OCTOBER 5, 1959

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

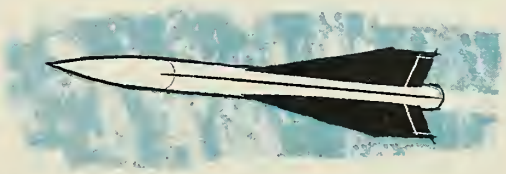
Need a **NONCRITICAL** *material to solve a* **CRITICAL** *heat problem?*

Consider these Goodyear Aircraft capabilities in the field of high-temperature laminates –

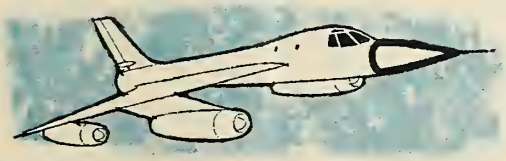
HERE'S AN INEXPENSIVE BLAST DEFLECTOR – made of reinforced plastic – which can withstand the direct blast of a rocket engine. Goodyear Aircraft stands ready to design and fabricate economical, reusable blast deflectors to your specific requirement.

CRYOGENIC FUEL TANK INSULATION by Goodyear Aircraft is less than ¼-inch thick, yet has proved its ability to prevent "boil off" of liquid gaseous rocket fuels, such as liquid oxygen and liquid hydrogen. Use of a plastic laminate for this purpose can mean substantial weight, space and cost savings.

NOSE CONES FOR GLIDE RE-ENTRY VEHICLES can be produced at Goodyear Aircraft to a wide range of specifications. The reason: extensive experience with ablative and thermal-resistant techniques. Do you need a lightweight nose cone material that can withstand 2000° to 2500° for an hour or more? Whatever your re-entry requirement, a specially compounded high-temperature laminate may well be the answer.



LEADING EDGES OF MISSILES or aircraft can be protected against prolonged high-temperature exposure by plastic laminate coverings which conform to the metal structure. Reinforced plastic laminates by Goodyear Aircraft can also be used for jet vanes, rocket nozzles, fins and other miscellaneous missile components.



RADOMES FOR AIRCRAFT which operate at Mach III and above have been produced at Goodyear Aircraft. Goodyear Aircraft has a vast background in radome engineering and manufacturing for both the solid and honeycombed layered constructions.

"PLASTIC" MISSILES – built by Goodyear Aircraft – could utilize a variety of plastic laminates and fabrication techniques. Advantages of such all-plastic components: no use of critical material, high strength-to-weight ratio, low cost in mass production, rust- and corrosion-resistant.

Your inquiry is invited *regarding these specific capabilities – or any requirement calling for a noncritical, high-strength material which must retain its properties under the most demanding heat and stress conditions. WRITE: Goodyear Aircraft Corporation, Dept.* 916 PS *Akron 15, Ohio.*

ENGINEERED PLASTICS *– ONE OF THE PRIME CAPABILITIES OF*

GOODYEAR AIRCRAFT

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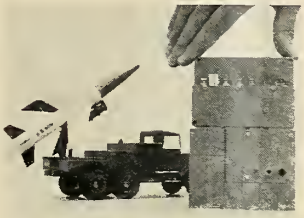
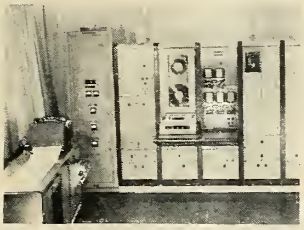
AUDITED PAID CIRCULATION ABC — NBP — READERSHIP Customer RESEARCH — BUSINESS PAPER LEADERSHIP ABP

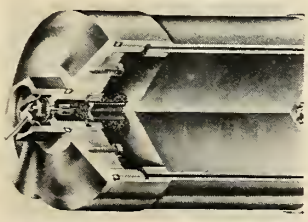
COVER: Nord Aviation *SS-10's* mounted on Bell H-13 helicopter at Ft. Rucker, Ala., where Army pilots are being trained to use the French missiles in close support of ground troops.



MARTIN's subminiaturized FM/FM telemeter for *Lacrosse* transmits 10 channels of go/no-go data. Progress in telemetry has been impeded by lack of coordination. Survey starts on p. 15.



CEC's computer input facility has editing equipment and IBM 727 tape transport (at right) for providing tape compatible with IBM 704 computer. For a report on the system, see p. 23.



AEROJET produced this pyrotechnic igniter installed in a gas generator. Pyrotechnics are probably the most-used ignition system today. A survey of the field begins on p. 30.

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

31,700 copies of this issue printed

OCTOBER 5 HEADLINES

ASTRIONICS

MISSILE SUPPORT

U.S. Reg. Pdg.

ASTRONAUTICS ENGINEERING

U.S. Reg. Pdg.

NEW MISSILE PRODUCTS

THE MISSILE WEEK

U.S. Reg. Pdg.

DEPARTMENTS

—when and where—

OCTOBER

Institute of the Aeronautical Sciences, Anglo-American Aeronautical Conference, Hotel Astor, New York, Oct. 5-7.

Society of Automotive Engineers, National Aeronautics Meeting, Aircraft Manufacturers Forum and Aircraft Engineering Display, The Ambassador Hotel, Los Angeles, Oct. 5-10.

Electronics Industries Association Conference, University of Pennsylvania, Philadelphia, Oct. 6-7.

Radio Interference Reduction and Electronic Compatibility Conference, sponsored by the **U.S. Army Signal Research and Development Laboratories,** conducted by Armour Research Foundation of Illinois Institute of Technology and Institute of Radio Engineers Professional Group on Radio Frequency Interference, Museum of Science and Industry, Chicago, Oct. 6-8.

Aeronautical/Astronautical Problems of High Speed Flight Meeting, Sponsors; **AFOSR/Aero Sciences Directorate, ONR, OOR, NSF,** and **Stanford University,** Stanford, Calif., Oct. 6-8.

AFOSR/Solid State Sciences Directorate, AEC, ONR, NSF, OOR, Stanford Research Institute and several industrial organizations, International Symposium on High Temperature, Asilomar, Calif., Oct. 6-9.

AFOSR/Propulsion Research Division, Aeronautical Sciences Directorate and **AVCO-Everett Research Laboratory,** Second Symposium on Advanced Propulsion Concepts, (Classified) Boston, Oct. 7-8.

Society of Experimental Test Pilots' Symposium, Pilots Role in Space Exploration, Beverly Hilton Hotel, Beverly Hills, Oct. 8-10.

American Institute of Electrical Engineers, Fall General Meeting, Morrison Hotel, Chicago, Oct. 11-16.

National Electronics Conference, sponsored by **American Institute of Radio Engineers, Northwestern University,** and **University of Illinois,** Hotel Sherman, Chicago, Oct. 12-14.

Institute of Aerophysics, University of Toronto, Decennial Symposium, Toronto, Canada, Oct. 14-16.

University of Denver, Conference on Hypervelocity Projection Techniques, Denver, Oct. 20-21.

American Standards Association, Tenth National Conference on Standards, Sheraton-Cadillac Hotel, Detroit, Oct. 20-22.

Society for Experimental Stress Analysis, 1959 Annual Meeting, Hotel Pick-Fort Shelby, Detroit, Oct. 21-23.

Armour Research Foundation, 15th Annual National Conference, Hotel Sherman, Chicago, Oct. 26-30.

AFOSR/Mechanics Division, Aeronautical Sciences Directorate, WADC, ONR, (host) **AEC, ERDL, BUORD, BUSHIPS, BUAER, NASA, Maritime Adm.,** First International Symposium on Gas Lubricated Bearings, Washington, D.C., Oct. 26-28.

B.F.Goodrich

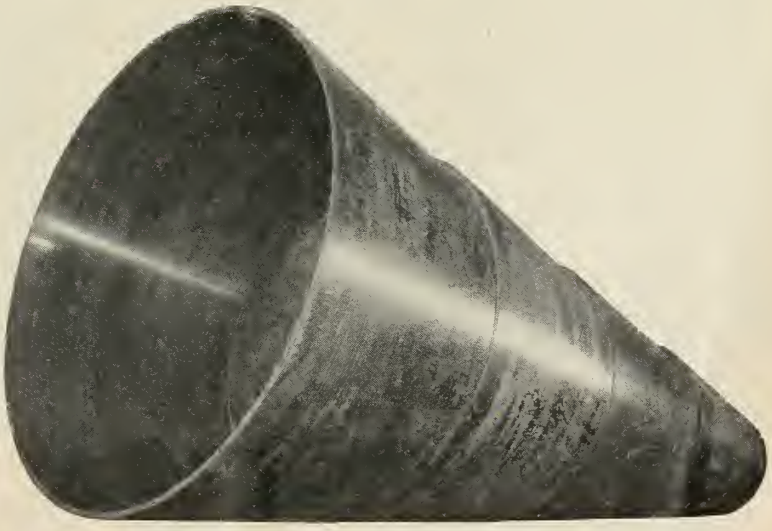
WHAT IS IT? Probably the biggest homogeneous void-free laminate ever built . . . a B. F. Goodrich ablation shield for an experimental re-entry vehicle designed and built by General Electric to be test flown on an Air Force Atlas ICBM.

Fabricated by a special B. F. Goodrich winding technique, the shield contains about five miles of high-temperature resin tape. This fabricating technique, which is also being used for many other specialized B. F. Goodrich products of various types and sizes, completely eliminates precision matched metal molds, cuts tooling costs by hundreds of thousands of dollars, and saves plenty of lead time. Autoclave curing replaces massive high pressure presses.

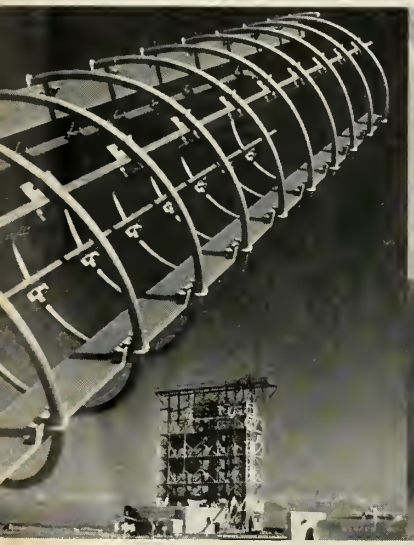
Throughout the construction of this re-entry vehicle shield, B. F. Goodrich maintains constant quality control of resin content and residual volatiles. Modern radiological facilities are used for final checking.

The fabrication and curing of such huge void-free parts illustrates the advances made by B. F. Goodrich in producing high-temperature, reinforced plastic products. So if you're up in the air and want down-to-earth answers on plastic laminate constructions, contact *B. F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Dept. MR-109, Akron, Ohio.*

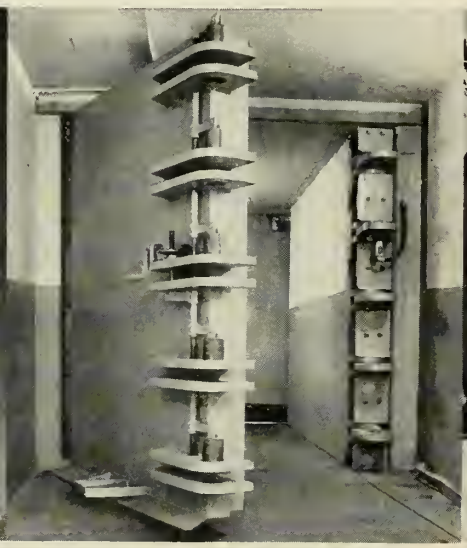
B.F.Goodrich *aviation products*



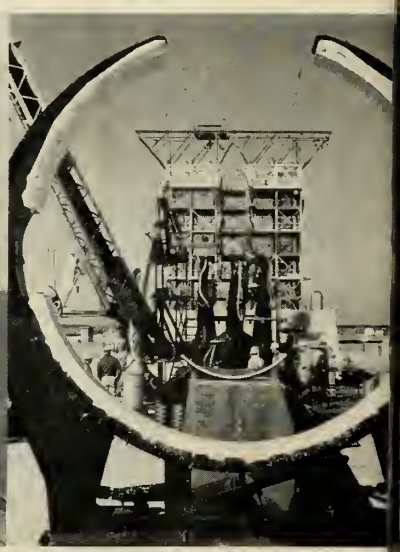
About the earthly side of Canaveral—Only recently, it spawned little more than snakes and other crawling creatures. Today, high flying birds are poised there, and because they can't jump off from sand, most of the Canaveral manpower and materials go into ground support equipment. And virtually all the steel material required can be purchased from one source—United States Steel. Whether we're talking about carbon steel, high-strength low-alloy steel, constructional alloy steel, or stainless steel, steel fence, electrical cable, wire rope or cement,



On this vertical oscillating radar tracking unit, every nut, bolt, and insulator collar is Stainless Steel. To the right, is a Stainless Steel fuel tank, and beyond that rises the U. S. Air Force Thor gantry tower, with a structural steel frame similar to a nine-story building.



The door to the U. S. Air Force Atlas blockhouse weighs 24 tons. It is solid manganese steel about eight inches thick. At X minus 15, the door automatically locks and it is blast-proof and vapor-proof.

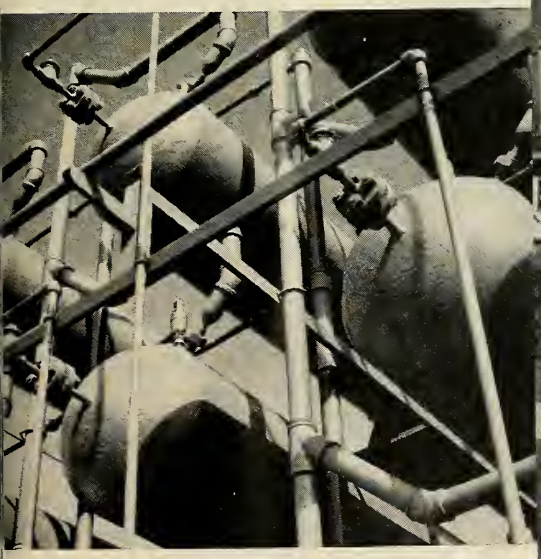


The mobile transporter for the Thor is strong but light on its wheels because it was designed with weight-saving high-strength steels. Slanting to the left is the steel umbilical tower which carries Stainless Steel fuel lines and control lines.

United States Steel maintains the technical services to provide the proper assistance to cope with any problem on these materials for ground support. When a ground support program is still on the drawing board, consult

United States Steel

USS is a registered trademark



These pressure vessels for the U. S. Air Force Bomarc A system are seamless steel cylinders about 20 inches in diameter and 26½ feet long. The cylinder walls are slightly more than an inch-and-a-half thick and will contain gas at pressure up to 4500 psi.

Stainless Steel pipes and Stainless Steel flexible tubing carry the fuel for the Thor complex. Fuel lines must be almost surgically clean to prevent explosions and assure proper flow. Inspectors check the lines with everything from microscopes to ultraviolet lamps. ▶

Important news for owners of CEC's 5-114 recording oscillograph

NEW RAPID-ACCESS DATARITE MAGAZINE

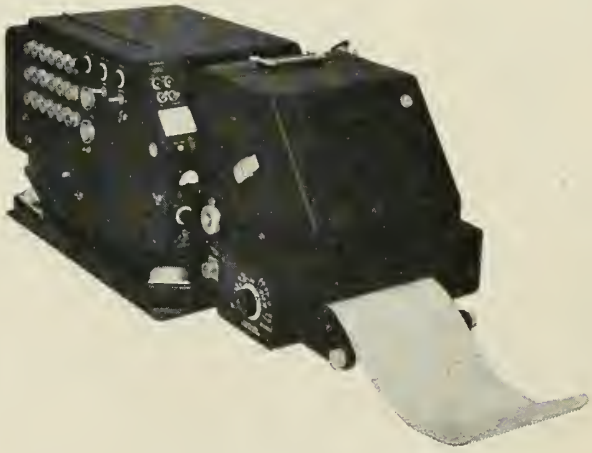
provides developed, dried, fully visible records almost instantly

Here is the DATARITE Magazine many of you owners of CEC's 5-114 Recording Oscillograph have been waiting for: The new 5-047. This DATARITE Magazine attaches directly to your 5-114. The result is a data-processing tool with all the capabilities needed for modern dynamic tests—especially attractive for low-budget programs.

RAPID-ACCESS . . . THE 5-047 DATARITE Magazine provides the shortest access time of any known process, and yields records of high trace contrast and permanency. The Magazine automatically develops and dries oscillograms as quickly as data are recorded. Ready-to-read test results are available almost simultaneously with the occurrence of events under study.

The 5-047 recording speeds are variable from .45 to 28.8 ips. Fully developed and visible record is available in 0.7 second at 28.8 ips record speed. There is a generous capacity of 400 feet of conventional thin-base recording paper, combined with writing speeds up to 20,000 ips. Power requirement is 115 v, 60 cps, 1500 watts for the combination of the 5-047 and the 5-114.

For complete details call your nearest CEC sales and service office, or write for Bulletin CEC 1500-X24.



Electro Mechanical Instrument Division CEC

CONSOLIDATED ELECTRODYNAMICS *360 Sierra Madre Villa, Pasadena, California*

Washington Countdown

IN THE PENTAGON

Ultimate fate of ABMA . . .
remains decidedly unclear in the wake of recent Pentagon space juggling. Both NASA and the Air Force are considered likely inheritors of the Army space agency.

• • •

Saturn is a prime target . . .
incidentally, of Administration budget cutters. The 1.5-million-pound-thrust clustered booster being developed at ABMA may turn out to be one the so-called "marginal" programs killed to keep the defense budget under the $40 billion annual ceiling.

• • •

Missile-lift by blimp . . .
may play a big role in the Space Age. Missilemen are considering proposals by **Goodyear** to transport the big boosters of today and the much bigger ones of tomorrow by non-rigid airships.

• • •

The Space project graveyard . . .
has new occupant—at least for the present. It's ARPA's *Project Suzano*—a space station study program. It hasn't a dime to work with and apparently no prospects of getting one in the budget-tight times ahead.

• • •

First test Courier . . .
communications satellite is presently scheduled to be launched next spring—probably about May. *Courier,* a delayed repeater satellite, is also the first of a series of communications satellites under development by ARPA and the Army.

• • •

First operational *Transit* . . .
navigation satellite is still scheduled to be in orbit by late 1961 or early 1962. The schedule is being held to despite the failure of the first test launching last month.

ON CAPITOL HILL

A full investigation . . .
of NASA contracting operations may be on the House Space Committee's calendar next year. The committee is particularly interested in NASA's $102-million contract with **Rocketdyne** for development of a single chamber 1.5-million pound thrust engine.

• • •

Some between-the-sessions . . .
inquiries by the House Space Committee also may be in the works for later this fall. One would involve patents on missile and space vehicle components.

• • •

Secretary of Science proposals . . .
appear to be picking up some new congressional support. Growing interest in the plan to create a Cabinet-level Science Department stems directly from the success of *Lunik II.*

AT NASA

The second *Big Joe* . . .
test has been cancelled because NASA *Project Mercury* engineers learned all they need to know from the first test. Though the *Atlas* booster failed to function properly, the capsule performed perfectly and a high enough velocity was attained to test re-entry.

• • •

The NASA budget request . . .
for FY 1961 may exceed $700 million. However, whether NASA can get that much from the Budget Bureau remains to be seen.

• • •

Test Scout No. 1 . . .
is scheduled to be launched late this year. The **Chance Vought** satellite booster is expected to be operational sometime next summer. It will be capable of putting 300-pound satellites into 200-mile orbits.

AROUND TOWN

Some of the reports . . .
being passed as "the latest" in the nation's capital:

. . . Deputy Defense Secretary Thomas Gates is considered the most likely successor to Defense Secretary Neil McElroy.

. . . More significant cuts and stretchouts in many defense programs are expected this fall and winter.

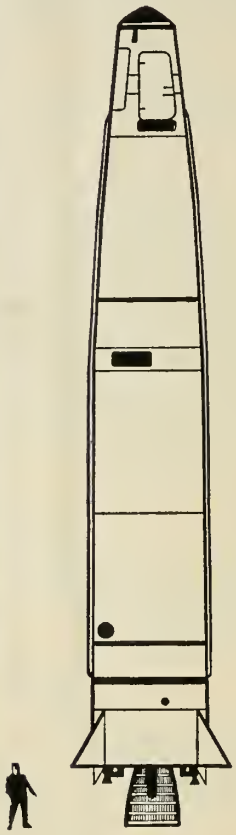
. . . *Project Mercury* costs in many cases are running 10 times higher than expected.

The man:

. . . a launch-control specialist in a *Thor* SAC squadron. His instruments report each automatic step in the launching procedure of the big IRBM. U.S. Air Force and Royal Air Force missilemen are receiving *Thor* training side-by-side . . . have readied and fired these missiles within a 20-minute count-down.

The missions:

. . . are many—because of the Douglas *Thor's* versatility. As a highly mobile weapon with atomic capability, it sternly warns potential enemies against aggression. As a powerful and reliable booster, it is playing a leading role in our exploration of outer space with satellites and probes.



The missile:

. . . can destroy targets as far as 1500 miles away within minutes after hostile action is detected. Douglas *Thor* missiles were the first intermediate range ballistic missiles to be deployed overseas. The United Kingdom has announced the delivery of the first *Thors*, for operation by Royal Air Force personnel.

Depend on **DOUGLAS**

The Nation's Partner in Defense

Industry Countdown

MANUFACTURING

Automet is a brand new . . .

Army missile system under development by ABMA. The highly secret weapon reportedly is solid-fueled and is in the test vehicle stage.

• • •

ICBM mobility . . .

proponents are proposing a railroad launching system for *Atlas* and *Titan*. They believe Soviet guidance—as evidenced in the moon hit—has made it highly inadvisable to stick to the fixed-base concept until *Minuteman* comes along. Studies have been run showing it is possible to shoot either an *Atlas* or a *Titan* from a train—despite the liquid fueling problems. The chief obstacle is cost: much higher than *Minuteman*.

• • •

High BMD officials . . .

now are in the process of evaluating competing missile train systems designed by two teams—**American Machine & Foundry** and **ACF Industries** and **Paul Hardeman Inc.** and **Bethlehem Steel.** A contract may be awarded before the year is out.

• • •

Production run of combat . . .

Boeing *Minuteman* ICBM's will be 805, according to latest word around Washington. This would be sharp reduction in the 2600 originally planned.

• • •

Recruiting engineering talent . . .

is still a big business. One major advertising agency now has seven fulltime employes running a $1-million campaign just for one manufacturing client. Another New York agency with multimillion-dollar billings is devoted exclusively to recruiting and researching ways to keep high-priced scientific personnel.

• • •

Steel pinch . . .

is being felt by missile makers as a result of the steel strike. Pentagon sources say "minor slippages" have occurred in deliveries for missile subsystems and for rocket cases and pressure vessels. So far, however, no serious shortages have developed.

PROPULSION

Consumable solid rocket . . .

case is a new wrinkle proposed for weather soundings over populated areas. **Thiokol-Utah** is working on a plastic case with an oxidizer-resin mix that will burn with the solid fuel.

• • •

For purists . . .

the Air Force is insisting that liquid oxygen should not be called "LOX." The proper name: LOTWO (LO_2).

• • •

Eagle engine . . .

will be developed by **Aerojet General Corp.** under an $8 million contract from **Grumman Aircraft Engineering Corp.** The propulsion unit for the Navy air-to-air missile reportedly will utilize a high-performance solid fuel.

ASTRIONICS

Instantaneous ICBM . . .

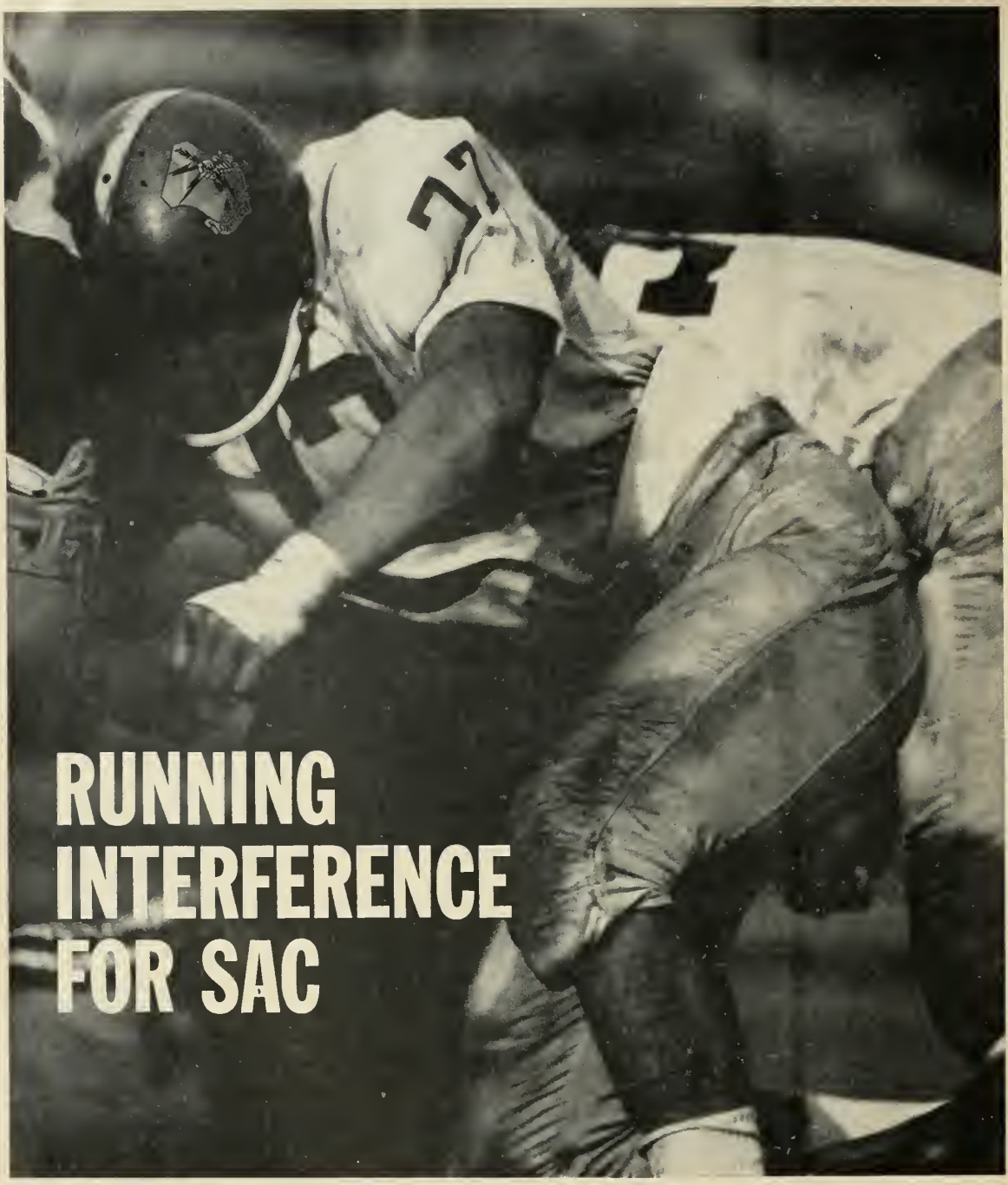
launching from a train (or other mobile system on land) is now possible through a variation of SINS (ships inertial navigation system) developed for *Polaris* submarines. TINS navigation device would eliminate the need for trains to line up at benchmarks in order to program targeting data.

WE HEAR THAT—

American Machine & Foundry . . .

is in the market to acquire two electronic companies—one for computation and data processing and the other for guidance systems . . . German spaceman Dr. Walter Dornberger (*Dyna-Soar*) may leave **Bell Aircraft** for an important Washington job . . . **Union Carbide's Linde Co. Division** is building a liquid oxygen and nitrogen (135 T/D) plant near the missile facility at Fort Crowder Reservation, Neosho, Mo. . . . *Blue Water* is the code name for the new **English Electric** solid-fueled surface-to-surface tactical missile being developed for the British Army.

More About the Missile Week on Page 39



RUNNING INTERFERENCE FOR SAC

Now SAC's B-52G has a pair of hard-running teammates... the GAM-77 Hound Dog air-to-surface missiles. They can lunge into action at supersonic speeds to clear a path for the bomber by knocking out ground-defense centers hundreds of miles away. A pair of Hound Dogs carried under the wings of the Boeing B-52 increases the bomber's striking power ... gives it a triple-punch capability. Successful test launches of the jet-powered missiles are being made on schedule over the Atlantic missile range. The system will be deployed by 1960 under the present accelerated development program.

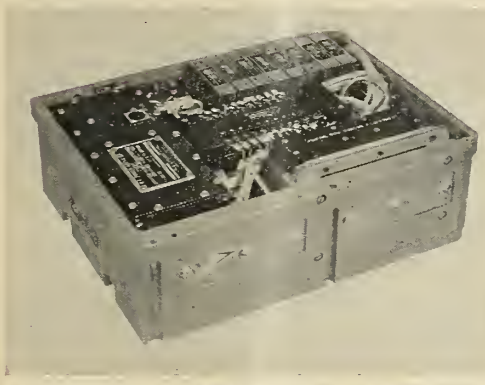
The Missile Division of North American Aviation is weapon system contractor for the GAM-77.

MISSILE DIVISION

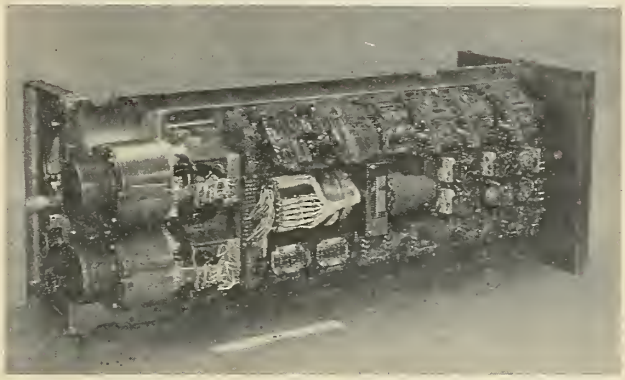
NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA

What's Wrong in Telemetry?

Lack of unity and realistic standards have hampered progress in a field vital to development of missiles; but something is being done about it



TELE-DYNAMICS system for *Bomarc B* uses ruggedized modular construction. The firm, a pioneer in the field, makes FM, PAM and PDM systems.



BENDIX ICBM telemeter weighs less than 90 pounds with power supply and transmits 172 information channels. The transmitter's power is 100 watts. Bendix turns out PM, PDM, is developing PCM.

by Hal Gettings

WASHINGTON—Lack of coordination and poor organization between missile makers, instrumentation manufacturers and the government/contractor-operated missile test ranges are impeding progress of the nation's blossoming telemetry industry.

And many in the industry feel that things will not be better until a joint industry-government group is formed to bring unity and understanding among the three principals. Such a group is now being formed—and is getting mostly unqualified endorsement.

The absence, to date, of such a group points up one of the main problems of this vital aspect of the missile and space program. Technologically, telemetry has made significant—if not completely satisfactory—progress. But, as in other fields, the pattern has been too much time and effort wasted because of poor organization and coordination.

Here's the rub: Instrumentation manufacturers find it hard to build the proper equipment to hazy and often unrealistic specifications. Missile makers don't know the capability and limitations of instrumentation. And the missile ranges don't know test requirements far enough ahead to plan and budget for equipment installation.

Boiled down, it simply means that one doesn't always know what either of the other two is doing.

• **Dearth of data**—A good example is the fact that Electronic Industries Association, usually considered an objective authority on all matters electronic, doesn't even have a classification relating to missile telemetry. And the National Security Industrial Association does not, to date, have a committee assigned to this field.

There's no information on exactly how big and important the business is. Estimates range from $120 to $250 million annually, with the expectation that the next 10 years will see double the present volume. Figures are hard to break down and separate, however; telemetry laps over into control and guidance, and there is a question as to just where data reduction and computation begin and end.

No one questions the importance of telemetry in its relation to the development of successful operational missiles and space vehicles. A flight system may have any number of experimental components or subsystems, but never may it have experimental telemetry. Missiles aren't fired to test the telemetry, but a proven reliable telemeter must be aboard every missile if its performance is to be measured and evaluated.

Progress in this field calls for continuous research and development independent of specific flight systems. New materials and subsystems must be developed, exhaustively tested, and integrated into telemetry designs. Designs must be service-tested and proven before incorporation into flight systems.

• **Who's in the business**—Telemetering systems manufacturers are few. Probably the leader in the field is **Radiation, Inc.**, with the bulk of its $13-million annual volume in telemetry and associated areas. They have pioneered in digital systems and automatic data

processing. Radiation recently received contracts totalling around $6 million for the **Boeing** *Minuteman* PCM telemetry. Details of this equipment are not yet available, but it is reported to be the most advanced and complete system yet developed.

Epsco, Inc. has done considerable significant work in digital telemetry and data conversion, with an annual volume of approximately $2½ million. One 10-bit PCM system just delivered handles up to 25,000 samples per second with an accuracy of 0.05%. Epsco also builds 17-bit equipment.

Bendix-Pacific has built an outstanding capability in both systems and components. They have produced FM and PDM equipment and have PCM under development.

Tele-Dynamics, Inc. is one of the pioneers in telemetry. They claim to be the only firm offering a complete system including the radio link. Their equipment embraces FM, PAM, and PDM systems and components.

Ralph M. Parsons does extensive system and feasibility studies for range instrumentation. They are the largest producer of FM decommutation equipment and also turn out transmitters and data converters. They built FM and PDM systems for the *Bomarc* and outfitted the Atlantic Missile Range picket ships.

Other systems manufacturers include **United Electrodynamics, Lockheed, Space Electronics, Applied Science Corp. of Princeton, Philco,** and **Melpar.**

Component and equipment makers include **Dynatronics, Telechrome, General Electronic Laboratories, Nems-Clarke, Advanced Electronics, Hallamore, Rheem, Centronix, Hoover Electronics, Packard Bell, Consolidated Electrodynamics Corp., Electro-Mechanical Research,** and **Telemetering Corp.**

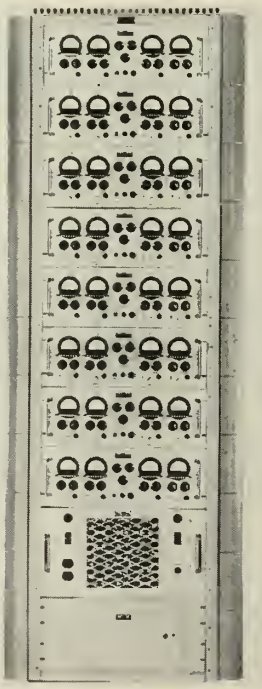
• **Frequency allocation**—Restricted band widths allocated to telemetry use have been a constant source of problems. The 225-260 mc band has been assigned for use until 1970, and after that on a non-interference basis. This band has holes in it, however, and the proximity of high-powered radar brings complications.

The higher frequencies becoming available have their problems, too, and there's an urgent need for extensive R&D to provide equipment for these bands. Transmitter efficiency at these frequencies is relatively low; compromises will be necessary to balance increased information-handling capability against reduced electrical efficiency. A new heterodyne technique, permitting superposition of several standard analog multiplexes and simultaneous transmission of very-high-frequency data over a single r-f channel, may make it possible to cut overall system size and weight.

If telemetry engineers had their "druthers," they probably would prefer frequencies in the 400-500 mc band. Under present assignments, however, it is extremely doubtful that anything in this area will ever be available. If enough R&D effort is brought to bear on the problem, future telemetering frequencies probably will be in the kilomegacycle bands.

• **Analog vs. digital**—Frequency-division multiplex systems have, until recently, been the only type of practical telemetry used. FM/FM, of course, remains the primary technique and probably will be for some time to come. Others—PDM, PPM, PAM—are also used extensively.

In spite of its shortcomings, many factors argue for continuing use of FM. Primary is the fact that practically all ranges are set up to handle FM information—and the facilities investment is tremendous. Too, where continuous data is required, only analog information will suffice.



NEMS-CLARKE Diversity Combiner/-Adder blends outputs of up to four receivers connected to different antennas and gets a single, high-quality signal.

Like the farmer who wasn't farming half as well as he knew how, FM telemetry is potentially much better than its present operations might indicate. Some advances have been made toward greater efficiency and further developments are being studied. The problems of noise and distortion are inherent in the system, however, and every step in analog data handling—from pickup to reduction—is subject to cumulative inaccuracies.

• **Digital techniques**—Practical digital systems have been built only recently. They offer considerable advantages—in speed, accuracy, capacity and reduction facility—but also problems. Power and space requirements are much greater than for a corresponding analog system; much work must be done to improve stability, size, and reliability of the airborne coders and multiplexers. In general, however, many feel that the problems of pulse-code modulation will be solved and it will pretty well dominate future telemetry.

• **Compatible systems**—The advantages of analog and digital systems have already been combined with some success. The addition of compatible digital equipment to existing analog systems can provide improved data acquisition, processing, and control subsystems at a fraction of the cost of total system replacement. As an interim measure, a compatible system offers versatility, accuracy, bandwidth utilization efficiency, and improved signal-to-noise ratio.

Future Developments

Microminiaturization promises much for the future of telemetry. When we can produce stable and reliable ultra-small components and circuits, we will have removed the primary objection to airborne digital equipment. But, although some equipment of this type has been used, practical systems are still some years away.

• **Digital transducers**—The advantages of direct digital output from information pickups are readily apparent. The problems involved are tremendous, however, and no significant breakthroughs are within sight. Several companies are researching this area on a small scale, but no more than nominal progress is expected.

• **Magnetic amplifiers**—Although they are getting little attention from instrumentation manufacturers, mag-amps have considerable promise for telemetry. They are now being made much lighter and provide much faster response than generally supposed. Recent investigations have shown that

critical selection of core material can lead to efficient, highly reliable amplifiers.

• **Transient measurement**—Much needs to be learned of the effect of transients on missiles—temperature, shock, etc. This can be investigated only with better telemetry than is now available. Consequently, better transducers and components with extremely high response must be developed. A further complication is that little is known about the effect of transients on the transducers.

• **Sophisticated systems**—Telemetry eventually will profit greatly from development of more sophisticated systems. Although the ultimate in sophistication is a long way off, and perhaps will never be attained, research into more intelligent systems is expected to yield dividends in bandwidth conservation, accuracy, and reduction capacity.

Ideally, a telemetry system would reject static and irrelevant data and select and transmit only pertinent information. It would include its own calibrator, and filter out incorrect data. It would be able to program and superimpose channels to use only minimum bandwidth.

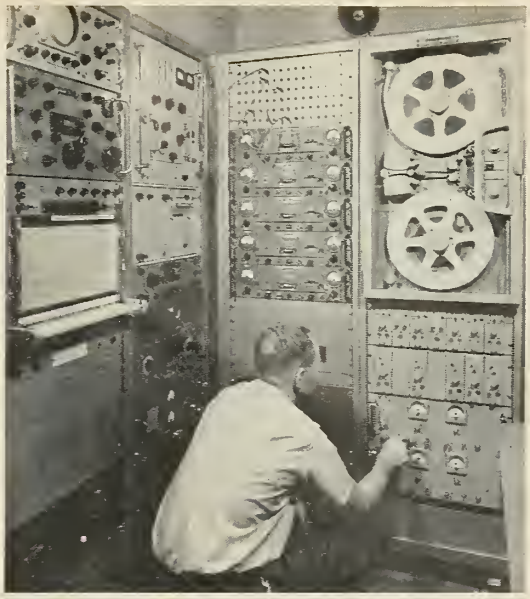
Probably the first evidence of more refined and advanced techniques will be in the form of more sophisticated code forms and in autocorrelation and cross-correlation. These must be perfected in the near future.

• **Diversity techniques**—Some research has gone into the advantages of diversity techniques for improving telemetering transmission. One study by Parsons showed that both space and polarization diversity would be practical and helpful. Frequency diversity was also shown to be desirable but not practical—due to bandwidth requirements.

• **Data reduction**—Laborious and inaccurate manual reduction of analog data has been a major log jam in missile test evaluation. Considerable money and research has gone into eliminating this deficiency and several improvements have evolved in recent years. Actually, ground data processing has already progressed beyond other aspects of telemetry. Innovations have been accepted much faster, since a failure in this equipment does not result in a permanent data loss. Extensive R&D in the telemetering link is required to catch up.

One advantage of digital data, of course, is that it lends itself easily to fast, automatic, and accurate reduction. Straight digital systems incorporate this feature. In addition, several new systems have been developed to convert received analog data to digital format for ease in processing.

The first of these was one developed for Project *Vanguard* by NRL and Radiation, Inc. Others have followed; several of varying capability are in service today.



BANK OF high-precision equipment lines one of two windowless trailers which give ABMA a mobile means of testing instrumentation designed to telemeter information from satellites.

The Royal Canadian Air Force has just installed what it calls "one of the world's most efficient missile testing systems" at its Cold Lake, Alberta, rocket range. This equipment collects three different forms of analog data and reduces it, in real time, to a BCD format for digital computer entry. It handles 53 channels and reportedly can process data from an entire test flight within 16 hours. Previous manual-reduction methods required 3200 man-hours.

• **Data display**—The visual display of telemetered data is especially important in rapid evaluation and reduction. During the missile flight, real-time displays are important to monitoring personnel; during data analysis, time and effort and computer use can be saved by editing raw data before reduction.

Much progress has been made, particularly in the digital systems. Real-time quick-look, with both digital annotation and discrete-level analog plots, is provided in several systems. High-speed x-y plotters, also using the multistylus technique, are being developed. Lockheed only recently announced completion of one new plotter, used in the *Discoverer* and *Polaris* programs, that is 17 times faster and 12 times cheaper than old methods.

Meeting the Challenge

Progress is being made in many different aspects of telemetry. Although many feel that overall progress is too slow, strides have been made clearly suggesting that telemetry may be equal to its future missions.

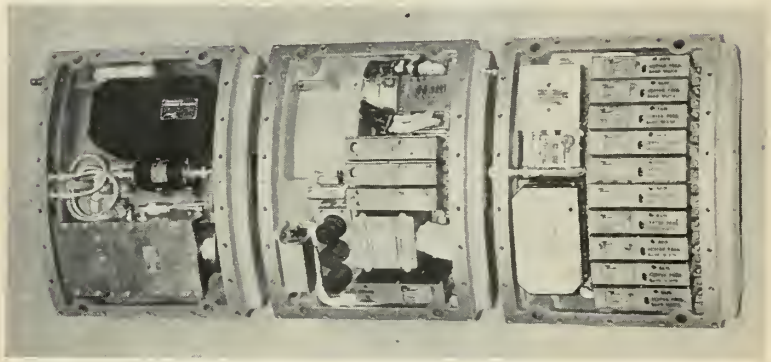
• **Direct re-entry telemetry (DRET)**—**Avco Corp.** scientists have reportedly broken the previously impenetrable barrier of the ionized layer surrounding a re-entry body. Using an unspecified UHF band, they reported feasibility of direct re-entry telemetry last May. Such a technique would allow continuous real-time transmission—as well as communications—during the entire transitional phase of a flight from outer space to earth. Details of the technique are classified.

DRET would be invaluable in re-entry vehicle tests and have wide application in such programs as *Mercury* and *Dyna-Soar*. Presently, it is necessary to record data during the re-entry phase and then transmit it in the few seconds left before impact—or hope to recover the vehicle and recordings intact.

• **Pulse-code modulation**—The use of PCM has advanced considerably during the last year. The "Digilock" system developed by **Space Electronics** (M/R, June 13) is the first "orthogonal" type to appear. It has many of the advantages of pure digital, but eliminates some of its disadvantages. Digilock approaches the maximum communication efficiency possible under information theory and incorporates both variable accuracy and variable data rate. With its maximum data rates, one system can provide information bandwidth equivalent to several FM/FM systems.

General Electric has developed a PCM/PS (phase-shift) system which

capacity for progress demonstrated . . .

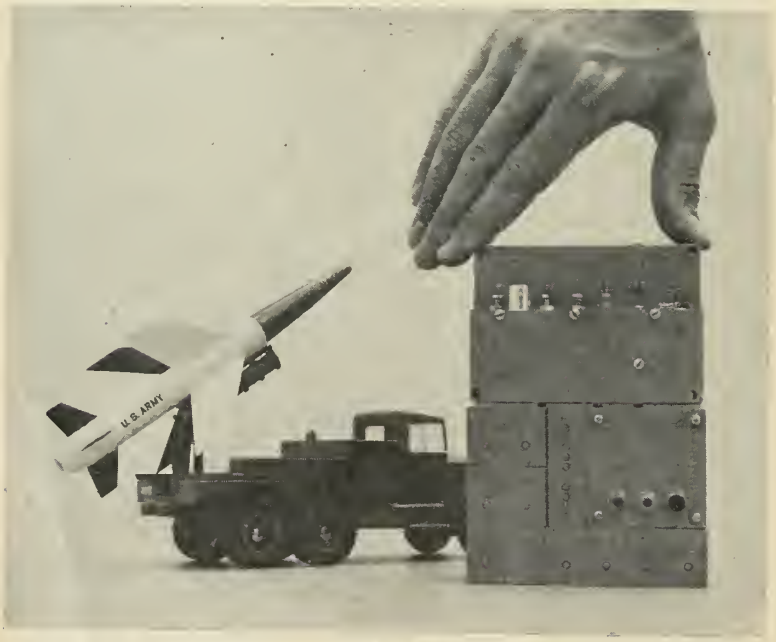


TELEMETER for the Navy's Bendix *Talos* provides 45 information channels. Except for a 14-watt transmitter, the unit is completely transistorized.

uses correlation detection and a novel redundancy coding technique. Transmitter power required is equal to or less than that of an ideal PCM-FM system. Use of a synchronous receiver permits r-f detection at S/N ratios less than –8 db.

• **Delta modulation**—Sometimes called "the poor man's PCM," delta modulation was the subject of a recent study program at the University of British Columbia. The system is simple and cheap and has many of the advantages of pulse-code techniques. It works by a feedback loop which compares an instantaneous measurement with its simultaneous integrated value —hence the name "delta." Its big advantage is that it makes it possible to lose a pulse without disturbing the code sequence.

• **Frequency modulation**—Competition with other systems has brought a growing awareness that FM components and techniques could well be improved. Research has already yielded some concrete results and more are anticipated.



MARTIN'S subminiaturized *Lacrosse* FM/FM telemeter transmits ten channels of go/no-go data for the highly accurate surface-to-surface missile.

In the area of telemetering receivers, substantial progress has been made (M/R, Aug. 24). The incorporation of phase-lock predetection recording, and parametric amplifiers are especially noteworthy.

Hoover Electronics has introduced a new development, called "Vernitel," which, it claims, upgrades FM system accuracy by a factor of ten—to a point comparable with PCM—without requiring additional bandwidth. The unit contains a quantizer which separates information voltage into a coarse voltage of 16 discrete levels and a vernier, or residue, voltage. Each of these voltages controls a standard FM subcarrier oscillator.

A diversity combiner/adder produced by **Nems-Clarke** operates to improve the quality of received signals. This unit—considerably more than a comparator—combines and adds up to four inputs and produces an output signal stronger than any of the separate inputs. It can be used with different antennas for polarization or space diversity or—with synchronization circuitry—for true frequency diversity.

ASCOP recently developed relatively sophisticated equipment which analyzes data before transmission to the ground (M/R, Dec. 1, 1958). Its principal advantages are savings in space, weight, and bandwidth. Using three units—spectrum analyzer, amplitude probability analyzer, and a time-of-occurrence marker—it statistically analyzes collected data and extracts its significant information content for transmission, recording, and evaluation.

"Telebit," **Space Technology Lab's** telemetering system for *Explorer VI* (NASA's "paddlewheel satellite"), is the most advanced flying today. This tiny system is designed to transmit data over interplanetary distances up to fifty megamiles. It contains a computer which adds and calculates collected data, stores it, and then transmits it to earth at programmed intervals.

Further improvements in oscillators, discriminators, transmitters, and receivers promise to enhance the quality and prolong the usefuless of FM telemetry. Better calibration and operation techniques—and better training of operating and maintenance technicians—are prime areas for future effort.

The capacity for progress has been demonstrated. If this progress can be coordinated and realistic standards can be formulated and adhered to—and if proper attention is given to further research and development—telemetry will overcome its existing deficiencies and take its rightful place in the forefront of missile development.

Data Handling System May Increase Use of Digital Tape Recording

This 100-lb. tape recorder with a total capacity of 2,400,000,000 information bits is touted as having great potential for future space exploration

PASADENA, CALIF.—The successful performance of high-density pulse-packing techniques in a new airborne magnetic tape recorder points to greater use of digital recording aboard future missiles and planes.

The equipment, with unprecedented pulse-packing capability, was developed by the **Datalab Division** of **Consolidated Electrodynamics Corp.** and **Douglas Aircraft Co., Inc.**, for an automatic data handling system used in flight testing.

Weighing only 100 pounds, it has a capacity of 1500 bits per inch on each of 16 tracks along its one-inch tape—providing a total of 2.4 billion bits.

• **Initial requirements**—High-density recording was demanded by the flight testing system for which the recorded was first developed. Douglas wanted an airborne system that would sample 100 primary channels each at a frequency response of 100 cps. Also, the system had to be able to record an hour's test time, and its size and weight had to be minimal.

In common practice, it takes five samples to reproduce a sine wave. If the system must accommodate sine waves from 100 channels, each at 100 cps, the recorder must have the capacity for 5x100x100 samples per second, or a total of 50,000 samples per second. To make possible an hour's recording at this sampling rate on a 14-inch reel of magnetic tape, required a technological breakthrough in pulse packing.

Finally, Douglas chose PCM telemetry; the recording equipment had to be compatible with the system.

• **PCM telemetry**—This telemetry mode was selected for several reasons. It is most accurate. It is less susceptible to distortion by noise than other transport speed. Datalab engineers say this will be important in future space exploration because it makes it possible to restransmit from relay stations without distortion.

TAPE RECORDER stores 1500 bits per inch on each of 16 tracks. Note flangeless reels. Overall dimensions are 6⅜ by 18 by 26 inches.

Accuracy will not deteriorate over long transmission and, if secrecy is necessary, PCM can be enciphered. Also, digital data can be conveniently introduced into computers for quick computation of results.

• **Disadvantages solved**—Previously, there were several disadvantages in digital recording. Tape economy was poor. And tape skewing can cause serious error because the bits making up a data word are recorded parallel across the tape. When played back, serious skewing will cause bits in adjacent words to mix.

The first disadvantage, poor tape economy, was answered by the system's unprecedented pulse-packing capabilities. To produce a reliable and accurate airborne recorder with high-density packing, engineers concentrated on three features: magnetic heads, tape guidance system and reeling system.

The most critical tolerance observed in fabrication of the magnetic heads were gap scatter (center-to-center spacing of the gaps measured in the direction of tape motion) and base squareness.

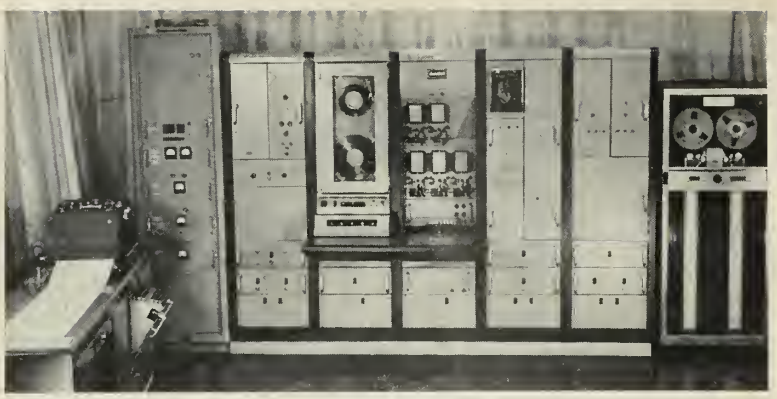
The system records 11-bit binary coded words representing a number on a scale of amplitude from each point which data are acquired. All bits making up a single word are recorded simultaneously across the tape. With the aid of three clock tracks, these are later played back on a ground station reproducer. Sequence of playback must coincide with the record sequence, and, because of the high density of signal packing, this requires adherence to close tolerances. Gap-scatter tolerance and maximum tilt are 0.0001 inch. These tolerances are checked by optical and electronic devices.

The record head has a low inductance center-tapped winding, permitting it to be driven with transistors. The playback head has a larger number of turns to increase amplitude during playback.

The physical composition of magnetic tape can cause its velocity to vary across the width when it travels across the magnetic heads, leading to misalignment of the recovered pulses. This "differential flutter" can also result from uneven drive across the tape width, inadequate guidance, or uneven tape edges. Conventional recorders frequently allow a 0.0003 inch displacement between outside tracks on a one-inch tape. This limits the packing density.

A solution was found by using a long bow-shaped chute with no moving parts to guide the tape across the magnetic head. Inner walls of this guide are flat to within 0.0005 inch. This simple but practical device reduced differential flutter to one-third that of conventional recorders.

For tape reeling, Datalab engineers



COMPUTER INPUT facility had editing facilities and IBM 727 tape transport (right) for providing tape compatible with IBM 704 computer.

developed a flangeless reeling mechanism that preserves the accuracy necessary to record and reproduce high-density signals, while at the same time reducing weight and space.

Without flanges, the reel hubs could be brought together to take advantage of the fact that the supply reel decreases in size as the takeup reel increases. This made possible a 3.5-inch reduction in the length of the recorder case, and an accompanying decrease in weight.

Precision reeling is brought about by accurate follower arms which guide the tape at its point of tangency to the reel. The squeegeeing action of the follower arm made it possible for 17% more tape to be contained in the same diameter reel because of more compact winding. Tape length is 8400 feet instead of 7200. The coil of tape proved firm enough to support itself during operation and handling.

To maintain the position of the tape on the hub during shock or acceleration, tapered guide rollers are placed above and below the supply and takeup reels. The rollers are mounted by low-friction ball bearings to prevent interference with tape travel under extreme environmental conditions of flight testing. In normal operation they do not touch the tape.

Constant tape speed is maintained by pinching the tape to a rotating capstan driven by a hysteresis-synchronous motor powered by a 400-cps precision frequency source. When the transport is energized to record, a tachometer senses tape speed as it builds up. When tape speed equals capstan speed the tachometer signals the pinch roller to pinch the tape to the capstan. Mechanical filtering eliminates flutter which might be transmitted by the drive belts.

Despite the diminishing radius of the supply reel and increasing radius of the takeup reel, constant tape tension is maintained to prevent stretching and distortion. The reel motor supplies the torque that pulls the tape. Cords of nylon with glass braid covering serve as clutches to control the position of each tape follower arm and to provide holdback torque for each reel in proportion to the radius of the reel.

The tape recorder system is mounted on a deeply ribbed casting of aluminum-magnesium-zinc alloy that is precision-machined for flatness. The ribs that provide chassis rigidity also serve as ducts which channel cooling air past all heat-producing components. By combining the functions of structural support and ducting, weight was again minimized. This approach to cooling also prevented dust, which might enter with cooling air, from getting into vital components. Air filters, which increase weight and decrease cooling efficiency, were eliminated.

• **Operation**—The airborne acquisition system is one of three separate but integrated groups of equipment comprising the Automatic Data Handling System. The others are a ground control and record station and computer input station.

The airborne system performs the duties of signal conditioning, calibration, amplification, multiplexing and analog-to-digital conversion. Signals are recorded on the tape recorder and simultaneously telemetered to the ground control and record station via PCM FM.

Each of the 100 primary channels can be sampled at rates up to 500 times per second with errors not exceeding one part in 1000. Any primary channel in ratios of 10:1 and/or 100:1. As a result, a maximum capacity of 10,000 inputs, each sampled five times per second, is possible.

A bar chart display allows a pilot or flight engineer to monitor up to 100 channels of test data visually. This display consists of up to five rectangular cathode ray tubes displaying 20 channels each.

An operator control panel has facilities to initiate system calibration, to indicate elapsed time, to enter event marks on the tape, to change frame rate, to control the magnetic tape recorder and to control the electric power to the airborne system.

Airborne equipment is modular to allow easy changes in input configuration as flight test requirements change.

• **Station facilities**—The ground control and record station is housed in a 33-foot trailer. A 12-foot dish-type telemeter antenna and its rotating mechanism are mounted on a separate trailer, as is a power generator that allows the trailer to function independently.

This station receives telemetered signals from the airborne system and, after serial-to-parallel conversion, provides a separate magnetic tap record for back-up or rapid data processing, 100-channel bar chart display, time history plots of up to 20 channels, display of elapsed operating time, event mark indication, and a counter which indicates dropout and transmission errors. Two direct-writing oscillographs are located on special readout tables for convenience in viewing and analyzing the records.

The bar chart display, elapsed time indicator and voice communication equipment are located in a control console which serves as an observation and control center for the flight test. From here test engineers can guide the flight to a successful conclusion, rather than waiting for the data to be analyzed before determining success of a maneuver.

Magnetic tape recordings from either the airborne system or ground control and record station are played back by the computer input station, which has editing facilities for selecting only channels and frames of data that are essential for each particular computer program. This enables the most economical use of computer and personnel.

• **Data processing**—It is possible for test data to be processed and computations made available to development engineers before the flight of the vehicle under test is completed.

Five modes of editing are provided: flight-test data-tape search at high speed, time selection, channel selection, frame selection, and arbitrary selection of frames by the computer station operator for averaging methods. In addition, the system can be programmed to enter all calibration data into computer memory.

After editing, the desired data are entered into a magnetic-core storage unit which formats the data for recording on an **IBM** 727 tape transport. In turn, the IBM 727 recording introduces data into a 704 computer.

SPACE RESEARCH

BRISTOL SIDDELEY GAMMA ROCKET ENGINE POWERS BLACK KNIGHT- BRITAIN'S HIGHLY SUCCESSFUL SPACE RESEARCH VEHICLE

On 11th June, 19,000 lb of thrust sent Black Knight to the threshold of outer space—500 miles above the Woomera rocket range in Australia.

This was the third successful firing *(there have been no failures)* and much of the credit for Black Knight's trouble-free performance must be given to the Gamma.

The Bristol Siddeley Gamma 201 is a liquid propellant rocket engine. Four trunnion-mounted chambers burn kerosene with HTP and each chamber is fed by its own turbopump unit. The complete weight of the engine compartment is less than 700 lb (dry) and Gamma delivers 19,000 lb at altitude—16,400 lb at sea level.

Black Knight is a research vehicle and no military applications are planned. But the experience gained and lessons learned from this highly successful space probe will be invaluable in the development of Britain's IRBM—Blue Streak.

So impressive is Black Knight's performance with the Gamma powerplant that even more advanced applications are being actively developed. In fact, Black Knight coupled with Blue Streak is first choice to put Britain's projected space satellite into orbit.

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Universal Checkout Center Is Urged To Match Weapon System Advances

Packard Bell, with experience in Polaris, Thor and Falcon programs, believes concept will reduce inventories and personnel and enhance portability

LOS ANGELES—A new concept—in many ways revolutionary—for a centrally located, universal test center has been proposed by **Packard Bell Electronics Corporation.** The idea is a by-product of the company's extensive R&D efforts in automatic checkout equipment.

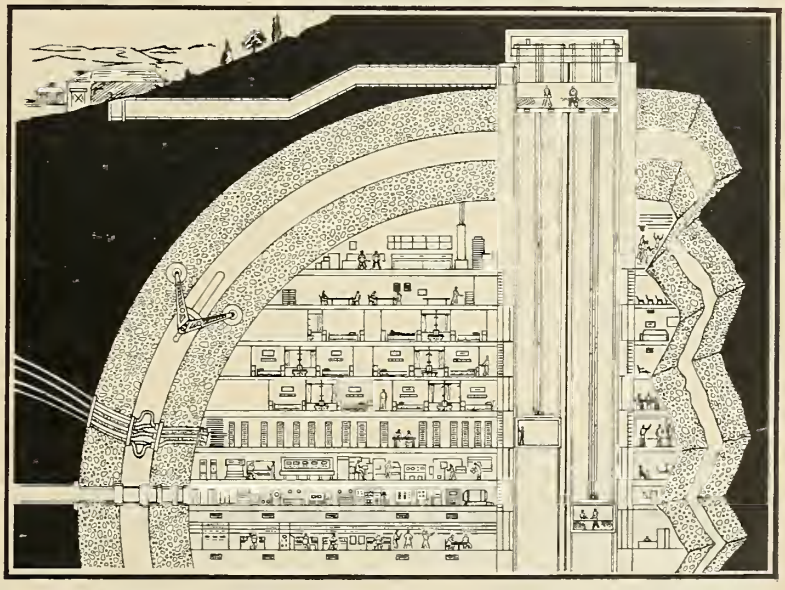
Packard Bell feels that the Space Age demands new concepts in support equipment to match the ever-increasing sophistication of weapon systems and space vehicles—and that the use of specialized electronic support equipment at each launching area or air base will soon become outmoded.

In place of vast quantities of duplicate equipment, one or more centralized control centers containing multipurpose support equipment and necessary elements of command could be established in emulation of the SAGE system.

From strategic sites, these test centers could remotely check out ready missiles, aircraft, or other weapon systems, validate their readiness or isolate areas where malfunctions exist, indicate their status to all appropriate commands, and release or hold the instrument of combat as indicated by test results.

Implementation of such a program, the company feels, will reduce manpower and material requirements, speed the reaction of the armed forces, and make it possible to include in all command decisions such factors as foreign policy, logistics and the overall tactical situation.

• **The concept**—Packard Bell recognizes that some persons might consider the idea of a universal test center—possibly located in the geographical center of the United States—to be impracticable.



PROPOSED universal test center would be spherical concrete structure providing space for normal operation of computers, communications checkout, and missile command functions. Remotely operated TV cameras would supply surface observations.

"The engineer and the scientist will think of the communication problems; the military man will think of jamming problems and loss of communication through enemy action; and the layman will consider the whole idea just another Utopian concept that may come to pass in the dim future," the company said. "But (the idea) seems a must, rather than a scientific extravagance."

• **Justification**—The company brings out these points: (1) It is apparent that the 1000-to-4000-aircraft raids of World War II will not occur again; (2) It is unlikely that any country again will overwhelm another by sheer strength of numbers because atomic and hydrogen bombs have dissipated this possibility and have left the U.S. with the firepower of 1000-to-4000-aircraft weapons concentrated in very small packages.

These facts justify establishment of a centralized test center, Packard Bell says, since the number of weapon systems with which communications must be set up is minimized; there will be comparatively few commands, and each will be capable of releasing many times the power of a 1000-plane raid with each of its systems.

both air and ground links . . .

As for responsibility, the company observes that: (1) Unleashing these "all-or-nothing" weapons, when required, will be a responsibility of the top command of the United States and will carry the policy stamp of the government; and (2) Although launch responsibility is a top-command decision, determination of weapon operational readiness is today a matter of decision for local commanders, whose decisions may be subjectively biased by local conditions or the pressure of time; and (3) It is apparent that the determination of readiness is misplaced at the local level because the determination that a hydrogen bomb carrier, with its potentiality of a million mortalities, is ready to be launched is not a local command decision any more than its launching.

• **Area of decision**—The company said that it appears that determination of armed readiness must be made in a central area where the leaders of industry and government have the facts for an instantaneous pre-evaluated solution. "Only in an atmosphere where emotional details are eliminated and scientific logic is substituted can this determination be made."

The universal test center, containing general-purpose computers, armed forces command elements, and direct communication with all field elements, affords such an environment, the company believes.

• **Link between systems**—Connection of the centralized test center to its weapon systems will be a basic problem. One of two methods may be employed to establish a connection between any checkout system and any weapon system. These are the direct connection by a cable and the indirect connection by an air link.

Today's weapon system developments deal almost exclusively with the immediate problem of providing a necessary functional connection between weapon system and checkout system. Sophistication in this area is neither sought nor desired.

For instance, designers of electronic equipment normally desire a large number of test points to ensure the highest possible certainty of weapon readiness. The airframe designer, on the other hand, is reluctant to supply excessive wire runs due to the weight penalties incurred. These two desires naturally conflict and can only be compromised in a manner which does not precisely satisfy either engineering requirement. The linking method for the remote, centralized test center will have to be one that imposes a minimum of weight penalties and yet makes possible the necessary degree of weapon readiness assurance.

Cable connection via a direct cable to the weapon system has several advantages, the company feels. Electrical interference in jamming is minimized, test signals enter directly and are not unduly attenuated, and a larger quantity of tests per equipment can be made.

But Packard Bell pointed out that air-link checking, on the other hand, has the advantage of requiring no physical contact with the aircraft or missile and allows the test to proceed while the instrument of combat is in motion. Each of the methods is supreme in one area. Air-link checking, for instance, is not feasible at production-line centers where cable connections can readily be made. By the same token, tests can be made during turnaround periods via an air link more quickly than by any other method.

For the test center, an air link, suitably coded in the manner employed by present-day IFF equipments, could be used along with a ground line for parity checks or for redundant information.

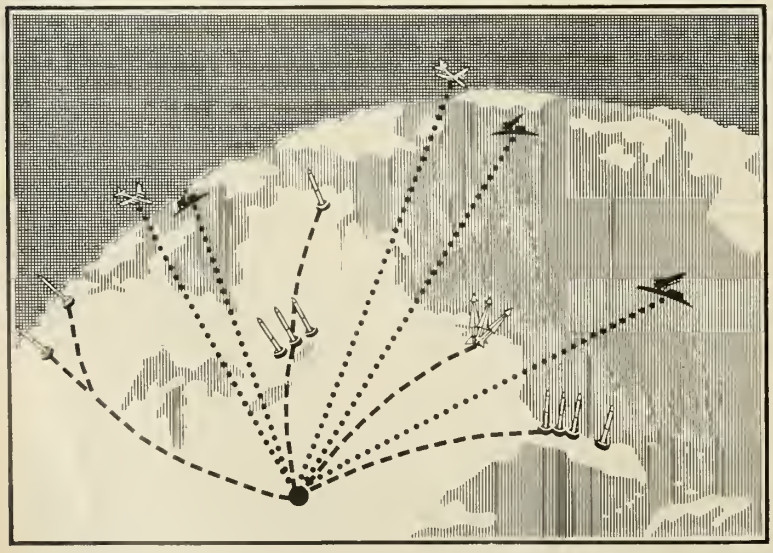
• **State of the art**—Many of the weapon systems now coming into being utilize some form of centralized checking. In these systems a special-purpose computer is connected to test areas within approximately a half-mile and is used in much the same way as a remote test center.

The only difference between a completely universal remote test center and these present concepts, the company feels, is distance. "It seems evident that if a signal- and power-carrying line can be run for a half-mile it might also be extended to several hundred or several thousand miles and obtain the same functional capability."

• **Advantages of center**—The greatest advantage of the centralized test center, according to Packard Bell, may be the portability allowed for the weapon system. With suitable test-center repeater stations in operation, weapon systems might be operated at an instant's notice from any locality in the world. The black-box testers and associated test trailers, along with a host of skilled maintenance personnel, could be reduced to a minimum.

A weapon system might move as the tactical situation dictates, rather than as a function of logistics or local support capability, the company adds. With logistics problems minimized, military commanders would be able to make military moves unbiased by the considerations which have compromised past and present tactics.

The practicality of a test center presupposes some form of universal tester which may be applied to many weapon systems. If this test system were to be merely a composite of all present systems, the quantity of equipment would be impossible to house. However, a vast majority of these test systems can be eliminated because of the similarity



MAP SHOWS how centralized test center would have ground connections via cable and air links radiating to radar observation points, planes, missiles and warships.

of inputs and outputs. These consist of such factors as voltage, impedance, current, radiated power, frequency, and mechanical motion.

The company feels that a multipurpose system which will support many systems can be designed and made considerably smaller than the sum of test equipment used by these weapon systems individually. Such systems are available even today and have demonstrated their usefulness in the present generation of missiles. The armed forces are investigating the optimum combinations of units in multipurpose equipment available at this time.

Not least among the prime advantages of a centralized test center is the consideration of cost. With cost and manpower requirements increasing at an expanded rate with the sophistication of weapon systems, a point is being reached where the law of diminishing returns will take full effect.

For instance, in missile weapon systems, approximately 80% of the weapon system is composed of support elements or checkout equipment. This means, for a given amount of increase in weapon system dollars, only a 20% increase in weapon-system capability is obtained.

Packard Bell says that implementation of a centralized test center will appreciably reduce the $100 billion in military electronic inventories and cut the number of personnel (approximatly one million) employed to service this inventory.

• **Studies continuing**—Studies made by the company over the past two years are being continued as "advanced-development" efforts. In the meantime, the company says literature on present checkout equipments indicates that a centralized test center as has been described is feasible and necessary. It is eminently practical, Packard Bell spokesmen declare; it is less costly than present practices, and it coordinates the channels of command as the situation indicates.

Since each of the armed forces has its own particular checkout problems and checkout philosophies, it would appear that a joint effort should be made among the Army, Navy, and Air Force to implement such a design and to consider it for simultaneous use. In this way manpower and dollars could be expended for maximum efficiency and the betterment of each service's weapons.

The horse-and-buggy days of a one-to-one relationship between testers and equipments has passed. The pressure of world circumstances and the advance of science exert an inexorable pressure in the direction of a centralized control area.

Cabin Conditioning System Weighed

British researchers find air-purifying, oxygen-replenishing system for a man would weigh 55 lbs. for 2 days, 235 lbs. for 10 days

LONDON—Cabin conditioning equipment for a satellite manned by one Astronaut might weigh from 55 to 235 pounds, for a flight ranging from two to 10 days.

This conclusion was reached by George Beardshall and Peter W. Fitt of **Normalair Ltd.**, Yeovil, in a paper given at the British Space Flight Symposium.

Beardshall and Fitt outlined conditioning systems designed to maintain temperature at about 68°F, oxygen between 20% and 60%, humidity below 10 mm Hg, and CO_2 below 7 mm Hg. At an average human metabolic rate of 400 BTU/hr., they assume oxygen intake of 0.105 lbs./hr., carbon dioxide output of 0.125 lbs./hr. and water output of 0.16 lbs./hr. They set figures a little high because of the sketchy knowledge of physical reactions—including excitement—to weightlessness.

Evaporation was rejected as a method of cooling because this would result in overboard ejection of mass that must be in the vehicle as extra weight at takeoff. Instead, it was assumed that the vehicle will be designed to have a passenger cabin as completely leakproof as possible.

Temperature control would instead be largely based on reflection and absorption of solar radiation, through the choice of external finish and construction—a method already proved partly successful in the smaller unmanned satellites.

Since the Astronauts may have to enter the craft as much as eight hours before takeoff, a ventilation system must be provided to avoid unnecessary consumption and use of the cabin conditioning before takeoff. This could be done by an external ventilation source that would be disconnected during final phases of countdown. Slight pressurization would make possible last-minute leak tests.

• **Maintaining pressure**—Gas storage and control problems are simplified, Beardshall and Fitt noted, if atmospheric pressure during flight is maintained at a figure somewhat below ground level. Since the pressure within the compartment will have been approximately equal to that of ground level, a method must be chosen for allowing the cabin pressure to drop to flight level—say 18,000 feet.

Two methods are possible, they declared. One is to use a simple relief valve that limits vehicle pressure to a maximum allowable figure. This would take care of possible overpressurization caused by malfunction of oxygen supply equipment. The second method would employ an aneroid controlled valve to increase atmospheric pressure if it falls below an established minimum.

Whichever means is chosen, the maximum rate of decompression will reach about 0.75 psi/sec. for an acceleration of 6 g. This is more rapid than advisible for a passenger embarking on an already hazardous journey. Beardshall and Fitt suggested the use of a relief valve with built-in restriction to slow the rate of decompression to about 0.25 psi/sec.

Basically, the system for maintaining a satisfactory atmospheric environment is made up of oxygen supply and facilities for removing excess carbon dioxide and water vapor. Re-

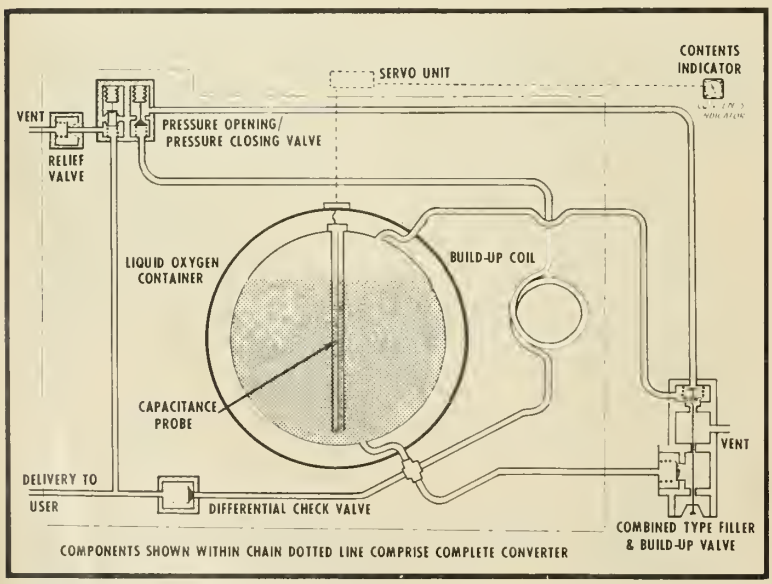


FIG. 1—Liquid oxygen provides a supply of life-giving atmosphere for Astronauts. Continuous introduction of heat boils the liquid steadily until pressure above the fluid closes the cutoff valves.

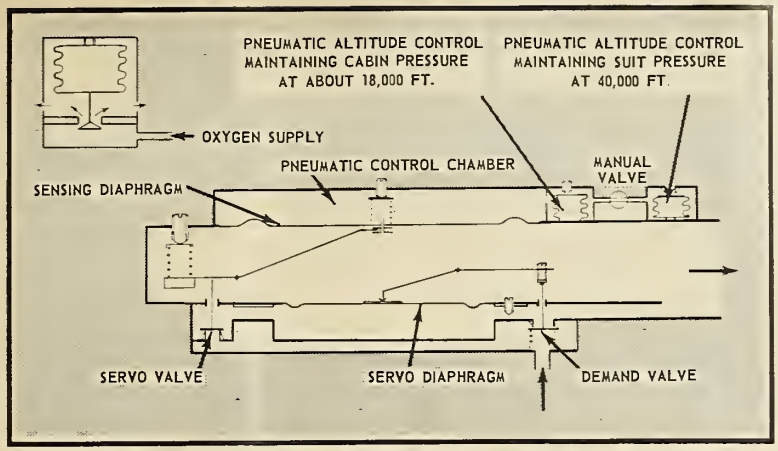


FIG. 2—Pressure controller regulates the flow of oxygen both to the cabin and to the suit used in case of atmospheric contamination in the cabin.

moval is accomplished by circulating cabin air through absorbing chemicals. Since CO_2 and H_2O are produced as a result of oxygen consumption, the oxygen must be steadily replaced.

• **Heaviest item**—The oxygen supply and its container are the heaviest item in a cabin conditioning system. A gaseous oxygen supply was rejected because of the obvious problems entailed by the size of its container. Storage in chemical form would raise problems in conversion to breathable form. Storage in liquid form would pose the fewest difficulties. Beardshall and Fitt reported, even though it would require refrigeration below −119°C.

A typical liquid oxygen supply, of the kind used for aircraft, is shown in Fig. 1. The liquid is stored in a Dewar vessel made of materials such as copper or stainless steel. The vacuum jacket eliminates, as far as possible, any heat transfer that might warm the oxygen above its boiling point.

The liquid passes by hydrostatic head to the external circuit to be vaporized. Continuous introduction of heat to the inside of the container warms the liquid and raises the vapor pressure above its surface until an automatic cutoff valve stops circulation.

Two features of such a converter prevent its use in its present form in space travel, Beardshall and Fitt declared. First, those now being produced in the size needed for a one-man expedition suffer evaporative loss at a rate closely paralleling one man's consumption. For example, a 5-liter converter can lose 20%, or about 2½ pounds of oxygen per day.

A man in a sealed environment consumes less than 1 lb. daily. Some 5-liter converters show loss of less than 1 lb. per day. Obviously, there is little margin for controlling rate of flow. For longer flights, there is no reliable evidence that any converter will contain oxygen much longer than 20 days.

A second objection is that it is difficult to predict the condition of the liquid oxygen at zero-gravity conditions. It probably would be a suspension of droplets in mist form, according to Beardshall and Fitt. Under such conditions, a fall of pressure would follow any draw-off from existing converters. They said it would be necessary to revise the circuit completely to provide some means of restoring the pressure.

• **Oxygen flow**—A controller in the system must regulate a flow of about 2 liters/min. of oxygen under normal conditions, even under the severest work conditions. It could be an aneroid set to open a small valve in the oxygen delivery line when cabin pressure falls below the established minimum. Fig. 2 illustrates such a unit.

Impurities are removed from the air on a short flight by a chemical means only. On a 10-day trip, there is nothing to be gained in attempting to generate oxygen from the waste carbon dioxide. The weight of the equipment or plant life would be prohibitive. Nor is there any major objection to carrying sufficient water for the passenger's needs.

For absorbing carbon dioxide, many studies have shown that lithium hydroxide is best. Originally, lithium chloride was used for water absorption. More recently, however, there have been reports that LiOH may absorb some water too. Beardshall and Fitt said research is in progress at Normalair to establish the efficiency of the absorbing chemicals. But regardless of efficiency, they said the system will resemble that in Fig. 3.

• **Circulation**—A fan and motor will be needed to maintain a proper rate of circulation through the absorbents. This will require power, another drain on the vehicle's auxiliary power supply. They noted, however, that in the event of failure, the passenger can provide his own circulation by breathing directly into the chemicals.

The final overall system (Fig. 4), Beardshall and Fitt reported, would require from 55 lbs. for a two-day flight to 235 lbs. for 10 days, and could be available in a relatively short time.

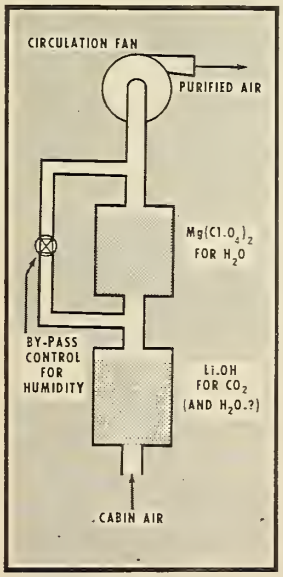


FIG. 3—Chemical absorption system removes CO_2 and H_2O from the air in the cabin.

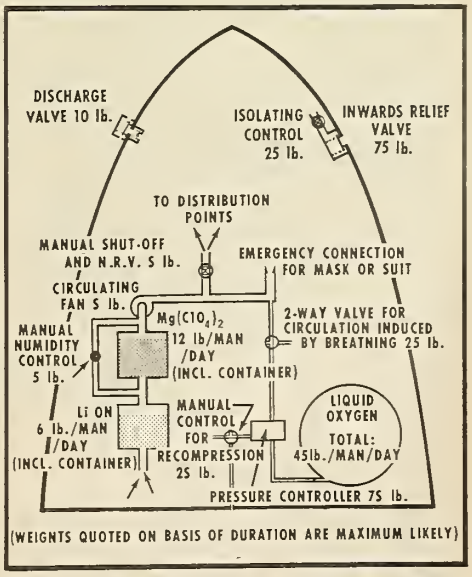


FIG. 4—Complete control of atmospheric environment is provided by the cabin conditioner. Here is the scheme of the overall system.

ARPA Keeps Its Space Research Role

by James Baar

WASHINGTON—As the fog of press releases drifts away it has become increasingly clear that there was far less than met the eye in the Pentagon's much-noted announcement on the distribution of ARPA's space holdings.

ARPA pinched itself and like Mark Twain found that it was in a position to say that the reports of its demise were much exaggerated.

In fact, there will be no funeral at all. And for a very simple reason: There is no body.

The net effect of the Pentagon announcement—and a letter to the Joint Chiefs of Staff from Defense Secretary Neil McElroy that was the basis for it—is this:

• The Air Force has been made responsible for (as McElroy put it) "development, production and launching of space boosters and the necessary system integration" connected with them for all military purposes—"except for such research and development as may be conducted by ARPA."

• Four ARPA space projects—*Samos, Midas, Notus* and *Transit*—have been assigned to the military services: the first two to the Air Force; *Notus* to the Army and *Transit* to the Navy. However, their actual transfer with supporting funds may not come for one to two years, and before that takes place ARPA will remain responsible for them.

• ARPA will continue as the Defense Department's agency for advanced military research both for both space and more earthbound projects.

• The effect on NASA is nil.

The assignment of the four projects by McElroy was nothing more than part of the overall plan for development of advanced programs under ARPA direction until they reach a stage of R&D where the Defense Department feels they should be turned over to a military service to complete their development and operate them. (M/R, Sept. 28)

ARPA Director Roy Johnson has said projects should be assigned to the military services that will use them about two years before the projects are operational. ARPA has been pressing the Joint Chiefs of Staff for months to begin making such assignments.

However, the Joint Chiefs have been been unable to reach agreement on who was to get what. And the first four assignments are understood to have been made by McElroy in the face of continued disagreement among the Joint Chiefs.

It is noteworthy that the ARPA satellite detection fence that has been developed by the Army and Navy was not assigned although its assignment is far more due than that of the early-warning *Midas* satellite.

As yet, no calendar for the transfer of the four assigned projects has been worked out. However, McElroy's letter makes clear that the transfers involve much more than an automatic process.

He said that "prior to assuming responsibility, the appropriate military department will submit to the Secretary of Defense detailed plans for the system including user relationships with the unified and specified commands and other appropriate agencies."

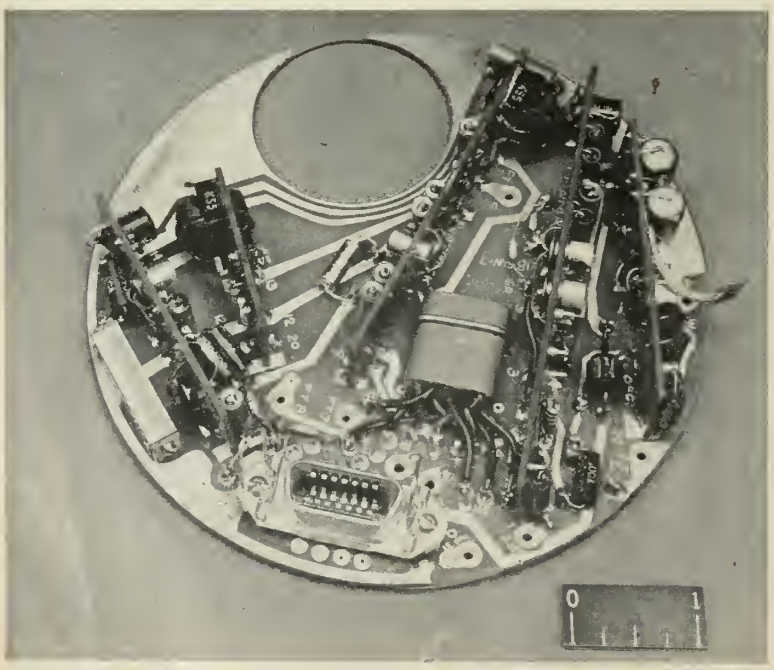
Moreover, he said the transfer must pass through the Joint Chiefs and the office of Pentagon R&E Director Herbert York. He said "the date of transfer . . . from ARPA will be approved by the Secretary of Defense upon the recommendation of the Director of Research and Engineering."

One of the earliest of the projects to be transferred may well be the *Samos* reconnaissance satellite. The *Transit* navigational satellite probably will come next, about a year or so from now.

The transfer date for both *Midas* and the *Notus* communications system of satellites is anybody's guess. One of the complicating features about *Notus* is that it is really four satellites and McElroy's letter spoke only of the "interim communications satellite." That could mean only the first one—*Courier*.

McElroy's letter left wide open the fate of *Saturn*, the clustered 1.5-million-pound-thrust booster being developed by the Army Ballistic Missile Agency for ARPA. But it forced farther into the open the bitter struggle over the Army space program.

Subsequent comments by York made clear that whatever happens to *Saturn*, the Army's days in the space business appear numbered.



THE ARPA-ARMY Project *Courier* delayed repeater communications satellite, in an advanced state of development, contains this electronic equipment.

Ignition Keeps Pace with Challenges

Present trend is toward hypergolics for restarts and pyrotechnics for single-shots—both may be passed up in future systems. Part I of a two-part survey.

by Frank G. McGuire

LOS ANGELES—A highly reliable ignition system is, by its very nature, the heart of engines using chemical combustion products. Despite this basic importance, it has until now received little attention in technical writing.

Ignition has come a long way since the days when a 13.5¢ dynamite device was used in rockets—the final cost of a system nowadays may run into literally thousands of dollars. But this is misleading—the basic cost of a unit may be only 5% of this final cost; the rest can be chalked up to quality control, lot acceptance testing and various other costs.

Qualification testing has, at times, cost one hundred times as much as development costs of a unit. And development costs have been known to reach ten thousand times the production cost. Even the 13.5¢ dynamite igniter has doubled in price since the days when it was a standard item.

Many manufacturers are involved in ignition system work. M/R is indebted to **Aerojet-General, Holex, Inc.,** and **McCormick Selph Associates** for the material in this roundup. Other companies and organizations active in this field include: **Beckman & Whitley; Ordnance Associates; Propellex; American Potash & Chemical; Redel, Inc.; B G Corp.; Bendix Aviation, Scintilla Div.; Librascope; Ordnance Research and Development Co.,** and many other companies.

The various types of ignition systems can be generally classified into six categories: pyrotechnic, electrical, torch, hot-spot or heated wall, catalytic, hypergolic. Combinations of these are used frequently, of course, depending on requirements. The prime consideration in many instances is reliability under operating conditions. This is set at reliability levels of 99.99%, and in cases where multi-stage vehicle has as many as 50 pyrotechnic initiation systems, the desirable becomes the necessary.

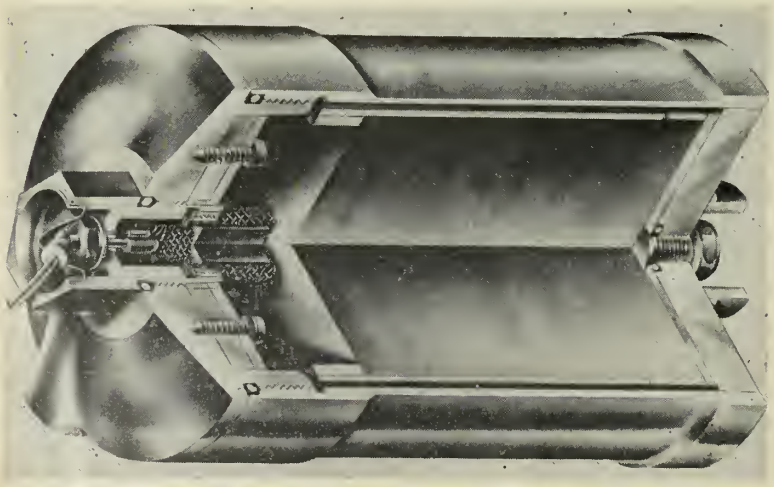
The choice of a system may be influenced by characteristics of single or repetitive starts, peculiarities of the combustion process, altitude starting conditions, high-pressure chamber conditions, methods available for initiation, timing, and type of installation.

• **Pyrotechnic progress**—Probably the most widely-used type of ignition system currently is the pyrotechnic device. These have steadily increased in reliability, resistance to environmental conditions, shelf life, control of ignition delay-time, uniformity of performance, elimination of ignition shock (brisance), high ignition temperatures, high-altitude starting, direction of combustion products, and safety.

Most rocket engines require raising pressure and temperature in the combustion chamber to predetermined values to insure positive initial ignition and sustained combustion of the propellant. Once this has been accomplished, the characteristics of the combustion chamber nozzle are such that propellant combustion will be maintained after termination of the ignition phase.

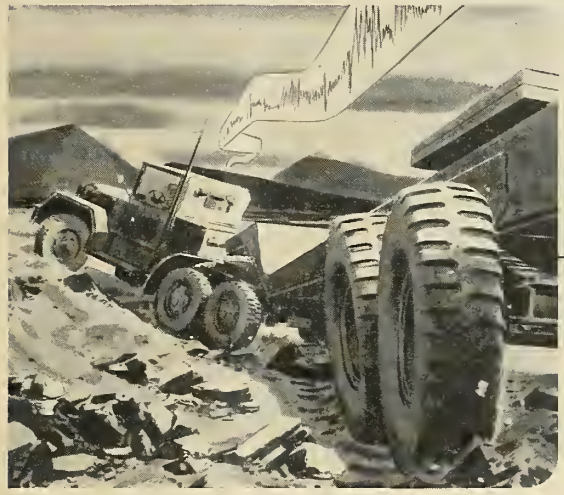
To achieve the required conditions, a pyrotechnic ignition device is usually comprised of three elements. In order of initiation, they are the ignition primer, the ignition booster, and the main igniter charge. Variations of this setup may occur in small engines, where only the first two of these would be used, or very large engines, where all three would ignite a miniature rocket engine, which in turn has to provide sufficient temperature and output to ignite a large mass of propellant in the main engine.

Black powder igniters, long a standard item, have been replaced because of their variable performance, excessive functional violence and other poor qualities. To supersede black powder, Aerojet-General developed a binary pyrotechnic composition containing aluminum powder. This mixture, registered as "Alclo", has desired properties of high temperature, fast burning, high caloric evolution, ignition flash point temperatures over 500°F, and absence of ignition shock. The "Alclo"



PYROTECHNIC igniter installed by Aerojet-General in a gas generator. Pyrotechnic devices have been greatly improved and are probably the most-used system.

Pioneering Achievements in Missile Support Equipment at JPL



VEHICULAR EQUIPMENT . . . has been designed and developed having greater stamina and of much lighter weight. Specially designed prototype units were tested on rough terrain under the severest operating conditions. From these tests, significant design data resulted.

GROUND HANDLING EQUIPMENT . . . for servicing missiles and readying them for launching has been designed, developed and tested. However, a continuing program is in process at the Jet Propulsion Laboratory to further the state of the art in this important field.

MOBILE MISSILE SYSTEMS . . . were designed, developed and tested for use in transporting and servicing missiles. A tractor-trailer with launching pad in one complete unit was developed. Other equipment for loading and transporting missiles via air, land or sea has been developed.

GROUND SUPPORT EQUIPMENT . . . is developed to operate under conditions of rain, snow, ice, and heat. Mud and desert sand also create difficult environmental problems. Objectives are ease of operation and handling permitting the missile to be readily unloaded from airplanes, or landing craft and quickly positioned for firing.

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designs have steadily improved . . .

FIRST IN the order of initiation is the ignition primer, tiny but with very high reliability. Here is a trio of Holex, Inc. Model 1029B high-altitude primers.

composition is usually pelletized.

In a system using these components, the ignition primer is ordinarily fired by passing an electric current through a resistance wire to raise the wire temperature above the ignition temperature of the primer composition which surrounds the wire. Flame temperatures in ignition primers run around 3000°K, brisance is low, and a high degree of reproducibility of the flame pattern is required. The low brisance, or shock, output is necessary to minimize mechanical stresses on the igniter booster load.

(A high-shock-producing ignition primer could shatter the pellets of the main igniter charge, changing the burning area of them, and give a different pressure vs. time output, thus producing an unpredictable igniter action. The resulting flame pattern might not produce the necessary complete envelopment of the propellant.)

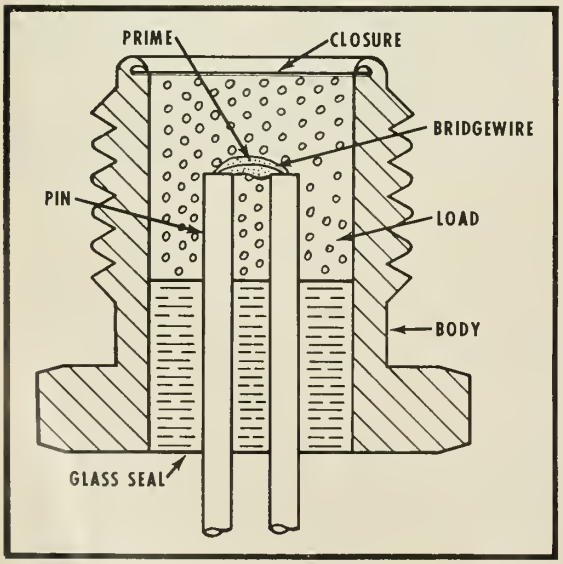
• **Design changes**—In addition to the composition of the charge, igniters have changed structurally. Early models consisted of a gliding metal case, sealed by a phenolic plug through which the electrical leads projected. The initiating bridge-wire was soldered to the ends of the leads and primed with a bead of heat-sensitive material. The main charge, as mentioned previously, frequently consisted of various granulations of black powder.

Improvements in this design include the use of the dual bridge-wire, glass-to-metal-seal type igniter that is highly reliable, easy to install, has three milliseconds or less ignition delay, is not affected by prolonged flow of subcritical voltages, and is not subject to ignition by atmospheric electrostatic discharge. It generally uses an explosive bridge-wire, instead of a low-voltage prime explosive squib.

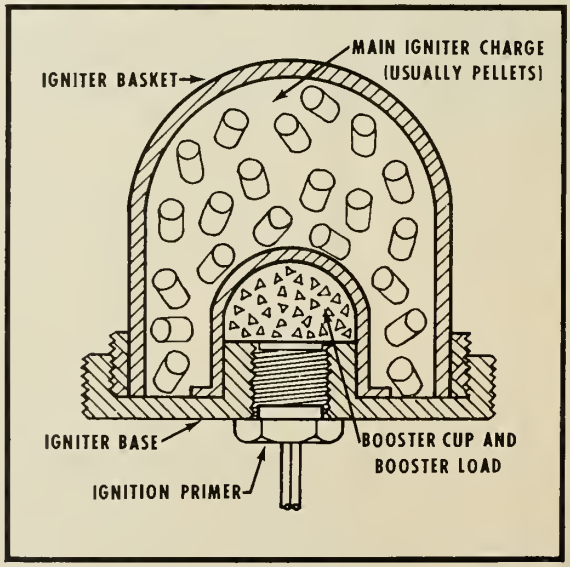
Another improvement is the use of flame directors and perforated metal baskets that produce a large ball of flame. In addition, the ignition interval is now ¼ of what it was in early models.

In addition to the development of improved charges, such as Aerojet's "Alclo" and others, the glass-to-metal seal pioneered by McCormick Selph Associates has done much to bring pyrotechnic systems to their present level. Mc/S/A feels it made the first significant contribution along these lines by using the glass-to-metal seal for getting electrical energy into the case while still providing a pressure seal. Most companies now use the technique.

As a result, the most recent models of ignition primers use the design encompassing a steel body with a hermetic glass-to-metal seal through which the electrical leads enter the primer cavity. Threading is provided to allow easy installation and removal, as well



CROSS-SECTION of Holex Model 1029B high-altitude ignition primer. Extreme quality control is applied.



TYPICAL IGNITER cross-section is shown in another diagram by Holex. Flame temperatures are near 3000°K.

EXTENSIVE DOW PRODUCTION FACILITIES FASHION VARIED NEW MAGNESIUM WARES

Coiled sheet, thin wall castings, many other production items are now available from Dow's big rolling mill, foundry and fabrication facilities.

Manufacturers on the alert for improved materials and production methods would enjoy a quick tour of the four Dow plants that turn out magnesium products. New ways of forming and fabricating magnesium now being practiced in these plants open up new areas of use for the lightweight metal.

TOOLING PLATE, extra flat, is annealed to eliminate residual stresses.

At the huge Madison, Illinois, rolling mill, for example, they're making magnesium sheet that doesn't require stress relief after welding. This is a major step forward in light metal technology and a boon to manufacturers using magnesium assemblies. Madison has also increased the maximum width of sheet to six feet. Five different sheet alloys, including elevated temperature alloys, are now available either flat or in coils.

To keep abreast of the rapidly increasing demand for precision jigs and fixtures, Madison keeps a close watch on the tolerances of Dow magnesium tooling plate. Typical flatness tolerances, for example, are 0.010 inches in any six feet. This means greater accuracy and less machining for users of Dow tooling plate. A mammoth 13,200 ton extrusion press, also located at Madison, is now turning out magnesium extrusions up to 30-inch circumscribed circle in size.

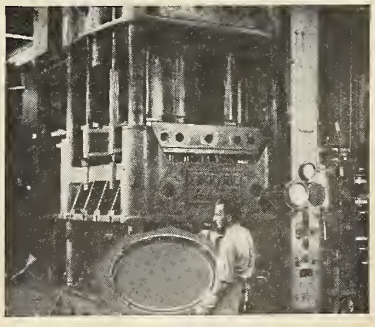
Over in Bay City, Michigan, interesting things are happening, too. At the well-equipped Dow magnesium foundry, largest in the U. S., sand and permanent mold castings of all sizes and shapes are being produced on a volume basis. Complete facilities are maintained for heat treatment, styrene DMI impregnation and chemical treatment. A well-staffed quality control team makes sure that all specifications are met or exceeded, and that the most modern equipment and techniques are fully utilized.

The Bay City foundry casts many complex and difficult designs. Large castings with walls as thin as 0.100 are now being produced. Other useful developments include cast-in tubeless passageways for use as hydraulic lines, special coring techniques for casting enclosed shapes and new magnesium casting alloys.

A new die casting plant is now on stream at Bay City. This facility houses the most advanced magnesium die casting equipment, including cold chamber metering units which automatically feed metal to the machines and contribute to unusually high production rates. To assure close alloy composition control in both die casting plant and foundry, a direct reading spectrometer provides frequent and precise analyses of the molten metal. Similarly, X-ray equipment is also available where radiography is needed in quality control.

The Dow fabrication plant, also in Bay City, offers capacity for volume work on magnesium assemblies. Here, too, developmental work on magnesium is constantly in progress. The plant is set up to handle large or small jobs, and plenty of both. Its activities include deep drawing, bending, spinning, stamping, piercing, machining, arc and spot welding, assembly, chemical treatment and painting. This plant has pioneered many "firsts" in magnesium production, such as hot drawing, spot welding and automatic welding.

DOW FOUNDRY offers production capacity for sand and permanent mold castings of all sizes.



LARGE DRAW PRESS at Dow's fabrication plant forms magnesium sheet in one operation.

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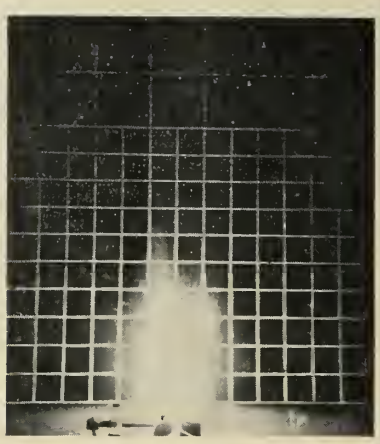
variety of flame patterns . . .



INDICATION of the range of ignition flame patterns is shown in these photos by Holex, Inc.

LEFT—The pattern using 400 milligrams of Holex No. 1 ignition mixture.

TOP LEFT—Four old-style primers.

ABOVE—The pattern from 160 milligrams of FFFG black powder.

TOP RIGHT—Ninety milligrams of Holex No. 1 mixture, as used in Model 1029B. (No flash bulb.)

RIGHT—Holex 1649 with one-gram Alclo booster charge.

as a positive seal of the igniter assembly as a whole. The metallic closure at the other end of the primer body is mechanically and chemically bonded in place.

The bridge-wires in these modern units are generally resistance-welded to the electrical leads of the unit, rather than soldered, and extreme quality-control steps are taken to insure a secure weld that will withstand shock, vibration and high thermal shock.

The environmental stresses which these units must be able to withstand are varied: a 40-foot drop without actuation or impairment of future ability to actuate normally; guaranteed not to fire at 0.5 ampere, but guaranteed to fire at 3.0 amperes; twenty immersions alternating between liquid oxygen and boiling water without impairing operating characteristics; and operational capability over 250,000 feet.

Ignition primers of this general type (specifications vary widely, of course, including the no-fire/all-fire electric current specs) have high reliability. They are basically susceptible to one failure in five thousand units for a single-bridge-wire part, and one failure in a half million units for a dual-bridge-wire unit having separate power supplied to each bridge-wire.

The construction of the opening through which the ignition mixture fires has a great deal to do with the resulting flame pattern. Tests conducted by Holex, Inc., have shown that some charges of 160 milligrams of explosive (in this particular case, it was FFFG black powder), can create a flame pattern more intense and larger than 600 milligrams of the same explosive. The difference consisted of a smaller opening, ⅛-inch, through which the larger charge fired. This allowed greater opportunity for heat transfer to occur and increased the velocity of the gases, both actions resulting in a cooler pattern. Increasing the size of the opening to ¼-inch eliminated this problem.

• **Testing and qualification**—In the early stages of ignition system development, as many as 10,000 ignition primers have been fired to obtain a statistical reliability level. This volume was necessary because individual units did not have the required reliability, and forced resort to a measure of redundancy. The extent of the redundancy was determined through large volume tests that established a reliability figure.

Quality control and reproducibility of the action of modern primers has made it possible to determine a statistical reliability level through testing a smaller number of units. A lot of 1200 ignition primers might require destructive testing of only 200 units. This leaves 1000 for operational use, and generally allows a lower overall production figure.

It has been found that this level of testing is adequate for the newer, more sophisticated primers now being made, and that no significant increase in re-

liability would result from testing a larger percentage of units. It has been maintained in the industry that this results in higher costs per individual unit, but total costs, when applied to a complete program, are probably equal, or even less, for the same or a higher degree of ultimate reliability.

• **Design considerations**—Until relatively recently, rocket engine manufacturers often purchased an ignition primer from the primer manufacturer, then incorporated this device into an ignition system of their own design. Increasing demands on environmental factors have caused a shift away from this policy to one of subcontracting the entire ignition system to a producer specializing in this field. Given the specification for such a system, the subcontractor then has complete responsibility for design, test, and production of it, and ultimate reliability rests on his shoulders.

Ignition system design can be definitely spelled out by the rocket engine prime contractor, using specified design considerations, as follows:

• Size and form factor of the ignition system package.

• Method of inter-connection into the rocket engine.

• Required output, expressed as a pressure/time curve related to the free volume to be pressurized. This curve will normally have upper and lower limits related to the temperature extremes permissible.

• Minimum allowable flame temperature and gas temperature.

• An expression of limitations of gas products. This may include specifications on maximum particle size permitted, percentage of metallic oxides, amount of solid particles vs. gases, and limitations on the maximum permissible corrosive effect tolerable.

• Environmental characteristics. This will include data on the shock, impact, acceleration, vibration, altitude, minimum and maximum operating temperatures, storage temperatures, and other considerations.

This method of completely subcontracting the ignition system does not relieve the rocket engine prime contractor from responsibility for testing the ignition system package to see that it meets specs, but it does allow him to devote more time and resources to design of the rocket engine. The ignition system contractor, on his part, can vary the internal parameters of the igniter package to produce the most efficient and reliable unit.

Once the specification has been established, variations in the type of primer, size and shape of flame pattern, complete environmental testing, and other qualification requirements may now be carried out by the subcontractor without time-consuming technical liaison with the engine producer.

Pyrotechnic ignition system design thus far has kept pace with requirements of rocket engines, both solid and liquid. This will probably be the case for the foreseeable future, since the technologies for both fields are so similar. The engineering and chemistry problems are common to both fields, and it is logical to assume that progress will be comparable in each area.

More advances are expected in reliability and design efficiency as experience and research increase. Every ignition system challenge to date has been met, and industry spokesmen feel that this will continue to be the case.

reviews

AN EXPERIMENTAL STUDY OF THE EFFECTS OF NON-UNIFORM WALL TEMPERATURE ON HEAT TRANSFER IN LAMINAR AND TURBULENT AXISYMMETRIC FLOW ALONG A CYLINDER, R. Eichorn, E. R. G. Eckert, and A. D. Anderson, University of Minnesota for WADC. Order PB 151680 from OTS, U.S. Department of Commerce, Washington 25, D.C. 68p. $1.75.

In a study of the measurements of both hydrodynamic and thermal characteristics of flow over an axial cylinder at subsonic speeds, it was found that the boundary layer along an axial cylinder tended to become asymmetrical, as it approached the transition point.

In turbulent flow, this asymmetry vanished again.

For both laminar and turbulent flow the average boundary layer growth was predicted by the standard flat plate relationships. Simple methods were deduced for determining the effective hydrodynamic length of the boundary layers. Local and total heat transfer measurements were made with both laminar and turbulent flow for various unheated starting lengths followed by increasing wall temperatures linearly.

TRANSIENT HEAT TRANSFER IN LAMINAR FLOW IN THE ENTRANCE REGION OF TUBES WITH HEAT CAPACITY, V. S. Arpaci, MIT for WADC. Order PB 151717 from OTS, U.S. Department of Commerce, Washington 25, D.C. $2.25.

Studied was the transient heat transfer phenomenon in laminar incompressible flow at the entrance region of tubes having small length-to-diameter ratios.

In order to create the effect of heat capacity of the tube-wall, the principle of conservation of energy for the tube-wall was considered. This was in addition to the usual fluid continuity, momentum, and energy equations. Since it was assumed that the velocity profiles at the entrance region of the tube could be approximated by the velocities of the laminar incompressible flow over a flat plate, the solution of the fluid flow problem was taken from previous work.

The remaining two partial differential equations, the fluid and tube-wall energy equations, were solved by using successive approximations. A modified Nusselt number based on the step temperature input is defined.

THERMAL BUCKLING OF CIRCULAR CYLINDRICAL AND CONICAL THIN-WALLED SHELLS. Do Abir and others, Polytechnic Institute of Brooklyn for WADC. Order PB 151740 from OTS, U.S. Department of Commerce, Washington 25, D.C. 169 p, $3.

Results of a theoretical and experimental investigation of the thermal buckling of circular cylindrical and conical thin-walled shells are given.

A 20 KW induction heating generator was used to simulate the effects of aerodynamic heating. The report is divided into six sections, with the first three covering the thermal buckling of circular-cylindrical shells. The remaining three sections investigated circular conical thin-walled shells.

Two basic types of tests were conducted on the circular cylindrical shells. Unreinforced shells were subjected to a thermal output varying in the peripheral direction with about the same longitudinal direction in the first test. In the second trial, circular cylindrical shells, reinforced by axially symmetric longitudinal stringers, were examined at a uniform thermal output.

NATIONAL BUREAU OF STANDARDS' JOURNAL OF RESEARCH, July-August 1959.

The featured article is a complete survey of radio and ionospheric observations made by National Bureau of Standards during the IGY.

The program ranged from the large synoptic network of ionospheric vertical sounding stations to selected experiments concerned with equatorial forward scatter, sporadic-E, radio noise, night airglow, and observations on satellite signals.

Included in a summary of some of these projects and a preliminary report on the results obtained in the following areas of research: World warning agency, ionospheric vertical sounding stations, VHF equatorial forward scatter, radio noise network, radio satellite observations, airglow observations, world data center for airglow and ionosphere.

CATALOG OF TECHNICAL REPORTS ON TRANSISTORS. Order CTR-310 from OTS, U.S. Department of Commerce, Washington 25, D.C. $.10.

A 1959 revision of the catalog lists 146 technical reports on transistors avail-

able to industry through the facilities of OTS.

The reports, some printed and others on photocopy or microfilm, are the results of research by the Army, Navy and Air Force between 1949 and June, 1959.

DEVELOPMENT OF WROUGHT BERYLLIUM ALLOYS OF IMPROVED PROPERTIES: PART I, J. G. Klein, L. M. Perleman, and W. W. Beaver, the Brush Beryllium Company, for WADC. Order PB 151711 from OTS, U.S. Department of Commerce, Washington 25, D.C. 154p. $3.

Rolled and extruded metal of commercial purity was evaluated with regard to its mechanical properties from room temperature to 1200°F.

The structurally modified beryllium developed was compared with the commercial beryllium's fabrication by extrusion and rolling, crystallographic and metallographic structures, and mechanical properties.

Some of the conclusions reached are that preferred crystallographic orientation will improve tensile properties in the direction of work; recrystallization and grain growth must be avoided in cross rolling from extruded bars; beryllium produced from subsieve-size powder and also high-oxide powder, 2.1 to 2.5% BeO, can be used to obtain wrought metal with tensile properties superior to those of commercial grade metal.

STATEMENT REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946 (Title 39, United States Code, Section 233) SHOWING THE OWNERSHIP, MANAGEMENT, AND CIRCULATION OF

MISSILES AND ROCKETS, published weekly at Harrisburg, Pennsylvania, for October 5, 1959.

1. The names and addresses of the publisher, executive editor, managing editor and business manager are: Publisher, Edward D. Muhlfeld, Washington, D.C.; Executive Editor, F. Clarke Newlon, Washington, D.C.; Managing Editor, Donald E. Perry, Washington, D.C.; Business Manager, Leonard A. Eiserer, Washington, D.C.

2. The owner is: American Aviation Publications Inc., 1001 Vermont Ave. N.W., Washington 5, D.C. Stockholders owning 1% or more of total amount of stock: Wayne W. Parrish, Washington, D.C.; Leonard A. Eiserer, Washington, D.C.; Eric Bramley, Washington, D.C.; Jay Shuler, Springville, N.Y.; Robert R. Parrish, Chicago, Ill.; E. J. Stackpole, Harrisburg, Pa.; Fred S. Hunter, Washington, D.C.; A. H. Stackpole, Harrisburg, Pa.

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4. Paragraphs 2 and 3 include, in cases where the stockholders or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees hold stock and securities in a capacity other than that of a bona fide owner.

5. The average number of copies of each issue of this publication sold or distributed through the mails or otherwise to paid subscribers during the 12 months preceding the date shown above was: 27,687.

LEONARD EISERER,
(Signature of business manager)

Sworn to and subscribed before me this 14th day of September 1959.

PATRICIA M. SNARE,
Notary Public.
(My commission expires April 30, 1960)

west coast industry . . .

By FRANK G. McGUIRE

If the steel strike is hurting industry, it isn't the aircraft/missile industries. All indications are that the strike could go into 1960 before a serious pinch developed, although December will bring tighter supply of some special types of metals. Present stockpiles appear to be completely adequate, thanks to anticipation of just such a need. Relatively low production levels in some large steel-consuming airframe firms are also helping avoid a crisis. **Douglas, Lockheed, North American, Aerojet-General,** and other companies have told M/R that, up to this point, there might as well not be a strike. But the pinch will come if the strike goes a few more weeks.

'The West is discriminated against . . .'

says a study made by a UCLA professor of history, Dr. John Caughey. "Spot a factory or distributor in the West, and another in the northeastern U.S.," he says, "and put a customer equidistant between these two suppliers. The freight rate from the West will almost invariably turn out appreciably higher than that from the East." Dr. Caughey concludes that the western United States and the industry here suffers economic discrimination in tariff laws, code of patents, licensing of patents, pricing system, and freight rates.

Magnaflux Corp.'s new test system . . .

for brazed honeycomb panels should substantially reduce inspection costs, if present indications are borne out. North American Aviation is investigating the method of thermographically checking panels for the B-70 and the F-108 before the latter program was cancelled. Although not committing itself, NAA says the system "shows great promise." The **Magnaflux** method, termed Bondcheck, is understood to cost less than $10 per square foot, locating and permanently recording irregularities in brazed honeycomb panels.

Leach Corp.'s Inet Division . . .

in August recorded the highest monthly sales volume in its history, amounting to a potential $2.5 million. Principally responsible were orders for *Titan, Bomarc B* and missile-cruiser support equipment.

Aerojet's subcontract awards . . .

for the past three years have totalled almost $300 million, and small business received $210 million of this figure. The company expects to make over 100,000 separate procurements this year.

Topp Industries' latest merchandising aid . . .

is a hi-fi recording of the automated control system being made by the firm's subsidiary, **Micro-Path, Inc.** The machine uses a stylus-type device to transfer instructions on magnetic tape, and the sound produced forms the basis for a progressive-jazz-like arrangement which has been put on a hi-fi record.

Lockheed's new materials-handling aid . . .

is a vacuum-pad lift bar which enables the company to handle curved panels of 1200 pounds, eight feet by 35 feet, with very little difficulty. Now being used on the Electra production line, the rig easily moves panels from one production station to another without the use of time-consuming rigging operations. The vacuum-pad unit could also take care of complex curved panels on a missile production line.

Rocketdyne's latest *Jupiter* engine . . .

has run up an impressive record of reliability. One engine, #5086, went through 23 consecutive full-thrust, full-duration tests at Redstone Arsenal. The 150,000-pound-thrust engine required only one minor component change in the 24-day-duration series. Over 25,000 items of data were recorded for analysis, and more than a quarter-million gallons of propellant were used by the engine during the series.

• **Cape Canaveral**—An "early" model *Polaris* test rocket was destroyed Sept. 28 when it spun out of control shortly after first-stage separation on a programmed 700-mile flight. It was the third failure in 39 shots.

• **New York**—Maj. Gen. Ben. I. Funk, chief of the AMC's Ballistic Missile Center, says the **Boeing** *Minuteman* "promises to represent a major economic breakthrough" which will enable the nation to maintain ICBM spending at current levels. While not naming any figures, he said the solid-fueled weapon would be "considerably" less expensive than *Atlas* and *Titan* when it is in production.

• **Washington**—In a "clarification" of its "zip" fuel program, the Air Force said it would continue production of boron compounds at the **Olin-Mathieson** pilot plant in Lewiston, N.Y., through the remainder of 1959 and probably into next year. AF indicated that there is still hope the fuels will be useful in rockets and it will employ the 1600 pounds per day of pentaborane and decaborane produced at Lewiston in R&D.

• **Hempstead, L.I.**—The Air Force has awarded **American Bosch Arma Corp.** $53.4 million in contracts for all-inertial guidance systems for operational *Atlas* ICBM's. The company says the "major portion" of support equipment and production test equipment will be subcontracted on competitive bids.

• **New York**—A $42.6 million contract to build, install and test the first 18 underground launching systems for *Titan* sites at Lowry AFB, Denver, has been awarded **American Machine & Foundry.** Contract raises AMF's total *Titan* business to more than $103 million . . . The Air Force says construction of a *Titan* base will start this fall at Ellsworth AFB, S.D., and it will cost $47 million. Contracts will be let in November for construction work.

• **Pasadena**—Now operational: a $3.5-million continuous-flow wind tunnel to test missile stability and control at Mach 9 speeds at **Jet Propulsion Laboratory.** Tunnel is being operated under an Army Ordnance contract.

• **Grand Rapids, Mich.**—A signal from an orbiting U.S. satellite picked up by the Army's Astro-Observation Station at Ft. Monmouth, N.J., and relayed here opened a new $5-million facility of **Lear Inc. Instrument Division,** which manufactures gyros.

• **Washington**—The Air Force cancelled the firing of a **Martin** *Bold Orion* ALBM from a B-47 at NASA's paddle-wheel satellite in the first attempt to test feasibility of knocking down reconnaissance satellites with air-launched ballistic missiles.

• **Reno, Nev.**—The Interior Department announced the development of a simple, cheap method of producing commercial grade tungsten and molybdenum powders for use in alloys. The one-step process reduces the mineral, scheelite, resulting in 99% plus pure tungsten and 98% pure molybdenum through a fused-salt-bath-electrolysis. This is in contrast to the normal costly, commercial processes which do not recover the pure molybdenum.

Rockets Detect X-rays Created by Solar Flares

WASHINGTON—X-rays with energies as high as 80,000 volts have been detected by rockets fired into the upper atmosphere during the recently completed Project *Sunflare II*. The high-level emissions are produced during the most active phases of solar flares, and indicate temperatures as high as one hundred million degrees centigrade.

The solar flare studies were made by Naval Research Laboratory scientists with 12 *Nike-Asp* rockets fired from Point Arguello, Pacific Missile Range. Background for the project was furnished by two previous studies, project *Rockoon* (1956) and *Sunflare I* (1957). Data gained by this early work led to more sophisticated instrumentation capable of the greater sensitivity needed to measure the X-ray flux.

Singer Reports Reds Use Outmoded Magnetometer

WASHINGTON—Soviet space scientists are using a magnetometer 13 years out of date, Dr. S. Fred Singer reported last week.

Singer told an American Rocket Society meeting that the instrument, designed for ground use, takes much more space, weight and power than those used in U.S. research satellites. "They never thought about designing magnetometers for rockets," he declared.

The University of Maryland physicist, a top authority on cosmic and space radiation, said Soviet basic researchers are completely isolated from rocket designers. On his visit to Russia last summer, Singer added, he never met any rocket experts although he had free access to other scientists.

Singer said he has changed his mind and now does not believe the Soviets will soon put a man in orbit. He believes their next spectacular projects will be a near miss of Mars next summer and a "straight up and down" shot of a rocket carrying a man.

Lovell Says *Lunik* Data May Be Inferior to Ours

LOS ANGELES—The U.S.S.R. probably is getting less scientific information from *Lunik I* and *II* than the United States receives from its space probes, according to Dr. A. C. B. Lovell, director of the Jodrell Bank Experimental Station in Great Britain.

Dr. Lovell pointed out that although the payloads *Lunik I* and *II* were massive, they were not as precise or as sophisticated as U.S. payloads.

The British scientist, here on a private visit, also suggested that the U.S.S.R. may have much larger radio telescopes than the 70-foot dishes shown him on his recent trip to the Soviet Union. He noted that *Lunik I* had been tracked for a half-million miles by the Russians, and said none of the equipment he saw was capable of such a feat.

propulsion engineering . . .

By JAY HOLMES

Nuclear rockets propelled by hydrogen . . .
are a little less exotic than other non-chemical propulsion systems. The technology of nuclear fission reactors is well along. Liquid hydrogen now is available in large quantities. Thus the building of a nuclear rocket is mainly a job of scaling existing reactors up to the power level needed while scaling down their weight. Yet there is opportunity for a major gain in specific impulse. NASA calculations indicate such a powerplant can have I_{sp} of 800 seconds, compared with 400 for the best conventional chemical systems.

Furthermore, big payload fractions are possible . . .
as much as 10%, compared with 3% for chemical propulsion, in ships weighing 75 tons or so. Researchers believe a nuclear booster will be available about 1970 and will be much cheaper than chemical boosters of comparable size. They are thinking in terms of a reactor generating 10,000 to 30,000 megawatts—which would develop 400,000 to 1,200,000 pounds of thrust.

A huge advance in reactor technology . . .
is taken for granted in such thinking. The biggest present reactor—on the ground, of course—generates less than 1000 megawatts and weighs several times 75 tons. Furthermore, chemical systems will be less costly and less complex for lighter payloads. For the monstrous boosters needed for space travel, however, chemical fuel alone could cost as much as $10 million.

A nuclear rocket is conceptually simple . . .
It has one stage. The powerplant is not discarded. The fore portion consists of the astronauts' cabin. A large center section is a liquid hydrogen tank, which also serves as a shadow shield, providing part of the protection against radiation from the reactor, in the rear. The valve system bleeds hydrogen, which boils to cold gas and acts as the reactor coolant. Then the gas passes through the center of the reactor, where it expands rapidly, providing propulsion.

Smaller nuclear rockets will be available sooner . . .
than a nuclear booster—perhaps in five years. A small nuclear rocket, placed in orbit by a chemical booster, could power a space ship to the moon, land, take off, return to earth and re-enter the atmosphere. Lift off the moon requires less thrust because the moon's surface gravity is only 1/6 that of earth. A powerplant designed to do this job might generate 1000 megawatts and give 40,000 pounds of thrust. Even smaller plants, upwards of 10 megawatts, could do some of these jobs.

Continuous operation is the big advantage . . .
of a nuclear rocket. The reactor can operate almost indefinitely. The only limitation is the amount of hydrogen propellant; even this isn't much of a limitation—liquid hydrogen is extremely light (0.6 lb./gal.). There's no reason why a nuclear space ship can't maneuver in the space beyond the outer Van Allen radiation belt as long as hydrogen remains in its propellant tank.

Materials are the biggest barrier . . .
to nuclear rocket development, just as to improvement of conventional powerplants. There are the usual high-temperature problems in designing rocket nozzles, plus one distinctive headache—the nozzle must be made of material that isn't attacked by hot hydrogen. This rules out graphite. Tungsten will withstand hydrogen but it is notoriously weak. The chances are that a powerful, reliable, lightweight nuclear engine will be available for space propulsion by the time the material quandary is solved.

SATELLITE'S VIEW OF EARTH —The picture at the right was taken by a two-pound camera device in *Explorer VI* from 20,000 statute miles. The satellite was 24,000 statute miles from the Pacific area pictured. Though not intended for this purpose, the picture distinguishes between cloud structure and ocean reflection to a degree that the picture corresponds to the meteorological pattern of that day. (See picture at left.) NASA scientists feel the test shows that such a system would be feasible to detect cloud formations over a large area from a circular-orbit satellite.

Silica Forming Process Offers New Sizes, Shapes

CORNING, N.Y.—The unique thermal and electrical properties of silica glass may be more fully exploited through a new forming process developed by **Corning Glass.**

Called "Multiform" fused silica, the method produces sizes and shapes never before possible and equal to any achieved by conventional ceramic forming.

With properties differing only slightly from those of the parent glass, the product is undergoing evaluation for use as a flush-mounted missile radome.

Multiform-fused silica tends to sublime before melting and plasma jet tests show uniform ablation. The material can suffer long exposure at 1700°F, softens at 2880°F and has excellent resistance to thermal shock.

Center Being Built for Worldwide Monitoring

MOUNTAIN VIEW, CALIF.—An unusual master control center for worldwide monitoring of satellite flights is being designed and built here by the **Space Communications Division** of **Radiation, Inc.** for **Lockheed Missile and Space Division.**

The development control center (DCC) will continuously receive and evaluate data from an orbiting satellite, receive information direct from all tracking equipment around the world, command this equipment, receive corrections and program data to the satellite, plot world-wide weather, satellite locations and altitude, and keep track of the status of all tracking equipment. In addition, the center will also relay messages via closed-circuit TV to the Vandenberg AFB blockhouse.

The center will go into operation 24-48 hours before launch with a full-dress rehearsal and flight simulation to check equipment operation. After launch, data will be fed into the center by TWX and telephone. Tracking stations will be directed and programmed on the basis of calculations derived from this data.

Charts at the center plot the weather at all stations, the location of the satellite, and the status of all tracking equipment. The center receives instant notice if any equipment breaks down.

A $1.5-million communications system will tie the DCC to the blockhouse, tracking stations, BMD, air rescue service, and other participating facilities.

'Pinch Plasma' Advocated For Future Satellite Use

WASHINGTON—Plasma accelerators will be useful for trajectory correction, attitude control and satellite boosters before they are ready to be applied in long-range propulsion.

Bernard Gorowitz, Kenneth Moses and Per Gloerson of **General Electric's Missile and Space Vehicle Department** told the Fourth Symposium of Ballistic Missile and Space Technology at UCLA recently that plasma accelerators could be used sooner in the area of corrective maneuverability.

At Northwestern University, the Third Biennial Gas Dynamics Symposium of the American Rocket Society heard Alfred E. Kunen, manager of the plasma propulsion project at **Republic Aviation,** propose that "pinch plasma" engines be used to power satellites after they have attained orbit.

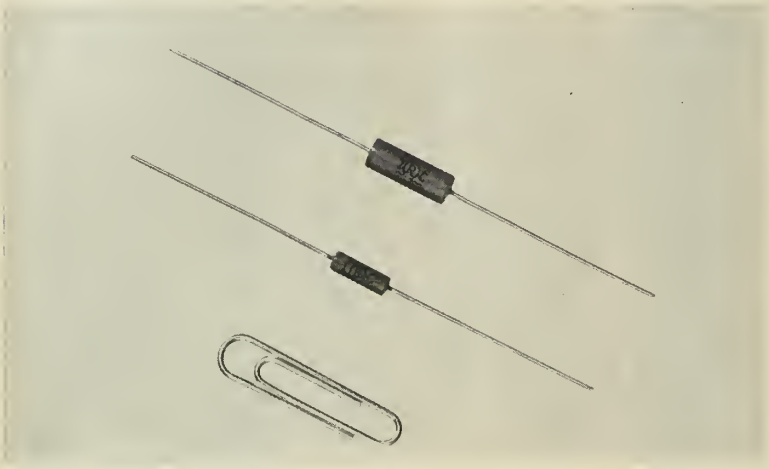
Kunen said that such control would "sharply hasten the day of man-carrying and reconnaissance satellites."

A satellite could then stay in orbit longer, change orbit if need be, and prevent tumbling over itself.

"Pinch plasma" engines would be ideal for this because of their extremely low fuel consumption and low fuel weight.

In operation, the hot gas fuel is changed into a plasma state by electrical discharge in the engine's compression chamber. The current then passes around the electrically conductive plasma, setting up a cylindrical magnetic field. This magnetic cylinder pinches the plasma into a tiny area so designed that it shoots out the rear at very high velocities.

The Republic scientist said that the plasma engine would power a space ship designed for interplanetary flight.



Resistor Sizes Cut by One-half

A totally new method of deposited carbon resistor manufacturing by the **International Resistance Company** has resulted in reduction in size and weight of resistors by more than 50%, the company says.

The advance was signalled by development of a radical new deposited carbon alloy, but this in turn required a redesign of almost every element in the resistor. An insulating spiral path, which determines the resistance value, is now diamond-cut in the much harder alloy film, rather than sand-blasted as formerly. The result is a much more precise incision, with consequent improvement in stability and reliability.

The highly conductive terminating point, which bonds the end-cap connections to the film, is still another new development, according to the maker. Over the resistance element are two new types of moisture-resistant undercoat, also especially developed for this product.

Completing the double-barrier insulation is a new-type molded, break-resistant casing, which, though heavy-duty, is well within MIL size. This molded insulation results in improved load-life characteristics, better dielectric characteristics, and greater opposition to the effects of moisture. It provides all the advantages of ceramic solder-sealed types, without the hazards of seal leakage, breakage and low dielectric strength.

These radically improved resistors are available in ¼ watt, ½ watt and 1 watt sizes, in resistances from 10 ohms to 25 megohms. Standard tolerance is 1%, although 0.5 and 2% types are also available.

Circle No. 250 on Subscriber Service Card.

Retractable Cutter Bar Turner Now Available

New in the field of single spindle bar automatic tooling, a retractable-cutter bar turner is announced by the **Warner & Swasey Co.**

Advantages of the new bar turner, which is designed for the company's 2AB single spindle bar automatic, include highly efficient metal removal with exceptionally close tolerances and smooth, burnished work finishes. Automatic cutter retraction and resetting, according to Warner & Swasey, eliminate tool withdrawal marks and prolong cutter life.

Capable of handling bars from ½" to 2¾" diameter, the new turner clamps directly in the dovetail of the pentagon turret. One coolant line, emanating from the pentagon coolant distributor, is the only separate connection necessary in mounting the bar turner on the machine.

Under cut, the turner's tool holder slide, which is spring-loaded, bears against a spring-loaded stepped cam. Upon completion of the cut, forward motion of this cam is arrested when a screw—connected to the cam—strikes a special stop positioned on the front cross slide housing of the machine. The pentagon turret then continues to feed forward about 1/8" to the end of its stroke, sliding the turner's tool slide off the cam and retracting the cutter.

The cam and cutter are automatically reset in an off-index position by an overhead mounted resetting cam. This resetting cam bears on a roller located on the bottom of the cutter slide.

Circle No. 251 on Subscriber Service Card.

Bonding Material Reduces Honeycomb Sandwich Costs

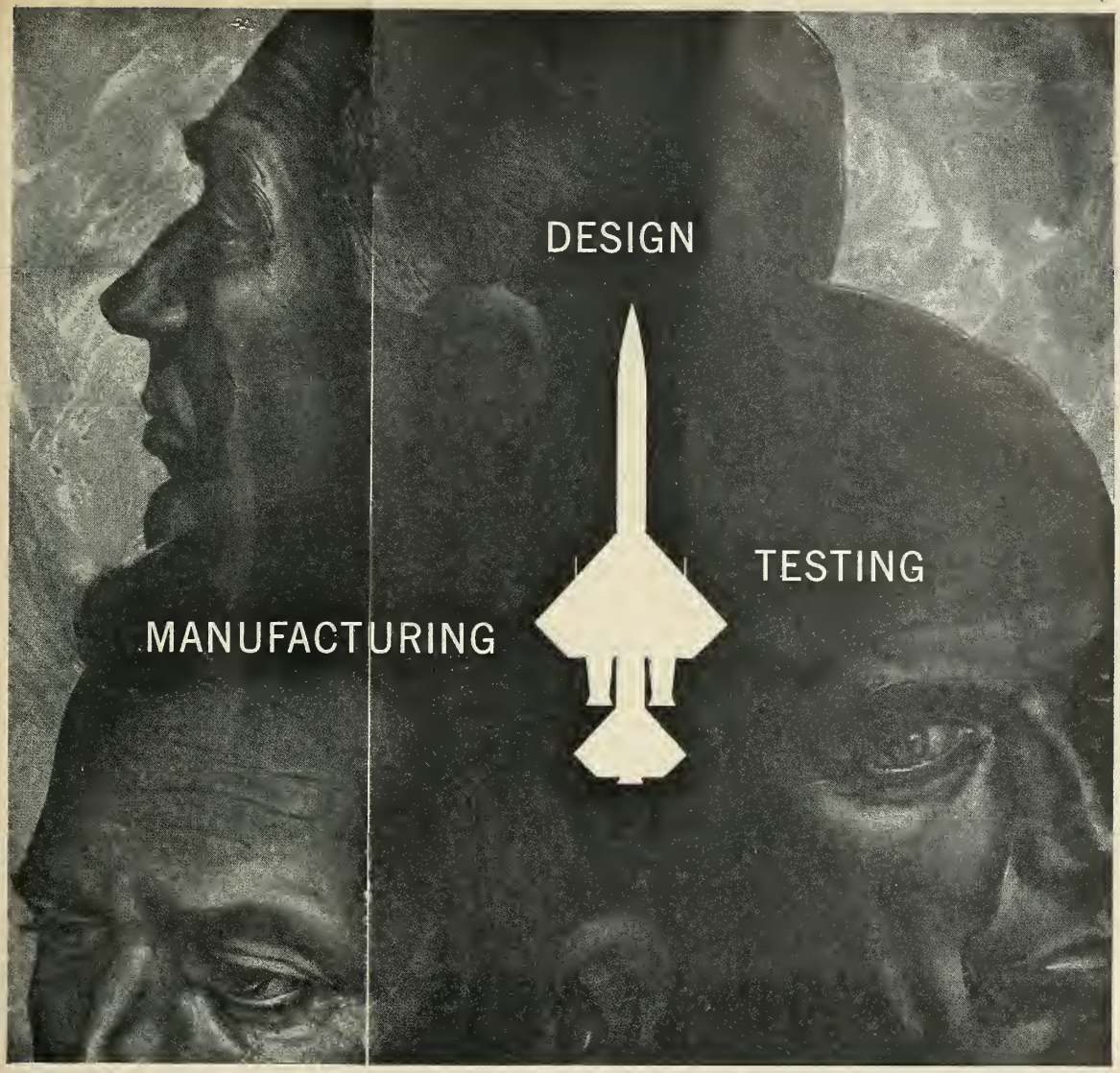
The cost of non-structural honeycomb sandwiches has been reduced by introduction of an inexpensive, easy-to-handle bonding material consisting of cotton cloth and a partially-cured phenolic resin.

Designated as Narmtape 105 by the maker, **Narmco Resins & Coatings Co.**, the new product comes in continuous rolls that may be cut to size with scissors or textile cutters. The tailored sections are then laid in place, and the assembled sandwich heated under slight pressure in order to achieve the desired bond.

Narmtape sharply reduces the total cost of sandwich assemblies. Estimates are that the adhesive can be cut and put in place at a total bonding expense of less than fifteen cents per square foot. This is less than half the cost of most adhesive systems now being used in the construction of honeycomb panels.

Honeycomb bonding presents a

special problem, since the adhesive must fasten the thin honeycomb cell walls at right angles to the outer skin —and seldom is the honeycomb cut sufficiently flat for all the cell edges to meet the skin perfectly across the width of the sandwich. Enough adhesive must be provided, therefore, to bridge any gaps that might be present, and to "wet" the sides of the cell walls



FOR REINFORCED PLASTICS, PICK THE PROVEN LEADER

Deadly darting missiles and super-sonic fighters now prove in flight the advantages of Brunswick leadership in critical space-age components. Brunswick designs, tests and manufactures reinforced plastic and filament-wound super-sonic radomes to meet most *environmental* needs.

Critical Brunswick components are now specified and/or used in missiles such as the McDonnell Quail, Lockheed Kingfisher and Polaris, and Boeing Bomarc; in aircraft such as the Convair F-106A and B-58, North American F-108, McDonnell F3H, F4H and F-101, and Republic F-105.

From filament-wound radomes by the unique Strickland "B" Process to honeycomb-core, foam-in-place or anti-icing type radomes, Brunswick supplies the reliability of proven leadership. Write to Brunswick-Balke-Collender Co., Defense Products Division, 1700 Messler St., Muskegon, Michigan.

BRUNSWICK

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to form strengthening fillets.

The flame-proofed cotton cloth in Narmtape 105 acts as a carrier for the modified phenolic adhesive. Impregnated under rigorous quality control procedures at the factory, the cloth assures an evenly-distributed adhesive layer across the entire sandwich area. Following impregnation of the cloth, the adhesive resin is partially cured (to "B" stage). Result: a dry, easily-handled product that can be stored for months at room temperature.

When the assembled sandwich is raised to full curing temperature (approximately 300°F), the resin in the cloth softens and flows to fill the gaps between honeycomb core and skins—then, in less than thirty minutes, hardens into a solid, thermosetting plastic film.

To provide an exceptionally tough, resilient bond, the phenolic resin in Narmtape 105 is modified with a vinyl butyral elastomer. This provides good adhesion with a variety of honeycomb core materials, including aluminum, paper, and fiber glass. Paper and fiber glass cores are usually sealed with a resin coating before bonding. Aluminum sandwich skins are degreased and etched, to obtain maximum adhesion.

Narmtape 105 has a weight of 0.05 pounds per square foot, and an uncured thickness of 0.007 inches. It is available in 36- to 52-inch widths, in continuous rolls with a polyethylene film separator. In the cured state, the adhesive system has a tensile-shear strength in excess of 2500 psi on aluminum, making a strong and stable bonding agent for such applications as fabrication of architectural panels, truck bodies, and insulating walls.

Circle No. 252 on Subscriber Service Card.

Computer Searches Tape File, Types Information

The Univac Tape Searchwriter, an integrated system which provides an economical method of searching a magnetic tape file for a desired item and then automatically types the information, has just been announced by Remington Rand Division of **Sperry Rand Corporation.**

Users of Univac II computing systems will find it particularly valuable as peripheral equipment. It permits finding tape-recorded records and printing the desired information without consuming computer or programmer time. It may also be used as an error-checking interrogator because it incorporates all the error-checking features found in Univac systems.

The device is transistorized to reduce size and increase reliability. It is conveniently arranged so that typewriter, operating controls, and tape transport are within easy reach of an operator. Except for the tape handler the system is also self-contained. Power supplies, read-write amplifiers, control circuits including bad spot logic, error-checking circuits, and tape control are integral.

A Synchro-Tape typewriter is included, which permits identification of the desired item manually on the typewriter keyboard or automatically from previously prepared paper tape. When the search is completed and the sought-for item located, the typewriter types the information or punches it on paper tape, or both, as desired.

Any standard Univac characters can be entered from the keyboard or paper tape as the key or identifying data. As the key is entered, it is also printed on the typewriter. When the item is located, it is printed in standard Univac code except that only 44 of the 63 characters are printed as standard characters. The other 19 are printed as a single special symbol. This has been done to prevent the necessity of writing carriage shift characters for the typewriter on magnetic tape.

To simplify switching within the Synchro-Tape typewriter, the punch unit always runs as the key is entered either from the keyboard or from paper tape. When the item is printed or punched, the paper tape may also be operated. The paper tape may be removed in this feed if tape punching is not desired.

Circle No. 253 on Subscriber Service Card.

Atlas ICBM Switch's Weight Sharply Reduced

A new motor-driven switch developed by the **Kinetics Corp.,** has saved 43 pounds weight in the *Atlas* missile.

The new switch used in the Series D missile weighs only 7 pounds, compared with a weight of 50 pounds for the switch that was used in the Series A missile.

The new Kinetics motor-driven switch is more rugged and reliable than previous designs and is impervious to shock and vibration. A typical Kinetics switch exhibits no contact chatter over the whole vibration spectrum, from 5 to 2000 cycles, 40g's. The voltage drop across typical switch contacts is less than 10 millivolts at 22 amp.

The high density design results in many more circuits per cubic inch, saving space. There are no permanent magnets or springs, no latching devices. This is truly a motor-driven switch using no elements of relays. The switch can be transferred at 40 g's, 2000 cycles. Once it's transferred, no power is required to hold it in position, saving batteries.

Circle No. 254 on Subscriber Service Card.

Magnetic Limit Switch Has No Moving Parts

A new magnetic limit switch which has no moving parts and acts on promixity of its two sensing elements, rather than actual physical contact, has been introduced by Consolidated Controls Corporation, a subsidiary of **Consolidated Diesel Electric Corporation.**

Known as the Amplet magnetic limit switch, the device is seen by its manufacturer as ideally suited to those automation applications where precise control of the relative motion between two parts of a machine is required. Typical applications include limiting cuts or traverse on such machine tools as shapers, planers and drill presses; stopping conveyors at pre-determined positions; continuous sequencing and counting, and automatic weighing and filling.

The device consists of three parts—a probe, which is normally mounted on a stationary part of the machine being controlled; a magnetic trigger, which is mounted on a moving part of the machine or on the part being machined, and a power amplifier, which increases the power output of the probe to useful levels.

In operation, the probe, which is connected by wire to the power amplifier, gives an "off" signal until the permanent magnet trigger, which has no wired connections, approaches within a pre-determined distance. At that distance the probe, without mechanical movement of any kind, gives the electrical equivalent of a "snap" action to an "on" signal condition.

The "snap" action, response time of the unit, requires less than 1 millisecond. By adjusting a sensitivity control on the power amplifier, the distance between probe and trigger at which action takes place is variable from .020 to .200 inch. When motion is reversed, the "on" signal remains until the trigger has moved a distance varying from .002 to .02 inches, depending on adjustment, away from the probe, at which point the "off" signal is restored. The point at which action takes place is repeatable within .001 inch if relative travel paths between probe and trigger are at a constant distance.

Power amplifier units are available either normally "off" or normally "on." In the latter case, of course, action is the reverse of that described above.

Power input to the unit at full load is seven watts of 115-volt, 60-cycle AC. The output signal is 50 microamperes in the "off" condition and five watts of 24-volt DC in the "on" condition.

Circle No. 255 on Subscriber Service Card.

—contracts—

MISCELLANEOUS

Tapco Group of Thompson Ramo Wooldridge, Inc., for the development of a miniature accessory power supply. (Subcontract from **Sandia Corporation**). Amount not disclosed.

Tinsley Laboratories, Inc., Berkeley, Calif., for a Schlieren air flow visualization system for a new supersonic wind tunnel near Saugus, Calif. (Subcontract from **Lockheed Aircraft Corp.**) Amount not disclosed.

$2,000,000—**The General Bronze Electronics Division**, Garden City, N.Y., for antenna systems for the ballistics early warning system program. (Subcontract from **General Electric Co.**)

$1,600,000—**Taico Engineering Co.**, subsidiary of **The Gabriel Co.**, for the manufacture of rocket motors, rotational and vertical thrusters and other components.

$500,000—**FXR, Inc.**, Woodside, N.Y., for the design and manufacture of a powerful radar transmitter. (Subcontract from **Cornell Aeronautical Laboratory, Inc.**)

$77,000—**Pacific Automation Products**, for work on the first Azusa Mark II missile tracking system. (Subcontract from **Convair Astronautics**).

$56,000—**Aerojet-General Corp.**, for a feasibility study of the use of small rocket devices for individual combat soldiers.

NAVY

Sylvania Electric Products, Inc., Woburn, Mass., for special switching transistors to be used in the *Polaris* weapons system. (Amount not disclosed).

$445,000—**Consolidated Systems Corp.**, Subsidiary of **Consolidated Electrodynamics Corp.**, Monrovia, Calif., for construction of a data processing system at the Naval Ordnance Aerophysics Laboratory, Daingerfield, Tex.

$70,000—**Summers Gyroscope Co.**, Santa Monica, Calif., for spare parts used in depot maintenance and overhaul of vertical gyro indicators.

$30,000—**Armour Research Foundation of Illinois Institute of Technology**, for conducting investigation to develop ductile beryllium composites and determine the mechanical properties of materials produced.

$28,500—**New York University**, for conducting an investigation and perform tests to develop high temperature resistant resins bases on complex information with organotitanates.

AIR FORCE

$42,600,000—**American Machine & Foundry Co.**, New York, to build, install and test the first 18 operational underground launching systems for the *Titan* ICBM at Lowry AFB.

$15,500,000—**Federal Electric Corp.**, Paramus, N.J., for non-personal services to operate and supply support for the White Alice communications system in Alaska.

$12,105,000—**Kollsman Instruments Corp.**, Div. of **Standard Coil Products Co., Inc.**, for automatic astro compass support equipment and related spare parts and technical data.

$3,000,000—**The Mitre Corp.**, Lexington, Mass., for research, development and advisory assistance for the air defense systems integration division.

$2,166,420—**General Electric Co.**, for long-range search radar antennas for AN/FPS-7 radar system.

$1,000,000—**Summers Gyroscope Co.**, Santa Monica, Calif., for spare parts kits and other spare parts items used in depot maintenance and overhaul of gyroscopic indicators.

$1,000,000—**Westinghouse Electric Corp.**, for electrical equipment to power and guide *Atlas* missile. (Subcontract from **Goodyear Aircraft Corp.**)

covering the

IR spectrum

from the near to the far

Infrared at ITT includes complete detection systems as well as basic components

INFRARED is today, as it has been for a number of years, one of the "hottest" activities at ITT.

ITT Laboratories is equipped to design and develop new ideas in generation, transmission, detection, and utilization of infrared radiation.

ITT has made many important contributions in IR techniques —not only from one end of the spectrum to the other, but from simple devices for viewing objects in the dark to air-to-air search-track and tracking of satellites in orbit.

ITT's advanced position in the IR systems field is founded on its broad experience in basic IR components, such as lead telluride, doped germanium, and indium antimonide detectors; black-body radiation sources; image converter, photo-multiplier, and Iatron® direct-view storage tubes for display of IR information.

For increased detector efficiency, ITT has developed a full line of coolers, including cryostats for gaseous nitrogen, recirculating liquid nitrogen coolers, and liquid nitrogen dispensers that will cool cells for many hours—even after more than a day in storage. ITT also supplies component and system test equipment.

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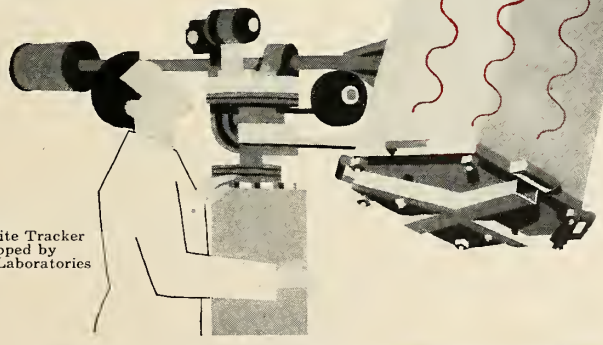

Satellite Tracker developed by ITT Laboratories

Among the infrared research activities at ITT Laboratories

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. . . contracts

$1,000,000—**Raytheon Mfg. Co.**, Andover, Mass., for studying communications techniques for the *Minuteman* ICBM. (Subcontract from **Boeing Airplane Co.**)

$691,753—**Consolidated Electrodynamics Corp.**, Monrovia, Calif., for digital pressure measuring system.

$600,000—**Hoffman Laboratories Div., Hoffman Electronics Corp.**, for the development of a large area solar-electric power system for use in space satellites.

$500,000—**International Business Machines Corp.**, N.Y., for additional facilities and modifications for research and development of an advanced guided missile program.

$500,000—**Radio Corp. of America**, Defense Electronic Products Division, Moorestown, N.J., for one mobile instrumentation radar.

$239,999—**Beckman Instruments, Inc.**, Anaheim, Calif., for multichannel system for analog to digital conversion.

$129,112—**Yardney Electric Corp.**, N.Y., for the production of automatically activated silver-zinc batteries used as primary power sources for the *Minuteman* ICBM. (Subcontract from **Autonetics Div. of North American Aviation, Inc.**)

$54,100—**Ampex Corp.**, Redwood City, Calif., for magnetic tape recorders and magnetic tape.

$50,873—**Documat, Inc.**, Belmont, Mass., for modification of microfilm viewers.

$40,000—**Pennon Electronics, Inc.**, Bell Gardens, Calif., for manufacture of custom magnetic regulated power supplies to be used in ground checkout operations for the *Minuteman*. (Subcontract from **Autonetics Div. of North American Aviation, Inc.**)

ARMY

$30,162,502—**Raytheon Mfg. Co.**, Andover, Mass., for supplemental engineering services and ground support equipment for the *Hawk* missile.

$10,995,680—**Western Electric Co.**, N.Y., for continued work on *Nike-Hercules* missiles.

$750,000—**Collins Radio Co.**, Cedar Rapids, Iowa, for service and materials for one primary tracking station and two secondary satellite tracking stations.

$555,000—**Chrysler Corp.**, Detroit, for support equipment for the *Jupiter* missile.

$359,247—**Raytheon Mfg. Co.**, Andover, Mass., for repair parts for the *Hawk* missile system.

$277,460—**Sperry Rand Corp.**, Sperry Utah Engineering Laboratory, Salt Lake City, Utah, for *Sergeant* missiles. (Two contracts).

$99,832—**Electro-Optical Systems, Inc.**, Pasadena, Calif., for study of mechanisms.

$88,770—**Western Electric Co.**, N.Y., for *Nike* spare parts and components. (Two contracts).

$74,985—**S. R. Brunn Construction Co.**, Kansas City, Kan., for construction of warhead building for *Nike-Hercules* facilities, Kansas City Defense area.

$74,417—**Radioplane Div., Northrop Corp.**, Van Nuys, Calif., for instruction and maintenance of target missiles.

$43,519—**Electro-Optical Systems, Inc.**, Pasadena, Calif., for research and development work on advanced solar energy conversion devices.

$40,000—**California Institute of Technology**, for hypersonic research.

$37,964—**Radioplane Div., Northrop Corp.**, for low-speed drone system.

$37,646—**University of Colorado**, for continued research to study the nutritional adequacy and probable toxicity of foods sterilized by ionizing radiations.

$33,000—**North American Aviation, Inc.**, Canoga Park, Calif., for design and development.

$26,514—**University of Louisville School of Medicine**, for continued research on mechanism of conservation of body fluids.

$21,797—**Douglas Aircraft Co.**, Santa Monica, Calif., for *Nike* spare parts and components.

For the AF—Its Biggest Job

Whether or not you agree with the decision—and there are some who do not—the action of the Defense Department in making the Air Force responsible for all space transportation was a long overdue step toward putting the entire U.S. military space program into an established technological context.

For the first time, it establishes space not as a place but as a field of endeavor. It allows military operations in that field to be viewed in relationship to similar traditional operations. It permits space requirements in such areas as communications, reconnaissance and navigation to be judged not as they relate to space alone but as they relate to the requirements of the military as a whole.

Perhaps this matter of requirements is actually the greatest gain to come from the Department of Defense decision, greater even than the step the decision takes toward solving the entire roles and missions problem.

Military proceedings have long been based on requirements in accordance with missions. A service is assigned a mission. It then develops requirements in accordance with that mission. The requirements, translated into hardware, are tanks, submarines, airplanes—or satellites.

The Advanced Research Projects Agency was established as a palliative after *Sputnik I*, and although ARPA has done excellent work in some cases, it could not escape being an ivory tower when it came to relating requirements to missions. With the present complexity of modern weapons, it has become impractical to adopt anything but a weapon systems approach to production. And under the weapon system concept the parceling out of any major project piecemeal among the services, as ARPA attempted, can hardly fail to produce inefficiency and delays.

General Bernard Schriever, whose adoption of the principle of concurrency in the production of ballistic missiles resulted in chopping almost two years off the estimated production time, told the Senate Space Committee last Spring:

"Weapon System development based on technical feasibility requires that the military do a number of things:

"1. Conduct a vigorous research, applied research, component and subsystem development program.

"2. Conduct constant evaluation and analysis of the above programs, aided by science and industry, to insure timely initiation of space weapon system development programs.

"3. Centrally manage and control space weapon system programs to insure effective systems engineering, integration and testing, which is essential to the intricate technical interface between and among the several subsystems comprising the total weapon system."

General Schriever added:

"The ability to apply this philosophy of weapon system initiative to space vehicles will be complicated if there is an excessive division of subsystem development projects among agencies or if there is not a timely decision as to the operator." Later in his testimony Gen. Schriever indicated that placing development of military space projects under ARPA left things complicated indeed.

The decision of the Department of Defense to give the Air Force the role of space transportation does not deny the utilization of the space field to other services. Any service with a recognized requirement can and will develop the necessary equipment. As the using service, it will carry out the research, the evaluation and the management while concurrently producing the support equipment and training the using personnel. In the Navy, as currently programed, this will be a navigational satellite. In the case of the Army—a communications satellite. The Air Force—and the Air Force alone, militarily—has the role of integrating all systems and of putting the satellites in orbit.

The decision to clarify the space roles of the services has been a long time coming. Giving the job of space transportation to the Air Force seems to us a logical step. There are many unsolved questions that still remain. Is there still a job for ARPA —still very much in evidence—to do? What will become of the Army's Ballistic Missile Agency and the scientific team there which has contributed so many "firsts" in the space field?

The Air Force, incidentally, will probably need and would probably welcome their help—if this isn't heresy. For the Air Force, at the moment, is recognizing the burden of a great responsibility. And is approaching possibly the greatest assignment of its existence with very great humility.

CLARKE NEWLON

letters

Further on *Seaslug*

To the Editor:

We were very pleased to see in the M R Missile Encyclopedia (July 20) an account of our *Seaslug* ship-to-air missile. For your records, however, I would point out that *Seaslug* is a beam rider and not, as you state, a semi-active homer. This fact was security-cleared and released after you had gone to press.

John M. Davis
for Publicity Manager
Sir W. G. Armstrong
Whitworth Aircraft Ltd.

Red 'Ball of Fire' Photo A Phony?

To the Editor:

Your photo of a Soviet "Ball of Fire under water" (Aug. 24, p. 24), appears to be either a misinterpretation or a fake. Note that the "coaxial projector" at lower left is obviously illuminated from upper left, by the shadows cast, not from the discharge in front. The discharge itself can be duplicated by an end-on view of other electrodes.

USSR scientists have proved they are capable, but honest scientific theories on ball lightning may readily be embellished by propagandists, as I suspect has been done in this instance, to show amazing but probably non-existent practical results.

The "frequent natural phenomenon" of bead or chain lightning you theorize as possibly pinched-off plasma, I believe is only simply explained visual illusion. If a lightning stroke following the usual erratic path in one vertical plane follows a relatively direct path in another vertical plane rotated approximately 90° from the first, the portions of the discharge path which first appeared to travel approximately horizontally to the right or to the left will appear to advance or recede from a viewer located 90° about the phenomena with respect to the first viewer; and the concentrations of luminous energy at these positions as seen by the second viewer will appear as intensified "beads" or links in a "chain" in the discharge path. This theory can be readily proved by simultaneously photographing lightning strokes by two cameras oriented 90° about the storm center.

Charles C. Littell, Jr.
Engineering Associates
434 Patterson Road
Dayton 19, Ohio

The photo appeared in the magazine Soviet Union and there is no need to expect that the electrode illumination comes from the discharge itself or that the photo was faked. Agreed, in some instances bead lightning can be explained as optical illusions. Bnt it also could be pinched-off plazma phenomenon.—Ed.

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NEW PRODUCT BRIEFS

PECIALIZED RECEIVERS. Nems-Clarke ompany, a division of Vitro Corporaon of America, announces two new ecial purpose receivers, Types 1905 d 1906. These two equipments are a velation of what can be accomplished miniaturizetion through employment solid state design, state of the art iniaturized components, and the latest packaging techniques. Standard rack ounting size is 19" wide by 8¾" high. ypes 1905 and 1906 are less than half is size with panels 19" wide by 3½" gh by e maximum of 15" deep. A eight reduction of approximately 50% also realized. In addition . . . physical ace economy is enhanced by a greater equency range coverage of 30 to 260 egacycles. Two bands are employed: ie of 30 to 60 megecycles, and the her from 60 to 260 megacycles. Type 05 reception is AM and CW, and ype 1906 reception is FM, AM, and W.

The tuners in these receivers are degned to produce an extremely low oise figure and incorporate practical ning structures capable of tuning 30 260 megacycles, with uniform perrmance over the band.

rcle No. 225 on Subscriber Service Cord.

LICON-RUBBER ADHESIVE. A new lhesive for bonding RTV (room-temerature-vulcanizing) silicon rubber to etal is now available for evaluation om Hughson Chemicel Company, A Dision of Lord Manufacturing Co. Desigted as Adhesive EX-B579-1, it prodes bonding during the room temperare cure of silicone rubber compounds. ubber-tearing bonds are produced hich have excellent environmental resistce to broad temperature conditions. is one-part, one-coat adhesive does t stain. Excellent bonds can be obined with a wide variety of RTV silicon bbers to steel, aluminum, brass, copper d other metals as well as glass, porous ramics, cured epoxies, phenolics and her resins, synthetic fabrics and treated flon. Adhesive EX-B579-1 is well suited the processing and performance ndards of the electronics industry ere RTTV silicones are used for potg and insulating of connectors and ner components. Other applications clude aircraft gasketing and sealing.

rcle No. 226 on Subscriber Service Cord.

OXY RESIN. Processes for insulating nsormers to meet the grades of MIL-T-27A with scotchcast brand epoxy resin ere outlined in e new eight-page booklet issued by Minnesota Mining and Manufacturing Co. Sections of the booklet deal with background on MIL-T-27A, transormer design, resin handling and proven processes for applying epoxy resins. The methods outlines include: dip coating, molding potting metal encased units and encapsulating open type transformers.

Circle No. 227 on Subscriber Service Cord.

SERVO. A new one-ounce servo motorgenerator just introduced by the Daystrom Transicoil Corp. represents an advancement in servomechanism miniaturization. The "size 5" unit, including gearbox, is less than half as big as its smallest predecessor. The unit will undoubtedly find wide use in missile control systems where size and weight are such critical factors. Savings here have compound results: when one component is significantly reduced, then its accessories—power supplies, amplifiers, heat dissipators end insulation—can also be reduced.

Circle No. 228 on Subscriber Service Card.

PRECISION TRANSDUCERS. A new precision Kavlic transducer has been announced by Vinson Manufacturing Company. These transducers were specifically designed to provide unit to unit tracking with a maximum error of .002" over a 1" range. The null position is constant within .001" from unit to unit and varies a maximum of .001" within the temperature range of −65° to +300° F. Other specifications include linearity of ±.15% and sensitivity of .88 V/in V. Secondary impedance is 28 ohms, and recommended input voltage is 8-10 volts @400 cps.

Circle No. 230 on Subscriber Service Cord.

PNEUMATIC AIR VALVE. Dynamic Controls Corp. has developed and is now producing in quantity a pneumatically operated air valve of extreme sensitivity. The valve will operate from the full open to the full closed position with a change in signal pressure of 1 psi or less, depending on the valve size required. The signal pressure and the controlled pressure are isolated from each other. The unit, which was designed for missile and aircraft application, weighs only 0.3 lbs., but can be subjected to temperatures of 360° F.

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MISSILE LITERATURE

VIBRATION ISOLATION SYSTEM. A new concept in vibration isolation for gyroscope and other delicate navigation equipment has been developed by Allied Research Associates, Inc. The suspension system provides freedom for omni-directional rectilinear motion, but maintains high-stiffness constraint against rotation. With this system, it is possible to eliminate the damaging and error-inducing effects of environmental shock and vibration without compromising the precision of initial angular alignment. The mount exhibits low resonant transmissibility and has its elastic center located so as to decouple translation and rotation. Performance is effective over a wide temperature range. The mount assembly utilizes a unique configuration of metal C-shaped springs to obtain the desired stiffness characteristics. System damping is provided by elastically supported unit dampers which are consistent over a wide system to eliminate hysteresis torques. As a result, precise static alignment of the mounted unit is possible and the error in angular returnability is virtually eliminated. The mount provides shock attenuation, improved vibration isolation at high frequencies, low resonant peaks, decoupled angular and translational modes and angular alignment characteristics. Two configurations of the mount are currently in production and are each incorporated in an aircraft navigation and bombing system. Performance characteristics of each exceed specifications, with one mount featuring an angular returnability of 30 seconds of arc.

Circle No. 200 on Subscriber Service Card.

PLATINUM PRODUCTS. J. Bishop & Co. Platinum Works, has just issued a 20-page platinum products catalog which includes the complete standard line of platinum products, chemicals, recovery and refining facilities of this company, as well as information on clads and composites of platinum group metals with base metals. Reference is made to the items that can be manufactured to customer specification upon request. Clear, clean cup tables for conversion, etc., are included.

Circle No. 201 on Subscriber Service Card.

ELECTRONIC GALVANOMETER. A new bulletin presenting specifications and a complete description of a multi-purpose electronic galvanometer is available from KIN TEL Division of Chou Electronics. Outlined in the bulletin are the operating characteristics and applications of the KIN TEL Model 204A Electronic Galvanometer. The 204A is a chopper stabilized instrument that can be used for current measurements to 2×10^{-11} amperes. It is 20 times as sensitive as the mechanical mirrored-type galvanometer and its all-transistor construction makes it much more rugged. The bulletin details the instrument's other uses, such as a DC null detector, a linear deflection indicator, microvoltammeter, and inverting DC amplifier. A circuit diagram and description and tabulated specifications are included to provide complete technical information on the unit.

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LIQUID FUELS COMBUSTION. A com prehensive guide to literature on fur damental research on liquid fuels con bustion has been reprinted and is no being sold by the U.S. Department c Commerce's Office of Technical Service Titled "Injection and Combustion c Liquid Fuels," the 789 page monograp was prepared originally in 1957 a WADC Technical Report 56-344 b specialists at Battelle Memorial Institut working under contract with the U.S Air Force's Wright Air Developmen Center. The monograph covers litera ture, published through 1956, on liqui fuels combustion research. It contains critical review of material in the un classified literature relating directly t the fundamental physical phenomena ir volved in high-intensity combustors an other steady-flow combustion processe Included are sections on atomization c liquid fuels, ballistics and evaporation c droplets, laminar flame propagation, tu bulent flames, premixed flames, stabili limits, droplet combustion, diffusic flames, and ignition.

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GRINDING MACHINE. Design fe tures, applications, specifications and a cessories of the new Heald Model 273 Universal Internal Grinding Machine a described in an eight page illustrate two color brochure. The Model 273A a high precision grinder for internal, e ternal and rotary surface grinding. will grind straight or taper bores, ou side diameters, flat, convex or conca surfaces. Developed specifically to f the need for a low cost, high precisic grinder, the Model 273A finds its be application where internal grinding of variety of single parts or small lot pr duction is required. The standard Mod 273A has a capacity for chucking ar straight or taper grinding outside di meters on work up to 12" O.D. Sinc the wheel head can be mounted in se eral positions on the cross slide and wi the variable speed workhead drive—15 to 450 rpm—the Model 273A can hand a wide range of work on shaft, gea bushing, hub and spacer faces and ou side diameters. Besides cup wheel fa ing, the 90° swivel of the workhead c the 273A allows periphery wheel grin ing of broad or narrow surfaces. Co cave and convex surfaces can also b ground by swiveling the workhead any point up to 90°.

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RECORD READERS. A catalog c Benson-Lenner data products defines th term "record reader" and discusses th various types of record readers pr duced by the corporation. The catalo discusses special purpose record reade which are used to convert informatic recorded in pictorial or graphic for into either digital or proportional analo resistance form. The catalog also de cribes various types of automatic plo ting machines used for graphing bu ness, military and scientific data from variety of inputs invluding punch-card punch-paper tape, magnetic tape, ma ual keyboard and the outputs of aut matic data handling systems.

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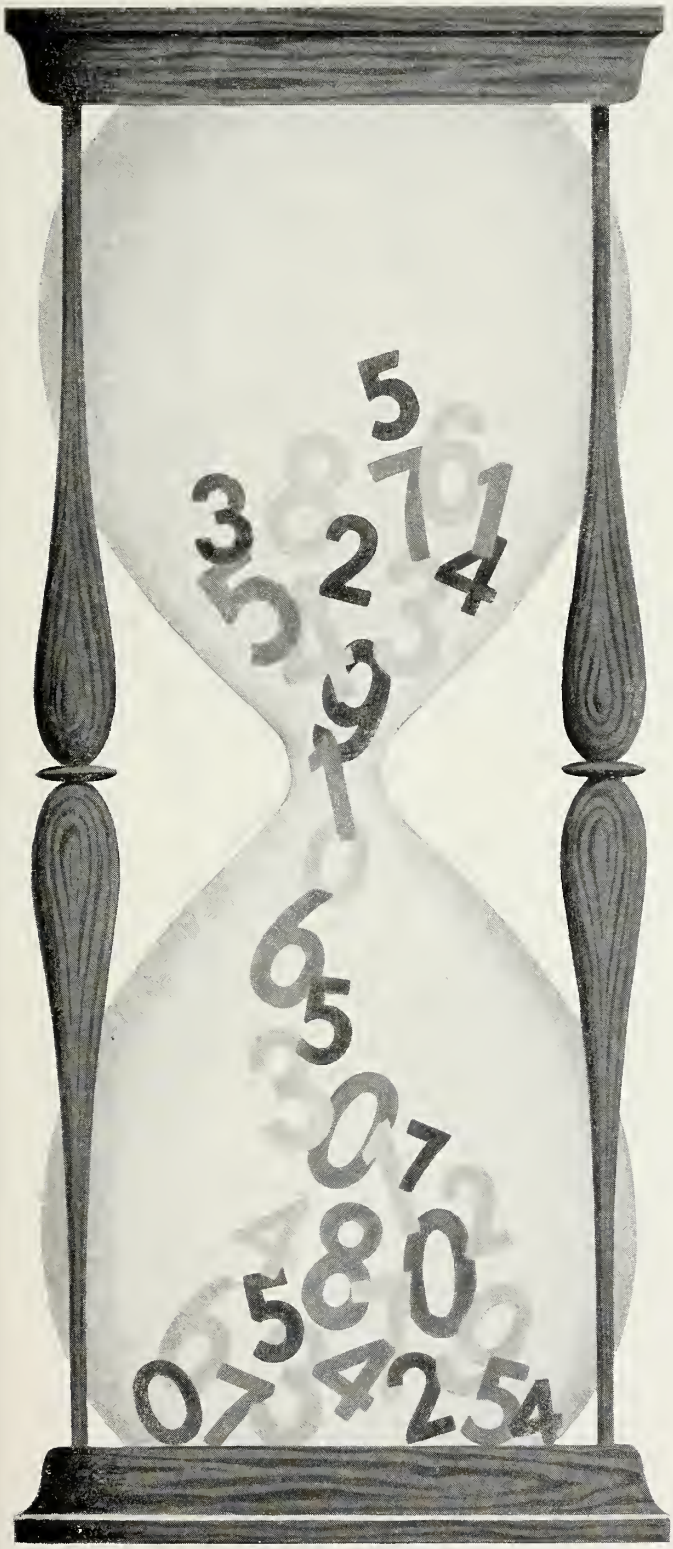

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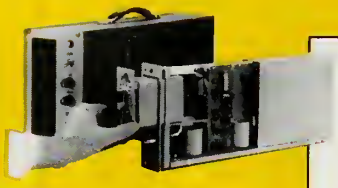

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