his Issue:

SPACE FLIGHT

missiles and rockets

INCLUDING MISSILE ELECTRONICS

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

APRIL, 1958

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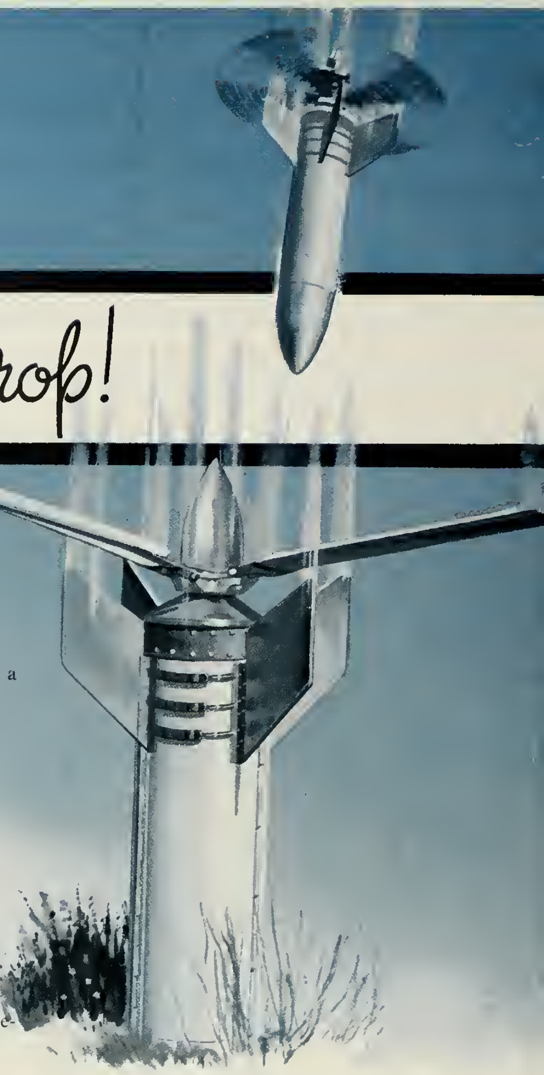

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this issue: Lunar Rockets and Space Vehicles

news and trends

special features

columns

departments

missile electronics

next issue: Missile Components and Subsystems

cover picture:

Many light years' travel away, in the far reaches of our galaxy, is the constellation Monoceros. This cluster of stars and cosmic dust, east of Orion, may some day be the goal of space explorers. Even then, many years will be required to make the round trip. The nebulosity in Monoceros was photographed in infrared by the 200 inch telescope at the Palomar observatories.

Japanese science artist Itokawa visualizes an unmanned rocket vehicle landing on the moon. Electronic and guidance devices will be needed to insure that such vehicles go where they are aimed, unfold landing legs and activate reverse-thrust rockets as required. Perhaps such projects are more a challenge to the electronics and guidance industry than to the propulsion experts.

missiles and rockets

Magazine of World Astronautics

April, 1958 Volume III, No. 4

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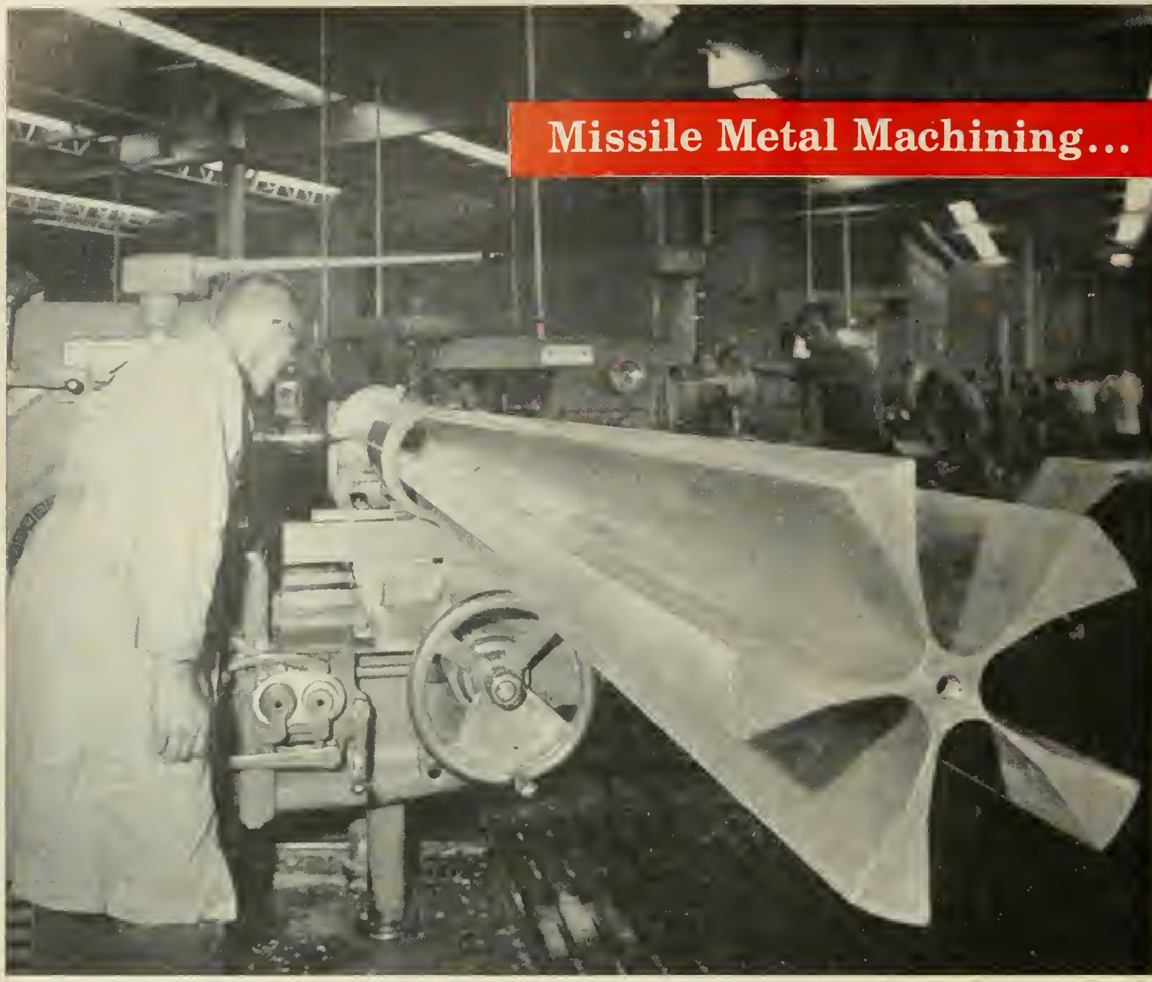

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We're Falling Behind Again

The attitude of the Administration toward our missiles and rockets programs can be summed up in two words: impractical and inadequate. As for its attitude toward nuclear rocket research, there is only one word: calamitous.

We are falling behind again—in the face of the harsh news from Russia (see page 37) that its first atomic-powered airplane will be flying soon.

One thing is crystal clear: the fact that we possess both the knowhow and the ability to build a nuclear rocket. Scores of nuclear scientists at the recent ARS meeting in Dallas and at the Nuclear Congress in Chicago agreed that we have been extremely slow and much too hesitant in getting any atomic rocket program under way. They assert that this country could have had a working test model of an atomic rocket powerplant today if we had activated some of the ideas and proposals submitted by our nuclear experimenters some five years ago.

It was generally known at the time that the Russians were progressing rapidly in the nuclear rocket field. But our national leaders exhibited an inexcusably disinterested, outright perilous attitude. Not only was it considered ridiculous to talk about nuclear-powered aircraft (and practically all work on such projects was ordered to a halt), but anyone who discussed openly the feasibility of nuclear rocket propulsion was labeled a dreamer—probably because the only imminent application of such systems was for space flight!

Rep. Carl T. Durham (Democrat, North Carolina) and Chairman of the Joint Congressional Committee for Atomic Energy, struck a solemn note at the recent Nuclear Congress in Chicago when he declared that civilian control of the military atomic energy and outer space programs is being endangered by crippling efforts of the military to enhance its role in both projects.

Two years ago Russian rocket researcher and physicist G. Nesterenko outlined in much detail drawings of an atomic rocket engine. More recent technical papers and numerous official statements by other reputable Soviet scientists clearly indicate that a substantial amount of work is being conducted in this field in the Soviet Union. In the meantime we continue to discard the importance of such work and are doing little or nothing about it.

It's almost unbelievable that it took a *Sputnik* to speed up America's satellite program. Even more fantastic is the thought that we must wait for the first flight of the Russian atomic airplane to understand the necessity for the stepping-up of a nuclear aircraft and rocket powerplant program in this country.

The administration didn't have any valuable explanations when the *Sputnik*s were launched; there were numerous speeches and lots of talk about America moving ahead. There was agreement that we needed a scientific advisor at cabinet level, that we must establish a space flight agency, reorganize our educational system and pay more attention to our scientists. The situation, it was agreed, was alarming. Yet little or nothing tangible has been done to correct it.

Probably the American public accepted the sorry news about Russia's rocket advances as a bitter fact that you just couldn't blame anyone for—*maybe*. But we doubt that anyone will accept any more Russian technological victories such as a nuclear airplane, an atomic-powered space rocket or a rocket to the moon. We already have fallen far behind. Another technical defeat may leave us behind forever.

Erik Bergaust

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Section is removed to show internal detail of closed end.

An end sawed from the full length tube illustrates internal and external ribs as well as end detail.

Joining the twin barrels was solved by a dovetailing operation. The wide external rib seen in Fig. 2 provides dovetail area.

Overall tube length is indicated here. Entire unit is one piece. Dovetailing is the only assembly operation required.

Producing cold-forged rocket launchers for the Chance Vought Crusader is another example of Hunter Douglas ingenuity. The 3" O.D. tube, approximately 100 inches long with an .046" wall, with one end closed, required a fantastic arrangement of internal and external longitudinal ribs, almost impossible to fabricate by conventional methods.

Even cold forging with its ability to integrally form complex part geometry, was put to rigorous tests. For example, cross sections of the tubes were non-symmetrical, generally a serious taboo in cold forging techniques. Further, the non-symmetrical design aggravated longitudinal bow, yet tubes had to be straight within .120" overall. Finally, retention of a minimum wall adjacent to the heavy section presented the problem of uniform metal flow. The heat treated tubes must withstand 1400 psi hydrostatic pressure without deformation.

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Washington Trends

by Elizabeth Oswald

Navy needs a breakthrough improving air search radar capability substantially if missile cruisers are to do their job. What's wanted is a lightweight antenna which can be handled by mechanical means. Otherwise, use of missiles for cruisers and destroyers will be limited. Navy has an industry committee working with BUShips specialists trying to solve the problem.

One approach to the solid-propellent breakthrough is to add aluminum powder to composite fuels, according to RAdm. F. S. Withington, long-time chief of the Bureau of Ordnance. More than 15 percent powder is being added by at least one company. Heat generated with the addition of the powder makes the fuel almost too hot to handle with current materials. However, use of the powder described as finer than cigarette ash provides a substantial boost in energy.

First two bases to be equipped for handling the Air Force's *Goose,* decoy missile built by Fairchild, have been designated. Some $10 million will be spent on developing Ethan Allen AFB in Vermont and Duluth Municipal Airport in Minnesota.

Battle between metal and plastics manufacturers may be brewing as a result of the apparent decision of Army Ordnance to stay with metal boosters for *Nike-Hercules* despite the reportedly successful firing of more than 150 fiber glass boosters for *Nike-Ajax* which are frangible, breaking up like clay pigeons after burnout. Argument is that the glass fiber boosters are cheaper, use no critical material and provide no danger of injury to people and property when the boosters drop off. Growing feeling is that interservice rivalry at development and research levels is being overplayed. Real competition exists in cloudy areas of roles and missions, with each service fighting to preserve operating functions. Record indicates cooperation between services on many research projects, the outstanding example being the work of the Navy and Air Force with the National Advisory Committee for Aeronautics.

Chances are that Dr. James Killian, Jr. will recommend establishment of a new space agency, under civilian control. Proposal won't necessarily affect the role of Advanced Research Project Agency as a coordinating agency within Defense Department but should stop any plan to make ARPA a kind of super new governmental service.

Indications are that any new agency would lean heavily on existing facilities and personnel of the National Advisory Committee for Aeronautics and its well-established techniques for working with the Army, Navy and Air Force. Future of ARPA will be raised again when Congress starts marking up the Defense Appropriation Bill for fiscal 1959.

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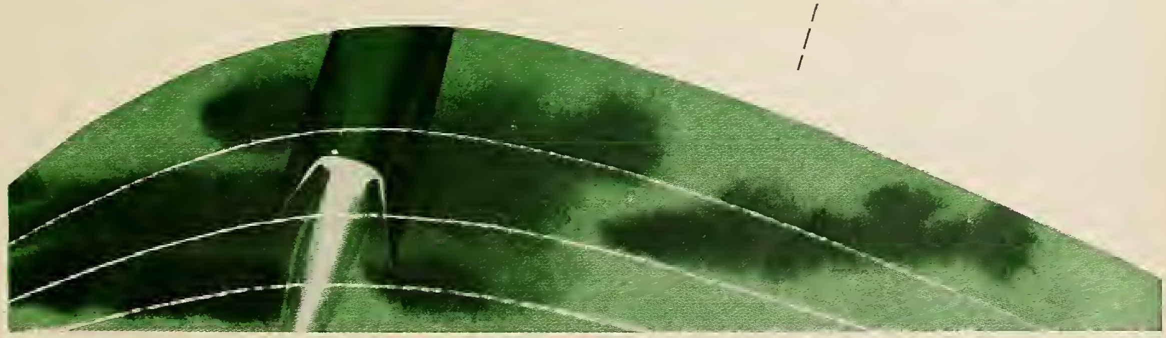

HIGH ALTITUDE PHOTO ABOVE EGLIN AIR FORCE BASE

New Version Coming Up

To the Editor:

I have noticed with interest that you have available a "Guided Missile Encyclopedia." As I am a member of the department of the U.S. Army Air Defense School which is charged with the writing of Department of the Army Field Manuals for surface-to-air missiles, it occurs to me that such an encyclopedia would be of considerable interest to us.

It would be appreciated if you would quote us the price.

In passing, I might say that your magazine, m/r, is read enthusiastically by all of my associates in the Training Literature Division.

Capt. C. N. Johns
United States Army
Air Defense School
Fort Bliss, Tex.

Reprints of the 1957 encyclopedia are available at $1.00 each. The July issue of m/r will carry an even more comprehensive missile encyclopedia.—Ed.

Enemy Dismissed?

To the Editor:

I think you will agree that the term "anti-missile missile" is a cumbersome description for an agile bird. What will we call the "anti-anti-missile missile" when it arrives?

The time has come when we should name the anti-missile missile a "dismissile" and the weapon with which we destroy it ought to be termed a "counter dismissile."

Robert Bicknell
Washington, D.C.

No Slight Intended

To the Editor:

We have, of course, more than a passing interest in the missile electronics procurement article in your February issue, authored by Selig Altschul.

But we must be frank and say that we could not understand why our division was not included in the chart on page 76, identifying companies in various phases of electronic controls or missile activities. As you probably know, Autonetics does a gross annual business approximating $100 million in the electronics and electromechanical fields.

We would therefore expect to be included in the published list on the basis of our business volume and size. Anything that you might be able to do to see that we are included in future lists would be sincerely appreciated.

Kerme Anderson
Autonetics Division,
North American Aviation, Inc.
Downey, Calif.

Chart was intended to be representative, rather than complete. Because of this, many companies with intense activity in the missile-electronic field were omitted.—Ed.

Silicone Limits

To the Editor:

We were very pleased to see the excellent coverage in the March issue of the many ways in which silicones are being utilized to produce better, more reliable rockets and missiles. However an unfortunate contradiction about the operating limits of silicone lubricating fluids appears in the lead article.

The staff report that General Electric's Versilube (R) silicone fluids are functional in the 575-700F is of course correct. In fact, hydraulic equipment designed for use with these fluids at double the 350F level mentioned by Mr. Rous is commercially available.

It is unfortunate that Mr. Baker, in his article "Silicone Applications in the Missile Industry," did not cover all of the major silicone producers in obtaining material for his survey on silicone applications in the missile field. Thus he did not mention significant General Electric contributions such as the Versilube fluids; SE-555, a silicone rubber with the physical strength formerly associated only with organic materials; the RTV (Room Temperature Vulcanizing) compounds for a variety of applications where silicone rubber could not previously be used . . .

W. E. Harris
General Electric Co.
Waterford, N.Y.

Mr. Rous' treatment of hydraulic fluids in his article "Materials Build a New Technology" was not intended as a roundup analysis of the hydrogenated aromatic mineral oil or methyl phenol silicone market. His brief mention of the current 350°F limit for silicone base fluids was a reference to the broadly accepted status of the market. We appreciate your efforts in re-emphasizing the current availability of your silicone lubricant that operates above the 350°F "limit."

In the article "Silicone Applications in the Missile Industry" no effort was made to completely cover this vast industry. It was presented as a selective representation of one company's products and their applications.—Ed.

Missile Business

by Seabrook Hull

No-profit contracts may be one result of a basic philosophical change occuring in top Pentagon circles. Conversely, other defense contracts may allow much greater profits than can now get through the Renegotiation Board. Nothing formal has yet been done in these directions. But frustration over the lack of incentive in the current methods of doing defense business, plus the lack of any means of enforcing performance on contracts is leading to an almost universal determination "to do something about it."

Of considerable cost, both in dollars and in terms of defense in being, is the fact that defense contractors have no real incentive to perform according to the original terms of the contract agreement—delivery on time at the price agreed to of hardware than can reliably do the job. Neither is there any means of policing companies that knowingly bid low on a contract on which they cannot possible perform without repetitive renegotiation of the price and terms of the contract.

Experienced Pentagon officials, at the Department of Defense and Service Secretary level, are increasingly convinced that the present system of armed forces procurement needs modifying so as to reward those who perform well and penalize those who don't. One plan now receiving wide consideration would allow greater-than-now profits to companies who performed in an outstanding manner by delivering on time, at agreed to or better-than-agreed-to prices, by making product improvements, etc. At the same time the proposed system would penalize those companies which failed to perform according to agreement by reducing or eliminating their allowed profits.

Such a system would have a number of benefits. It would encourage many efficient companies who now have no interest in defense business, because of low profit rates allowed, to compete for business. It would provide more of an incentive than conscience (as now) for performing as contracted. Finally, it would benefit the American public by getting more defense in less time for less money.

Air Force has officially blessed the group method of systems bidding. In a letter from AMC Deputy Director of Procurement and Production Major General Wm. T. Thurmond to the National Security Industrial Association, the Air Force described the "group" as a possible accepted form of contracting. The letter stated that the weapons system concept was susceptible to management proposals from systems managers and subcontractors for future design and development. It said that the subcontractors in the group should include all the systems elements, such as airframe supplier, electronics, guidance, propulsion, groundhandling (etc.) suppliers. In mind are such groups as those by Hoffman Electronics, and Stavid Engineering.

This letter may have more significance than meets the eye. Some are interpreting it as official recognition of the fact that the military cannot always just go to the traditional airframe makers for systems contracting; that syndicates may turn out to be a good alternate source—so long as they are properly organized, giving due attention to the antitrust laws, small business, responsibility for performance and knowledge of just how to file and negotiate as a group. In any case, it's a development well worth watching.

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contract report

Trends

Seven rules for getting Air Force contracts were laid out before the Texas Manufacturer's Association at a recent dinner in Houston by Assistant Air Force Secretary for Materiel Dudley C. Sharp. Here they are: (1) Get to know Air Force projects—their mission, specifications and time requirements; (2) be cost-conscious and keep overhead charges to a minimum; (3) study the engineering side of the project and figure out how to do it with a minimum of effort and overtime; (4) be prepared to fund the initial stages of the program; (5) have sufficient production talent and the most advanced tools; (6) know your production limits and bid accordingly; (7) know Air Force contracting procedures.

Secretary Sharp said: "Any contractor who consciously applies these actions can obtain defense contracts which would be profitable to himself as well as to national security." Sharp added that 8.2% of Fiscal Year 1957 prime contracts went to the smaller firms while the 21.5% of prime contracts going to large firms was eventually subcontracted to smaller firms—for a total of $1.5 billion.

In fact, a much greater share of both prime and subcontracts are of the small business variety. It's true that they may go to big companies, but they are small in dollar volume and they go to divisions of large companies which are, in effect, small firms. In other words, the volume of business available to small business is much greater than that indicated by official statistics.

New prime and subcontract leads include: Official O.K. given by Defense Department missile czar William A. Holaday to Air Force for three more IRBM/ICBM projects, including: a solid-propellant ICBM; *Polaris* as a land-based IRBM; development and production of a new oxidizer for *Titan*.

Another possible contract lead: Army is eyeing a hopped up version of the Navy's *Talos* for possible development as an anti-missile missile. Navy also is interested in further development of *Talos* as a countermeasure for ballistic missiles fired from submarines. Problems Army and/or Navy would like to see solved include: guidance for anti-missile missile role; better propellants for longer range and faster interception. Still another lead to watch: AF may buy *Regulus* II missile for surface-to-surface work.

Two bills on Capitol Hill will affect defense contracting—if they're enacted. S.3223 would extend the Defense Production Act for another two years. This is the law that gives the Office of Defense Mobilization its authority. Status: expected to be extended without question, including government guaranteed loan provision. H. R. 10830 is concerned with helping in replacement of out-of-date machine tools. Would be concerned with maintenance of modern defense production equipment in both privately owned defense contract plants and government arsenals.

Another bill, well on the way to enactment, would return government accounting to an accrued expenditure basis. It has disadvantages, but would prevent recurrence of last fall's squeeze between cash on hand and debt ceiling which resulted in untimely defense spending cutback.

Navy's in the market for developers of newer and better heat-resistant materials, particularly for atomic propulsion systems . . . Rep. F. Edward Hebert's special House Armed Services Subcommittee is starting a new investigation, particularly of Pentagon logistics and procurement policies . . . U.S. has earmarked $666 million for missiles for other nations.

Awards

Nike-Hercules: Western Electric Co., $129,592,706 for *Nike-Hercules* missile and ground equipment contracts—from Army. Douglas Aircraft Co., $43.5-million for *Nike-Hercules* production and fabrication. Other contractors include Goodyear Aircraft Co. and Borg-Warner, booster hardware; Thiokol Chemical Corp., sustainer motors; Hercules Powder Co., booster motors; Consolidated Western Steel Co., launchers.

R&D on Missiles at Jet Propulsion Laboratory: California Institute of Technology, $22.7-million from Army.

Q-2 Firebee: Ryan Aeronautical Co., $1,387,293 for production, from AMC.

Thor and Atlas: Republic Aviation Corp., $1.5-million for *Thor* and *Atlas* nose cone components, from General Electric MOSD.

Summary of $118 million in Army missile contracts for December 1957, shows: to Western Electric Co. for *Nike* family contracts of $31,058,200; $5,808,750; $3,182,903; $1,360,800; $3,718,366, $13,175,420; and $1,175,760. To Raytheon Manufacturing Corp. for *Hawk* contracts of $2,072,726; $8,049,500; and $8,758,697. To Chrysler Corp. for *Jupiter* $10,940,123; $2,356,204; and $8,729,255. To Sperry Rand Corp. for *Jupiter*, $1,081,377. To Ford Instrument Co. for *Jupiter*, $1.1-million. Plus other contracts: Motorola, $2,072,726; RCA, $4,777,000; Douglas Aircraft, $2,472,424; Gilfillian, $2,877,000; and Martin, $5,829,000.

Other Contracts Include:

By New York Ordnance District: Ford Instrument Co., $404,619 for designing and developing inertial devices. Southwest Research Institute, $32,000 for research on advance medical problems encountered in flight through the upper atmosphere space.

By Philadelphia Ordnance District: Western Electric Co., Inc., $192,993 for *Nike* spare parts & components.

By Rochester Ordnance District: A division of Pfaudler Permutit, Inc., $123,554 for tank for missile.

By Los Angeles Ordnance District: North American Aviation, Inc., $963,000 for rocket engines. Northrop Aircraft, Inc., $69,000 for maintenance evaluation of DATICO equipment. Motorola Inc., Phoenix Research Laboratories, $150,000 for development of Airborne instrumentation. Douglas Aircraft Co., Inc., $4,757,939 for launching area items. Associated Aero Science Laboratories, $112,000 for civilian technical assistance. Douglas Aircraft Co. Inc., $131,092 for repair parts for *Nike* system. Gilfillan Bros. Inc., $29,868 for repair parts for *Corporal* missile system. Gilfillan Bros. Inc., $1,078,266 for engineering services related to *Corporal* missile system. Gilfillan Bros. Inc., $73,828 for replenishment spare parts for *Corporal*.

Cleveland Ordnance District: North Electric Co., $131,000 and $179,382 for communications system for *Jupiter*. Goodyear Aircraft Corp., $300,000 for cost contract for acquisition of additional manufacturing facilities. Ohio State University Research Foundation, $39,000 for research on the study of amine perchlorates as ingredients for fastburning propellants.

By AF ARDC: Armour Research Foundation of Illinois Institute of Technology, $34,870 for research on the physiological effects of ozone.

By AFMDC: University of Chicago, $53,233 for installation of an acceleration device on short track facility. Winzen Research Inc., $26,000 for cost overrun. North American Aviation Inc., Rocketdyne Div., $225,000 for liquid-propellant rocket sled system. Phillips Petroleum Co., $135,000 for cost overrun. Grand Central Rocket Co., $279,650 for rocket motors. Thiokol Chemical Corp., $105,480 for rocket motors.

By HQ AMC: Hol-Gar Mfg. Corp., $428,400 for gasoline generator sets. Marquardt Aircraft Co., $198,077 for services for test time at AF Marquardt Jet Laboratory. General Electric Co., $140,981 for 528L targeting sub-

system. **Cambridge Corp.**, $406,226 for MD-1 liquid oxygen tank semitrailer. **Radio Corp. of America, Defense Electronic Products Div.**, $322,565 for auxiliary interconnecting box for missiles.

HQ AFMTC: Wollensak Optical Co., $61,750 for sighting telescopes and accessory equipment. **Cubic Corp.**, $118,450 for increase of funds. **E. C. Morris and Son**, $29,900 for engineering services repair work on test stands and support projects WS-107A and WS-315A.

By HQ AFB: Systems Research Laboratories, $45,395 for modification of fuel test stand.

By Dayton AFD: Tru-Ohm Products Div. of Model Engineering & Mfg. Co. Inc., $26,227 for resistors. **Electronic Div., Westinghouse Electric Corp.**, $116,308 for Westinghouse microwave system map. **John Oster Mfg. Co.**, $25,875 for Oster type motor. **The Hass Instrument Corp.**, $65,520 for estimates for altitude test range. **Aerotec Corp.**, $39,809 for various pressure switches. **General Electric Co.**, $42,435 for transformer. **Sylvania Electric Products Inc.**, $42,120 for tube-electron. **Penta Laboratories, Inc.**, $79,200 for tube-electron. **Receiving & Cathode Ray Tube Operations, Raytheon Mfg. Co.**, $68,200 for tube-electron. **Minneapolis-Honeywell Regulator Co.**, $47,158 for pressure switch. **Van Wagner Co.**, $47,500 for inspections sets. **National Electronics, Inc.**, $58,370 for tube-electron. **General Electric Co.**, $192,183 for tube-electron. **Kuthe Laboratories, Inc.**, $340,972 for tube-electron.

By AFOSR: The Pennsylvania State University, $55,912 for research on crystalline solids. **Polytechnic Institute of Brooklyn**, $50,000 for research on analytical study of high-frequency oscillatory combustion and of scaling up of rockets. **Aerochem Research Laboratories, Inc.**, $54,015 for research on low-temperature plasma jet. **General Atomic Div.**, $57,753 for research on free-radical solids using beam techniques. **Polytechnic Institute of Brooklyn**, $40,000 for research on investigation of plates and shells under elevated temperatures. **University of Miami**, $31,173 for research on nuclear emulsion studies. **The Board of Trustees of the University of Illinois**, $30,300 for study of surface physics. **New York University**, $50,000 for research on elasticity. **General Electric Co.**, $653,317 for studies in heat transfer. **The Institute for Advanced Study**, $40,500 for studies in mathematical analysis.

By Army Signal Supply Agency: Aeronautronic Systems, Inc., $182,355 for research to conduct a study in the guided missile range instrumentation field, modification. **Haller, Raymond and Brown, Inc.**, $46,748 for directory for army electronic and deception equipment. **Trustees of Princeton Univ.**, $66,000 for investigation of high polymers. **Engleman & Co.**, $32,940 for investigation of the vulnerability of electronic equipment. **Stanford Research Institute**, $88,380 for investigation design for ground based antennas. **Tung-Sol Electric, Inc.**, $49,500 for research on utilization of magnesium-oxide electron emission. **Pacific Division, Bendix Aviation Corp.**, $36,135 for investigating the problems in high speed data transmission systems. **Hewlett-Packard Co.**, $60,600 for digital delay generator.

By Redstone Arsenal: Becco Chemical Div., Food Machinery & Chemical Corp., $88,140 for hydrogen peroxide. **Kaiser Aluminum & Chemical Sales, Inc.**, $45,700 for cable reels. **Permanent Filter Corp.**, for liquid oxygen filter. **Allan Aircraft Co.**, $25,196 for AN fasteners. **Collins Engineering Corp.**, $73,132 for AN fittings. **Electronic Associates, Inc.**, $32,025 for electronic equipment. **Thiokol Chemical Corp.**, $194,996 for continuation of research and development of large size rocket engine cases. **Thiokol Chemical Corp.**, $74,944 for engineering evaluation of improved two-level thrust system. **Linde Co.**, $96,360 for liquid oxygen and liquid nitrogen.

By Army, Corps of Engineers: MacGuire-Glaser Co., $168,418 for Army launching area No. 2, Phase II. **R. E. Clarson, Inc.**, $130,388 for telemetry lessee for launch complexes 11, 12, 14, 15, 16, and 19, and CZR camera pads for complex 19, AFMTC, Patrick AFB. **B. B. McCormick & Sons, Inc.**, $251,463 for construction of stone revetment, Canaveral Harbor, AFMTC. **Diversified Builders, Inc.**, $162,786 for construction of Calibration laboratory. **Fairbanks, Morse & Co.**, $119,931 for generator unit and emergency generator set. **Satchwell Electric Construction Co. Inc.**, $402,513 for propellant analysis lab, AFMTC, Patrick AFB. **R. E. Clarson Inc.**, $488,415 for electric power plant, Cape Canaveral Missile Annex, Patrick AFB.

By Army, Engineer Division: Clarkeson Engineering Co. Inc., $53,500 for items for *Nike* sites. **Crandall Engineering Co.**, for items for *Nike* sites. **A. T. Scanzillo Co.**, $93,291 for construction of additional building *Nike* Battery No. 17.

By Army, Engineer District: George A. Rutherford, Inc., $560,451 for engineering analysis. **C. H. Leavell & Co.**, $830,934 for missile assembly bldg., phase II.

By Purchasing and Contracting Office of Army: Harvey Machine Co., Inc., $102,295 for explosive foxhole diggers.

By Ordnance District, Army: Flexonics Corp., $79,287 for supply contract.

By Army, Mobile, Corps of Engineers: The Rust Engineering Co., $43,000 for architect-engineer services in connection with ABMA facilities FY 1958 at Redstone Arsenal. **Daniel Construction Co.**, $441,115 for construction of photographic & video instrumentation laboratory at Redstone Arsenal.

By Navy, Bureau of Ordnance: Aerojet-General Corp., $2,275,470 for solid propellant JATO, rocket.

By Navy, Sixth Naval District; Public Works Officer: Nat G. Harrison Overseas Corp., $362,500 for additional instrumentation for the AFMTC.

By Navy, Bureau of Aeronautics, Purchasing Office Dept.: Stanford Research Institute, $99,812 for investigating the application of steel honeycomb and other sandwich core materials. **Trionics Corp.**, $29,607 for research on heat-resistant elastomerics.

By Navy, Bureau of Ships: Stavid Engineering Inc., $56,194 for services of electronics field engineers.

By Navy, Purchasing Office: Arma Div., American Bosch Arma Corp., $52,800 for engineering services. **International Business Machine Corp.**, $42,000 for mylar magnetic tape. **United Aircraft Corp., Hamilton Standard Div.**, $103,224 for turbine starter. **Lukens Steel Co.**, $278,584 for steel plates. **Gilbert Dannehower, i/t/a High Precision Prod. Co.**, $55,663 for gear grinding machine.

By Naval Research Laboratory: Burroughs Corp., Electro Data Div., $42,355 for electrodata computer.

By Navy Dept.: McConathy, Hoffman & Associates, Inc., $71,885 for Burner Laboratory bldg.

By Navy, Office of Naval Research: Radio Corp. of America, $55,339 for development of high-power transistors. **University of Illinois**, $33,417 for research of extra-terrestrial radio sources.

By Naval Training Device Center: Sylvania Electric Products, Inc., $54,989 for automatic target tracking and intelligence data display device.

By Atomic Energy Commission: J. A. Tiberti Construction Comp., $815,572 for control building area. **Sierra Construction Comp., Inc.**, $2,058,355 for assembly-disassembly building. **Pittsburgh-Des Moines Steel Co.**, $107,360 for water storage tanks. **Petroleum Combustion and Engineering Co.**, $1,-209,000 for test cell and tank farm.

Fred Galant and L. B. Wells of Visalia, $890,346 for access road. **Perry Brothers Drilling Co. of Flagstaff**, $89,325 for water supply wells. **J. L. Croft and Sons, Inc.**, $472,307 for roads. **Hansen Plumbing and Heating Co.**, $147,037 for water distribution system. **A. D. Schader Co.**, $252,036.09 for railroad facilities.

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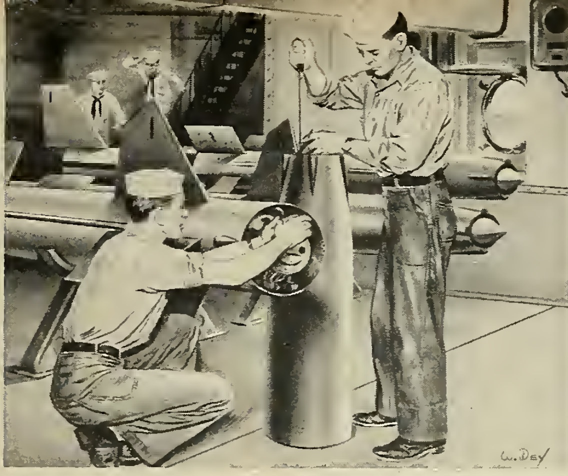


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APRIL

Eighth International Symposium, Electronic Wave Guides, sponsored by Microwave Research Institute of Brooklyn Polytechnic Institute, Engineering Societies Building, New York, N.Y., April 8-10.

ASME Maintenance and Plant Engineering Conference, Penn-Sheraton Hotel, Pittsburgh, Pa., April 14-15.

ASME Design Engineering Conference, International Amphitheater, Chicago, Ill., April 14-17.

ASME and AWS Engineering Division Joint Conference, Statler Hotel, St. Louis, Mo., April 15-17.

Institute of Environmental Engineers, Second Annual Technical Meeting, Hotel New Yorker, New York, N.Y., April 17-20.

AIEE, IRE, EIA, WCEMA Electronic Components Conference, Reliable Application of Component Parts, Ambassador Hotel, Los Angeles, Calif., April 22-24.

Second Annual Astronautics Conference, sponsored by Air Force Office of Scientific Research and Institute of Aeronautical Sciences, Shirley Savoy Hotel, Denver, Colo., April 28-30.

MAY

American Society of Tool Engineers, Second Annual Technical Meeting, New York, N.Y., May 1-8.

National Flight Test Instrumentation Symposium, Instrument Society of America, Park Sheraton Hotel, New York, N.Y., May 4-7.

Professional Group on Microwave Theory and Techniques, National Symposium, Stanford University, Palo Alto, Calif., May 5-7.

IRE, ACM, AIEE, Western Joint Computer Conference, Los Angeles, Calif., May 6-9.

Armed Forces Day "Open House" at most U.S. Military Bases. Observances in various cities May 10-18.

IRE, National Conference on Aeronautical Electronics, Biltmore Hotel, Dayton, Ohio, May 12-14.

JUNE

IAS, AIEE, ISA, National Telemetering Conference, Lord Baltimore Hotel, Baltimore, Md., June 2-4.

First National Guided Missile Industry Conference, Mayflower Hotel, Washington, D.C., June 4-6 (Robert H. Goddard Memorial Dinner June 6).

IRE Second National Symposium on Production Techniques, Hotel New Yorker, N.Y., N.Y., June 5-6.

American Rocket Society, Semiannual Meeting, Hotel Statler, Los Angeles, Calif., June 8-11.

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Propulsion Engineering

by Alfred J. Zaehringer

Look for new propellant materials. China Lake NOTS reports work on lithium hydroperoxide 1-hydrate. Other new propellant compounds coming out of the lab are lithium peroxide, boron-amines, alkyl borons, cyanogen, urazole and the organosilanes. Olin Mathieson is now producing commercial quantities of anhydrous hydrazine and also the aqueous grades; also being produced is the new hydroxyethylhydrazine (HEH) which is a good fuel and is hypergolic with certain oxidants. Pennsalt is introducing two new oxidants which may have considerable promise in solids: 3-nitroperchloryl-benzene and pehchloramide.

Lower-cost exotic fuels may be shaping up. Bellvue Laboratories of New York chlorinates cheap borax to make intermediate boron trichloride some 50% cheaper than existing high-temperature methods. It now takes about 10 pounds of the trichloride to make one pound of pentaborane or decaborane.

Propellant thermochemists will be interested in a program completed by AEC's Argonne National Laboratory. The thermodynamic behavior of many oxides, fluorides and chlorides has been determined to 2500°K and the data will be useful in determining the characteristics of rocket exhaust products and in finding pyrometallurgical methods for the separation of fission products from spent metallic nuclear fuels.

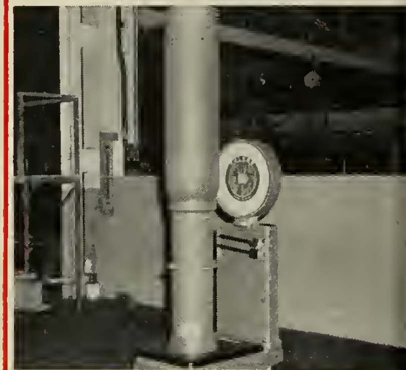
The Soviets have high-performance solid propellants. The last-stage rocket (used on both *Sputnik* I and II) used a large composite grain that delivered 0.75-1.0 million lb-sec. The sea-level specific impulse is estimated at about 273 sec. The average high-energy solid propellant now in use in the United States puts out about 225 sec at sea level.

More ammonium perchlorate for solid propellants is on the way. Pennsalt will produce the oxidant on the West Coast and at a site to be announced in the South. The process will be based on sodium chlorate as the raw material. Up to the present time, American Potash & Chemical at Henderson, Nev., was the sole U.S. large-scale producer. Now, with a blossoming of large solid rockets, more of this vital composite ingredient will have to be produced.

Nuclear rocket engine development will get a boost when Rocketdyne and the Air Force team up with AEC. The California firm has received a research and study contract with WADC on the atomic rocket. Present NAA atomic rocket view is quite conventional—an atomic pile which heats up an inert working fluid and exhausts it through a conventional nozzle.

Nuclear fuel elements for atomic rockets may be quite expensive. Based on present cost of \$15-\$30/gram for 90% enriched material (U^{235} or Pu^{239}), the fuel for a typical engine might cost over several hundred thousand dollars.

Forward end view of engine showing igniter assembly in place.



Completely balanced engine assembly is given final check for compliance to weight.

Zoom... PARISH puts the power behind this missile!

Parish-built rocket engine fires U.S. Army's LaCrosse missile.

The U. S. Army's Lacrosse missile takes to the air. This surface-to-surface guided missile is a rugged, close and general support all-weather weapon of high accuracy with a single shot kill power. *Parish* is producing the engine. Martin-Orlando makes the missile.

The engine and its numerous components require the utmost in precision engineering, fabrication and assembly. Balancing and weight are critical. For instance, the weight of the entire unit must be within ± ¼ of 1% of the total. Production fixtures and jigs had to be engineered for duplicate accuracy because any engine must fit any missile.

Parish Pressed Steel is the first company to successfully mass produce these solid-propellant engines. The reason: *Parish* has the unique combination of engineering experience, production know-how and precision equipment needed for such critical ordnance work. They're available for additional work right now. Call or write for additional information . . . today.

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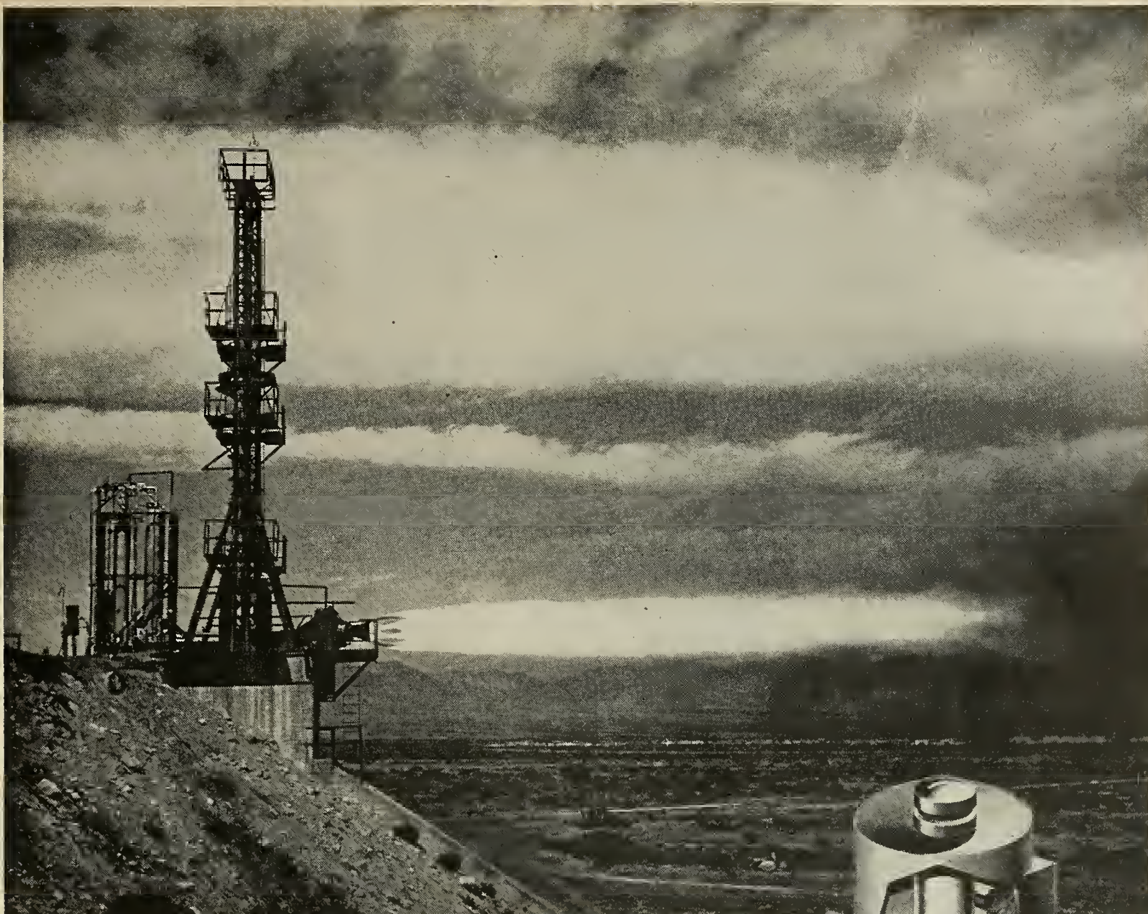

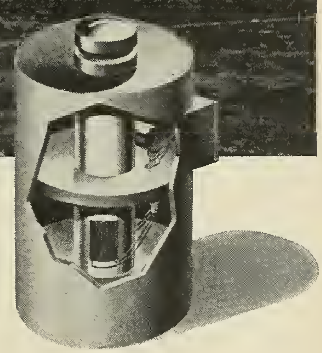

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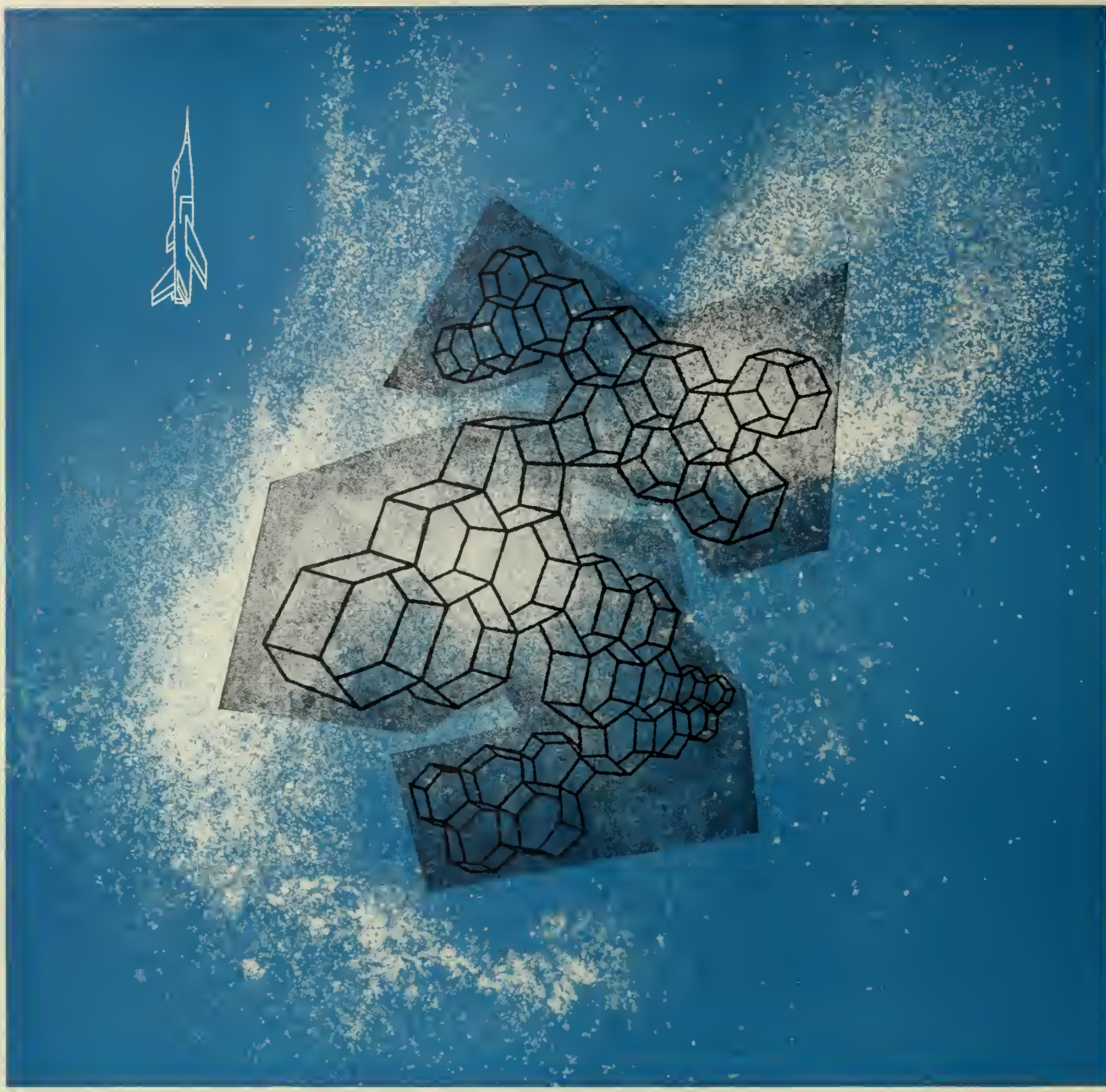

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VOL. 3 NO. 4

APRIL, 1958

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Old German Concept Becomes Reality:

Navy Pushing New *Subroc* Missile

Termed "ultimate" weapon by officials

By Erik Bergaust

Reliable sources have confirmed that the Navy is conducting a bidding competition for a new weapon to be called *Subroc*, or submarine-launched rocket. First use of the weapon would be for antisubmarine warfare but it could also be employed against other targets.

Faced with the prospect of not having operational *Polaris*-launching subs much before 1961 or 1962, the Navy will use the *Subroc* as its major submarine-type weapon at least until then. Washington officials have already dubbed the *Subroc*, "the interim ultimate weapon."

The Navy reportedly invited bids from 64 companies and received proposals from 29. Of the 29, about half will be asked to resubmit proposals in more detail and with dollar signs attached. This last action is scheduled to take place sometime between the middle of April and the 1st of May. Contracts will be let then and development will get underway.

Subroc based on an old German concept, is initially designed to be an underwater-to-air-to-underwater antisubmarine weapon. Reportedly Navy has set aside more money for this weapons system than any other except *Polaris*. Advantage of the weapon is that it is designed to be launched through conventional 21-inch torpedo tubes. Future plans for *Subroc* include its use as a tactical underwater-to-air-to-surface ballistic missile, and as an underwater-to-air antiaircraft and anti-missile weapon. Initial development, however, will be on the antisubmarine weapon.

Subroc will probably be somewhat similar to *RAT* in basic concept—a rocket booster for a sonar homing torpedo. Opportunities for business for missile metal machining firms will be considerable. *Subroc* will have at least four separate powerplants:

It will have a small motor to get it near or to the water surface, it could be a rocket—or turbine-powered propeller. At surface, main booster stage will fire. This will be conventional solid-propellant motor. *Subroc* will also carry a system of small retro rockets to help fix its ballistic trajectory. These will probably be liquid (hydrogen peroxide-potassium permanganate). Big solid-propellant motors will contain jetavators for guidance. Final propulsion system will be another underwater unit—either a conventional torpedo engine or a hydroduct (underwater ramjet) or a rocket motor.

The most striking feature of the *Subroc* is that it is to be designed for launching through conventional torpedo tubes, eliminating the problem of separately designed launchers as in the *Polaris* program. Most existing subs could be used immediately, including the three nuclear subs now afloat. Future *Albacore*-type subs would need no modification to carry *Subroc*.

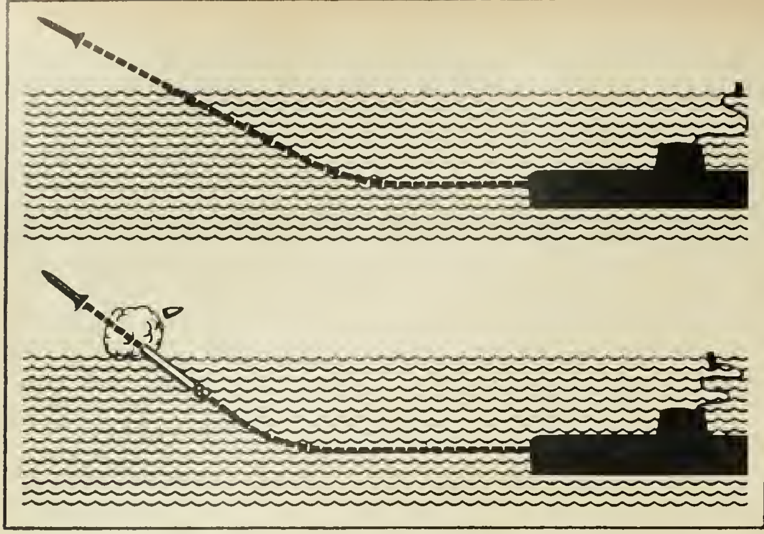
The *Subroc* is described as a torpedo-type weapon capable of being launched from a 21-inch torpedo tube. It is fired under water but takes to the air, using inertial guidance in flight, with an acoustic homing system cutting in when it re-enters the water. Targets would be programmed into self-contained guidance computers and would presumably be easy to insert or change if required.

The weapon will use a solid-propellant rocket for propulsion with jetavators for control and retro rockets for proper power adjustments to achieve a ballistic course. The warhead is said to be nuclear or thermonuclear, giving the acoustic homing and inertial guidance and control systems much greater leeway in finding the target because of the

Reds To Fly Atomic Airplane Soon

CHICAGO—Soviet nuclear rocket research is progressing "nicely" and their atomic-powered airplane will be flying "soon," according to Soviet scientists who visited the Nuclear Congress and the Atomic Exposition in Chicago last month. Nuclear rocket propulsion has been discussed openly in recent years by Soviet scientists. A meeting delegate said a Russian scientist had told him "we're probably ahead of the Americans in this field."

Several technical papers on nuclear propulsion for aircraft were presented at the Nuclear Congress. Simultaneously—at the semiannual meeting of the American Rocket Society in Dallas—four papers on nuclear rocket propulsion were given. ARS members expressed their hope that this country get a nuclear rocket program under way instead of the "nibbling" currently taking place. There was considerable criticism of how the military and the AEC had contributed to the delay of such programs.



SUBROC-TYPE missiles as conceived by the Germans in 1944.

hugely expanded kill radius possible.

With the current threat posed by Russia in the submarine warfare area, the Navy looks to the *Subroc* as a powerful deterrent. Russia now has somewhere in the vicinity of 500 submarines compared to our 100-odd active and 50 odd in mothballs so a weapon such as *Subroc* can act as quite an equalizer. In combination with airborne spotters, its range is probably something like 200 miles. This minimizes a trouble common to antisubmarine warfare—mistaking your own subs for those of the enemy.

Submarine warfare is complex and has many phases but the significant point about the *Subroc* is that it can be fitted into the existing structure without any modification to existing equipment. It can be carried by present-day subs, it can utilize nuclear warheads developed for other missiles, it can use existing elements of antisubmarine warfare such as blimps, patrol planes and sonar buoys, and it can draw on the missile industry for its component parts such as the rocket engine, the inertial guidance and the sonar guidance.

Antisubmarine warfare is the first use of the *Subroc*, but Navy planners see much more in the future. One suggested application would be a fleet of submarines launching *Subroc*s to clear an area in enemy territory for invasion, leaving a "clean" corridor for our forces. Another is for submarine-to-air using infrared homing.

Subroc is another indication of the Navy's real determination to stay in the missile business. The *Polaris* program has already sounded the death knell for land-based IRBMs and rumor has it that the Navy is thinking of a doubled-range *Polaris* which could revolutionize ICBM warfare. Now, with tactical uses such as pre-invasion softening and anti-aircraft, the *Subroc*, because it does not require any new supporting equipment, might well secure another chunk of the nation's defense complex for the Navy.

Couple *Subroc* with conventional torpedoes, rocket-assisted torpedoes, the *Polaris*, and an extended-range *Polaris*, and you have a missile system which can do just about everything in point-to-point tactical warfare. Navy officials have indicated they are pushing a plan to station a number of *Subroc*-type subs under the polar ice pack for instant retaliation. Experts seem to think it would be impossible for an enemy to spot these subs.

Army Secretary Witnesses Third *Explorer* III Launch

With Secretary of the Army Brucker and leaders of the Army missile team for an audience, *Explorer* III roared into space at 12:38 p.m., March 26 to join America's other two satellites in orbit.

Some 83,000 pounds of thrust provided by the *Jupiter* C first-stage's new high energy fuel, hydyne, lifted the four-stage vehicle off the launching pad at Cape Canaveral. The second, third and fourth stages which carried the satellite into orbit was made up of a veritable company of scaled-down *Sergeant* rockets.

The 80-inch long, pencil-shaped satellite weighing 31 pounds was packed with equipment to measure and transmit data on cosmic rays, micrometeorite activity, and temperatures. In addition, *Explorer* III carried a small tape recorder which could store information during flight and transmit it to a ground station on command. (See *Explorer* data story, page 47).

Extension o

by Frank McGuire

The Navy has a crash program in the works to foil the effectiveness of the Soviet undersea fleet. Known as the HERALD system, this is a massive, passive sonar installation; a harbor electronic ranging and listening device. Originally intended to protect harbors from undetected enemy submarines sneaking into a strategic port, the HERALD system is now being extended and improved to protect long stretches of strategic coastline against missile-launching submarines. (m/r, May, 1957).

Existence of the HERALD system was admitted, apparently accidentally, in a basic handbook for Naval officers. The handbook, on sale to the public through the Government Printing Office, indicates that the HERALD has been under development, and perhaps even in use, since World War II.

The Navy is pushing antisubmarine warfare to the utmost and beginning to release small amounts of information on the results of its developmental efforts in this field.

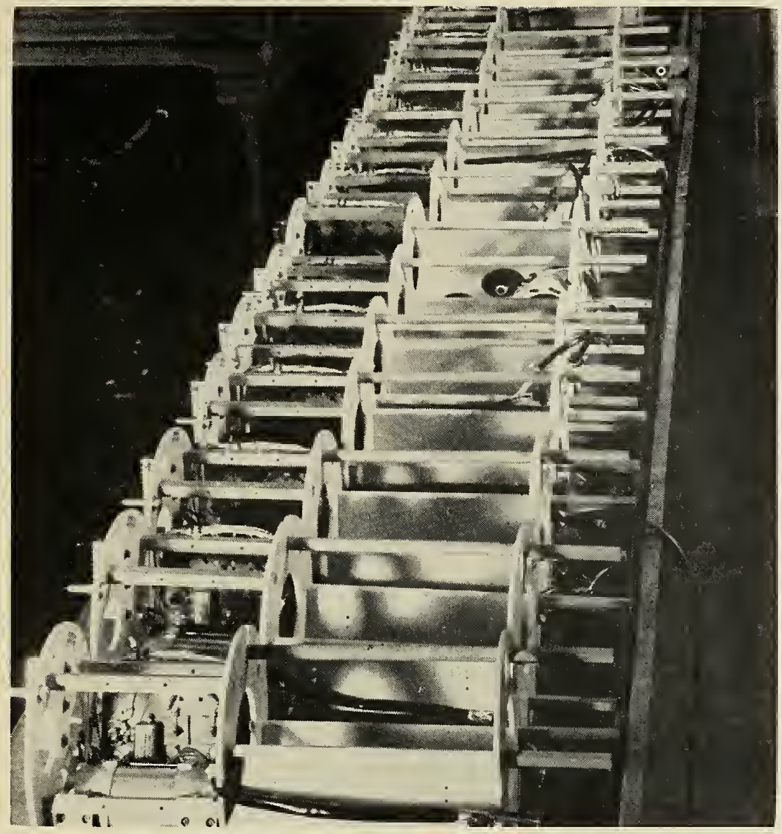
But the motto "silent service," is being carried through all phases of the submarine and antisubmarine program and is responsible for the tightest security measures in the U.S. defense setup.

It has become more difficult to obtain information regarding an obsolete torpedo than to get data on our latest bombers and missiles. The existence of the MK 32 torpedo, for example, was finally acknowledged to the press on January 15, only one day before the Navy announced that is was obsolete. Production of the MK 32 ceased in 1955.

Despite security precautions, however, the Navy is known to be working on several types of antisubmarine warfare (ASW) devices. The same heavily shrouded torpedoes loaded aboard submarines are openly mounted on destroyers tied up in domestic and foreign ports. The MK 43 *RAT* combination is a case in point since it is mounted on a standard 5-inch gun turret aboard Navy destroyers.

The MK 43 is expected to be followed by a more advanced version said to incorporate greater range, speed, accuracy and operating depth. This new weapon, probably to be called the MK 44 antisubmarine torpedo, is obviously under development by General Electric and under a pending $3.4 million contract, for more than 100 units which may go into prototype and pilot

HERALD Systems Planned



PARTIAL AFTERBODIES of the MK 43 torpedo rest on the line at the Naval Ordnance Plant in Forest Park, Ill. awaiting completion. The Mk 43, a rocket-assisted antisubmarine torpedo, is being replaced by the General Electric Mk 44 torpedo.

production at the Forest Park, Ill., Naval Ordnance plant sometime this summer. A great deal of plastic, glass fiber and electronic equipment is used to achieve lightweight construction and still maintain accuracy.

In sharp contrast to the 21-in.-diameter, 21-ft.-long standard submarine-launched torpedo, the MK 44 will be about a foot in diameter with a length of about eight ft. Two contra-rotating propellers which have a blade length of approximately two inches, but with an extreme pitch, are apparently cast of a lightweight metal such as aluminum. One annular stabilization ring is mounted at the rear of the fish.

According to the best guesses, the MK 44 will be rocket-assisted as is the MK 43, and can also be air-dropped or helicopter-launched. It is said to be quite reliable, but is intentionally not so refined as to be able to strike a beer can on the bottom of the sea. "Otherwise," said one engineer, "the enemy might litter the whole damned area with beer cans." However, the MK 44 is persistent—one model under evaluation reportedly made 13 passes at a target before scoring a hit.

The number of antisubmarine weapons using rocket power is growing. The *RAT* is actually an elementary form of rocket-boosted weapons, but future variations will be much more sophisticated and effective. ASROC, or antisubmarine rocket, a greatly advanced type of rocket-assisted torpedo, is being developed by a number of contractors, among which is GE, one of the bigger torpedo producers.

ASTOR, antisubmarine torpedo or atomic submarine torpedo, is a multi-mission weapon capable of carrying an atomic payload. It is believed to be based on a vehicle the size of a MK 18 torpedo. On this weapon system, the interchangeable warhead could be designed to accomplish a variety of tasks. One mission of the atomic-warhead torpedo would be as a supersubmarine killer with a great kill radius.

• **Propellers still tops**—Despite the exotic experiments being undertaken with underwater rocket-powered torpedoes using widely acclaimed infrared detection, there seems to be little immediate future for any operational weapons except those utilizing propeller-driven torpedoes guided by acoustics. Recent advertisements in trade magazines have praised the efficiency of underwater infrared detection, but information is lacking due to "security."

General Electric is understood to be testing an underwater shape with speeds in excess of 100 knots. It is apparently finding difficulty in effectively utilizing this speed.

The *Caribe,* another proposed antisubmarine weapon, would be a very fast, small torpedo with a light payload that might not sink a battleship, but would certainly punch large enough holes in a submarine to make it impossible for the submarine to voluntarily remain submerged long—if it expects to come up at all.

A major scientific complaint that has been made against Navy policy in the realm of ASW is the inbreeding that results from refusing to let industry actively take a part in basic approaches to the problem. There is no corresponding competition such as exists in the aircraft industry. Most torpedo development work is done by regular Navy installations, and the results are given to industry for development and production.

The Navy's past doctrine of having a strong "force in being" to combat war when and where it should occur has withered. This policy has now been most closely associated with the Air Force, while the Navy develops new weapons for antisubmarine work, produces a few at its Forest Park, Ill., Naval Ordnance Plant, and then puts the "production package" on the shelf to await a war.

The seagoing Navy thus gets a few new weapons to train with and conduct exercises with, but a wartime quantity is not expected to come through until wartime. The Navy, in the words of torpedo experts, is "expecting to win the next war the way we won the last one—through a huge production effort after hostilities have started. I wonder when they'll realize that they will fight the next war with what is actually in their hands on the day war breaks out?"

One of the prime causes of this situation is the severe budget limitation placed on the Navy. There is little reason to believe that the Red undersea fleet is any less dangerous than the air fleet. Projects like the HERALD system may detect a number of these submarines, but what operational weapon can prevent their success?

Vanguard—Long Countdown Succeeds

by **William O. Miller**

An important check point in the long countdown called Project *Vanguard* was written off as a complete success March 17 with the launching of a small test ball.

The St. Patrick's Day shoot was but one of the thousands of check points in the *Vanguard* program, which began over two years ago, and will continue for almost another year. As in the launching of a single vehicle, difficulty with any one of the components or adjustments delays the firing, so did the two previous tests temporarily halt the forward movement of the program.

Although the two previous attempts—one in December and one in February—did not place a satellite in orbit, nor even prove the launching vehicle, their failures were not unexpected and each of them contributed to the successful shoot.

The fact that the two previous shoots were in actuality "tests" seem to have been lost to the general public. Even on the day of the successful launching, Dr. John P. Hagen, Director of the project, declined to promise that the next scheduled launching would be successful.

However, the conditions under which the scientists and technicians of the Navy, the prime contractor—The Martin Company, and the International Geophysical Year worked for the last five months preceding the successful launching were most difficult in an almost unprecedented way. For almost two years the *Vanguard* program had progressed according to the plan of the U.S. National Committee for the IGY. Then, with the Russian announcements of *Sputnik* I and *Sputnik* II the *Vanguard* team was committed publicly by the highest office in the nation to a delivery incompatible with any scientific endeavor, particularly of an experimental nature. While this had little effect on the actual timing and scheduling of tests, the psychological pressure brought to bear on those responsible cannot be ignored.

• **Actually On Schedule**—Significantly, even with the two unsuccessful attempts, Project *Vanguard* is but very little behind schedule, as it was outlined over two years ago. At that time it was announced that an attempt would be made in the spring of 1958 to place a satellite in orbit. At the time, that in itself was a bold statement in view of the experimental nature of the project.

In any event, it is apparent that the old saying "nothing succeeds like success" is still valid. From a public apathy bordering on ridicule and threats of congressional investigation, the March 17 shoot has brought to those responsible the justified admiration of the scientific world and the renewed confidence in the free world's ability to take its place in space. Now it is acknowledged that never before in the history of rockets has such a complex and sophisticated vehicle gone from the drawing board to orbit in such a short time—a little over two years. This is even more impressive in view of the fact that *Vanguard* embodied many untried concepts and innovations, and did not have an unlimited budget. In brief, *Vanguard* delivered the planned payload with the planned thrust, with a little to spare, and within reasonable margins of the time scheduled.

• **Fired As Planned**—In discussing the launching, with m/r J. Paul Walsh, Deputy Director of *Vanguard* and the man in charge of the team at Cape Canaveral which launched the vehicle, said components and fuels used were as originally planned and that contrary to a rumor, no high energy fuels were used in the first stage. He went on to say that the vehicles to be used in the other seven firings scheduled for the remainder of the program will be basically of the same design as the one which put the 3.25-pound test ball in orbit.

"Success or failure is dependent on so many small things," Walsh said, "One small valve failure can spell failure for the entire operation."

Voicing the sentiments of the entire team he concluded:

"Months of extremely hard work and analyses of troubles have finally paid off."

All seven of the remaining satellites to be used will be equipped with the environmental study equipment which will measure and transmit information on air densities, temperatures, contact with meteorites and erosion effects. Actually, the test ball put in orbit March 17 was an extra dividend, as the firing was mainly to test the launching vehicle. The next launching will attempt to place the first *Vanguard* fully instrumented scientific satellite in space. All seven also will embody the Minitrack equipment for determining the positions of the spheres in their pre-determined orbits. All the spheres except one will be 20-inch magnesium spheres supplied by Brooks & Perkins Inc., of Detroit. The exception will be a 13 inch sphere of fiber glass laminate to be used in measuring the intensity of the earth's magnetic field.

• **Four Experiment Groups**—All of the information the scientists will seek falls into four categories at present. The final decisions as to just what components and experiments will be built into each satellite will be determined by the U.S. National Committee for the IGY. Actually, there are more proposed experiments and their necessary components than can be put into the remaining seven satellites.

As of now, the following information will be sought:

Group I—Measurement of the solar radiation in both the Lyman Alpha range and the X-ray spectrum. Two of the packages (the actual test sphere and a spare) will incorporate X-ray detectors in place of the Lyman Alpha detectors. Here, as well as where required in the other spheres, the Naval Research Laboratory will provide the sphere shell, the telemetering system, the Lyman Alpha detectors, telemetry, transmitter and antenna system.

Group II—Measurement of the cloud cover of the earth. By use of two infrared optical systems, the distribution and movement of clouds covering the earth will be determined. The optical system and telemetry is being developed by the Evans Signal Laboratory.

Group III—Measurement of the earth's magnetic field above the ionosphere. This is a NRL experiment, Dr. James Heppner in charge. The measurements of the magnetic field intensity will be accomplished through use of the fiber glass laminate sphere and a magnetrometer amplifier to be supplied by Varian Associates.

Group IV—Radiation balance experiment. This experiment, under Dr. Verne Suomi of the University of Wisconsin, will measure and compare solar energy or radiation from the sun to the earth and the radiation emanating from the earth, covering most of the range of the sun's energy. Detectors and telemetering encoders will be supplied by the University of Wisconsin.

In the original planning, Group II was the cosmic ray experiment which was developed by the State University of Iowa. This experiment was incorporated in the *Explorer* I launched by the Army. It also was included in *Explorer* II, which didn't orbit.

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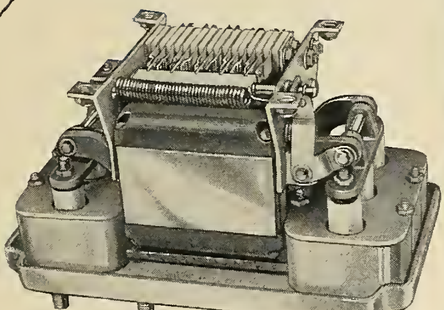

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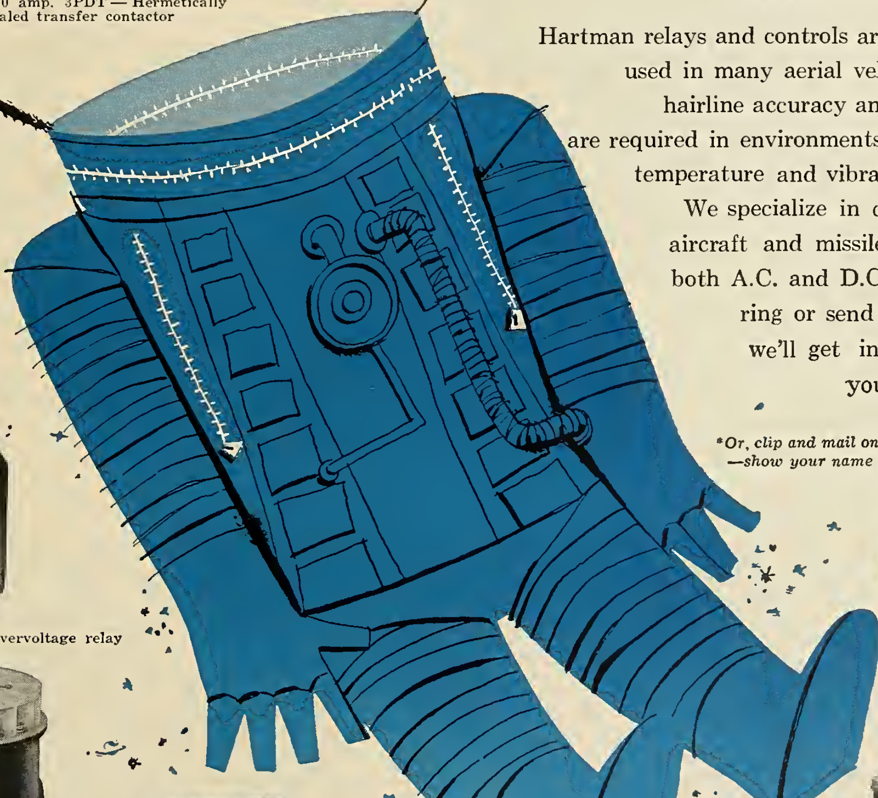

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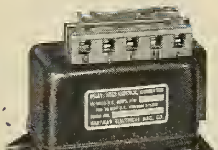

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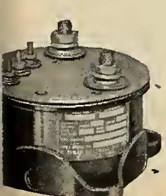

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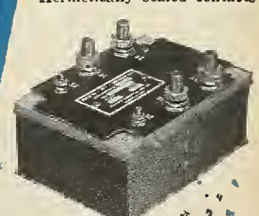

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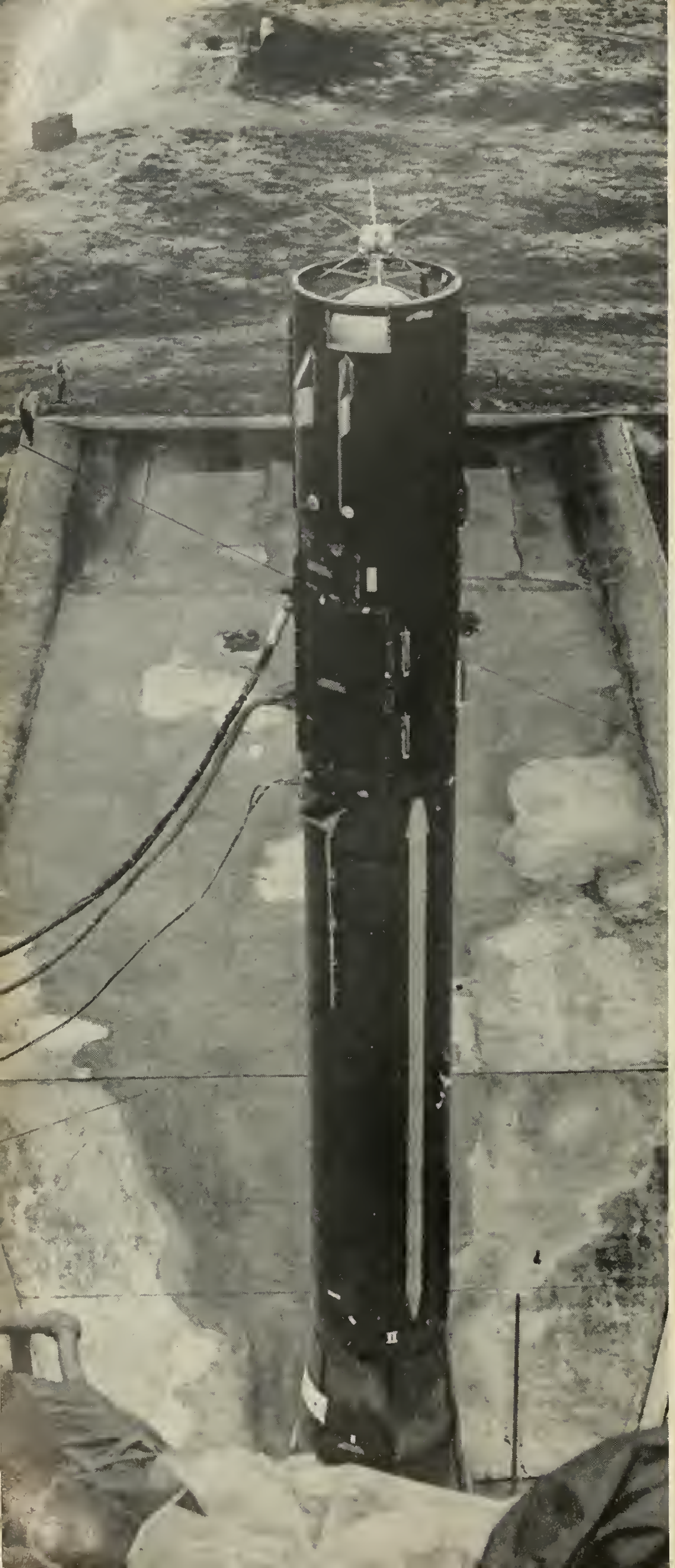


VANGUARD... the U.S. Missile in the News

Patience and perseverance paid off on St. Patrick's Day for the *Vanguard* program. TV-4, the sixth in the series of test vehicles, roared from its pad at 7:15.41 AM and successfully launched its baby satellite into an honorable orbit.

Shortly before the launching, the Navy reemphasized that the small satellite was put into the rocket for purposes other than putting it into orbit. The Navy said *Vanguard* I went along on the flight for the following reasons:
1) To determine by the satellite radio signals the rate of acceleration of the third stage rocket.
2) To test the satellite ejection mechanism.
3) "To take advantage of the *slight* possibility that an orbit might be obtained from a test flight. This, emphatically is not the principal reason for the inclusion of the sphere in TV-4."

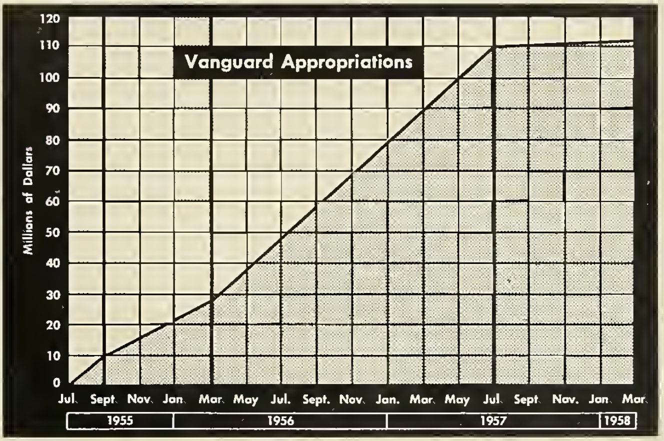
Dr. John P. Hagen, project director said that some parts of the *Vanguard* rocket "will surely be used in the more imaginative things that will be done in the next few years."

The total cost of the *Vanguard* to date is $112.1 million. Of this $46.3 million has been appropriated to the Defense Department; $18.4 million to the National Science Foundation; $4.4 million to DOD-Naval Research Laboratory for logistic support; $34.2 million as a supplemental appropriation for the overall program; $2.5 million, "miscellaneous"; $2.1 million for Moonwatch program. Of these totals, the rocket cost (Martin Co.) comes to $47.06 million. And $60 million goes for minitrack

stations, data reduction (IBM), satellites, instrumentation, etc. Chronologically, Project *Vanguard* started out in September 1955 with an estimated cost of $10 million. In March, 1956 this was raised to $28 million; in July 1957, to $110 million and in March, 1958, to $112 million.

Satellite Statistics

	Sputnik I	**Sputnik II**	**Explorer I**	**Vanguard I**
Size—	22.8″ dia.	19 ft. length	80″ length	6.4″ dia.
Shape—	Sphere	Cylinder	Tube	Sphere
Weight—(in lbs.)	184	1120	30.8	3.25
Length or diameter—(in inches)	23	Unknown	80	6-4
Speed—(mph)	17,660	18,170	18,470	18,000-19,000
Orbit Time—227 miles (in min.)	96.2	103.52	114.95	135
Lifetime—(in months)	3	5-6	24-48	60-120
Perigee—(in miles)	138	132	227	407
Apogee—(in miles)	598	1009	1575	2513
Rocket First Stage Thrust—(in lbs.)	250,000 to 395,000	250,000 to 395,000	83,000	27,000

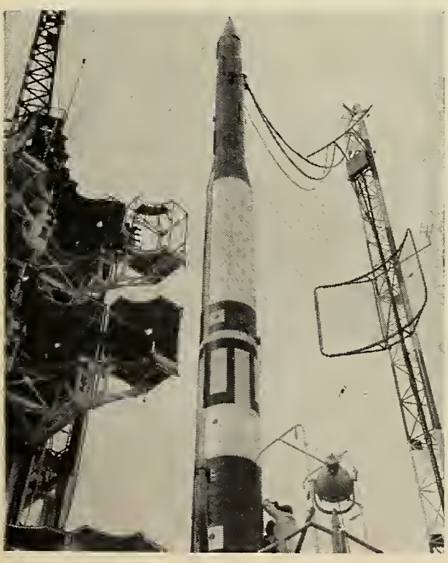


Sputnik I—Launched Oct. 4, 1957. Disintegrated first week in January after circling the earth about 1400 times.

Sputnik II—Launched Nov. 3, 1957. Still circling the earth. Expected to fall in April.

Explorer I—Launched Jan. 31, 1958, 10:58 PM.

Vanguard I—Launched March 17, 1958, 7:16 AM.



Titan Cooling Units Called Biggest Built

The first of three air-conditioning units to be used in connection with ground operations of the *Titan* ICBM has been completed by the C. G. Hokanson Co., Los Angeles, Calif., for The Martin Co., Denver, Colo.

Said to be the largest self-contained air-conditioning and water-chilling system ever built in the United States, the 25,000-lb. unit was completed just 63 days after receipt of the order from Martin.

Under continuous-duty conditions, the conditioner will deliver temperatures below 0°F, providing ambient design conditions exist. It is said to be capable of delivering moisture-free air to within approximately six grains of absolutely no moisture content, and will perform to the required specifications at altitudes from sea level to 6000 ft. If temperatures are below zero, the unit can heat the air to 120°F. After the desired conditions have been determined, automatic controls are provided to hold the conditions automatically and indefinitely.

Air Force to Launch Animal Satellites

The Aeromedical Field Laboratory at Holloman AFB has requested manufacturers' bids on an animal survival capsule to be ready for launching into an orbit by October, 1958. The capsules, to be less than 24 inches in diameter, are cylindrical and must weigh less than 200 lb. Survival equipment for 30 days must be included. A total of six capsules will be delivered by August, 1958, and will be launched at the rate of one a month commencing in October. Bids will be for study, design, development and production of the units.

Navy to Let Contract for Liquid Rocket Engine

Although the contractor has not yet been announced, the Navy plans to let a contract for a liquid rocket engine to be used as an auxiliary in fighter aircraft.

Details of the competition have not been released but the engine will be a throttlable powerplant designed for installation in the tail of the aircraft. It will be similar to the British *Napier* design, and will use the same fuel as the AR-1 engine developed by Rocketdyne and being tested in the FJ-4F *Furies*. The AR-1 burns hydrogen peroxide and conventional JP-4 fuel.

The aircraft in which the new engine will be used has not been released.

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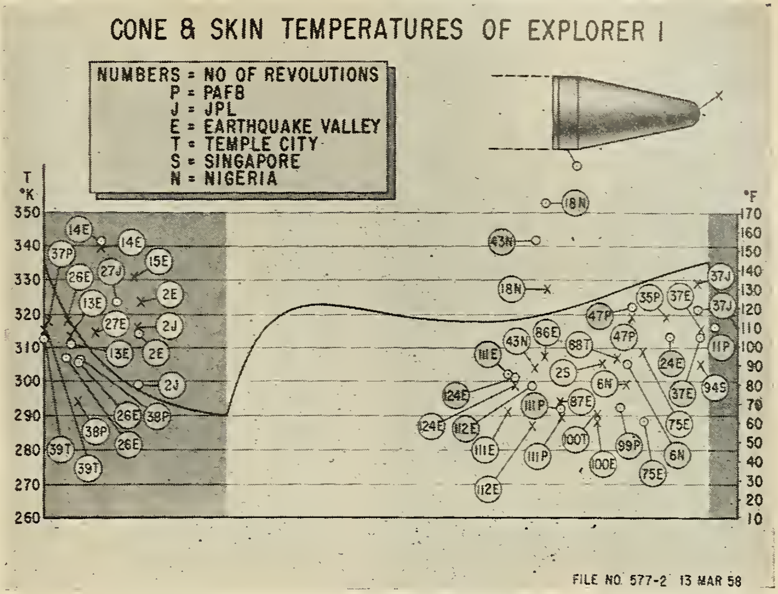
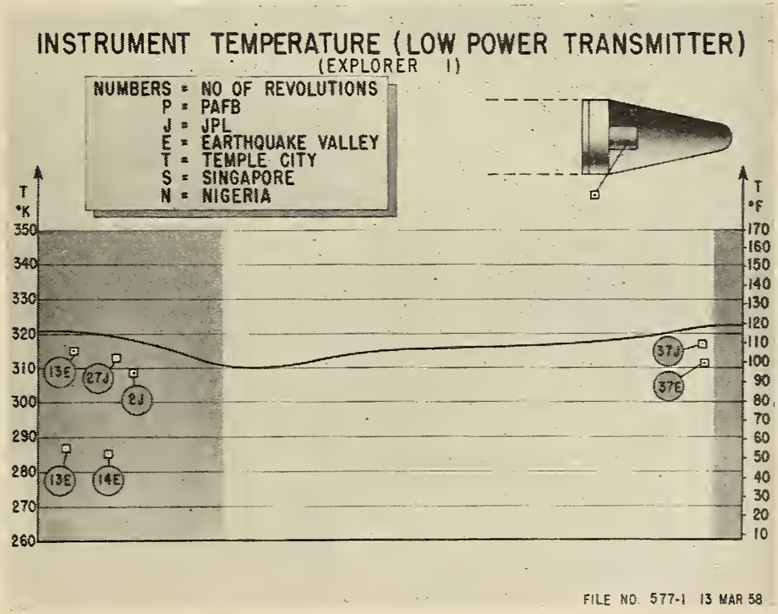
v. Braun Reveals *Explorer* Data





Dallas—At the recent meeting here of the American Rocket Society, Army Ballistic Missile Agency technical director, Dr. Werner von Braun, publicly released for the first time data received from the first U.S. artificial earth satellite—Army's *Explorer I*. Here m/r prints for the first time the plots of temperature readings received from the satellite during its first 124 orbits around the earth.

In the charts above, the continuous line curve represents temperatures as predicted. Shaded areas show where the satellite was in the earth's shadow. The points as plotted show actual measured temperatures. Note that predicted and actual vary considerably from one another. Note also that there are no temperatures which can be considered as excessive in that they would preclude manned space flight. Dr. von Braun said that *Explorer I* has demonstrated that present design (instrumentation, surface coating, etc.) is able to cope with conditions encountered, and that *Explorer I's* readings made it feasible to go head with more ambitious projects.

missile miscellany

This month, this page is going to start with questions: What ever happened to the Chamber of Commerce committee that, just before October 4, urged a sharp cutback in America's defense budget? Why is it the weekly earnings of workers in the aircraft industry jump sharply each December with no comparable increase in the output curve? What's this about Hughes having a new super-successor for Falcon, and about Grand Central Rocket coming out with a shorter, more lethal Sidewinder follow-up? What's the big deal that Allegany Ballistics Laboratory is getting so proprietary about? And why has the Air Force given Aerojet-General a $3.5-million facilities contract to enable them to get into the missile metal machining business—when there's plenty of this capacity around already?

Elsewhere, this page notes that Thiokol Chemical Corp. has a study contract on Minute Man, with implied assurance of follow-up contracts giving them development and production responsibilities . . . Radford Arsenal has bids out for 500 units of the Nike-Hercules booster with the idea of setting up a third source—and you should see the latter-day missile-makers flock to the bait! This page hopes they have some idea of what's involved . . . Tennessee Gas Transmission bought Grand Central Rocket, we hear, in order to diversify into something that would permit it to make more than the seven percent profit to which public utilities are limited . . . Meanwhile Grand Central plans a 50 percent expansion in the next few months; will keep all of its old responsibilities except propellant research which TGT takes over—and another question: Is Grand Central president Bartley going to stay, or has he got something else in mind? . . . And away down south, Army Ballistic Missile Agency has slapped full first priority on earliest possible completion and firing of TV reconnaissance satellite using RCA electronics system . . . Thiokol is reported to have gotten the solid-propellant booster contract from Boeing for Bomarc . . . Rohm & Haas has got the Nike Zeus propellant research program . . . Things seem to be livening up a bit . . . At ABMA crash programs are red-stamped "BLASTS."

AF has slapped a security classification on the new-type accelerometer developed by the Byron-Jackson division of Borg-Warner . . . And from B-W's Ingersoll-Kalamazoo division, word of encouraging progress on a new super-light, high-strength thin-wall casing that requires no machining; and of a revolutionary planetary ground-support vehicle that's amphibious by nature; does away with conventional wheels and troublesome "cat" tracks; and provides a vibration-free stable platform at 70 mph over plowed fields . . .

And AVRO-Canada's "flying saucer" is back in the news again with rumors running rampant, even including that it is powered by magnetic ion propulsion and is flying. Whether this is true or not, that it is on the verge of a major success seems virtually certain—backed by renewed AF interest and money . . . Diversey Engineering is making successful nose caps for Jupiter with a combination of hydro-spinning and contour machining . . . This page also hears where pyroceram is being chem-milled.

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Outer Space Base?

Navy—Supervised base readied at Point Arguello

Point Arguello—the latest in the galaxy of space names—probably will be this nation's takeoff point into outer space. That's the name the Navy's new Naval Missile Test Facility probably will bear.

Point Arguello NAMTF is coming into being on the 19,000 acres of the Army's old Camp Cooke which has been turned over to the Navy as part of the expansion and development of the Pacific Missile Range. The almost 100,000 acres of California real estate, coupled with the vast tracking facilities of the Navy's Point Mugu Naval Air Missile Test Center, will provide the United States with tremendously expanded facilities for development and testing of missiles and rockets of all services and all ranges.

The West Coast site offers several distinct advantages over the limited capabilities of the Cape Canaveral setup on the East Coast. Primary among these will be the capability of polar or north-south test firings of IRBMs and ICBMs.

Southward of Point Arguello, the nearest land is the Antarctic continent some 10,000 miles away. Habitable and populated areas to the north and south of Canaveral prohibit such tests on the East Coast. There are no space limitations as imposed by Canaveral's 12,000 acres.

Furthermore, the facility, just to the north of the Los Angeles area, places it next door to major missile manufacturers. All these advantages and the already highly developed Navy instrumentation at Point Mugu make the site ideal. The Navy, meanwhile, is planning expansion of the tracking facilities not only for the longer range north-south tests but for testing shorter range missiles on the Pacific range.

• **Canaveral continues**—Although the West Coast site offers many advantages, Cape Canaveral will continue as an important testing base. One distinct advantage the Florida base has is its capability for test firings to the east, taking advantage of the rotation of the earth and getting an object into orbit approximately 1000 mph faster. In any case, as the nation's missile and rocket programs grow, additional testing facilities and ranges are mandatory. Consequently, both the Canaveral range and the Pacific range are highly desirable.

For the immediate present the function of the Point Arguello facility will be to serve as a missile test and training base for the Navy, and provide facilities for the Pacific Missile Range in support of the Services' joint use of the range. The Air Force rapidly is developing the adjacent Cooke Air Force Base facilities as a missile training base.

• **Details due**—Details of the agreement under which the three services will use the facilities have not been announced. However, it is anticipated that the commander of the Navy's Point Mugu NAMTC, Rear Admiral Jack P. Monroe, will be more than just housekeeper and administrator and will have responsibilities and duties even broader than those exercised by Maj. Gen. Donald Yates of the Air Force at Cape Canaveral.

The complement of the Navy's Point Arguello facility initially will be 3 officers, 16 enlisted personnel and 4 civilians. Upon completion in the early 1960s personnel probably will number more than 1000.

The prospective commanding officer of the new facility is Cdr. Allen Rothenberg, a native of Newark, N.J. who calls Washington, D.C. his home. He was commissioned upon completion of flight training in 1941 and is a highly decorated veteran of World War II. Since July 1956, Cdr. Rothenberg has been deputy for administration to the commander of the Point Mugu NAMTC and the commander of the Pacific Missile Range, RAdm. Monroe.

Plastics Find Greater Use In Rockets and Missiles

Rapidly increasing capabilities to withstand higher temperatures and erosion indicate plastics will play an even more important role in the development of missiles and rockets, those attending the 14th annual National Technical Conference of the Society of Plastic Engineers were told by various industry representatives. Several new plastics also offer distinct advantages in missile tooling and where there is radiation danger.

Among those appearing on the program were Norman B. Miller and Eric L. Strauss of The Martin Company, who discussed the effects of high temperatures and erosion on reinforced plastic laminates. The Martin engineers said that above 250°F reinforced plastics lose strengths slower than aluminum, and that they have improved erosion-resistant characteristics. Conclusion drawn from tests in-

dicate damage in high-velocity air streams during the first 18 seconds is largely on the surface and that phenolic laminates can withstand 300°F for 60 seconds. Further, laminates form a protective burned surface. It also was pointed that while they are more stable, silicones have poorer strength characteristics. Polyester-glass laminates do not perform well at high temperatures, for short time uses and no effective surface coatings have been found, they concluded.

X-15 Production Details Show Space Flight Cost

Recently released information on the Mach 5, 150-mile high North American Aviation X-15 space flight rocket research vehicle provides a glimpse of things to come. Skinned and winged entirely of nickel-chrome stainless steel the manned rocket plane is a 65% welded structure, using both automatic fusion and resistance welding. Its skin side panels are chem-milled.

Other construction techniques on the X-15 include the brazing of all hydraulic connections; the enclosure of lines, controls, wires, plumbing, actuators, etc., in protrusions running down each side of the fuselage; inclusion of extension refrigerated air systems to combat X-15's operational temperature environment which ranges from plus 1,000°F down to minus 300°.

Reaction controls to enable maintenance of altitude in airless space will be hydrogen peroxide powered and include jet reactors in the nose for pitch and yaw control and in the wingtips for roll control. It is expected that X-15 will be flown during 1959.

Meanwhile, Pentagon is reviewing 10 proposals for boost-glide rocket bombers and expects to pick three for advanced engineering studies by May 1. Bell Aircraft and Convair are running neck and neck for first place.

USAF Academy Cadets to Study Astronautics

The U.S. Air Force Academy has added a Department of Astronautics to teach the fundamental physics of manned and unmanned space flight.

Through the six-semester-hour course, the Air Force said, it hopes to "develop an appreciation of the engineering and military compromises which must be made in the creation of a new weapon system."

Rocket-powered vehicles, including ballistic missiles, satellites and space vehicles, will be studied to illustrate the design process and how it is influenced by both technological and military considerations. Topics to be covered include stabilization and control of rockets, guidance, atmospheric re-entry, landings on celestial bodies in the absence of an atmosphere, survey of test techniques, and case studies of specific airborne and astronautical weapon systems.

Navigation Achieved for *Polaris* Submarines

The Ship's Inertial Navigation System (SINS), under development for the *Polaris*-equipped submarines, is reported by the Navy to have achieved the necessary degree of navigational accuracy to assure success of the Fleet Ballistic Missile program.

The SINS is similar in principle to inertial navigation systems used in long-range ballistic missile systems. The system provides precise navigation without reference to the stars, radio, radar, or other external methods of navigation. Essentially a computer, it provides the ship's position in latitude and longitude coordinates, true heading or course, surface speed, pitch and roll information—all to a high degree of accuracy, the Navy said.

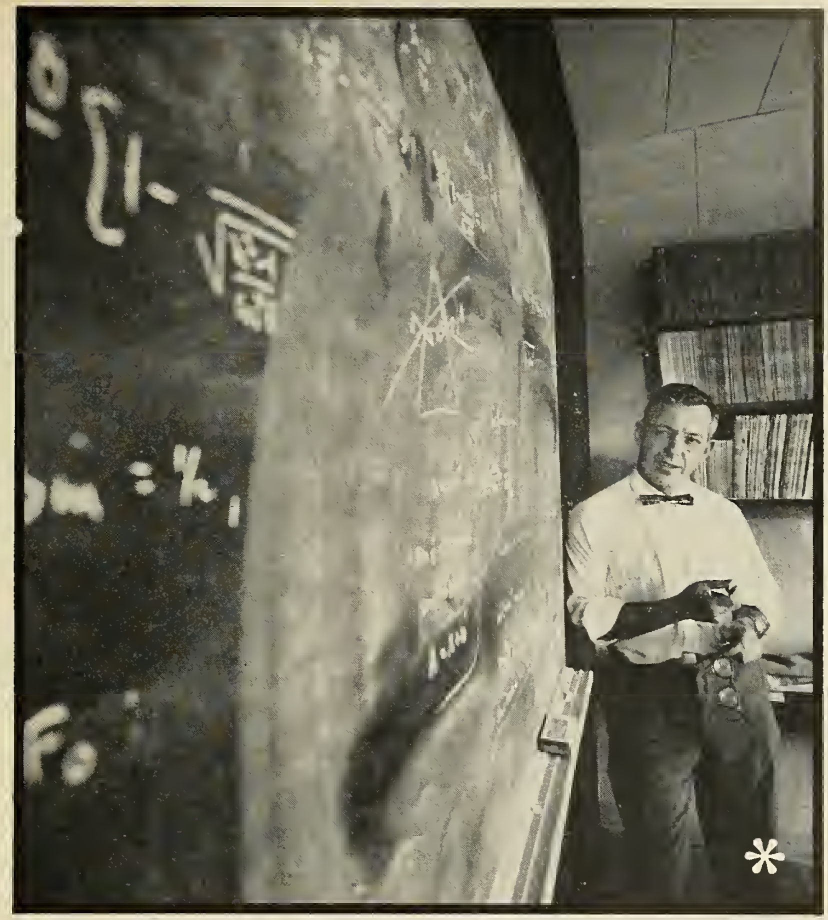
Basic to SINS is its stable gyro platform, or "stable table," which is maintained in alignment with the stars despite the turning and twisting movement of the vessel. The system is susceptible to long-term drift, making occasional reference to celestial fixes necessary. This information is analyzed, decoded and fed back into the system automatically by a Sperry-developed NAVDAC system.

AIA Group Pushes For Central Spec Index

The Aircraft Industries Association's Guided Missile Committee has been pressing the Department of Defense to compile and publish an overall index of specifications applicable to guided missiles, to replace the "incomplete separate service documents now available to guided missile manufacturers," it has been revealed.

The association said a study is now under way to determine the adequacy of guided missile test ranges. Results will be presented to the Department of Defense.

During the past year, AIA disclosed, the number of companies eligible for committee membership has increased 20 percent, because of an increase in the number of member companies who hold prime contracts for complete missiles.



an oblique look

tech/ops scientists know there are at least three ways of attacking a problem: head on, as an amphibious force hits a beach; flank-wise, as a tactician likes to strike; and *slantwise,* the offbeat way.

This is a basic principle in operations research, the new *team* method of attacking problems, in which *tech/ops* is a leader and pioneer. It is this habit of taking an oblique look—of applying a group of apparently unrelated disciplines to the problem—that has developed, at *tech/ops,* unique solutions in weapons systems, tactics, organizations and logistics.

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** Dr. Eric Clarke, tech/ops vice president, takes a look at a problem in his office at Burlington, Mass.*

Airborne Launcher for *Lacrosse*

The development of an airborne control system (ABC) for the *Lacrosse* surface-to-surface missile has been reported by Cornell Aeronautical Laboratory. Also under development is lightweight launching and handling equipment to make the system transportable by helicopter.

The present *Lacrosse* system, after initial launching from a position to the rear of the combat area, is guided to its target by a forward observer on the battlefield. With airborne control, the missile would be controlled from a position above the battlefield.

Because of its extreme accuracy and high payload, *Lacrosse* makes possible one-shot destruction of such difficult targets as pillboxes. Controlled by a forward observer, the system also can work fast, since it eliminates time taken in transferring target information back to the launching site.

Aerial observation should prove markedly superior in detecting targets, the Laboratory believes. The airborne control program also is particularly suited to the latest concepts of mobility for field armies.

Rapid progress on the ABC project during the past year carried it from study phase into actual flight testing of subsystem assemblies, CAL revealed.

Work on the lightweight launcher also is aimed at improved mobility.

READY FOR ACTION—*Lacrosse* in firing position. The new lightweight launcher is designed specifically for helicopter transportability.

According to the laboratory, the specific goal is to make the launcher, as well as other system equipment, transportable by helicopter to strategic points on the battlefield. The present *Lacrosse* uses a launcher mounted on a standard Army truck.

Chrysler Corp. Defends Redstone Cost Figures

Chrysler Corporation has defended its use of "time and materials" subcontracts for the Army's Redstone missile which the General Accounting Office reported to Congress had resulted in "unreasonably high" prices for Redstone parts.

Chrysler said it used that type of contract in the best interest of the missile program until realistic predetermination of cost could be achieved.

GAO had criticized subcontracts totalling 124 million dollars awarded by Chrysler. The price paid was based on estimated labor costs, overhead, profit and material. "Time and materials" subcontracts often are used in early development stages when it is difficult to say how much a part should cost. Such contracts were justified at the start of the Redstone work, GAO said, but later should have been shifted to fixed price contracts.

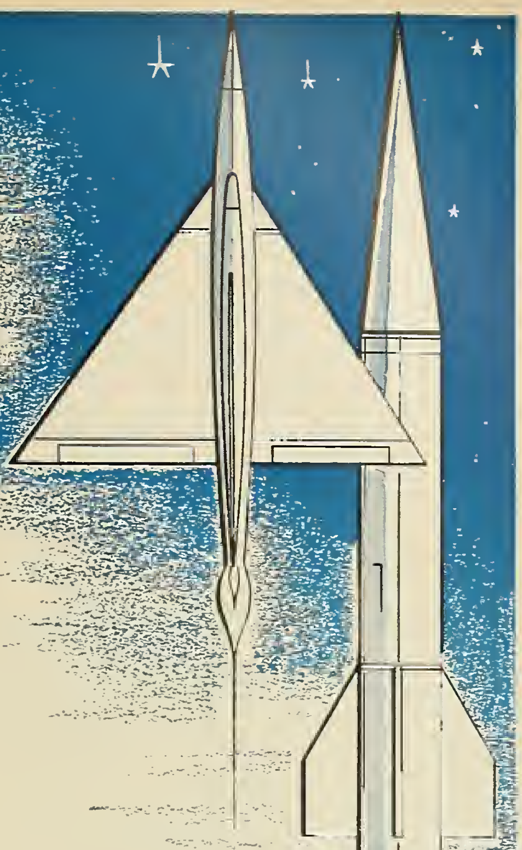
Bomarc Officers Complete First Phase of Training

The first group of Air Force officers to receive training on the *Bomarc* missile have completed the first round of technical instruction in operational use of the Mach 2.5 surface-to-air missile.

The officers, selected for this five-month maintenance engineering seminar, are attached to the recently formed 4751st Air Defense Missile Wing, 73rd Air Division, Tyndall Air Force Base, Fla. The officers have received their training at a special Boeing Airplane Co. school in Seattle.

These missile wing officers are being given actual "on the job" assignments in Boeing's Pilotless Aircraft Division for several months. Following this, their training will carry them to the *Bomarc* test firing unit at Cape Canaveral, Fla., and then to the *Bomarc* operational testing base.

SPACE AGE TEST EQUIPMENT



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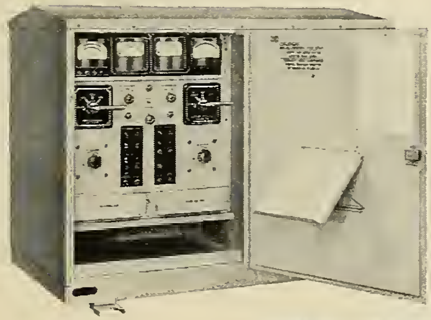

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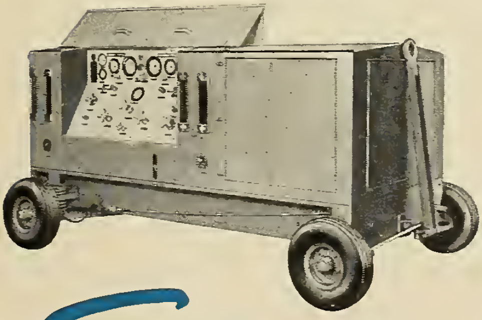

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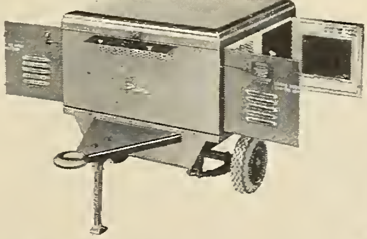

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Conservative White House Report On Space Flight Objectives

Proposed legislation designed to assure civilian agency control of outer space programs was due to go to Capitol Hill from the White House as m/r went to press.

Indications at press-time were that the proposal would define the place of the National Advisory Committee for Aeronautics in an outer space research program. Best guess was that a new agency using NACA personnel and laboratories as a nucleus would be recommended.

At the same time, a report by the President's Science Advisory Committee entitled an "Introduction to Outer Space", was made public with President Eisenhower's blessing. The report, in conservative, non-technical terms, defines both the interest of civilians and of the military in outer space, laying emphasis on the importance of space exploration in solving problems of communications and meteorology.

There was a tendency, in the report and the President's comments, under present conditions, to down-grade the value of space vehicles as weapons carriers. The committee said "In short, the earth would appear to be, after all, the best weapon carrier."

A timetable of scientific objectives stated only in terms of early, later and "still later" time scales is included with the explanation that specific timing will depend on the level of effort —that space research must not foreclose the continuation of research of a more prosaic and earthly type.

The committee, in concluding the report said: "it would not be in the national interest to exploit space science at the cost of weakening our efforts in other scientific endeavors. This need not happen if we plan our national program for space science and technology as a part of a balanced national effort in all science and technology."

As for the current effort, the committee warned that rocketry and other equipment used in space technology must usually be employed at the very limit of its capacity. This means failures of equipment and uncertainties of schedules are to be expected. "It therefore appears wise to be cautious and modest in our predictions and pronouncements about future space activities—and quietly bold in our execution," the report stated.

1st National Missile Meet Set June 4-6 at Washington

The National Rocket Club of Washington, D. C., has announced that the First National Missile Industry Conference will be held on June 4 and 6 at the Mayflower Hotel. The Aircraft Industries Association and the National Capital Section of the American Rocket Society have been invited to participate.

The NRC, which started as an informal monthly luncheon club, is a non-profit organization. Among its members are men from the Department of Defense, the three military services, the House of Representatives, the Senate, the rocket and missile industry and the press. Objective is promoting advancement of U.S. missile and astronautics programs.

Purpose of the First National Missile Industry Conference is to enable missile businessmen to get together with the experts and discuss their mutual problems. Meetings for the three-day session will be in the form of panel discussions, and topics discussed will be sales, procurement, subcontracting and business forecasting—all in the missile, rocket and space flight field. Participants in the panels will represent Congress, the Department of Defense, industry and the press.

Highlighting the conference will be the Dr. Robert H. Goddard Memorial Dinner, to be held on Friday, June 6, when various awards will be presented for outstanding contributions to the missile industry. One of these will be given by Wayne W. Parrish, President, American Aviation Publications, Inc.

Two leading missile manufacturers also will present awards. Proceeds of the dinner will be turned over to the Dr. Robert H. Goddard Fund of the Guggenheim Foundation. Thomas Wilcox, Rocket Club Executive Secretary, 1013 Woodward Bldg., Washington 5, D.C., is coordinating conference activities.

in′ge·nu′i·ty: *designing a 12-ton missile to fit inside an atomic sub*

Chance Vought's *Regulus II* missile is twice as long as a city bus. It is crammed with delicate instruments, armed with a nuclear warhead. Yet Vought engineers designed *Regulus II* to serve safely, efficiently aboard the Navy's newest nuclear-driven submarines.

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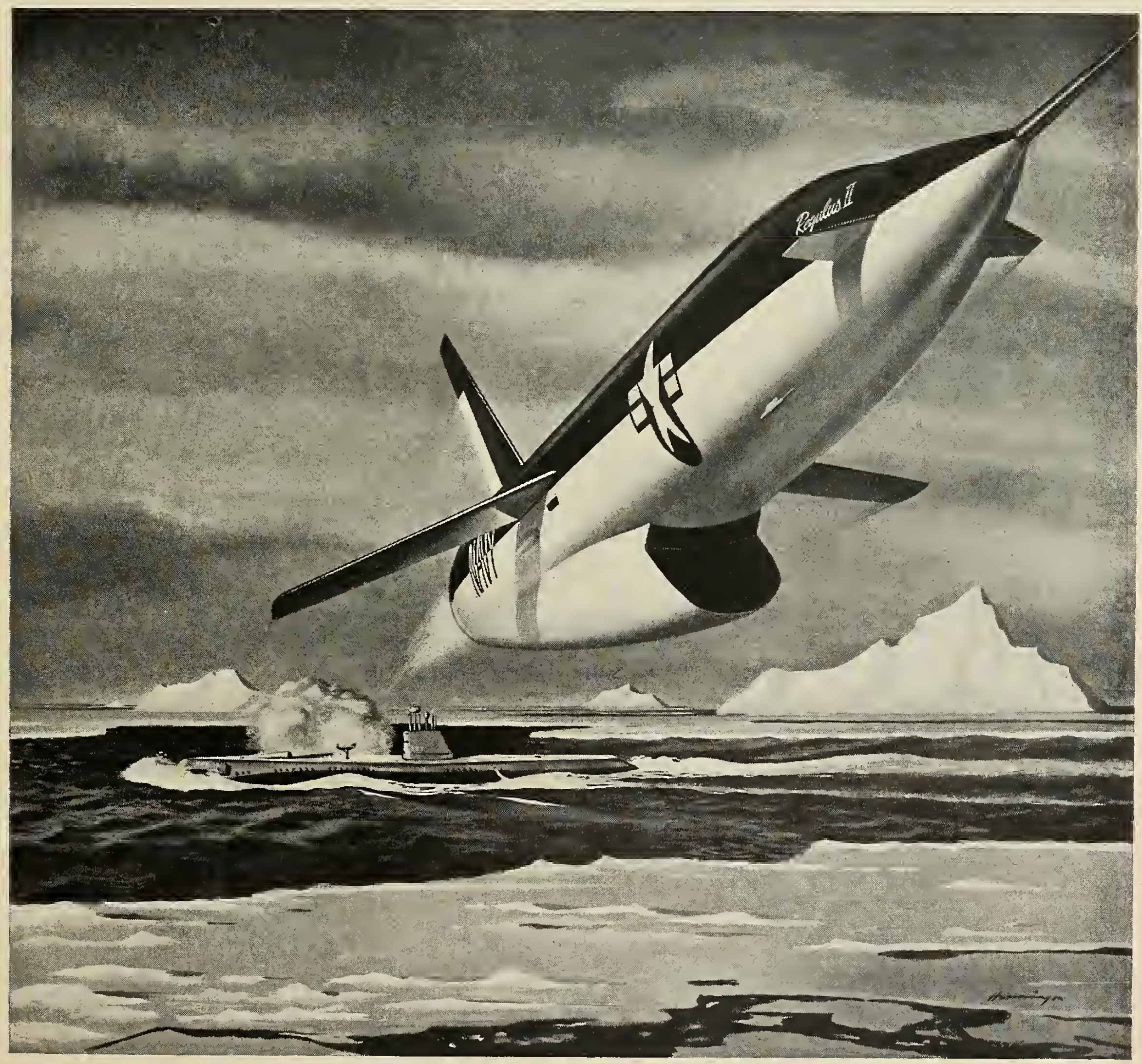

Miller, Fossen Join m/r Editorial Staff

William O. Miller has joined m/r as associate editor for military and legislative affairs. He formerly headed the radio and television branch of the office of the Chief of Information, U.S. Navy. From 1945 to 1950 he was assistant to the editor of the ATLANTA CONSTITUTION, a staffer in the Atlanta Bureau of the Associated Press and editor and publisher of his own weekly newspaper in Hampton, S.C.

Peer Fossen associate editor, optics and telemetry, comes to m/r from Page Communications Engineers, Inc., Washington, D.C. where he was editor-writer in the publications division. Prior to joining PCE he was associated with Army and Air Force technical publications.

m/r Columnist Receives USAF Civilian Award

Dr. Hubertus Strughold, dean of space medicine and m/r columnist received the Air Force's Exceptional Civilian Service Award during the recent Jet Age Conference in Washington, D.C.

Presentation of the plaque was made by Gen. Thomas D. White, USAF Chief of Staff at the conference banquet.

Advisor for Research to the Commandant of the Air University's School of Aviation Medicine, Dr. Strughold was cited for his "contributions to the complex problems of man's existence in space."

The space medicine expert organized the school's Department of Space Medicine in 1949, two years after his emigration from Germany.

Dr. Castruccio Named To m/r Advisory Board

Dr. Peter A. Castruccio, 32, advisory engineer at the Westinghouse Missile Subsystems Engineering Department, has been named to the m/r Editorial Advisory Board.

Dr. Castruccio, holder of several radar patents with numerous patents pending, is currently engaged in advanced planning of interplanetary electronics communications and navigational aids of the future. He formerly held positions with Bendix Radio and The Martin Co. in the field of military electronics.

The young scientist has written many papers and articles for technical magazines, including m/r. He majored in physics at the University of Sao Paulo, Brazil and won his doctorate summa cum laude in electrical engineering at the University of Genoa, Italy, at the age of 21.

Safety Device Developed for Handling Explosives

A newly developed safety device is giving added protection to research chemists handling hazardous compounds in the search for more powerful propellants.

Designed by Henry Rolewicz of the Redstone Arsenal Research Division of Rohm & Haas Co., the device is a portable shield consisting of three concentric baskets of perforated 1/8-inch sheet aluminum. The ¼-inch perforations are staggered on ½-inch centers to eliminate the possibility of direct passage from the interior. Tests, using up to five grams of "Composition C," have shown the shield will effectively stop all fragments while the perforations permit venting of the shock wave.

The device is most useful in transporting reactors or product receivers from test areas.

Space Age Conference a Hit in Los Angeles

The Los Angeles Chamber of Commerce struck pay dirt in a big way when it decided to put on a missile show last month.

The 1958 Western Space Age Conference and Exhibit was held March 20 to 22 at the Los Angeles Shrine Exposition Hall. Its theme: The U.S. Missile Market.

Planned by the chamber's industrial market development committee as a possible means of opening the gates to missile profits for the numerous small-size companies, which had been hard hit in the aircraft cutbacks, space for 200 exhibits was mapped out.

These were sold out within hours and another 150 spaces had to be added to meet the demand. When reservations poured in for two $8 luncheons and one $10 dinner (Dr. Wernher von Braun spoke on "The Space Age Time Table" at the latter), arrangements had to be made to accommodate 2000 instead of the originally anticipated 500 or 600.

"It turned out to be one of the most ambitious undertakings ever attempted by the chamber of commerce," said Kenneth F. Julin, president and general manager of Leach Corp. and chairman of the industrial market development committee.

Essentially, the purpose of the event was to bring the buyer and the seller together. About 50 prime contractors had exhibits. Show-stoppers included first public showing of the Douglas Aircraft Co.'s 40′ x 40′ working model of a *Thor* launching site and a scale model of the first U.S. satellite, the *Explorer*, by the Army and the Jet Propulsion Laboratory.

The two-day conference program, held in conjunction with the three-day exhibit, was arranged so that the first day was devoted to the business aspects of the U.S. missile market, with a keynote address by Dr. Lee DuBridge, president of Cal Tech, followed by addresses by Lt. Gen. Clarence S. Irvine, Air Force Deputy Chief of Staff for Materiel; Rear Adm. Jack P. Monroe, commander of the Naval Air Missile Test Center, Point Mugu; Vincent de P. Goubeau, vice president-materials, RCA, and Donald W. Douglas, Jr., president of Douglas Aircraft Co.

Technical sessions were held the second day with panels on such topics as quality control in missile production, metals and missiles, and tooling for missiles.

Emphasis on Flexibility Seen as Key to AF Missile Maintenance

Air Force's experience with an operational missile system in Europe (Matador) has helped to answer a couple of vital questions in respect to missile maintenance.

Chief concern of the policy makers has been whether the special requirements of missiles would necessitate major changes in the present aircraft maintenance organization. There was also the possibility that two separate systems would be required during the few years that manned aircraft will continue to play a prominent offense/defense role in the Air Force.

Two separate systems would be prohibitively expensive and cumbersome, while the entire maintenance organization would result in a long period of transition and a low level of efficiency for possibly several years.

Some surprising facts have emerged from this brief experience with operational missiles. Similarities between aircraft and missiles, in respect to maintenance problems, have tended to simplify the overall picture. In fact, Pentagon officials feel that the transition from manned aircraft to missile maintenance will be no more difficult than adapting the system to improvements in aircraft through the last few years.

One thing is certain, officials point out, and that is that the present system will be considerably streamlined out of necessity, and the overall maintenance organization will be much improved as a result.

Although the basic structure of the organization will remain the same, some minor changes have already been made, and more of them are already in the mill.

• **Retraining is problem**—The major problem in changing weapon systems is that of retraining technicians and specialists. It is here that ground is lost, and efficiency is sacrificed during the changeover.

However, it is also here that Pentagon officials are most enthusiastic. In clarification of this point an official told m/r that at the depot level all areas of missile maintenance can be taken pretty much in stride. As examples he cited sheet-metal work, engine overhaul, and electronics trouble-shooting and repair.

Metalworkers experienced on aircraft will encounter no real problems in the same area of missile maintenance. Engines are pretty much the same as those used on high-performance aircraft, it was pointed out, so again no real problem of retraining. Electronics equipment on modern aircraft is as complex and sophisticated as missile guidance systems. As these major areas are eliminated; airframe, engines, electronic gear; the problem resolves itself to one of lower echelon significance.

In this lower echelon of maintenance, the squadron level, the changes taking place are reshaping the overall maintenance organization. But, there is nothing happening here that the Air Force has not had experience in.

Retraining of "flight-line" personnel is something that must be done even in respect to old-type aircraft. The personnel at this level range from people who are new to the service to careerists, and most of the training in either case is for jobs that are performed on or near the flight line. "What difference," one official said, "whether the training is on aircraft or missile; its something we have to allow for."

• **New patterns**—Implementation of missiles as operational weapons has resulted in two new patterns at the squadron and group level, both designed to furnish the important aspects of flexibility and speed.

In the case of *Atlas* there is the combined-squadron, the maintenance and missile launching teams both within the same squadron organization. The same organizational structure is planned for *Bomarc*. There is a possibility that this type organization will be designated a ballistic missile unit.

The units now operational with *Matador* missiles are group level, with a TAC Squadron concerned directly with launching missiles, and maintained by a separate Maintenance Support Squadron. Maintenance squadrons are concerned with Receiving, Inspection and Maintenance (RIM), and Assembly and Maintenance (A&M).

Flexibility is built into the new units in that if the need arises for greater capability from any unit it can be expanded from a single-squadron unit to the group unit, and in the case of a group more TAC squadrons can be added, supported by the same maintenance squadron, and thereby doubling the firepower of a group without changing its basic organizational structure.

Alert teams from the A&M sections can be called to the flight line to make quick changes of control boxes, components or even engines, to keep alerted missiles in a state of readiness. Components removed from flight-line

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weapons are repaired in A&M's shops, at the depots, or if all these fail, by the prime contractor.

The byword in missile maintenance has been described as, capability of maintenance as close to the missile site as possible, with rapid and reliable flow of serviceable parts.

Ehricke Predicts Space Flight Timetable

Krafft A. Ehricke, assistant to the technical director of Convair Astronautics, said recently that progress in the current development program of the Atomic Energy Commission will provide practical powerplants for use in 1965-70.

Ehricke presented preliminary designs for a 200-foot, 90-ton, two-stage chemonuclear vehicle that he said would be capable of landing a 22,000-pound payload on the moon or orbiting a 30,000-pound payload around the planet Mars. Carrying a 15,000-pound payload, this vehicle could land a scientific expedition on the moon, with enough fuel remaining to take off, return to the edge of the earth's atmosphere and transfer personnel to a re-entry glider.

Ehricke's first stage is a delta-wing glider of 90-foot span, powered with conventional gasoline and liquid oxygen rockets developing 2.7 million pounds of thrust. It would return to earth after boosting the manned second stage beyond the earth's atmosphere.

Power for the second stage is provided by feeding liquid hydrogen to a rocket engine that has a nuclear pile as its energy source. Thrust is obtained by expelling a jet stream of hydrogen atoms from a rocket exhaust nozzle.

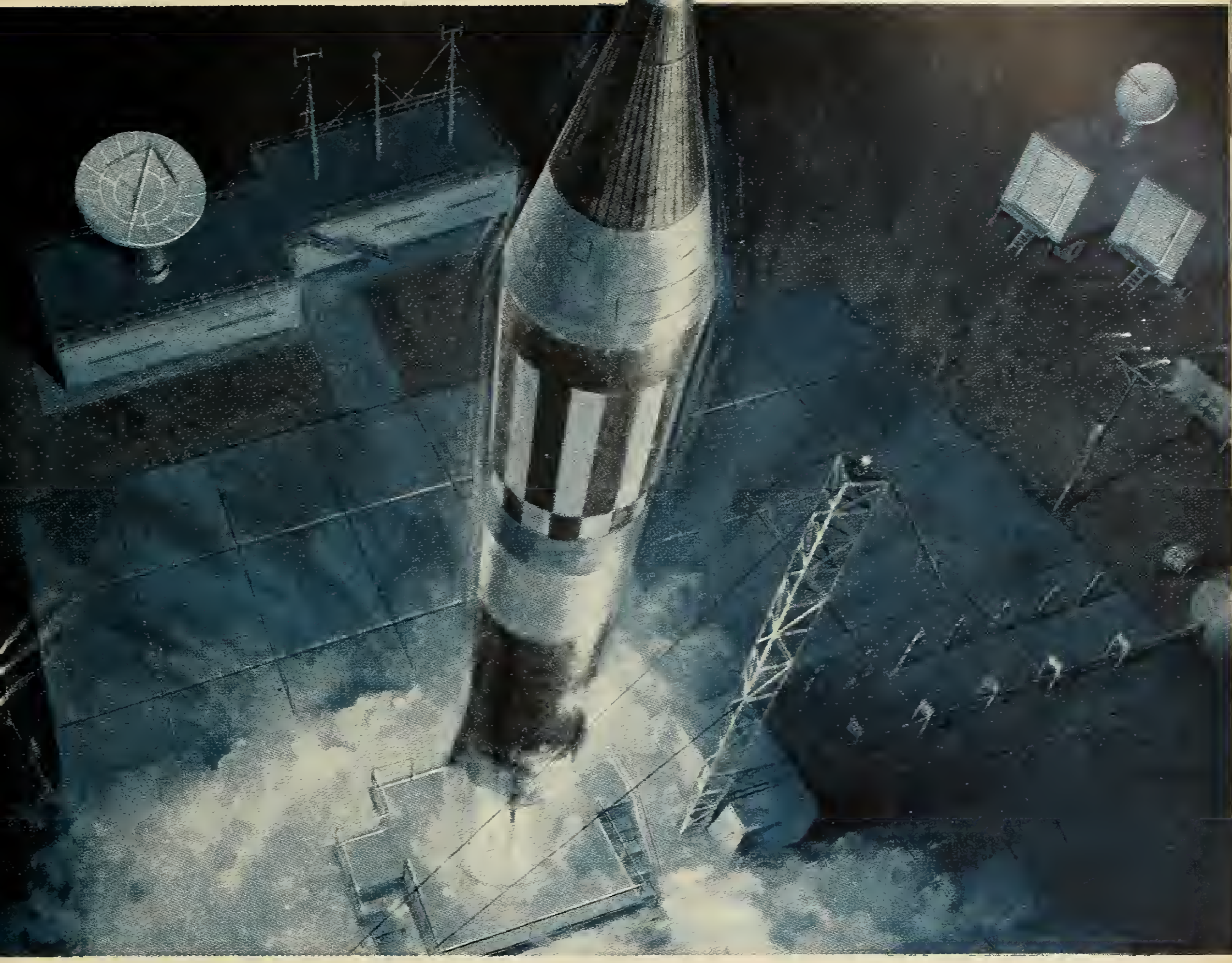
Ehricke presented the following timetable for lunar rocket developments, contingent on a concerted national effort:

Phase I, 1958-60—Shooting a rocket close to the moon, then impacting on the surface, circumnavigating the moon, establishing a satellite around it, and making a controlled landing.

Phase II, 1964-66—Landing instrumented vehicles on the moon; sending out manned rockets for lunar reconnaissance; and, in the period 1967-70, landing small scouting parties.

On the basis of findings in this phase, a decision will have to be made whether it is worthwhile to undertake building a permanent moon base, he said. If so, this would lead to:

Phase III, early 1970s—Building a supply system to establish and maintain permanent lunar bases.



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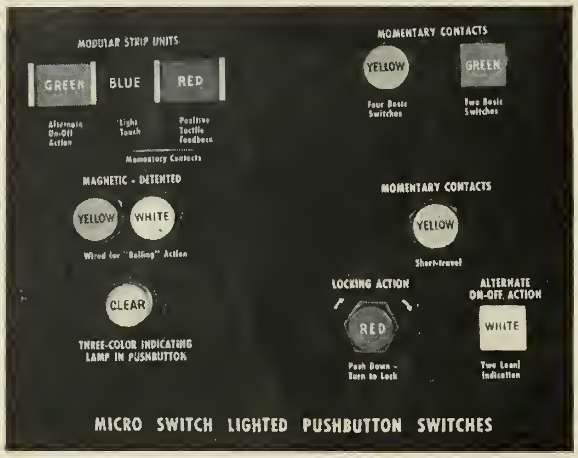

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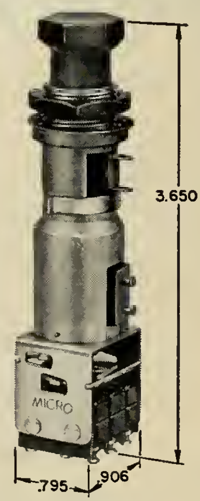

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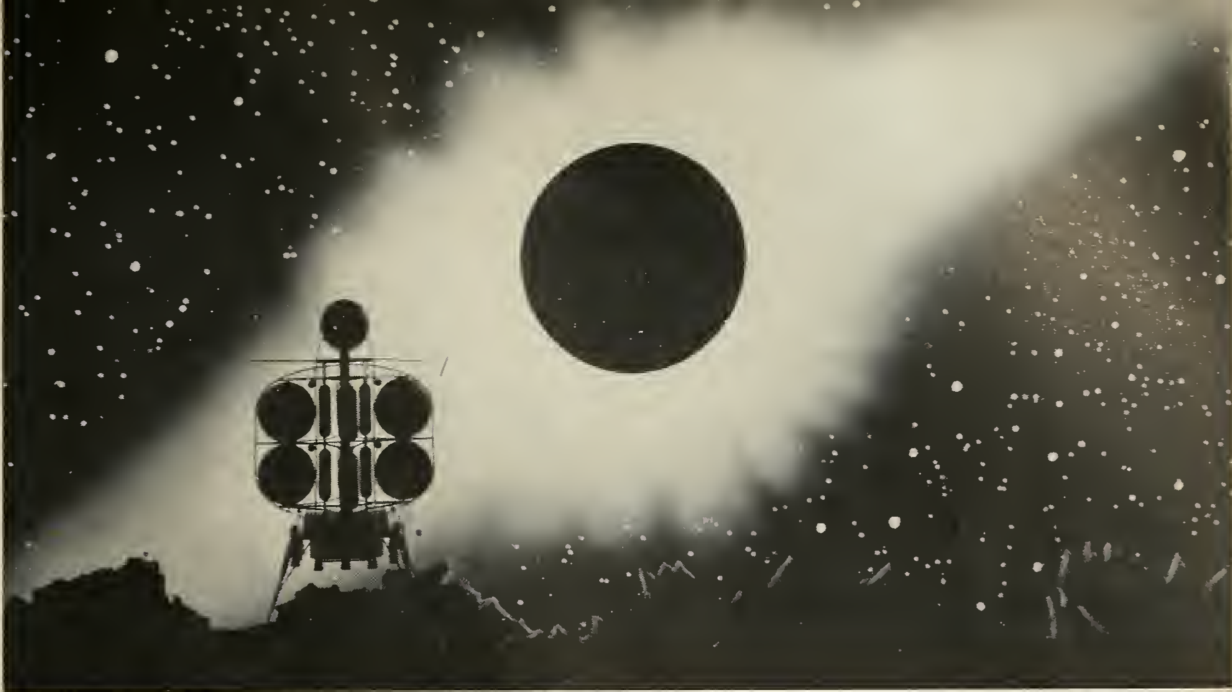


Itokawa

Many unknowns make one answer clear:

Man on the Moon?—Probes Due First

by Frederick I. Ordway, III,*
Ronald C. Wakeford

THIS YEAR man is accumulating scientific information in the general region of one earth radius out into space. He is actively planning to extend the altitude of both research rockets and artifical satellites to several earth radii.

Preliminary attempts may be made this year to impact a rocket on the lunar surface, or to effect a circumlunar trajectory by an instrumented probe. Within six to eight years it may be possible to bring the payload section of such a rocket back to earth, and, perhaps by 1968, we may be able to land a probe on the moon, monitor its takeoff, and guide it back to earth. By 1975 or earlier, it seems reasonable to expect that man himself will be on the moon.

• **Old travel plans**—Serious proposals for moon travel date from the time Tsiolkovski (1895), Oberth, Goddard and other pioneer astronautical scientists began to write on rockets, satellites and space travel.

In a 1930 lecture, France's Esnault-Pelterie could accurately say that the moon journey must be carefully planned and that it would be a rigid, exact matter. He knew that the ship would "start off slowly, so that while we are passing through the atmosphere our speed is increasing as rapidly as possible."

He figured that the top velocity would be reached after "eight minutes of travel, when we are 1200 miles above the earth." This French pioneer was cognizant of space medical problems, suggesting a maximum acceleration of three g's, distributed over the human body in the prone position.

Many of the early moon proposals were based on direct flight from the earth to the moon, while others sought to take advantage of earth-orbiting space stations, from which rockets would ascend to the lunar objective.

• **Newer proposals**—Modern proposals include both techniques, but often assume neither a lunar landing or return to the earth. The following plans are suggested: takeoff from earth's surface; takeoff from balloon platform in outer atmosphere of earth; takeoff from earth-satellite station from 200 to 1000 miles above surface.

A number of flight plans appear possible which might result in any of the following: probe space at lunar orbital distances; impact on the moon; circumnavigate the moon; establish vehicle in orbit around the moon; land instruments on the moon.

Finally it will be eventually desirable to return the moon vehicle to the earth, or at least to the vicinity of the earth. In the latter case we might develop a probe that would circumnavigate the moon, and then return on the leg of a trajectory passing close enough to the earth to enable interrogation of the instrumentation from a surface station.

If this probe could be pro-

**General Astronautics Corp.*

...Man on Moon?—Probes Come First

grammed to return to the earth's atmosphere, braking and parachute descent techniques could be employed to retrieve the instrumented section. The ultimate stage will arrive when man can fly to the moon, land, take off and return to a terrestrial base with a comfortable supply of fuel and other supplies in reserve.

• **Around the moon**—Krafft Ehricke and others have, in recent years, prepared numerous studies covering important aspects of lunar flight. In one paper, Ehricke and George Gamow have worked out many flight details of a circumlunar rocket, which they postulated would weigh 240,000 pounds and would have a 400-to-800-pound payload capability. Such a vehicle's velocity at the circumlunar end of the trajectory would be quite low, so that much information could be recorded by the instruments.

Of the total trip time of 157 hours, 50 would be under conditions permitting close observation of the moon. Closeup images might be sent to the earth by facsimile transmission techniques. Television recordings could be made on tape and played back when the probe returns to the earth's vicinity.

The term cislunar space has been introduced by Ehricke, to define the general region between the earth and moon where neither body dominates the rocket's path exclusively. This general region of space is significant to artificial satellite mechanics and as terminal points of returning vehicles.

Somewhere between 10 and 25 earth radii, a "flat minimum" exists where perturbations due to terrestrial oblateness and to the moon are small. At 125,000-150,000 miles out, the moon begins to become a strong perturbing force.

• **Navigation problems**—Many studies of the moon voyage have been based on simplified two-body calculations (earth and moon alone considered). But it is known that, once a rocket has moved out 4000 or more miles from the earth, both the moon *and* the sun commence to affect the flight path, and orbital calculations become very complicated.

When the sun is introduced as a perturbing agent, complex three-body situations exist which may eventually have to be handled by onboard electronic computers. Internal navigation would permit orbital corrections along the flight path. Depending on initial flight conditions, the rocket would hit the moon, or circumnavigate it and return to earth space, or swing around it and escape.

An earth-moon trajectory is complex. As an example, H. Lieske shows that to hit the moon, the accuracy of the velocity vector would be 100 ft/sec. In pointing angle, one degree would be necessary. Now, if it is desired to pass very close to the lunar surface and return to the earth's atmosphere at, say 50,000 feet, it is shown that at least one foot per second value would obtain for the magnitude of the velocity vector, and up to 1/1000th of a degree in pointing angle.

Aeronutronics Systems, Inc., has recently been involved in studies of impacting on the moon. The company has conceived of a technique that would utilize a light, compact optical system in the rocket to determine its distance out from the moon in terms of the size of the moon's image. By transmitting the resulting information over a data link, scientists would in effect obtain a view of the moon approach by an optical-to-electronic picture conversion scheme.

In preparing for the lunar voyage, the flight program will consist of three elements: the powered phase, coasting (unpowered) and landing. *Far Side, Explorer,* and *Sputnik* tests have provided useful experience for the initial phase, but as yet no significant experimental data has been accumulated on rocket landing maneuvers and what would be involved in them.

• **Moon satellite**—Earlier we mentioned the possibility of establishing a satellite around the moon. Rand Corp.'s R. W. Buchheim and others have treated the problem in some detail, and it seems logical to assume at least one such vehicle will be constructed prior to attempting manned lunar flight.

Buchheim shows that a lunar satellite in an eight-hour orbit would move relative to the moon at about the same speed as the moon moves in relation to the earth—that is, at about 3360 ft/sec. Thus, if the lunar satellite had a period greater than eight hours, it would constantly move relative to the earth in the same direction as the moon. If the period were under eight hours, it would move sometimes in the moon's direction and sometimes opposite to it. At 5000 miles out, it would have a period of just 24 hours. (In making these flight-path calculations, the sun, the earth's oblateness, and other perturbing agents were neglected.)

Establishment of a lunar satellite would serve a number of purposes: as a takeoff point for the descent of an instrumented probe to the moon's surface, as a communications relay point, as a tool to determine the shape of the moon, and as "lunar-physical" research device.

Ehricke has suggested that it might be fitted to detect a possible residual lunar atmosphere. It would seem possible to prepare a lunar version of the NACA sphere experiment designed for a *Vanguard* test; such a sphere would be released and observations of its motion in orbit might reveal the existence of a tenuous atmosphere.

• **Controlled landing**—Once man is able to effect a controlled landing

PROBES will explore, before men set foot on Moon's surface.

Convair

of an instrumented probe on the moon he will have made significant progress toward getting himself there.

Probably the first item to be landed would be suitable radio transmitting equipment. Later a variety of devices designed to study lunar characteristics would be expected, such as seismographic equipment, temperature-sensing equipment and, of course, the necessary power supplies.

In considering manned moon travel, all the space medical problems applicable to manned satellite and space flight will apply: zero gravity, cosmic radiation, acceleration, temperature, nutrition, artificial cabin atmosphere, waste removal, and, in general, the overall situation of life in a completely closed environment.

There are two general schools of thought among human factors specialists, concerning the role of man in lunar and circumlunar flight.

Some feel that the man must be alert during the entire flight, to observe, repair broken instrumentation and make any of a variety of emergency decisions.

Others would be content to leave man on the earth and allow instrumented probes to perform all the scientific observations, or at most, put the crew in a dormant state during the major portion of the voyage. They would be fed intravenously and sensing devices in the cabin would detect ambient conditions and order necessary corrections in atmospheric content, temperature, etc.

• **Man to the moon**—In a modern interceptor, armed with complex guided missiles, man is integrated into the overall guidance and control system. Often the greater part of his mission is monitored from ground-control stations, from the moment he enters into a zone of active defense or offense to the time he returns to base. His decision-making abilities are reserved only for emergencies and unusual situations.

A similar condition may prevail on early manned lunar flight, with the pilot being called upon only to make emergency decisions.

It is likely that all early navigation will be performed from astronomical observations on the earth and that corrections will be made by radio transmission.

The concept of communications between a moon rocket and the earth has received a considerable amount of study, and does not appear to offer insoluble problems.

• **AF moon rockets**—In February 1957 the Air Force Office of Scientific Research and Convair sponsored an astronautics symposium where it was emphasized that USAF already was working on a moon rocket project. Moon flight studies were reported underway at such organizations as Douglas and Convair, and the Rand Corp. continued to study the problems of circumlunar flight and moon landings for the Air Force. Convair reported that it had worked out a program to place 200 pounds of camera, television and tape recorder equipment around the moon.

Rand Corp. is concerned with tracking and communications problems as they relate to a moon vehicle. The particular vehicle under consideration would impact the moon, then telemeter data to earth stations at a relatively low rate (desirable because the things we are interested in learning about the moon's surface do not occur at rapid rates; and high transmission rates are not easily come by if low power is used). The rocket would be tracked and navigated from perhaps four stations well separated in longitude (since the earth rotates, we would want to have a number of stations so that the rocket could be viewed from at least one and preferably two at all times).

The configuration results in a rocket that would take two and one-half days to make the earth-moon voyage. The tracking parameters desired for measurements desired are: range; range-rate angles; angular rates with respect to some earth reference.

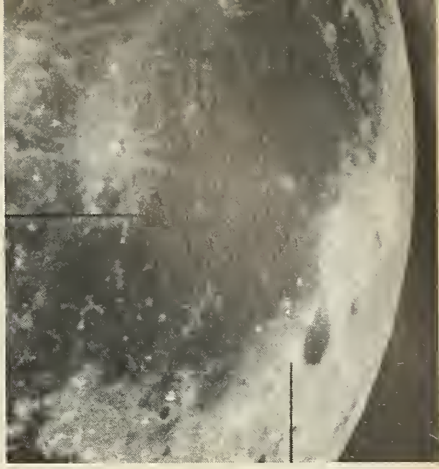
To obtain range it was suggested that a transponder beacon be used in the rocket, and rate could be obtained from the Doppler frequency shift, assuming that the beacon were sufficiently stable.

• **Two approaches**—Current proposals to place a vehicle in the vicinity of the moon are based on two philosophies: to use military off-the-shelf rockets to keep costs down and help insure reliability. Such an approach would undoubtedly speed up the moon program, and, in the earth satellite field, is exemplified by successful Army *Jupiter-C/Explorer* tests.

The second visualizes large ballistic rockets to boost tailormade research missiles. This is essentially the *Vanguard* approach, and while the equipment might be more sophisticated it would face the long series of delays and failures which plague any new rocket.

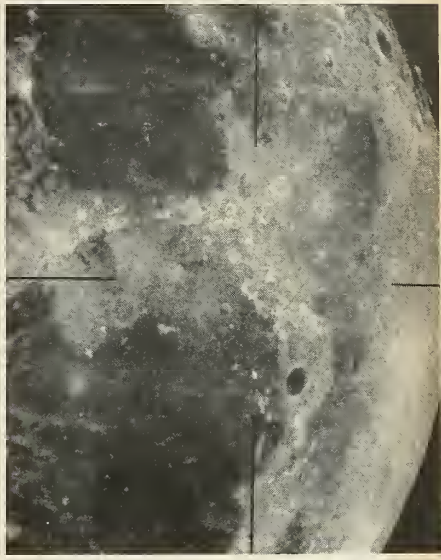
The Air Force Office of Scientific Research has contemplated the use of a long-burning, slow-accelerating booster rocket to minimize the problem of aerodynamic heating. Intermediate stages would then move the rocket out from the earth and the final stage, with a thrust of 50,000 pounds, would propel the vehicle into the moon's gravitational field. Booster candidates include any of the five current ballistic missiles: *Jupiter, Thor, Polaris, Atlas* and *Titan*, or the large 400,000-pound-thrust *Navaho* rocket engine. Aeronutronics has also proposed the use of existing off-the-shelf hardware based on *Far Side* but which would be in five stages as follows: cluster of four *Sergeants*, single *Sergeant*, cluster of three solid rockets (of type used in third stage of *Vanguard*), *Vanguard* third stage, and one scale *Sergeant* for the last stage.

Other projects involve impacting a rocket on the moon, especially with regard to causing either chemical or nuclear explosions on the lunar surfaces. Dr. S. Fred Singer proposed last year that useful scientific information could be gained by exploding



Perkin-Elmer

CAMERAS on Earth can see only part of the detail . . .



Perkin-Elmer

EVEN on closer view, more men must know about the Moon.

...Man on Moon?—Others Have Plans

an atomic bomb on the moon and analyzing the results. Such experiments are discussed in a later section.

• **Russian moon programs**—The West has no monopoly on moon projects. Russian scientists have long been interested in the prospects of moon travel, and their literature is well filled with both general discussions of the subject and more specific studies.

M. K. Tikhonravov, nearly eight years ago, wrote on a trip utilizing a rocket weighing 1000 tons, sent off with a velocity of about 11 km/sec. It would carry two men who would circle the moon once and return to the earth. If departure from an earth satellite was assumed, the vehicle would weigh considerably less (approximately 100 tons), and would take off with a velocity of 3.5 km/sec.

Other reports of about the same period suggest that a moon rocket had already been designed, that it was to be 60 meters long, have a maximum diameter of 15 meters, weigh 1000 tons and have 20 motors building up to 350 million horsepower.

Yu. S. Khlebtsevich has laid out a rather definite program for a lunar landing. In it he points out that we must know thoroughly the environment into which man must travel; insure the safety of the crew during takeoff, flight and landing maneuvers; and make full provision for return to earth. He emphasized that more complete information must be made available on the perturbations that would be encountered during the trip and their influences on flight trajectory.

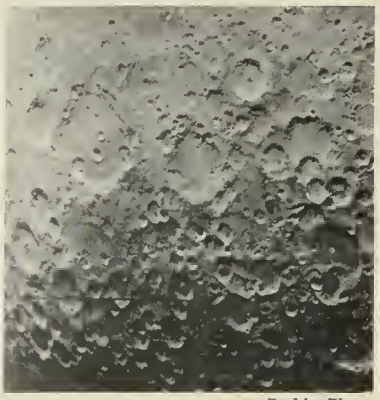
The Russians also suggested a radio-controlled, television-equipped, tank-laboratory to be set on the moon to give scientists a chance to observe the surface from close up.

Khlebtsevich assumes that man will want to stay on the moon for a considerable time and that his supplies will be delivered by radio-controlled rockets coming up from terrestrial bases. The early explorers would be in radio and televison contact with the earth and their actions would be constantly controlled by scientists and medical specialists, somewhat as was Major David Simons in the *Man-High* tests.

• **Automatic landing**—To assist in the automatic landing maneuver, the Russians suggest use of a very powerful terrestrial radar station, with a huge parabolic antenna aimed at the moon.

The following is from a translation of Rand's Casebook on Soviet Astronautics (RM-1760):

"Altimeters aboard the rockets receive the short impulses of this radar reflected from the moon's surface. They



Perkin-Elmer

REAL CLOSE-UP views can add much to knowledge of problems.

U.S. Navy

MOON over horizon (picture is on edge) in powerful lens.

determine the distance between the rocket and the lunar surface by measuring the interval of time between moment of flight of the radiated impulse past the rocket and receiving the radio echo reflected from the moon. The automatic landing device aboard the rocket, utilizing the data of the lunar altimeter, at the appropriate time turns the rocket with its tail section to the moon, and, according to a special program, guides its jet engines in the regime of braking. Finally the rocket reaches the goal of its journey and lands on the lunar surface."

N. Varvaros, chairman of the Astronautics Section of the Chkalov Central Aero Club, said in an article on moon flight in 1955:

"The general construction scheme of a rocket for flight to the moon . . . may be approximately as follows:

"The first stage (in order of operation) must have turbojet engines; the second, ramjet engines; the third and others liquid rocket engines."

The author is assuredly conscious of the need for fuel economy, and his proposed use of turbojet engines as propulsive devices for booster stages has recently been promoted in the United States.

Last year, m/r carried a report that Prof. G. A. Chebotarev (of the USSR Academy of Sciences' Institute of Theoretical Astronomy) had suggested sending automatic rockets into lunar space. With a total flight time of about 10 days, rockets might be sent to within 3100 miles of the moon's surface.

• **Active planning**—Other sources indicate that the Russians are actively planning instrumented lunar probes equipped with television-type cameras.

At the very least it is believed they desire to establish a radio transmitter on the moon, which would send back to earth such basic measurements as surface temperature conditions.

That the Russians have made more than general studies of moon travel is evidenced by Egorov's paper entitled "Some Questions on the Dynamics of Flight to the Moon" which appeared last year. The author reports that over 600 trajectories were calculated.

Many experiments can be conducted on the moon's surface. Scientists would want to determine accurately the lunar mass, gravity, hardness and composition of the surface and interior. Seismic studies of the crust and core, temperature measurements of the surface and subsurface, and the composition of the lunar atmosphere (if one exists) would be obvious candidates for investigation.

• **Moon conditions**—It should be noted that, as on the earth, lunar gravity will vary slightly from place to place; the exact variations will be determined only after a prolonged period of exploration. As this exploration proceeds it will be possible to determine the moon's mass very accurately. This is a somewhat more difficult experiment since it will be necessary to know the average diameter, as well as the true shape, of the moon.

Some authorities have suggested that the lunar surface may be covered by a thick rather than thin layer of dust. If this proves the case, it would be a major hazard both to vehicle landings and exploration; hence it would be advisable to have precise knowledge of surface conditions. Here again, a probe vehicle, launching small explosive rockets onto the lunar surface and recording the results, would provide invaluable information to manned vehicles.

A thorough chemical analysis of the constituent parts of the lunar surface will be high on the agenda of early exploration. From studies such as this we shall learn much of the formation of the moon, and of meteorites and interplanetary matter which should be abundantly available at or near the surface.

The moon's structure will be searched for sufficiently valuable minerals which could justify their being mined and ferried to the earth.

• **H-bombs on the moon**—It is not yet known definitely whether or not the moon has a molten interior. If it should, the thickness of the outer crust would be an immediate problem. An atomic explosion on the lunar surface would produce a shock wave that would tell much about the subterranean structure. It would necessitate another instrumented probe or observation base, located at a known distance from the explosion, to validate the experiment. An atomic explosion on the moon could also be observed from the earth, and thus, by analysis of the spectral distribution of the resultant light source, we would learn of the elements present in the impact area.

A major area of contention among scientists is the presence or absence of a lunar magnetic field. Some authorities feel that the proximity of the earth to the moon almost certainly will have oriented the ferro-magnetic elements of the latter body to provide at least a weak magnetic field.

It is generally held that the moon has no atmosphere, but this may be qualified by stating that some of the heavier gases may be contained in the lunar crust, and that some atmosphere may be found in crevices and gullies.

Experimentation by probe to detect a tenuous atmosphere by spectographic means would be difficult. It is most probable that this experiment will await the advent of man on the surface, or at least will not be attempted prior to establishing lunar satellites.

Temperature variation determinations, like atmospheric calculations, may best await the landing of a manned rocket, since greatly separated distances will have to be checked to correctly map this parameter. Probes could be utilized, but so many would be involved that it would probably be economically out of the question. At present earthbound infrared and microwave radio detectors can be used to measure the radiative temperatures of the lunar surface, and of course thermocouple techniques are widely employed.

• **Moon bases**—An extremely important fact which must be determined is the impact frequency and size of meteorites. With such data, it will be simpler to construct a base of operations for major exploration. This base could also provide some protection from cosmic rays, a hazard which has not been fully determined.

Early moon explorers will almost certainly use their landing vehicle as a base of operations, but space and weight considerations will reduce the living and working space to a minimum. To avoid this cramped atmosphere, small camps will have to be established on the lunar surface. Arthur Clarke has suggested that double-walled balloons inflated to about five pounds per square inch, and anchored to the ground, would be suitable.

Space and weight requirements for such equipment (shipped aboard the exploration craft) would be low. After inflation, a hard-setting plastic could be sprayed to prevent the balloon from collapsing should a large meteorite puncture the structure. The smaller, more common type of meteorite (less than a millimeter in diameter) would produce a hole which could be easily sealed.

It would be advisable to further protect the inflated balloon base by concealing it in a cave or crevice to ensure maximum protection for the occupants. Since early expeditions will be of short duration (probably two weeks or less), a permanent base would not be considered. The basic requirements for this minimum base would be a power source, an air-conditioning unit, an atmosphere and a heating unit.

By utilizing a mirror or highly polished reflector, the sun's rays could be concentrated onto a tube containing a liquid. The liquid would be vaporized and the resultant steam would drive a turbine, to produce the desired power. A sun-follower would be needed to continually orient the mirror.

It should be noted that two weeks of sunshine will be available before lunar nightfall.

• **Permanent base**—In time, a permanent lunar base will be established. The advantages of establishing such a base, from the scientific or military viewpoint, are as manifold as the difficulties associated with such a project.

The equipment and machinery payload of these freight rockets will all be specially designed for this single ap-

MOON COMPARED TO OTHER SATELLITES OF THE SOLAR SYSTEM

Satellite	Average Distance From Center of Primary, Miles	Diameter Miles	Siderial Period d/h/m	Magnitude
		EARTH		
Moon	239,000	2,160	27/ 7/43	-12.5
		MARS		
Phobos (1)	5,800	10-12	0/ 7/40	11-12
Deimos (2)	14,600	5-10	1/ 6/20	13-12
		JUPITER		
Amalthea (5)	113,000	100-150	0/11/57	13
Io (1)	262,000	2,000-2200	1/18/28	5.5
Europa (2)	417,000	1,750-1900	3/13/14	6.1
Ganymede (3)	665,000	3,000-3300	7/ 3/43	5.1
Callisto (4)	1,170,000	2,900-3200	16/16/32	6.3
6	7,120,000	100	250/15/0	13.7
7	7,290,000	30	260/ 1/25	17.5
10	7,200,000	20	260/12/0	18.8
12 (retrograde)	~13,000,000	14	625/ 0/0 ?	18.9
11 (retrograde)	14,000,000	18	692/12/0	18.0
8 (retrograde	14,600,000	30	739/ 0/0	16.5
9 (retrograde)	14,700,000	15	750/ 0/0	18.0
		SATURN		
Mimas (7)	113,000	300-350	0/22/37	12.1
Enceladus (6)	148,000	350-450	1/ 8/53	11.7
Tethys (5)	183,000	700-800	1/21/18	10.5
Dionne (4)	235,000	700-1000	2/17/41	10.7
Rhea (2)	328,000	1000-1150	4/12/25	10.0
Titan (1)	760,000	3000-3500	15/22/41	8.3
Hyperion (8)	923,000	200-300	21/ 6/38	13-14
Japetus (3)	2,215,000	1000-1500	79/ 7/56	11
Phoebe (9) (retrograde)	8,050,000	150	550/10/50	14-14.5
		URANUS		
Miranda (5)	75,000	200	1/ 9/56	17
Ariel (3)	119,000	500-1000 ?	2/12/29	15
Umbriel (4)	166,000	300- 700	4/ 3/28	15-17
Titania (1)	272,000	800-1200	8/16/56	14
Oberon (2)	364,000	600-1000	13/11/15	14
		NEPTUNE		
Triton (1)	220,000	2500-3100	5/21/3	13
Nereid (2)	3,500,000	200	359/ 0/0	19

plication. Special machinery would include rock drills, tractors and trucks.

Construction materials would have to be quarried and butt-joined together as accurately as possible since concrete could not be used in the form we now know it.

• **Moon colonies**—Eventually the moon may be colonized by several nations. Territorial possession will almost certainly be based on establishment of permanently manned bases, since no one is likely to be impressed by claims resulting from short-lived expeditions.

One of the more critical problems will be that of supplying food to the residents. Hydroponic gardening has been suggested.

It may be that in the distant future small cities will be constructed, completely enclosed by a structure permitting a reasonable facsimile of earth conditions to prevail. This would be a mammoth undertaking, but today's progress in all phases of the overall problem may well herald the laying of a lunar city's cornerstone within 25 years.★

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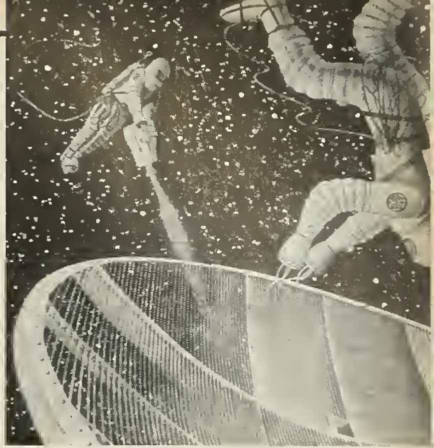
Selling Space Ships

by Seabrook Hull



Itokawa

IF YOU THINK selling missiles is baffling, try space ships. If you think missiles are expensive, try spaceships. If you think missiles present the toughest engineering problems, try spaceships. And if you think missiles have a future, try spaceships. There is not and never has been anything quite like them.

The market for tomorrow is small now, relative to that for missiles, but it will grow and grow until it becomes bigger than any military market heretofore seen in history. Russia will guarantee it. If you want in, now is the time to begin your sales campaign.

As missile buyers and missile makers alike once tended to lump manned aircraft and rocket-powered missiles in the same general technological category, they now look at the spaceship merely as an extension of the missile. Not only is this fallacious. but it can get all of us in a lot of serious trouble. The businessman that uses it will have trouble getting contracts, and those he gets will cost him and the taxpayer undue time and money. The military service that uses it will find itself with an operational requirement, but no operational hardware. And the country that uses it is liable to awaken one day to find that another country—namely Russia—got there "firstest with the mostest."

The space ship business is now largely in the feasibility study stage. Except for jury-rigged-but-effective devices using available military missiles, such as Army's *Jupiter-C*, there are no original space-flight projects in even the initial prototype assembly stage.

Whoever goes out into the market place now to sell spaceships had better be prepared to sell ideas and concepts first, rather than hardware. The first step is to convince your customer that space flight in any form really is feasible. He may be willing to spend a little money to be convinced—say, the cost of a feasibility study contract. But he's most unlikely to commit tens or hundreds of millions of dollars for hardware just on your enthusiasm and say-so.

Selling ideas is pretty much the same kind of marketing problem as selling products, though perhaps a little tougher because you don't have something solid to show your customer—something he can see and handle. But just as a piece of hardware must be mechanically convincing, so must an idea be fully supported with technical data, background experience, unassailable logic, etc.

The first thing to do in selling spaceships is to survey your market. Note who has the money; if possible, how much. Find out what's wanted, and establish an order of priority for various projects under consideration. If you're after a prime contract, investigate the three military services. If you're willing to take a subsystems contract, find out who's dickering for a prime contract and go to it. Maybe you're in a position to join forces with other companies with complementary capabilities to present a comprehensive proposal.

The group method of systems contracting has been given official approval by the Air Force and is probably acceptable to the other services as well. One company must assume the systems responsibility. This entails concept and coordination.

Once you've surveyed your market, check requirements against your (or the group's) capabilities. In the beginning, great assembly lines of production equipment are no asset. For a study contract you need a research and development staff, i.e., you need brains.

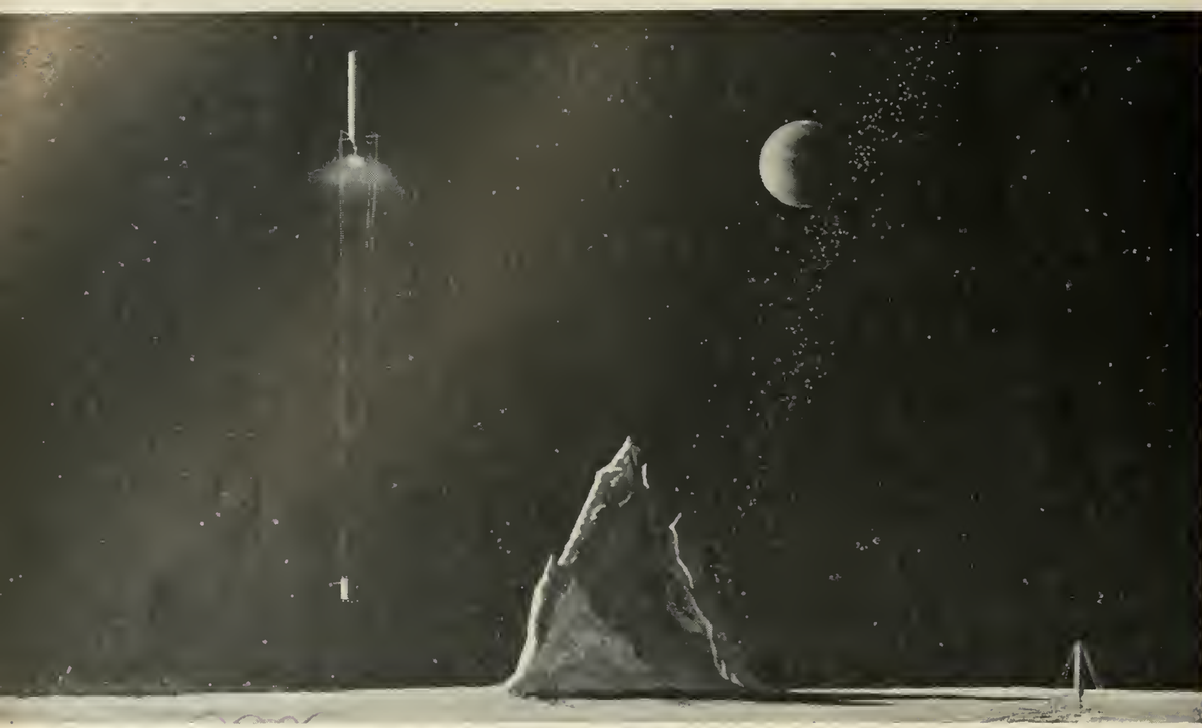
Once you've decided just how you may fit into the picture, find out who's doing what—now. For example, currently the U.S. Air Force is holding a series of meetings with a target of placing a study contract during May for a "Global Surveillance System." If you've got an idea for such a system, you should be present. But you are present by invitation only. So, get invited. This may be primarily a public relations job.

But once invited, have your ducks all in a row before attending. Remember, your customer has called on you for ideas—your ideas. He probably won't have much to offer, except by way of questions that aim at poking holes in your proposal. Have a complete package—the basic concept clearly presented; the arguments and supporting evidence methodically arranged; proof of your capability.

One thing that frightens your customer about space flight is its apparent staggering cost. Think your proposal through. Let ideas, creative engineering or what-have-you substitute for dollars. In other words, if your proposal is technologically and operationally equivalent to another, but yours is cheaper, you'll get the contract.

Another thing to keep in mind is that space flight is an entirely new realm. It is susceptible to entirely new approaches. In seeking your "ideas," start with the basic problem—say, to place man operationally in space for a period of three days. This would be a requirement. Get rockets, airplanes and everything else out of your mind. Revert to basic technologies. Apply them to the problem without prejudice of prior convention. Take an original approach.

To really gain a proper knowledge of your market's requirements, you should survey it yourself. Check these areas: getting man into space; keeping him there; getting him back; giving him tools to work with in space; giving him weapons (bombs and rockets are most impractical); landing him on the moon; new propulsion systems; materials in a new environment.



Itokawa

Problems in Space Navigation

Complex mathematics, design of vehicle involved in solution

by Louis G. Walters*

MOST OF THE INFORMATION regarding the external physical environment of the earth has been derived from radiation passing through the atmosphere

The benefits to mankind from the extension of knowledge of the universe can be foreseen only in a vague way, but there is little doubt that there is much to be learned, and that this knowledge will have a profound effect. Examples from the past are numerous; the most obvious being the slow development of knowledge of the nucleus of the atom, partly obtained from astronomical observations, which culminated so spectacularly in the energy of fission and fusion, after the means of exploring the nucleus were available.

Only recently have advances in the arts of propulsion and guidance made serious consideration of space exploration possible. Beyond the earth satellite, the orderly development of our knowledge of the solar system (and political considerations as well) leads to the moon as the logical second step into space.

• **Easy target**—Viewed as a target, the moon does not pose a difficult aiming problem. It is relatively large, subtending an angle of nearly one-half degree from the earth.

Its mass, 1.23 percent that of its parent, contributes to a larger apparent capture diameter through gravitational means. This apparent enlargement is most pronounced for low-approach velocities and can enlarge the capture diameter by a factor of 3 for fairly low-energy trajectories.

It travels in a slightly eccentric orbit, the plane of which is inclined to the ecliptic by 5°. Its perigee and apogee distances are 22,463 and 252,710 miles respectively, reflecting an average eccentricity of 0.055.

The period of rotation, or true month, is 27.32 days, leading to an average angular rate of rotation about the earth of about one-quarter radian per day.

The lunar orbit intersects the ecliptic at two nodes; regression of these nodes in a westward direction along the ecliptic has a period of 18.6 years.

These characteristics of the moon are useful in feasibility or "design" studies of the translunar trajectory wherein basic vehicle performance and trajectory error sensitivities may be assessed.

On the other hand, data required for precise navigation to the moon must be derived from astronomical sources such as the NAUTICAL ALMANAC, due to rapid changes which occur in the moon's orbit. These considerable month-to-month variations in the apparent lunar course are due principally to the influence of the sun.

**Aeronautic Systems, Inc., Los Angeles*

• Design and/or navigation—Note that a distinction between design and navigation studies has been made.

In the design, a simplified model of the earth-moon system is adapted. This leads to good engineering estimates of the rocket components' required performance.

These same studies, however, do not provide a basis for formulating firing tables, since they ignore many important perturbing influences on the translunar trajectory: they provide the basis for overall vehicle design, but cannot identify the location, time and direction of launch required to achieve lunar impact in practice.

But navigation studies require consideration of all factors that serve to determine the course of the vehicle relative to that of the moon, and the use of mathematical techniques which will lead to a precise end point.

Another contrast is the relative emphasis placed on design and navigation studies. Design studies have been conducted by groups interested in lunar impact and have tended to instill a high degree of confidence in investigators.

The navigation problem, however, is far more complex and has received only superficial consideration.

• Design studies—Determination of the translunar trajectory involves integration of the equations describing the restricted three-body problem in an appropriate coordinate system.

For design purposes, a simple model of the earth-moon system, consisting of a planar representation of the earth and moon, with each moving in a circular path about their common center of gravity (barycenter), has been widely used. This model (Fig. 1), with the x axis linking earth and moon, demonstrates the degree of apparent distortion arising from the rotation of the coordinate system, for it would be nearly elliptic in inertial space.

Fig. 2 is typical of trajectories where the energy is relatively low. As a result, the speed of the vehicle as it approaches the moon is low as well, and the resulting capture cross section is several diameters.

This effect is clearly shown by the group of trajectories which impact the moon and which represent the influence of initial variation in path angle over a range of 1.5 percent compared with its projected diameter of .5°.

The sensitivity to launch velocity is quite considerable; for the case shown, the variation of 50 feet per second displaces neighboring trajectories by 16,000 miles as they approach the moon. Noting that the capture diameter factor of the moon is about 2.5 to these low-energy trajectories, this limits the allowable velocity error to a range of 15 feet per second. Coupled with the careful velocity control, which must be exercised by guidance equipment, is an arrival time predictable to 0.5 hour.

As the energy of the vehicle is increased, the character of the trajectory sensitivity to initial condition changes markedly. Since the approach velocity increases as well (and at a much faster rate than the launch velocity) the effective capture diameter shrinks to the actual lunar diameter and modest path-angle errors are no longer tolerable.

The intercept also takes place on a portion of the trajectory which is not strongly displaced by velocity uncertainties, and larger velocity errors are tolerable.

As the trajectory energy is increased beyond that corresponding to escape, the moon's own motion begins to play a constructive role in the guidance mission. This effect is associated with a class of trajectories which are designated "high-energy" trajectories in contrast to those that have been considered earlier.

• Lunar motion effects—The role lunar motion plays in the guidance mission for a high-energy trajectory is described in Fig. 2.

Several trajectories, differing only in velocity, start from a given point near the earth and proceed out along the designated paths.

The outermost trajectory corresponds to the highest launch velocity and therefor will reach lunar distance earlier than the others. Meanwhile, the moon is also moving in its orbit, and the distance which it moves in the differential arrival time of two neighbor-

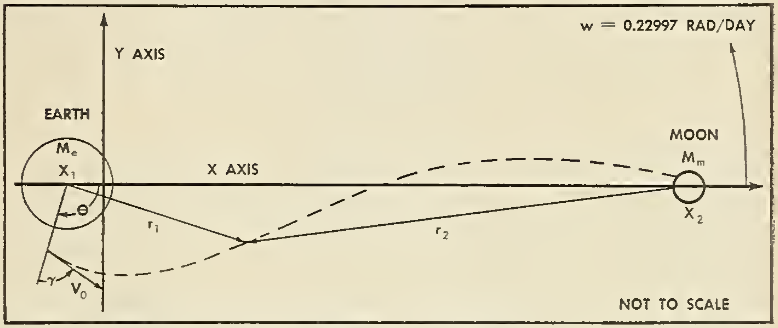


FIG. 1—Trajectory format for Earth-Moon rocket studies.

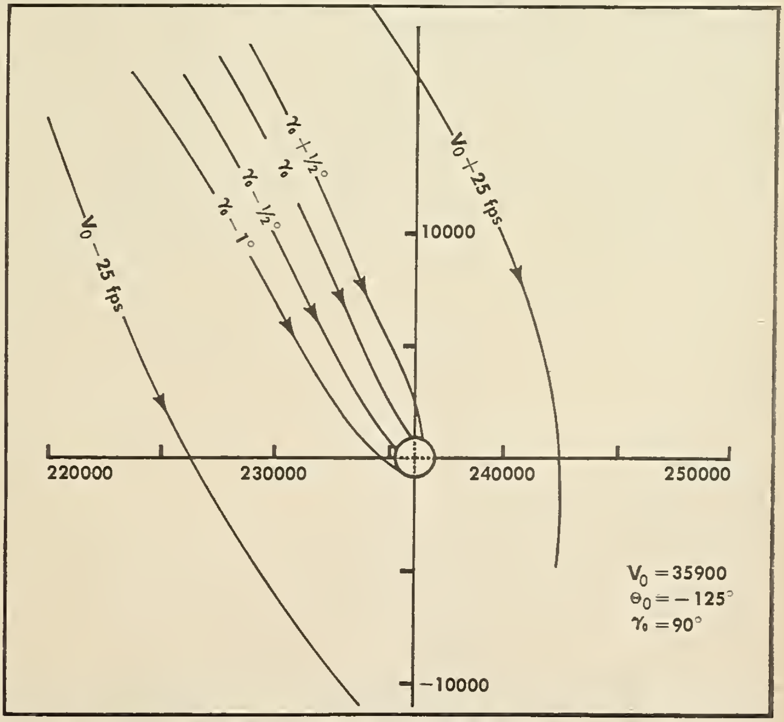


FIG. 2—Terminal trajectories for low-energy perigee launch at 100-mi. alt.

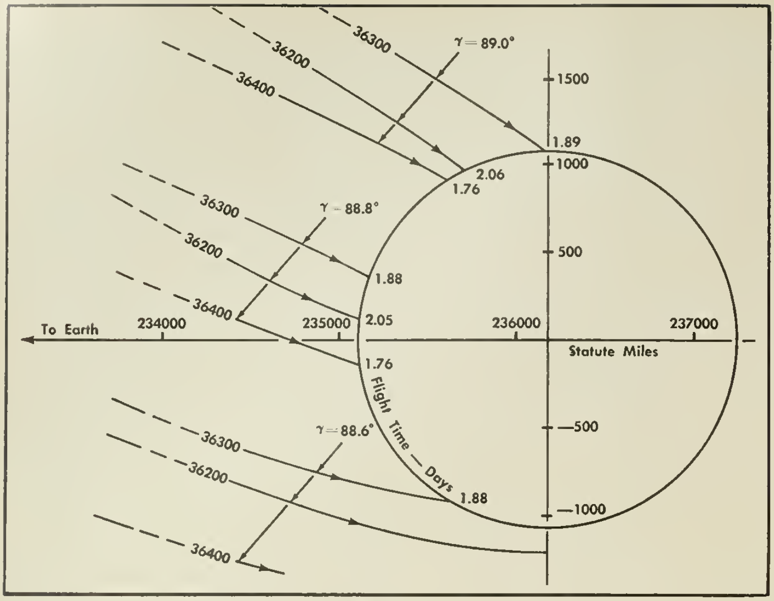


FIG. 3—Terminal trajectories for 100-mile launch: $\Theta = -$ N135°.

ing trajectories can be readily calculated.

If the differential arrival time of two neighboring trajectories can be adjusted so that the corresponding lunar displacement in its own orbit is identical to the physical displacement of the trajectories themselves, then lunar impact will occur in both cases.

The important consideration insofar as the launch is concerned is the required lead angle by which the moon initially leads the launch point. This lead angle can be computed for a Kepler orbit, ignoring the influence of the moon, and demonstrates, for velocities slightly higher than escape, a stationary value of required lead angle even as the velocity is varied over several hundred feet per second.

Thus, exact knowledge of the final velocity in this interesting situation is not required prior to launch.

A number of terminal trajectories which display this effect are given in Fig. 3. The design velocity in this case is in the neighborhood of 36,300 feet per second.

Clearly shown is the influence of variations of 100 feet per second on the impact point. As the velocity increase toward the design value, the impact point moves up the face of the moon; for higher values, the impact points then begin to retreat.

This effect can be utilized for a lunar impact mission. Careful control, of the path angle must be maintained.

This class of trajectories requires substantially more velocity than the low-energy class and, a greater expenditure of propellant is required to place payload on the moon.

The offsetting advantage is that little of this payload need be expended for guidance purposes. An additional consideration is that the arrival time at the moon will be uncertain by about three hours as in the case shown. This time uncertainty somewhat restricts the flexibility of the lunar mission in a manner which is not readily demonstrated in this two-dimensional analysis.

• **Navigational aspects**—The navigational aspect of the translunar trajectory is best visualized in terms of the projections of the orbits on a geocentric celestial sphere (Fig. 4).

The rocket is launched at the designated point and, for eastward travel from a launch point in the northern hemisphere, describes a course crossing the projection of the equator at a longitude some 90° east of the launch site.

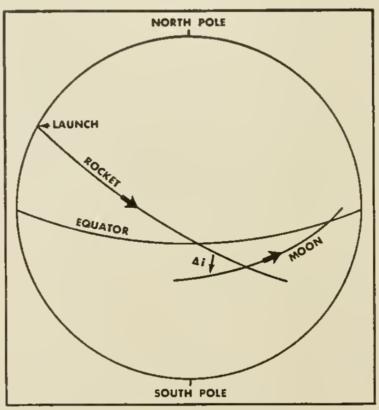


FIG. 4—Geocentric celestial sphere.

For a launch in a northerly direction, the rocket orbit would intersect the equator further east; in the case of a northward launch, this intersection would occur 180° east of the launch point. The lunar orbit, on the other hand, describes a path whose maximum declination depends on the relative orientations of the lunar orbit and of the earth's axis with the ecliptic.

The maximum inclination of the lunar orbit from the equator occurs when the ascending node coincides with the vernal equinox, and is 23.5° + 28.5°.

This situation existed in 1950 and will recur each 18.6 years as the lunar orbit plane regresses. Midway in this period, in 1959 for example, the inclination will reach only 23.5° −5° or 18.5°.

The angle of inclination between the rocket and lunar orbit planes at intercept is designated Δi. A desirable situation, assumed to exist in the design studies discussed earlier, is that these orbits are coplanar and that the problem is essentially two dimensional.

The ability to achieve this in practice depends on the latitude of the launch site and the maximum lunar declination. For a launch site located at higher latitude than the maximum lunar declination, coincidence of rocket and lunar planes is not possible.

The ideal situation involves launch from a site whose latitude corresponds to the maximum lunar declination, for under these conditions an eastward direction is required and the earth contributes the maximum velocity component due to its rotation.

From a practical point of view, a lunar mission originating from within the United States involves latitudes in excess of 28° and, as a result, the minimum relative orbit plane inclination Δi during 1958 will be 8°; this will increase to 9.5° in 1959 and will then decrease toward 0° in the late 1960s.

Fig. 5 demonstrates the azimuth heading required during 1958 from a launch latitude of 28° north as the lunar declination varies between its extremes (half lunar month) and for a typical low-energy trajectory. Also shown is the inclination angle between the orbit planes, Δi.

It is interesting to note that for launch latitudes less than 18.5°, it will always be possible to place a rocket vehicle into an orbit coplanar with that of the moon, at some time(s) during each month.

• **Uncertainty factor**—An interesting contraint on launch times is imposed by the uncertainty in flight time.

The design studies have associated arrival time uncertainties of 30 minutes and 150 minutes from design values for low- and high-energy lunar impact trajectories respectively. During this time uncertainty the moon can move an appreciable distance and, if the trajectories are not coplanar, a cross-trajectory impact error will result (Fig. 6).

For the high-energy case, the arrival time uncertainty of 150 minutes will tolerate orbital inclination of 10° without displacing the rocket more than 75 percent of the effective radius out of the lunar orbit. Under these conditions, Fig. 5 demonstrates that operations in 1958 from Florida, for example, must be confined to the period when the declination is between +5° and −15° on the southbound leg. Reference to lunar tables demonstrates an allowable launch period of five days in each lunar month for this high-energy case.

The low-energy trajectories do not suffer from large arrival-time uncertainties and, additionally, the effective lunar diameter is substantially greater. As a consequence, even the largest inclination given in Fig. 5 will not cause substantial cross-trajectory displacements.

Another important consideration is the actual computation associated with the navigation problem: this will differ in considerable detail from that used in determining vehicle design parameters, using a rotating two-dimensional coordinate system. For computations leading to actual firing data, the model must recognize these factors: (1) launch point latitude; (2) earth rotation; (3) lunar motion in declination; (4) structure of the lunar orbit; (5) perturbations of sun and equatorial bulge.

The advantages of a rotating framework vanish entirely when these are considered, and the computation must be three dimensional in any case. In addition, the reference frame for both launch point and moon are affected by precession and nutation and, consequently, are not inertial.

Another consideration is the means utilized for integrating the equations of motion. The accumulation of end-figure errors is often damaging in numerical integration, particularly where the number of steps is very large. The use of Cowell's method, for example, requires the integration of the total acceleration on the vehicle, and both the size of the terms and number of steps lead to substantial end-figure error.

Alternatively, a technique such as Encke's integrates only perturbations from a reference two-body orbit and the number of steps required is small, particularly in the critical early stages of flight.

Whatever technique is used must also provide a bound on the end-figure error so that the validity of the computational procedure may be assured.

• **Credits**—For those interested in pursuing this subject in detail, a list of references is included, which will provide foundations required for detailed studies of this problem. The author is indebted to Samuel Herrick and Robert M. L. Baker for their many constructive suggestions.★

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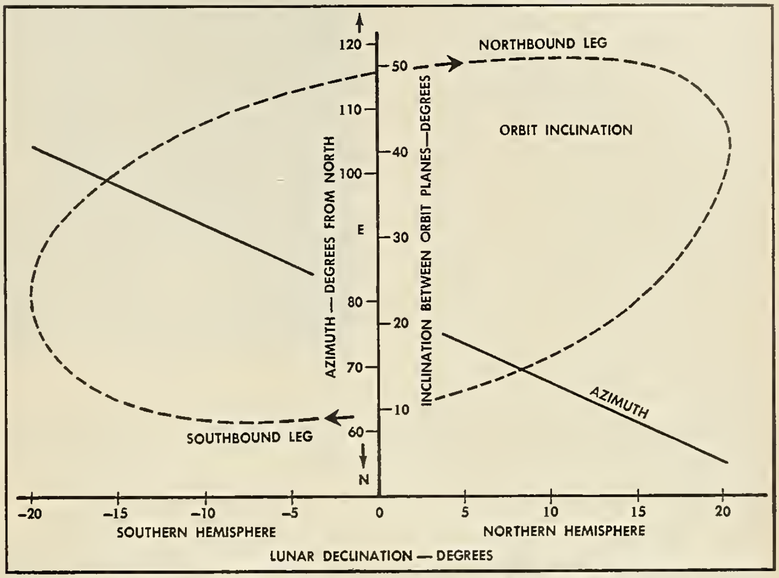


FIG. 5—Lunar trajectory conditions for current year (1958) for launch from Latitude 28° N.

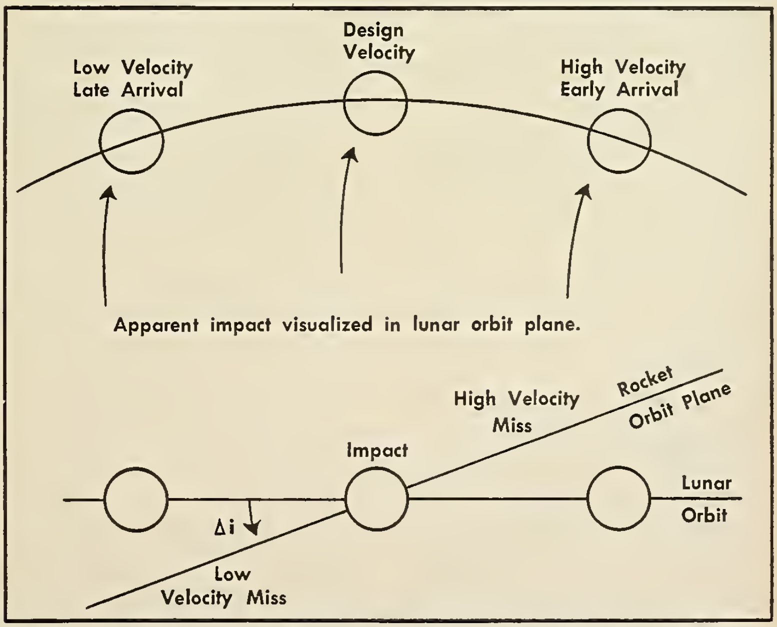
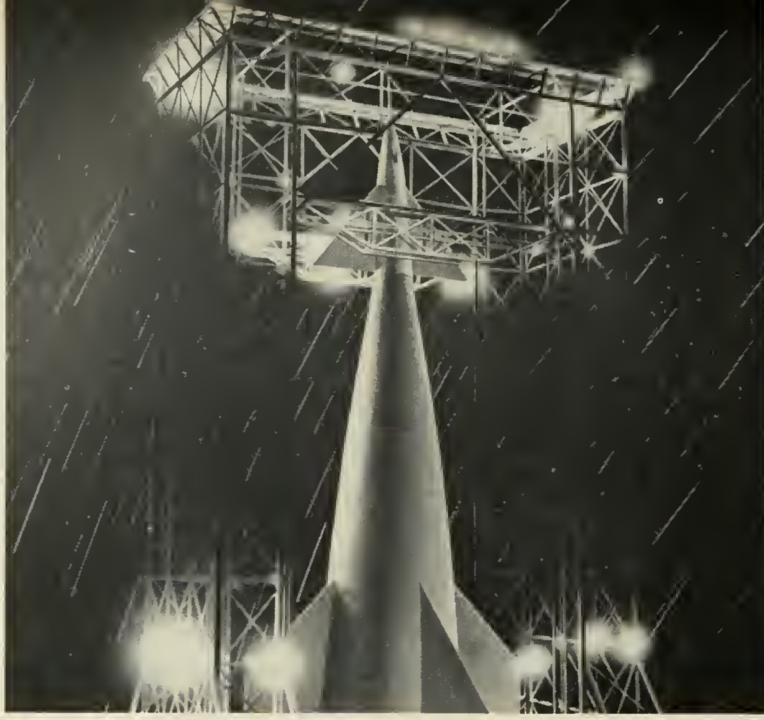


FIG. 8.—Actual miss, as viewed from Earth. Because of Moon's movement, if trajectories are not coplanar, miss can occur.

Flight into Space must be backed by earthbound equipment. That's good reason for . . .



Itokawa

Ground Support: A Must for Space

by Robert J. Laws*

MAN'S INNATE DRIVE and curiosity will never be satisfied until every new frontier has been explored and conquered—and space is the latest and most challenging frontier to confront him. The problem of devising the equipment to conduct this exploration is a tremendous one.

• **What's ground support?**—Ground support can generally be considered to encompass all items of a system other than the flight unit itself.

Unless ground support is taken seriously now, the flights of our guided missiles will be delayed. And, if the flights of the guided missiles are delayed, or the perfection of the overall system is delayed, because development of ground support equipment was left to the very last, we will ultimately delay realization of space flight.

The guided missiles and rockets of today are the true building blocks of space flight.

Conversely, if we do keep the proper balance between development of ground support equipment and that of flight equipment—insuring that the interim step of guided missiles and rockets is accomplished by developing all of the arts and techniques simultaneously—then we will stand a far better chance of achieving space flight in the shortest time and in the most efficient manner.

• **Can't ignore it**—The usual first reaction to the ground support side of the problem is something like—"Oh, we don't have to worry about that . . . that will be solved in plenty of time . . . those are arts and techniques that we know today . . . what we need is the guided missile, and then the satellite, and then the space station and from there we can just take off and go on . . ."

The first step should be to work with the guided missile and rocket developments of today. By making integrated ground support equipment a requirement, the groundwork for development of future systems is laid. Ground support would become an art . . . and would start the development of techniques and the training of people for the future work that will be required for outer space support.

The missiles being placed in our service arsenals take on different physical characteristics as a function of desired performance. There are the small air-to-air birds, the slightly larger surface-to-air and so on to the strategic monsters in the ICBM surface-to-surface category. These different "birds" require basically different types of ground support, each according to the various factors involved; i.e., whether the bird is to be employed tactically or strategically; from fixed or mobile positions; the type of fuel, rate of fire and many other physical factors.

• **Ground handling systems**—A closer examination of just one phase of the missile ground support system—the handling complex—emphasizes that the major difficulties experienced in supplying equipment for the system begin in the manufacturer's plant. As the subassemblies become assemblies, they must be moved from operation to operation, perhaps to preliminary checkout, and ultimately packaged and loaded for shipment.

And the package must be handled in much the same manner that it will be handled by the using unit. In some instances, upon receipt it will be stored and again moved prior to unpackaging. Then might come assembly of the various components, perhaps a checkout stage or flight simulation. Next, the

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components may be disassembled, repackaged, again handled and transported to lower echelons, the firing unit, or returned to the factory.

The firing unit may be anywhere from just outside the manufacturer's plant, as in the case of surface-to-air defense missiles, to any of our missile ships, or tactical and strategic air and land force installations located throughout the world. Ultimately the weapon must be loaded on the firing or launching device—which itself may range from the simplest stand or aircraft zero-length launcher to the complex, remotely controlled, trainable and elevatable launchers.

Up to this point, discussion has been limited to two of the variables which make handling of missiles slightly different from the handling of other commodities, but this is only the beginning.

What is it about the guided missile that dictates special equipment and techniques for handling? Certainly it is not the need for handling and rehandling, nor that it must be transported long distances. But the basic size and shape—in general, a long, cylindrical object with or without wings and fins—is one factor. Secondly, in many cases, this long, cylindrical object has no beam strength in itself and must be supported or cradled in some fashion at several points or through its length.

• **Shock and vibration**—As a general rule, the missiles contain electronic components or propellants which are vulnerable to excessive shock and vibration. Also, the load center, or gravity itself, changes with the various conditions of preparation. For example, a fueled missile or an unfueled missile, or a missile with a separate booster may vary the center of gravity (c.g.) location as much as 50 percent of the length of the load.

These are but a few of the factors which make this a special handling job and, of course, they are the result of the physical properties of the load itself. The problem further complicates itself when consideration is given to the operations in which the missiles will ultimately be involved. For example, there are requirements for extremely rapid handling—in the case of sustaining a given rate of fire when using the missiles as weapons. There may also be requirements for storage or protection from the elements which further complicate the handling problem. And, there is the further problem of handling long loads in confined spaces—such as aboard ships, submarines and, in some instances, aircraft.

• **Terms defined**—Still on the subject of handling the missiles, three terms should be defined in the fundamental vocabulary of the guided missile handling engineers. These are: "multipurpose, compatibility, standardization."

"Multipurpose Handling" — As mentioned earlier, the missile requires multiple handling operations in many locations and under varied conditions. The approach taken today is either the extreme of doing nothing and "making do" with jury-rigged equipment at the last minute; or designing a special piece of equipment to handle the missile under each of these sets of conditions. Multipurpose means simply that "equipment designed after considering all of the handling, situations through which a missile must pass from its fabrication to its firing, the irreducible minimum of handling devices."

For example, consider the multitude of handling operations described previously. A cradle could be designed so that it could be used as a part of the handling equipment in the manufacturer's plant, perhaps used as the assembly dolly for joining the subassemblies to form the finished product, and later used as a part of the packaging for shipment of the unit. Also, the device could be an integral part of the checkout equipment and/or the flight simulator. Perhaps, ultimately, the same device could become a part of the loading equipment for the missile.

This may be stretching the multipurpose concept just a little, but there undoubtedly is an optimum point somewhere between our position today and the concept just described. A positive effort must be made to develop multipurpose equipment and this is no small task. It requires that the technologies of shock, vibration, fueling, environment, handling and all the other facets of the problem be considered simultaneously by the ground support engineer.

"Compatibility"—There must be compatibility of a missile system within itself. The handling equipment with respect to the missile; the missile with respect to the launching device; the compatibility of the checkout equipment; the flight simulation equipment with the missile and with the launcher. This is all tied to the ultimate mission of the missile—whether it be a mail carrier, a weapon in the armed services arsenal, or a scientific research vehicle.

The need for compatibility is obvious. No one would use a ten-ton truck to carry a one-ton missile, nor provide a 50-gallon fuel trailer for servicing a missile requiring 500 gallons of fuel.

A planning program must extend further into the future than that. For equipment to be compatible, one item with another, within a system, it is necessary to set down the ultimate goal and consider every element at the moment design starts, so that each block of the pyramid fits together snugly.

"Standardization"—This term is a familiar one in the missile profession. When we speak of standardization as a fundamental requirement, we must digress from the close look at one system of space-flight equipment and group several systems into their natural families, just as the guided missiles of today group themselves into the surface-to-air or air-to-air or surface-to-surface categories.

Within a given category, then, there are undoubtedly instances where the size, weight, configuration of a weapon or the ground support requirements are similar. Knowing this to be the case, comparable systems can be laid out side-by-side, common ground found, the common items of equipment that could be used from one system to another system determined, and thus the pyramid block of "standardization" will be in sight.

Digressing again from the pure handling problem to other facets of the ground support problem, other possible fields of standardization materialize.

For example: flight checkout equipment, or flight-simulating equipment. This, of course, varies all over the lot from the "go, no-go" type test, to the elaborate laboratory test. Nevertheless, there could be common components across system lines. There are the dc amplifiers, charging units, transducers, in any given system—but have you ever heard of using a unit from one system in the other? Or something as simple as the fittings on a missile for supplying external air, or hydraulic oil or fuel?

• **Much to be done**—There is, thus, a lot that can be done about the current problem of ground support.

A project should be planned for maximum utilization of equipment, striving for compatibility and with specifications written which require standardization. This can be done for handling equipment, for servicing units, for fuel trailers and for checkout equipment and all the other items which make up the ground support equipment.

Actually this is a natural evolution that has taken place in every other program, system, or development that mankind has undertaken. All programs must and will continue to evolve, and they undoubtedly will be better for the extra time and experience devoted to them.

We are not, in general, giving ground support the attention that it deserves.★

Internal Dangers Threat in Space

by Alfred J. Zaehringer

WHENEVER manned space flight is considered, the subject most discussed is the problem of external hazards: cosmic rays, meteorites, gravity, etc. But internal hazards may be deadlier.

Two of the most obvious manned-vehicle problems are control of a synthetic atmosphere and the rocket-powerplant hazard.

Control of a suitable closed-cycle atmosphere is just now receiving attention. Improvement of rocket powerplants is now aimed at bettering reliability—especially for manned vehicles. But in any case, the pilot will be sitting on tons of usually extremely toxic chemical propellants. In addition to the chemicals, there are other contaminants—metallic poisons, and dusts.

Even in very small concentrations, exposure to propellant and chemical leakages and vapors could be very hazardous, especially for long periods.

Duration of endurance flights has been increasing, and manned rocket craft will certainly follow this trend: even the shortest manned flights may be a matter of days. For a manned satellite, the exposure time may be considerably longer. The greatest danger will come from the huge amount of chemicals that the rocket will carry. Leakage and subsequent liquid infiltration or vapor transmission into the habitable sections will cause a big problem. Even if the manned section could be completely encapsulated, there would be a secondary effect—chemical action on the capsule and possible subsequent contamination of the atmosphere.

The capsule itself will be subject to wear, which might give rise to metallic dusts. The slow decomposition products of solid propellants also could be dangerous.

Detection of all possible health hazards will have to be automatic. The human nose cannot be relied on to detect all toxic materials, since many chemicals that could be hazardous have little or no smell, or are not detectable by odor until rather high and dangerous concentrations arise. In some cases, symptoms do not show up immediately. Therefore, manned space satellites and long-travel-time vehicles will have to be equipped with detection systems.

In addition, such a "space sniffer" will have to furnish qualitative and quantitative information, and be ready to make the necessary corrections. It is likely that many of these operations will have to bc relegated to the oldest detection/analysis/action system known—man himself.

Table I: Oxidizers and Monopropellants

Compound	MAC	Odor	Symptoms, Effects
Ethylene oxide	25-100 ppm		Eye irritant; kidney damages
Fluorine	1-3 mg/m³	Pungent	Skin attack; throat, eye irritant
Fuming nitric acid	10 ppm	Acid	Eye, skin irritant; severe pulmonary damage at 200-700 ppm
Hydrogen peroxide			Mainly skin or eye irritant
Liquid oxygen		Odorless	Nontoxic; skin damage due only to cold liquid
Nitroglycerin	0.5 ppm	Ethereal	Headaches; reduced blood pressure
Nitromethane	50-200 ppm	Ethereal	Attacks nervous system, liver
Ozone	0.1-1.0 ppm	Pungent	Detectable by odor at 1 pp 500 million (skunklike); eye, throat irritant at 300 ppm; fatal in 2 hrs at 400-10,000 ppm
Tetranitromethane	0.1-0.5 ppm	Ethereal	Very toxic; eyes, lungs, liver damage; fatal in 10 min at 10 ppm

MAC: maximum allowable concentration PPM: parts per million

Table II: Fuels and Chemicals

Compound	MAC	Odor	Symptoms, Effects
Aniline	5 ppm	Oil-ammonia	Absorbed through skin; eye irritant; 100-150 ppm exposure for 1 hr w/o serious effects
Ammonia (Anhydrous)	100 ppm	Pungent	Eye, skin, throat irritant; detectable odor 53 ppm; 300 ppm, maximum tolerable for several hrs
Carbondioxide	5000 ppm	Odorless	Increased breathing rate, paralysis of respiratory center; 120,000-150,000 ppm causes rapid unconsciousness; death after several hrs at 250,000 ppm
Carbon-monoxide	100 ppm	Odorless	200 ppm, headaches in 2-3 hrs; 1600 ppm, nausea in 20 min; unconsciousness, death in 10-15 min at 6400 ppm
Diborane	2 ppm		Threshold limit, 0.1 ppm; 2 ppm, pulmonary damage; lethal dose, 50 ppm for 4 hrs
Ethanol	1000 ppm	Alcohol	Eye, lung irritations; intoxication
Furfuryl		Almondlike	Central nervous system attack
Gasoline	500-1000 ppm	Petroleum	Asphixiant
Hydrazine	5 ppm	Ammonia	Delayed severe irritant; burns, lung, liver, kidney damage.
Hydrogen		Odorless	Nontoxic; fire-hazard
Methanol	200 ppm	Alcohol	Central nervous system, optic nerve attack; blindness
JP	1000 ppm	Petroleum	Intoxication; headache; nausea
Pentaborane	3.3 ppm		Detectable odor, 10 ppm; lethal dose, 18 ppm

Table III: Metals

Metal	Concentration (per cubic meter)		
Beryllium	0.01-2	micrograms	mac
Lead	15	mg	tl
Magnesium	15	mg	mac
Manganese	0.15	mg	tl
Mercury	0.1	mg	tl
Molybdenum	5	mg	tl
Titanium (as TiO_2)	15	mg	tl
Vanadium	5	mg	tl
Zinc	0.15-0.5	mg	tl
Zirconium	5-15	mg	tl

mac: maximum allowable concentration mg: milligrams tl: threshold limit

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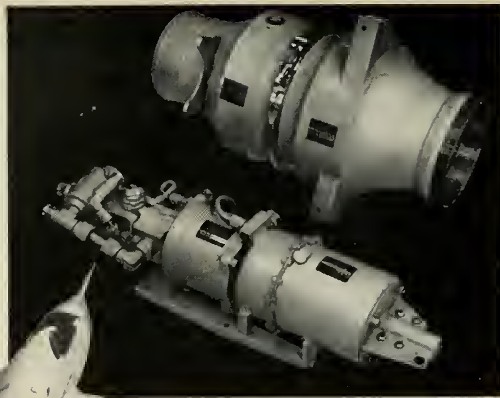

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Toxicity of High-Energy Fuels Poses Hazards for Handlers

by William H. Schecter*

THE HIGH-ENERGY fuels now being developed for use in missiles and manned aircraft were dramatically emphasized when the Army announced utilization of such fuels to provide additional thrust for the *Jupiter* C vehicle during launching of the *Explorer* satellite.

But the new fuels have an obvious disadvantage: they are toxic, and their combustion products are far from ideal. There is ample evidence that using such fuels for manned craft will present unusual problems for the designer. High-energy fuels are regarded as those with heating values much above those of hydrocarbon fuels. (The most important property of a fuel is the heating value, referred to as btu/lb. For example, boron-based fuels have approximately 7000 more btu's/lb than JP-4.)

**Vice President, Operations Callery Chemical Co.*

• **Which is best?**—A review of the possible types of high-energy chemicals shows that hydrogen, beryllium, lithium and boron compounds are the only ones likely to produce energies significantly superior to hydrocarbon fuels.

Molecular hydrogen could readily be produced, but, since it is normally gaseous, very low temperatures would be required to store it as a liquid and even then the density is too low.

Beryllium is a more likely prospect but it is scarce, extremely and insidiously toxic, and should probably be conserved in the long run for atomic energy applications. Lithium, a similar case except for toxicity, may find use in rocketry, but in conventional aircraft it seems both difficult and extravagant.

Thus, boron is the logical element on which to base fuels. It is available in large, concentrated deposits in the United States and has chemical properties which appear desirable from the chemical-processing point of view. Fortunately, it forms more or less stable liquid compounds with hydrogen, the best chemical fuel.

Modification of the boron-hydrogen molecules by the addition of hydrocarbon groupings gives fuels of the desired physical and chemical properties. As a supplementary benefit the boranes generally have wider ranges of flammability than hydrocarbons and consequently will allow operation of air-breathing engines at higher altitudes.

The boron hydrides have the obvious disadvantage that they are toxic.

• **Development history**—Callery Chemical Co.'s history is important as a case study in handling of these somewhat toxic and highly flammable materials. Callery's safety record is believed to be comparable to the industry as a whole.

Mine Safety Appliances Co. became interested in the possibilities of boron chemistry in 1946 and assigned a small group of its top scientists to investigate the chemistry of some of these compounds. From this research came indications of completely new horizons in the field of chemistry, and Callery was formed as a subsidiary to continue this work.

Charged with developing a high-energy fuel, the research and development staff inaugurated a program that involved subcontracts with 23 universities and 13 private research organizations. As a result of these combined efforts HiCal, a boron-based high-energy fuel, was produced in pilot-plant quantities within four years. Production of tonnage quantities is soon to become a reality with the completion of two new plants currently under construction—one a $38-million plant for the Navy and the other a $4-million company-owned plant.

• **Toxicity research**—It is difficult to discuss the toxicity of boranes in humans, because the incidence of acute toxicity has been low, and clinical observations are negligible. But extensive studies of acute toxicity of boron compounds have been made on small animals. The mechanism of the action in the body is not known, but in view of chemical activity, as indicated by physical properties and structure, it is easy to predict that the boranes could interfere with biological processes.

The most extensive studies have been made on diborane, which is gaseous at room temperatures. The main effect of breathing this gas seems to be damage to the lungs. Its toxicity has often been compared with phosgene.

• **Exposure limitations**—Experiments have demonstrated that pulmonary damage can be noted if a test animal is exposed at a concentration of about 5 ppm for 6 hours a day, 5 days a week; when the test is run at 2 ppm, similar damage is noted in a somewhat longer time. The American Conference of Governmental Industrial Hygienists (ACGIH) has adopted a maximum allowable concentration for daily exposure of 0.1 ppm. This, however, is not a completely realistic value, since no method has yet been developed which can reliably detect that concentration. Diborane can be detected by odor only to 3 to 4 ppm.

Pentaborane, a volatile liquid; and decaborane, a solid, differ from diborane in that they attack the central nervous system rather than the pulmonary system. Decaborane has also been found to cause damage to the liver and kidneys. Symptoms of exposure to these higher boranes include loss of coordination, convulsions, weakness, tremors and hyperexcitability.

The suggestion has been made that the symptoms are of two types because of differences in chemical reactivity of the boranes. Diborane is taken into the lungs, where it reacts rapidly with moisture and can cause immediate damage. Decaborane and pentaborane react with water much more slowly than does diborane, so they concentrate in fats and liquids and have a more pronounced effect on the central nervous system.

Repeated 5-hour daily exposures to 3.3 ppm pentaborane causes death in test animals. Pentaborane and decaborane are more toxic than diborane maximum allowable concentrations (MAC's) so the MAC's have been set at 0.01 and 0.05 ppm, respectively. Although pentaborane is toxic in lower concentrations than decaborane, the rate of recovery of rats from decaborane exposure is always slower.

The median detectable concentration by odor for man is 2.5 ppm for pentaborane and 0.35 ppm for decaborane. Pentaborane is said to smell like garlic or acetylene, and decaborane has an unpleasant or foul odor. Rapid olfactory fatigue adds to the hazard of depending only on the sense of smell.

Even the little work that has been done on boron high-energy fuel components demonstrates that they have an order of toxicity between that of pentaborane and of decaborane. HiCal component A, which is a major component of HiCal and the one studied most thoroughly, attacks the pulmonary and central nervous systems similarly to decaborane and pentaborane.

A convenient method of comparing the acute toxicity of compounds is the concentration necessary to kill 50 percent of the test animals (LC_{50}).

A more realistic measure of effective toxicity of such compounds is the Hazard Index which is a function of both toxicity and vapor pressure. Using this index, decaborane and HiCal component A are no more hazardous than many common chemicals such as carbon tetrachloride, benzene and hydrazine. This, of course, is due to low vapor pressure at room temperature.

• **Detectors needed**—The detection of low concentrations of boranes has been a most serious problem as has analytical work in general in the boron field. All of the modern analytical tools have been utilized on this problem: mass spectrometry, infrared and ultraviolet spectrometry, and chromatography, as well as the techniques of radiochemistry.

In spite of all this analytical development effort there are still no commercial borane detectors on the market at present, but Mine Safety Appliances has two types of monitoring devices under development. One is a small, hand-operated device which is sensitive to pentaborane to about 0.4 ppm. This instrument is very useful in detecting leaks and rechecking a location after a spill.

The other instrument shows great promise: it measures the concentrations of boranes electrically and is expected to determine concentrations below 0.1 ppm, probably as low as 0.01 ppm.

• **Safety measures**—Callery's safety record in the last two years is comparable to the petroleum industry in frequency—and is very much lower in severity than any of the process industries. This record has shown steady improvement as personnel have gained experience and further developed engineering techniques in this new commercial field.

In general, safety results from avoiding inhalation, skin contact or ingestion of any borane material.

Laboratory investigations are usually carried out in fume hoods, where the air is changed at the rate of five to ten times a minute. The laboratories are maintained at a positive pressure with an auxiliary heater-blower which supplies warm outside air.

Because of chemical reactivity as well as toxicity, experiments are carried out in an all-glass, vacuum-lined system whenever possible. This technique was developed primarily for use in the boron-hydride field and has the added advantage of giving accurate results using only small quantities of reactants. Equipment such as dry boxes are also used to combat the reactivity of the chemicals and to protect research personnel.

Because of the reactivity of various of the fuel intermediates, all equipment, whether in the laboratory, pilot plants or production units, is carefully flushed with nitrogen prior to use in order to remove water and thus insure safe operation. In setting up engineering scale research equipment, quarter-inch steel plate is used both as protection for the operators and as a panelboard. This, in connection with a "soft" wall on one side of the steel-walled rooms, has served very well for the last several years.

In addition each one of these rooms is exhausted by its own blower, and air entering the building is tempered and used to pressurize the experimental units.

In full-scale operations, the same basic rules are followed to give safe operating conditions: the buildings are adequately ventilated and much of the construction is of the outdoor type, thus reducing toxic exposure.

• **Boron uses**—Recent intense research has created great interest in boron chemicals. As of now the largest "new" use of boron compounds is as high-energy fuels. Many of the new compounds have unique chemical properties, and it is inevitable that they will find many chemical uses.

One of the most notable commercial chemical properties of boranes is their reducing ability. Most commercial reducing agents, although rather cheap, are not particularly selective. The boranes, though, are quite selective.

Various boron compounds have had application in such diverse areas as polymerization catalysts, fuel additives, bacteriocides and fungicides, and as a welding flux. It is possible to protect the more active metals with a film of unreactive metal boride including some of these compounds. Methyl borate is a nonaqueous solvent which could improve certain reactions.

One of the most recent applications of a boron compound is the use of trimethoxyboroxine to control titanium, zirconium and magnesium fires.★

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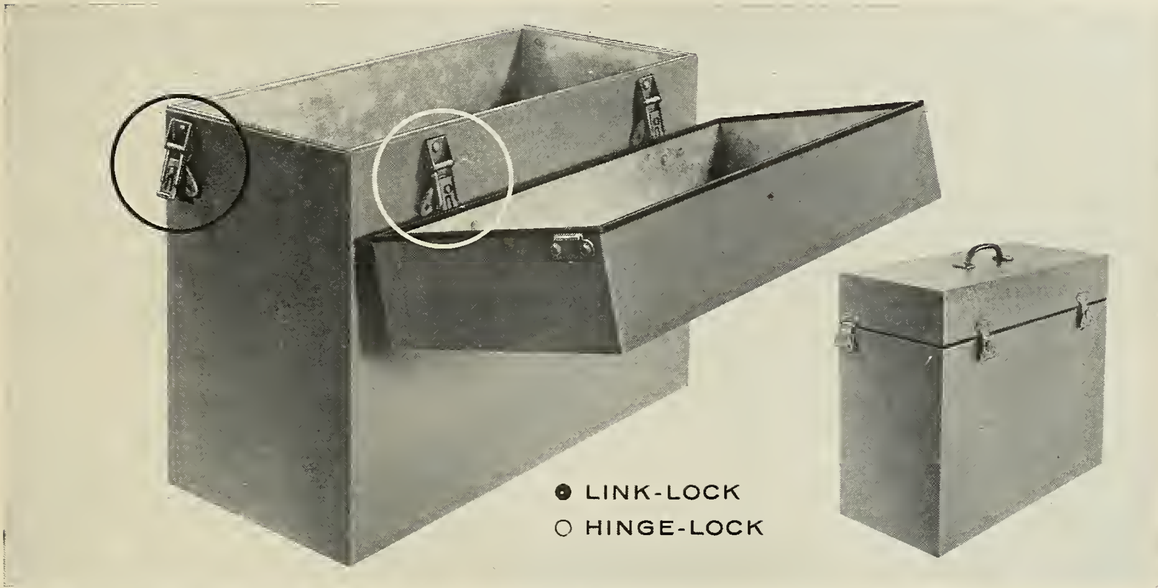

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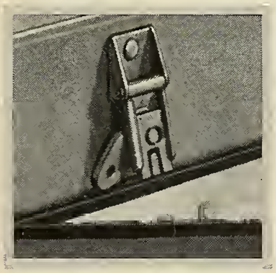

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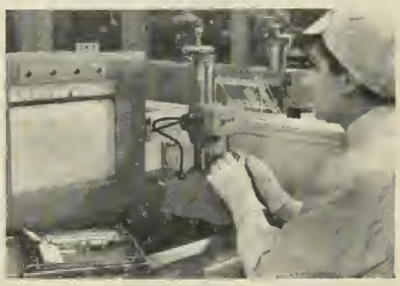

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J. Sentovic

How to Travel Outside Our Solar System

by Franco Fiorio*

IN THE ERA of ballistic missiles and satellite launching, the voice of an old master in the field of astronautical sciences reaches us from Rome, Italy, to tell of new approaches to solve the future problems of "cosmonautics."

The scientist is Prof. Gaetano Crocco, president of the Italian Rocket Society, and of the new Italian Ballistic Information Center, and father of Princeton's famed Dr. Gino Crocco. His ideas appeared in an article written in the Italian magazine, Civilta delle Macchine.

Prof. Crocco agrees with Dr. H. Strughold that in our solar "echosphere" there aren't many hopes of finding a suitable planet for the human race, which, under the mounting pressure of an ever-increasing population, will be forced to seek escape from the earth within a few generations.

This forecast brings about the need to know much more about both the planets of our solar system and other fixed star systems than is possible through astronomical observation tools (telescopes, spectrometers and the like).

Comparing the astronomer with Galileo and the astronaut with Columbus, Prof. Crocco points out that Galileo's theoretical findings that the earth is round, would never have been confirmed without Columbus'.

Similarly, man won't be able to plan an intelligent space travel program without a preliminary exploration by a few dedicated pioneers, who will evaluate, at close range, the possibilities of life for human on other worlds.

An important question: How far from the earth will man be able to travel and return, within the span of human life? To find an answer, Prof. Crocco has followed the same line of thought as Dr. Saenger, Dr. Ackeret and Dr. E. H. Krause in seeking an application of relativistic theory to applied cosmonautics.

First of all, to be able to reach cosmic distances, man has to learn how to fly his vehicles at cosmic speeds—very close to the speed of light. This means a new propulsion system with a specific impulse of some 30-million seconds.

Compare this astonishing figure with the 300 seconds of today's best chemical propellants and with the approximately one million seconds possible from nuclear rockets.

• **Cosmic jet stream**—However, the existence of cosmic rays, a sort of "jet stream" of particles of matter coming from the unknown depths of the universe and traveling at speeds very close to that of light, opens up many new possibilities for greater speeds.

Scientists all over the world have had considerable success in reproducing these speeds in giant accelerators.

• **Space propulsion**—Chemical propellants, even with high energy fuels and free radicals, are not suited for space propulsion. They lack the necessary energy; nuclear jet propulsion is the only possibility for substained interplanetary travel.

On this subject scientists have measured the thermic jet against the ion jet. According to a theory developed in Britain by Dr. L. R. Shepherd and A. N. Cleaver, Prof. Crocco has worked out—for a specific practical speed of interplanetary travel and for standard pressures in the combustion chambers—the following relationship between temperature and voltage needed:

$$1^\circ \text{ Kelvin} \cong 5000 \text{ Volts}$$

In other words, while a temperature of 1,800,000° K. would be needed for a "practical" speed of 190 miles

* *Dr. Fiorio is United States liaison chief for the Italian Aeronautical and Nucleonic Center, with his headquarters in Washington, D.C.*

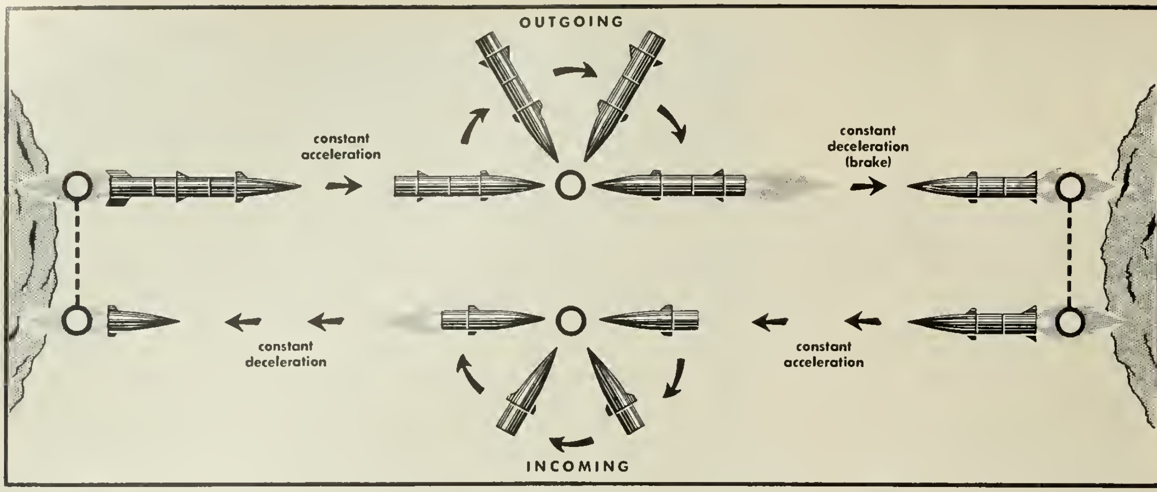

FIG. 1—FOUR STEP cosmonautic trip envisages reversal of vehicle, both on outgoing and returning trip.

per second, with a molecular weight of the jet exhaust of 2, the same result can be obtained with only 360 volts. The ion jet wins the contest easily.

An ion propulsion system might consist of an ion accelerator unit, powered by nuclear fission energy. At today's efficiency ratio of nuclear reactors, such an arrangement might reach a speed on the order of magnitude of 1/25 the speed of light.

The design and construction of a spaceship embodying these principles is perfectly feasible.

• **Not enough?**—But nuclear power at the efficiency ratio of today, with a top attainable speed of 1/25 of the speed of light—excellent for travel in our own solar system—is not good enough for travel to other solar systems or galaxies.

For this purpose Dr. Saenger visualizes photon rockets utilizing "radiation pressure" of "radiation quanta" with mass zero. Prof. Crocco disagrees with Saenger's proposal; he believes that "radiation pressure" is technically unsuited to cosmonautic propulsion due to the excessive dimensions of the radiators involved and very high operating temperatures.

He is convinced that a higher energy source is already available in matter itself—if and when human ingenuity can draw from the atom the full amount of energy available according to Einstein's equations, and convert it fully to propulsion power. It will be possible then to reach speeds quasi-equal to the speed of sound.

Both Saenger and Crocco are taking for granted that the development of either the photon rocket or the integral extraction of energy from the atom will take place.

• **Testing a cosmo-ship**—It is immediately apparent that it would be impossible to apply existing aeronautical or ballistic testing techniques to an experimental model of such a ship.

In fact, the only conventional way to test the ship close to the earth would be to curve its trajectory around our globe by a magnetic platform, using techniques similar to those in nuclear accelerators.

But the forces involved are out of the realm of practical possibilities: i.e., for a speed of 96 percent the speed of light, even ignoring the relativity effect, a force of 1300 tons would be needed for every gram of circulating matter. Adding relativity effect, this force becomes 500 tons.

This means that trajectories of bodies at relativistic speeds, are pretty much "inflexible" and cannot be deviated practically from a straight line.

The result is that for travel at relativistic speeds, only straight trajectories with the maneuvering possibilities limited to acceleration and deceleration, starts and stops can be considered.

A round trip to a target in outer space can therefore be planned either as a four or a six-step trajectory as shown in Figs. 1 and 2.

Fig. 1 shows the four-step trip: outgoing (constant accelerations and constant deceleration), and incoming (constant acceleration and constant deceleration) with inversion of the ship at the halfway point.

Fig. 2 is the six-step trip, with a constant speed phase inserted between acceleration and deceleration periods.

The speed of the cosmo-ship along the straight trajectory, up to approximately one-fifth the speed of light, can be computed by the laws of conventional astronautics:

$$B = \frac{v}{c} = \log \frac{Mo}{M} = \log R \quad (1)$$

where v is the speed of the cosmo-ship, *c* is the speed of the jet exhaust that we assumed "almost" equal to the speed of light, Mo the total mass at takeoff and M the mass at the time.

At speeds higher than one-fifth the speed of light, the conventional formula is no longer valid and Prof. Crocco presents this relativistic expression, valid in the vacuum and in the absence of gravitational forces:

$$B = \frac{v}{c} = \frac{R^2 - 1}{R^2 + 1}$$

The difference between the two regimes of speed are illustrated in Fig. 3, where it is clearly shown that how the conventional formula is no longer valid for high value of $R = \frac{Mo}{M}$ and is substituted by the relativistic expression by which the speed of the cosmo-ship increases asimtotically toward the speed of light, never reaching it: i.e., with B never reaching the value of 1.

• **Operation of the cosmo-ship**—The pilot of the cosmo-ship has what seems to be a very simple task:

If he adopts the four-steps flying plan he must accelerate the ship from zero to a maximum speed, halfway to his target. At this point he has to "reverse" the ship and start decelerating, to a stop on the chosen body.

The determination of maximum speed and of the halfway distance could be a very knotty problem—but there is a solution: if the rate of acceleration is kept equal to the rate of deceleration, (both of them kept constant by a special mass regulator)

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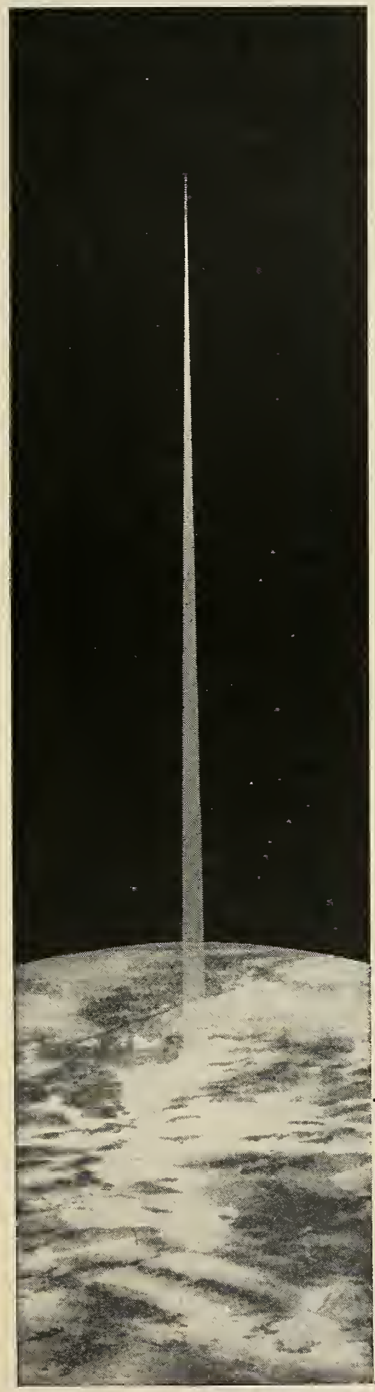

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PAUL D. CASTENHOLZ, Pacific combat veteran, graduated B.Sc. (Eng.), UCLA 1949. From research engineer his grasp of rocket engine work raised him through a supervisory post in experimental development to assistant group leader in combustion devices, and then to group leader of experimental engines. Recently completed requirements for his MSc. Relaxes with hi-fi, fishing and back packing.

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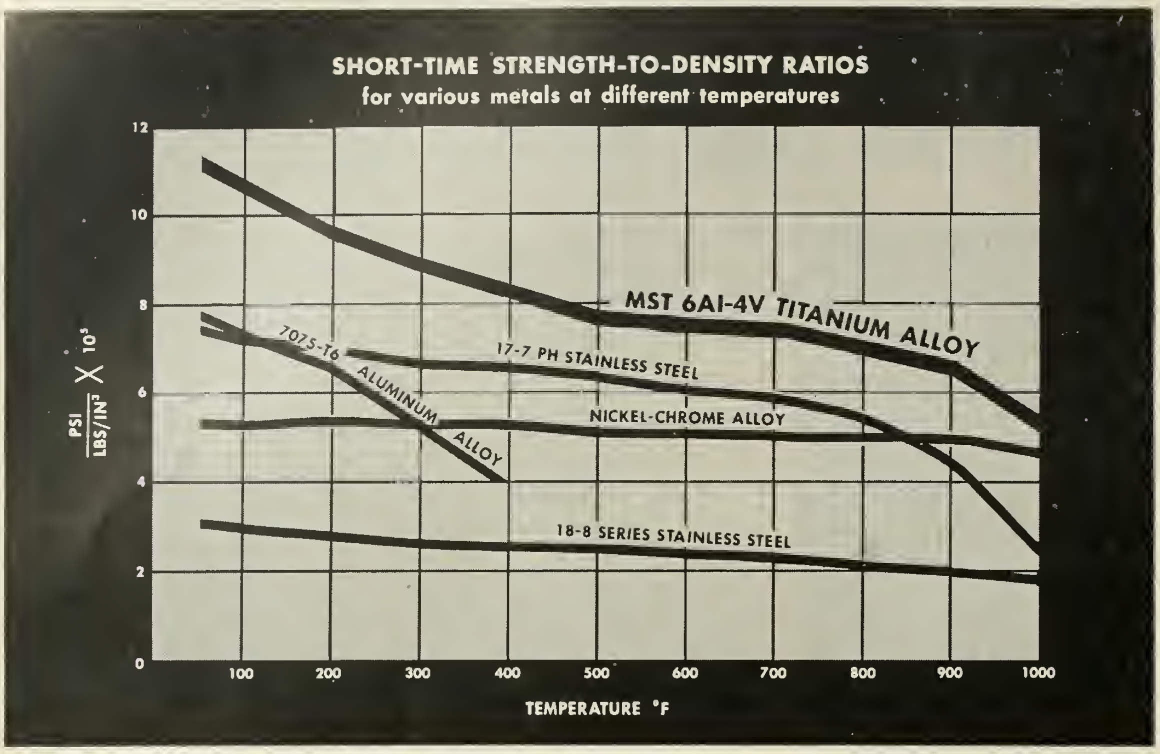

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Write Dept. C-5 for copy of "Titanium Alloy Properties"

SELECTION GUIDE TO MST ALLOYS

Typical Mechanical Properties of Annealed Titanium and its Alloys

	Form	Ultimate Tensile Strength, psi	Yield Strength, psi	Elongation %*
COMMERCIALLY PURE TITANIUM				
MST Grade III	Sheet, Bar	70,000	50,000	25
(3 different strength levels)	Sheet, Bar	85,000	65,000	23
TITANIUM ALLOYS	Sheet, Bar	100,000	80,000	20
MST 6Al-4V				
Annealed	Bar	140,000	130,000	15
Age hardened (1)	Bar	165,000	155,000	12
Age hardened (2)	Bar	180,000	165,000	10
Annealed	Sheet	140,000	125,000	12
MST 3Al-5Cr	Bar	155,000	145,000	13
MST 4Al-4Mn	Bar	150,000	140,000	14
MST 8 Mn	Sheet	137,000	125,000	16

(1) 1650°F—1 hour—WQ; 1100°F—2 hours—AC
(2) 1700°F—1 hour—WQ; 1000°F—8 hours—AC

WQ—Water Quench
AC—Air Cool

* Values for 1" on bar and 2" on sheet

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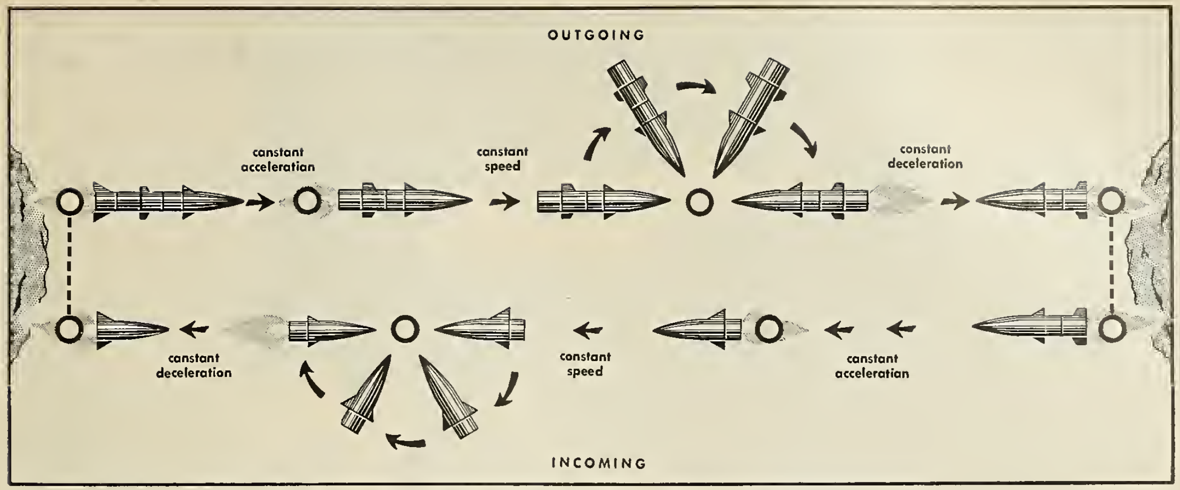

FIG. 2—SIX-STEP cosmonautic trip adds work for pilot, calls for careful reading of instrumentation.

the formula (1) and (2) supply a way to determine speed and distance through the measurement of $\frac{Mo}{M} = R$, i.e., the consumption of nuclear fuel.

Of course, the assumption is valid only for motion in a vacuum and in the absence of gravitational forces. Therefore, it applies only to cosmic travel, and not to interplanetary flight within our solar system.

Measurements taken inside the cosmo-ship will check with the ones taken on earth for only a short time: until the ship reaches one-fifth the speed of light.

If the pilot chooses a constant acceleration of 9.5 meters/sec^2—very close to g—the identity between ship and earth measurements is valid only for the distance of 32 times the radius of the solar system. The pilot can thus determine the moment he reaches a relativistic speed by checking his fuel consumption, which would indicate an R = I.2214, equivalent to 73 days of flight.

From then on, the pilot flies at relativistic speeds and the advantage of the relationship between speed and consumption comes into play: the pilot doesn't have to worry about relativistic time and acceleration; all he has to do is to keep a close check on constant acceleration as indicated by his ship-borne instruments and to measure his fuel consumption, to determine exactly when he has to "reverse" the ship the distance covered and the exact speed of the ship.

In the case of a constant acceleration and deceleration of 9.5 m/sec^2 the crew should also be in good physiological condition, since the whole trip would be made at a personal weight very close to weight on earth.

In this case, the relativistic relationship between fuel consumption and the distance n measured in light-years, according to Prof. Crocco is:

$$n = \frac{(R - 1)^2}{2R}$$

Though the pilot doesn't have to worry about computation of the elapsed time doesn't mean that time has no importance for the crew. Both astronomical time—terrestrial time—and the relativistic time are important, because they affect the very life of the travelers.

As Saenger, Krause, Ackeret and many others have already pointed out, relativistic "dilation" affects the crew's time, making it shorter than terrestrial. The Crocco equations, establishing the relationship between terrestrial time T, relativistic (crew's) time Te and distance covered n (in light-years) are:

$$ATe = \log R$$

$$\frac{T}{T_e} = \frac{R^2\text{-}1}{2R \log R} \qquad n = \frac{(R\text{-}1)^2}{2R \log R}$$

where: R has the usual significance and A is a coefficient function of the ship's acceleration becoming equal-l for an acceleration of 9.5 meters/sec.^{2} A very quick calculation shows that, for A-1, and R-10, an elapsed time of 4.5 terrestrial years is equivalent to only 2.3 years of the crew's life and is sufficient to travel a distance of 4.05 light-years.

In other words, under those particular conditions, the crew has the illusion of traveling at almost twice the speed of light.

• **Limits of Cosmonautic travel**—Two important factors in future cosmonautic travels will be the fuel consumption characteristics of the propulsion system and the physiological length of the human life.

Starting from the assumption of a cosmo-ship with a total weight/payload (including fuel) ratio of 1300, i.e., of the order of magnitude of today's artificial satellites, and accepting the "optimum" conditions outlined before (as the full exploitation of the energy of the atoms: a vehicle speed "quasi" equal to the speed of light, etc.), Prof. Crocco comes to the conclusion that, for a four-step constant acceleration round trip (Fig. 2) in space, a practical limiting distance might be 16 light-years.

It would take almost 30 years of life for a roundtrip of that kind, which could reach the star, Altair, and approximately 50 other stars within the same radius from the earth.

If, instead of the convenient four-step, constant acceleration scheme, the more sophisticated, six-step (Fig. 2) scheme is adopted, the advantage of using only the fuel consumption as a distance and speed gauge is lost, and for the stretch traveled at constant speed, the accurate measurement of the relativity time is also mandatory.

On the other hand, for the six-step scheme Prof. Crocco is able to demonstrate that the limiting distance for equal values of Ie and R is almost double that in the four-step scheme.

It therefore would be possible to reach the distance within a sphere of a 34-light-year radius, containing approximately 480 fixed stars.

These by no means are the limits of man's ultimate frontiers in the exploration of space. Some day it will be possible to devise a way to utilize as fuel the energy of fragments of matter existing in space. In this case the frontiers of the universe could be pushed even farther away and an increasing number of new stars would fall within reach of the human race.★

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Forgings	77	198	1144
Bar and Tube	83	186	414
Total	1,115	2,004	5,558

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Recoverable Boosters Are Studied to Cut Manned Space Flight Cost

by D. C. Romick, R. A. Belfiglio and F. B. Sandgren*

Goodyear

WITHIN A RELATIVELY short time, manned space flight can be expected to assume large-scale proportions. In anticipation of this, the concept known as *Meteor*[1,2,3] employing manned recoverable boosters, has been analyzed and studied under sponsorship of Goodyear Aircraft Corp. (m/r, March, p. 134).

The basic assumption implicit in the idea of manned space flight is that it will be possible to obtain satisfactory re-entry and control of the final stage. *Meteor* extends the principle of re-entry and control to the manned booster phases as well as to the final stage, reducing the cost of the launch to the expenditure of fuel without simultaneously destroying the expensive booster hardware.

Primary objective in the *Meteor* concept is reduction in cost of manned space-flight operations. Other benefits include freedom of selection of launch site, and choice of orbit without danger that expended boosters will fall into inappropriate areas.

Manned space flight in the immediate future will utilize existing non-recoverable booster hardware. A practical necessity, it is economically feasible because of the comparatively few flights involved. But long-range operational requirements of manned space flight will involve continuous operation of reconnaissance patrols, communicacations relay systems, and establishment of a satellite space station for lunar and interplanetary probes.

The number of flights required for these operations will make the costs of expendable boosters prohibitive. It appears inevitable, then, that some method should be devised to recover the expensive booster stages of any space-flight system, even though added initial investments and effort will be required. The *Meteor* concept is designed to take advantage of these possible long-range economies.

• **Vehicle for recovery**—In the concept of *Meteor,* a three-stage vehicle is employed. The first and second stages—after separation—glide to auxiliary bases where they are fitted with turbojet engine pods and tail fairings, so that they can be flown back to the launching base for reuse. The final stage is also a winged glide vehicle, which on re-entry, returns to the launching base.

A variety of third-stage vehicle configurations or loadings may be employed, depending upon the mission. The final stage is big enough to be used for reconnaissance, bombing, interception, or satellite ferry missions. The same first and second stages and the auxiliary subsystems can, therefore, be utilized for all missions.

• **How many needed?**—In order to establish a basis for comparison, the magnitude of future operational uses was first determined, then an operational schedule was used to estimate the number of vehicles involved, and the cost of the operational system was calculated. This cost analysis is based on using *Meteor Jr,* a minimum-sized ferry rocket vehicle.

An aggregate of projected requirements for various possible missions have been plotted in Fig. 1, on the basis of the daily number of flights. Military demands include reconnaissance, bombardment, interception, and building and supporting a space station. Non-military demands include scientific research, meteorology, astronomy, and communication relay—all on an individual basis, with a view toward eventual establishment of a space platform for various public services and scientific functions. Such platforms can be expected to serve both military and nonmilitary missions, to support extra-orbital ferry flights.

The abrupt reduction in the slopes of the upper total curve anticipates the introduction of newer models with greater carrying capacity. In general, the utilization curve of any one model resembles a normal distribution curve.

The number of vehicles required to satisfy the demands of the missions outlined depends on the number of flights each vehicle can supply. This, in turn, is determined both by the total number of flights of which the vehicle is capable, and availability by scheduling.

The total flight capability depends on the operational design life of the vehicle, the operational attrition and the operational life span in years. As for any manned aircraft, the design life of the vehicle cannot be a limiting factor. The incidence of "washout" type accidents was estimated by analysis of data on current military operations, discussions with pilots about comparative flight characteristics, and reliability studies of the takeoff phase.

From this analysis an attrition rate was assumed to be one per 1000 flights per vehicle. From consideration of the life span of military models, an operational life span of 100 years was assumed; this was consistent with the projected operational flight requirements shown in FIG. 2.

Schedule availability is dependent on the operational turn-around time of the vehicle system. Analytical consideration was given to the time required for each separate operation. The first stage required 29 hours; second stage 33 hours, and the final stage 29 to 49 hours, depending on the mission. From these values the average number of yearly flights per vehicle was determined to be 250.

Based on this availability, the maximum number of vehicles required at the peak demand for a particular model, plus the attrition to that date, determined the total number of vehicles required. The attrition rate does not reduce the number of vehicles required below the demand curve for the usage of a particular model as it is superseded by advanced design; the

* *D. C. Romick is head, astronautics section, Weapon System Department; R. A. Belfiglio is manager, Engineering Planning and Scheduling Department, and F. B. Sandgren is manager, Design Development Department, all of Goodyear Corp., Akron, Ohio.*

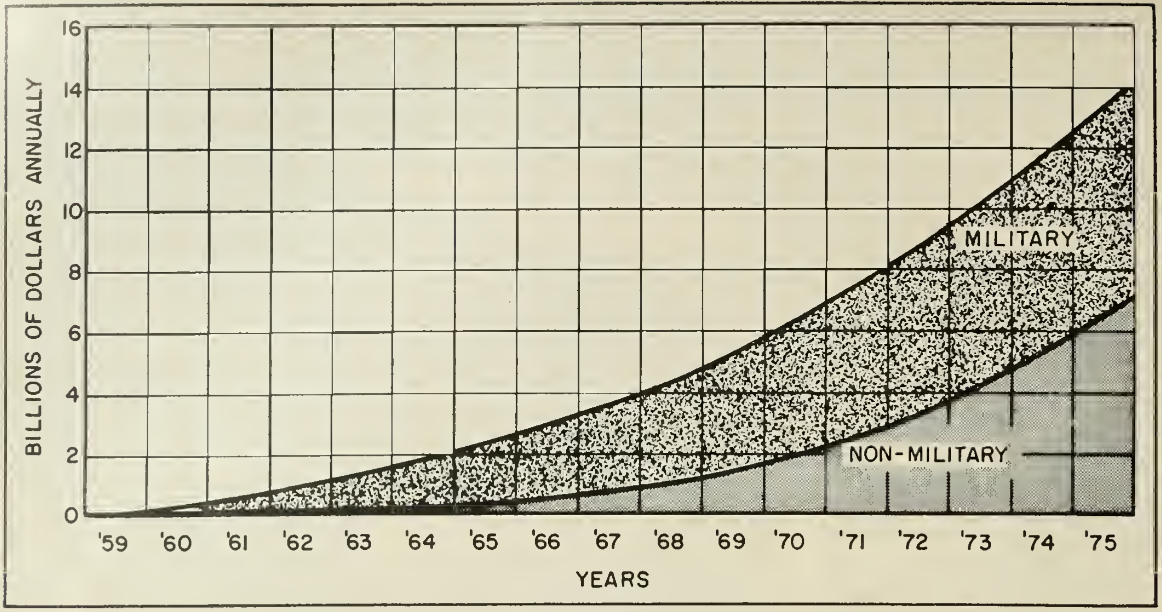

FIG. 1—Projected total costs of *Meteor Jr.*, for two probable uses.

number required at the aforementioned peak of demand, therefore, has been entered in Table 1. The longer turnaround time of the third stage resulted in doubling the requirements for this stage.

• **Figuring costs**—Having established the number of vehicles required, it was now possible to estimate the cost of the system. Cost per vehicle was obtained by application of typical bomber costs.

This technique appears reasonable; the empty weight of stage 1 is less than a B-52, the empty weight of the stage 2 vehicle is less than a B-57 or a B-45, and the overall complexity of these stages does not seem significantly greater than that of modern bombers. Progress curves were plotted for manpower, material and rocket-motor costs in order to achieve reasonable production costs. In production, *Meteor Jr* costs per pound for the booster-stage vehicles should approximate bomber production costs.

To determine overall system costs, data previously discussed was compiled to form Table 1, which represents the elements of cost involved for various mission characteristics, which are indicated by the values in the first three columns, and are similar to those used to derive the curves of Fig. 2.

For example, the fifth entry below the dashed cross-over line on Table 1

Table 1: Comparative System Operation Cost (Meteor vs. Expendable Booster)

Line No.*	Mission Characteristics: Operating period (years)	Mission Characteristics: No. of flights	Mission Characteristics: Peak daily flights	Recoverable Vehicles: Boosters I and II (No.)	Recoverable Vehicles: Boosters I and II (Cost)	Recoverable Vehicles: Final stage (No.)	Recoverable Vehicles: Final stage (Cost)	Recoverable Vehicles: Total vehicles	Total system: Recoverable	Total system: Expendable	Cost flight: Recoverable	Cost flight: Expendable	Cost Ratio Exp./rec.
1.	1	30	1/5 to 1/2	1	$ 26,000	1 or 2	$ 1,460*	$ 27,460*	$ 150,000*	$ 98,460*	$5,000,000	$3,282,000	2/3
2.	2	100	1/2 avg- (1 every other day)	1	26,000	2	1,460	28,920	289,000	285,000	2,890,000	2,850,000	1
							Cross-	over					
3.	5 1/2	1,000	1	2	50,000	4	2,300	52,300	523,000	1,300,000	523,000		2 1/2
4.	8	3,000	2	5	105,000	9	3,700	108,700	1,087,000	3,900,000	362,000		3 1/2
5.	8	5,000	3 1/2	8	148,000	16	6,100	154,100	1,541,000	6,500,000	308,500		4
6.	4	5,000	7	14	222,000	26	8,700	230,700	2,300,700	6,500,000	461,000		3
7.	10	10,000	5 1/2	14	222,000	27	9,000	231,000	2,310,000	13,000,000	231,000		5 1/2
8.	10	20,000	11	27	364,000	53	14,500	378,500	3,785,000	26,000,000	189,000		7
9.	10	50,000	27 1/2	66	704,000	133	28,000	732,000	7,320,000	65,000,000	146,000	$1,300,000	9
10.	10	100,000	55	132	1,200,000	265	46,000	1,246,000	12,460 000	130,000,000	124,500		10
11.	6	50,000	60	140	1,250,000	280	48,000	1 298,000	12,980 000	65.000,000	260,000		5

(*000 omitted)

The operations as listed could serve as follows:

Line 1. Scientific missions (astronomy, space biology, electronic and chemical research, etc).
Line 2. Same, over longer period of time, expanding capability.
Line 3. Limited reconnaissance mission, as well as scientific.
Line 4. More extensive reconnaissance capability, and/or limited interception and patrol mission.
Line 5. Same as line 4, but greater capability.
Line 6. Intercept missions, or building and supplying a small satellite space station.
Line 7. Good-sized station-building mission, though at a slow expansion rate.
Line 8. Station building mission, combined with other above listed missions.
Line 9. Combined missions somewhat corresponding to those shown in Fig. 2.
Line 10. Extensive combined mission capability.
Line 11. Special high-density bombing mission capability.

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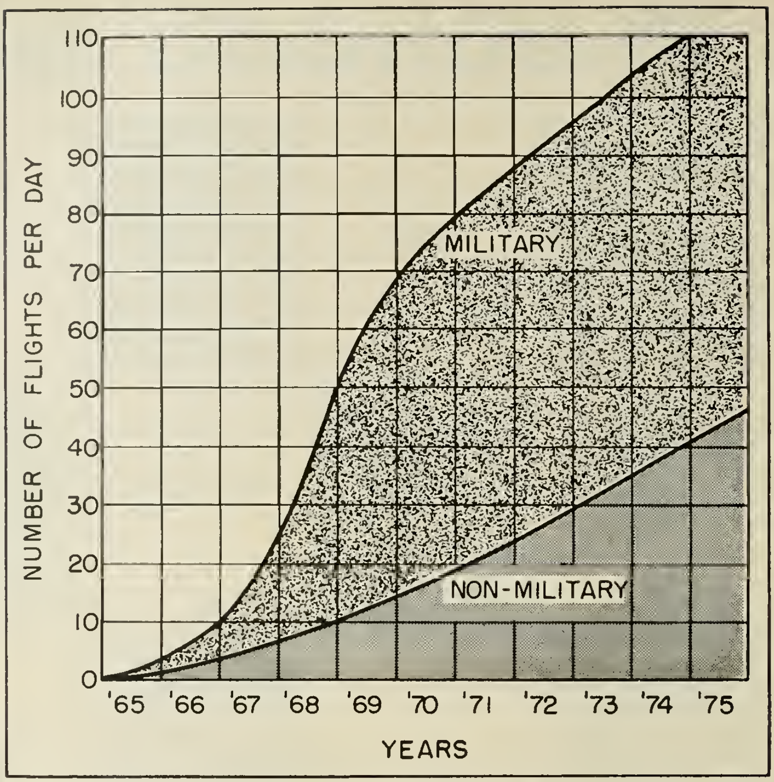


FIG. 2—Projected operational flight requirements for missile system employing with either recoverable or expendable boosters.

assumes 10,000 flights over a ten-year period with an average peak rate of 5½ flights per day.

To accomplish this, 14 pairs of recoverable booster-stage vehicles and 27 final-stage vehicles are required, costing a total of $231 million. After adding the corresponding operational costs, the total system cost using recoverable boosters is $2.31 billion. For the same number of flights, the total system cost using expendable boosters is about $13 billion. This yields an average cost of $231,000 per flight for *Meteor Jr* recoverable boosters, compared to $1.3 million per flight using expendable boosters for this size operation.

The ratio of expendable booster systems to *Meteor Jr* system cost is, therefore, about 5½ to 1, and becomes more favorable as the number of required flights increases. It appears that the cross-over point is around 100 flights. If total flight requirements are less than 100 flights, the cost ratio will probably favor the expendable boosters.

It is possible, however, that flight flexibility of the booster stages of *Meteor Jr* may facilitate development testing to a point where cost cross-over is reduced to considerably less than 100 flights. At any rate, this analysis shows that for more than 1000 total operational flights the economic superiority for the recoverable booster feature continues to increase.

From the information thus obtained it becomes possible to project corresponding total cost for a *Meteor Jr* system operation of the extent indicated in Fig. 2. This projection is presented in Fig. 1.

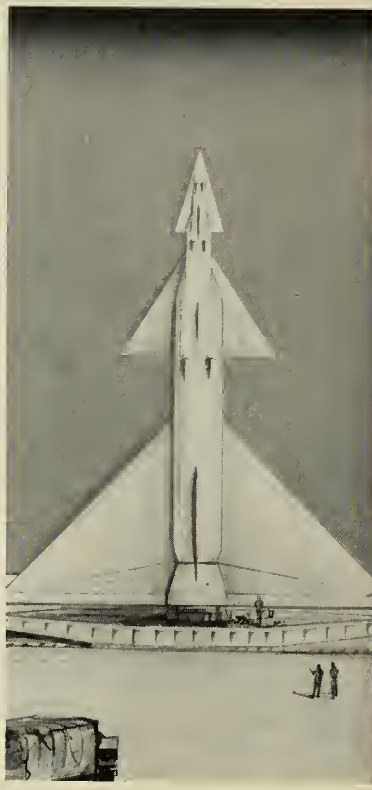
The projected total costs on Fig. 1 start rather modestly in the early '60s and reach a peak of $14 billion annually in 1975, when projected daily flights into orbit exceed a rate of 100 per day. The costs reflected in FIG. 1 are all overall, including development, procurement, and operational and maintenance costs.

This program appears economically feasible if compared with long-range predictions in our Gross National Product (GNP), National Budget, and Defense Department budget. The division of costs between military and nonmilitary agencies could have a "checks and balances" effect upon integrated program activities and tend to hold costs to within reasonable proportions.

The above analysis shows that, while such orbital operations will be expensive (as have all new systems of higher performance), they need not

be excessively out of good proportion.

Furthermore, it is believed that the *Meteor Jr* recoverable booster system enjoys a marked economic superiority over an expendable booster system. This economic superiority ranges from 1/3 to 1/10 the cost of the expendable booster system, depending on the nature of the missions and the total number of flights required. ★



Goodyear

ARTIST'S CONCEPT of the minimum-sized METEOR JR. being readied for firing on the launching pad.

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Budgeting for the Space Age

Why is it so hard to get good estimates on cost of programs? Here are some answers

by Seabrook Hull

A TOP BUDGET OFFICIAL at the Pentagon told m/r recently:

"Before October 4, I could have told you exactly what the defense budget would be in fiscal year 1960 and 1961. Now, I haven't any idea." No one in the Pentagon really knows what even the first space flight projects will be, much less which long-range projects should be picked. Nor will they know, until they have rationalized basic budgeting procedures.

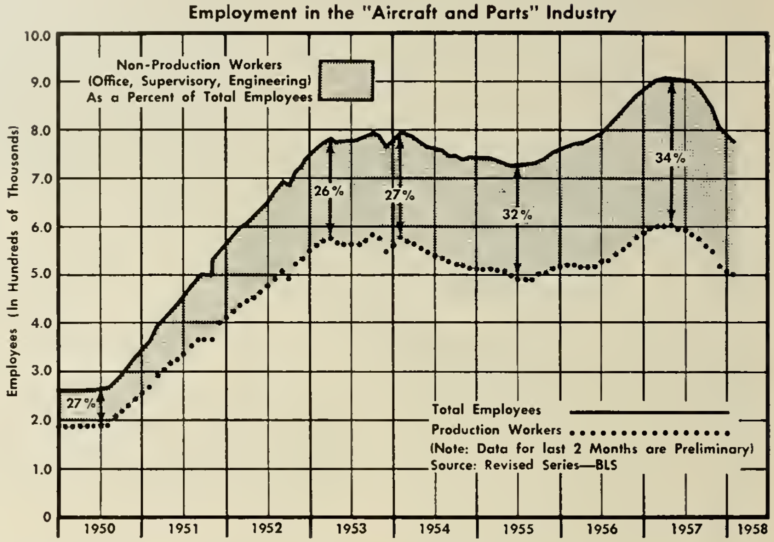
It cost the American taxpayer $700 million "not to get *Navaho.*" From the time money was first appropriated in 1951, through 1959 (projected), our big ballistic missile programs (ICBMs, IRBMs, FBMs) will have cost us over $6 billion, not including military pay, etc. This total doesn't include all the massive facilities required for operational deployment of these birds, nor the cost of the bare missiles themselves—with such price tags as $2 million each for *Atlas;* $1 million for *Thor*.

There's talk of a requirement of perhaps 40 *Polaris*-launching submarines, at $60 million each—a total of $3.2 billion, again without the missiles. Each submarine will carry 16 *Polaris* missiles, which will run the total *Polaris* systems bill up at least another $1 billion. *Bomarc* as finally deployed may add another $5 to $10 billion.

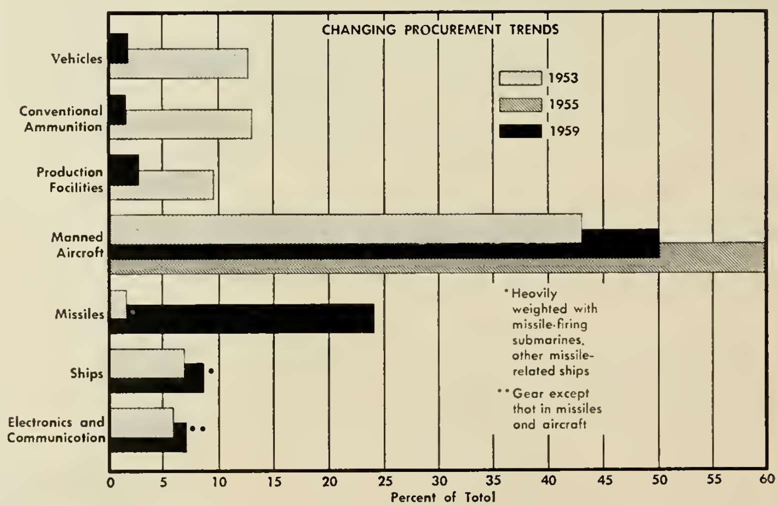
Even the little birds like *Sparrow* III, *Falcon, Nike, Terrier, Bull Pup,* etc., cost from $10,000 to over $50,000 each when produced and bought in thousands. Again, ground-handling and other ancillary costs (running usually to many times the cost of the birds themselves) are not included in the figures.

• **And space to come**—These are just a few samples of the costs of this interim age of missiles. Yet they serve to demonstrate that this is the most expensive era we have ever encountered. And, we haven't even begun to think of space—space, the age when a single vehicle may cost $1-billion just to develop; when an operational capability may top $1 trillion.

However, budgeting for missiles



PROPORTION of overhead personnel to production men in the aircraft and parts industry indicates the relative rise in overall costs attributed to overhead increases. This trend has greatly increased labor costs.



DRASTIC CHANGES in defense policies have resulted in almost revolutionary shifts of expenditure toward entire new industries geared to the space age. The decrease in conventional weapons is obvious.

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provides a preview of budgeting for space flight. And those experts in government and industry who have reason and insight to look ahead are gravely concerned with what they see. In a word, the United States is already pushing the limits of its capabilities, not only financially, but technologically, politically and industrially as well. Yet despite this fact, we are forced daily to shelve for now, or forego entirely projects considered absolutely essential by some of the most competent military brains in the country. Reason: we can't afford them.

This is all in the missile age. Yet, it is an accepted fact that space flight, once it gets going, will compound the costs. It is a dilemma. At least it is so long as Russia can selectively choose her fields of battle, while we try to cover all eventualities. However, it is not a dilemma without answer. But in resolving it we may bring about even more radical changes in our way of government, our economics, our attitudes, etc., than we now contemplate.

The initial problems of space-age budgeting are maniflold, including: education; inaccuracies (both intentional and inadvertent) at planning and budget sessions; overlap of old with new military concepts; the leapfrogging pace of technological progress; obsolescence; selectivity; contracting methods; performance on contracts; utilization of resources; financial and political limits; costs estimating. The problem in a nutshell: to get inspirational-but-low-cost results through systematic planning.

Overriding, there is always the conduct of U.S. policy in world affairs. Though not strictly a part of military budgeting, it most definitely controls the level of military preparedness—thus, expenditures. This article is not concerned with the conduct of U.S. foreign policy, but assumes the competition between the United States and Russia, and thus the race for space, will continue indefinitely.

We must go into space. And, as always, we'll have to pay for it. This much we know. But beyond that we are groping. Here's a rundown on the problems and the current thinking on their solutions:

• **Education**—Education in the case of space-age budgeting refers to the problem of (1) convincing top planners of the need to go into space and (2) their acquiring enough general knowledge about specific things for them properly to guide our effort.

Though critically hampered by the self-interest and innuendo of bitter interservice rivalry, this is happening. That man can go into space and that, say, the moon has a direct military significance is now accepted. Only the details of how best to go into space remain in doubt. This includes, for example, recognition and appreciation of wholly new methods of approach—original thinking.

• **Inaccuracies**—A major problem is finding out just what should and should not be attempted. This depends, for one, on an accurate determination of the status of various projects and the level of development of various technologies.

These cannot be accurately determined so long as top military men present slanted pictures to both the Secretary of Defense and Congress. This occurs all too often, either intentionally or through inadvertence due to improper briefing by subordinates.

The Congress and the Defense Secretary are aware of this but, as yet, have taken no positive action to stop it.

Meanwhile, optimum planning for beating Russia in the military space flight area, within the limits of U.S. resources, remains impossible so long as fact is clouded in half-fact, opinion, service politics. At least top Pentagon officials now recognize that they cannot trust everything they are told.

• **Overlap**—Ever since World War II, this has been a serious problem. While whole new concepts of warfare are being proved, conventional forces must be maintained in up-to-date operational readiness, "just in case."

In large measure this means double spending. This kind of overlapping—ICBMs plus SAC bombers or spacecraft vs. aircraft, for example—is not susceptible to any easy solution, but must depend on judgment to keep overlapping costs to a minimum. We can gain some leeway this way (see bar chart) but not enough. Increasingly, the cost of new weapons have forced us to shave conventional forces. If anything, this trend will accelerate as we move into space. For example, we gained $4 billion in "new" programs, 1959 over 1953, merely due to cutbacks in vehicles, manned aircraft, conventional ammunition, etc.

• **Leapfrogging science**—It used to be that progress in weaponry occurred step-by-step. But while today it may take five years to progress from, say, step one to step two, it may also only take six years to jump directly from step one to step four. Is it more equitable to move in sequence from the B-52 to the B-58 to the chemical bomber (WS-110) to the atompowered airplane to (finally) the manned space bomber, or is it more equiatble to skip a couple of the intermediate steps and go directly to spaceships?

Actually, this oversimplifies the problem, but the step-by-step route costs immeasurably more than leapfrogging and takes a great deal longer. The tendency to start projects should be no less than the willingness to cancel them—or at least to knock them down from a weapons-system to a technological study. For example, when *Navaho* was canceled the decision might have been made to continue development of large ramjets, which have a great potential for close-in (40,000 miles) space flight.

• **Obsolescence**—This is tied in directly with the problem immediately above. In the step-by-step (or simultaneous) approach to development, a breakthrough may obsolete whole concepts overnight. Top Pentagon concern over this is mounting, and is increasing the willingness to cancel.

"To cut through to the truth," is one of the main reasons for setting up Defense Department's Advanced Research Projects Agency. If it goes as planned, it will be a powerful influence on the military's conversion to space flight.

• **Selectivity**—In the past, whenever the United States faced a new military requirement, it could and did take several approaches to its solution. This was back in the days when weapon systems were relatively cheap. In the space age, the shot-gun method will have to be abandoned. Of the many, many proposals for a "global surveillance system," for example, only a few will be study or preliminary design contracts. Even fewer will reach any kind of hardware stage. Only one, probably, will ever reach the production state. This harsh selective approach is dictated purely and simply by cost. And, it's effective only if the "right" project is chosen.

• **Contracting methods**—The wide variance between Army, Navy and Air Force contracting procedures, and costs and results obtained has led the Pentagon to initiate a detailed study (now underway) of the various methods of doing military business—AF's method of placing systems contracts with industry vs. Army's technique of keeping the systems responsibility with the various arsenals; Army's unique co-contracting system used, for example, on *Jupiter*, etc.

Another possibility: More and

more of the military arsenals and bases will be reorganized along corporate lines, particularly as regards bookkeeping. This has already been established (with marked savings) in shipyards, fuel supply offices, etc. Greater cost accountability in the military establishments will have its effect on industry.

• **Contract performance**—Target is the contractor who knowingly bids or negotiates low just to get the contract (or simply due to bad estimating) and then asks for and gets one extension of funds and time after another.

Pentagon is considering several methods of attacking them. One would involve giving contracting officers more authority to place contracts, meaning they would ignore the low bidder if they thought he would fail to perform according to terms. This has obvious disadvantages. Another approach that is held in more favor (but which faces stiff political opposition) would let size of profits on contracts very with performance, both up and down.

• **Utilization of resources**—This is primarily a manpower problem. But there's no point in budgeting more projects than we have the technical ability to handle. Right now 35-to-40 percent of all first-level scientists and engineers in the United States are working on government or government-supported projects.

Surveys and experience reveal that this is about the limit, without reverting to some kind of draft—either direct or indirect. Reasons include: many scientists just don't want to work on government projects due to security rules, red tape, etc.; can get more money developing a better car or deodorant, etc.

The Defense Department has decided that any military budget materially above the current $40-billion level would rapidly dilute our technical talent to a point where the more money we put in, the less we could get out. Nevertheless, we are faced with the prospect of a $1-billion-a-year increase in military and/or space flight spending for some years to come.

• **Financial and political limits**—This goes to deficit financing and/or higher taxes. To give even half the present serious space-flight proposals a proper try would cost us twice as much as we're now spending on defense, upward of $80 billion. Individually, Army, Navy and Air Force wouldn't have trouble hiking that total to $150 to $200 billion.

There would be only two ways to


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pay for this—deficit budgeting, which sooner or later would bankrupt the country through inflation; higher taxes, which are politically out of the question. Also, high taxes would eventually sponge up all the money for industrial expansion. Thus, even if there were no other limiting factors, money alone will force a major rationalization of the Pentagon's approach to budgeting.

• **Estimating costs**—This is one of the most complex budgeting problems of all. Labor and material costs are constantly on the rise. Bureau of Labor Statistics figures help to chart these. But in the more exotic areas, such as space flight (either manned or unmanned), they defy forecast. No one now can tell the extent of complexity—or simplicity.

Take, for example, manned re-entry. This can be accomplished with wings and the "in-and-out" skip method, with retro rockets, with steel drag 'chutes, with magnet drag or—who knows? Which is cheaper now; in the long run? Which is more or less complex? How do you balance low-cost - but - maybe - primitive availability now, against long-term development potential? How do you balance, and having balanced, how do you choose? What are the criteria?

These are budget problems that run up the cost of any program. The difference is that in the past they were luxuries we could afford. Now it's difficult to see how we can afford the space age on a bare survival basis, much less with luxuries.

Contemplate, for a moment, a manned round-trip exploration of Mars under present budgeting procedures and levels of technology—or an operational base on the moon manned, maintained and serviced. They make present-day missile costs look like peanuts. These projects run to tens, even hundreds of billions of dollars.

Yet, within the next quarter century, we will be compelled not only to build a base on the moon, begin exploration of Mars, but long before that we will have to have operational military space capabilities patrolling the "immediate environment of earth." We can gain some by splitting the responsibilities among our allies and coordinating our efforts. But the bulk of the burden will inevitably fall on the United States. We can only do it, if we become efficient.

This is the one basic secret of space-age budgeting, one that requires unselfish cooperation from everyone concerned in any way with the space program.★

Food on Film—Best Space Diet?

Packages for food and other supplies for space travel may be made of edible, "vitamin-loaded chemical films," according to an Air Force packaging specialist.

Speaking before a meeting of the Southern California section of the Society of Industrial Packaging and Materials Handling Engineers, Albert Olevitch, chief of the packaging laboratory at Wright-Patterson AFB, said that if food value can be put into a film it would become a favored packaging material for space shipments.

Pointing out that films used today on such food items as frankfurters are digestible, he declared that it is entirely probable, that soon, containers will not be tossed into the ash can.

"They will be eaten or used as plant food," Olevitch predicted, "or they will be converted through some means into useful gases or some other product."

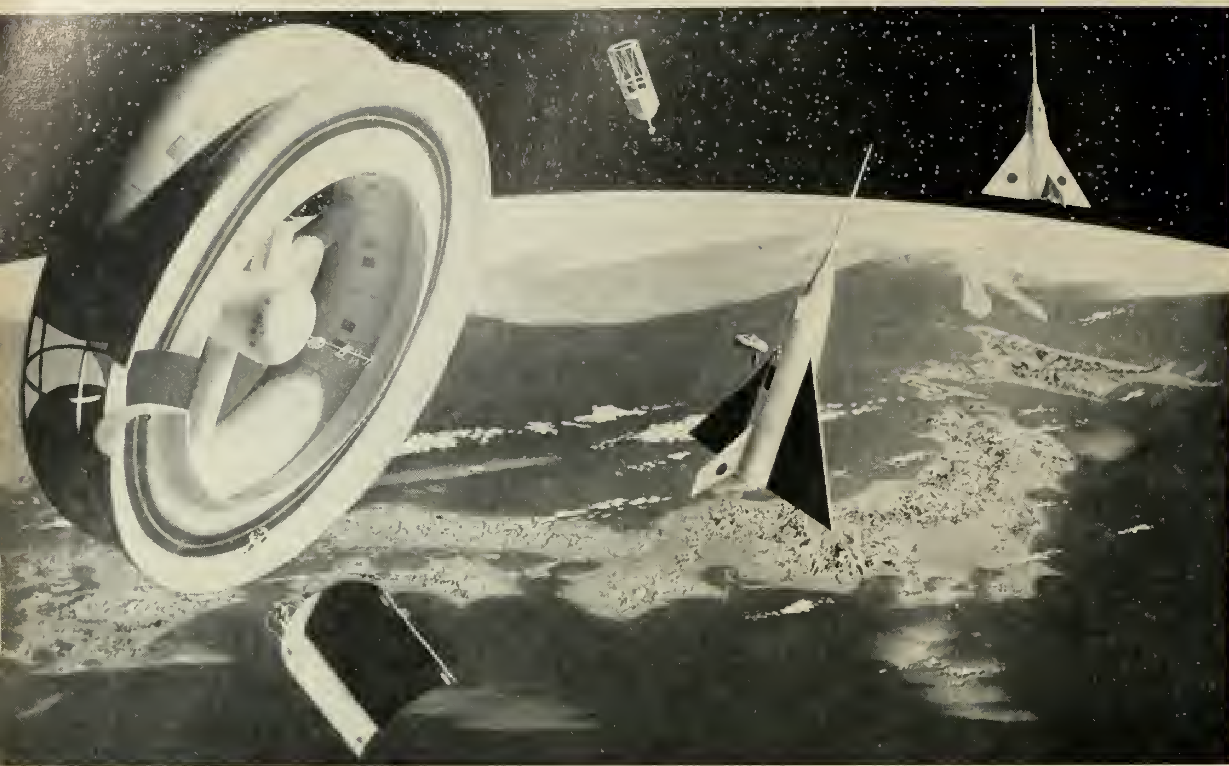
Noting that every ounce of material taken on a space flight must be made as useful as possible, the AF specialist said that packaging and other elements of supply must be considered along with the building of vehicles. Increasing priority is being given to packaging research and development in problems related to space operations, he added.

The lack of moisture in space will eliminate rust, but the relative vacuum of space increases problems of shock protection for packaged goods.

Acceleration and vibration factors in rocket vehicles are not expected to be as troublesome to packaging engineers as potential damage caused by accidental dropping of a package by a worker carrying it on the moon. As there is no air resistance, it is theorized that the impact shock would be prolonged; the dropped item would shudder for a long period after landing.

• **Dinner—bags of film?** Olevitch said the first container need for space travel will be those for cargo operations between earth and a space platform. Flexible, high-strength, nutritious films formed into bags or restraining walls appear to be the best solution. Where rigid containers have to be used, they probably will be made of aluminum or magnesium, or a new edible material.

Packaging engineers also will have a problem in designing test-instrument containers for moon drops. One possible solution is the use of compressed air to automatically inflate plastic bags to cushion the landing impact. To prevent the instruments from vibrating for long periods, the bags would have to be precisely punctured on impact so they would collapse gently.



Itokawa

Social studies must go on, to find out . . .

How To Keep Space Crews Content

by Donald N. Michael

WHEN WE CONTEMPLATE the social psychology of space crews, we are attempting a far more difficult thing than is the case when we predict the hardware in which these crews will be sent into space. The social psychology of group behavior has far to go to reach the state of advancement on the hardware side—in spite of the spectacular work of psychiatrists, social psychologists and cultural anthropologists.

Therefore, it is not possible to state categorically the sociopsychological problems to which space ship crews will be exposed, nor the training and selection procedures that may be used. What can be done, however, is to list some of the social and psychological circumstances and consequences which probably will have significant implications for space crew operations. Such a list makes it clear that we cannot be sanguine about man's capacities to work effectively in space over long time periods.

Flights of less than, say, two-weeks duration probably won't produce as many of the problems to be described, though trouble can arise at any time.

• **Environment is first**—The first spaceships may carry crews of more than one and, say, less than six. (If the crew were much larger, interpersonal relationships will be such that the fact that they are in space will make relatively little difference.)

Volume per crew member will be at a premium. Even if the ship is constructed in orbit, the cost of construction will increase with the size and facilities of crew quarters, since the materials will still have to be ferried from earth. It is assumed that there will be no radical breakthrough in propulsion methods—if volume per crew member is essentially unlimited, many of the special sociopsychological problems disappear.

The nature and mission of many spaceship operations are such that the diversions available to crew members will be relatively limited and monotonous. All there is to respond to are the instruments, other crew members, and whatever items are provided for recreational and off-duty purposes—limited because of cabin space constraints. During the freeflight periods of the trip there will be little vibration or outside sound. Even "viewing the scenery" will be limited, since micrometeorites would abrade an unprotected optically clear surface. Hence viewing may be infrequent.

And, when the crew does look at the universe, away from the sun, it will see blackness, with myriads of steady points of light of slightly different colors, all of them so far away that there will be no sense of depth. Toward the sun, the intense contrast between light and dark will make view-

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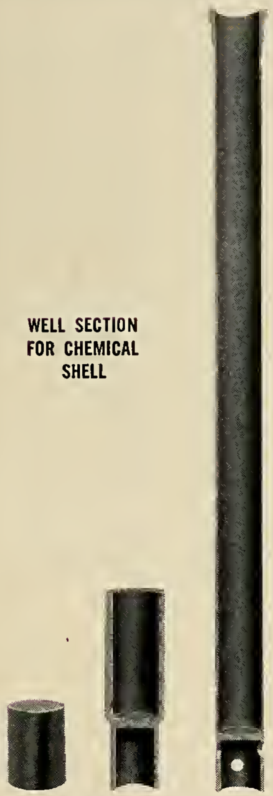

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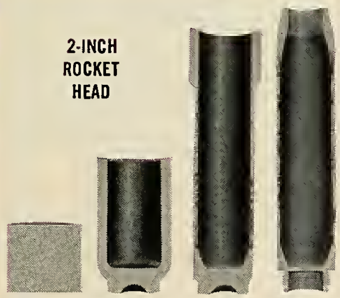

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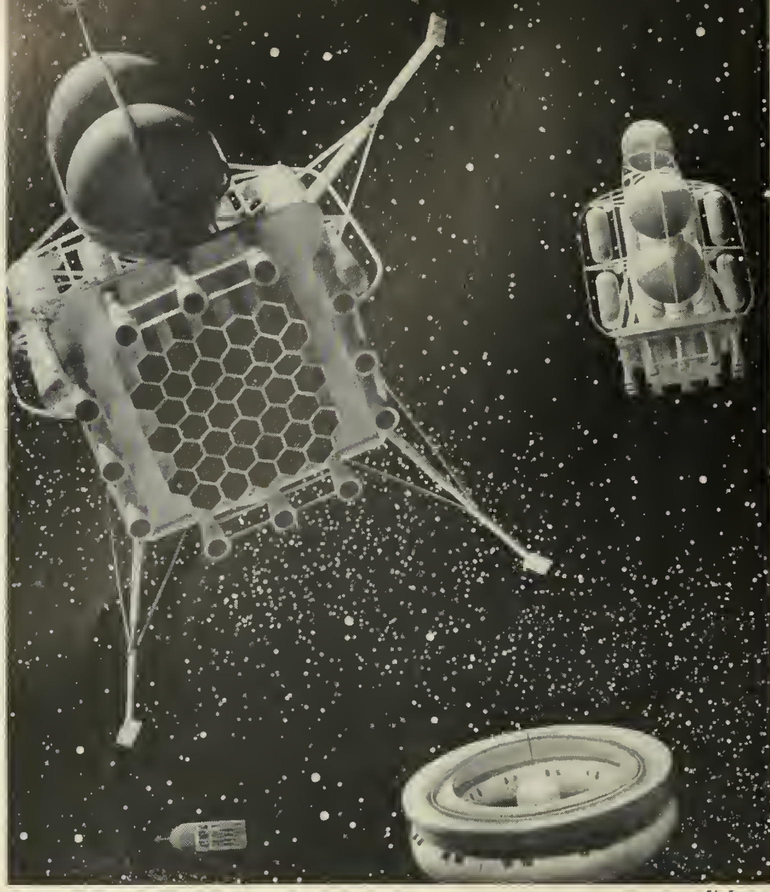

Itokawa

. . . Keeping Space Crews Content

ing painful or at least very difficult.

Since the constellations are likely to appear in different arrangements from those perceived on earth, there will not even be this familiarity to orient upon. Thus, the universe may not offer much in the way of stimulus novelty. (Satellite occupants may have a better time of it with the earth to look at.)

Finally, disaster will be close at all times: from meteorites big and small, from equipment malfunctions, from human malfunctions and probably in the long run, from genetic damage to crew offspring from cosmic rays. Early spaceships and their crews will most likely represent an ecology with almost no tolerance for error or malfunction.

• **Then social**—The social and psychological factors combined with the environmental ones, may also generate personal and interpersonal behavior that could mean the difference between success or failure.

It is obvious that the crew will have to be carefully selected. But what standards, screening, training procedures must be developed to produce a crew that can cope with such an environment and with each other?

First, it must be assumed that membership in a space crew will be voluntary, and that volunteers have been fully apprised of the dangers they face. Who would volunteer for this activity? We might list men attempting to escape from something; men who want to prove something to themselves or to others; men who are curious about new experiences; men dedicated to service, either military or scientific.

These people are willing to go into space in spite of the unprecedented and extraordinary hazards. Thus, whoever they are and whatever their motives for volunteering, they are not likely to be "normal" human beings—normal humans find less risky means of meeting their problems. This is not to decry these motives; they have often served the human race well. But the origins of these motives must be understood in order to evaluate their consequences, under the circumstances faced by space crews. The man who is dedicated to military service may not be able to endure boredom as well as the man out to prove compulsively that he is better than his father was.

The problem, then, is to find the combination of normality and abnormalitys that will make the best team members.

"Team members" is the important term here: an antisocial, possibly slightly schizophrenic, personality might survive adequately in a one-man spaceship. Such a man probably won't do on a team. And yet, will the typical socially interactive and dependent personality do either?

• **Too close?**—The adage says that familiarity breeds contempt. Under some circumstances it breeds more than that: in constricted quarters it may well be a major threat. French anthropologist and explorer Gontran de Poncins spent part of a winter with an eskimo trader, Paddy Gibson, in an isolated outpost and had this comment in his book KABLOONA:

"I liked Gibson as soon as I saw him, and from the moment of my arrival we got on exceedingly well. He was a man of poise and order; he took life calmly and philosophically; he had an endless budget of good stories. In the beginning we would sit for hours . . . discussing with warmth and friendliness every topic that suggested itself, and I soon felt a real affection for him.

"Now as winter closed in round us, and week after week our world narrowed until it was reduced—in my mind, at any rate—to the dimensions of a trap, I went from impatience to restlessness, and from restlessness finally to monomania. I began to rage inwardly and the very traits in my friend . . . which had struck me in the beginning as admirable, ultimately seemed to me detestable.

"The time came when I could no longer bear the sight of this man who was unfailingly kind to me."

Both military and civilian sources indicate that under conditions of persistent danger, constrained operating environment, and mission-length of unusual duration, similar responses have characterized relationships between crew members in relatively conventional, but technologically advanced environments.

Thus, it might be that a likely combination of personalities, would be persons who are almost social isolates. Such men would be intolerable or infuriating under conventional conditions. But such personalities might be sufficiently insulated from the others to permit them to maintain themselves as an operating unit.

Of course, there is at the moment, no certainty that these social isolates would effectively fulfill their technical functions. After all, if they are so insensitive to their fellow crew members, it may be that they will be insensitive to the social commitment they accepted: to perform certain technical tasks with required precision and intelligence.

• **Weightlessness a factor**—Does the operational outlook for a more socially interactive crew look brighter in spite of the difficulty of keeping each from becoming hateful to the other? In some ways, yes. For example, man's self-image derives in part—and in good part is maintained—by his learned awareness of the sensations and responses of his body. It is also defined and maintained by his learned responses to, and awareness of, the environment in which he lives.

Since a prerequisite for initial screening will be excellent physical condition, it is not difficult to imagine that many of the personalities whom we might consider for space crews would have more than the average awareness of their bodies. And since another prerequisite must be special competence and special interest in the mission, he will have had more than an average exposure to an environment rich in content and change.

But in a space cabin the crew member is probably going to be weightless and the environment is going to be stimulus-poor.

Weightlessness means that there will be many things about the operation of the crew member's body which will be different, and which he will not be able to control as easily or as precisely as had been his want.

In effect, then, his self-image is threatened. For example, the man who assuages his anxieties about his masculinity through his physical control, might find himself anxious about his masculinity if he loses this control. Unless otherwise reassured, say, by his fellow crew members, he might attempt to "prove" his masculinity in other ways—such as bullying.

Psychological difficulties possibly arising from lack of weight can't be ignored. So far about one-third of the subjects exposed to weightlessness found it definitely distressing while another one-fourth found it "not exactly a comfortable feeling." The exposure time has been less than one minute. There is a long way to go before it can be concluded that weightlessness will not present important psychological difficulties.

The social isolate would also suffer anxiety under these circumstances but for him social support would neither be forthcoming, or as important. The choice of social isolation as a way of life is itself a means of coping with a threatened or tortured self-image.

• **Remedy for boredom**—A socially interacting and emotionally interdependent crew may help counteract the boredom and isolation of some long space flights. Literature on the psychology of boredom and of low-stimulus environments points in the same direction: emotional depression, intellectual deterioration and a tendency to hallucinations.

This general deterioration of mind is vividly described by de Poncins:

"Insensibly . . .things changed . . . silence that had been so remedial, that had soothed me . . . began to seem to me a weight. The horizon was closing in round me.

"But more than this, an almost physical operation of shrinking was going on. I who had come from outside had first been enclosed by the Arctic. Then my horizon contracted to the limits of Gjoa Haven; from Gjoa Haven the circle had been reduced to the dimensions of the post; and now, in the dead of the polar winter, the line I hesitated to cross was drawn in a radius of five feet round the stove."

Consider then a space cabin, its routine of occasional measurements, the boredom of monitoring the equipment, its physical constraints, its weightlessness and the pervasive sense of isolation. This environment may well produce depression and hallucinations. It may be that only the presence of other crew members will provide each member with criteria for determining when he is hallucinating and when he is not.

It would seem, then, that a crew of personalities at least somewhat emotionally dependent on each other might have some advantages.

But these advantages can only be gained at the expense of weight and thereby cost, since such a crew will require certain adjuncts to the primitive space cabin environment.

Certainly the opportunity for privacy is a prerequisite. The operation of the ship might be so organized that each man is usually isolated from the others—with some central area where they can come together. Some volume will have to be provided for physical exercise; this might also be the meeting area.

Certain stimulus enrichers must be provided: as simple as a kaleidoscope (which has the great advantage that it never provides the same stimulus twice); possibly elaborate pinball-type machine which would encourage the setting of tiny goals and provide the opportunity and the challenge of reaching them.

It may take a TV or radio reception capability to keep the crew truly in touch with reality. It may even develop that mixed-sex crews are the more efficacious for many reasons, not the least of which is that the temperaments and values of men and women are sufficiently different to provide much stimulus each for the other. Mixed crews would present problems, but not unique ones.

In view of the nature of some of the factors contributing to the difficulties in selecting space crews, it may be worthwhile to surmount them by trying to bypass them. One approach worth consideration is that of recruiting crew members from other more sedentary and less time-bound cultures than our own.

• **Training**—It is clear that we face equally vast problems in training space crews. For example, the need to readjust the self-image in the light of the behavior of a weightless body probably can be transferred from the space ship environment to a prespace-ship training period aboard a weightless satellite.

It seems clear that we will be able to put crews into space well before devising adequate psychological tests.

Since the satellite itself may for many years be the first and only testing ground for prolonged exposure of space crews, there will also be the difficult problem of selecting men for this crew. Presumably some sort of regimen of one-man-satellite training exposures will be developed in order to select men for this crew, but by any measure selection of the first crews will be difficult.

• **What can be done**—What can we do, then, to develop a plausible social psychology of space crews before the event?

For one thing we can look to the behavior of terrestial explorers for insight into the social psychology of teams living under environmental extremes.

Then too, most exploration was undertaken in an age when men were richer in self-sufficient resources than is the rule today. This inner strength is even less likely to be the rule as population and urbanization increases and imposes greater pressures toward social conformity.

We can continue and extend studies on behavior under confinement presently underway at the Wright Field Aero Medical Labs, and by Lockheed. We can attend more seriously to the work of the psychiatrists and the cultural anthropologists. We must come to understand that the social psychology of space crews is essentially a problem in the social psychology of society. Larger crews, plenty of room and sufficient diversion would eliminate many of the problems which give space crew life its special and difficult characteristics.★

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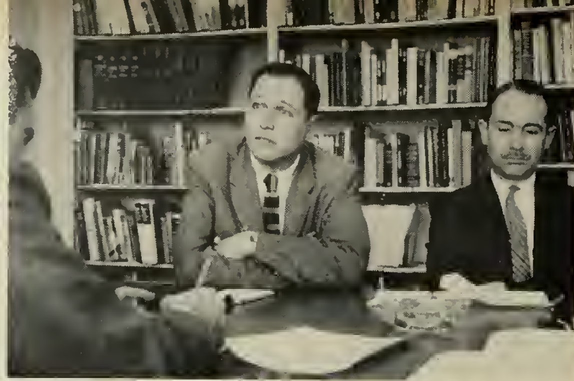


Dr. Tolcott: Our role is to contribute . . . .

Getting Set For Space Flight . . .

The five scientists participating in this exclusive m/r conference are members of the professional staff of Dunlap and Associates, Inc. of Stamford, Conn. In its 10th year, this organization engages in contract research and consulting on commercial and military problems, particularly those problems where the human being is a central factor. Much of the work done by the firm now relates to missiles and is identified with such terms as Human Engineering, Operations Research, Personnel Research, and Motivation Research. The participating scientists are: Drs. Martin A. Tolcott, Vice President and Secretary; Kenneth W. Yarnold, Vice President; Joseph E. Barmack, Assistant Vice President; Donald N. Michael, Senior Research Associate, and Jesse Orlansky, Vice President.

Q: **Why should we explore space?**

A: (Tolcott) In my own opinion there are two main reasons: one would be the collection of scientific information which would be useful to mankind in general; the other is the collection of information that would be militarily desirable to the United States.

Q: **Well, do you think that this is any more urgent now that the Russians are already up there with Sputnik?**

A: (Tolcott) I think with good planning this shouldn't have any effect.

Q: **Do we have good planning right now?**

A: (Tolcott) I think the new emphasis on scientific research is perhaps the most important manifestation.

A: (Orlansky) I dare say a year of planning is necessary; if the planning was good, it would be time well spent. None of us, I'm sure, are so gifted that we have all the knowledge necessary for space flight, now or even a year from now. However, for political purposes, one might want to get some action as quickly as possible.

A: (Barmack) I would like to supplement Marty Tolcott's two reasons for exploring space with two others: he mentioned (1) military and (2) scientific. To these I would add (3) economic and (4) political. I am highly dubious of the military value of going out into space.

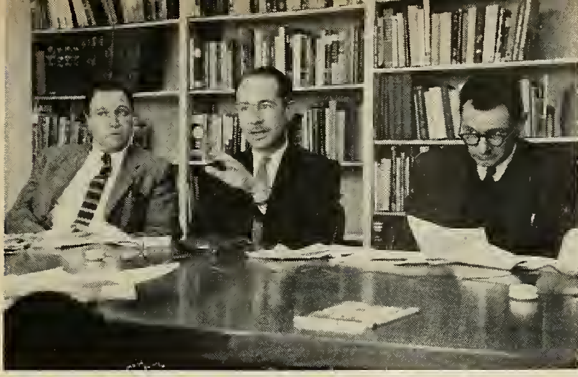
Two military functions have been suggested by official sources: to provide a platform for releasing bombs; as a reconnaissance device.

Q: **Would anyone like to enlarge on the planning aspect?**

A: (Yarnold) I would like to make a statement on planning. I don't think any scientist can ever sit down and so an so *should* be done. But he can do a study as to what might happen if so and so *were* done. I do not believe that there has been enough operations research devoted to the question of what do we gain or lose through various sorts, sizes and shapes of space programs. The public has been complaining that it's now six months since Sputnik and we still haven't a program. I think you're right—that there has not been any real scientific effort to study what such a program should be. There has been only some talk.

Dr. Michael: Two other things have to be added . . . .

Dr. Orlansky: I would not say I'm enthusiastic . . . .



Dr. Yarnold: I think the cost would be trivial . . . .

Dr. Barmack: When all is said and done . . . .

Q: **How long do you think we will have to talk?**

A: (Yarnold) Unless we adopt a scientific method of evaluating the probable consequences of each type of action, we'll talk forever. First we should set up a study group.

Q: **Who should these people be?**

A: (Yarnold) They should include many types—economists, psychologists, physicists, engineers. They should have a definite mission, a definite budget and a definite time limit. You might require some decisions within three months. I do not think it's being done now. Over and over again, very commendable and competent groups make studies, and the results are buried because whoever sponsored it doesn't like the results.

A: (Michael) Two other things have to be added: It has to be a group which is not obligated to beg any questions, and it ought to be so set up that findings are published—even if in sanitized form.

Q: **Will you elaborate on this study group. How big should it be?**

A: (Yarnold) You ask me to speak very much off the top of my head—just what I'm objecting to doing.

But I would think that the group itself should be fairly small, but very high level. We have background for such a group in the Weapons System evaluations group. Their charter is something like what is needed. They should have at their disposal lots of sub-groups.

The basic leading group itself should be small, to prevent discussion and study going on forever—there should be a definite time limit. The group should have a budget and be told to come up with its best recommendations at a definite date.

I think the cost will be trivial compared to what we can gain—it could probably come up with a very good study in perhaps three months or less, and spend less than $500,000.

Q: **Let's ask the question—Do you think it should be military or civilian?**

A: (Barmack) In that connection, Vice-President Nixon was recently quoted as saying that the exploration of space is a civilian task. He said that the goals of basic research in the space field should not be set by the military—we can't tie down our scientists to specific objectives that military or political leaders may deem possible.

A: (Yarnold) It depends on what you want. If you want to go out to fight, then you're just as well off letting the military set the research goals. If you want to go for some other reason—to advance science—then you might turn it over to civilians. If you have an applied objective the fact that a program is turned over to civilians doesn't make it basic research.

You know, you asked me a while ago to talk off the top of my head about what I would really like to see. Speaking for myself, I'd like to see a Congressional committee set up the study. It would thus not be tied either to the military or civilian side—but the government as a whole. It might even work.

Q: **Let's assume the action you suggest has been taken, the study is made and is successful. Then what will happen to their recommendation to Congress?**

A: (Yarnold) The recommendation would present a choice to the parent Congressional committee.

Q: **Where would such a recommendation lead?**

A: (Michael) I feel that if the findings are to be implemented, the report has to be prepared in such a manner that its findings will be the responsibility of im-

Dr. Michael: Let's take a runthrough . . . .

Well, we can wind things up . . . .

portant leadership in this country . . . as did the Rockefeller and Gaither reports. If it's just a report without big name behind it, it may very well die on the vine, no matter how good it is.

Q: **Let's switch again, to another important phase. What about education? There is a disagreement about whether we should teach astronautics in the schools. Should we augment the educational program, and to what extent would we include astronautics?**

A: (Barmack) This question can be broken down into many sub-questions. As you know, the Air Research and Development Command has been considering development of a post graduate university for training astronautic scientists. I don't know what the current decision is—at last reports, it had been cut out for budgetary reasons.

One may also raise the question as to whether you should have a special form of engineering training at the college, in addition to the post-graduate level. Finally, how far down in the educational system should instruction reach —down to the high school?

A: (Tolcott) It seems to me that there's a lot that can be done by augmenting the basic scientific courses already in existence. Chemistry and physics courses might be strengthened with some of the information that might be obtained through space flight.

Q: **There seems to be general agreement here, but are we capable of doing it? Have we the manpower and the money to change our textbooks?**

A: (Yarnold) We certainly have the money, and experiments in which a few science teachers are spread around among a large number of students by television techniques are interesting and encouraging.

I think perhaps we have to fight a public posture in which society as a whole seems to be afraid of science.

A: (Barmack) May I throw in a note here? It is very easy for us to identify problems that require a mathematical or physical science approach for solution. But it takes more than math, physics and engineering to win the struggle. Aren't we plugging for the wrong disciplines?

A: (Yarnold) I couldn't agree with you more whole heartedly.

Q: **You say that we are capable of improving our educational system, but do you think that we are attempting to do this? Are you satisfied with what has been done?**

A: (Yarnold) No, I'm dissatisfied with it, but I think there is an attempt being made. The thing is being discussed, at least.

Q: **What should we do to get the leadership we'll need to push such changes through?**

A: (Yarnold) For one thing Congress could earmark money it appropriates for education: tie it definitely to teaching of science. Or, we could set up national standards, with nationwide examinations which students are expected to pass at stated intervals.

Q: **Will it require additional funds?**

A: (Michael) It probably will. But in order to get the kind of public support and public interest needed, we will have to get a substantial shifting of American values and standards. This will require planning, and involves more than the physical sciences: considerations of philosophy, sociology and psychology must be brought in.

Q: **Who should do it, and how should it be done?**

A: (Tolcott) It seems to me it should be

done on a local level—we as individuals have an obligation to do something in our own school boards. It is a problem to be attacked on a number of levels. On a national basis. I think we should contact our Congressmen and give them our ideas.

A: (Yarnold) Without better education and a lot more education, we cannot solve any of the problems. We can't have an adequate space program.

Q: **Well, do you think this is in any way tied up with the fact that we still don't have a space program—six months after Sputnik was launched? Does the scientific planning take longer or is it being influenced by politics?**

A: (Tolcott) I think I perceive in your question a more limited view of space programs than I'm thinking of. A space program involves a lot more than launching satellites. The launchings are the part that the newspapers publicize most, and which therefore become identified with our national strength. This is unjustified and dangerous. In the broader sense, we do have a space program. The real issue is the relative amount of effort to be allocated to each phase of it.

Q: **What is your opinion right now of the value of space flight?**

A: (Orlansky) I would not say I'm enthusiastic. I am neither for or against space flight. Practically everyone who owns an airplane company wants to transform it into a missile company—therefore they are for space flight and don't need our support.

The ingredient that we can bring to space flight is a degree of rationality and planning so that we will know ahead of time why we are doing it and what we are going to get out of it. We are especially interested in the way in which men will be employed in this venture.

After all, Dunlap and Associates don't sell rockets and don't build airframes. We do have special knowledge about human behavior in the role that man can play in space flight. This includes how society would be affected, how the man in the street reacts to space flight, and how the vehicles are designed.

Q: **Well, I think we can wind things upon that. How does that sound?**

A: (Michael) Let's take a run through and see if anyone has anything to add.

A: (Tolcott) It still seems to me somewhat incongruous to be talking about space flight when, for example, we can't run our trains on earth when the temperature drops below twenty degrees. It seems to me that there's a big gap between our present technological knowhow and the kind of speculations we've been engaging in during this session today.

I think the only general point I would like to make is that all the problems of how should we explore space; how much should we explore space; should we explore space; are all tied to our national capability, which now appears to be at a lower level than that of the Russians. The real problem which will in turn solve all of these other problems, is scientific education. Without that we have nothing—we never will have a space program that's any good, or any other program that's as good as we should have to keep the U.S. in its rightful place.

Q: **Then do you feel that planning for a scientific education should precede planning for a realistic space program?**

A: (Orlansky) I think the planning for both should be done concurrently. The requirement is for research and planning, not for expertizing. We have research methods readily available to get the facts that will clearly identify alternatives and their possible consequences.

A: (Yarnold) I would just like to suggest that certainly for space flight and for the future ahead of us, we need a scientific education, but my strong feeling is that if we're going to cope with the society that space flight provides—both for good and for evil—we're going to need more than scientific education. We're going to need a humanistic education—in part scientific—for the majority of our population, or we will end up with technological chaos.

A: (Barmack) I would say in concluding what we've been discussing here that for myself—and maybe for all of us—efforts in the exploration of space should be encouraged to a considerable extent. The decisions on government support should be based on a careful assessment of our national goals, the things we might do to achieve these goals, the problems to be encountered, the prospect of success, the costs and the possible utility of the findings that have been made.

Then, when all is said and done we'll get certain scientific information of very great value for military purposes and certain basic scientific information of general value. Either of these could be sufficient justification. And, of course, you can never take away the satisfaction of curiosity and sense of adventure all this will give us and the nation.

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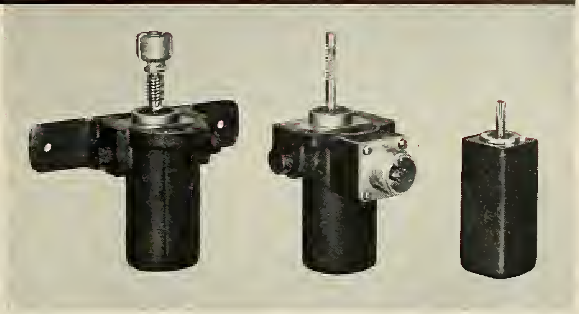

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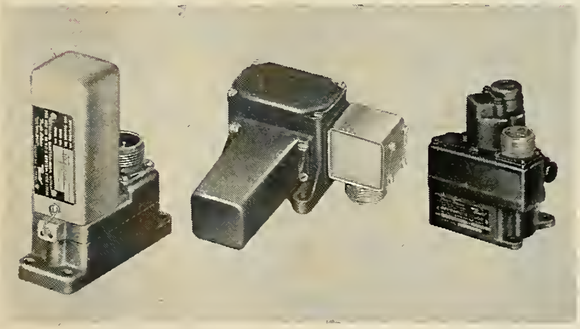

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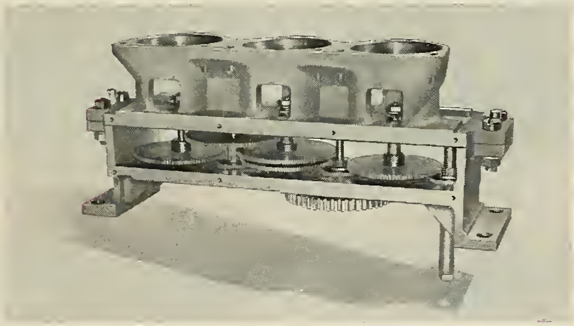

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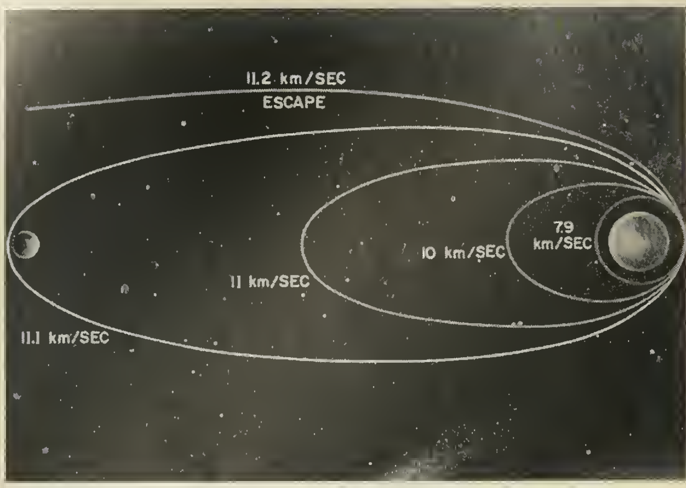
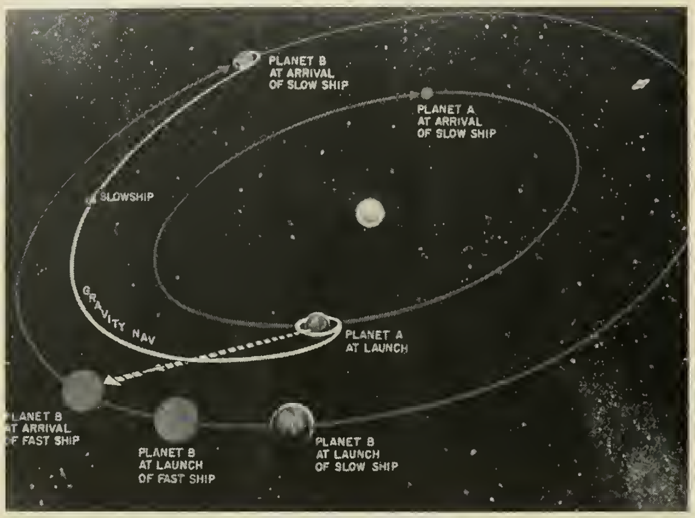


Guidance and Control in Space

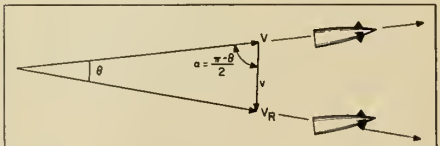
The pictures and text on these pages were prepared from material used in training courses for Westinghouse Air Arms Division engineers by Dr. Peter A. Castruccio, Advisory Engineer.



The drawing (top left) represents velocities required of a space vehicle for achieving various elliptical orbits between the earth and moon and beyond. The 11.1 km/sec figure represents the velocity for sending a pay load to the far side to the moon. It should be noted that only a 1 per cent increase will produce escape velocity.

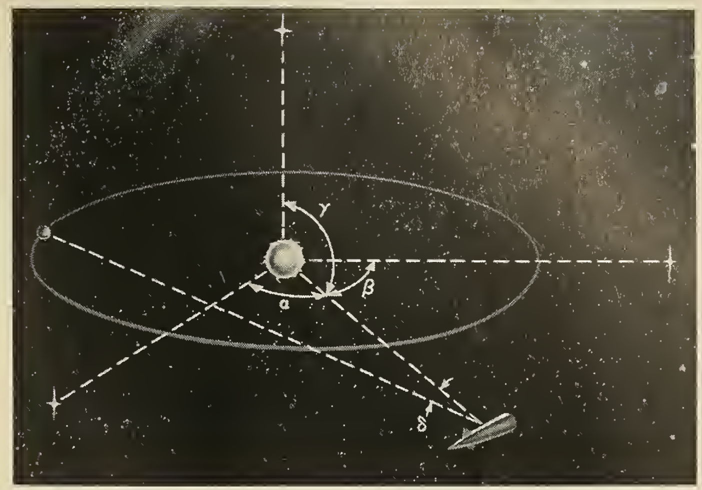
(Left) chemical propellants limit inter planetary flights to elliptical trajectories. By utilizing the velocities of departure and the gravitational attractions of the sun, flights paths for intercept with the arrival planet can be calculated. A fast ship utilizing continuous thrust could make almost a straight line intercept with the arrival planet.

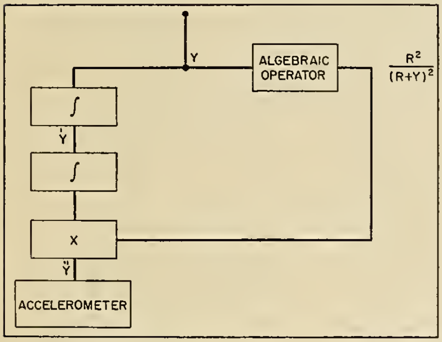
(Left) once a vehicle is in space, the problem of changing its course created complexities. To change direction of travel, (below) small rockets thrusting normal to the ship's horizontal axis are required.



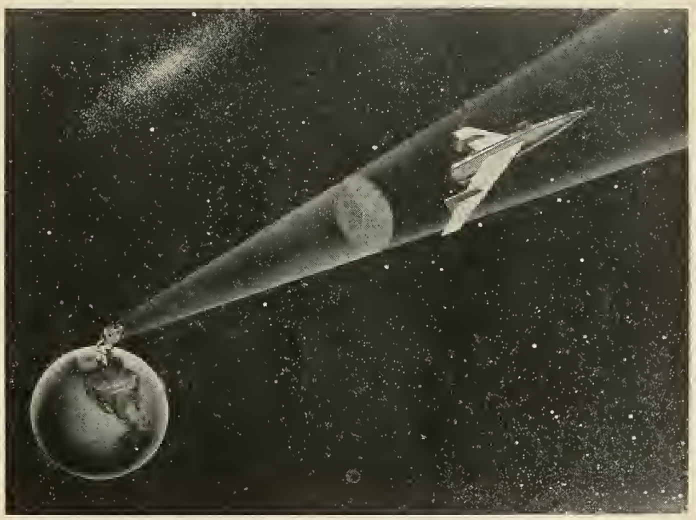
IF THE TRAJECTORY MUST BE DEFLECTED BY AN ANGLE θ, THE CORRECTING SPEED MUST BE $v = 2V \sin \theta/2$
THE CORRECTING THRUST MUST BE ORIENTED AT AN ANGLE $\frac{\pi-\theta}{2}$ TO THE INITIAL VELOCITY

Instantaneous knowledge of vehicle's position in space is of paramount importance to navigation. This must be achieved by Celestial Reference: sightings are made on three stellar bodies, in addition to the sun. An azimuth shot is then made of a planet in the earth's solar system to determine ships position with respect to the known positions of the sun and planet.

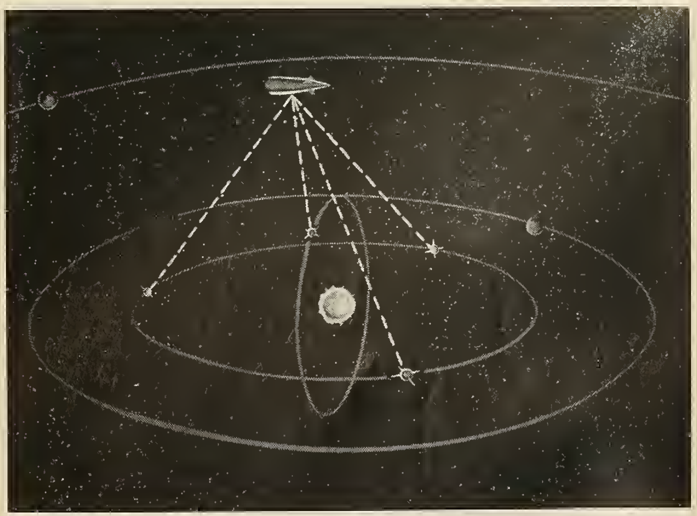




(Top) one method of navigation is through inertial guidance or IDR (Inertial Dead Reckoning). By integration of the output reading of an accelerometer, which in turn is fed into a computer, the velocity and the distance traveled is obtained.



A method of guidance (right, center) developed by Westinghouse Air Arms Division is referred to as the Cooperative Optical System or optical projection method. When on course the ship instruments will receive a "white" color signal. Any deviation from flight path will result in a color signal.



Radio satellites or more properly revolving planetoids orbiting about the sun would provide an accurate method of interplanetary guidance. Three of the planetoids would travel in one orbital plane with the fourth planetoid traveling in a plane as near 90° from the first plane as possible. Measurements of the distance of arrival of the planetoids signals with relation to space ship will provide a fix on the ship's position.

Space Medicine

by **Hubertus Strughold, M.D., Ph.D.**

The fundamental purpose of studies in space cabin simulators, such as the seven-day test in February at the School of Aviation Medicine, is of a biotechnical and biomedical nature.

The biotechnical task is to test a sealed cabin, equipped with air-regenerating devices, as to its capability to keep a man alive and alert over a longer period of time. The biomedical side of the experiment includes the physiological study of the best kind of simulated, artificial atmosphere, the question of the best pattern of day-night cycle, and the psychology of isolation and confinement.

In the language of ecology and logistics, it is the aim of these studies to attain an optimum of comfort for the occupants, a maximum of efficiency of the air-regenerating and controlling devices, and a minimum of volume and weight. That not all conditions encountered in space flight can be simulated in such a ground-based simulator is generally well understood.

Komsomol Pravda has reported that Soviet scientists at a laboratory in Baboshkin near Moscow were developing a wing-flapping machine called an ornithopter, and that a demonstration of it had proven "unusual efficiency." The model craft has a 1-to-1½ horsepower engine and can lift 165 pounds. This would probably be about 180 English pounds.

This is interesting in the light of the long debate as to whether the human body—with its muscles as a power plant—could do that job, as first suggested by Leonardo da Vinci, and discussed by the physiologists Borelli in 1680 and Von Helmholtz in 1873.

To fly with his own muscle power, a man weighing 68 kilograms—with flight equipment weighing 108 kg—has to produce 2 horsepower. Under optimal machine technological conditions, the work could be decreased to about 1 horsepower.

But from studies in modern muscle physiology, we know that a strong man can produce only 15 mkg/sec or ⅕ horsepower for longer periods of time (higher output is possible for a very short time). A sprint runner may produce 5 horsepower. A race rower may produce 1.8 horsepower for 10 minutes. Long-distance runners and rowers can reach not more than 0.3 horsepower in one hour of work.

If we assume ⅕ horsepower as a possible maximum for a longer period of time, horizontal flights would require a 5 to 6 times higher energy output than a strong man can produce.

It might be possible, by improving the aerodynamic efficiency of a flapping-wing craft, to reduce the energy output required from 1 to ⅗ horsepower. In this case, short hops are conceivable.

In 1938 in Berlin, an aeronautical engineer demonstrated a wing-flapping device to me. For an explorer on Mars with reduced gravity (48%), and assuming the same air density and composition as on earth, it would be quite easy to fly around with musclepower. The Russian method attempts to replace the musclepower by a motor about six times as high in energy output than the musclepower of a strong man.

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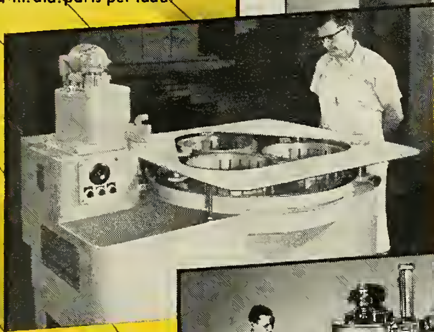

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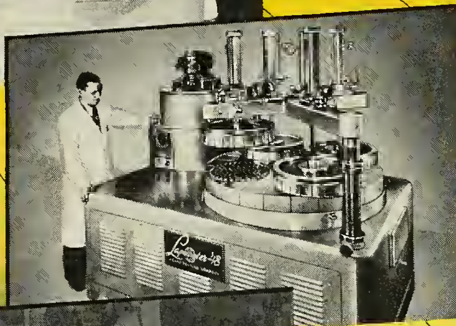

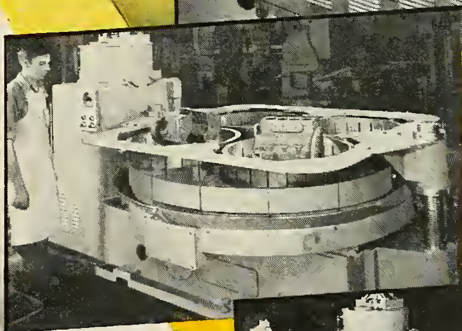

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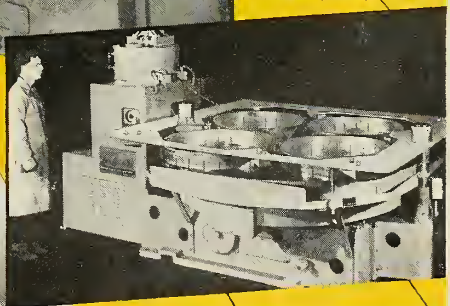

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World Astronautics

by Frederick C. Durant III

The "Mars jars" at the USAF Department of Space Medicine (Randolph AFB, Tex.) are attracting increased interest. Samples of sandy soil from Arizona's Painted Desert are sealed in quart jars in an approximation of Mars' atmosphere. Atmospheric composition, humidity, surface temperature cycles, etc. are based on the best estimates of astronomers. First results indicate some microorganisms die quickly while others multiply easily under simulated Martian conditions. Related studies in the field, known as astrobiology, have been reported in French and Russian literature.

Readjustment problems—While intensive effort is underway to relate the capabilities and functions of "man on earth" with those of "man in space," Dr. Hubertus Strughold has suggested that another area of study will necessarily develop. This he terms "man back from space." Dr. Strughold pointed out recently that humans exposed for extended periods in a space capsule may find it difficult to readjust to terrestrial life. Once the physiological and psychological effects of weightlessness and "detachment" of space flight have become "normal," a period of time may be necessary for readjustment.

Another problem may be possibly dangerous strains of bacteria or viri indigenous to Mars which a terrestrial visitor might unwittingly bring back with him. This potential hazard will probably require quarantining upon return to earth. Dr. Strughold points out that such thinking is without practical application today. However, so was professional consideration of space medicine 10 years ago.

Updated—A few months ago an estimate was made in this column of the totalized period of weightlessness experienced by USAF pilot Maj. Herbert D. Stallings. The figures given were long out of date. Maj. Stallings told me recently that he had logged more than 37 hours of zero g during 4000 test flights in parabolic arc flight paths.

New light or speed of light—Those persons interested in relativistic effects of space vehicles traveling at speeds approaching the velocity of light should note a recent report from AFMDC at Holloman AFB, N. M. The paper, entitled "Relativistic Treatment of Rocket Kinematics and Propulsion" (No. AD-135004), examines reception and expulsion of particles including photons, in classical and relativistic cases. Optimization of a vehicle's final velocity is determined as a parametric function of available energy and final mass. Authors P. F. von Handel and H. Knothe conclude that exhust velocities must be increased 100,000 times to enable a vehicle to approach the velocity of light. Furthermore, the effect of relativistic time dilatation becomes noticeable only when traveling about 2/3 light velocity or more.

Surprising Accuracy—Because of its small size. it was anticipated that *Explorer* I might never be viewed optically. However, establishment of the orbit by the "microlock" telemetry system was so accurate that three U.S. Moonwatch teams made sightings within two days after launching.

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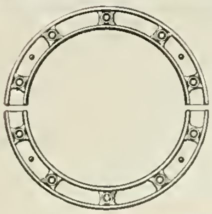

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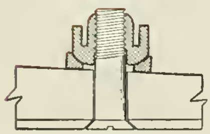
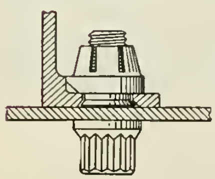


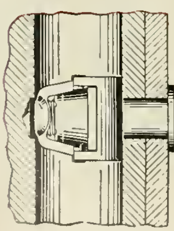
Bolting non-parallel surfaces

No more costly spot facing, step milling or hand selecting tapered shims! ESNA's counterbored, self-aligning types include one lug, two lug, gang channel, standard hex and high tensile types. Ball-and-socket relationship of nut and special base allow an 8° tilt in any direction from centerline to compensate for draft angle or tapered sections.



Fastening stressed joints subject to temperatures up to 1300°F.

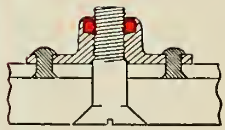
For really "hot" applications such as jet engine flange assemblies or fire wall sections, where fastener dependability is critical, ESNA offers the "long-beam" locking device. The full cantilever of these sections assures protection against failures related to relaxation, creep and similar problems caused by the effects of extremely high temperatures upon metals. **(Ask for ESNA Bulletin No. 5715 Design Manual for High Temperature Self-Locking Nuts.)**



Simplifying major substructure joining

An ESNA barrel nut doesn't have to be held for wrenching . . . doesn't need precisely mated bolt holes. The barrel-shaped fastener is simply finger-pressed into a drilled or reamed hole until the special clip snaps into position at the bolt hole location. The .030" float of the nut section of this fitting avoids misalignment problems and the bathtub recess for wrenching area is eliminated. New NAS 577 barrel nut (180,000 psi) now available. Also 160,000 and new 220,000 psi series.

ELASTIC STOP NUT CORPORATION OF AMERICA

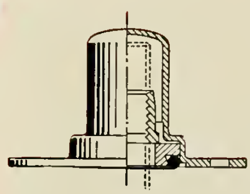


Applications requiring guaranteed high reusability through more than 50 on-off cycles.

Where repeated tear-down and re-assembly or frequent readjustment is required, the exceptional elastic "memory" and non-galling characteristics of ESNA's standard nylon locking insert guarantees long lasting locking torque and fastening dependability. Available in all sizes and configurations of standard aircraft type nuts. Parts can also be designed to order and in any standard configuration, with guaranteed re-use factors as high as 300 on-off cycles.

Attaching components in areas with limited wrench clearance.

Miniaturized insert-type hex nuts with across-the-flats dimensions as small as .109 in the 0-80 size . . . or all metal (550°F.) nuts to AN365 or NAS 679 performance specifications with internal wrenching hexagon faces (which permit use of smaller wrench sizes) are available for use at locations where space and weight limitations are paramount. Complete lines of NAS miniature anchor nuts in carbon steel and A286 stainless steel are also in production. **Ask for your copy of the NAS/ESNA Conversion Book.**



Sealing against fuel tank leakage

No danger of highly volatile fluids leaking past bolt threads with ESNA's self-sealing, floating anchor cap nut! The one piece cap unit is provided with "O"-ring seal around its base *which seals immediately the nut is riveted to the surface.* The self-locking nut enclosed within the cap has .025" float to compensate for misalignment. Also available in gang channel nut strips.

—WHAT ARE YOUR FASTENING PROBLEMS?—

Dept. N49-491, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, N. J.

Please send me details on the following:

- ☐ Installing access panels
- ☐ Sealing against leakage
- ☐ Fitting in limited space
- ☐ Bolting non-parallel surfaces
- ☐ Simplifying substructure joining
- ☐ Assuring high re-usability
- ☐ NAS/ESNA Conversion Book
- ☐ Bulletin No. 5715 High Temperature Design Manual

Name__________ Title__________

Firm__________

Street__________

City__________ Zone___ State______

Space Talk In Spotlight

Wayne W. Parrish discussing missile production problems with ex-Air Force Secretary Senator S. Symington.

A missile in the making? Rolls Royce Ltd. Board Chairman James Pearson, missile-maker D. W. Douglas and RR Assistant Chief Engineer Dave Huddie, at reception given for Douglas by m/r publisher Parrish.

Also at the Air Force Association's Jet Age Conference was Convair's Krafft Ehricke, here being questioned by m/r's Norman Baker.

m/r editor Erik Bergaust recalls old times with Polar pioneer and industry consultant Bernt Balchen at the recent Jet Age Conference held in Washington, D. C.

At AFA Jet Age Conference, Ballistic Missile Division Chief, Maj. Gen. Bernard A. Schriever, (center) is flanked l. to r. by ATLAS manager Col. Otto J. Glasser and TITAN boss Col. B. P. Blassingame.

J. V. Naish has been elected president of Convair Division of General Dynamics Corp., succeeding **Gen. Joseph T. McNarney.** He formerly acted as executive vice president of the division and now becomes senior vice president of General Dynamics as well as president of Convair.

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

Dr. Alfred H. Williams has been elected to the board of directors of the International Resistance Co. Dr. Williams is currently chairman of trustees. University of Pennsylvania and previously was president of the Federal Reserve Bank of Philadelphia.

James Cox has been elected executive vice president and **Paul W. Booth** as vice president in charge of engineering at Hoffman Laboratories, Inc.

Dr. E. M. Baldwin has been appointed general manager of Fairchild Semiconductor Corp. He will also serve as vice president and member of the board of directors.

Lee S. Busch, technical director for Mallory-Sharon Metals Corp., has been reappointed to NACA's subcommittee on power plant materials.

Herbert Harris, Jr., has been appointed manager of Sperry Gyroscope Co.'s Air Arm Division. He formerly was chief engineer for the division. Simultaneously, **Edward M. Brown** was named treasurer of the firm.

Dr. George L. Haller has been elected a vice president of General Electric Co. Since 1956 he has served as general manager of GE's Defense Electronics Division.

Johannes G. Schaberg has joined Control Data Corp. as a staff engineer. He will have senior responsibility for the company's activities in missile guidance systems development.

Leonard K. Schwartz has been named a vice president of Hughes Tool Co. Since 1940, he has been with Lockheed Aircraft Corp. His specific duties with Hughes have not yet been announced.

Dr. James F. Jenkins, Jr., has been appointed director of development at Interstate Electronics Corp. He is responsible for direction of major projects involving missile test and evaluation instrumentation.

W. L. Smith has been named sales manager of Products Research Co.'s newly created Aviation Division, producer of sealants.

S. D. Heller has been appointed to the newly created post of vice president, Ballistic Missile Early Warning System of RCA Service Co. At the same time, **K. M. McLaren** assumes the post of vice president, missile test project, succeeding Heller.

Frederick Stevens has been named to head the electronic systems and equipment facility of Northrop Aircraft, Inc. and **Thomas H. Quayle** will head the firm's systems support facility, formerly designated Northrop-Anaheim.

Anthony J. Randazzo has been appointed manager of the Packard-Bell Electronics Corp.'s Rome, N. Y., office.

David M. Kyllonen has been appointed technical manager of the Muskogee, Okla., Division of Callery Chemical Co.

Major Bill R. Nash, formerly with Headquarters, ARDC, has joined the Washington firm of Thomas Wilcox Associates, consultants to the missile industry.

Ross F. Miller has been named chief engineer of Nortronics electronic systems & equipment elements.

INTER-OFFICE MEMORANDUM

To Advertising Department *Subject* Recruitment Advertising for Engineers

From Vice President - Engineering

As the result of expanding activity in recent months, we have come up with a few openings for good engineers. Specifically, we need designers in the following product groups:

Pneumatic accessories
Electric motors
Fuel systems controls (pumps and valves)
Hytrol anti-skid braking system (electro-mechanical)

The requirements are not pressing: our present team can still carry the increased load. We're proud of the boys we now have, and it's important that we find exactly the right people to add to the group. Therefore, before you rush into print with the usual sort of "recruitment" advertising, here are some thoughts to use in formulating your message:

1. We don't hire engineers by the carload, and we don't stockpile them in reserve until the right project happens to come along. Our people are busy...very busy; and they like to be busy. They follow through on their ideas from inception to development and qualification. They feel a real responsibility for the hardware that finally results from their work. Therefore, we need more idea men with initiative and drive who are not afraid to get their hands dirty.

2. Don't write a lot of guff about "security" and "bright future." The kind of men we want carry their security around with them. They have the self-assurance that comes from ability and experience. Chances are they've known about our company for several years and have followed our progress in the industry. If they answer our ads, it means they like us - and they think they can help us to grow.

3. The kind of man we want will join us because we treat our engineers in the same way we treat our other key people. We don't isolate them and we don't put them on pedestals. We expect results; we know how to look for results; and we reward amply when we find them.

One other point: the man who meets our requirements is probably too busy to write a long resume and application letter. Just tell him to call me personally, or to drop me a short note to let me know where I can contact him - to Hydro-Aire, Inc., 3000 Winona Avenue, Burbank, California. Phone: VIctoria 9-1331.

Frank Cooper
Vice President -
Engineering & Sales

FRC:mk

West Coast Industry

by Fred S. Hunter

Security costs money in the missile business. Lockheed's guard force for its California Aircraft division totals 150. The guard payroll at its missile systems division, already up to 200, is growing. Lockheed soon learned it needs two shifts of guards, even though only one shift is being worked. Seems the men who design and develop missile systems and missile components have the habit of working freely on their own time. This idiosyncrasy of showing up to work during nonworking hours requires added guard shifts to check 'em in and out.

"Mounties" in California—And, speaking of Lockheed's guards, would you believe that its missile systems division has a mounted force? Yep, on horseback. These mounted guards patrol the new 4000-acre Santa Cruz Mountains test site. This is a wooded area, so the guards double as rangers, spotting forest fires and the like. And in the hunting season they also keep a lookout for men with guns, who might venture into the area by mistake. Lockheed wouldn't want one of its missile experts mistaken for a deer.

Bright-eyed engineers at Radioplane have been using their coffee break and lunch time to theorize over a launching system that would send the grainstorage tanks of the nearby Budweiser brewery into outer space. Not only has their thinking reached the point where they believe it can be done, but a second group (equally bright-eyed) are certain they have a satisfactory recovery system devised. Naturally, it's called project *Hopnik*.

Boron into space: Kern County Land Co., rich old California cattle, oil and land organization, which recently made an investment in electronics, may also share in the new space age through its boron holdings. Reports put its Mojave Desert reserves at about 40 million tons. That would be the second largest known deposit of boron. U.S. Borax & Chemical reserves total about 100 million tons.

Reports around Los Angeles have it that North American Aviation definitely has submitted follow-on proposals on the X-15 to the Air Force to put an unmanned version into orbit, using the big three-barrel, 400,000-lb.–thrust rocket booster developed for the defunct *Navaho*, then a manned orbital version, and finally a piloted *X-15* to circle the moon and return.

Sample of the dynamic nature of the missile industry: Aerojet-General Corp. is a subsidiary of General Tire & Rubber, but not wholly owned. There's Aerojet stock currently selling around $300 a share in the over-the-counter market. As recently as 1954, it was selling for around $25 a share. Aerojet sales of $2.5 million in 1946 zoomed to $162 million in 1957, and that's a rate of climb equalling its own rockets.

Soviet Affairs

by Dr. Albert Parry

Russian researchers are cautiously talking of one interesting project of theirs: the use of lightning as a smiting weapon.

Creating artificial lightning, and adding it to the Red war arsenal as a weapon against enemy planes, is a novel Soviet idea. Experiments along this line are currently carried on in laboratories at Moscow and Leningrad.

The objective is ball or globe lightning, rarer than forked or zigzag and sheet or heat lightning.

In general, ball or globe lightning has not been as well understood as the other types, and has always intrigued Russian scientists. In the early 1940s scientist George Babat experimented with such lightning and finally succeeded in creating it artificially in the laboratory attached to the Leningrad *Svetlana* Plant.

Babat's work was continued by Professor Peter Kapitsa, one of Russia's foremost atomic-and-hydrogen, rocket-and-missile specialists, who in the 1950s took over Professor Babat's work and improved upon it with his own genius.

Kapitsa came up with his hypothesis as to the physical laws of the origin of natural ball lightning, and this hypothesis is considered by Soviet science to be a great step forward in creating and guiding artificial ball lightning.

Officially, the Soviets declare that they would use artificial lightning for peaceful uses only.

A Soviet technical writer, N. Dolgopolov, recently remarked that such lightning "would with extraordinary speed cut into the ground and form mining shafts with solid, streamlined walls," making Russian ore-mining a fabulously speedy and most economical process, and sure to cause a veritable revolution in the world's mining generally.

But unofficially, the Soviets are also considering ways and means of using artificial ball or globe lightning against enemy planes.

A team of Kapitsa's and Babat's students are now closely studying known cases of accidental "bull's-eye" hits of Soviet planes in flight by natural ball lightning, and they are drawing certain conclusions from this study. A case involving such a hit near Komsomolsk in the Soviet Far East in August 1956, when a Soviet air transport miraculously survived a bolt of globe lightning, is considered particularly fruitful.

More frankly—and with much authentic technical detail—the future possible use of artificial globe lightning against enemy airplanes is described in at least two works of Soviet science fiction.

Now, globe or ball lightning strikes men and their machines with a totally blind fury. But the Soviets want to harness this fury, to make it "see," to guide it as a truly terrifying, demoralizing, and shattering missile against definite targets—against whatever enemy faces the Soviets in the air in case of war.

Four new

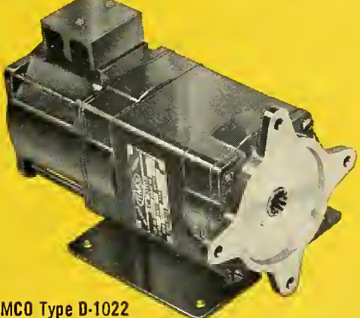
MOTORS for MISSILES

by EEMCO

EEMCO TYPE D-978

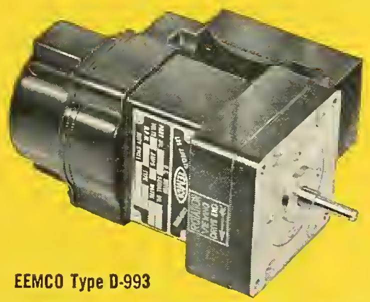
Designed by EEMCO
for missile application
where prolonged testing is required under full load at a temperature range of +180° F. to +400° F.
SPECIFICATIONS: **Volts:** 27 volts DC (24 to 32 volt range). **Horsepower:** ¼ HP (⅔ HP max. short time overload). **R.P.M.:** 12,000. **Weight:** 2.75 pounds. **Military Specifications:** Radio noise filter meets MIL-I-6181B. Explosion proof requirement meets MIL-5272A-Proc. 2. **Altitude Operation:** Tested successfully at over 200,000 feet altitude. **Features:** Built for high shock and vibration loading.

To design and produce motors for missiles that perform well beyond the limits of military specifications yet which maintain specified size and weight limitations is a constant objective at EEMCO. The design, development and testing of motors that achieve these extreme performance characteristics requires EEMCO to conduct company-financed independent research far beyond that normally conducted by a manufacturer of its size. In many instances EEMCO has been able to meet rigid specifications, in fact exceed them, when other producers have failed. For example, three of these extremely rugged new EEMCO motors illustrated will perform with reliability in the atmospheric conditions encountered at altitudes in excess of 200,000 feet, and they are built for unusually high shock and vibration loading. Please note the outstanding capabilities of the individual motors shown.



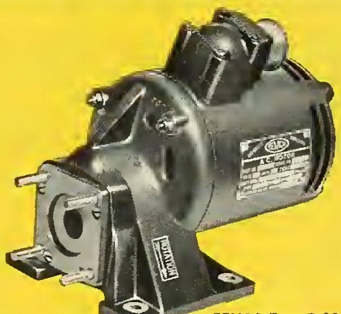
EEMCO Type D-1022

Designed by EEMCO for extremely high altitude operation with ambient temperature capacity to 165° F. Type D-1022 is capable of unusually high shock and vibration loading.
SPECIFICATIONS: **Volts:** 56 volts DC. **Horsepower:** 8.5 HP at 85% efficiency. **R.P.M.:** 12,000. **Duty cycle:** Two minutes. **Ambient temperature:** 165° F. **Weight:** 14.75 pounds. **Military Specifications:** Explosion proof requirement meets MIL-5272A-Proc. 2. **Features:** Built for high shock and vibration loading.



EEMCO Type D-993

Designed for missile applications where prolonged testing is necessary. Type D-993 will stand long idling periods with intermittent loads up to 1.25 HP. It is capable of withstanding vibrational accelerations of up to 125 "G's" in a frequency spectrum of 30 to 300 cycles per second.
SPECIFICATIONS: **Volts:** 28 volts DC (24 to 32 volt range). **Horsepower:** .65 HP. **R.P.M.:** 9600 RPM. **Weight:** 6.2 pounds. **Military Specifications:** Radio noise filter meets MIL-I-6181B. Explosion proof requirement meets MIL-5272A-Proc. 2. **Altitude Operation:** Tested successfully at over 200,000 feet altitude. **Features:** Built for high shock and vibration loading.



EEMCO Type D-899

Rated at 2.75 HP on continuous duty, EEMCO Type D-899 200-volt 400-cycle 3-phase motor is made with high temperature insulation allowing continuous operation at 3.5 HP or a correspondingly high ambient. D-899 contains an integral gear box.
SPECIFICATIONS: **Volts:** 200 volts, 400 cycle, 3-phase. **Load:** 2.75 HP continuous duty. **R.P.M.:** 3140 RPM. **Power Factor:** 83%. **Overall Efficiency:** 76% for entire unit including gear box. **Military Specifications:** Meets MIL-M-7969A (ASG). **Weight:** 11.25 pounds. **Features:** Type D-899 may be made splash- and drip-proof with minor alterations. Gear box, acting as motor support, places base at approximately the center of gravity of a motor-pump assembly thereby limiting extreme shocks and vibrations encountered in a missile.

EEMCO HAS DESIGNED and produced motors and actuators for missiles and aircraft exclusively for the past 15 years. It has made nothing else. Exhaustive research and testing aimed at perfection in the art of building these units has been a constant objective since EEMCO was founded. As a result, extreme precision and reliability has been attained in its products; therefore many of the latest missiles and aircraft being developed and manufactured for our Armed Forces today contain EEMCO motors and/or actuators.

Your inquiry is invited.

EEMCO **ELECTRICAL ENGINEERING & MANUFACTURING CORP.**

4612 West Jefferson Boulevard, Los Angeles 16, California—Telephone REpublic 3-0151

DESIGNERS AND PRODUCERS OF MOTORS, ROTARY AND LINEAR ACTUATORS . . . EXCLUSIVELY!

3-553

Circle No. 55 on Subscriber Service Card.

Missile Age

by Norman L. Baker

Acceleration of future production schedules for the *Titan* ICBM, and a major step-up in development of the X-15 research rocket plane are two projects certain to be included in the Defense Department extra-spending package for fiscal year 1959.

The X-15 program is suffering propulsion headaches: The 60,000-lb-thrust rocket engine under development by Reaction Motors refuses to come up to design thrust. Meanwhile, the X-15 test schedule calls for first glide tests this fall and first powered flights in early spring '59.

The Defense Department spent $16.5 million on rocket test stands at the Holloman AFB Missile Development Center, then halted the project and gave the go-ahead to construct IRBM and ICBM static test stands from scratch at other locations. With the Air Force in an all-out effort to corner all the space projects, Missile Development Center officials are confident that the center must receive a large share of the business.

Project Rover, a Los Alamos study to determine the feasibility of using nuclear power to propel rockets, is still in the research and development stage. During studies so far, various concepts have been evolved, and some have been promising enough to justify incorporating into detailed design studies. First tests of reactor systems at the Nevada test site are now scheduled for late this year. Flight tests of rockets propelled by a nuclear system are not expected for about five years.

Nike Hercules missile defense system has been supplied a needed boost with the award of two contracts totaling $129,592,706 to Western Electric for production of an undisclosed number of the missiles and the related ground equipment. Douglas will produce the missile and some of the support equipment. Chief subcontractors are Consolidated Western Steel Co., which makes launchers; Goodyear Aircraft Co., which makes the boost engines, and Borg-Warner Co., which makes parts for the booster.

The Air Force is reported to be highly pleased with the recent test of the *Thor* equipped with a General Electric Mark 1 operational nose cone. Production of the extremely flattened cone is now under way at General Electric's Missiles and Ordnance Systems Department in Philadelphia. *Thor* is now in the payoff phase of testing and Air Force officials are confident that deliveries to operational squadrons will be made on schedule.

The Russians are in a crash program to develop a manned, hypersonic rocket bomber that cannot be brought down by an anti-missile missile. The rocket bomber is expected to be operational by the time the *Nike Zeus* is developed. The hypersonic bomber has considerable lattitude in attack techniques and therefore is almost invulnerable to a conventional anti-missile missile.

charting physical properties of the atmosphere

AiResearch Assembles Latest Standard Information in Working Form

THE CHARTS on the following pages present the latest recognized standard properties of the earth's atmosphere. Based upon the best available data, and representing over a year of research, calculations, and careful rechecking, the charts were created by The Garrett Corporation's AiResearch Manufacturing Division, Los Angeles, under the supervision of Frederick H. Green, Assistant Chief of Preliminary Design. The work was closely coordinated with the Geophysics Research Directorate of the Air Force in order to obtain the latest information.

In 1942, AiResearch created its first Atmosphere Chart, which showed the then-known properties of the atmosphere up to about 65,000 ft. This was extended in 1945 to 80,000 ft, and in 1948 to 100,000 ft.

This year, AiResearch is issuing two charts, the Atmosphere Chart and the High Altitude Chart. The Atmosphere Chart covers the range from sea level to 100,000 ft, which is the basic operating region for current air-breathing aircraft. With the advent of the space age, we are starting to crowd ourselves out of this region into the realm of the High Altitude Chart, which goes up to 2 million ft.

Two original paintings by Chesley Bonestell, the dean of American space travel illustrators, form the backgrounds of the charts. These incorporate a high degree of pictorial accuracy in the portrayal of terrestrial features, sky, and the various vehicles by which man has progressed in his conquest of space. This progress is illustrated in numerous record flights including the recent records of Captain Iven Kincheloe at 126,000 ft in a rocket aircraft and Major Simons' balloon flight of 102,000 ft.

Atmosphere Chart

The Atmosphere Chart presents accurate values of temperature, pressure, and specific weight of the air for altitudes up to 100,000 ft. From sea level to 65,800 ft, the columns on the sides and the white temperature profile in the center of the chart are based on the ICAO Standard Atmosphere, established by the International Civil Aeronautics Organization and adopted by the National Advisory Committee for Aeronautics. Above 65,800 ft, the data in the columns and the dashed portion of the central profile are taken from the U.S. Extension to the ICAO Standard Atmosphere and the ARDC Model Atmosphere, 1956, which are in agreement. In addition to the Standard temperature profile, curves are shown for the Hot and Cold atmosphere temperatures and for the arctic and tropical profiles. The pressure and specific weight values shown are consistent only with the ICAO temperature profile, but are usable with the other four temperature profiles.

The ICAO Standard profile represents an average temperature for latitudes within the Temperate Zone of the northern hemisphere. The Hot and Cold temperature profiles, based on Military Standard MIL-STD-210A, represent extreme temperature criteria for the design of military equipment. They do not necessarily represent the absolute extremes observed; rather they are the values determined by scientific judgment not to be surpassed more than 10 per cent of the time during the most extreme month.

The arctic and tropical profiles provide criteria for consideration in problems dependent upon a hydrodynamically consistent homogeneous polar (arctic) or tropical atmosphere. These atmospheres cover extreme latitude zones in the northern hemisphere. The arctic atmosphere presents a mean day in the 60 to 90 degree North latitude zone and the tropical atmosphere presents a mean day in the 0 to 20 degree North latitude zone.

High Altitude Chart

The High Altitude Chart presents properties of the earth's atmosphere up to 2 million feet. In addition to extending the specific weight and pressure scales of the Atmosphere Chart, the High Altitude Chart contains values of geopotential altitude, acceleration of gravity, molecular weight, and real kinetic temperature.

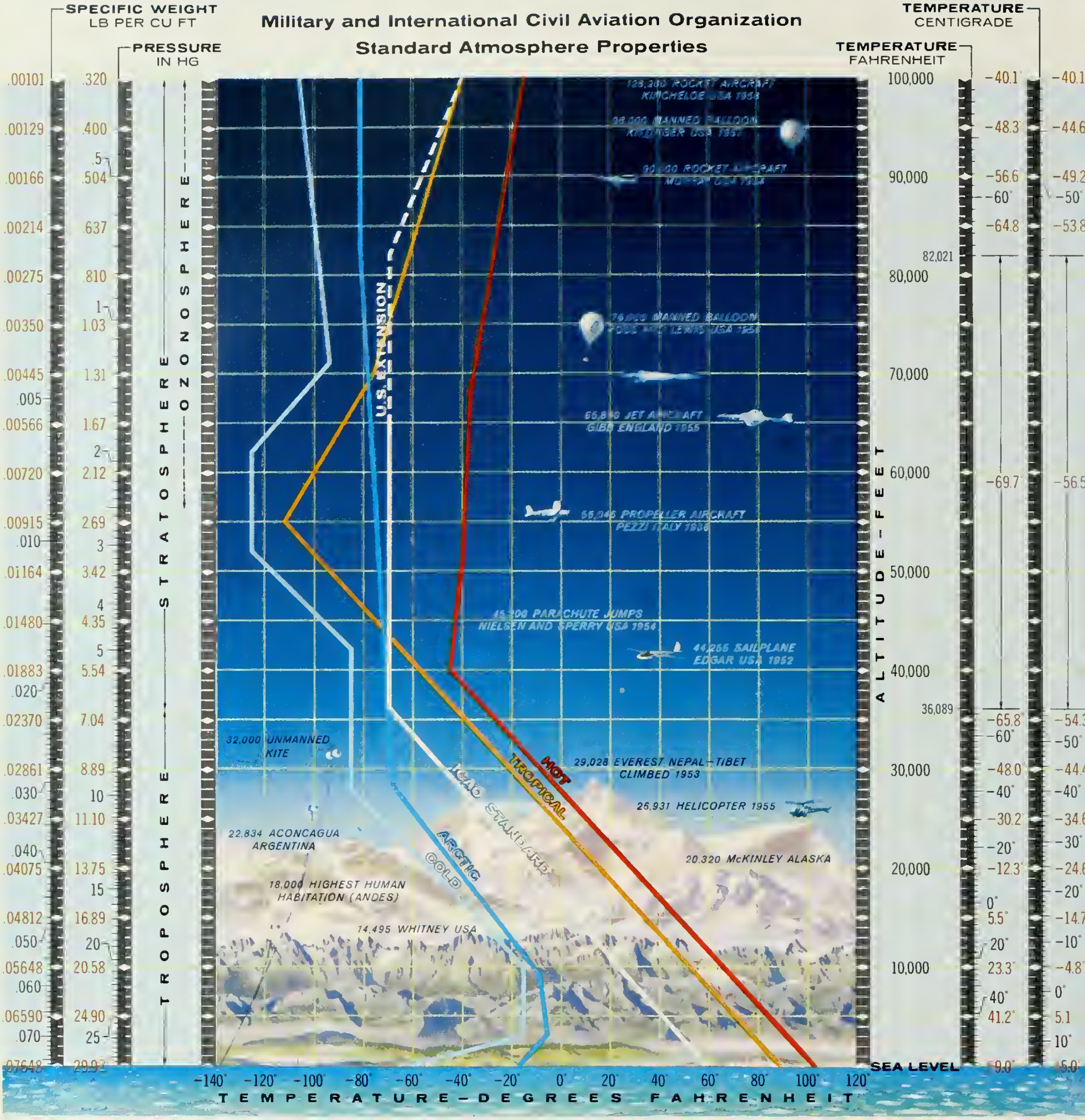
The scales are readily interpreted with a moment's study, but the reader should note that the values of specific weight and pressure on this chart appear in terms of negative exponents and decrease as one reads up these scales. Thus the shorter black graduations are related to the longer division mark immediately *above,* and not below, them. For example, the pressure at 1,460,000 ft is 5×10^{-11} inches of mercury. Also, the geopotential altitude scale is plotted in black graduations, while the basic geometric altitude scale is plotted in white graduations and diamonds.

Real Kinetic Temperature

Real kinetic temperature, shown in the High Altitude Chart, is a measure of the kinetic energy of molecules and atoms constituting the atmosphere at any specified altitude. It is the appropriate temperature to be used in thermodynamic and fluid dynamic calculations, and is the same thing as the ambient

(continued)

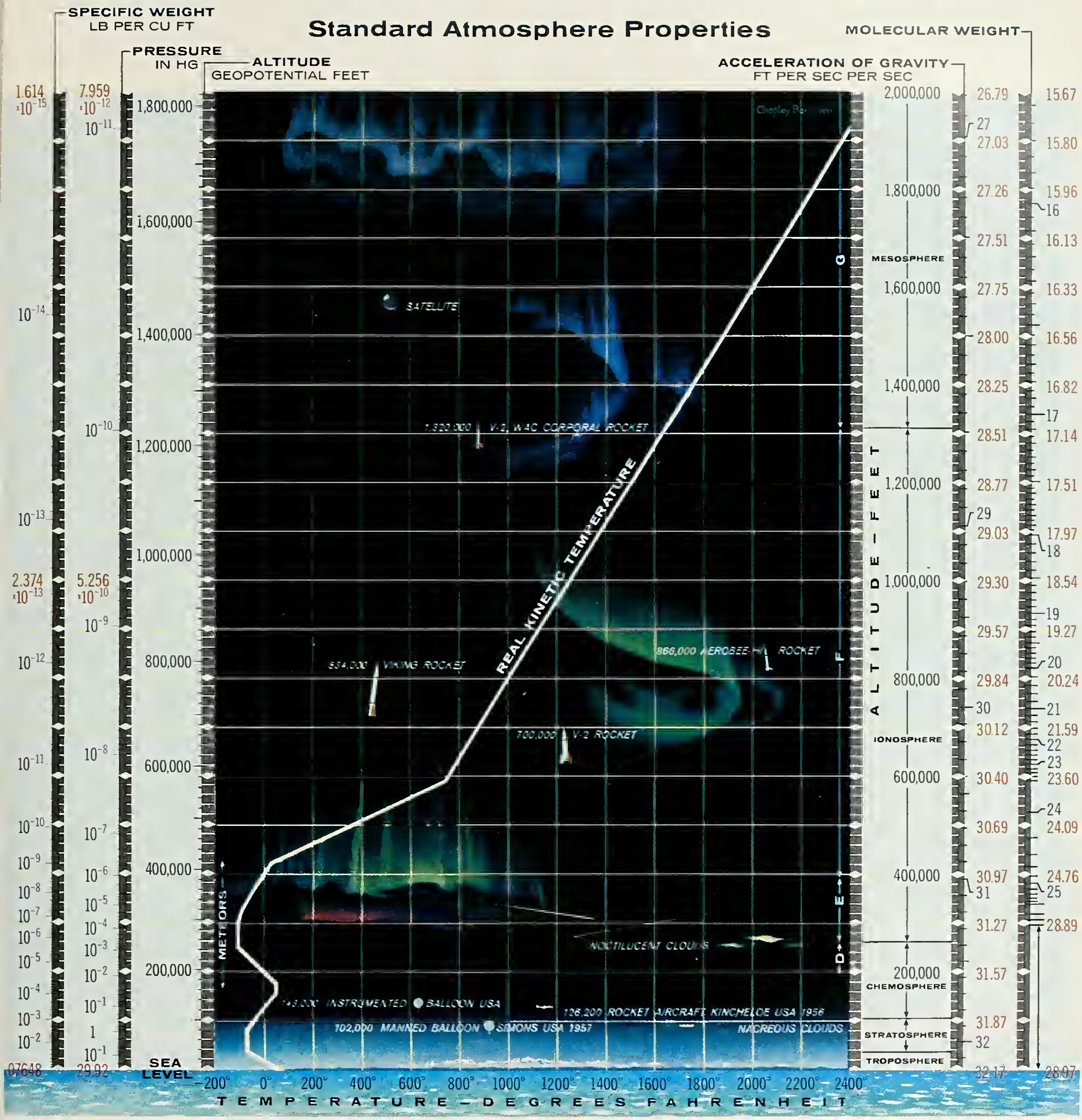
ATMOSPHERE CHART



This chart presents the latest recognized standard values of temperature, pressure and specific weight of the air for altitudes up to 100,000 feet. The pictorial inserts represent steps in man's achievement in learning to reach and to exist at high altitudes. From sea level to 65,800 feet the columns on the sides and the central profile all refer to the International Civil Aviation Organization Standard Atmosphere. The NACA Standard Atmosphere, 1955, and the ARDC Model Atmosphere, 1956, are consistent with the ICAO Standard Atmosphere up to 65,800 feet. Above that altitude the data in the columns and the dashed portion of the central profile are taken from the U. S. Extension to the ICAO Standard Atmosphere and the ARDC Model Atmosphere, 1956, which are in agreement. The pressure and specific weight values shown are consistent only with the Standard temperature profile. The hot and cold profiles represent U. S. Military extreme temperature criteria. The tropical and arctic profiles represent U. S. Military homogeneous atmospheres for the tropical and arctic regions.

EDITOR'S NOTE: This chart was prepared by The Garrett Corporation's AiResearch Manufacturing Divisions as a service to industry and the military and is reprinted by Missiles and Rockets with The Garrett Corporation's permission as copyright owner.

HIGH ALTITUDE CHART



This chart presents standard values of temperature, pressure and specific weight of the air, based on the ARDC Model Atmosphere, 1956, for altitudes up to 1,780,465 feet. The altitude column on the right presents geometric altitude. The energy required to lift an object 2,000,000 geometric feet is only 1,824,988 times that required to lift it one foot above sea level, because of the decrease in the acceleration of gravity with altitude. This relative amount of energy is shown in the column on the left as geopotential altitude. Real kinetic temperature is a measure of the kinetic energy of the molecules and atoms constituting the atmosphere. Its numerical value is determined by the assumed molecular weight of air as well as the assumed temperature lapse rate. The molecular weight of air is assumed constant from sea level to 299,516 ft. Its decrease above 299,516 ft. to 590,401 ft. is attributed to the dissociation of oxygen; its decrease above 590,401 ft., to diffusive separation and dissociation of nitrogen. The symbols D, E, F and G refer to the respective ionized regions of the atmosphere.

EDITOR'S NOTE: This chart was prepared by The Garrett Corporation's AiResearch Manufacturing Divisions as a service to industry and the military and is reprinted by Missiles and Rockets with The Garrett Corporation's permission as copyright owner.

static temperature referred to in current aircraft design work and coincides with that of the standard atmosphere shown in the Atmosphere Chart.

It should perhaps be noted that readings from the temperature curves will not in general indicate the temperature of any body suspended in or through the atmosphere. Both aerodynamic heating and thermal radiation must be considered in calculating body temperatures. In particular, at high altitudes the few molecules of air near an object have little effect upon the object's temperature, compared with the heating effect of the sun's radiation. And were the object stationary and in shadow, shielded from the sun's rays as well as from other sources of radiated heat, its temperature would approach absolute zero, scarcely affected by the molecular action of the rarefied air.

Direct, independent measurements of temperature have been made only at relatively low altitudes, below 143,000 ft. Above that altitude, conventional instrumentation on sounding rockets yields only the ratio of temperature to molecular weight. Molecular weights have been measured only to about 300,000 ft so that "measured" temperatures extend no further. Above 300,000 ft the temperatures shown have been computed using assumed values of molecular weight based on the best available theory and experiments, together with values of the ratio of temperature to molecular weight as determined from rocket instruments up to about 1,000,000 ft, and from theory or other knowledge above this altitude.

In constructing the curves, standard variations of the ratio of temperature to molecular weight with geopotential altitude were assumed, consisting of a series of straight lines for various altitude regions. After applying the molecular weight functions described in the section below on "Molecular Weight" the result is a temperature curve which is also a series of straight lines up to about 300,000 ft but exhibits a definite curvature in the region just above 300,000 ft and again in the region above 600,000 ft. These curvatures are due to the abrupt changes in slope of the molecular weight curve described below.

Molecular Weight

Atmospheric composition at high altitudes is thought to vary considerably from that near sea level. The variation in composition may result from dissociation of various molecules of the atmosphere as well as from diffusive separation of molecules of various masses in a gravitational field. While several theories describing these phenomena exist, there are only a few data to support or disprove these theories.

At altitudes up to about 300,000 ft the molecular weight appears to remain approximately constant, and has been so assumed for the present chart. Between about 300,000 ft and 500,000 ft it is thought that the dissociation of O_2 is the principal factor in producing a change in molecular weight. Rocket measurements of O_2 concentration provide partial support to this contention. Diffusive separation and the dissociation of N_2 are thought to dominate the variation of molecular weight of the mixture of atmosphere gases above 600,000 ft.

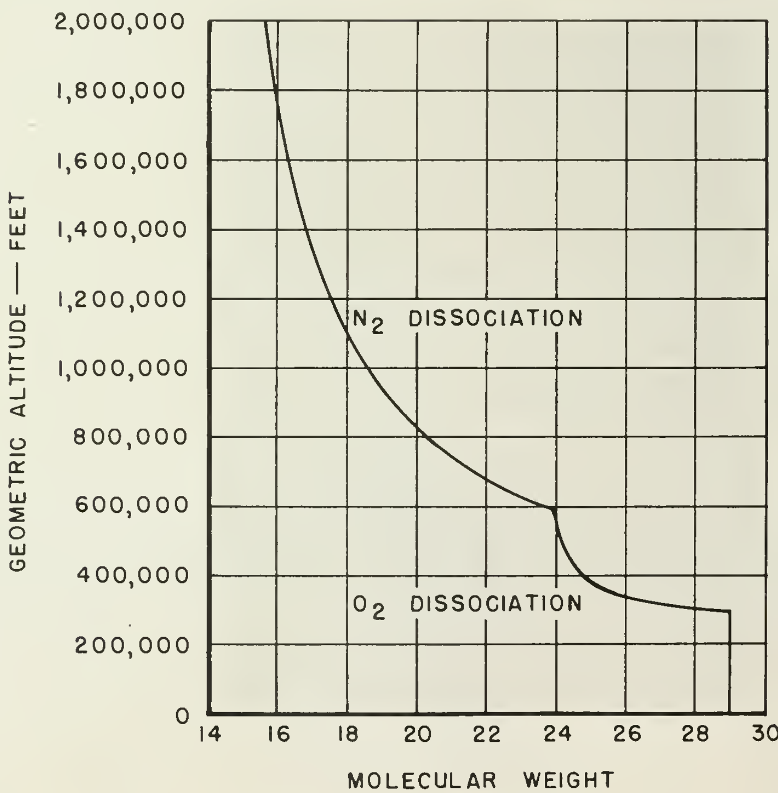
The Geophysics Research Directorate developed analytical functions in the form of two equilateral hyperbolas that are a reasonable approximation of the theories, assumptions, and data defining molecular weight. The figure shows a plot of the resulting molecular weight.

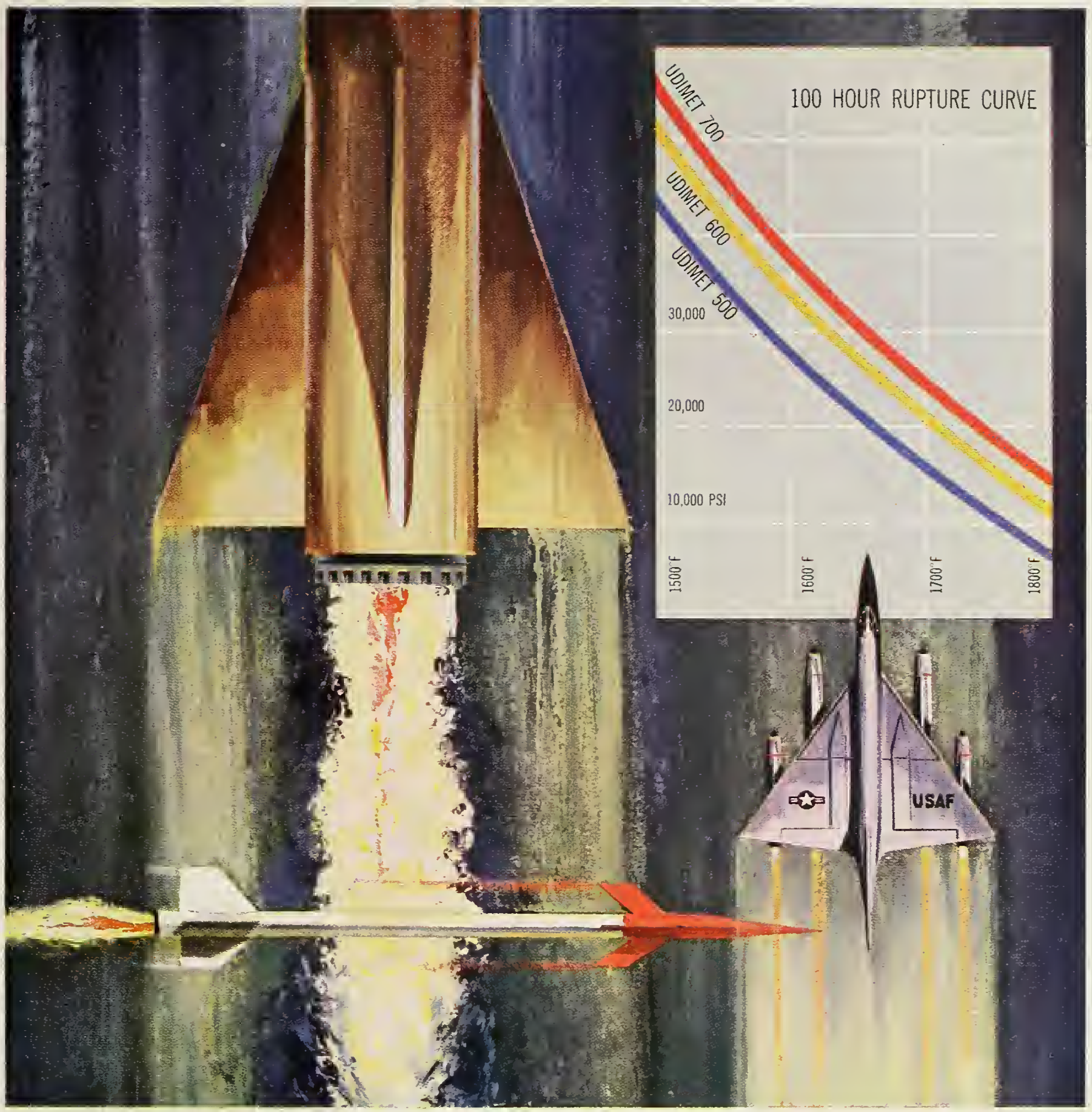
Geopotential Altitude

The concept of geopotential derives from the fact that the amount of energy required to lift an object decreases with altitude because the acceleration of gravity decreases with altitude. The geopotential of a point is defined as the increase in potential energy per unit mass lifted from mean sea level to that point against the force of gravity.

Geopotential altitude, which reflects the relative amount of energy required to lift an object to a given altitude, is a parameter involving both gravity and altitude and thus reduces by one the number of variables in equations relating the various atmospheric properties. This reduction in the number of variables comes without requiring the erroneous assumption of constant acceleration of gravity.

A unit of geopotential altitude is thus actually a measure of energy. It is very useful for certain atmospheric studies, but the geometric altitude was selected as the basic altitude function for these charts because of its clear physical meaning.





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APRIL, 1958

IRE Switches From Recruiting To Sales

By Raymond M. Nolan and Peer Fossen

New York—The big show came to New York again this year, and with it came a change of emphasis—from recruiting to selling.

The recruiting effort of 1957—which caused many companies to shy away from this year's Institute of Radio Engineering convention, was largely absent.

Except for a few companies with heavy major missile programs, recruiting was confined to a search for experienced specialists. Company officials agreed that such talent is hard to come by, but that inducements besides salary—such as profit-sharing incentive plans—might be of some help.

One trouble is that most desirable men are already comfortably slotted in top spots with their present employers, and are loathe to leave, even for attractive incentive offers.

• **Missile shift reason?**—Many reasons have been advanced for the decline in recruiting activity, and, while some blame it on the current recession, most recruiters agreed that the shift in emphasis from aircraft to missiles has been the deciding factor.

With airframe activity lessening day by day, the era of the platoon system of engineering seems to be drawing to a close. In the small-to-medium-sized companies now prominent in the missile field, the emphasis is on individual quality rather than on mass "scatter" attack. This one factor, more than any other, means that enough basic engineering talent is on the market to fill industry needs.

However, this situation excludes companies with programs of such a nature that they cannot meet contractual requirements without substantial addition to staff.

• **More exhibits**—With the marked shift in emphasis to selling, the convention this year and more and better exhibits than ever before—over 950 exhibitors and something like 2½ miles of exhibits. Enough interest was generated to result in a waiting line at the New York Colosseum doors at opening time on the first day of the convention. Exhibits ranged from a full-sized 28-foot diameter parabolic antenna to a pinball machine which impacted a klystron tube with High-G shock when players hit the right bumper.

Most significant fact about the various exhibits was the selling effort connected with them. Attendees were able to ask questions about either technical or money matters and get answers from teams manning the booths. As one exhibitor put it: "We're selling hardware, not buying bodies."

Gossip at the sessions ranged from the question of who would be the prime contractor on the Navy's projected *Subroc* program, to who had the fanciest digital read-out device. In this latter category, viewers were confronted with some of the most spectacular electronic equipment in existence today. Automatic read-outs displayed ranged from electronic adding devices, complete with plus signs, to fast-cycling counters with hundreds of individual read-out tubes.

• **Trend to missiles**—Very significant was the trend away from aircraft orientation and toward missiles.

This was strongly indicated by the most important meeting of the convention—the Tuesday night session on the Waldorf-Astoria's Starlight Roof. Its theme: Electronics in space.

Participants were E. Stuhlinger, of the Army Ballistic Missile Agency; C. S. Draper, of Massachusetts Institute of Technology; Maj. D. G. Simons, of the Air Force; J. B. Wiesner of MIT, and F. L. Whipple, of the Smithsonian Astrophysical Observatory.

Their discussion concerned the evolution from existing concepts to the role of electronics in space—not only that, but electronics for defense and for war.

The round-table which included these scientists discussed informally the use of electronics for propulsion, navigation, communications, telemetry and instrumentation. The basic question raised was: what new areas must be anticipated for existence inspace at blast-off, en route and in the terminal environment.

Much discussion throughout the convention concerned the subject of reliability. Panelists and audience could go back three or four years to a time when this concept did not exist, but all concerned realized that reliability is the hinge on which all developmental work swings.

Alfred R. Gray, of The Martin Co., Orlando, pointed out that the "statistical cliche" cast no reflection on the general subject of reliability. However, he emphasized that he has no quarrel with those reliability engineers who have constantly stated that the theoretical relationship between component-part reliability, complexity and weapon-system reliability are so important in the overall weapon system field.

He indicated that there has been a pendulum swing, during the last three years, from a relatively uncontrolled reliability to a type of reliability effort using "too many chiefs and too few Indians."

One of the more interesting papers presented concerned radar antennas capable of detecting enemy missiles up to 3000 miles.

Devices to sense signals in the 3000 miles range would normally be large and unwieldy, and therefore difficult to sweep back and forth. However, the antenna described by engineers of Westinghouse Electric Corp. solve this problem by cycling the beam electrically while the antenna remain fixed.

This is particularly important on stations such as the northern DEW line and the Texas Tower picket line where high winds are normal weather conditions.

The general consensus of delegates was that the IRE has finally swung away from a promotional operation designed to recruit large numbers of engineers into a real trade convention—one which has the primary purpose of selling the products manufactured by the exhibitors.

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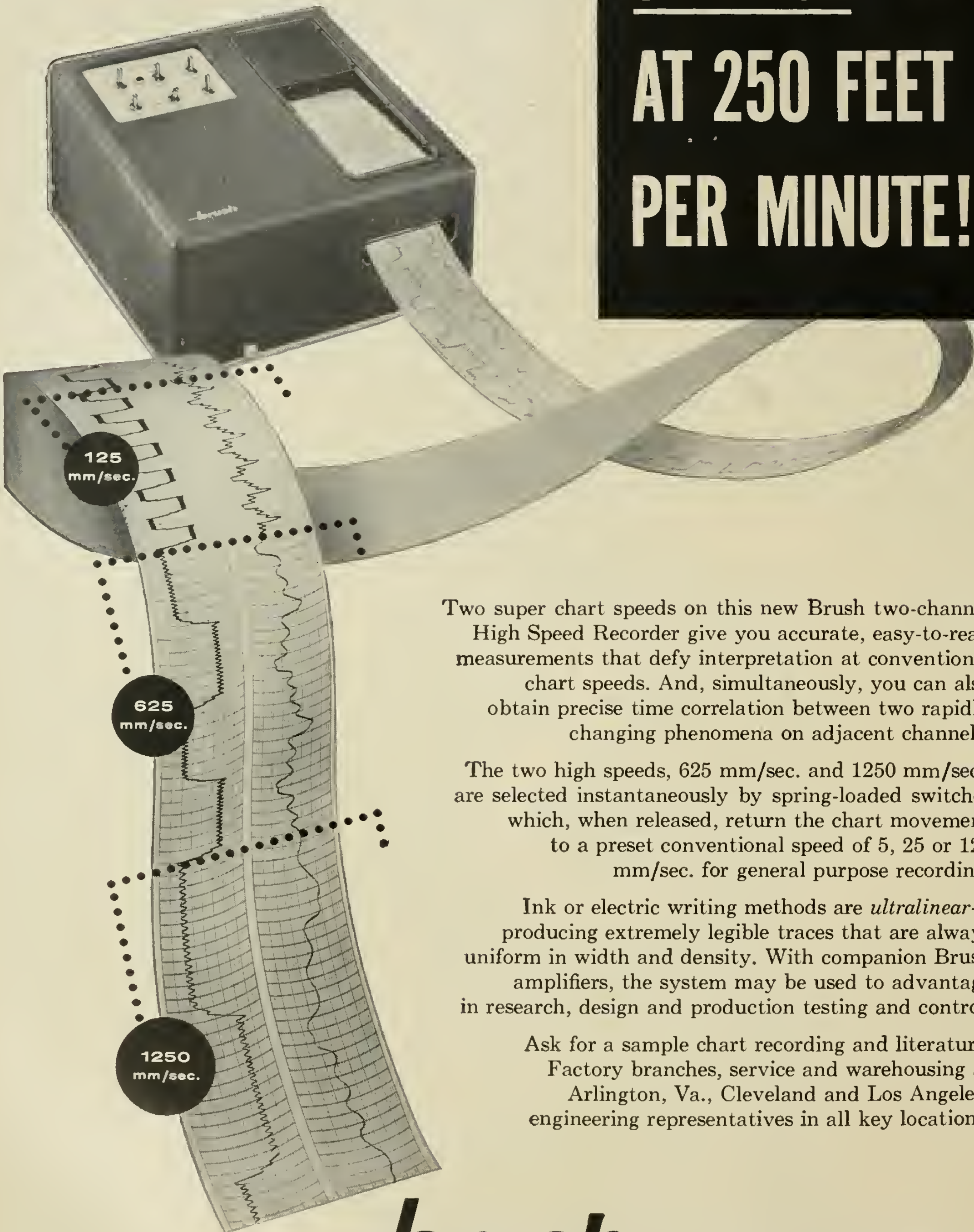

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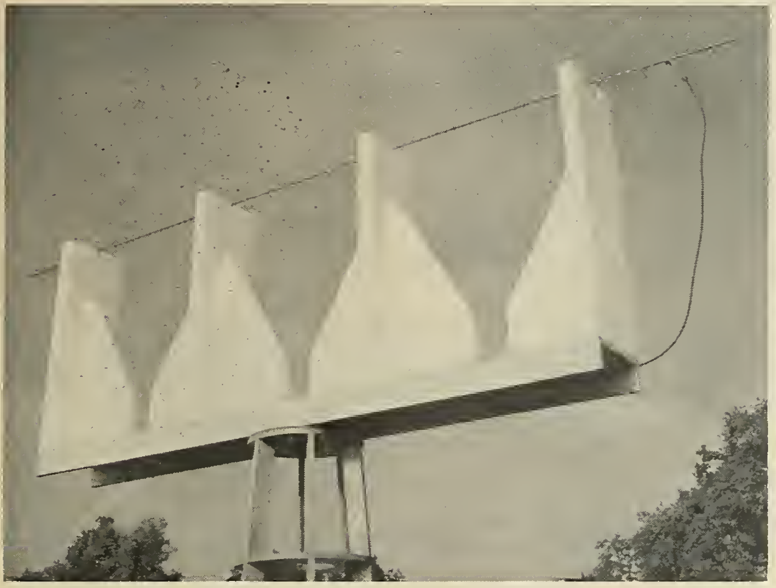


Antenna Design Aims At Sensitivity

The ever-growing application of electromagnetic waves for communication, navigation and detection has served to intensify antenna research activities. Main research objectives: greater efficiency and reliability, lower initial cost, reduced maintenance expenditures and simplicity.

The search for newer and better antennas has resulted in strangely shaped structures and monstrous configurations that are a far cry from the early straight-wire aerial.

Stanford Research Institute is currently experimenting with an entirely new antenna concept designed to meet the need for more sensitive point-to-point radio and TV communication in the vhf-uhf (30 to 3000 mc/s) range. A short segment of this antenna is similar to the common parallel rod Yagi TV antenna, but the overall design differs in that the cross rods are displaced in a spiral around the axis which is considerably longer than that of the Yagi.

Extending the length is desirable, since the signal-amplifying ability of an antenna normally increases in proportion to increases in its length. In the case of the conventional Yagi, however, there is a practical limit beyond which added length yields very little increase in signal intensity. The new spiral arrangement of the rods is expected to overcome this limitation and enable the full advantage of a long axis.

The experimental model in the accompanying photo has a physical length of 10 feet and the plane of the cross rods makes a complete (360°) twist over the length of the axis. Antennas of many times this length are expected to be used advantageously in installations which would normally require expensive paraboloids. Indications are that the gain of a twist antenna 50 wavelengths long would be about 25 to 26 decibels.

A second SRI project involves a parabolic segment antenna designed for research use in Alaska in conjunction with a large dish-type antenna to study the aurora. The large "dish" transmits 400-mc/s signals which are reflected by the aurora and picked up by the parabolic segment antenna located approximately 50 miles away. Data obtained from the received aurora-modified signals are being used to study the characteristics of the aurora.

SRI is also conducting a series of tests at the Radio Propagation Field site to study moon and meteor "echoes." A broadside Yagi array is being utilized in conjunction with a large dish antenna. 100-mc/s signals are beamed from the large dish to the moon where they are reflected to the broadside Yagi. The returning signals provide data about the moon's surface as well as about the upper atmosphere. Other studies are being made of the way signals are reflected from meteors.

Electronics Spending Continues Rise

Department of Defense spending for missile electronics over the first half of FY 1958 totaled $572 million according to Electronics Industries Association's second quarter report. The report indicates the amount for the second quarter to be $299 million, or $26 million more than reported for the first quarter. The combined military spending for electronics over the first half of FY 1958 amounted to $1,893.5 billion, while the total for calendar 1957 reached an all-time high of $3.9 billion.

Intended primarily to depict trends, and subject to later revision, the EIA computation shows the following missile electronics figures (in $ million) for the first and second quarters for fiscal years 1957 and 1958:

1st Quarter FY 1958	2nd Quarter FY 1958	1st Quarter FY 1957	2nd Quarter FY 1957
$273	$299.0	$205	$259

Total electronics spending for same period was:

Budget Category:				
Aircraft:	340	346.0	213	270
Ships & Harbor craft	23	25.0	17	19
Combat vehicles.	1	–.2	2	2
Support vehicles	1	.7	..	1
Missiles	273	299.0	205	259
Elec. & Comm.	204	214.0	130	236
Research & Dev.	73	74.0	65	76
Miscellaneous ..	11	9.0	5	13
	926	967.5	637	876

For further comparison, see m/r February 1958, page 75.

Missile Warning System Under Study Two Years

Arthur L. Malcarney, executive vice president of RCA Defense Electronic Products, recently revealed that award of a missile-warning system contract by the Air Force to RCA had been preceded by a company-financed program of research into the area.

"A warning system against possible ballistic-missile attack is not a new problem to us," Mr. Malcarney said. "Utilizing our own resources, we have been studying the situation for more than two years."

The new warning system will be installed at top-secret locations where long-range radar will be utilized to seek out and pinpoint any ballistic missile firings with hostile intent. The connecting radar outposts will feed the information to a centrally located brain center in the United States.

Computers "Fire" Rockets in Tests

Machines cut actual launching need to minimum

by Peer Fossen

WHEN THE WHITE SANDS Proving Ground in New Mexico was established shortly after World War II to study captured V-2 rockets, America's military men believed the only sure way to test a missile was to fire it and then watch it closely.

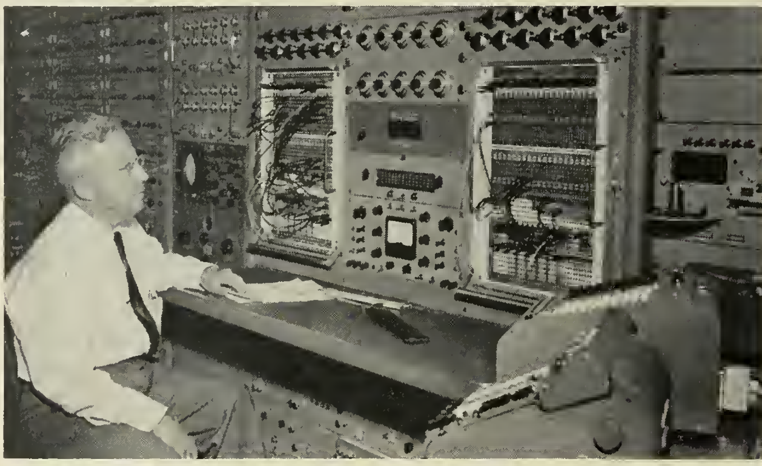
As experience was gained in this new field, the concept changed drastically, and today, the military is obtaining as much valuable scientific information by "mock" firings in the two-year-old Flight Simulation Laboratory as from actual range launchings. Scientists working in the laboratory are saving the country's taxpayers millions of dollars each month.

Although flight simulation is still in its infancy, its fantastic growth in this short span has prompted the need for better working quarters. A large new building with increased facilities is planned for next year, to meet this need.

Simulated missile performance is nothing new in scientific circles. V-2 scientist Guenther Hintze carried out "mock" launchings on a somewhat smaller scale in Germany toward the end of World War II. The efforts were rather limited due to inadequate equipment and the newness of computer technology. Actual missile components were at that time tested on tilting tables in the laboratory at the Peenemunde base.

Hintze, who came to WSPG with other German missile experts in 1946, today spearheads the work here as chief of the Flight Simulation Laboratory. Since setting up simultation at WSPG he has perfected the system to the point where no component of the missile is required for the "mock" testing in the laboratory, a desired improvement.

The flights are simulated mathematically by giant computers, reducing actual missile launchings appreciably. The data collected through the laboratory tests rarely varies more than two to five percent from those obtained through actual launchings, a very low variation.



GERMAN-BORN scientist Guenther Hintze prepares an analog computer to "fire" a missile at WSPG's Flight Simulation Laboratory.

Everything about the missile, and the many variables that might influence its flight behavior, are expressed in mathematical equations. These equations reflect such variables as the missile's weight, size, velocity and thrust, as well as data on atmospheric conditions that might affect the simulated missile flight.

The equations are fed into computing machines to set up the firing problem. Setting up a master problem might cost from $5000 to $10,000, but this is a small sum considering the multitude of test flights that will arise out of one problem. A slight change in one variable will create a completely new flight.

In comparison, a live test firing of even the most inexpensive American missile will cost $100,000 or more.

Two types of computing machines are used for the tests, digital and analog. The digital machine ejects its information in the form of numbers while the analog computer expresses its answers in voltages which are later plotted on graphs.

The "mock" firings at the laboratory far outnumber the live launchings on this integrated range shared by the Army, Navy, Air Force, and Marines. The value of the simulation program, says Guenther Hintze, can be summed up in these three major points:

1) Range safety—Simulated firings indicate whether a planned range firing would overleap the safety boundries, proving a trajectory in advance of actual launching.
2) Savings—The laboratory firings are inexpensive as compared to live launchings.
3) Flexibility of flight patterns—Flights can be planned in the laboratory down to the smallest detail. It is always possible to back up and start over again with a minimum of time, effort and cost.

In spite of the essential role simulation plays in missile development and testing, there is a limit to the kind of information and data it can yield. The final answers to missile-performance speculations and problems must come from the real firing. But simulated firings such as these will make the task easier.★

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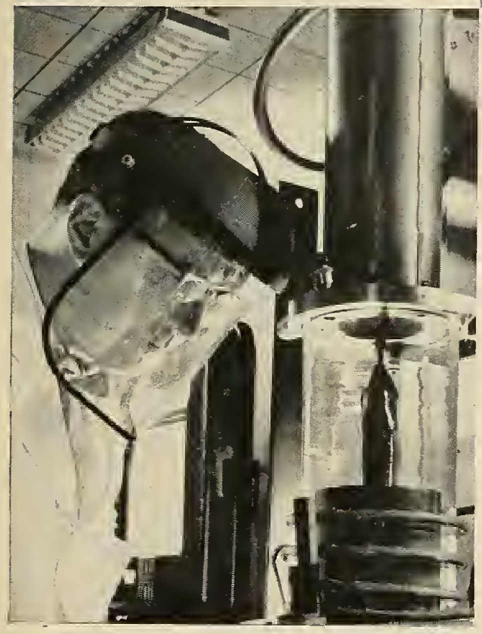

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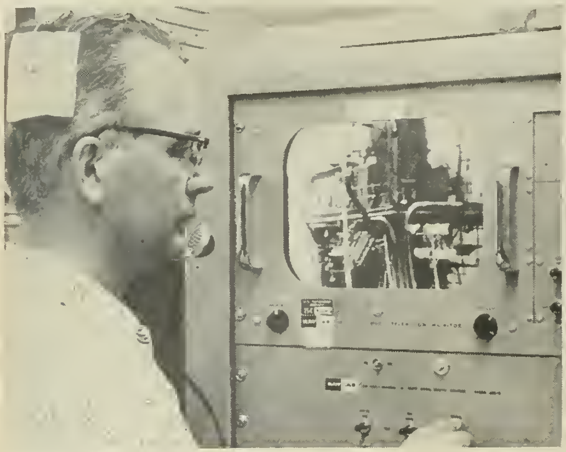
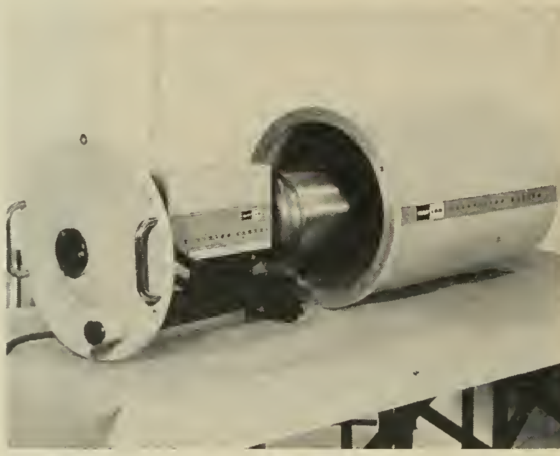


SIZE COMPARISON. Package on right is one of several proposed for uses other than satellite.



NUMBER OF MERCURY cells needed for 500 milliwatt transmitter (on left) and number of similar cells needed for new transmitter.

Reduced-Size Satellite Transmitters Coming

by Raymond M. Nolan

Now that the United States has succeeded in launching satellites of both the *Explorer* and *Vanguard* types, attention has shifted from the launching to the satellite payload. This has thrust the satellite transmitter and its associated power pack into the spotlight as a really critical element.

Research along the lines of ultra-miniaturized transmitters and smaller power packs by the Naval Research Laboratory and the DuKane Corp. of St. Charles, Ill. has resulted in a design which should play an important part in future orbiting payloads and also in moon-orbiting or impact payloads.

The new transmitter, which should allow broadcasting from two to four times as long as present satellite units, is a 500 milliwatt version of NRL's 100 milliwatt satellite transmitter. It is crystal controlled and employs three recently developed Western Electric transistors capable of operating as oscillators or amplifiers at 108 mc/s, the IGY satellite frequency.

The special circuits developed for the transmitter give much greater overall efficiency than is now possible with vacuum tubes. In fact, a tube transmitter developed for the same purpose requires five times the battery voltage and five times the battery power needed by the new transistorized unit. In reference to satellite use, this means a highly significant saving in weight, since fewer batteries can do the same amount of work. Or, using the same batteries, the satellite transmitter can broadcast for a longer period of time.

This particular transmitter, described by Michael Supitilov, DuKane Research Director, as a "new combination of known components," is designed primarily for use in the satellite program. Its broadcast signals would be used in telemetering information on space conditions to monitor stations throughout the world, and as an aid in tracking the satellite's path.

The tiny unit weights less than three ounces, and occupies less than six cubic inches of space (a pack of cigarettes occupies about seven cubic inches). For a power output of 500 milliwatts, it uses one-half to one-fourth the battery power needed by any other transmitter now known.

Typically, the output stage of a conventional tube-type transmitter doing the same job would need 4620 milliwatts input power to produce 500 milliwatts output. By contrast, the output stage of the new transmitter needs only 930 milliwatts power to produce the same output. The corresponding efficiencies are 11 percent and 54 percent.

As an additional advantage, the unit operates on a single 20-to-24 volt battery, whereas a tube-type transmitter requires both low-voltage filament and high-voltage plate supplies.

Tubes also generate, and the heat must be dissipated, a problem which crops up often in miniaturization. The transistor circuit greatly reduces this problem. Simplified circuitry and re-

Comparison of DuKane's 108 Megacycle Satellite Transmitters

Stage Characteristics at 500 Milliwatt Output

	Tube Type	New Transistor Type
Collector Voltage	....	20 volts
Collector Current (pair)	....	45 milliamps
Collector Circuit Input Power	....	900 milliwatts
Collector Circuit Efficiency	....	58%
Emitter Power Input	....	30 milliwatts
Plate Circuit	120 c. @32 ma.	....
Screen Circuit	120 v.@5 ma.	....
Filaments	2.25 v.@80 ma.	....
Total Input Power to Final Stage	4620 milliwatts	930 milliwatts
Overall Final Efficiency	10.8%	53.8%

duced shielding problems because of low operating impedances also make it possible to squeeze an amazing amount of transmitting power into an extremely small space.

The transmitter can be operated on solar batteries, drawing its power from the sun and sending out its signals indefinitely, but with one-half to one-fourth of the solar surface heretofore required for exposure.

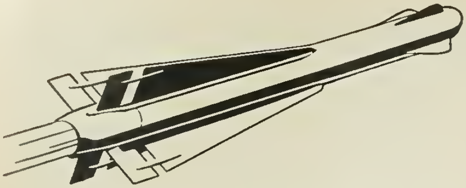
A comparison of the operating efficiencies of the new circuit and a typical tube-type circuit is given in the box.★

Westinghouse Develops New Missile Gyro

Westinghouse Electric Corp.'s Air Arm Division recently announced the development of a new subminiature rate integrating gyro for missile guidance and airborne armament control systems. The new design designated as SIR-1 (subminiature integrating rate) gyro Model No. 1, incorporates manufacturing techniques which make possible a cost reduction of as much as 50 percent over comparable gyros.

Main design objectives are: (1) simplified construction of both the moving coil and the magnet stator of the torque assembly; (2) ease of initial alignment and simplicity in fabrication of the signal generator; and (3) use of solid stator for the spin motor, eliminating manufacturing operations necessary with conventional laminated assemblies.

The following performance characteristics have been released by West-



inghouse as result of its tests:

Range—plus or minus 120° per second;

Resolution—0.002 degree/second (the earth's rate is 0.0042 degree/seconds);

Linearity—within 0.1 per cent of maximum value;

Mass Unbalance of Gimbal—0.3 dyne-centimeter;

Dimensions—length, 3 inches; maximum diameter, 1½ inches at mounting ring;

Weight—7 ounces;

Angular Momentum—3000 dyne-centimeter seconds;

Viscous Damping—3000 dyne-centimeter/radian/second.

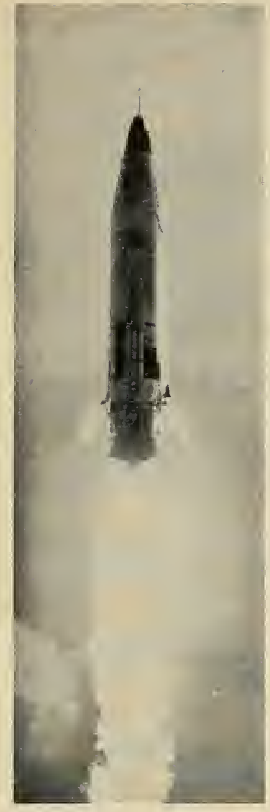
Other features of this development include: (1) a d'Arsonval torque generator for linearity of command and absence of residual torques; (2) a new signal generator for linear measurement of gimbal angle and the absence of residual torques; (3) jewel gimbal bearings for minimum friction; (4) a continuous temperature-controlled fluid damper for a constant damping factor; (5) a full-floated gimbal assembly to insure resistance to the effects of shock and vibration, and to insure low friction at the gimbal bearings; and (6) a high-torque spin motor capable of reaching synchronous speed of 12,000 rpm in four seconds.

Several development models and a preproduction prototype of the unit have been completed.

ICBM Detection Rig Transmits High Power

Cornell Aeronautical Laboratories and the Army have revealed what is considered an important advance in development of ICBM detection devices. An ICBM, because of its extreme speed and unusual configuration, is difficult to detect with present-day radar equipment. Therefore, any radar contemplated for anti-missile use must have a great deal more power than a corresponding radar used in aircraft detection.

CAL, working on the project under an Army Ordnance research contract applicable to Army missile systems, designed the high-peak-power microwave equipment. Using a special microwave generator, the laboratory has transmitted radar-like signals at a peak power of 21 million watts. This power output is many times more powerful than heretofore believed possible, and is believed to be the largest peak power ever radiated.









What do these latest aircraft and missiles have in common?

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With component reliability getting increased attention from missile and aircraft designers, it is significant to note the number of supersonic weapon systems equipped with Genisco accelerometers.

A complete list reads like a roll call of tactical and strategic missiles and aircraft now in the nation's arsenal. Included are such weapons as the *Atlas, Thor, Nike Ajax, Nike Hercules, Bomarc, LaCrosse, Bull Pup, Talos, Dart, Matador, Corporal* and *Terrior* missiles; and the F100D *Super Sabre,* F101 *Voodoo,* F106A, and Canada's CF105 aircraft. What better proof of the reliability of Genisco instruments than this acceptance by designers of these weapons?

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1.12-1.70	L	RG-69/U	RXB103085		10°E	D.C.	250	130	15.2
			TD-21	6881	90°H	D.C.	250	65	15.2
			TD-29	7101	90°H	A.C. and D.C.	250	130	18.0
			TD-33		90°H	A.C. and D.C.	250	75	15.2
2.6-3.95	S	RG-48/U	TD-12	6358	10°E	D.C	250	80	15.2
			TD-22	6782	90°H	A.C and D.C	250	45	15.2
			TD-31		10°E	A C and D.C.	250	85	15.2
			TD-32		10°E	A.C. and D.C.	250	140	18.0
			TD-34		10°E	D.C.	250	155	18.0
			TD-35		90°H	A.C and D.C.	250	80	18.0
			TD-38		10°E	PULSE*	(250)	(90)	15.2
3.30-4.90	S	WR-229	TD-24	6852	10°E	A.C. and D.C.	250	65	15.2
			TD-30		10°E	A.C and D.C.	250	110	18.0
3.95-5.85	C	RG-49/U	TD-10	6356	10°E	D.C.	250	70	15.2
			TD-39		10°E	PULSE*	(250)	(80)	15.2
			RXB103422		10°E	D.C.	250	(110)	18.0
5.85-8.20	X	RG-50/U	TD-10	6356	10°E	D.C.	250	70	15.2
			TD-39		10°E	PULSE*	(250)	(80)	15.2
			RXB103422		10°E	D.C.	250	(110)	18.0
8.20-12.40	X	RG-52/U	TD-11	6357	10°E	D.C.	200	75	15.2
			TD-23	6882	10°E	D.C.	200	115	18.0
			TD-40		10°E	PULSE*	(200)	(85)	15.2
			RXB103093		90°H	D.C.	200	(35)	15.2
			RXB103394		90°H	A.C. and D.C.	(100)	(50)	15.2
12.4-18.00	K	RG-91/U	TD-18	6684	10°E	D.C.	200	70	15.2
			RXB103399		10°E	D.C.	200	(110)	18.0
			RXB103409		10°E	A.C. and D.C.	(100)	(65)	15.2
			TD-41		10°E	PULSE*	200	(80)	15.2
			RXB103411		90°H	A.C. and D.C.	(100)	(50)	15.2
			RXB103254		90°H	D.C.	200	(40)	15.2
18.0-26.5	K	RG-53/U	TD-13	6359	10°E	D.C.	200	65	15.2
			RXB103423		10°E	D.C.	200	(100)	18.0
			TD-42		10°E	PULSE*	(200)	(75)	15.2
			RXB103411		90°H	A.C. and D.C.	(100)	(50)	15.2
26.5-40.0	K	RG-96/U	RXB103251		10°E	D C.	(150)	(120)	15.2

NDTE 1: Anode current and tube drop are D.C. values. Values in parentheses are tentative.

NDTE 2: D.C. operation—Cathode at one end only.
A.C. and D.C. operation—Cathodes at both ends.
Pulse operation—Cathode at one end specially designed for pulse operation.

NDTE 3: The Excess Noise Ratio in DB is 10 log $\left(\frac{T_{eff}}{290} - 1 \right)$

*If the anode current during the "on time" of a square pulse (of greater than 100 micro sec. duration) is nominally the same as the rated D.C. anode current, the tube drop during this period will be approximately the same as the rated D.C. tube drop.

26

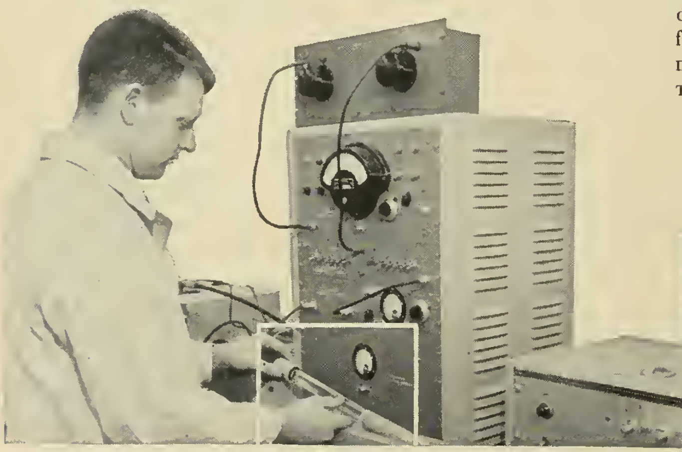
NEW TYPES ADDED TO BENDIX NOISE SOURCE TUBE LINE!

Expanding its line from 9 types to 35 types, Bendix Red Bank now offers a great variety of noise source tubes.

But great variety is only one advantage. Noise source tubes that are free from ambient temperature corrections are the result of making tubes so that no correction in noise figures is necessary from —55°C. to +85°C. What's more, long life and unusual stability result from precise quality control—far beyond the usually accepted tolerances for such products.

Whatever your applications, whether for 10° or 90° angle mounting, check with our specialists for the most efficient solution. Write RED BANK DIVISION, BENDIX AVIATION CORPORATION, EATONTOWN, NEW JERSEY.

West Coast Sales & Service: 117 E. Providencia Ave., Burbank, Calif.
Export Sales & Service: Bendix International Division, 205 E. 42nd St., New York 17, N.Y.
Canadian Distributor: Computing Devices of Canada, Ltd., P. O. Box 508, Ottawa 4, Ontario



Microwave test equipment used in calibrating all Bendix noise source tubes.

Red Bank Division

Bendix AVIATION CORPORATION

Circle No. 62 on Subscriber Service Card.

Navy to Test *Polaris* In about 18 Months

Polaris, underwater missiles and detection of submarine-launched missiles were major items discussed at a recent press conference held by RAdm. F. S. Withington, Chief of the Navy Bureau of Ordnance.

Adm. Withington told newsmen the Navy would carry out the first actual tests of *Polaris* in about 18 months. The tests, he said will be conducted off the Cape Canaveral test center, first from a fixed platform and then from a mobile launcher. Following further test launchings from the USS *Observation Island,* the underwater missile will be taken aboard a submarine as a full-fledged operating weapon.

Turning to another phase of submarine-launched missiles, Adm. Withington said detection of such missiles is still an important unsolved problem. A third item in the same area was the admiral's statement that the Navy is interested in an underwater-to-air-to-underwater missile. In the area of submarine detection and defense, he stated sonar capability today is five times as good as that in use during World War II.

Other points which came up during the conference included a proposal to use a beefed up version of the *Talos* as anti-missile missile is under consideration by the Army. The admiral explained the proposal calls for boosting the ramjet propulsion of *Talos* to a speed of Mach 10 within the next 10 years, and added the comment that the missile would be capable of flights to an altitude at more than 50,000 feet.

Touching on other matters, Adm. Withington said the addition of metallics to composite fuels is a major breakthrough in solid fuels. While the addition of metallics greatly increases the energy, a big problem is methods of handling the heat generated when aluminum powder is added to the fuel supply, he said.

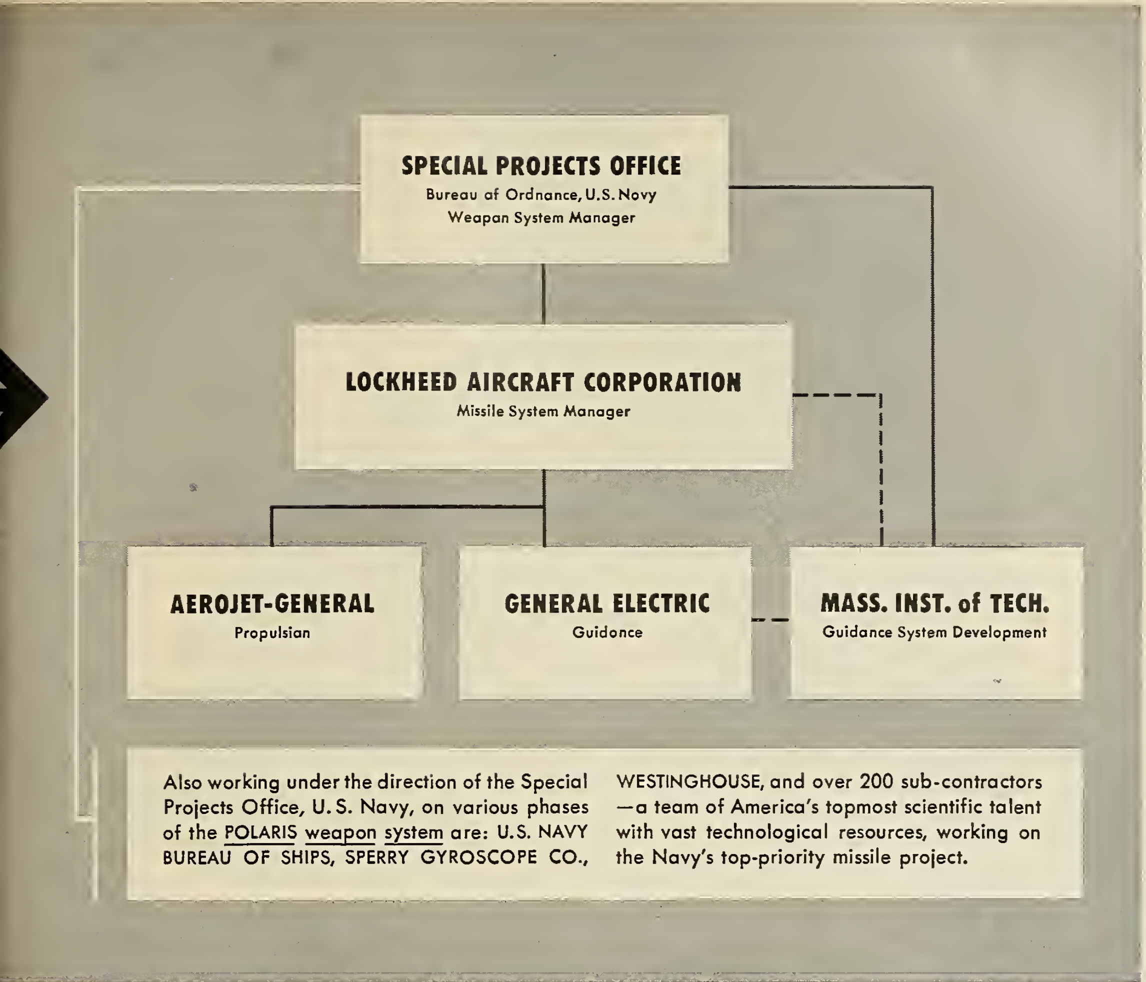
Adm. Withington said nuclear warheads are not planned for use in mines and the rocket-assisted torpedo, known as *RAT,* because of *RAT*'s short range and the fact that it would be too dangerous to use fissionable material in actions originating on the ocean bottom.

It will be several years before all ships of the Fleet can be equipped with missiles because of the expense, the Ordnance Bureau Chief told members of the press.

This is the task force developing the

POLARIS

—new Fleet Ballistic Missile for the U.S. Navy



Fourteen months ago Lockheed was appointed missile system manager of the POLARIS. The objective: to develop a solid-propellant missile with a thermonuclear warhead, which could be launched underwater from nuclear submarines to hit targets 1,500 miles away. The technological problems involved were admittedly the most complex yet encountered in the history of ballistic missile development.

Progress to date on the POLARIS has exceeded all expectations of the U.S. Navy. Lockheed is proud to be associated with its fellow task force members and the sub-contractors developing the complete POLARIS weapon system. The brilliant contributions and splendid teamwork of these more than 200 POLARIS subcontractors, and their dedication to our mutual goal—greater security for our nation—speeds the progress of the POLARIS missile system, prime responsibility for which is Lockheed's.

LOCKHEED *means leadership*

LOCKHEED MISSILE SYSTEMS DIVISION: *Palo Alto, Sunnyvale and Van Nuys, California*

MISSILE RESEARCH & DEVELOPMENT • BALLISTIC MISSILE SYSTEMS MANAGEMENT • ROCKETRY • ULTRASONIC AERODYNAMICS • OUTER SPACE INVESTIGATIONS • NUCLEAR PHYSICS • ADVANCED ELECTRONICS • HIGH-SPEED AUTOMATIC DATA REDUCTION • RAMJET PROPULSION TESTING

Circle No. 63 on Subscriber Service Card.

Circle No. 64 on Subscriber Service Card.

New Products

Multiplexer handles signals from 90 units

A device for PDM commutating and coding has been developed by Consolidated Electrodynamics. Termed the type 40-101 Plexicoder, the instrument commutates signals from up to 90 transducers at 112.5 samples per second and converts them into duration-modulated pulses suitable for telemetering or magnetic tape recording. The unit is designed for flight-test instrumentation in missiles, rockets, or manned aircraft.

In the instrument, low-speed magnetic switching at the input, with high-speed commutation and coding accomplished by interrupting a light beam, replaces rotating wiper-arm assemblies and wide-band chopper-stabilized amplifiers. Transients in the data-channel input circuit are practically eliminated by galvanometers with their inherent natural filtering characteristics.

Designed for a service-free life of 1000 hours, the Plexicoder is compatible with low-output resistive-type transducers, its output can modulate a transmitter or subcarrier oscillator, and it can be used with standard magnetic-tape recording equipment. It will accept single- or double-ended, high- or low-level inputs.

In the device, each input signal is fed through two hermetically sealed, magnetically operated switches, which act as a double-pole, single-throw switch, to a galvanometer. The unique design of this input switch eliminates induced voltages normally associated with a magnetic switch. These switches are opened and closed in a predetermined time sequence by moving magnets, so that a given galvanometer is energized by a transducer for only a specific time period. Each galvanometer may accept as many as six different inputs in sequential fashion.

The Plexicoder can provide four different operating modes or conditions from the same instrument, merely by changing adapter plugs in the input circuit. These modes are 90x1.25, 45x2.5, 30x3.75, and 15x7.5. In each mode, the commutation rate equals 112.5 samples per second.

The unit is shock mounted and will operate in any position. The instrument weighs 45 lbs. and is approximately 25″ high, with a diameter of 8¼″ except for the end section, which is 10½″. The unit is pressurized at 3 to 5 psi.

Circle No. 243 on Subscriber Service Card.

Clothes for Fuel Handlers Resists Acids, Corrosion

Newly developed industrial apparel of 100% DuPont Dacron has been introduced by Worklon, Inc. In addition to being resistant to damage by acids and corrosive chemicals, the new clothing has been proved unusually resistant to concentrated hydrogen peroxide.

Worklon blue or grey Dacron shirts, pants, laboratory coats and coveralls retain their tensile strength even after eight hours of immersion in 90% concentration of hydrogen peroxide at room temperature. The apparel will not ignite, even on longtime contact with H_2O_2.

Circle No. 239 on Subscriber Service Card.

Ceramoplastic Heat Limits Set Higher After Test

Operating temperature limits on Mycalex Corp.'s Supramica 560 ceramoplastic have been raised, due to an accidental overexposure of the material to 1600°F. The company had originally established the upper limits of the material at 950°F, but a control failure in the test oven boosted the temperature on a sample to 1600°F for more than 24 hours. The only damage done to the specimen was that two steel inserts were burned away, while the ceramoplastic sample suffered only scorched edges in the process but maintained its strength, retained its shape and was still firmly bonded to the remains of the steel bolts.

Circle No. 235 on Subscriber Service Card.

. . . New Products

Teflon Tape Bonded to Copper Foil

Continental-Diamond Fibre Corp. is developing a glass-supported Teflon tape with copper foil bonded to one or both sides for use as etched flexible cable harnesses for missiles. The tape may also be used as flexible connector in multiple-array printed-circuit "stacks" for computers and control devices.

In this new printed-circuit material, electrolytic copper foil in weights of either 1 or 2 oz. per sq. ft. is applied to one or both sides of cementable glass-supported Teflon tape. Depending on the weight of copper foil and the Teflon tape grade, the overall thicknesses run from .006" to .016".

At the present time, CFD can furnish this material on a developmental basis in lengths up to 30' and widths up to 6". The company expects, within 60 or 90 days, to manufacture it on a production basis in lengths of 100 ft. or longer.

The new flexible materials have excellent shock and vibration resistance, combined with high mechanical strength and dimensional stability, plus excellent electrical properties. It can be bent to a radius of ½". If supplied with copper foil on one side only, the other side can be furnished "cementable" or "non-cementable," as desired. For certain specialized applications, copper foil cemented to unsupported Teflon tape can be supplied.

Circle No. 242 on Subscriber Service Card.

High Temperature Relay Resists Shock, Vibration

A sensitive, miniature-tube relay with high shock and vibration resistance and 125°C ambient temperature capabilities is available from Potter & Brumfield, Inc. A 30% increase in shock and vibration resistance and a 50% decrease in power consumption was effected by redesigning and repositioning the armature and contact systems, balancing the armature, and improving the ampere-turns to reluctance ratio.

This SPDT relay operates on 40 milliwatts under shocks of 30g and vibrations of 10g to 500 cps. Where high shock- and vibration-resistance are not required, the unit, designated PW, will operate on 25 milliwatts. The relay will operate on current up to six amps and voltages up to 115 VDC.

The PW can be supplied with 7-pin miniature plug-in headers for tube socket or printed circuit mounting or with pierced solder lugs and brackets for flange mounting above or below the chassis. A balanced armature permits mounting in any position without significantly affecting shock and vibration resistance.

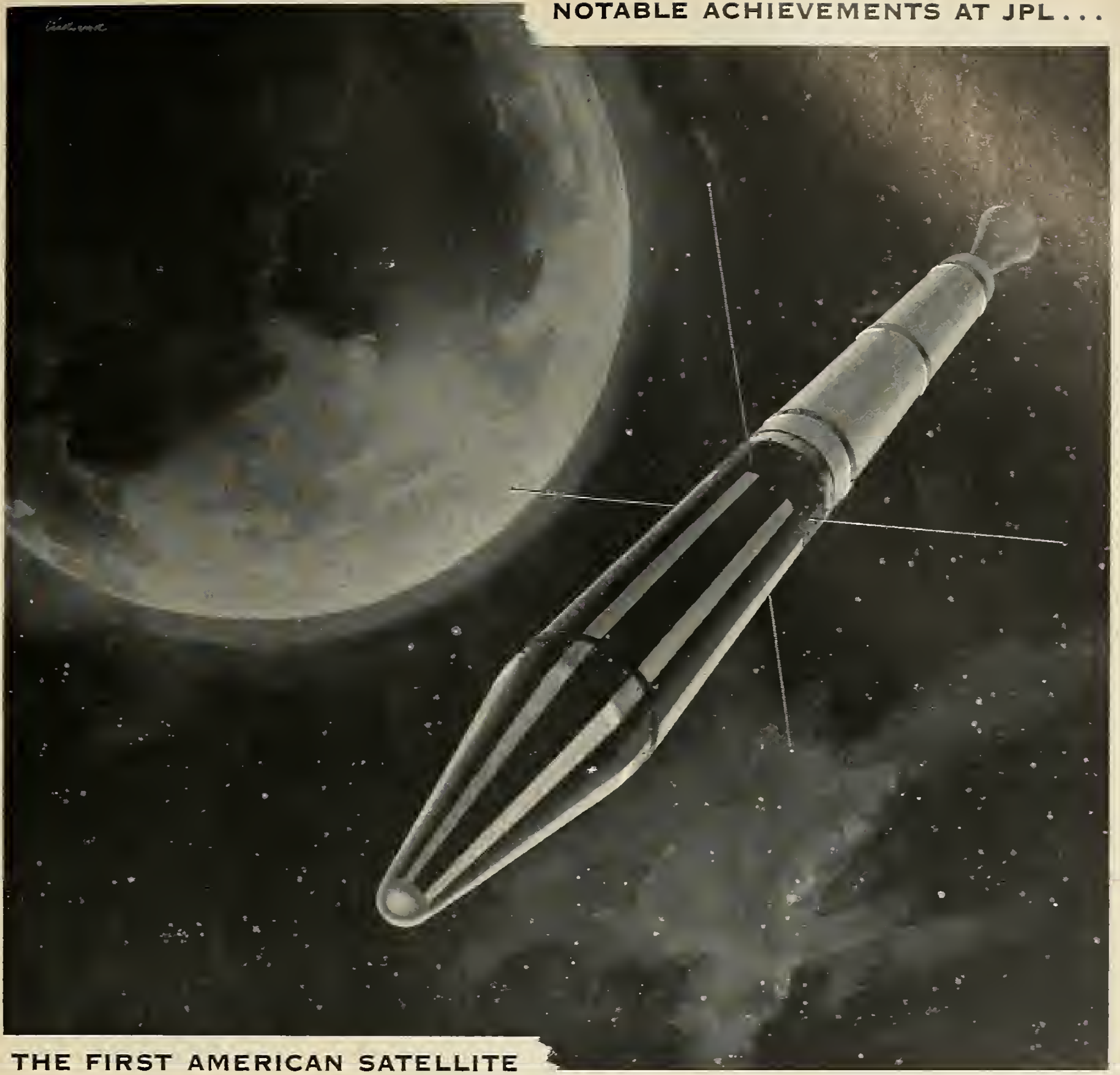
Circle No. 228 on Subscriber Service Card.

Miniaturized Switch Has Long Life Under High Heat

A miniaturized precision switch with a minimum life of 25,000 operations at 600°F has been introduced by Micro Switch, a division of Minneapolis-Honeywell. Designed for use on jet engines, rocket-powered missiles and electronic gear subjected to a great deal of heat or radiation, the new switch can be utilized in any application where a small high-temperature switch is desired without sacrificing quality.

The new switch, designated "V-3-1301," has a case, cover and plunger molded from a special-type glass-bonded synthetic mica, which features maximum dimensional stability, ability to withstand repeated shock and vi-

NOTABLE ACHIEVEMENTS AT JPL . . .



THE FIRST AMERICAN SATELLITE

With the launching of the "Explorer," in joint co-operation with the Army Ballistic Missile Agency, the Caltech Jet Propulsion Laboratory fulfills one of its prime functions as a pioneer of the future.

The Army's request for JPL to join in the effort to put an American satellite in orbit was the type of appeal most likely to arouse the enthusiasm of the Laboratory personnel — nearly 2,000 of them.

Challenged by this exceptional opportunity, JPL personnel designed and fabricated the final three stages of the Jupiter "C" missile and, in addition, designed and developed the satellite itself in 80 days.

The close co-operation and co-ordination of effort with the ABMA and the U. S. National Committee for the IGY, make JPL proud to have been a close partner with the U.S. Army in developing and launching the first American satellite.

Now, JPL, maintaining its established policy of scientific research, continues to assist in tracking, receiving, correlating and evaluating data from the "Explorer" as one of its many contributions toward solving the problems of the future.

CAREER OPPORTUNITIES NOW OPEN IN THESE FIELDS

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bration, resistance to moisture and extreme humidity, resistance to radiation and complete resistance to formation of radioactive byproducts. The switch has a two-piece snap-action spring that provides sure contact.

Flat bosses around the mounting holes, on both sides of the switch case, facilitate rigid mounting on common screws or rods for multiple cam control of several electrical circuits. The contact arrangement of the high-temperature switch is single-pole double-throw. The switch may be wired either normally-open or normally-closed. It has standard screw-type terminals.

Characteristics of the V3-1301 include operating force, 6 to 14 oz.; release force, 4 oz. min.; pretravel, .047″ max.; differential travel, .006″ to .016″; over-travel, .031″ min.; weight, .017 lb. max.

Electrical rating of the switch is 10 amperes at 125 or 250 vac; ½ ampere at 125 vdc, ¼ ampere at 250 vdc. At 30 vdc the inductive rating is 10 amperes at sea level and 6 amperes at 50,000 ft. The 30 vdc resistive rating is 10 amperes, or 6 amperes for a motor.

Circle No. 225 on Subscriber Service Card.

Simulation Table Planned for Smooth Operation

The "Micro Gee" simulation table is designed for angularly displacing gyros and accelerometers, in pitch and roll, either statically or dynamically. Extremely smooth operation is obtained by using specially designed driven pendulum mechanisms.

The servo controlled table is used in conjunction with an analog computer to make "flight testing" of a complete aircraft or missile stabilization system possible on the ground, as contrasted to such programs where gyro and accelerometer dynamics are linearly simulated. In addition, the two-degree-of-freedom simulation table may be used as an oscillating table to determine the threshold characteristics of high performance gyros and accelerometers.

The table will follow signals such as those from an analog computer, a low-frequency function generator, a tape recorder, or a digital-to-analog converter, when these signals are applied to the input terminals of the dc power amplifier that drives the table.

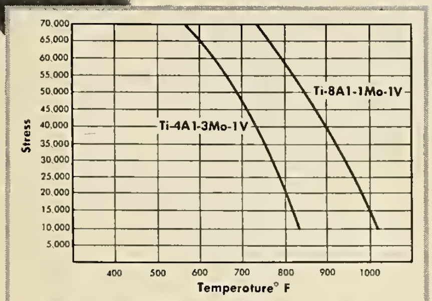
Circle No. 229 on Subscriber Service Card.

Ratio Transducer Gives Accuracy Over Wide Range

A new Mach number and pressure ratio transducer utilizing design advantages of a force balance mechanism to provide exceptional accuracy has been developed by Burton Mfg. Co. The unit operates at very high altitudes and over wide temperature ranges and features freedom from bellows or diaphragm hysterisis effects and friction errors.

This basic system operates from −65°F to 185°F and to very high altitudes. Its accuracy is of a high order at critical operating points. The advice produces an electrical output to the ratio of static and pitot pressure input. However, it can be provided to produce electrical output in response to the ratio of any two independent pressures as an output, within the capacity of the instrument. The output can be through a synchro or a similar ac-type unit, or a potentiometer, depending on specific requirements.

In this transducer, bellows translate pressure into forces acting upon beams. Misplacement is sensed through an inductive pickoff, the signal of which is amplified. Through a servo loop, a fulcrum moves to a position



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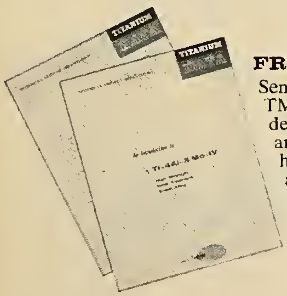
Whether your creep problem is sagging socks or stretching struts, the result is pretty much the same: Things don't hold their shape the way they should.

Garters we don't have. But we do have new titanium alloys which offer a rare combination of excellent creep resistance plus light weight (density 0.163 lb/cu. in.), great tensile strengths (to 175,000 psi), and outstanding corrosion resistance.

In bar and forging stock, there's Ti-8A1-1Mo-1V. Its short-time elevated temperature properties are similar to Ti-6A1-4V, one of the most widely used titanium alloys. Yet "8-1-1" offers as much as a tenfold increase in creep strength between 600° F, and 1000° F. This means that, for an equivalent stress level, Ti-8A1-1Mo-1V raises the effective operating temperature *150° F.*

In sheet stock, there's Ti-4A1-3Mo-1V, which offers excellent formability because of good tensile elongation, bend ductility, and low yield strength in the solution-treated condition. Yet this alloy can be heat-treated to strengths of 175,000 psi.

At Toronto, Ohio, Titanium Metals Corporation of America is now operating the world's only plant designed and instrumented solely for rolling and forging titanium. With this facility, TMCA can furnish you the best quality metal, on the fastest delivery schedule, at the lowest possible price in the industry today.



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which balances out forces upon the beam.

The system is basic in design and may be applied to produce an output as the result of Mach number or any pressure ratio. With a minor adaptation, the system provides a highly sensitive and accurate altimeter.

Circle No. 236 on Subscriber Service Card.

Parabolic Antennas Include Mounts, Systems

A series of 19-foot parabolic antennas are available from Technical Appliance Corp., including various combinations of mounts and feed systems using the same reflector.

The reflector is made up of four pie-shaped sections to facilitate easy transportation to installation site. The individual sections are readily assembled into an extremely rugged structure. The structural base of the antenna is a circular ring truss 8 feet in diameter. Preformed radial members fan out from the ring truss to the tips of the reflector. Circumferential tubing is heliarc-welded to the radial members. A rigid ring circumvents the entire structure. Reflecting surface is ½″ expanded aluminum mesh, the entire antenna being iridited and painted for long-lasting finish.

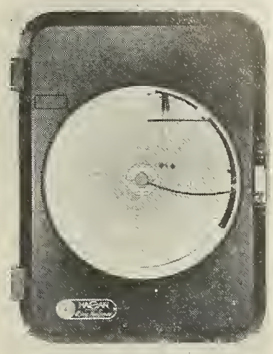
A choice of ground mount or tower mount is available. Both permit azimuth and elevation adjustments through 10″ of travel. Standard feeds are either dipole or horn-type, and special feeds for specific requirements are available on order. In addition, the reflector is available without feed system and with or without mount.

Circle No. 240 on Subscriber Service Card.

Signal Simulator Checks Telemetering Ground Units

The ASCOP MSS-3 is an accurate and flexible laboratory standard for simulating PW signals of 30x30, 45x20, 60x15, and 90x10 configurations for the checking and calibration of telemetering ground stations. It is specifically designed for use in the testing of PW telemetering stations used in the aircraft and missile field, as well as for engine teststands, nuclear reactors, powerplants, and similar projects. The MSS-3 makes use of solid-state devices throughout, with transistors operating in the switching mode exclusively. It provides accurate PW test signals while containing no commutator, operating mechanical components, nor electronic tubes. Consequently, the life of the unit is neither dependent on mechanical considerations nor tube life. Both standard PW and a differentiated PW output to simulate PW/PM signals are provided.

Circle No. 233 on Subscriber Service Card.



Electronic Recorder Reads Up to Four Remote Sources

An electronic recorder that can receive and record output from as many as four remote ring balance meter-operated slide wires has been developed by Hagan Chemicals & Controls, Inc. The instrument can be used to record any quantity measured by a Hagan Ring Balance Meter, including fluid density, liquid level in open or closed vessels, boiler-drum water levels and temperature- and pressure-compensated fluid flow readings.

Heart of the recorder is a newly designed electronic receiver, a compact unit housing an amplifier, input box, servomotor and slide wire. As many as four receivers can be installed in a single recorder. Various accessory combinations, including a pneumatic transmitter for control system signals, slide wire output for logging systems, alarm contacts and computing devices, can be used with the receiver.

Circle No. 227 on Subscriber Service Card.

Glass Fiber Jet Vane Reinforced With Resin

American Aerophysics Corp. has announced the successful fabrication and test of a jet vane manufactured of laminated glass fiber, reinforced with phenolic resin. The Jet Propulsion Laboratories of the California Institute of Technology, designers of the jet vane configuration, have stated that tests in the rocket blast of a missile have proven extremely successful.

A unique arrangement of laminations was employed which produced superior resistance to the severe eroding environments within the rocket blast. Instead of laying the laminates in parallel, they were placed with their edges sloped in the direction of the jetstream in order to avoid separation or tearing of the individual laminates. An extremely high-strength phenolic resin was used as a binder.

Circle No. 238 on Subscriber Service Card.

Pinhole Coil Winder Does Miniscule Job

Stanford Research Institute has developed a machine capable of winding coils on torroidal cores almost invisible to the naked eye. The machine is capable of winding coils with an outside diameter equal to the diameter of the hole through which they are wound, either from the center to the outside of the core, or through two adjacent holes in the same core. The ability of the machine to wind such coils is not impaired by the diameter-to-length ratio of the hole, or holes through which the coil is to be wound. It would be possible to wind a coil through two 0.010″ holes spaced on 0.060″ centers in a 3″-thick core.

The wire forming the coil is made to pull itself through the hole or holes through which the coil is wound. The set up time on the laboratory model of

the machine is about the same as on a standard commercial torroidal winding machine and can be reduced drastically on a production model. Actual winding time per turn is about equal to a standard commercial machine.

Circle No. 241 on Subscriber Service Card.

Linear Displacement Gauge Measures 0.001-in. Change

Model 0502 miniature linear displacement gauge available from Tucson Instrument Corp. gives potentiometer-type output for linear displacements as small as 0.001" with a total travel of 0.050". The resistance range of the elements is from 1700 to 5000 ohms. The unit can withstand environmental conditions at temperatures from −25°F to 185°F, shock of 100 g's, vibration of 0.60", double amplitude 20-55 cps and 10 g's 55-1000 cps. Individual calibration graphs are supplied with each instrument.

Circle No. 226 on Subscriber Service Card.

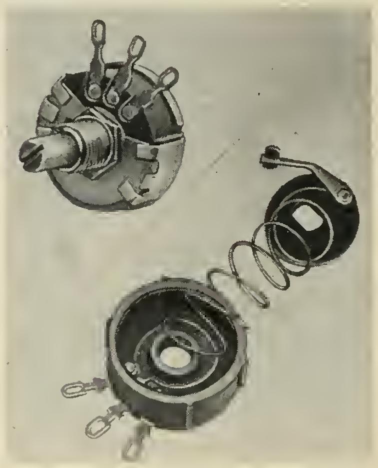
Heat Resistant Laminates Can Handle 3500°F

Continental-Diamond Fibre Corp. has introduced a new type of high-heat-resistant "Dilecto" laminate and "Celoron" molded parts for missile and rocket applications involving operating temperatures up to 3500°F or higher.

A major advantage of the new reinforced plastics is that they retain an exceptionally high percentage of their excellent mechanical properties after exposure to these elevated temperatures for short periods.

One application of the new asbestos-base phenolics involves continuous operation at 500°F and intermittent operation at 900°F. Other tests indicate that these laminates and molded parts have withstood temperatures of 2500° and 3500°F for limited periods. They are suitable also for applications based on the new concept of "ablation" or "using up" of materials in certain rocket and missile operations, where temperatures of 4000-5000°F are encountered.

Circle No. 234 on Subscriber Service Card.



Resistor Design Change Reduces Noise Level

Reon Resistor Corporation has developed a completely new design in a molded composition potentiometer. The elimination of the wiper arm collector by use of a beryllium copper spring between the contact arm and the center terminal greatly reduced the electrical noise generated by all conventional potentiometers.

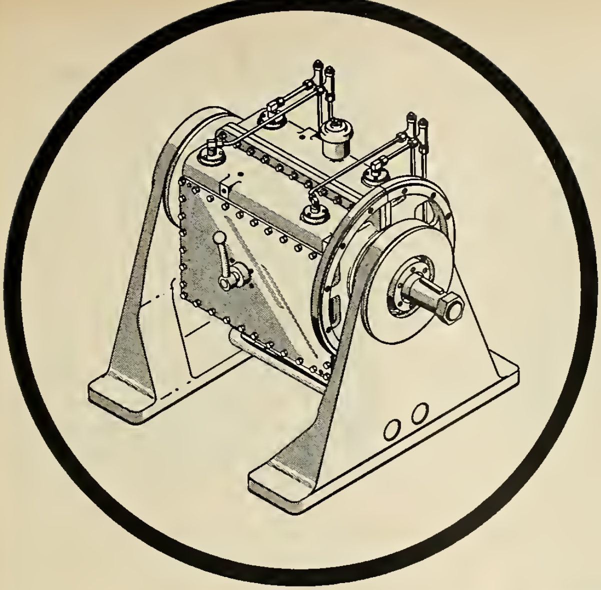
One moving point of contact, the carbon brush, on the resistance element reduces the noise to less than one-half and extends the rotational life of the potentiometer to over a million cycles. An overall resistance change of approximately 6.3% is average.

This potentiometer is manufactured to meet the "Y" characteristic of the new MIL R-94B specification, and is available in all tapers with both standard and locking bushings, as well as water-sealed units.

Circle No. 232 on Subscriber Service Card.

Self-Balancing Ratiometer Adjusts Precision Tools

A dual-channel self-balancing ratiometer for the calibration or adjusting of precision instruments has been introduced by Wallace O. Leonard, Inc. Useful for a wide range of applications,



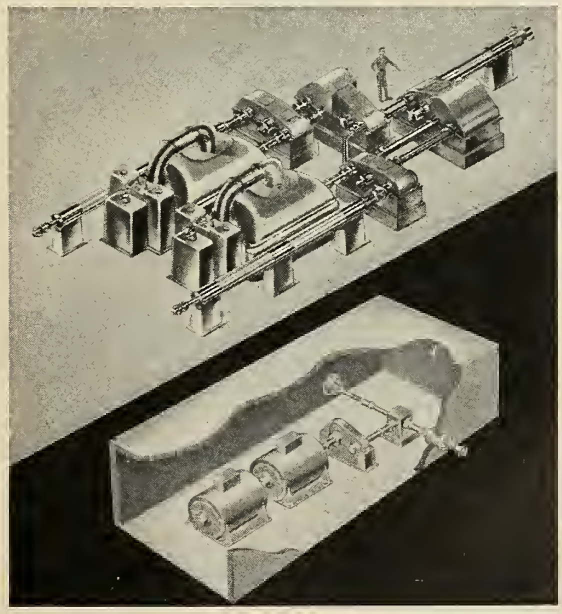
Here's a trunnion-mounted, multi-speed unit used with a dynamometer test facility for guided missile pumps. This unit has a top output speed of 60,000 RPM with a pitch line velocity in excess of 30,000 FPM or more than 340 miles per hour. Unit measures approximately 25 inches in length.

WESTERN GEAR

TEST STANDS and DRIVES...designed to

50,000 HP or 100,000 RPM

This giant test stand facility was designed for use by a leading Eastern aircraft manufacturer. The 2 steam turbines deliver 22,500 HP each. Top output speed is 9,000 RPM and the pitch line velocity is 30,000 FPM.



This test cell presented an "impossible" problem . . . how to transmit 3,000 HP at 7,000 RPM through a right angle gear box? The wall-mounted gear boxes are provided with quick change gear sets which can be shifted from 7,000 to 11,000 and 17,000 RPM. Inspection after unprecedented hours of service show the gearing to be in excellent condition.

Circle No. 68 on Subscriber Service Card.

Western Gear is designing and building drives and test stands for leading missile-components manufacturers and development laboratories ranging up to 50,000 H.P. or 100,000 RPM. Successful tests have carried designs to 200,000 RPM. Pictured on this page are three recent applications. Note the coupon below.

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the unit, with a guaranteed accuracy of 0.0005 ratio, can be utilized on potentiometer output instruments, voltage dividers, initial condition dividers for analog computers and many other precision jobs.

Designated model 700100-2, the ratiometer is designed for either laboratory or field use. It operates on normal 60-cycle line voltage. The self-balancing feature allows the operator free use of both hands for instrument adjustment while continuously observing the potentiometer wiper position. A null indicating light is mounted on the front panel for positive indication of a null condition. A switch allows channel selection for simultaneous checkout of two instruments.

Circle No. 231 on Subscriber Service Card.

Dual Output Generator for Missile Electric Power

The Ruckstell Corp. has completed development and is producing a new high-performance generator for missile electrical power. The dual-output permanent magnet, 24,000-rpm, ac generator produces 5 kva of 3-phase, 400-cps, 20/208 volt, and 3.4 kva of 6-phase, 1600-cps, 23-volt power which is rectified to direct current.

Using a lightweight, static-type voltage regulator to supply a toroidal back-winding, the 400-cps voltage is maintained constant with 0.5 volts for all steady load conditions and has a rapid transient response, recovering from full-load switching in 0.1 second. The rectified direct-current output has an inherent regulation of 26 to 30 volts dc. Overall efficiency of the generator is 90%, and greater reliability and lighter weight are achieved by the elimination of the exciter, brushes and slip rings.

Circle No. 237 on Subscriber Service Card.

New Plastic Tubing Zips Off or on Wires

Designed specifically for use in the electronic circuits of missiles and aircraft, nylar zippertubing is being manufactured by The Zippertubing Co. The product is said to be less expensive and easier and faster to install than conventional tubing coverings requiring pulling wires through tubing or short ex-

truder runs. Used as a protection for existing installed wires, cable or tubing, or as a cable jacket or shield, the new tubing saves up to 90% of installation costs and permits accessibility to work-points when required.

By laminating mylar zippertubing with aluminum, it is possible to construct shielded cable quickly without the use of additional equipment. The product is available in any desired size from 3/8" to 4" in 1/8" increments

(I.D.) and has an external flap for bead protection. It supplants vinyl zippertubing for use in applications that require wire, cable, or tubing protection against the harmful effects of chemicals.

Clear or metallic-colored mylar zippertubing is available in lengths from 20 to 30,000 feet. Other colors are available upon request. When sealed, the tubing will withstand a lateral pull strength of 60 psi.

Circle No. 230 on Subscriber Service Card.

Flow-Control Valve Permits Precise Control

A new, low-cost flow-control valve, said to permit precise control of air, gas or low pressure hydraulic flow with unrestricted return is being produced by Valvair Corp. Known as the Valvair Micro-Trol, the new valve features locked screw adjustment and a unique combination of controlling elements, a threaded stem and molded nylon flapper. The lower range of flow rates is metered by adjusting the position of the ground cylindrical stem within a concentric bore in the valve body.

As the regulating portion of the stem clears the bore, the stem end contacts the flapper, lifting it off its seat. Flow is then controlled by the clearance between the flapper and seat. Thus, flow is regulated with fine adjustment, from cutoff to full flow. On return, the flapper lifts clear, affording unrestricted passage of the controlled medium. Flow-rate adjustment is retained by an external lock nut on the slotted adjusting stem.

Valvair Micro-Trol valves are available in sizes ranging from ¼ in. through ¾ in. NPT. Flow area through the valve is said to exceed nominal rated pipe size. Valve body is of cast Navy M bronze, stem is stainless steel and the flapper is molded nylon. An O-ring seals and retains the stem.

Circle No. 271 on Subscriber Service Card.

Motor-Generator Produces Exact 400-Cycle Frequency

A small motor-generator set has been developed recently by the research department of Kato Engineering Co. for use in conjunction with military missile development programs. The generator portion of the unit produces an exact frequency of 400 cycles per second. It is single phase and rated at 1100 watts. The generator is self-regulated with voltage change kept within

Circle No. 113 on Subscriber Service Card.

5% from no load to full load.

The direct current motor is mounted on the same shaft, within the same frame as the alternator and is equipped with a speed governor which maintains constant speed despite load variations. The straddle mounted outlet box and control panel contains the necessary input and output lead wires and receptacles, voltmeter, ammeter, and dc motor starter. The unit is splash proof. Similar AC motor driven units are also available in completely brushless design.

Circle No. 272 on Subscriber Service Card.

Hose Built to Handle Fuming Nitric Acid

Hewitt-Robins, Inc., has developed a hose capable of handling fuming nitric acid missile fuel. The new hose is lined with a tube made of Teflon fluorocarbon resins capable of withstanding the chemical action and high temperatures encountered in the handling of fuming nitric acid. The fluorocarbon tube is reinforced with fabric and covered with a blend of natural and synthetic rubbers bonded to the tube. The hose will withstand temperatures up to 500°F. It is available with stainless steel fittings in diameters ranging from ½ to 3 in. and in lengths up to 75 ft.

Circle No. 273 on Subscriber Service Card.

Micro Switch Shows New Rotary Selection Switch

A new series of environment-proof subminiature rotary selector switch assemblies has been announced by Micro Switch Division of Minneapolis-Honeywell Regulator Co.

Small size is combined with complete-seal construction and precision multi-circuit switching. The assemblies, designated the 25AS series, are especially suited for use on aircraft and electronic control panels where space is at a premium. Dependable operation can be obtained in a temperature range of −65° to +212°F, the company claims.

The rotary selectors are supplied with from one to eight of the lightest environment-proof switching units. From two to eight detent positions are offered. The detent mechanism imparts a positive "feel" between each detent. There is a 45° angle between detent positions.

The precision switching units are sealed with an elastomer seal which is bonded to the pin plunger and alumi-

New Clark TOOLS SOLVE HOLE MAKING PROBLEMS

CLARK SPADE DRILLS
for lower cost per hole!
Easily reground to smaller diameters. Shanks drilled for coolant circulation. Straight or Morse tapers. Standard sizes 1¹⁄₁₆" to 5", other sizes on order. Prompt delivery!

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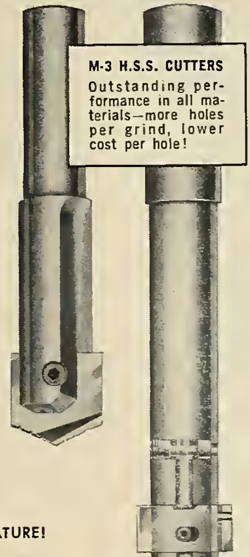
Free floating action, instant blade removal without destroying the set-up. Sizes: Finishing ⅝" to 6"; Roughing 1" to 6". Straight shank or Morse tapers. Other sizes on order.



M-3 H.S.S. CUTTERS
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Circle No. 116 on Subscriber Service Card.

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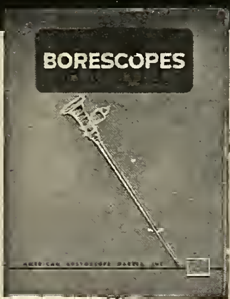
This booklet is for you!



This comprehensive, elaborately illustrated booklet provides practical information on the use of the famous A. C. M. I. Borescope in various industries, for the inspection of interior areas or surfaces not otherwise visible—together with full data on the types of Borescope available, and on their care and maintenance. Have you received your copy?

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HIGH-ENERGY FUEL BRIEFS FROM CALLERY

The Callery countdown has begun. When it reaches zero, two new fuel plants will stand ready to produce HiCal, trade-name for our high-energy zip fuel. The fuel from both plants will be HiCal 3, a liquid boron-carbon-hydrogen fuel for aircraft and missiles.

PLANT CONSTRUCTION ON SCHEDULE
One of two new plants is under construction at Muskogee, Oklahoma; the other at Lawrence, Kansas. Both plants are on schedule. The first units of the Callery-financed Lawrence plant were put into operation on April 1. And the plant at Muskogee — the one we're building for the Navy — should be finished by the end of 1958.

TARGET DATES FOR PRODUCTION
After reasonable lead-time to start the plants up, we anticipate fuel production at Lawrence by mid-1958 and some production at Muskogee early in 1959.

A WORD ABOUT AVAILABILITY
Distribution from the Navy-owned Muskogee plant will be handled by the Navy. No commercial sales foreseeable here. And while the fuel capacity from Callery's Lawrence plant is virtually all committed *now*, there may be quantities of fuel available in the *future* for authorized users.

ALSO ON TAP
We will also produce these other chemicals of interest to the propulsion field: Decaborane, Diborane, Triethylborane, Amine-Boranes and TMB. TMB is a metal fire extinguishent. It is effective against magnesium, zirconium and titanium fires. Still other chemicals of interest — primarily to the chemical industry — will be available in production quantities.

HOW WE CAN SERVE YOU
Although we will be fuel and propellant manufacturers ourselves, we would be very glad to consider *your* expected future large-scale requirements for fuel and propellant intermediates. When need for such materials becomes apparent, please get in touch with us.

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Stuart G. McGriff
Product Manager
Fuels and Propellants
Callery Chemical Company

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CHEMICAL COMPANY
9600 PERRY HIGHWAY
PITTSBURGH 37, PENNSYLVANIA

Circle No. 117 on Subscriber Service Card.

mum housing. The lead wires are embedded in an epoxy casting resin. Multiples of these single-pole double-throw basis switches allow a variety of wiring combinations.

With the seals deliberately broken, each basic switching unit is rated at 3 amperes, 28 vdc, inductive load, sea level; 2.5 amperes, 28 vdc, inductive load, 50,000 ft.

Circle No. 277 on Subscriber Service Card.

Pressure Calibrators For Transducers

Wallace & Tiernan Inc. have developed improved types of precision aneriod and dial type manometers for use as portable calibrators of pressure transducers.

Models of the calibrators have absolute pressure ranges starting at zero to 31.5 in. of mercury absolute and extending as high as zero to 150 inches of mercury absolute. Differential pressure ranges start at 0 to 120 inches of water and extend to 0 to 300 in. of mercury. The accuracy of all models is 0.1% of full-scale range. Readability and sensitivity to pressure change is one part in 10,000 and hysterisis has been reduced to a minimum.

Circle No. 274 on Subscriber Service Card.

High-Speed Pump Features New Gear Design

A high-speed hydraulic pump featuring a new gear design has been introduced by Hupp Aviation Co. Designated the Hupp Hydroid Pump, the unit features gears with an elliptical profile that eliminates trapping of liquid between teeth.

The patented gear design is the first to be developed exclusively for pumping fluids instead of for power transmission, according to the manufacturer. The nontrapping feature permits speeds in excess of 4000 rpm with hydraulic pressures of more than 1500 psi. Flow rates from three to more than 250 gallons per minute are available for specific applications.

Ability to operate at high speeds eliminates need of costly reduction gearing accessories on hydraulic applications. It is expected designs will be tailored for uses where higher pressures, quieter operation and gear pump economy are required.

Circle No. 276 on Subscriber Service Card.

Maintenance Kit Labels Lubrication Points

A plan of preventive maintenance for marking lubrication systems has been developed by the Meyercord Co. of Chicago. The plan provides for positive identification of lubrication points on machine tools, as well as on lubrication equipment and bulk containers. The markings are special type transfers, known as Lubri-Cals. They are resistant to abrasion, weathering, oil immersion and temperature variations. The kit consists of a total of 4276 markings which provide the proper frequency of numerals, letters and instruction nameplates for identifying lubrication points and for specifying the required lubricants for each application. Numerals are placed adjacent to the lubrication point on the machine along with a letter denoting the required lubricant.

Circle No. 275 on Subscriber Service Card.

Readout Counter Has Life of 300 Million Counts

A high-speed electro mechanical switch readout counter with a life expectancy of 300 million counts and offering switch readout function on each point of its five digital wheels has been developed by Autron Engineering, Inc. Now in production the Neuron switch readout counter features rates to 40 counts per second and is available with either manual or electrical instantaneous pulse reset. Also available are models responding to a variety of ac and dc actuation voltages.

Intended for industrial high-vibration and heavy g-load airborne applications, the counter has a bidirectional stepping mechanism which cannot double-index during shock, vibration or overvoltage.

Autron claims the switch contact life is 50 million operations at recommended ratings. Static switch current capacity is 1 amp and the dynamic switch current capacity is 100 milliamps.

Circle No. 278 on Subscriber Service Card.

Printed Circuit Connectors. New contact design eliminates possibility of damage to either contact or circuit board during assembly or multiple insertion. Eversole Associates, Inc.

Circle No. 279 on Subscriber Service Card.

. . . New Products

Lightweight Fuel Control For Missile Powerplants

Chandler-Evans Division of Pratt & Whitney Co., Inc., has developed a series of lightweight low-cost fuel controls for use on small gas-turbine powered missiles and target drones. Known as the model MC fuel control series, each unit is simple in design and incorporates a pneumatic speed governor which enables it to maintain constant speed from sea level to 60,000 feet.

Each unit is a unitized fuel system incorporating a positive displacement gear pump, a metering valve and a bypass valve.

Circle No. 281 on Subscriber Service Card.

Sensitive Transducer Features Reliability

Servomechanisms, Inc. has designed a pressure transducer, designated SMI type TR 719, for conversion of an ac excitation to a dc output signal that is proportional to differential or absolute pressure. The unit has been made for use in telemetry pressures such as aerodynamic, powerplant or hydraulic systems. It can also be employed in various other applications such as the sensor in a dc feedback loop. It is said to be ideally suited for high accuracy and high environmental missile requirements where standard potentiometer transducers exhibit excessive friction, resolution and unreliability.

The unit operates in the ranges from 15 to 3000 psi and the manufacturer states that its design allows accurate and reliable operation under relatively high shock, vibration and acceleration.

Circle No. 282 on Subscriber Service Card.

Power Supply Fills Precision Requirements

A transistorized power supply developed by Southwestern Industrial Electronics Co. has been made available for any desired output between 1 and 25 vdc. Rated output current is 350 ma and the regulation over the entire input voltage and output current ranges is 1%.

The 120 vac input is reduced through a specially designed SIE transformer, rectified in a bridge circuit and filtered. The aluminum case contains output terminal connections, switch, pilot light, and a 0.25v adjustment control on an anodized front panel.

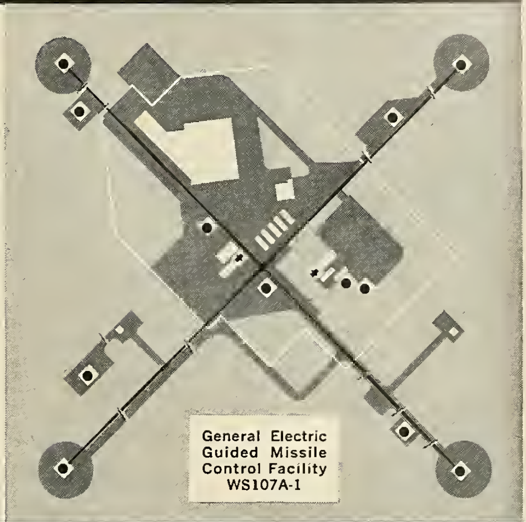
Circle No. 280 on Subscriber Service Card.

GRADUATE EE'S: GENERAL ELECTRIC DISCLOSES HIGH PRIORITY PROGRAM FOR ATLAS

GUIDANCE SYSTEM. MANY POSITIONS OPEN IN ELECTRONIC MISSILE TECHNIQUES=

ACCURACIES ON ORDER OF 1 PART IN 10 MILLION

required for portions of G.E.'s ICBM ATLAS Guidance System


General Electric Guided Missile Control Facility WS107A-1

Delivering an ICBM over a > 5000 mile trajectory into the target area demands a guidance system of unprecedented accuracy—and this is the calibre of the electronic system General Electric engineers are creating for ATLAS.

But achieving designated accuracies and reliabilities in the laboratory is not enough. *These high standards must be maintained in actual operational environments, with virtually no interruption or degradation.*

CAREERS IN STEP WITH THE FUTURE

Engineers who join the Missile Guidance Product Section of G.E. are doing more than hastening development of one of the nation's most urgent programs—guidance for ATLAS. As Manager of the Section Richard L. Shetler states: *"With this job behind us, there will remain no significant obstacle to the practical guidance and navigation of other space vehicles."*

PROGRAM ACCELERATION OPENS UP WIDE RANGE OF POSITIONS IN:

Systems analysis, evaluation & integration
Systems and component reliability
Transistorized circuits, pulse circuitry, IF-Video circuits
RF and Microwave components & plumbing
Communications control devices
Doppler radar design & development
Digital data processing techniques, data transmission involving D & D of ground-based & airborne antennae, transmitters, receivers; application of transducers, transponders, etc.
Test operations, including planning, range instrumentation & test execution; development & application of automatic test equipment

If you feel that your special skills and interests fit you to work in any of the above areas, why not write us in detail? Qualified candidates will be invited to visit our facilities to meet with technical managers and gain first hand knowledge of the living advantages of our locations at Syracuse and Utica, N. Y.

Write in complete confidence to Mr. E. A. Smith, Room 4-G

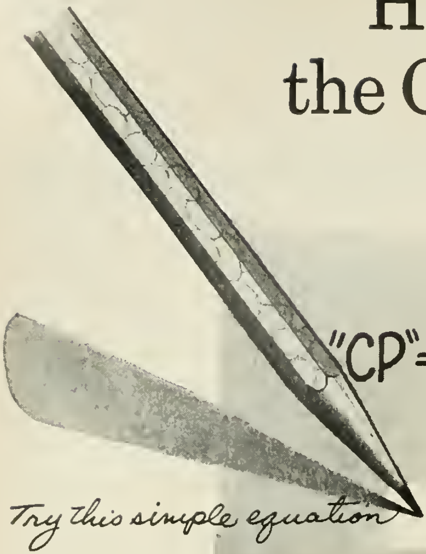
MISSILE GUIDANCE PRODUCT SECTION

GENERAL ELECTRIC

Court Street, Syracuse, N.Y.

ENGINEERS

How Do You Evaluate the Career Potential ("CP") of a Position



$$\text{"CP"} = EA + 2\,[F+M] + \frac{2\,[RS+B-G]+I^2}{4} + 2$$

My Present "CP" = ____________

"CP" VALUES; to test your "CP," circle the value you'd give each symbol below, substitute, AND SOLVE. *(Top value obtainable, 99.5)*

	"CP" VALUES	LOW			HIGH
E	Encouragement to Exercise Initiative & Creative Imagination	2	3	4	5
A	Assignment (Nature of)—from Routine to Very Challenging	5	6	7	8
F	Field—Conventional Product to Area where Technical Breakthroughs Expected	2	3	4	5
M	Modern Facilities—from Limited to Extensive Equipment for Testing and Research	2	3	4	5
R	Recognition of Individual Contributions—Chief Reason for Advancement.	2	3	4	5
S	Salary—from Unsatisfactory to Excellent for Level of Work	5	6	7	8
B	Benefits—from Limited to Best in Industry, including Encouragement to Join Professional Societies; Liberal Support for Graduate Study	2	3	4	5
G	Increases—Primarily by Seniority Rather than Merit.	2	3	4	5
I	Your Individual Skill, Creativeness and Ability to Take Responsibility	5	6	7	8

If your solution is 85 or less, it will be worth your while to inquire about the new opportunities in research and development now open at Republic Aviation.

These are specialist positions—requiring men of high calibre and a strong background of experience for advanced work on supersonic and upper atmosphere projects in aircraft, missiles and space vehicles.

The Department Head in your field will personally study your resume. If he feels there is an opening here which will engage your interest and fit your qualifications, he will arrange for an interview. And provide you with specific information—with which to evaluate your Career Potential at Republic.

CURRENT OPENINGS FOR SPECIALISTS
(With 5 to 10 years experience)

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Heat Transfer · Air Load Requirements
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Mr. George Hickman, Engineering Employment Manager

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Your requests for information will be forwarded promptly to the companies concerned.

NEW PRODUCT BRIEFS

LIMIT SWITCHES. Hermetically sealed limit switches offer operation from—65° to 600°F and consist of corrosion-resistant metal enclosure protecting a double-pole double-throw switching unit. MICRO SWITCH.

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SOLDERLESS TERMINALS. Rectangular tongue solderless terminals in insulated or noninsulated types are designed for hard-to-reach applications. Available for 22-16 and 16-14 size wires, the units have full 1/4" working shank and V-type groves in throat for firm grip and vibration proof connection. Constructed of pure cooper and electro-tinned for maximum corrosion resistance. Other plating may be specified. Hollingsworth Co., Solderless Terminal Div.

Circle No. 248 on Subscriber Service Card.

SYNCHROVERTER CHOPPER. Low-noise miniature chopper features low thermal construction and particularly suited to chopper-stabilized d.c. amplifiers where thermal stability and extremely low noise are vital. Has complete electrostatic shielding of the coil from the contact assembly, embodies modular construction and has operating range frequency of 0-700 cps. Thermal stability under general laboratory conditions is less than —2 microvolts. The Bristol Co.

Circle No. 249 on Subscriber Service Card.

ALUMINUM OXIDE CERAMIC. Nonporous 99.0% aluminum oxide ceramic material exhibiting 30% more strength than the best commercial high aluminas of 96% to 98% aluminum oxide. The material has a tensile strength of 34,-000 psi, or as strong as cast iron. It retains 75% of this tensile strength (20,000 psi) at 2000°F. The material, designated Coors AD-99, is said to be a superdielectric, with a loss factor lower than tetrafluoroethylene resins. The AD-99 ceramic is available on a production basis from Coors Porcelain Co.

Circle No. 250 on Subscriber Service Card.

SILICONE FLUID. A new methyl phenyl silicone fluid capable of withstanding more than 1000 hours exposure to air at 250°C without decomposing or jelling has been marketed by GE. Designated 81705, the fluid is applicable over the temperature range —40 to 500°F. It has low volatility, high flash point, good electrical properties and good lubricity. General Electric.

Circle No. 251 on Subscriber Service Card.

RECTILINEAR POTENTIOMETER. This unit, designed for a variety of missile applications, including hydraulic actuators, motor gimbals and control surface indication is said to be particularly adaptable where linear position measurement is required under difficult environmental conditions. The device will operate accurately under vibration conditions up to 20 g's in temperature environments up to 275°F. Servonic Instruments Inc.

Circle No. 252 on Subscriber Service Card.

MOUNTING SYSTEM. Lightweight standardized mounting system designed for the protection of fuel control equipment from destructive vibration and shock in high temperature propulsion section of missiles. Robinson Aviation, Inc.

Circle No. 253 on Subscriber Service Card.

UMBILICAL DISCONNECTS. Designed specifically for missile umbilical disconnects or other severing functions where guillotine choppers are not feasible, this explosive electrical disconnect is designed around the 55-circuit Bendix pygmy connector. It converts the pygmy unit into a reusable explosive-actuated device without altering the electrical characteristics of the original connector. Beckman & Whitley, Inc.

Circle No. 254 on Subscriber Service Card.

SHUTOFF VALVE. Manual shutoff valve model 949T for high pressure gas systems materially exceeds valve requirements of MIL-C-2680. Primary features of the valve include easier operation with threads out of fluid stream above the stem seal, reduced operating torque and increased depth of finger indents in handle. Provides positive, leakproof shutoff by means of a resilient O-ring; yet the O-ring is withdrawn completely and automatically from the fluid stream as soon as the valve begins to open. Throttling is accomplished by a conical metal plug which varies the orifice area. James, Pond & Clark, Inc.

Circle No. 255 on Subscriber Service Card.

PHASE METER. Phase accuracy of 1° from 10 cps to 10 kc is a feature of a transistorized phase meter designated model 328-A. Operating characteristics include long-time stability, frequency range from 10 cps to 50 kc, direct reading from 0° to 360° in 6 ranges of 60° each on a 5" meter scale, recorder connections and operation from an external 45-volt battery, if desired. Acton Laboratories.

Circle No. 256 on Subscriber Service Card.

MISSILES AND ROCKETS
April, 1958
Expires 30 Days After Above Date

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• • New Missile Products

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MISSILE LITERATURE

ACCELERATION TESTS. An illustrated folder covering centrifuge acceleration test equipment, giving specifications, performance data and accessory information has been published by the Rucker Co.
Circle No. 200 on Subscriber Service Card.

TAPE RECORDER. Sixteen-page brochure on the model 800 airborne magnetic tape recorder describes the equipment and gives complete specifications and operating features. Photographs and a tabular presentation of the various data requirements are included. Ampex Corp.
Circle No. 216 on Subscriber Service Card.

STAINLESS STEELS. Product data sheet discussing magnetism of wrought and cast stainless steels and its relation to corrosion resistance is available from Alloy Steel Casting Co.
Circle No. 201 on Subscriber Service Card.

THERMO-PANEL COILS. Bulletin describes new type of unit to replace standard pipe coils in heating or cooling processes. The panels consist of two metel plates, embossed and welded together to form flow channels. Bulletin gives design features, price information and various other data. Dean Thermo-Panel Coil Division.
Circle No. 202 on Subscriber Service Card.

SMALL BUSINESS PROBLEMS. Research and problem-solving in small businesses are treated in this report for the Office of Technical Services. Report states that small- and medium-sized manufacturing firms depend to a large degree on the large firms who supply them with raw materials and equipment for the solution of their technical problems. Department of Commerce.
Circle No. 203 on Subscriber Service Card.

CERAMIC FABRICATION. Recently published book representing the combined knowledge of 22 specialists and providing details on both the technical basis and present practice in the field of ceramic fabrication processes. Priced at $9.50, the book is available from John Wiley & Sons, Inc.
Circle No. 204 on Subscriber Service Card.

POLYETHER FLEXIBLE FOAMS. Technical bulletin containing six pages of new fundamental data on the formulation, preparation and curing of polyether flexible foams, together with a summary of the properties and performances of the resulting products. Data is given in tabular form and a 90-day graph on the effect of humid aging is included. National Aniline Division.
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ALUMINUM SHEET AND PLATE. Illustrated 320-page volume includes aluminum's characteristics and practical application for a variety of sheet and plate fabricated parts and assemblies. Book describes aluminum's availability, physical and chemical attributes, production methods end alloys. Kaiser Aluminum & Chemical Sales, Inc.
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TUBE FORMING. Catalog covering tube-forming facilities of Aeroquip Corp. and giving case histories of customers' tube requirements and fulfillment by Aeroquip. Engineering data, design hints for engineers and illustrations of tube-producing machinery are included. Aeroquip Corp.
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PERMANENT MAGNETS. Loose-leaf style illustrated handbook fully covers the nature, characteristics and economic uses of permanent magnet materials. It contains sections on permanent magnet design, magnetic measurements, theory of ferromagnetism, and electromagnetic theory, among other subjects. Includes a 125-page specifications and data section presenting nominal magnetic, physical and mechanical data as well as other information. Supplemental data will be mailed to keep the volume up to date. Crucible Steel Co. of America.
Circle No. 208 on Subscriber Service Card.

MISSILE TRACKING CAMERA. Full technical details on the Gordent 200 camera which measures 6" long, 3½" high x 2½" wide. Camera is intended for missile tracking, testing and airborne flight-data recording. Literature covers high-speed magazines as well as optical and other accessories. Gordon Enterprises.
Circle No. 209 on Subscriber Service Card.

PRINTED CIRCUITS. Booklet listing some suggestions on printed circuit layout and design. Based on production experience and incorporating information not readily available in standard literature. Ansley Mfg. Co.
Circle No. 210 on Subscriber Service Card.

RUBBERIZED ABRASIVES. Industrial catalog lists rubberized abrasives for deburring, smoothing and polishing operations. Describes nature, uses and other data on product. Cratex Mfg. Co.
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CALIBRATOR & TESTER. Four-page brochure details performance and specifications of impact wrench calibrator and tensile tester. Describes uses in checking fastener strength, calibration and maintenance of power wrenches, and setting assembly torque standards. Skidmore-Wilhelm Mfg. Co.
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FREQUENCY MEASUREMENTS. Data file 111, describing methods of measuring low to UHF frequencies, rotational velocity, flow, pressure, temperature and strain. Covers telemetry and setting up secondary standards of frequency. Uses graphs & charts liberally. Beckman/Berkeley Division.
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ELECTRONIC REQUIREMENTS. A guide to environment design requirements in research and development of electronic parts has been prepared by the Defense Department. The volume deals with related test procedures, components under nuclear radiation, missile components and highly specialized components. Data is given for temperature, pressure, moisture, vibration, shock, acceleration, explosive atmosphere, sand and dust, salt atmosphere, flammability, nuclear radiation and fungus resistance. OTS, Department of Commerce.
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MECHANICAL RUBBER. Bonding of molded mechanical rubber to metal (including aluminum), compounding of rubber for tailor-made jobs, and uses of metals when cushioned with rubber where metal-on-metal cannot be used, are described in a 24-page illustrated booklet available from Henry Engineering Co.
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