 18.

As of Jan. 1, 1959, actual spare parts and contractual cost of reparable bond room items requisitioned totaled $578,011.09; divided by the total of 98,561 hr. flown, this equaled a total cost of actual logistical spares support of $5.87 per hour. Adding hourly labor cost of $3.41 and hourly fuel and oil cost of $3.16 (based on Phase VI test data), total hourly cost comes to $12.44.

PRIVATE LINES

Cessna delivered 315 business planes in March, bringing its total deliveries for first three months of 1959 to 958 airplanes compared with 760 airplanes delivered in the first quarter of 1958 and 598 in the same period of 1957. . . . Total sales for the first six months of Fiscal 1959 came to $47,344,000 including $2,560,000 of sales by its new subsidiary, Aircraft Radio Corp. Sales volume compares with total sales for same period of last year of $44,427,000. Net earnings after taxes for the first half of Fiscal 1959 were $3,615,659, highest for this period in Cessna's history. President Dwane L. Wallace estimates Cessna total earnings for Fiscal 1959 as over $95 million. This compares with $86.1 million in Fiscal 1958. Daily production rate as of mid-April was three Model 150s, three Model 172s, two Model 175s, one Model 180, three Model 182/Skylane, and one-plus Model 310.

Gross sales of $16,357,760 are reported for first six months of its current fiscal year by Piper Aircraft Corp., an increase of 31% over the same period last year. Net income after taxes was $1,249,155, an increase of 28% over similar period last year. March sales of $3,316,586 were the highest monthly total in Piper's history. Company increased production rate from 10 to 12 planes daily as of May 1, consisting of two Apaches, five Comanches and five Tri-Pacers, Caribbeans, trainers and agricultural airplanes.

Cessna 210 four-place business plane, with retractable landing gear, received Type Certificate from the Federal Aviation Agency on completion of its test program.

Annual "open house" will be held by Philadelphia (Pa.) Glider Council at Glider Port, Perkasie, from Aug. 1 through Aug. 9. Camping and swimming facilities will be available at nearby locations. PGC recently added a Schweizer 1-26 to its 2-22, these are in addition to the five privately owned 1-26s and L-Ks.

Cessna Planes Span Near Half-Century

Nearly a half-century of aviation history is spanned by replica of spruce, linen and wire 40-mph. monoplane built and flown by Clyde V. Cessna in 1912 and Model 310C light twin 200-mph.-plus five-place business plane currently being produced by the company he founded. Vic Yingling, owner of Yingling Aircraft, Inc., Wichita (Kan.) Municipal Airport, studies the old-timer's 36-hp. Anzani powerplant. Replica was exhibited at the airport during recent tribute paid by business and aviation leaders to Cessna President Dwane L. Wallace, in recognition of his 25th year with the company.

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:

Olympic Radio & Television Division, The Siegler Corp., Long Island City, N. Y., amplifiers, type ME-1A, Aerno. 60-3861, for supply retrofit, (PR MA-9-05A-590), 6,000 ea., $1,355,160.

Bell Helicopter Corp., Ft. Worth, Tex., H-13H helicopters, spare parts, ground support equipment and technical data, (MIPR R59-900-TCSMC-A), $500,000.

Kollsman Instrument Corp., Elmhurst, N. Y., acquisition and installation of building installations (mechanical and laboratory and testing equipment), (PR 67707), $113,446; engineering assistance on the installation and testing of the MD-1 Astro Compass being installed in B-52 aircraft, PR PE-9-05A-4217, amendment No. 1), $63,000.

John R. Hollingsworth Co., Phoenixville, Pa., mountings, MT-1151/APX-25 for use on B-52, F-101 and KC-135 aircraft, (PR's PW-9-16K1-4252 and MD-9-16K1-55101 and amendment No. 1), 2,867 ea., $27,236.

Aircraft Gas Turbine Division, General Electric Co., Cincinnati, Ohio, turbojet aircraft engines, YJ93GE-9 and related data for B-58 aircraft, (PR EP-9-2840-4450), 5 ea., $1,392,500.

Ampex Corp., Redwood City, Calif., Ampex FR-1107 magnetic tape recorder/producer, miscellaneous components and spare parts, (PR 913159-A and amendment No. 1), $211,275.

Miller-Holzwarth Co., Salem, Ohio, FN-(8) easels, for use on ground photographic equipment, IFB 33-600-59-82, (PR MO-9-16B-1804), 32 ea., $25,548.

Chemical Division, Olin Mathieson Corp., Baltimore, Md., monomethyl hydrazine for testing and evaluation in support of weapon system 138A, (PR EM-9-RD-6296), 12,000 lb., $75,679.

Jack & Heintz, Inc., Cleveland, Ohio, generators, engine driven, 300 amp. 30 v., d.c., AN3633 1A, P/N G300-4B2 for H-19 aircraft, Aerno. 42-2010, IFB 33-600-59-144, (MIPR R59-4312 and amendment No. 1), 100 ea., $45,850.

Westinghouse Electric Co., Dayton, Ohio, high power silicon transistor production refinement program, (PR BM-9-MMP-9083), $150,000.

Lycoming Division, Avco Manufacturing Corp., Stratford, Conn., 126 ea., T53-L-1A shaft-turbine aircraft engines for installation and support of Army HU-1A aircraft, (PR EP-9-2840-4227, MIPR-R59-902-TC), $2,700,000.

American Electronic Laboratories, Inc., Philadelphia, Pa., 1 ea., development model pulse generator AN/UPM-91(XR-1), (PR MD-8-17C-18024), $81,038.

Hughes Aircraft Co., Culver City, Calif., engineering services to provide support to Air Force Cambridge Research Center in planning operation and analysis of the F-106/SAGE integration flight test program, (PR EG-9-11B-4462), $100,000.

Fairchild Camera and Instrument Corp., Syosset, N. Y., 1,035 ea., O-15 clock assemblies; 40 ea., CA-70 cameras for use on aircraft, type unknown; (PR MA-9-6645-373 and MIPR R59-3289-15-NOas), $44,792.

Hughes Aircraft Co., Culver City, Calif., 5 ea., A/ASQ-25 aircraft and weapons control systems for use on F-106B aircraft, (PR EG-9-11B-4510), $866,250.

The Goodyear Tire and Rubber Co., Akron, Ohio, 147 ea., wheel assemblies, nose, 15.00-16, type III for C-133B aircraft, IFB 33-600-59-107 (PR EA-9-03B-4357), $35,160.

Propeller Division, Curtiss-Wright Corp., Caldwell, N. J., 220 ea., blade fairing and heating element assemblies, de-icing, spares for C-124C aircraft, (PR WR-9-1610-210), $1,140,741.

Airborne Instrument Laboratory, Cutler-Hammer, Inc., Mineola, N. Y., design, development and fabrication of one (1) ea., molecular amplifier group; end use will be 2150-2350 mc. telemetering system, (PR 08513), $232,310.

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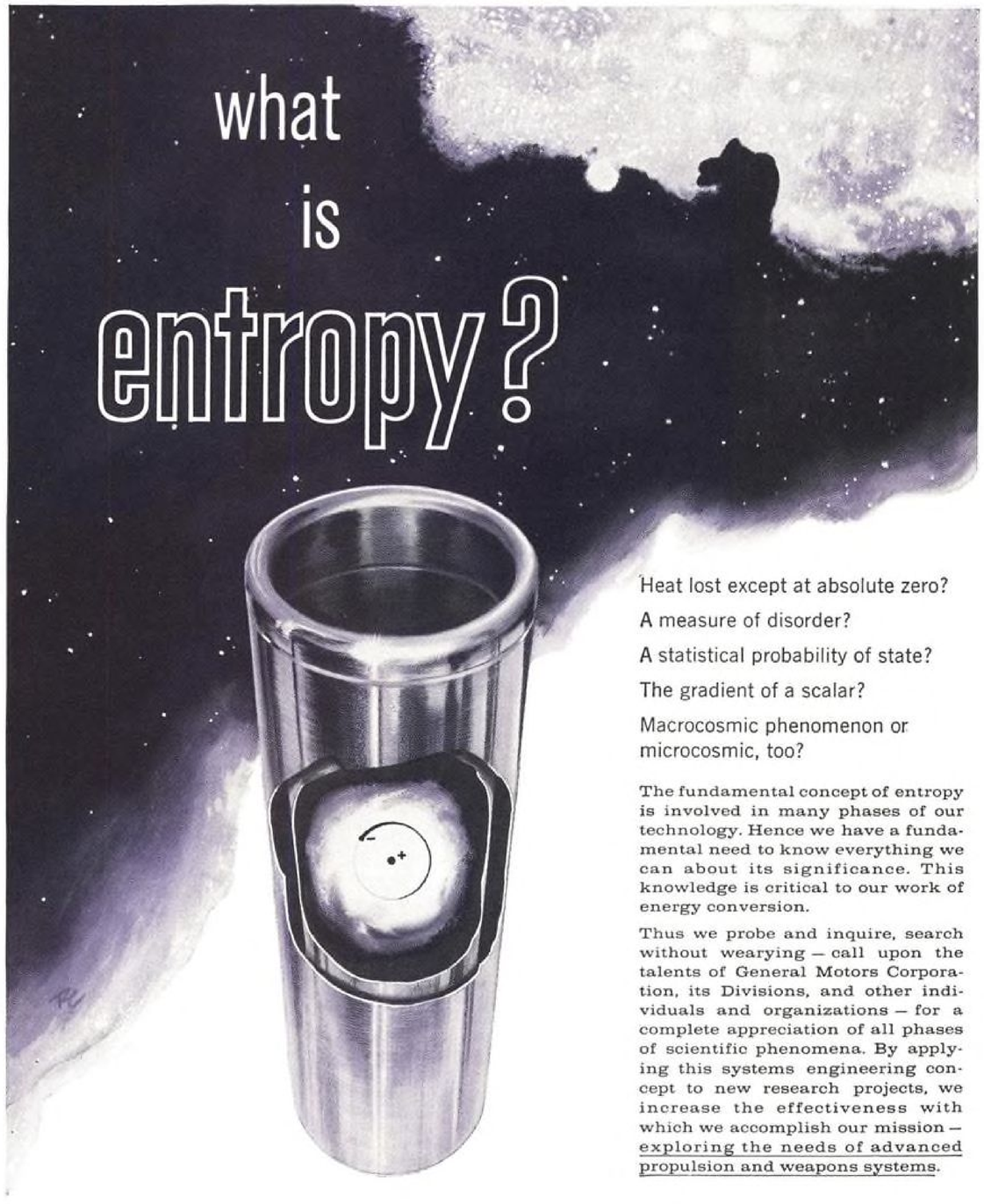

Heat lost except at absolute zero?

A measure of disorder?

A statistical probability of state?

The gradient of a scalar?

Macrocosmic phenomenon or microcosmic, too?

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ALLISON
Division of General Motors,
Indianapolis, Indiana

CAB Accident Investigation Report:

Steep-Turn Stall Causes Viscount Crash

At 2319, April 6, 1958, a Capital Airlines Viscount, N 7437, crashed and burned near Tri-City Airport, Freeland, Mich. All 44 passengers and the three crew members were killed.

Capital Airlines Flight 67, a regularly scheduled flight between New York, N. Y., and Chicago, Ill., was making final approach at Freeland by visual reference to the ground when the accident occurred. While making a left turn to final approach the aircraft was flown beyond the extended centerline of the runway and its bank was steepened considerably to effect realignment. The aircraft was observed to return to level flight and pitch steeply to the ground.

Weather observations at the time indicated a ceiling of approximately 900 ft., rather severe gusty surface winds, and moisture and temperature conditions conducive to a rapid accumulation of ice on the airframe. The stall warning device of the aircraft is believed to have been inoperative at the time of the accident.

The resolution of all known facts is that an unanticipated stall occurred while in a steep left turn at an altitude too low to effect recovery. The greatly increased stall speed in a steep turn, an inoperative stall warning device, and adverse weather conditions are believed to be the primary causative factors relating to this accident.

Corrective Action

As a corrective measure the Board brought to the attention of the Civil Aeronautics Administration the necessity of having the stall warning device on Viscount aircraft function properly at all times. Accordingly, corrective action is being taken by the FAA and the carrier to ensure, insofar as is practicable, that this device functions as is required.

Furthermore, the inadequacies in the wind-observing equipment were drawn to the attention of the Weather Bureau and more modern equipment has now been installed.

The lack of night-time visibility check points is a problem which is not peculiar to the Tri-City Airport at Freeland. Discussions with the Weather Bureau regarding this problem have revealed that they hope to overcome the problem to a large extent by installing automatic runway visibility measuring equipment at all airport weather stations. This visibility program is part of the Weather Bureau's current five year plan.

INVESTIGATION

Flight 67 of April 6 was scheduled between LaGuardia Airport, New York, and Chicago, Ill., with intermediate stops at Detroit, Flint, Trl-City Airport (serving Saginaw, Bay City, and Midland), Mich. N7437, the aircraft to be used on this flight, was flown from Cleveland, Ohio, this date and, because of weather and field conditions at LaGuardia, was landed at Newark Airport, Newark, N. J. Accordingly, Flight 67 was rescheduled to originate at Newark instead of LaGuardia.

The flight departed Newark at 1916, 1 hour and 16 min. late, with a crew of Capt. William J. Hull, First Officer Earle M. Binkley, and Hostesses Ruth M. Denecke and Sue Anne Wessell. Hostess Wessell was among those deplaning at Detroit. The trip to Flint was flown in accordance with an IFR (instrument flight rules) clearance and was routine; the aircraft landed there at 2237.[1]

Flight 67 departed Flint for Tri-City Airport at 2302 and was to be flown in accordance with an IFR clearance at a cruising altitude of 3,600 ft. At the time of departure the gross takeoff weight of the aircraft was 57,091 lb., which was well under the allowable gross takeoff weight. According to company records the load was properly distributed. There were 44 passengers on board.

At 2306, four minutes after takeoff, the flight, pursuant to clearance instruction, reported to Flint tower that it was at 3,600 ft. and was departing the Flint outer marker. At this time the tower requested the estimated time of arrival at Tri-City and was advised that it was 2315. Flight 67 was then given the following clearance: "ARTC (Air Route Traffic Control) clears Capital 67 to hold north of the Saginaw omni range, one minute pattern, right turn, maintain 3,600 ft. Expect further clearance 2320, change to company frequency for this clearance."

This clearance was acknowledged and, as per instructions, the frequency was changed to that of the company at Detroit. At 2310, Capital at Detroit relayed the following clearance to the flight: "ARTC clears Flight 67 for approach at Saginaw (Tri-City) Airport. Report time on the ground to Saginaw radio." These instructions were verified.

The flight then called Saginaw ATCS (Air Traffic Communication Station) and was given the local 2300 weather observation and the runway in use, No. 5. The Tri-City Airport does not have a traffic control tower. The 2300 Saginaw weather was reported as: Measured ceiling 900 ft., overcast; visibility 3 mi.; light snow showers; temperature 34; dewpoint 33; wind northnortheast 18, peak gusts to 27 kt.; altimeter 29.48; comments—drizzle ended and snow showers began at 2225.

At 2316 Trip 67 advised Saginaw radio that it was over the airport. A short time later, ground witnesses observed the lights of the aircraft when it was on the downwind leg of the traffic pattern. The aircraft was seen to make a left turn onto base leg and at this time the landing lights of the aircraft were observed to come on. During this portion of the approach the aircraft was flying beneath the overcast, estimated to be 900 ft., and appeared to be descending.

Fire Erupted

When turning on final, Trip 67 flew a short distance beyond the extended centerline of the runway and the turn was seen to steepen for realignment with the runway. Soon after this the aircraft was observed to level off and then to descend steeply and strike the ground. A large fire immediately erupted. Available emergency equipment was alerted and brought to the crash site. The operators of this equipment observed that there was some delay in making effective use of such equipment due in part to its inaccessibility at the time of the accident and in part to their unsuccessful attempts to initially get it operating.

Investigation disclosed that the aircraft struck the ground in an open cornfield muddied from a previous rain. A large tree, approximately 65 ft. high, was directly in the line of flight and 148 ft. behind the point of impact. There were no marks on this tree made by the airplane during its descent. The wreckage site was 2,322 ft. from the

[1] All times herein are Central Standard based on the 24-hr. clock.

Viscount Stall Tests

Weight	56,800 lb.		55,700 lb.	
Flaps	32–40	40	40	20–40
Angle of bank	L 60	0	L 45	L 60
Stick shaker position	OFF	ON	ON	OFF
Buffet speed (knots)	127	89.5	113	132
"g" break speed (knots)	127	82.5	109.5	132
IAS at stall (knots)	127	75	107	127
Altitude at stall	11,200	12,000	11,310	10,550
Altitude at recovery	10,700	11,600	11,300	10,300
Elevator force at "g" break	84	30	66	96
Elevator force at stall	84	62	72	73
Maximum "g"	2.2	1	1.5	2.44

approach end of runway 5, almost directly in line with the runway. Line of sight from the main wreckage to the end of runway 5 at its centerline was 45 deg. The entire wreckage was confined in an area almost equal to the length and span of the aircraft. It was determined that the aircraft struck the ground on its nose and the leading edge of the right wing, with this wing sufficiently forward so that its leading edge was parallel to the ground. The angle of impact was approximately vertical.

The main wreckage, consisting of the major portions of the fuselage, empennage, and wings, was found lying in an inverted position. Most of the aircraft was consumed by the intense fire which followed ground impact. There was evidence that several minor explosions had occurred. These explosions were caused by the ignition of isolated pockets of fuel which were formed after the aircraft struck the ground.

It was apparent that the nose of the aircraft struck the ground with considerable force. The lower half of the nose section, including the nose wheel bay, was compressed by impact forces into a mass one-fourth of its original size and was buried in the ground.

The upper section, which includes the front entrance; the airstair door; baggage racks; the cockpit area, including control columns, instrument panels, radio racks, pilot seats, etc., was severed from the aircraft and continued along the line of flight. Various parts of this section were found at distances ranging from 35 to 60 ft. from the initial point of impact. Portions of the upper skin of the aircraft, from the windshield rearward to station 337, were found approximately 85 ft. from the point of impact.

Aircraft Components

The entire wreckage was found not only within the stated small area but aircraft components were approximately in their normal positions relative to the structure of the aircraft. Both wings were severely damaged by fire and a great deal of the wing structure was melted. The bottom spar caps of the wing were completely burned out in places. The entire wing spar webbing was gone except at wing section attach points. The upper skin of the wings, which was lying adjacent to the ground because of the upside-down position of the aircraft, in some instances, was practically all that was left.

The push-pull rods, a part of the control system of the aircraft, were not intact because portions of these rods, which are made of aluminum, had melted. The flight controls in the tail section were intact and functioned normally when tested. Examination of all of the damaged controls failed to reveal any evidence of their malfunctioning prior to impact.

It was determined from examination of the flap system that the flaps were selected to the 40-deg. "Down" position and also that they were extended to this position. Most of the instrument gages were so badly damaged it was impossible to obtain readings, and the gages which could be read were of little significance.

The fuselage was badly damaged and little could be gained from its examination. All seats from the main cabin area had been torn out and were distributed throughout the entire wreckage area. Seat belts, which were found, indicated that these belts had been fastened at the time of impact. From the rear pressure bulkhead rearward there was little damage except from external fire on the right side caused by burning fuel. The top one-third of the vertical fin and rudder was bent 90 deg. to the left on impact with the ground. This damage was caused when the aircraft turned upside-down. The left horizontal stabilizer and elevator were essentially undamaged except for some wrinkles. There was considerable fire damage to the aircraft structure back to the rear entrance door. From this point rearward fire damage was confined to the right side.

Gear Position

The nose gear and the main landing gear were determined to be in the "Down" position at the time of impact.

The nose gear Downlic switch, a part of the stall warning (stick-shaker) circuitry, was found mounted in its normal position on the aft side of the nose strut with its wires still attached. The rubber boot that covers the wires over a distance of approximately four inches from the switch had been partially burned away. However, the rubber boot over the switch plunger was still in position and was undamaged.

Prior to checking the switch electrically, a number of actuations of the plunger were made but no audible operation of the switch was heard nor could contact of the points be felt. Subsequent inspection disclosed that although the operating plunger was in the withdrawn position the rocker or armature subassembly, which supports the movable switch contacts, was in the position it assumes when the operating plunger is depressed. This position permitted the switch contacts associated with the stall warning circuit to be in contact at all times regardless of plunger position. Initial electrical checks disclosed no continuity between these contacts; however, during subsequent checks by the examining group and tests conducted by the National Bureau of Standards continuity did exist between the closed contacts.

The switch contacts in question are normally open in flight and are closed upon landing by movement of the operating plunger, whereupon the stall warning system is rendered inoperative. Upon becoming airborne the plunger is withdrawn permitting the rocker subassembly to be returned by spring force, thereby opening the contacts and arming the stall warning circuit.

Magnet Positions

It was found that the rocker would return to normal when the lower magnet was removed but would remain in the depressed position when operated with the magnet re-installed. A similar behavior was noted with the two switch magnets interchanged. Upon restoring the magnets to their original positions, the switch operated properly and continued to do so. It was also determined that the sensing unit of the stall warning system was installed April 28, 1957, and was not calibrated prior to the accident.

In addition to the examination of the

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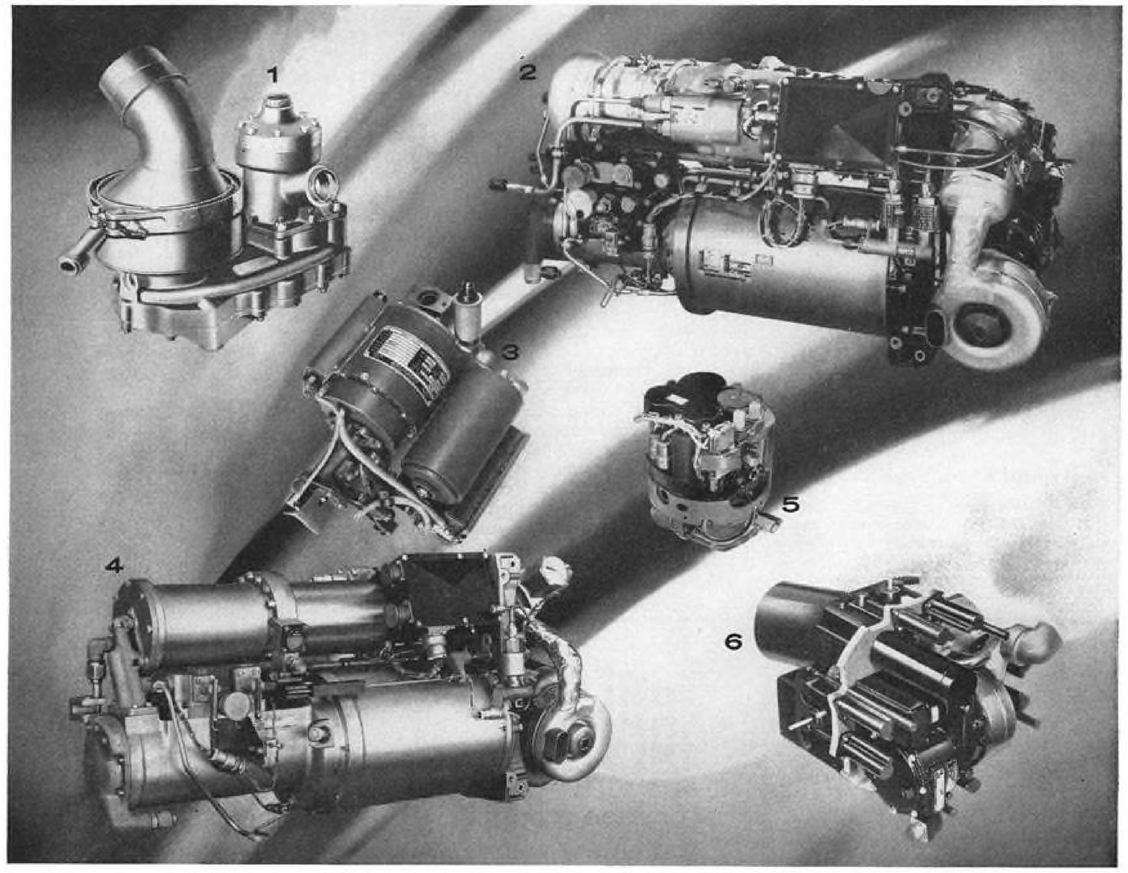

1. *Solid propellant—hydraulic output* 2. *Liquid propellant—hydraulic and electric output* 3. *Solid propellant—electric and mechanical drive output* 4. *Liquid propellant—hydraulic and electric output* 5. *Solid propellant—hydraulic and electric output* 6. *Solid propellant—hydraulic, electric and steering outputs*

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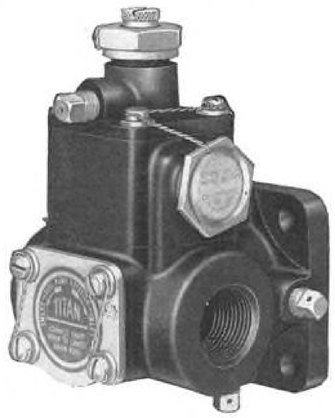

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nose gear switch, the National Bureau of Standards conducted static and dynamic acceleration tests on four similar switches and the test results indicate the extreme improbability of the nose gear switch malfunction having been the result of crash impact.

All four engines and their respective propellers were forward of the wing spars in a straight line and were in about their normal positions relative to their respective attach points on the aircraft. No. 2, 3, and 4 engines were buried in the ground to a depth of about five feet. No. 1 engine had struck a gravel pile and had penetrated into the ground to a lesser depth. All engines lay inverted nose down with their rear portions angled 45 to 70 deg. with respect to the horizontal. The engines separated from the aircraft at their respective mount feet and adjacent structure, and as a result of impact forces were damaged in varying amounts.

The immediate cases of all engines were broken permitting the separation of the turbine end components. These parts were found lying reasonably close to the remainder of their respective engines. All engines were damaged by ground fire following impact. There was no powerplant fire damage of the nature associated with in-flight fire. Engine controls were severed in such a manner their position prior to impact could not be determined.

All turbine shafts were broken as were three of the second stage impeller shafts. Main rotor shaft bearings as well as other bearings throughout the engines did not show any signs of operational distress. Lubrication had been inadequate in each instance. The observed damage was consistent with that caused by axial loading to which these parts were subjected at impact. The high pressure turbine blades and the nozzle guide vanes of all four engines were splattered at random with bits of molten metal.

Engine accessories were functionally tested or, if this was impossible because of damage to them, were disassembled and examined. All appeared to have been capable of normal operation prior to impact. Three fuel trim actuators were recovered and these were found positioned to "full increase trim." Separation of the turbine sections from the remainder of the engines resulted in many combustion chambers coming detached. The ensuing detailed examination of the damaged engines and their accessories did not reveal any condition which indicated maloperation prior to impact.

The four propellers were imbedded in the ground adjacent to the nose sections of their respective engines. The propeller shafts of the four engines were bent generally downward with No. 1 being also bent slightly to the right. Associated with this bending was a buckling of the shaft flanges. Bending of the propeller blades was predominantly rearward. The most severe bending occurred to the blades which were uppermost as related to a normally positioned engine when rotation ceased.

The propeller operating piston positions were established as soon as the propellers were removed from their imbedded positions. These positions represented the following blade angles: No. 1, propeller, 28 deg.; No. 2 propeller, 35 deg.; No. 3 propeller, 31.5 deg.; and No. 4 propeller, 25 deg. These blade angle positions were all in a range above the flight fine pitch stop position established at 24 deg. of blade angle pitch. There was no indication that a failure or malfunction occurred to any of the propellers prior to impact.

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Propeller Data

The four-bladed Rotol propellers vary in pitch from 0 to about 56 deg. in normal operation. This is accomplished by means of a constant speed unit (governor) which is interconnected with the throttle to provide a single cockpit control lever for each engine. In flight the minimum blade angle is limited to 24 deg. by an inflight fine pitch stop. A ground fine pitch range, 0 to 24 deg., prevents excessive turbine temperatures at low power and creates a desirable aerodynamic drag to retard the aircraft when on the ground, thereby reducing landing run. Numerous safeguards have been incorporated in the propeller circuitry to prevent the propellers from going into the ground fine pitch range while in flight.

Among these are seven switches that must make contact before the propeller blades can go into the ground fine pitch range. These are: a manually operated circuit arming switch; two switches, one each on the right and left main landing gear oleo struts; and four switches, one actuated by each throttle, that are closed when the throttles are below the 14,200 rpm. position. In addition, two warning lights are provided to indicate when the aforementioned switches have all made contact. Also, each propeller is fitted with a switch that is actuated when the propeller blades move into the ground fine pitch range thereby illuminating an indicator light for that propeller.

During the investigation a number of eyewitnesses, located on and around the airport, were interviewed. While they were not in complete agreement as to what they saw, in general it was as follows: None actually saw the contour of the aircraft in the darkness, but some did see its lights and hear the noise of the engines. They said that the aircraft was first seen on the downwind leg of the traffic pattern to runway 5 and that this leg was flown close in at an altitude of 600 ft. or higher above the ground. They further stated that as the aircraft turned on base the landing lights came on and the aircraft continued on base beyond an extended centerline of the runway where a steep left turn was made for realignment.

A licensed commercial pilot and other witnesses testified that the airplane was banked 50 to 60 deg. during this turn. The witnesses then described a roll out of the turn followed by a pitch-over and a nose-down descent to the ground. It was also thought by some that immediately after the roll out of the turn the aircraft nosed up slightly accompanied by a surge of power. The lights, which were seen in varying combinations, were the navigation, landing, and taxiing lights. The wing ice lights or cabin lights were not seen. Some witnesses said that after the aircraft struck the ground, reflection from the fire lighted the scene and the tail of the aircraft could be seen momentarily in a somewhat upright position.

The weather at the time of the accident was described by these witnesses as freezing drizzle and strong wind gusts. Some said that pronounced gusts occurred while the aircraft was in the landing pattern. Witnesses were asked to participate in an experiment whereby they were placed at the position from which they observed the airplane the night of the accident in order to watch the flight of a similar Viscount over a flight path believed to be that of N 7437. The purpose of the experiment was to determine as near as possible the probably flight path and altitudes. The altitude of the aircraft immediately prior to the pitch-over was estimated to be between 400 and 600 ft.

Flight Tests

Since this accident occurred when the aircraft was flying in the low-speed range of the flight envelope, the Board decided that the flight characteristics of the aircraft in this speed range and under various operating conditions and difficulties should be explored and evaluated. Accordingly, the manufacturer was asked by the Board to conduct certain flight and simulated flight tests. These tests included the determination of exactly when the stall warning (buffet) occurs during an approach to a stall from level attitude and in a turn. These were to be accomplished with the stick shaker both operative and inoperative. Additional tests included those with certain propeller flight locks removed and others showing the effect of wing ice on the stalling speed of the aircraft.

All flight tests were conducted using a standard type Viscount 745D airplane especially instrumented to record the wanted information. The aircraft was loaded to 57,200 lb. and the center of gravity position was 0.236 SMC (standard mean chord). Throughout the tests 12,000 rpm. was used and excess "g" force conditions from 0.25 to 1.0 were applied in all straight power-on stalls. These stall tests indicated that a sufficient margin of airspeed existed between the stick shaker warning and the actual "g" break.

A rapid change in nose-up pitch was experienced as excess "g" forces were applied resulting in an extreme nose-up attitude and a rapid decline in airspeed. The turning flight stall tests (both power on and power off) were made with the aircraft in a 30-deg. bank. Again stick shaker warnings were adequate for safety; excess "g" forces were applied up to 0.5. Stalls occurred in these tests between 70 kt. to 93 kt. In all stall tests recovery was positive and prompt with little loss in altitude as a result of the stall.

Flight tests were made with the inflight fine pitch stop removed on the inboard propellers. The basic conditions of overshoots and slow flight with the propellers at or near ground fine pitch were covered in these tests. The tests showed that the propeller blades remained at pitch angles above 22 deg. with power settings as low as 11,000 rpm., 60 lb. of torque, and a true airspeed of 90 kt. During the tests of overshoots close to the runway at true airspeeds varying from 97 to 125 kt., the aircraft handled in a normal manner at speeds down to 100 kt. Below this speed

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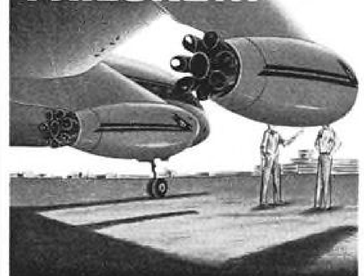

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the fining of the propellers, when throttles were advanced, prevented a successful go-around without striking the runway.

The slow speed flight tests, with the same locks removed, made at true airspeeds down to 95 kt., initially resulted in a very severe yaw; this was caused by only one propeller reaching 0 deg. pitch. In another test when both propellers reached 0 deg. together there was an extremely heavy nose-down pitching moment which required great care and throttle manipulation to effect recovery; a loss of 500 ft. in altitude was experienced.

In order to determine the effect of wing ice on stalling speed, wind tunnel tests were made using a 1/15th scale model. Measurements were made of lift, drag, and pitching moment for a range of incidences up to and through the stall with flaps set at 0, 30, and 40 deg. These tests showed that the presence of ice caused a loss of lift and an increase in drag, which factors produced an increase in stalling speed and a decrease in time to stall. Any other changes in the flying characteristics were considered negligible.

Because it was believed possible that the nose-over and dive could have resulted from a stall occurring during the turn, and because the stall tests previously made by the manufacturer were all made at lesser angles of bank, the Board later requested the CAA to conduct additional stall tests more closely simulating the conditions described. These tests were made in England and again a representative of the Board was present as an observer. The same model aircraft as that involved in the accident was used and it was properly instrumented to furnish the wanted information.

Fourteen stalls were made. The aircraft weighed 56,800 lb. at the start of the tests and its weight during the final tests was calculated to be 55,700 lb. The center of gravity was 0.236 SMC. During the tests certain conditions remained constant, the landing gear was extended, elevator trim was 0.6 divisions nose down, and 11,600 rpm. was used. Flap settings varied between 20 and 40 deg. and the stick shaker was off in all but four instances.

Stall Tests

Four of these stall tests are described in the box on p. 123 so that a clearer understanding may be had.

In three cases the flaps were changed to a new setting during the stall at the onset of natural buffet; this temporarily destalled the wing. Throughout the tests normal recovery action was initiated after each stall and the aircraft responded in a normal manner.

In addition to the above tests performed by Vickers-Armstrongs, Ltd., the following organizations ably assisted in the investigation of this accident: British Royal Aircraft Establishment; Air Investigation Branch, British Ministry of Transport of Civil Aviation; British Air Registration Board; Eclipse-Pioneer Division, Bendix Aviation Corp.; Borden Corp.; and the National Bureau of Standards.

In the original flight tests made in England for the certification of the Viscount 700 series aircraft it was found that the natural stall warning from buffeting did not, in some configurations and power settings, extend over the speed range required by the British Civil Airworthiness Requirements. Accordingly, a stick shaker was embodied to comply with these stall warning requirements.

When this aircraft was certificated by the CAA, the presence of this stall warning device on the aircraft was accepted and the aircraft was found to comply with all of the applicable provisions of Part 4B and Part 10 of the Civil Air Regulations.

The Tri-City Airport is located at Freeland, Mich., at an elevation of 667 ft. above sea level. It has three paved runways, the longest of which, No. 5-23, is 5,662 ft. long. This runway is equipped with high intensity lights having an intensity control of five brightness stages. The other two runways are lighted to a lesser degree of intensity. These lights, together with threshold lights, a rotating beacon, and a lighted tetrahedron comprise the lighting of the landing area. Located on the airport is a low frequency nondirectional radio beacon used for ADF approaches, and terminal omni for omni approaches.

The airport does not have an airport traffic control tower or a weather station. Weather and other information is furnished the pilots by a local CAA ATCS. Capital Airlines does not have radio equipment available at Tri-City Airport. All information the company wishes sent to its flights must be transmitted by longline to Detroit and then relayed to the flight or must be given the flight by the ATCS operator at Tri-City. Capital Airlines minimum ceilings and visibilities for Viscount aircraft making instrument approaches to Tri-City Airport are 500 ft. and 1½ mi.

The ATCS station at Tri-City was operated by one man at the time of the accident.

This man was responsible for taking and transmitting hourly weather observations, maintaining a guard on the air-ground radio frequency, broadcasting weather observations and forecasts for a selected group of stations twice each hour, and operating the airport facilities (VOR, ADF, runway lights, etc.). There are no standard charts at the Tri-City Airport displaying visibility reference points. A table of such reference points is available and this relies upon such factors at night as automobile lights, house lights, lights on barns, etc., in determining visibility distances between ⅝ of a mile and 3½ mi.

Ceilings are determined at night by means of a ceiling light and clinometer. During the day ceiling balloons and pilot reports are used for this purpose.

Wind, Weather

Wind velocity is determined by means of an instrument using both a light and a buzzer. The number of light flashes seen or buzzes heard during a given period determines wind velocity; wind direction is also noted by a flashing light. In order to arrive at a reasonable determination of wind conditions it is necessary for the operator to observe the instrument for at least a minute. Using this type of equipment it is impossible to accurately measure peak velocity of wind gusts.

At the time of the accident a low pressure center was moving across southern Michigan and had just moved eastward between Detroit and Toledo. As Flight 67 approached Tri-City, ceilings were between 900 and 1,100 ft. with visibility reported as being three to four miles. There was light snow and a freezing drizzle. Surface winds were reported from the north-northeast 18 to 27 kt. At 1930, the U.S. Weather Bureau issued a "flash advisory" pertinent to the time and place of the accident forecasting low ceilings and visibilities, rain or snow, fog, possible freezing drizzle near the surface with moderate and occasionally heavy icing in the clouds.

Company dispatch did not call this advisory to the attention of the crew. Pilots of two other Capital Airlines aircraft, which landed at Tri-City a short time prior to the accident, reported that both moderate turbulence and icing conditions were encountered. The captain of a Capital Constellation, which landed just 13 min. prior to this accident, testified that his aircraft had approximately one inch or more of ice on its wings on landing. This condition was not reported to either the company or CAA.

Capital Airlines does all the dispatching of its aircraft from Washington. On the route from New York to Chicago one dispatcher handles the flights as far as Detroit and from that point on the flight is the responsibility of another dispatcher. Capital Airlines' weather office in Washington is associated with dispatch and operates on a strictly advisory basis. One forecaster is employed for each shift. It is his duty to prepare and analyze surface weather charts every six hours covering the company's routes. Each dispatcher is briefed on anticipated weather trends as he comes on duty and the forecaster attempts to point out to the proper dispatcher any significant weather developments which occur over his routes.

The company's weather office does not provide any weather information directly to pilots but works exclusively through the dispatcher.

All pertinent weather information is available to pilots when the flight's papers are being prepared.

Flap Operation

Wing flaps on Viscount aircraft may be extended over a range of 47 deg. This is accomplished by four flap lever positions which represent respectively 20, 32, 40, and 47 deg. of extension. The company Flight Training Manual recommends pilots not extend flaps beyond 20 deg. at airspeeds in excess of 142 kt. Full flap extension requires approximately 30 sec. The manual further recommends that the landing gear and landing lights not be lowered at speeds above 160 kt.

Company recommended approach speeds are "A—Enter airport pattern 140 kt. and 20 deg. flaps—turn on final. B—Extend gear and 32 deg. flaps—reduce to 120 kt. and stabilize approach. C—Extend 40 deg. flaps—reduce to 110 kt. 'over the fence speed.' D—Just prior to touchdown—cut throttles, extend 47 deg. flaps."

Capt. Hull was a veteran pilot who had been with Capital Airlines 17 years. He had approximately 1,700 flying hours on

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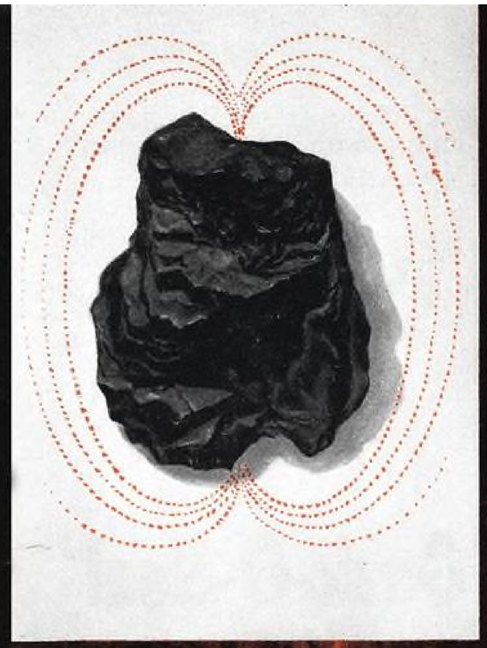

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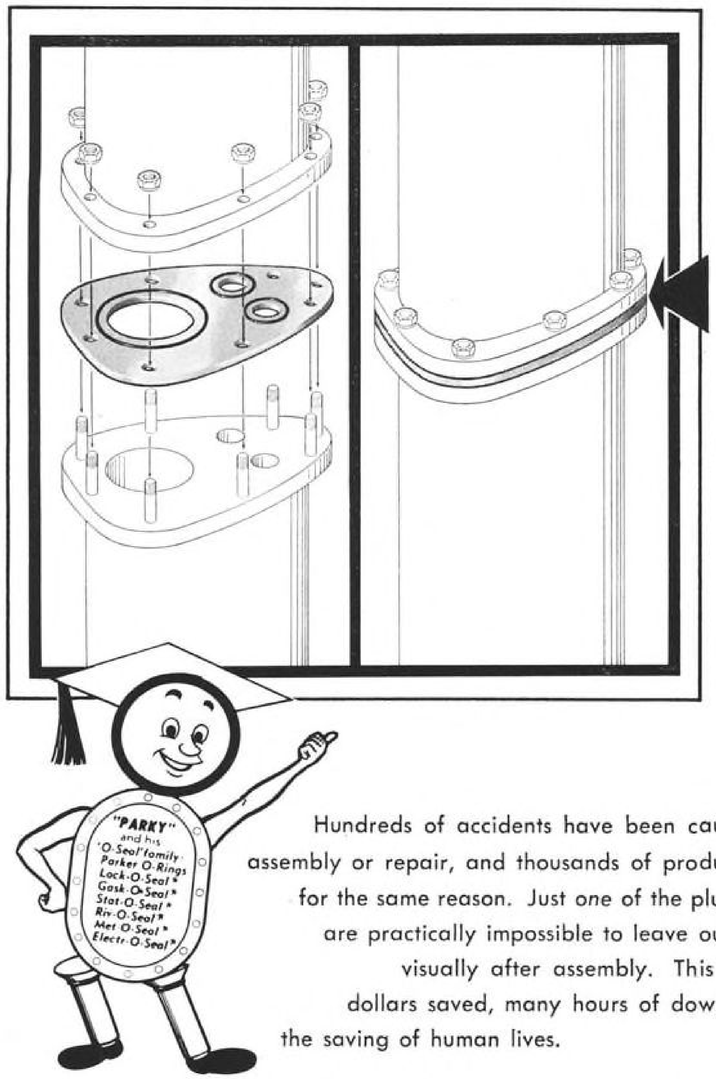
*Copies of the proceedings of the first two symposiums were published by the Stanford University Press, Palo Alto, Calif. and are available in book form. Results of this year's symposium will be published shortly by the same house.



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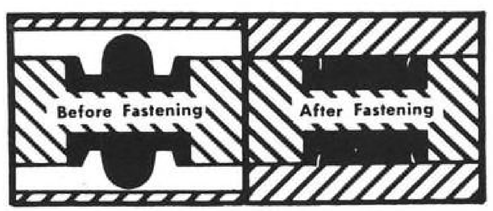

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Viscount aircraft and a total of more than 16,000 hr. on all aircraft. He was known to be a careful and conservative pilot.

ANALYSIS

From all available evidence the Board believes that the aircraft structure, its control surfaces, and powerplants were in proper operating condition prior to the crash. Although the flight control linkages could not be examined in their entirety, because of damage caused by the intense fire, those portions examined showed no evidence of a control malfunction.

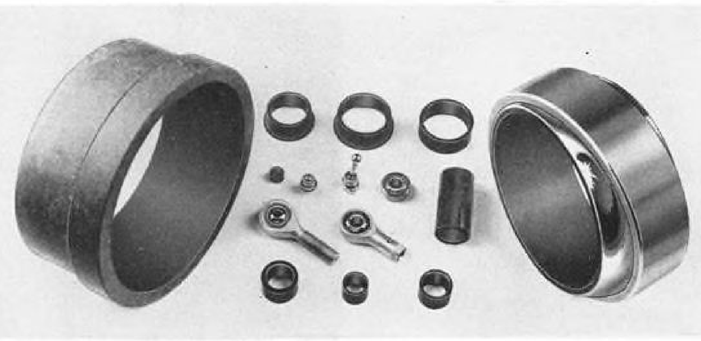
The Dowmic switch that arms the stall warning system when the aircraft is airborne was found to be malfunctioning after the crash. Examination of the switch and acceleration tests conducted on similar switches indicate strongly that the malfunction existed prior to the accident.

In the course of its investigation the Board was provided test data by Vickers-Armstrongs, Ltd., concerning the effects of heat upon the Dowmic switch, and it was suggested that the malfunction of the subject switch could have been the result of its being heated in the fire that followed impact. The physical evidence indicates that the switch was subjected to crash fire heating; however, the Board notes that the behavior of switches heated in laboratory tests does not coincide with the behavior of the subject switch. The specimen switches either failed to function at all after heating or at best they functioned intermittently, whereas the subject switch, following removal and reinstallation of its magnets operated repeatedly with normal switching action.

Similar malfunctioning of Dowmic switches has been experienced by Capital Airlines in normal fleet operation without the switches having been subjected to high temperatures. One such malfunctioning switch was intercepted and examined by a CAB investigator as it was returned for overhaul. It had been removed as an "inoperative" unit. This switch repeatedly failed to open its contacts when the plunger was released unless it was given a sharp blow with the hand. Later on, without having tampered with it in any way, the switch was found to operate normally and subsequent examination at the National Bureau of Standards failed to disclose any apparent reason for its earlier malfunction.

Impending Stall

The stick shaker is designed to warn the pilot of an impending stall and this is accomplished by means of the ability of the device to sense the angles of attack during an approach to a stall. The device is further designed to furnish the pilot an adequate warning under all flight attitudes normally experienced during transport flight. Under the conditions of flight Capt. Hull is believed to have experienced this night, had the stick shaker been operating the warning should have been approximately 15 kt. before the "g" break. During the flight tests which were performed subsequent to the public hearings, the tests made at banks of 60 deg. did not have the stick shaker in operation. Therefore, the above figure is an approximation based on calcula-



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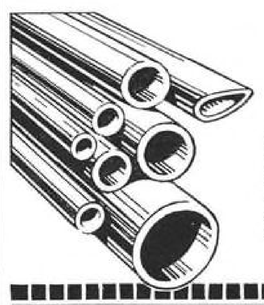

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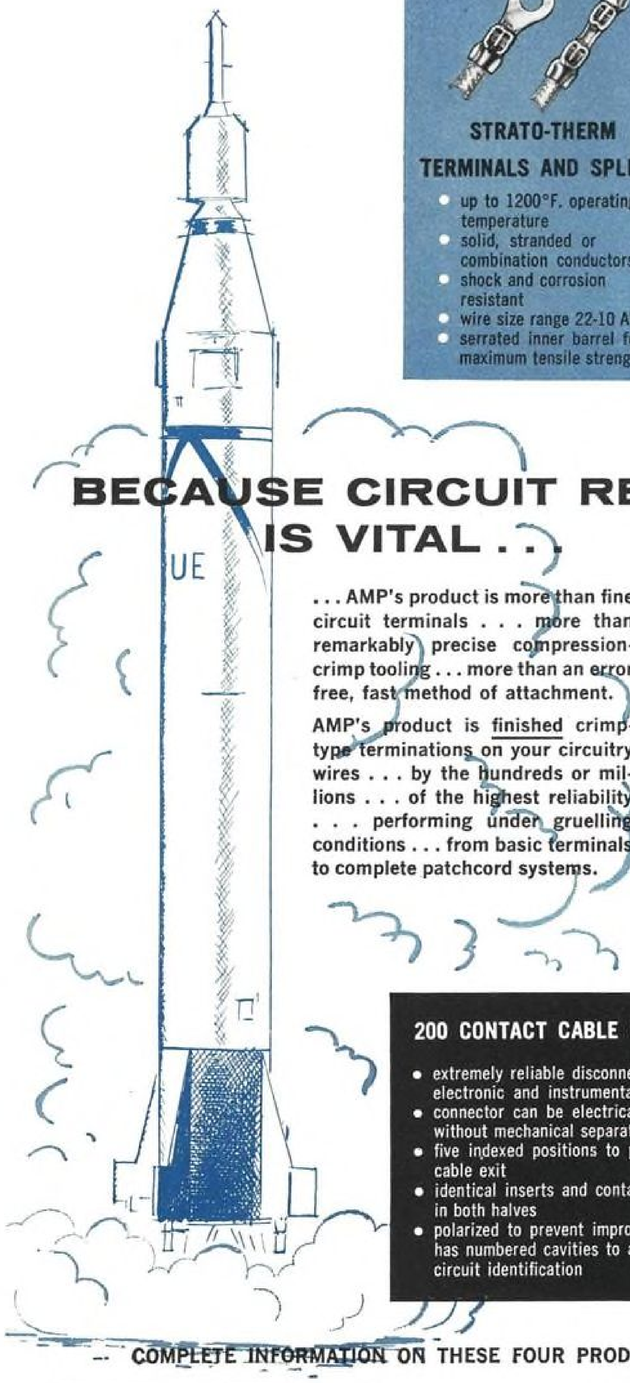

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tions made from actual flight test data.

The detector unit of the stall warning system had been replaced sometime prior to this flight. In view of the fact that this unit was not calibrated by flight testing prior to the flight, there is no assurance that an adequate stall warning would have been given, even had the Dowmic switch functioned normally.

Flight Path

During the investigation, it was determined that the aircraft while flying at an altitude between four and nine hundred feet above the ground pitched over and dived nose-down striking the ground in or near a vertical position while on a northeasterly heading. There are a number of facts which point to this conclusion. The open flat terrain presented a clue, an undisturbed tree 67 ft. high, 148 ft. behind the wreckage and in line with the flight path of the aircraft. While the fact that this tree was not damaged does not necessarily indicate a steep impact angle of the aircraft it does establish a minimum approach angle of 22 deg. Other facts which definitely point to a steep impact angle are:

1. There were no trenches, craters, or gouges in the ground except where the wreckage lay.
2. There was no evidence of cartwheeling, bouncing, or of the aircraft striking the ground with any horizontal velocity in any manner which would produce wreckage scatter over a large area; in fact, the wreckage was confined to a small area.
3. The engines were buried inverted about four or five feet in the ground, No. 1, 2, and 3 at a 45-deg. angle and No. 4 at a 70-deg. angle.
4. The right wing leading edge had trenched the ground next to and extending from the No. 4 engine for a distance equal to the partial span from this engine to the wing tip.
5. The nose gear received only minor damage and no impact marks were found on it except on the torque link.
6. The main landing gear was found extended, locked, and undamaged by impact.
7. The forward floor beams, stations 22 to 132, collapsed to form a mass 30 in. deep; each of these beams was displaced only two inches higher than the next rearward beam. This entire mass was buried directly under No. 132 bulkhead.

Inverted Position

The fact that the aircraft was found inverted is explained in this manner: Evidence indicates that it struck the ground in a vertical or near vertical position and that the rotational forces present during the descent caused it to continue over on its back with the engines contacting the ground at some angle beyond the vertical. This is substantiated by the manner in which the propeller blades were bent; the bending downward of all four propeller shafts; the comparably little damage to the nose gear strut; the crushing downward of the outer eight feet of the leading edge of the left wing into two separate folds; the nature of the damage to the windshield, the forward VHF antenna, and the control pedestal and fuselage skin.

Also, by extrapolation of certain data

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AVIATION WEEK's first four months share of the combined total pages placed in the above named publications was 50.7%, an increase of 6.3% over the first four months of 1958. Space/Aeronautics'share of the total was 25.6%, up 1.9%. Missiles & Rockets received 18% of total pages for a loss of –2.1% and American Aviation's share was 5.7% for a loss of –6.1%.

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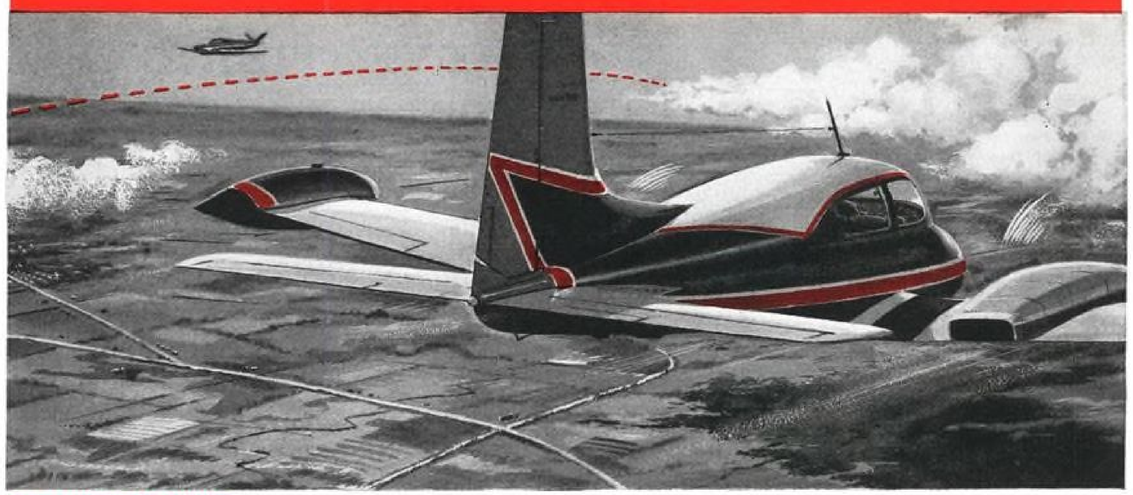

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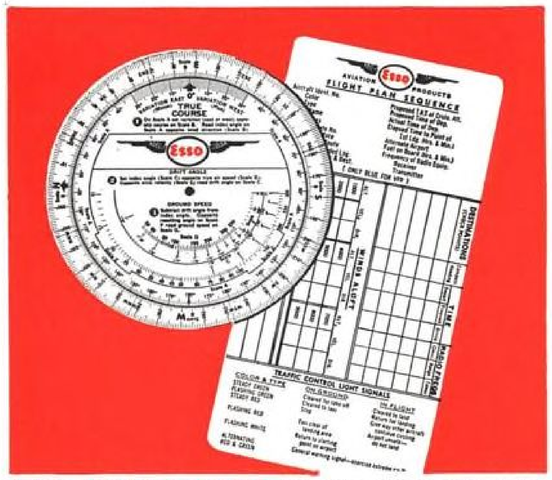

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taken from NACA TN4158, "Accelerations in Transport Airplane Crashes," agreement was found to exist between these results and the Board's conclusions with respect to the angle of impact.

In an effort to determine the cause of the sudden pitch-over and steep descent considerable study was given to the propellers and their related systems with particular significance placed on the possible movement of the blades below the flight fine pitch stops during the approach. It has been determined that such a malfunction of one propeller, whereby the inflight fine pitch stop was withdrawn, thus permitting the blades to move to a low pitch, would not initiate an abrupt maneuver such as occurred in this instance. Furthermore, the electro-hydraulic stop as well as inherent propeller operating characteristics provide safeguards which practically eliminate the changes of such an occurrence creating a hazardous situation. This conclusion confines the study to those portions of the propeller system that are common to all four propellers.

The circuitry, which permits withdrawal of the inflight fine pitch stops after the aircraft is on the ground, is so arranged that a double fault must exist to accomplish this function in flight. Furthermore, the existence of such a double fault would be indicated by warning lights in the cockpit and precautionary measures to counteract such a development would have been available to the crew. In addition, test circuitry to detect a single fault in either the positive or negative side of the circuit is provided. Consequently, it is considered that the propeller inflight fine pitch stop control circuitry provides protection against inflight withdrawal of the stops to such a degree that unwanted withdrawal did not occur in this instance.

Propeller Drag

The inherent propeller-engine operating characteristics are such that a considerable degree of protection against insurmountable drag during approach is provided. This is true in that the propeller is being governed in accordance with engine power and airspeed throughout the approach. High drag is developed only at low airspeeds, 108 kt. or less, and with throttles completely retarded. The blade angle would remain above the inflight fine pitch stop with as little as 11,000 rpm., with power applied. It is believed, therefore, that the inherent operating characteristics of the propeller would preclude any high drag situation occurring during the final phase of a normal approach. This has been substantiated by both test flights and propeller wind tunnel tests.

Since it was evident that there was no malfunction or failure of the powerplants and aircraft structure prior to inpact, attention was focused upon the operational phase of this accident.

There is no question of the crew's competence to fly Viscount aircraft. Both captain and first officer had considerable flying time in Viscounts, and both were properly certificated by the CAA. As stated before, Capt. Hull was known by those close to him and by the CAA to be a careful and conservative pilot.

From the witnesses it was learned that

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the downwind leg of the traffic pattern was flown close in. It was also revealed that the aircraft, when on the base leg, flew beyond the extended centerline of the runway and that a steep left turn in the form of an "S" was made for realignment. Some of the witnesses said that they believed the airplane regained a level attitude momentarily on final, and that this position was followed by a slightly nose-high attitude and then a vertical dive to the ground.

With the probability ruled out that the propeller blades moved into the ground fine pitch position during flight, the possibility that the aircraft stalled was carefully considered. Many flight tests have been made of the stall characteristics of the aircraft in level flight and shallow turns; under these conditions normal recoveries have been easily made. Also, the inherent stall characteristics of the airplane in these attitudes are not vicious and recovery is normally made with little loss of altitude. Therefore, it seems extremely unlikely that a stall occurred from a level flight attitude. However, if an unanticipated stall occurred during a steep turn at any altitude below 1,000 ft., a safe recovery might be impossible.

A study of the stall tests showed clearly that with the stall warning device functioning the pilot should receive warning of impending stall in sufficient time to execute corrective action.

However, with this device inoperative, and with the aircraft in steep turning flight, the warning and the "g" break occur almost simultaneously.

While tests indicated that the aircraft could be controlled within safe limits under all conditions tested, it is also true that a fully developed stall was never permitted. Further, the pilots who flew throughout these stall tests have considerable experience in flight test operations, and, since each individual test was carefully planned, there was never an element of surprise. Expecting the stall to occur, the pilots were able at all times to prevent the stall from reaching dangerous proportions. From previous tests made by the manufacturer it was learned that when a stall occurs during a steep turn, the aircraft tends to roll to the outside of the turn, "over the top," and enter a spin in this manner.

The approved Flight Manual for the aircraft defines the stall as that condition of flight when the lift coefficient has reached its maximum value ($C_L$max.). It further states that if the angle of attack is increased beyond this point a wing drop and a nose-down pitch cannot be prevented. Should an attempt be made to correct the roll in a power-on stall by use of ailerons alone and without simultaneous forward movement of the control column, the wing drop may be large (greater than 90 deg.), probably associated with a large change in heading and a considerable loss of height.

Training Program

Because of the conditions described, it appears that the company's Viscount training program lacked two important factors: the dissemination of necessary information to all pilots relative to the importance of the stall warning device with respect to adequate warning and the dangers con-

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fronted when it is inoperative, plus the stall characteristics of the aircraft with various flap settings in turns steeper than those normally made.

On the night of the accident, the low pressure center moving eastward between Detroit, Michigan, and Toledo, Ohio, brought colder air into southern Michigan and changed the precipitation from rain to snow and freezing drizzle. With it also came variable ceilings and visibilities. At the time Flight 67 was flying between Detroit and Saginaw, weather conditions at altitudes up 5,000 ft. were conducive to icing. This condition was further substantiated by the captain of a Capital Airlines' Constellation which landed at Saginaw 13 min. before the accident, who said that he observed his aircraft accumulate about one inch or more of ice on the wings during the approach to Saginaw.

The airframe de-icing equipment of N7437 was found in the "off" position. While it is customary for some company pilots to turn off the wing de-icers during the approach when wing conditions are considered not critical it is likewise considered important that at no time did ground observers see the ice lights in operation and atmospheric conditions favored a rapid accumulation of ice. The Viscount windshield is continually heated and will not accumulate ice and therefore cannot alert the crew to airframe ice accumulation.

At 2312 Flight 67 called Saginaw ATCS and was given the 2300 local weather observation. This observation indicated a 900-ft. ceiling, visibility 3 mi., light snow showers, and a wind from the north-north. east at 18 kt. with gusts to 27 kt.

Antiquated Equipment

The Board is aware that the equipment used by Saginaw ATCS to measure wind direction and velocity is antiquated and in no way comparable in efficiency with more modern facilities used for this purpose. If modern wind equipment had been available, more accurate and up-to-date wind data could have been furnished the crew.

It is probable that the existing weather conditions contributed materially to this accident. The close-in approach, short radius of turn, and the steep bank may well be attributable to an attempt by the pilot to keep the lighted runway in sight because of the restricted visibility occasioned by snow showers and freezing drizzle. Since the investigation disclosed that the wing flaps were 40 deg. down it is believed that the pilot lowered the flaps to this position either just before or during the turn.

This would suggest that the airspeed in the turn was 142 kt. or less, the recommended never-exceed airspeed with flaps lowered beyond 20 deg. With the type of approach described, combined with a possible accumulation of ice similar to that encountered by the Constellation, maximum gusts in excess of those being recorded (tending to cause the natural stall warning buffet to be unrecognizable), increased stalling speed in the steep turn close to the operating speed, and an inoperative stall warning device, a veteran pilot could suddenly find himself in a stall situation from which he could not recover.

CONCLUSION

It is the Board's conclusion that while in a steep turn for alignment with the runway the aircraft stalled and entered a spin over-the-top from which there was insufficient altitude remaining to recover.

As a result of this accident the Board recommended to the CAA on June 16, 1958, that there be provided a means of checking for reliability the stall warning systems on all Viscount aircraft. On Dec. 1, 1958, the CAA issued Airworthiness Directive No. 58-24-4 applicable to all Viscount models 745D and 810 aircraft, which provides as follows:

(1) In order to provide a means of checking the electrical continuity of the stall warning system, install a switch in the cockpit and associated wiring for the nose gear oleo switch and Safe Flight wing detector vane. Revisions to the airplane flight manuals for models 745D and 810 include instructions to the pilot for making the necessary checks.

(2) Periodic checking to assure proper calibration of the detector vane and correct functioning of the de-icing heater are also required.

The Board informed Capital Airlines that all pilots should be advised of:

1. The importance of the stall warning device with respect to adequate warning and the dangers confronted when it is inoperative.

2. The stall characteristics of the aircraft in turns steeper than those made normally.

In addition to the above the carrier, with the approval of the CAA, has taken the

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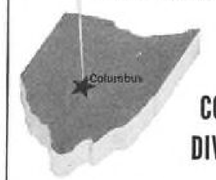

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following corrective action:

1. Oleo switches on main gear legs have been changed to a hermetically sealed improved type.
2. A fleet project has been established to move the stall warning circuit, normally associated with the nose gear oleo switch, to one of the new type hermetically sealed oleo switches on the main gear. This has been done to obtain maximum reliability.
3. At each block overhaul the detector unit of the stall warning indicator is replaced with a zero time unit and the aircraft is flown to test its operation and accuracy. Instructions covering this procedure have been placed in the maintenance manual. Whenever a detector unit is changed for any reason the above procedure must be followed before the aircraft is released for scheduled flight.
4. The detector unit of the stall warning indicator has been made a no-go item and is listed on the cockpit "No-go List." Any malfunction reported must be corrected prior to dispatch of the aircraft.

PROBABLE CAUSE

The Board determines that the probable cause of this accident was a stall during a steep turn resulting in an over-the-top entry to a spin at an altitude too low to effect recovery. Contributing factors were an inoperative stall warning device, gusty winds, and possible ice accretion on the airframe.

By the Civil Aeronautics Board:

James R. Durfee
Chan Gurney
Harmar D. Denny
G. Joseph Minetti
Louis J. Hector

SUPPLEMENTAL DATA

The Civil Aeronautics Board was notified of the accident on April 6, 1958, soon after occurrence. An investigation was immediately initiated in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. A public hearing was ordered by the Board which was held in two sections, the first in Saginaw, Mich., June 3 and 4, and the second in Washington, D. C., July 8 and 9, 1958.

Capital Airlines, Inc., is a Delaware corporation and maintains its principal offices in Washington, D. C. The corporation holds a current certificate of public convenience and necessity issued by the Civil Aeronautics Board to engage in the transportation of persons, property, and mail. It also possesses a valid air carrier operating certificate issued by the Civil Aeronautics Administration.

Capt. William J. Hull, age 43, was employed by Capital Airlines on April 9, 1941. He held a currently effective airman certificate with airline transport and all other appropriate ratings. He had a total flying time of 16,050 hr., of which 1,702 were in Viscount aircraft. He satisfactorily passed his last CAA physical examination Mar. 28, 1958. His last semi-annual proficiency check was given by the company's check pilot Nov. 30, 1957.

First Officer Earle M. Binkley, age 27, was employed by the company Oct. 12, 1956. He held a currently effective airman certificate with commercial, airplane single-engine land, and instrument ratings. He had a total of 2,030 flying hours, of which 975 were in Viscount aircraft. His last CAA physical examination was satisfactorily taken July 23, 1957.

Hostess Ruth M. Denecke, age 28, was employed by the company July 30, 1954. Hostess Sue Anne Wessell was employed by the company April 26, 1957.

The Aircraft

Viscount aircraft, model 700D, N 7437, was manufactured Aug. 30, 1956, by Vickers-Armstrongs, Ltd. The aircraft was equipped with four Rolls-Royce model R. D. A. 6MK510 engines. The four propellers, model C. R. 130/4-20-4/12E, were manufactured by Rotol, Ltd.

WHO'S WHERE

(*Continued from page 23*)

Changes

Dr. James T. Grey, director-research planning staff, Rocket Divisions, Thiokol Chemical Corp., Trenton, N. J.

Vincent J. Mankowski, assistant director of research and development, Clearing Division of U. S. Industries, Inc., Chicago, Ill.

Col. Carver T. Bussey (USAF, ret.), manager of Republic Aviation Corp.'s Dayton, Ohio, office succeeding **Jack A. Weglage** who is returning to Republic's main plant to become support manager for F-105 weapon system.

Theodore F. Debaw will join Grand Central Rocket Co., Redlands, Calif., in a project management assignment. Also: **Capt. Edward M. Owen** (USN, ret.), manager of Grand Central's Washington, D. C., office.

Harold F. Schulte, chief engineer, Wheelabrator Corp., Mishawaka, Ind.

Harry S. Myers, Jr., special assistant to the vice president-engineering, Aerojet-General Corp., Azusa, Calif. Also: **Rear Adm. L. C. Baldauf** (USN, ret.), technical specialist-corporate quality control staff.

Osmund T. Fundingsland, director of research, Raytheon Manufacturing Co., Waltham, Mass.

George F. Breitwieser, chief engineer, West Coast missile and surface radar department, Radio Corporation of America, Los Angeles, Calif. Mr. Breitwieser also was named Atlas project manager for RCA.

A. J. Perry, assistant sales and service director-logistic support programs, The Martin Co., Baltimore, Md.

International Telephone and Telegraph Corp. has established a new unit, ITT Communication Systems, Inc., Paramus, N. J., to handle development, design and master planning of the Air Force Communications support system. **Ellery W. Stone** will head the project, and **F. L. Ankenbrandt** will be deputy project director. The following have been appointed associate directors of engineering: **Robert C. Ferrar;**

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Dr. William C. Leone, manager, Industrial Systems Division of Hughes Products Group, Hughes Aircraft Co., Los Angeles, Calif.

Harold R. Boyer, director of military products, General Motors Corp., Detroit, Mich.

Arvin O. Basnight, deputy assistant administrator, Office of Management Services, Federal Aviation Agency, Washington, D. C.

Theodore W. Shidler, Jr., manager of marketing, General Electric's Small Aircraft Engine Department, Lynn, Mass.

Roland Lawrence, director of engineering and research, Electronic Components Division, The Deutsch Co., Los Angeles, Calif.

T. P. Frost, chief test pilot, Bristol Siddeley Engines Limited, Coventry, England.

Ralph E. McGruther, director of labor relations, Bendix Aviation Corp., Detroit, Mich.

Jack Massar, staff assistant to the division manager, Aircraft Equipment Division, Consolidated Diesel Electric Corp., Stamford, Conn. **Murray Stone** succeeds Mr. Massar as manager of the customer service department. Also: **R. J. Enyeart,** senior project engineer-advanced engineering, aircraft equipment engineering department.

Bruno J. Salvadori, chief engineer, All American Engineering Co., Wilmington, Dela.

Dr. Donald J. Gimpel, director of engineering, Arnoux Corp., Los Angeles, Calif.

Gerard W. Kaufhold, sales manager-infrared systems, Crosley Division, Avco Corp., Cincinnati, Ohio.

W. W. Harris, corporate director of contracts, American Bosch Arma Corp., Hempstead, N. Y.

James B. Hoffman, director of quality control, Hoffman Laboratories Division, Hoffman Electronics Corp., Los Angeles, Calif.

Eric Weise, director of a new systems research activity, Defense and Technical Products Division, Rheem Manufacturing Co., Downey, Calif.

Howard E. Thompson, supervisor-production planning and control, and **James R. Robinson,** engineering services administrator, Technical Products Division, Waste King Corp., Los Angeles, Calif.

B. F. Carpenter, sales manager-electronic control and guidance equipment, Air Force Sales Unit, General Electric's Heavy Military Electronics Department, Syracuse, N. Y.

Jack C. Hoagland, director of engineering, Daystrom Pacific, Los Angeles, Calif.

Arthur V. Sommer, chief engineer, Arma Division, American Bosch Arma Corp., Hempstead, N. Y. **Merritt C. Chandler** succeeds Mr. Sommer as manager of the company's Chicago Division. **Ernest A. Goetz,** who has been Arma's chief engineer, will devote full time to his corporate position of technical assistant to the president of American Bosch Arma.

John Liu, associate director of research and development, Clearing Division of U. S. Industries, Inc., Chicago, Ill.

Dr. Stanley Winkler has joined the Technical Planning Staff in Advanced Systems Research, International Business Machines Corp.'s Military Products Division, Owego, N. Y.

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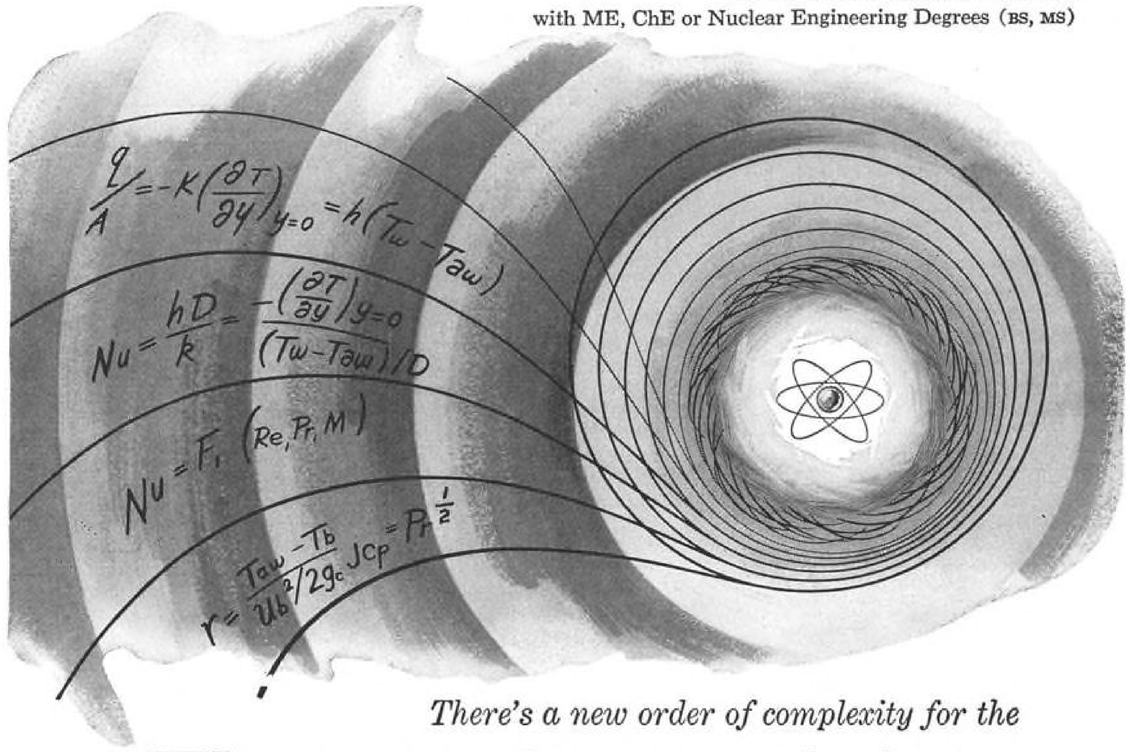

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AVIATION WEEK

Fellow Engineers and Scientists:

My company has asked me to tell you of the unusual opportunities in operations research at System Development Corporation. These range from positions for engineers and scientists who would like to develop their skills working in a team under an experienced leader to opportunities for those who are looking for positions of leadership. I hope that the following account of our work will lead you to inquire for further information.

Briefly, SDC's business is automated decision-making systems. More fully, we develop large scale, computer-based information processing systems in which the computer is used as an on-line, centralized control element for a system operating in real-time. At this stage of the art these systems are semi-automatic, the man-machine type in which man shares the repetitive control function with the computer. Our work is concept-oriented, rather than hardware-oriented, and deals with problems of over-all system design, data processing development, and man-machine system training.

The most fully developed large-scale semi-automatic system is the SAGE (Semi-Automatic Ground Environment) Air Defense System. We have a major responsibility in the development of SAGE. Our experience and unique team skills have led to diversification of our activities; we now have important contracts for other major military and government systems vital to our country. The demand for our services is reflected in our growth from 70 to more than 2,700 employees since 1955, and the intriguing possibilities of automated decision-making are only beginning to be realized.

In this brief message, I can only suggest the variety of operations research problems at SDC. Perhaps the most important point is that this variety is limited only by the imagination and initiative of our scientists.

Some examples of areas of work are: (1) allocation of decision-making functions between man and machine for optimal system performance; (2) measures of system capacity and system performance; (3) exploration and evaluation of design changes by operational gaming; (4) quality control and testing of operational computer programs; (5) allocation of computer capacity among several system functions; (6) scheduling and costing of production of operational computer programs; (7) optimal assignment of mixed weapons to targets.

SDC recognizes the importance of a well planned research program for the vitality and future of the company, and we are carefully organized to carry out such a program. The following are some areas our operations research people are involved in: (1) simulation and operational gaming techniques in problems of control systems; (2) information retrieval and theory of information processing; (3) medical data processing; (4) universal language for computer programming; (5) logistics. We have unusual facilities for research at SDC—these include one of the largest computer facilities in the world and outstanding simulation laboratories.

We have given considerable thought to organizing the activities at SDC to provide for professional development and self-expression. Operations research professionals are carefully assigned so that their individual talents are matched with company needs. These assignments are reviewed regularly to make sure that developing talents are directed into new company opportunities. We regard the publication of research articles and participation in professional societies as activities important to the company. We encourage new ideas and provide the time and means to explore them.

SDC is one of the leaders in a field which will have a remarkable technological and scientific development. It is a new and vigorous company with a bright future. I encourage you to join us.

Please write Mr. R. W. Frost at the address below if you wish to pursue this invitation.

William Karush

William Karush
Assistant Director for Research
Operations and Management Research
System Development Corporation

11-105A

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Please direct your inquiry in strictest confidence to Mr. E. A. Smith, Dept. 5-B

DSD

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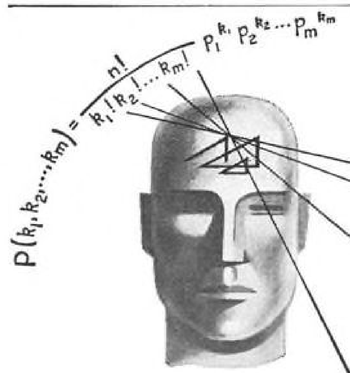
ENGINEERS – SCIENTISTS



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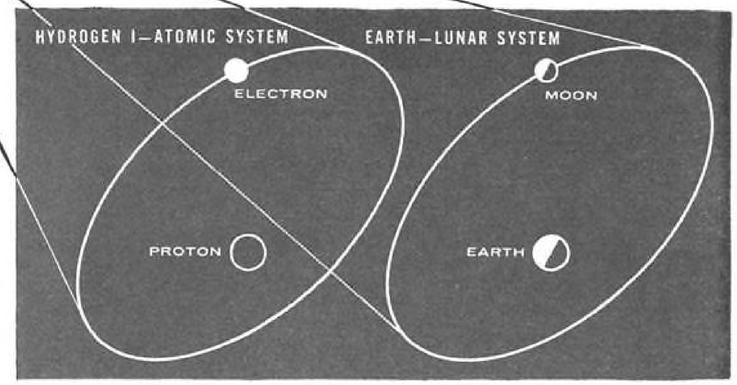

BOLD MINDS

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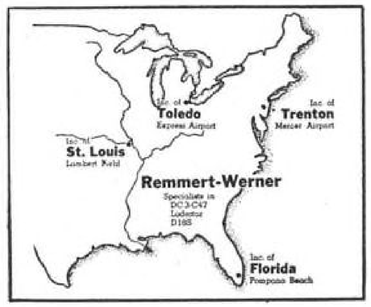

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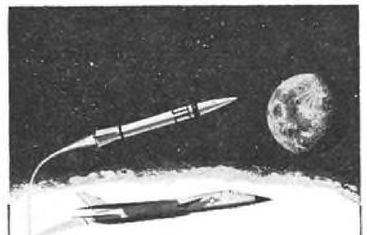

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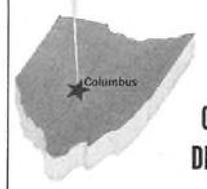

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LETTERS

Better Understanding

Your editorial of Feb. 16, "Rewards and Responsibility," discusses most seriously airline management-pilot relationships and the responsibilities of both to the public. That you emphasize the latter is not only eminently correct but characteristic of the public spirited attitude you have always shown.

I believe that we could further agree that both management and pilots can find ample self interest in seeking better ways to serve the public and better ways to minimize public inconvenience while solving issues that arise between them. While I do not question your good faith or good will, there does seem some implication on your part that the pilots are less responsible in their approach than is management. I wonder if such a position can be maintained. Any course of action which is economically destructive is mutually destructive. ALPA leadership has been quite articulate on this point. I further suggest that, for selfish reasons perhaps, pilots more clearly identify themselves with passengers' best interests. I think this is manifestly clear in such matters as safety and realistic schedules.

I do not suggest that management is indifferent—far from it, but rather to emphasize the pilot's day-to-day intimacy with such considerations.

You deplore what you characterize as a casual attitude on the part of some pilots and cite three examples: the incident involving a Pan American jet; the results of spot checking some NEA pilots; and the Braniff accident near Miami. I respectfully call your attention to the following: the pilots on the jet both enjoy important managerial positions, both have conducted themselves in complete accord with the wishes of management (in regard to contractual issues over the jet), and completely in opposition to the wishes of the ALPA thus, unfortunately, alienating themselves from their fellow pilots and adding to the friction between management and the pilots.

Be that as it may, there does not appear to be a scrap of evidence justifying the charge that these two men were guilty of a casual attitude. In simple justice, I can assure you that such an attitude is typical of neither man.

I suggest further that their unhappy experience demonstrates the reasonableness of ALPA's position in regard to the need for another qualified pilot on this particular aircraft!

I do not wish to discuss the NEA or Braniff incidents, lacking personal knowledge, except to ask who is responsible for pilot training and checking?

Now, please continue to urge all of us to find better understanding and more sympathetic and constructive attitudes toward one another's problems. We need each other and the public has need for our services.

JOHN BURN
Airline Pilot
New York, 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.

Safety vs. Noise

Regarding AVIATION WEEK's article, "Port Authority Noise Investigators Criticize American's Jet Takeoffs," Mar. 30, p. 46, please be advised that nowhere in the article have I been able to find reference to the following facts which seem necessary to achieve a fair appraisal of the situation described.

During the period described in the article, by directive from the Port Authority, the operators were instructed to use as "a mandatory preferential runway," Runway 25. In practical terms, devoid of weasel words, the directive stated:

a. The roughest (not the longest) runway on the airport will be used providing crosswind component does not exceed 26 kt. (this later modified to read 13 kt.). (Pilots state that at jet takeoff speeds the structural integrity of the aircraft is in serious jeopardy due to the roughness of this runway.)
b. With the wind in the northeast semicircle, only downwind takeoffs are authorized from 10 p. m. to 7 a. m. None may be made on the longest runway.

Along with many in the industry, I hailed the Port Authority's firm stand which ultimately achieved muffling of jet engine noise to tolerable levels. But now, it seems any margin of safety which might be enjoyed by utilizing judicious procedures in the operation of these fine aircraft has been negated for political expediency by the dictates of the omnipotent Port Authority. If friends or family of yours or mine are the first to become involved in the disaster certain to come as a result of "compliance" with these dictates, who will be comforted by Wiley's statistics then? Not me, brother, nor you.

The fact that the FAA will tolerate issuance of such unsafe restricted operating rules is beyond my comprehension.

Rather than pointing the finger of scorn at American, I believe that the expressed policy of American to cooperate with the anti-noise program without ever forgetting that operating safety is always the first consideration is not only evidence of good judgment, but is in truth fulfilling the obligation of the law imposed on public carriers. A pox on Wiley's statistics. Yours for safer operations.

JACK A. DURHAM
Captain, American Airlines
Pound Ridge, N. Y.

P. S. If the foregoing should merit printing on your Letters page, please do not withhold my name as I firmly believe there is no place in our society for anonymous critics who lack the courage to identify themselves with their stated opinions.

Airframe Paint

Possibly the most significant factor in the continuing plague of midair collisions and near misses appears to be going unnoticed. In my opinion it may well have been instrumental in the recent T-33—Viscount collision and in the 1956 Grand Canyon disaster.

The overtaken aircraft has invariably been painted white.

White paint is the most effective camouflage imaginable for airborne aircraft. The sunlit portions of a white aircraft in a VFR sky will be a close color match for clouds in the background. Those portions not illuminated by direct sunlight or reflected cloud light will be illuminated by the blue scattered radiation of the atmosphere, and will appear to be as blue as the sky itself. The only features available to distinguish such an aircraft from its background are windows, insignia, and relative motion against the background. In the case of a white airliner in a steady cruise condition, with clouds in the distance, being overtaken at a relatively small difference in speed, the motion factor is practically nonexistent, and the airliner will be highly camouflaged.

Nor is the camouflage effect limited to bright sky and cloud conditions, for a white surface will always appear to be of the same color and brightness as the light striking it. The white paint can be just as effective a camouflage in an overcast sky.

White paint was specified as camouflage for the undersides of United States Navy patrol planes in World War II. The principle involved is that the indirect light from the sky, reflected back up to the aircraft from the earth's surface, will render the white surface the same color as the sky overhead.

A striking example of the effectiveness of white paint as camouflage is found in a color photograph of an all white Avro Arrow which appeared on p. 36 of the Feb. 9 issue of AVIATION WEEK. The aircraft is pictured in a rolled attitude against white clouds, blue sky, and blue reflected ground light. The sunlit portions are nearly invisible against the clouds and the shaded portions are nearly the same blue as the sky and ground. It is readily apparent that this aircraft owes its visibility primarily to its black nose and tailpipes, and the RCAF markings.

It is to be hoped that the responsible civilian agency will look into this seeming detriment to air safety. Increased "swivel necking" cannot be the only solution. More than three airlines in this country today paint their airliners white, and each issue of AVIATION WEEK brings pictures of new aircraft with large percentages of the vertical surface area painted white. Probably the safest paint scheme, pending the widespread use of fluorescent paints, is none at all.

The nature of the reflection from a metal surface at least does not defy detection.

J. C. AJEMIAN
Bridgeport, Conn.

THE KILLER CAMEL

Fifty feet above the Somme River, time ran out on the life of Baron Manfred von Richthofen, Germany's greatest ace. Behind his red Fokker was Captain Roy Brown in a British-built Sopwith Camel. The Canadian was low on ammunition but

(Continued on page 70)

ADVANCED FUEL MANAGEMENT ...FROM SMI

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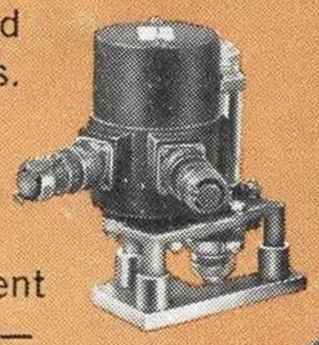

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