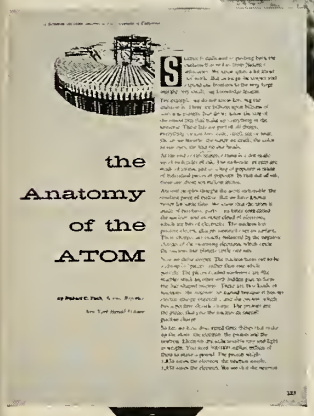

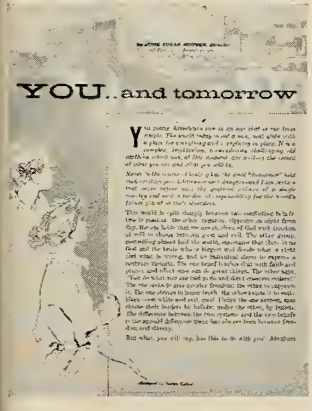

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Propulsion .....MICHAEL LOREN
Industry .....JAMES J. HAGGERTY, J
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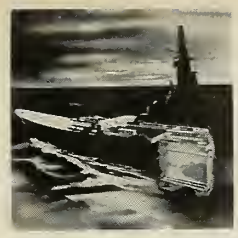
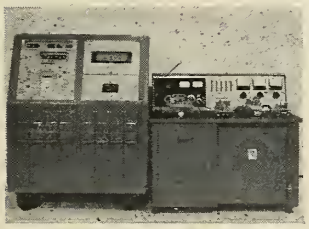
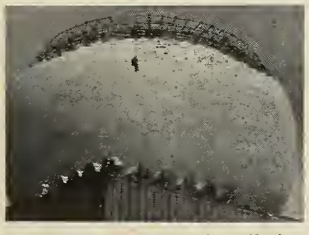


COVER: seaborne support for *Talos* is shown in previously unpublished picture by GE artist. For story on the Navy's triple-threat missile, see p. 24. For story on GE's *Talos* hoist, p. 26.

READY for installation at *Atlas* ICBM bases are plastic-wrapped 1600 KW transformers, symbolizing massive missile support needs. A summary of the huge market starts on p. 21.



COMPLETELY solid-state and modularly constructed is Stromberg-Carlson's SCATE, a typical advanced automatic check-out system. A survey of this rapidly growing market starts on p. 53.



BMEWS prototype installation recently completed near New Jersey Turnpike. Two BMEWS sites have been established in Alaska and Greenland. Turn to the report beginning on p. 67.

missiles and rockets ®

MAGAZINE OF WORLD ASTRONAUTICS

SEPTEMBER 21 HEADLINES

ANNUAL MISSILE SUPPORT ISSUE

ASTRIONICS SUPPORT

NEW MISSILE PRODUCTS

THE MISSILE WEEK

DEPARTMENTS

About the earthly side of the Nike Ajax.

The U. S. Army's Nike Ajax is a strange but potent bird. Graceful, tough, packed with delicate instruments. He will fly only once in his lifetime—only in the event of an enemy attack. To launch him with split-second timing and accuracy, the Army puts most of its manpower and most of its materials into ground equipment. And virtually all the material required other than electronic equipment can be purchased from one firm—United States Steel. Whether you're talking about carbon steel, high-strength low-alloy, or ultra high-strength alloy steels, Stainless Steel, steel fence,

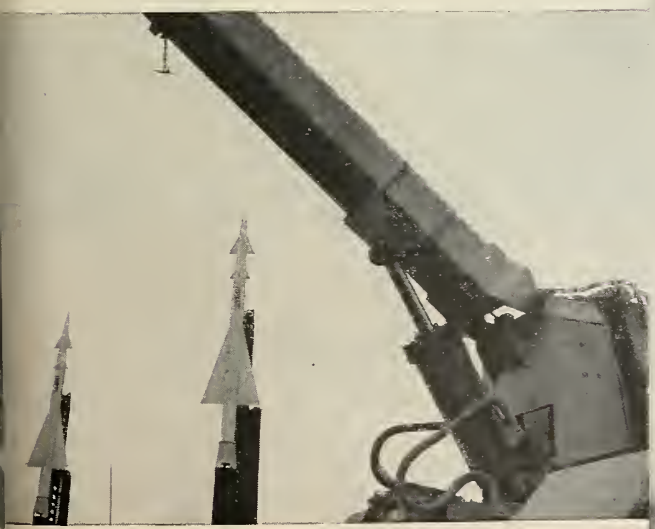
The Nike Ajax spends his days in a concrete and steel nest like this one. ICBM's will also live this way, but in nests that will take *thousands* of tons of concrete and steel. U.S. Steel specialists work continually with designers and construction engineers to find ways to use steel to its full advantage on such projects to build stronger with less materials . . . to build them faster.

It takes miles of wire and cable to rig a Nike nest. It will take *hundreds* of miles when bigger birds are put to roost. The Army uses many types of steel and steel products in a Nike nest. U.S. Steel conducts research and knows how to cut costs for any steel product used in ground support equipment.

electrical cable, cement or wire rope, United States Steel maintains the technical services to provide the proper assistance to cope with any problem on materials for ground equipment. When a ground support program goes to the drawing board, consult with

United States Steel

USS is a registered trademark



How light can you make a steel boom for any missile system without sacrificing strength? The proper selection of USS High-Strength Steels or Constructional Alloy Steels has cut the weight of similar equipment as much as ⅓—and *increased* the strength and service life.

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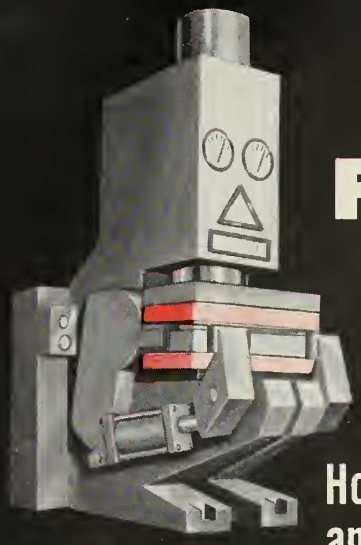

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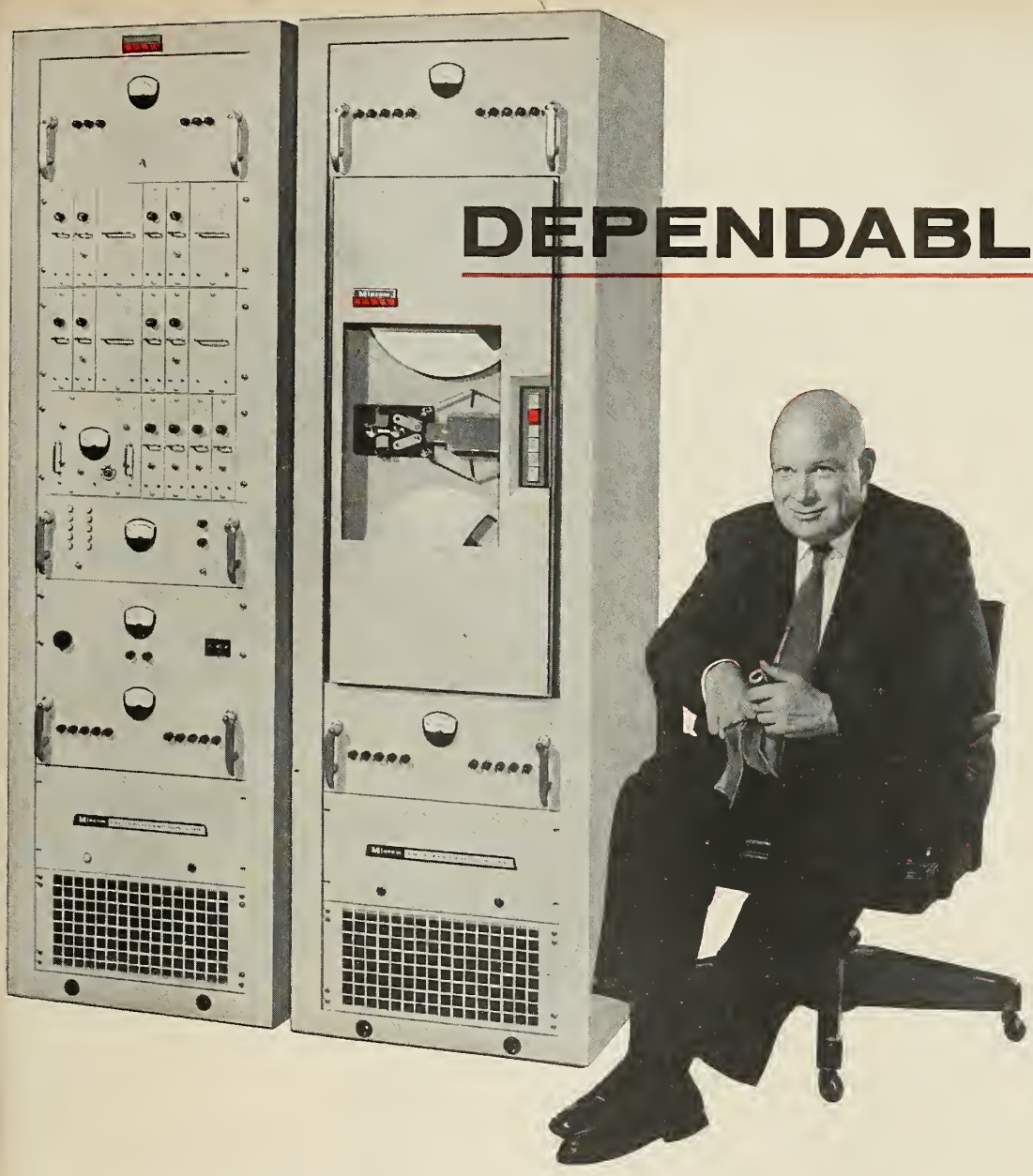

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Washington Countdown

IN THE PENTAGON

The first experimental *Samos* . . .

the ARPA-Air Force reconnaissance satellite, is expected to be launched about next March. The R&D satellite will be placed in a polar orbit—enabling its camera at one time or another to see all points on the earth.

• • •

The first operational *Transit* . . .

the ARPA-Navy navigational satellite, is expected to be in orbit no later than early 1962. However, a virtually operational *Transit* satellite may be in orbit by the end of next year.

• • •

Doubling the warhead . . .

of the **Boeing** *Minuteman* and **Lockheed** *Polaris* appears possible if ARPA's project to boost the performance of solid propellants about 20% is successful. Both missiles pack about a one-megaton warhead. Some scientists think ultrafine aluminum powder may be a good bet.

• • •

A catchy name . . .

is being sought by the Air Force for its air-launched ballistic missile. The **Douglas** missile is known popularly by the initials ALBM. But the Air Force apparently wants something snappier.

• • •

An Hawaiian base . . .

on the big island of Hawaii for launching and tracking polar-orbit satellites is reported to be under consideration. **The Ralph M. Parsons Co.** has submitted a proposal for the base with a $38.8-million price tag.

• • •

Testing of *Bullpup* . . .

for compatibility with Air Force jets is being conducted. However, the Air Force is expected soon to begin ordering the Navy-air-to-ground missile with few changes for operational deployment.

• • •

Manned Moon flights . . .

from the United States probably will be made from orbiting space platforms rather than Earth unless current Pentagon planning is changed. The whole question is before ARPA scientists for study and early decision under Project *Suzano*.

ON CAPITOL HILL

Congressmen aren't forgetting . . .

the tremendous success of *Lunik II*. Only the pell-mell rush to get out of town before Soviet Premier Khrushchev arrived staved off a congressional investigation of why Russia beat the United States in planting a flag on the moon. An investigation is almost certain to be held later this fall or next January at the latest.

• • •

L'affaire Power . . .

is bubbling along. The Pentagon has told the House Information Subcommittee that it banned SAC Commander Power's book about U.S. missile and bomber forces because it was against Defense Department policy for him to write it—not because of what he wrote. The Subcommittee's next question: Since when?

AT NASA

A big cut . . .

has been decided on in the worldwide tracking network planned for Project *Mercury*. The reason: Lack of money. Originally NASA planned to build 14 bases costing a total of more than $15 million.

• • •

Fifty-million miles . . .

is the distance NASA scientists hope signals from *Thor Able III's* solar cells will carry. NASA plans to launch the *Able III* satellite into orbit around the sun late this fall. If accurate enough data is received about its orbit, scientists will be able to track it every time its orbit brings it between the earth and the sun.

AROUND TOWN

One of the big fights . . .

of the British elections will be over U.S. *Thors* in Britain. The Laborites will charge the **Douglas** liquid IRBM's don't have the needed fast reaction time—under 15 minutes.

• • •

Some of the reports . . .

being passed as "the latest" in the nation's capital:

. . . Russia may try during Premier Krushchev's visit to top *Lunik II* with an up-and-down flight by a manned missile.

. . . Pressure for East-West space projects is expected to grow.

. . . The first French A-bomb test is imminent and nuclear-tipped missiles will follow swiftly.

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Industry Countdown

MANUFACTURING

'Plug-in' payloads . . .
standardized at 270 pounds and the same configuration will be inaugurated soon by ARPA in many U.S. space vehicle programs. Modifications of the workhorse *Thor-Able* three-stage missile will be used for the first packaged systems. The method is aimed at saving time and money and considerably simplifying both design and launching operations.

• • •

Satellite re-entry system . . .
which will deliver a large number of relatively small packets back to earth on command has been devised by **Hughes Aircraft.** One application of the system would be to drop weather-reporting radio transmitters in remote areas.

• • •

***Minuteman* mobility battle . . .**
being waged behind the scenes at the Pentagon is one to watch. It will be a key future item in the missile support market (see p. 21). The controversy is over 1) the percentage of the programmed 2600 *Minuteman* missiles to be made mobile, and 2) whether they will be on rails, wheels or waterborne. One factor weighing against mobility is that the solid-fueled ICBM will be as fragile as a clutch of grouse eggs, and very tricky to handle. Latest word from the Air Force is that a "sizeable" portion will be mobile.

• • •

Ultrapure silicon . . .
metal production plant will be sought by Air Force next year. On full stream, impurities must be held to one part in six billion—a tough requirement.

PROPULSION

French are making significant . . .
strides in solid-propellant castings. Service des Pondres government agency at its St. Medard facility near Bordeaux has successfully fired several grains of 1000 pounds weight and is actively researching aluminized powder injections. The agency also has developed a polyvinyl chloride material for ammonium perchlorate.

• • •

Vernier guidance . . .
for extended space probes is a possible mission of **Republic Aviation's** plasma jet engine. Development of a lightweight, high-yield electric power source to run it, however, still remains one of the most critical unsolved spaceflight problems.

Container structure . . .
including rocket assembly with casing, gas producer and igniter for separate storage of liquid propellants has been patented by the Navy.

• • •

Ultrafine aluminum powder . . .
in 300-to-400 micron range will be developed for Navy by **National Research Corp.** under $100,000 contract. It will be followed by a contract to develop similarly fine powder aluminum alloys with other materials—zirconium, magnesium lithium, etc.—for rocket propellant use. This is the new technology which put boron out of business.

ASTRIONICS

All of Prof. Fred Singer's . . .
calculated principal characteristics about the Van Allen radiation belts have been supported by subsequent satellite and space probes.

• • •

***Explorer VI* 'telebit' . . .**
telemetry has provided enough data to indicate a much longer concentration of low-energy particles in the Van Allen belts than previously postulated—about 200 kev, according to Dr. G. E. Mueller of **Space Technology Laboratories.**

• • •

A joint report . . .
by Holly, AF Special Weapons Center, and Johnson of **Lockheed,** indicates composition of radiation at altitudes up to 1000 km. Radiation penetrating 30 mg/cm² is predominantly electrons. The data still supports earth neutron-albedo theory.

WE HEAR THAT—

Gold plating for missiles . . .
is still considered by metallurgists and missile engineers as having no equal as a protective against re-entry heat (except for nose cones) . . . **General Dynamics** is another firm taking an interest in controlling solid-fuel burning with sound in the 150 decibel region . . . More structural applications is the goal of a beryllium extruding process being developed by **Northrop** and **Beryllium Corp.** . . . Research on explosive forming of zirconium will be started by Interior Department's Bureau of Mines this year and will be followed by work on deep drawing and extrusion . . .

More About the Missile Week on Page 107

GROUND SUPPORT EQUIPMENT

A Proven Kearfott Capability – Kearfott's prominence in the design and production of ground support equipment is a result of 15 years' experience in producing precision servo systems, computers, gyro reference systems and inertial guidance equipment. Kearfott test equipment is designed on modular principles which increase flexibility and economy and eliminate the obsolescence factor since modules can be readily modified or replaced. Modules are designed to be compatible with one another, thus providing test capabilities for a wide variety of applications.

Inertial Guidance System Test Console

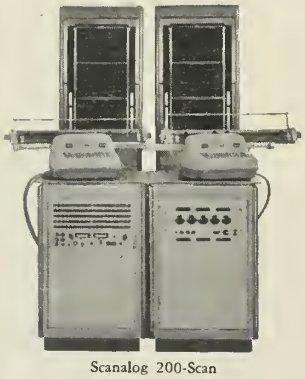
IN-PLANT TEST EQUIPMENT: Rack-mounted modules comprise the necessary metering circuits, signal generators and power supplies, switching circuits and junction boxes to perform the following tests on inertial reference systems:

Voltage and phase • Current • Heating cycle checks • Verticality of platform in ground erection mode • First order erection time in ground erection mode • Measurements of platform roll and pitch output angles in ground erection mode • Measurements of free drift of platform in azimuth in ground erection mode • Measurement of azimuth gyro torquer scale factor in ground erection mode

FIELD-TYPE TEST EQUIPMENT: Modularized, self-contained unit that provides all power and signal voltages to operate, test or trouble-shoot a gyro. All inputs to and outputs from the gyro are accessible at convenient jacks where connections to measuring equipment can be made, thereby enabling operator to evaluate gyro performance completely. Modules are slide-mounted for ready access if repair, modification or product improvement replacement are required. This portable equipment performs these basic tests:

Insulation resistance • Warm-up time • Torquer scale factor measurement Gyro transfer function • Free drift • Gimbal offset drift • Continuity Signal Generator Null • Phasing • Gyro drift • Fixed torque restraint

Floated Gyro Test Console

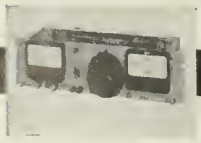


Scanalog 200-Scan
Alarm Logging System

GENERAL PURPOSE DATA PROCESSING: This data handling system provides a reliable, precise means of monitoring, logging and performing an alarm function of up to 200 separate temperature, pressure, liquid level or flow transmitters. Manual controls are provided for scanning rates, automatic or manual logging, data input relating to operator, time, day, run number and type of run. 200 numbered lights, corresponding to specific points being maintained, provide a visual "off normal" display for operator's warning. This system has growth built in and can be expanded in capacity to 1024 points and in scanning rate to 2000 points per second.

Write for complete information on Kearfott's ground support equipment.

Engineers: Kearfott offers challenging opportunities in advanced component and system development.



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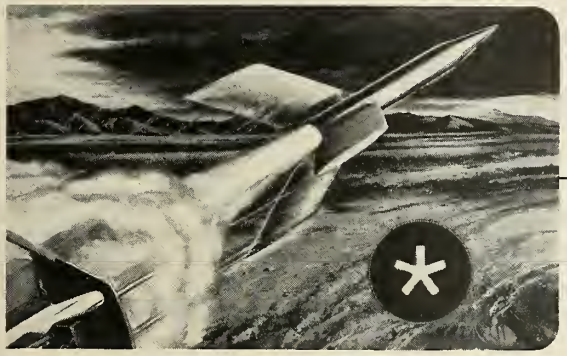
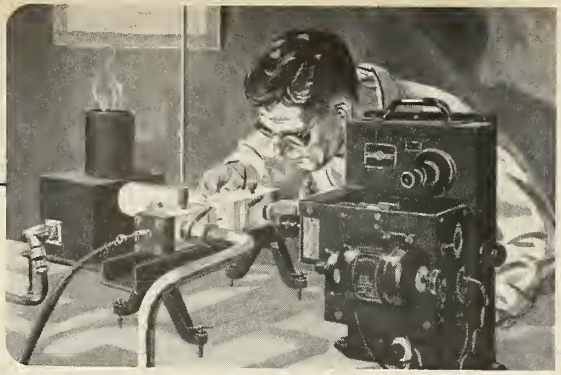
Pioneering Achievements in Rocketry at JPL

LIQUID PROPELLANT SYSTEMS... were pioneered at JPL. Development work began in 1943 and led to the first practical rocket power-plant in the United States in which spontaneous ignition took place upon mixing of the oxidizer and fuel.

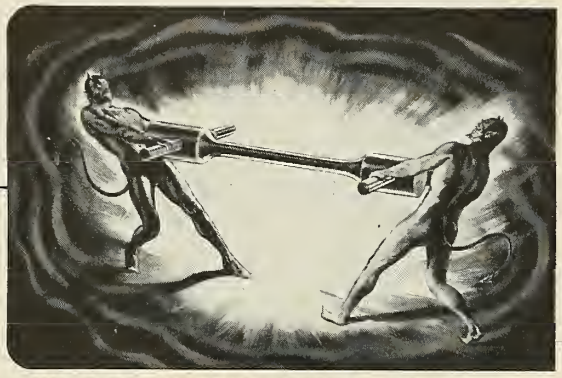


SOLID PROPELLANT SYSTEMS... received momentous impetus in 1947 with the successful flight of the Thunderbird, a test rocket. This JPL pioneering achievement demonstrated a new technique which has since revolutionized the field of solid propellant rockets.

DEVELOPMENT . . . of efficient rocket power plants involves large scale testing and the application of knowledge from many scientific and engineering fields—thermodynamics, combustion, heat transfer, fluid mechanics, and metallurgy.



HEAT TRANSFER . . . studies at JPL with a camera using a Kerr cell shutter taking photos at 20,000 frames per second were the first high-speed, high-resolution motion pictures successfully recording the action of nucleate boiling.



MATERIALS RESEARCH AND TESTING . . . is one of many supporting research programs under way at the Laboratory and are considered a "must", in providing needed data for engineers concerned with the design and development of propulsion systems.

TESTING . . . of rocket engines resulted in the establishment of a center for recording rocket engine measurements when in 1948 the Lab established the first system serving five engine test cells. This has now expanded to a complex multi-channel system.

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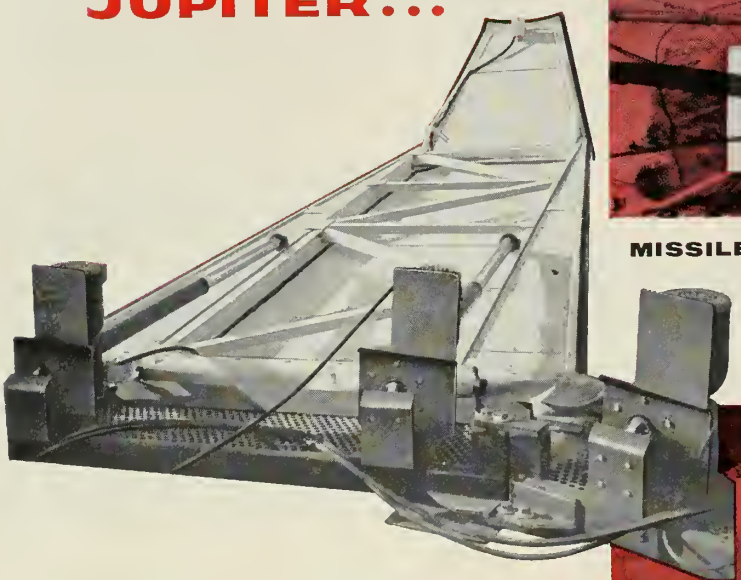
HURRICANE-PROOF "OVERCOAT" FOR THE JUPITER...

MISSILE SHELTER-PANELS RAISED



MISSILE SHELTER-PANELS OPEN

"buttoned up" by 24 Saginaw b/b Screws

Buttaning up the "avercaot" for the Jupiter IRBM is a cinch far the Saginaw Ball Bearing Screw! The "avercaat" is a portable prefab stondby shelter designed by Barnes & Reinecke, Chicago, and U. S. Army Engineer Research and Development Labaratories, Fart Belvair, Va., ta pratect the missile's tail and personnel working an it. The shelter has 12 base sectians with hinged panels raised electrically ta farm a weather-tight seal around the Jupiter's hull.

The Soginaw b/b Screw canverts *rotary* motion into *linear* with over 90% *efficiency*. This enables the Saginaw Screws to dependably raise or lower these panels—and hald the shelter securely in place—even in the face af 76 mph hurricane winds. In fact, each Saginaw Screw is able ta withstond o cambined wind and weight stress of almost five tans! The Saginaw Screw also affers substantial savings in space, pawer and weight which make the shelter easier ta transpart and assemble.

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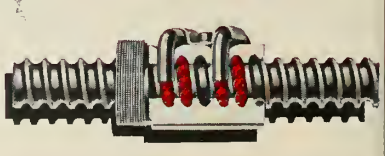

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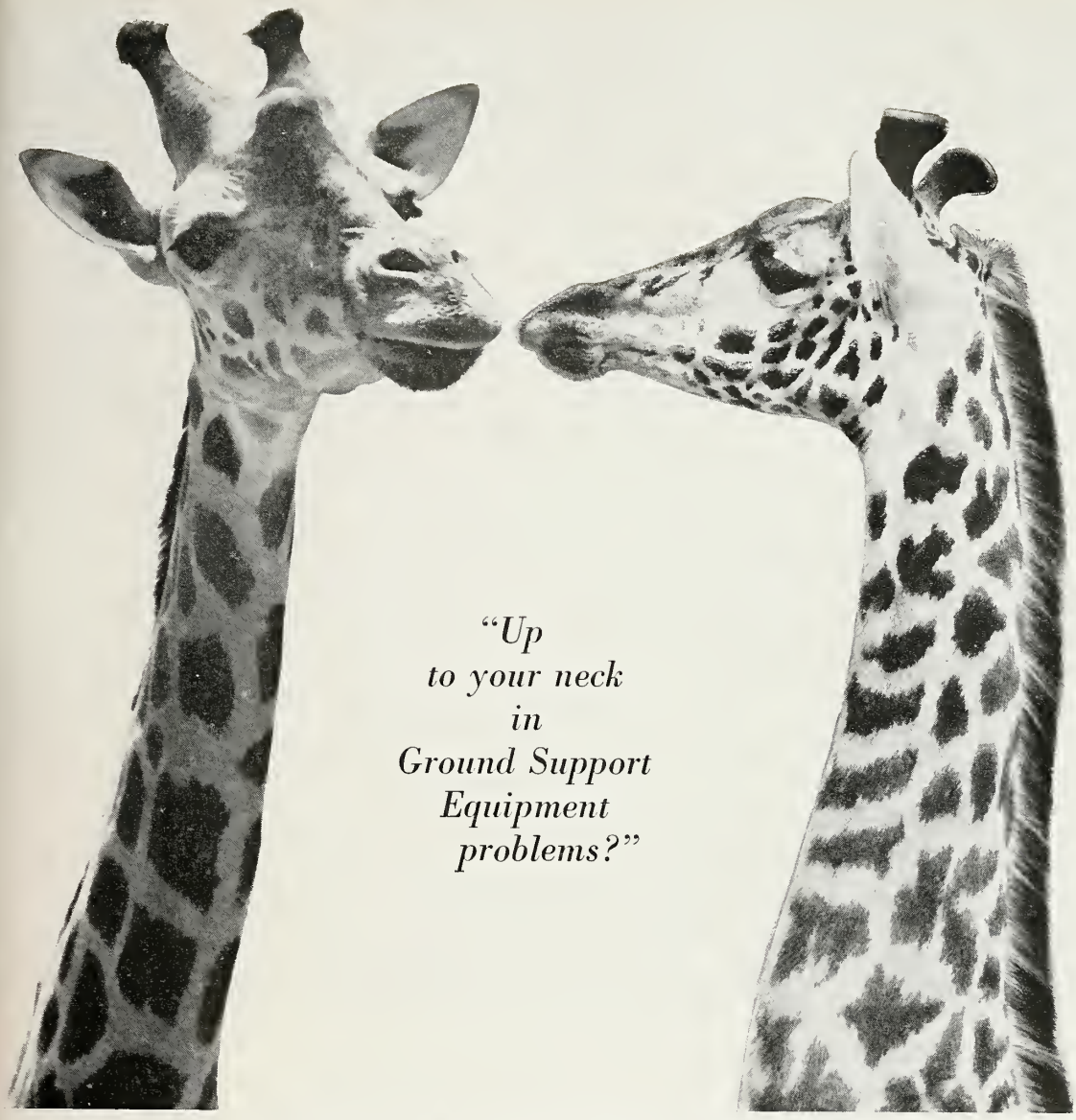

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Missile Support—$40 Billion by '67

Hardened ICBM bases and Polaris submarines are setting the pace for an expanding market—A complete forecast for the vital years 1960-61

by William E. Howard

WASHINGTON—Today's huge ICBM base construction program and the Navy's big switchover to missiles are pushing the already booming missile support industry into a new era of expansion.

Throughout the Defense Department more than $3 billion will be spent in FY 1960 on the bases, ships, machinery, communications, fueling, guidance and fire control systems to back up the Nation's vast missile program. Next year, as more and more missiles become operational, the amount promises to rise substantially.

Over the next seven years—barring a drastic change in the arms race with Russia—a projection by the M/R Research Department shows a support market potential topping $40 billion.

Dominating the outlook for the support field—indeed the whole missile industry—is the swift buildup of ICBM bases and the nuclear-submarine launched *Polaris* IRBM. With the deployment of the first operational *Atlas* ICBM's at Vandenberg AFB, the entire ICBM effort is now moving into high gear.

How many ICBM's will the United States build? The actual number is a closely held DOD secret. But it is extremely likely base construction will accelerate over the next five years.

Today, the Air Force is constructing 11 (7 *Atlas*, 4 *Titan*) installations and in the next few months is expected to announce nine additional ICBM sites. The FY 1960 construction budget contains $550 million for ICBM bases—most of them "hardened" (underground) to withstand a nuclear attack.

Fully 80% of the $100 million total cost of one hard ICBM base is in the ground environment.

• *Titan* **cost breakdown**—Each ICBM base now is costing between $40 million and $45 million just to build—digging the silos or emplacements for 10 missiles (including one spare) and putting down the reinforced concrete for the entire facility.

Total equipment cost for one *Titan* squadron is an additional $47.3 million. Here's the breakdown: launchers—$19 million; guidance systems—$14 million; fueling systems—$9 million; automatic checkout—$4 million; communications and fire control—$1 million; and transportation and handling equipment—$350,000.

Some of the $550 million in construction money probably will be used to start the first *Minuteman* bases next year. DOD plans call for production of about 2600 of the second generation solid-fueled **Boeing** *Minuteman*. The great majority of them will be emplaced in "hard" silos in widely dispersed squadrons of 20 to 30 missiles. The remainder will be put aboard mobile launchers.

Missile Support Equipment Procurement

(millions of dollars)

	1960 (Estimated)	1961 (projected)
Air Force	$ 642.5	$ 810
Army	421	440
Navy	1,029*	1,200*

*Includes Polaris submarines and missile surface ships

Missile Base Construction

(millions of dollars)

	1960 (Estimated)	1961 (projected)
Air Force (ICBM)	$550	$630
Air Force (other) .	117	100
Army (Zeus)	58	?
Army (other)	90	100

Many variables—a shift in emphasis on strategic weapons or a change in the Cold War—could affect the ICBM base program. However, it is apparent that DOD presently is pursuing a course which could mean a total of 25 to 50 ICBM installations by 1965 and a support market of $2 billion to $4 billion from this source alone.

• **Bigger electronic demand**—A lion's share of the missile support equipment market—20% this year and expected to double by 1965—is going into electronics. Missile base guidance systems comprise a considerable part of the rising demand, and the largely remotely-controlled *Minuteman* will require an even greater percentage than *Atlas* and *Titan*.

Programs which will increase electronic output in the years ahead also include:

• SAGE and BMEWS and the entire global communications network giving the nation warning of an oncoming attack and the means to send retaliatory planes and missiles into action. In FY 1960 about $800 million will be spent on these systems by the Air Force—and the great proportion of it in giant radar dishes, computers, etc.

• Communications, navigation and fire control systems for *Polaris* and the surface-ship family of Navy *Tartar, Terrier* and *Talos* missiles.

• Missile ranges. More than $30 million is programmed for the Pacific Missile Range in FY '60 and before it is completed several years hence, the Navy expects to spend $256 million. About $44 million is being earmarked by the Army for an electronic equipment testing range at Fort Huachuca, Ariz., where it plans ultimately to spend a total of $107 million. It also is planning multi-million dollar improvements in the instrumentation of

bigger slice for electronics?

the White Sands Missile Range.

• *Zeus* **question**—One of the major decisions now confronting Pentagon experts in making up the 1961 budget is the Army's *Nike-Zeus* anti-missile missile. To achieve operational capability by 1963—and to have the bases from which to fire the big AICBM, it is estimated DOD will have to program $1.5 billion to $2 billion for *Zeus* next year.

The system for detecting oncoming missiles and intercepting them will be largely on the ground.

Ultimately, if *Zeus* gets a go-ahead (and strong arguments are being brought against the wisdom of the system) it could cost $5 billion to $10 billion—with about 80% of this amount going into ground environment.

Zeus points up an interesting trend that is already being advanced by the Navy in *Talos*, *Terrier* and *Tartar* missiles. That is: to make the birds "dumb" as possible.

"Most missiles right now are too smart," says a Navy R&D official. "Too much of what we consider to be non-expendable equipment—the expensive guidance system—is in the missile. We want to make the missile itself stupider and keep most of the guidance system on board ship. This will mean building bigger computers—but I think it will save money in the long run."

There is a chance this trend may catch on in the larger missiles, providing a bigger slice of MSE for electronics.

• **Mobility**—Much is being said these days about ICBM mobility, but little is being done in the way of funding. M/R has learned that a proposal to put the solid-fueled *Minuteman* on rails camouflaged in freight trains has been shelved—at least temporarily.

The latest idea is to mount them on special overland truck-trailers, and move them about unpopulated Federal lands in the far west. Trains are considered vulnerable to nuclear blast ground shock. They also would invite random missile strikes at cities in a big war.

Best bet is that mobility will be left largely to the Navy, both in *Polaris* subs and with surface ships outfitted with *Polaris* and other long-range missiles. The Air Force also is developing an air-launched ballistic missile to fill the mobile requirement in the weapons "mix."

The ALBM system when perfected probably will have a capability of computing all necessary targeting data aboard its carrier plane—creating a demand for more and more electronic miniaturization.

Including the cost of submarines and shipbuilding, the Navy potentially is as big—or bigger—a missile support market than the Air Force.

More than $2.3 billion already has been funded in the *Polaris* program. This includes money for five FBM submarines under various stages of construction as well as R&D for the missile. In the FY '60 budget $196 million has been appropriated for four more FBM subs.

This could be just the beginning—particularly if the Navy prevails in the "mobility" role. Naval officials are talking in terms of 40 to 50 FBM subs. The chances are good they will get 25 or 30. With the nuclear-powered subs costing $100 million apiece equipped, exclusive of missiles, this would be a substantial program.

Each FBM sub carries 16 missiles costing about $500,000 each off the production line. Price tag for a combat sub: $108 million.

The cost of converting moth-balled battleships and cruisers to *Polaris* launching platforms could run into the hundreds of millions.

The Navy also is building (at $100 million per copy) one *Talos* guided missile cruiser and has plans for two more. Appropriations in FY 1960 call for building three guided missile frigates—$180 million; three guided missile destroyers—$103 million; and converting one cruiser to a *Talos* launcher—$107.5 million.

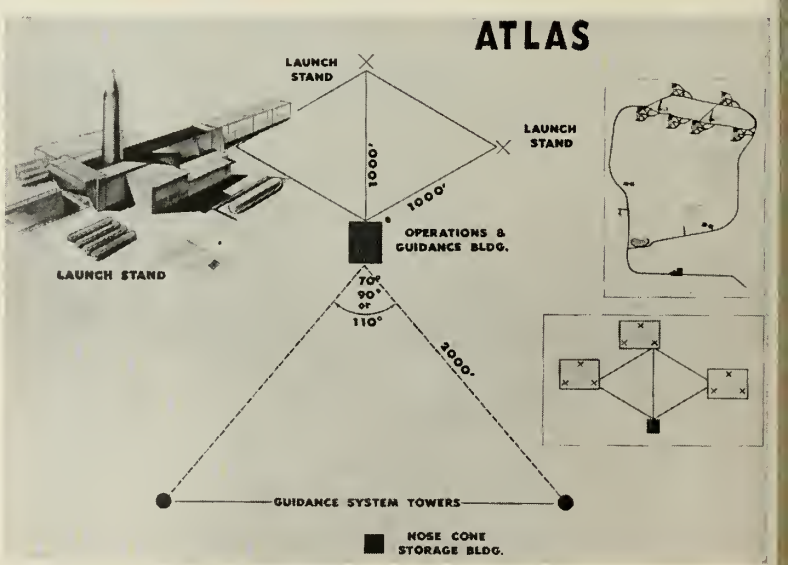
What the Navy is allowed in the way of shipbuilding funds, says one high Navy official, is "directly related to our missile capability." When funds are cut, the cut is taken out of the missile—not the ship. If a ship is started this year, and some time before it is completed there is a cutback, the ship will be completed—but its missile armament will be reduced accordingly.

The Navy does not make any budget breakdown of its direct missile support requirements. But officials estimate that for every $100,000 "that flies," there is $10 million worth of seaborne equipment backing it up.

• **Non-ballistic bases**—The FY 1960 military construction bill has dealt a blow to both the *Bomarc* and *Mace* programs. Congress wants most of the pending *Bomarc* construction held up until DOD determines whether the anti-aircraft missile bases should be located further north, perhaps in Canada or Alaska. Funds were deleted for hardening the Tactical Air Command *Mace* in overseas bases.

Mace is now a completely mobile weapon and considered vulnerable. The charge for MSE, test and checkout equipment for a *Mace* group consisting of 40 missiles comes to $17.5 million.

• **Market trends**—DOD in FY '60 has earmarked a total of about $5.9 billion for missiles. This amount contains a hefty 30% for R&D of the birds as well as their support equipment.



FIRST *ATLAS* sites are above ground. Seven *Atlas* bases are being built, with the three launchers at Vandenberg AFB the first to become operational. BMD has $550 million in ICBM construction funds in FY '60—may soon announce 9 more sites.

Actual spending on support equipment for operational missiles including ship procurement will run to about $2.1 billion. The base construction bill totals $815 million. BMEWS, SAGE, missile ranges and test facilities will send the total support bill well over $3 billion.

Through 1962, missile expenditures are expected to increase at the rate of about $1 billion a year. With the trend now definitely setting in for more and more missiles to become operational, the support requirements will increase, with a proportionately larger share of the missile dollar.

Expect the support market to get more competitive. Further modifications of the U.S. missile program are inevitable next year as a result of the Eisenhower Administration's decision to freeze the DOD budget at the current $40 billion-or-less ceiling. This limitation is forcing some hard decisions—among them *Nike-Zeus*—to be made now by defense planners drawing the FY '61 budget, which will be presented to Congress in January.

SAC's big bomber program may be a prime target for cutbacks. But so will many marginal missile programs.

Budget planners will find some elbow room in anticipated lower missile and missile support production costs as they come out of the R&D stage.

Next year, Air Force experts are predicting there will be a great deal more "breakout" of systems items such as launchers, handling gear, fueling systems etc. into competitive bidding.

TRIO OF GIANT plastic-wrapped 1600 KW transformers stand on the Wyoming prairie prior to installation in an *Atlas* ICBM base. They symbolize enormous power requirements and vast quantities of special equipment needed by missiles.

The Army already is following an active "breakout" policy, and the Navy can be expected to also as it moves deeper into the electronics field—both for missiles and its stepped-up anti-submarine warfare program.

The Army will remain a big user of mobile equipment for tactical "artillery" missiles, especially the solid-fueled 700-mile *Pershing*, successor to *Redstone*. Also needed: more compact fire control systems.

• **Need for "doers"**—The missile support field is wide open for newcomers. Says an ICBM-base planner:

"What we need are more doers. Up until now everyone has been concentrating in laboratories and factories on the developing the birds and their support equipment.

"Only now are we realizing that the field—the base—has become an extension of the factory assembly line. And here is where we are having troubles. We need people who know how to get out and work under field conditions and put these systems together so they will work—and on time."

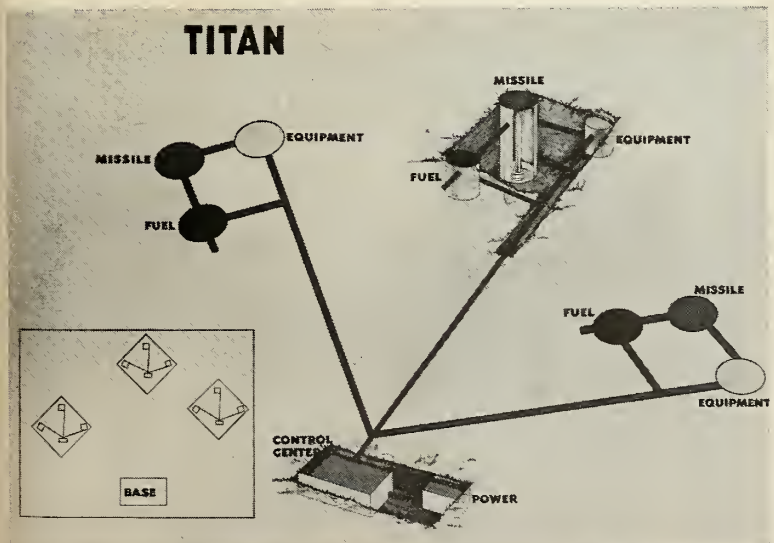
The official told M/R "industry has not recognized the magnitude of the job—in fact, we all have underestimated the difficulty of working in the field."

This points up another problem brought out in an M/R survey of the support field—the great complexity of equipment comprising major systems. Throughout the industry there is demand for greater and greater simplicity in support items, a trimming away of unnecessary automation and "gold plate."

Industry and military people alike connected with the ballistic missile program are infused with a sense of urgency. They want to get the job done the best way as quickly as possible.

"You can't figure out the best way to lift a 110-ton missile out of a 160-foot hole in the ground and launch it, within five minutes, including fueling time, entirely by sitting at a drafting table," says an engineer. "You have to get out there with the missile in the silo and design around the problems you run into."

"There's one thing to remember," he adds. "The big bird has to work perfectly today, next month, next year, in five years, and we hope maybe never. But if it does fly—nothing short of perfection in the support equipment and all the way around will make it hit the target."



FOUR *TITAN* installations are being built now by the Air Force BMD at a cost of more than $40 million each, just for the facility. Equipping a nine-launcher complex costs an additional $47.3 million. Support is 80% of the total system.

Talos Turns Triple Navy Threat: Anti-Air, Bombardment and AICBM

New Talos to kill planes 100 miles away; Super Talos anti-missile missile may be seaborne defense of U.S. homeland

by James Baar

WASHINGTON—*Talos*—the Navy's pint-sized giant killer—is turning into a key triple threat weapon of the Missile Age.

Bendix *Taloses* are the new "big guns" of the fleet, capable of smashing ships and shore installations with nuclear or conventional warheads.

They are death on missile-launching aircraft at ranges greater than 65 miles.

And they are the seed from which the Navy expects to bring forth a possible sea-going anti-missile missile called the *Super Talos*.

These capabilities and potentialities combine to make this rocket-boosted ramjet missile one of the most important in the Navy's missile arsenal.

Hundreds of millions of dollars are expected to be spent for *Taloses* to arm at least seven cruisers by early 1962. Many hundreds of millions more are expected to be spent on *Talos* radars and other shipboard missile support equipment.

These figures are for the present day *Talos* and improved models alone. They do not include the cost of *Super Talos* for which the Navy has high hopes and urgent need.

The highly-secret *Super Talos* would be used to bat down missiles fired against carriers, cruisers and other surface ships. It also might be developed for defense of continental United States against ICBM's and missiles fired from submarines.

The significance of the development of a seagoing AICBM in the evolution of U.S. strategy would be very great.

A seagoing AICBM would rival the continued development by the Army of **Western Electric's** *Nike-Zeus*. It would greatly increase the need for large surface ships. It might even bring back the battleship as a combined anti-missile missile ship and *Polaris* launcher.

Moreover, in the more modest role as a defense against missiles launched at surface ships, the *Super Talos* would meet a growing threat to the fleet.

Today, once a missile is launched, a surface ship has no defense against it beyond mobility. At present this is still considered effective. But tomorrow, ever-improving guidance will diminish the effectiveness of maneuverability to almost nothing.

TECHNICIAN checks *Talos* **in storage area on converted missile cruiser Galveston.**

• **Sired by Kamikaze**—The history of the *Talos* dates back to the end of World War II when the Navy began searching for a new weapon to use against Japanese kamikaze attacks. To find one the Navy began the top secret *Bumblebee* program at Johns Hopkins Applied Physics Laboratory. A family of missiles—*Talos, Terrier* and *Tartar* —has resulted.

The 7000-pound *Talos* is the heavyweight of the group. Its **Bendix** solid booster and **McDonnell** 40,000-pound thrust ramjet crammed into less than 30 feet of missile give it a speed of Mach 2.5. Its **Sperry-Farnsworth** dual guidance—beam rider and homing—give it a high degree of accuracy. It can operate at more than 75,000 feet.

Improved models of *Talos* will have considerably longer range and greater

speed and accuracy. The *Super Talos* now under development is understood to be so far advanced over the *Talos* that it bears little resemblance to it.

However, despite differences, *Super Talos* is being designed as a part of the *Talos* system. For example, the Sperry AN/SPG-49 super radar used on shipboard in the *Talos* system is undergoing further development to enable it to detect oncoming missiles.

The first operational *Talos* was fired from the converted missile cruiser Galveston last February. Next year three more converted missile cruisers—the Little Rock, Oklahoma City and Albany—are scheduled to be ready for arming with *Taloses*.

Present plans also call for deploying *Talos* aboard the nuclear-powered cruiser Long Beach and the converted missile cruisers Chicago and Columbus. The Long Beach will be operational in 1961; the Chicago and Columbus in early 1962.

Talos will serve on all of these ships in its double role of an anti-aircraft and heavy bombardment weapon.

As anti-aircraft, *Talos* is designed to defend surface ships from air-launched missiles by striking missile-carrying aircraft before the missiles are launched.

Its effectiveness in this role is improving as its range is extended. Current designs call for extending its present range of about 65 miles to about 100. Later plans call for pushing the range even farther out.

• **The big punch**—As a bombardment weapon, *Talos* has become the successor to the old 16-inch gun—the former big punch of the fleet.

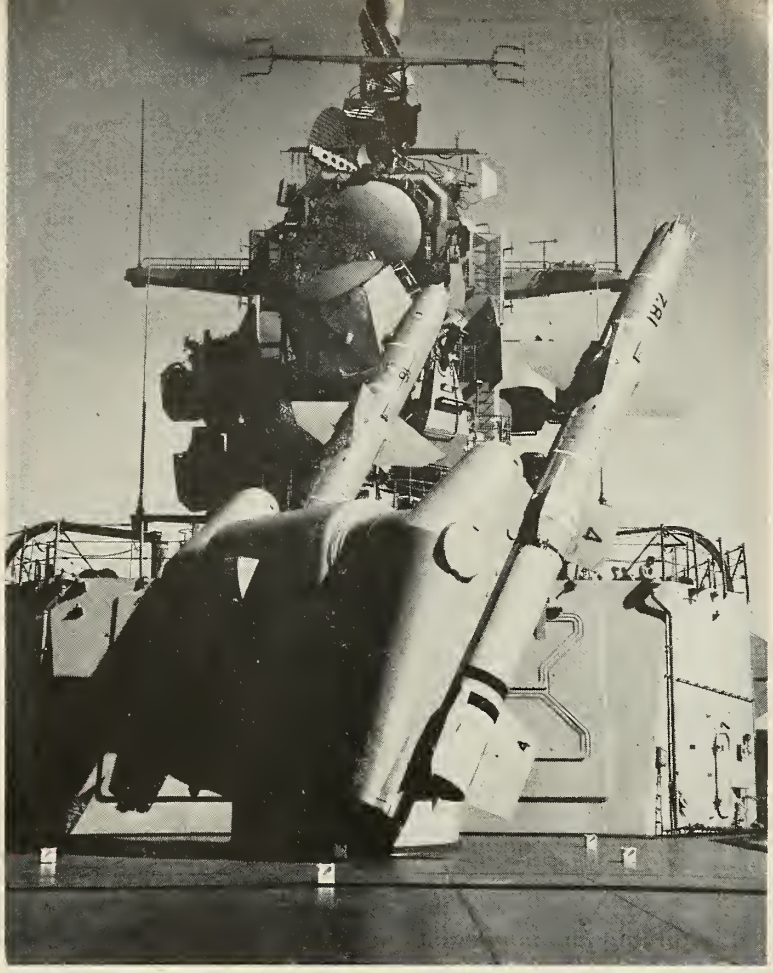
The missile—a little more than twice the weight of a 16-inch shell—can smash a surface target with either a conventional warhead of significant size or a nuclear warhead. Its rate of fire is believed to be at least as good as the two-a-minute rate of the 16-inchers. And its present range is four times as great.

In action, *Talos* will complement its smaller cousin—the **Convair** *Terrier*. The 10-mile range *Terrier* with its conventional warhead serves both as anti-aircraft and a bombardment weapon.

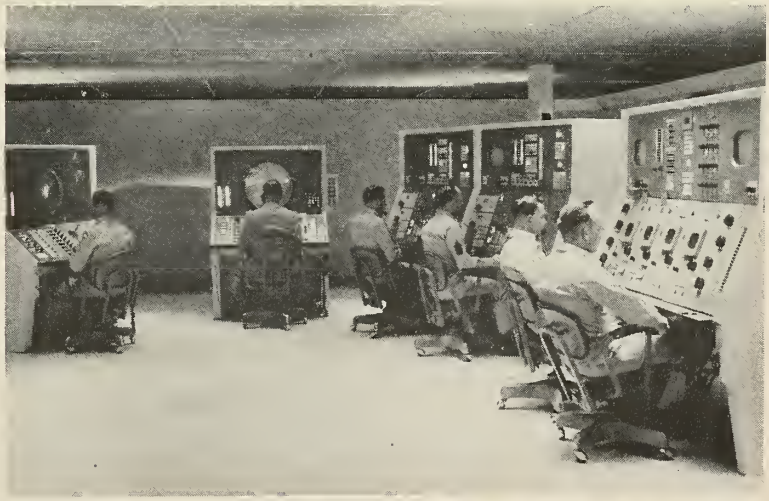
The trend is clear. Conventional guns are being stripped from the fleet at an increasing rate.

The missile cruisers Canberra and Boston are partly equipped with *Terriers* and partly with eight-inch guns. The *Talos*-armed Long Beach will carry no guns at all.

In the years ahead, the symbol of tactical seapower is certain to be more and more the long shadow of the blunt-nosed *Talos* and its successors.



LAUNCHER, trained and elevated to starboard, holds a brace of triple threat *Taloses*. Successor to the 16-inch gun as the Navy's "big punch," the Bendix missile is being deployed aboard several cruisers and its range is constantly being extended.



HEART OF the *Talos* defense unit is the fire control center, where consoles are arranged in a soundproof room with shadowless lighting. During full automatic operation, operators merely observe; but they can inject elements of judgment.

'Articulation' Solves *Talos* Handling

High-speed movement from magazine to launching deck is engineered by an articulated rack which drives missile hoist

by **R. A. Burt**

PITTSFIELD, MASS.—One problem in the design of the *Talos* shipboard missile-launching system was the transfer of missiles from the below-decks magazine to the level of the launching deck.

In the *Talos*-armed ship, space allocated for hoisting machinery is below the hoistway, rather than above as in more conventional land-based hoist systems. This dictated a "push up" instead of a "pull up" hoist design. Basic hoist power, two 60 HP direct current electric motors controlled by variable voltage from a motor generator set, is physically located below the magazine.

The magazine must be sealed from the rest of the launching system by a gas-tight door at the level of the launching deck. The hoist must lift missiles up through the magazine door during loading operations, but permit a tight seal of the magazine during preparation for launching and actual firing of the missile. This requires a hoist configuration without any complicated mechanical parts to interfere with effective magazine door seals.

Talos is the largest and heaviest of the shipboard surface-to-air missiles. The dead weight of the hoist and load (missile and stowage tray) is 32,000 pounds. This must be moved with speed and precision a vertical distance of as much as 35'.

To meet these requirements, **General Electric** engineers considered a number of alternate designs. Tension arrangements using cable or chains, and compression designs using chains, gear racks, screw jacks and pistons, were evaluated. The design selected is a direct gearing device consisting of a stationary axis pinion which engages and drives a moving rack. One of the unique features of the hoist drive mechanism is a gear rack having joints which allow the rack to articulate or bend into a sharply curved shape.

• **Rack guides**—At either end of the hoist platform are attachment points for the articulated rack. The hoist structure is constrained by hoist guide rails to move only in a vertical direction. The same guide rails also constrain the articulated rack from lateral and axial motion.

At the bottom of each hoist rail is a housing which contains the drive pinion. Mechanical shafting connects each pinion through a worm gear reducer to its electric drive motor. The two drives for either end are then connected together by a synchronizing shaft which keeps both hoist ends accurately aligned.

Below the pinion boxes are curved rack guides which bend into a horizontal position. Whenever the hoist is lowered the unloaded sections of the articulated rack pass out of the bottom of the pinion box and into the horizontal rack storage housings.

The hoist guide rail provides for guiding and restraining the rack. Positions of the rack which are actually supporting the hoist load are under a substantial compressive load and need constraint to prevent buckling at the joints. This constraint is provided by rollers mounted at each rack joint. These rollers fit closely into the hoist guide rail. Axial constraint to prevent column buckling of the rack is achieved by caps on each end of each rack joint pin. These caps bear against opposite ends of the hoist rail cavity and thus support the rack throughout its entire stressed length.

Even more accurate guiding and constraint of the rack is required at its mesh with the pinion. Here the rack-pinion mesh is strongly constrained against tooth separating forces but weakly constrained in the vertical—axial plane.

Tooth separation loads are carried by shaft mounted rollers which bear against the back of the rack sections at the pinion mesh. The roller axis is located at the vertical position which provides correct balance of the average resultant load force and pinion tooth force. The other two rollers give additional stability to the gear mesh as well as providing for negative hoist load conditions.

• **Gear tooth alignment**—Weak constraint against axial movement and angular movements in the axial-vertical

MINIATURE model is one-third actual size of rack articulation developed for *Talos*. Rollers fit closely in rail.

About the Author

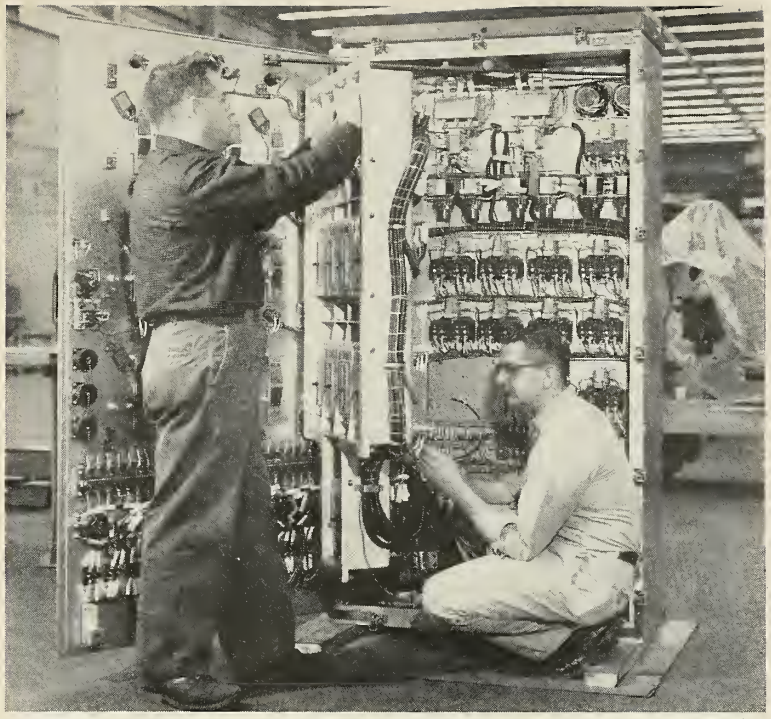
Mr. Burt is an advanced mechanical design engineer in the Ordnance Department of General Electric Co., developer of the multi-million Talos Mark XII missile launching system which will be installed aboard nuclear-powered cruisers.

plain are obtained by the springs at each rack pin joint. At either end of each pin point are Bellevielle springs interpositioned between the rack section and each end cap. By allowing slight angular adjustments of the rack in a vertical plane, some self-alignment of the rack and pinion teeth occurs and concentration of loads at the tooth edges is avoided.

To achieve a satisfactory rack joint design, accurate gear tooth alignment must be obtained without sacrificing load capacity of either the gear teeth or the rack structure. Although compression loads predominate, there are momentary tension loads of substantial magnitude which must be carried by the rack. The joint design chosen is a multiple tongue and curve configuration pinned at the tooth center line. Accurate location of the pin hole with respect to the tooth faces allows reasonable tooth load division between portions of the interlocking rack sections.

There is an optimum location of the bore for the rack joint pin with respect to the tooth and the rack body which equalizes the strength of the joint against the various failure possibilities. For instance, breakage might occur straight across the base of the tooth or a break might occur from the tooth fillet into the pin bore. Repetitive stress tests were made on models with several different hole locations. Results of the tests were used as a basis for selecting the optimum hole location for maximum all around strength.

Lubrication is provided by both oil bath and pressure jets. An oil tank is built integral with the curved storage housing. As rack sections pass through the low point of the storage housing they are immersed in oil. In addition, a small pump feeds oil to a series of jets located at the point where gear rack teeth mesh in the pinion box.



CONTROL cabinet for *Talos* launching system. Panel provides power distribution for launcher power drives, missile warm-up power and control power supply portions.

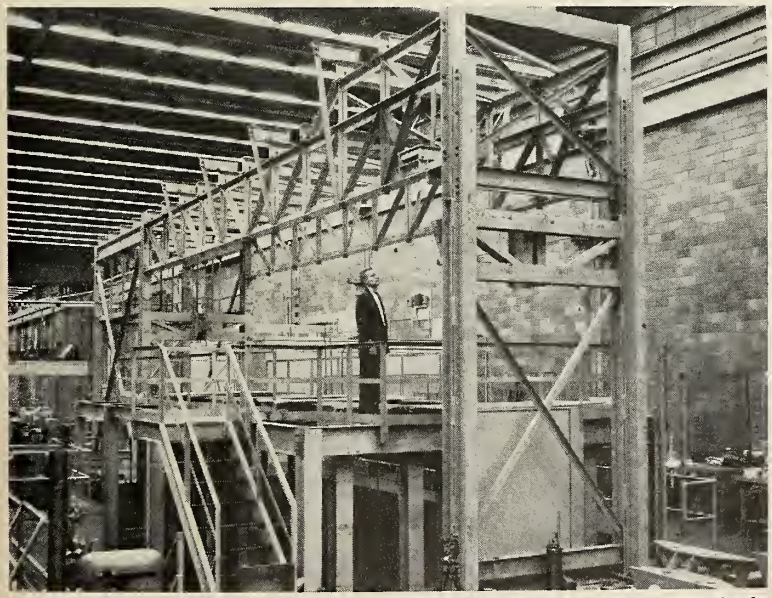
• **Absorbs bulkhead "breathing"**—The articulated rack design appears to be the best all around solution for the requirement of the shipboard *Talos* magazine hoist.

The magazine door seal becomes relatively simple. All of the moving hoist platform and drive parts can be retracted into the magazine and the hoist rails can be switched out of the doorway. Only a simple flat surface is left to be sealed.

A relatively small diameter pinion can be used with the rack-pinion design. As a result, the total gear reduction can be accomplished in one stage of reversible worm gearing. Substantial weight and space savings are thus obtained. Direct gearing also introduces little or no "pulsation" in the rotary to linear motion conversion such as is inherent in linked chain drives.

The effects of distortions of ship structure become negligible because the rack joints are parallel to the relatively stiff ship bulkheads and perpendicular to the direction in which maximum distortions of the local ship structure are expected. As the magazine bulkheads breathe back and forth, this motion is readily absorbed by articulation at the rack joints.

Articulation of the rack does appear to add complications to the design and manufacture of a gear rack. However, in an overall appraisal, articulation is the feature that makes possible a simple compact drive.



HOIST built by General Electric weighs, without missiles, 350 tons, making it the largest piece of ordinance in the Navy. Power is directly below the magazine.

Big Rockets Multiply MSE Needs

Trend is toward reducing sophisticated engine equipment. But man-in-space requirements, new fuels will demand R&D of new support items

by Henry W. Gilfillan

CANOGA PARK, CALIF.—Designers of rocket engine support equipment face a variety of new problems. These are occasioned by the larger and larger powerplants that are and will be required and the introduction of new propellants, both of the storable and high-energy types.

New problems are the result of our insatiable ambition to achieve greater and greater things in rocketry. The diminution of some of our old problems is due partly to the fact that our hardware is becoming simpler and more reliable, requiring less field checkout and routine maintenance.

The greatest thing, of course, that ever happened to support equipment was its recognition as an important part of the weapon system, the realization of its true extent and cost, and the intensity of effort which this realization triggered.

One of our past problems has been simply that of learning to analyze functional requirements realistically and of coordinating properly, both internally and externally. A few years ago it was hard to get the attention of an engine designer long enough to consider support matters. He was, understandably, too preoccupied with the more glamorous and apparently much more pressing job of developing a good reliable engine. It was difficult to coordinate properly with associate contractors concerned with the same weapon system, in matters relating to "integrated" support equipment. That is, equipment generated primarily by engine requirements, but whose design must be coordinated with missile systems or missile supporting equipment.

Examples of integrated MSE might be special slings for installing an engine into a missile airframe. The pickup points, of course, are determined by the engine itself, but other dimensional requirements are determined by the airframe and the methods of engine installation to be employed—horizontal installation, for instance, for *Jupiter*, or vertical for *Thor*. Another example would be electrical launch controls, with their intimate interconnections with missile circuitry and MSE. In these cases, it was hard to determine the inter-faces of responsibility.

In the early days, the maintenance concept was just evolving and the serious impact on design of maintenance analyses, belatedly conducted, was not yet fully appreciated.

• **R&D and standardization**—The press of time was an added factor. Support equipment engineers have always been hardest hit by schedules. They were generally handed a nearly operational missile design and then told to go ahead and design and develop operational MSE and get it to the armed forces well ahead of the airborne hardware. This left them no time for R&D. It is a matter of history that our precious prototypes were sometimes reluctantly relinquished in order to meet first production delivery schedules. As a result, we were really forced to develop our equipment while it was in production or actually in the field. We have now come to regard R&D concurrent with production as normal.

Another matter of concern was that of standardization between weapon systems and space vehicles. No one will argue against standardization as regards design and development time and overall cost. But, in the past, it has sometimes been difficult to persuade the "program" or "project oriented" people to accept any design or performance compromises that would be solely in the interests of standardization.

In the matter of configuration control, we have had to learn to evaluate changes in airborne hardware properly with respect to their effect on support equipment. We have come to appreciate that what may sometimes seem to be an innocent improvement to a missile may wreak havoc with the correspondingly affected support equipment as well as with handbooks, spares, trainers, training courses, and logistics in general.

We have had to learn to resist certain rather human temptations. Developing automatic checkout equipment, for instance, is a fascinating pursuit. But we must take care not to overautomate unnecessarily just because it is more fun to do it that way. We have had also to avoid a tendency to perpetuate 'traditional' system and component checkout procedures that are no longer really necessary.

• **Eliminating sophisticates**—It used to be considered mandatory that an engine system be checked out using actual launch control equipment. This is a good philosophy during R&D, when changes are extremely rapid and when it cannot be guaranteed that launch control equipment is truly compatible with the engine until they are checked out together. In an operational situa-

About the Author

Henry W. Gilfillan is section chief for the Ground Support Equipment unit at the Rocketdyne Division of North American Aviation. He is responsible for all the engine handling equipment for Redstone, Jupiter, Thor, Atlas, Saturn booster, and Nova F-1 programs. After obtaining a BS in electrical engineering at the University of Michigan in 1939, he was a research engineer with Chrysler Corp. until 1951, when he joined Rocketdyne as a senior engineer in research. He directed development of electrical control components until last year, when he took over his present assignment.

tion, however, there is less of this uncertainty, and, consequently, checkout equipment can be considerably simplified in engine and missile maintenance areas. It was found that under the old philosophy, most of the time required to checkout an engine was really spent in checking out the launch control equipment instead.

We were forced also to comb through our procedures and handbooks and weed out unreasonably accurate or unnecessarily sophisticated field checkouts which would require correspondingly sophisticated and complicated support equipment. We had to rouse ourselves occasionally from our preoccupation with engineering elegance of design of airborne equipment and from our lack of concern for down-to-earth, potentially wartime, field conditions. Engine designers have learned to be a trifle more thoughtful about including some very minor design provisions to meet support needs. We remember how we all once wished very much that one more lifting lug had been provided on one of our engines.

• **Reducing MSE—Rocketdyne** recognizes that the only sound, fundamental way to reduce the cost and amount of MSE hardware is to develop simpler, more reliable engines and components which need little in the way of field checkout and field maintenance.

For example, the single thrust chamber engines we were building in 1955 were comprised of 88 components. Our 1959 models have only 33, and our 1960 engines will have only 5 components. This, of course, results in much higher engine reliability and in greatly reduced MSE. Regrettably, the amount of MSE is not reduced in direct proportion to the reduction in components, but the effect is gratifying indeed.

The other part of the Rocketdyne approach hinges on proper timing. As has been pointed out many times by support people, design of support equipment should begin concurrently with the design of the missiles and engines themselves. There is a danger, however, of starting to draw pictures too soon. The trick is to start actual design not too late—but not too early either. In the inception of a missile design, the following begin at the very outset:

• Investigation of the vehicle or weapon system operational concept.

• Investigation of the maintenance concept.

• Investigation of engine system support functional requirements.

• Investigation of engine component support functional requirements.

Following these, model specifications are written (whether or not there is a contractual requirement for them). These spell out all functional design requirements of each support item insofar as they can be determined at this stage. Then all sources of existing equipment, i.e., military inventories, commercially available equipment, and equipment already developed for other programs, are investigated. If it is suspected that other contractors may already be developing equipment with similar functional requirements, this is investigated too.

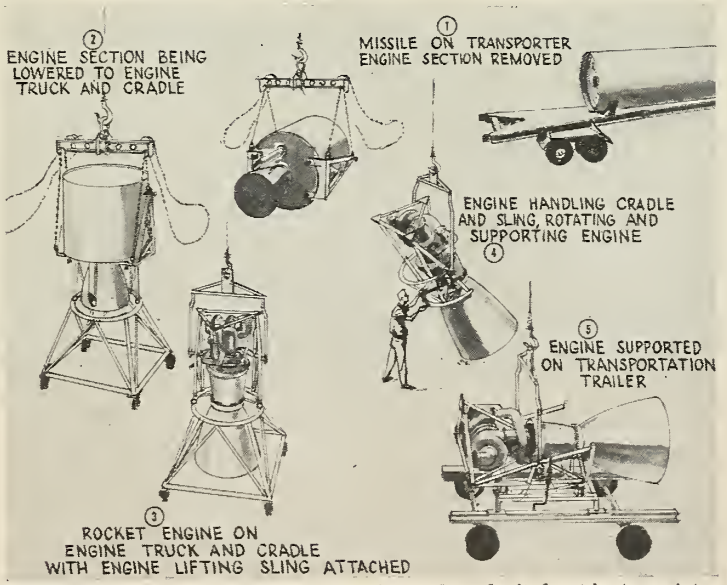
We have developed a number of semi-standard modules, especially in the checkout and servicing areas, which can be applied "as is" or with small modification to most new engines, missiles or space vehicles. New prototype design begins only when functional requirements are firm enough to result in prototype hardware that will be reasonably close to the final operational configuration. Final production design release is held up as long as possible without jeopardy to customer need dates. In this way, prototypes are available for development for as long a period as possible.

• **Compatibility**—In order to tie the knot of coordination securely between engine designers and support equipment designers, it is now required that they sign each other's layouts. Thus, the engine people can be assured of functional and configurational compatibility of the MSE with their engines and, in turn, the MSE designer can adequately be assured that proper design provisions have been made for engine handling, servicing and checkout. As a final safeguard to guarantee compatibility, Rocketdyne now regularly conducts "RIOT" (Resolution of Initial Operational Techniques) programs. These are in the nature of validation tests, wherein the engine, its support equipment, the handbooks and the man who has been trained to use all three, are all brought together and operated as nearly as possible as they will be in the field. Thus the last remnants of incompatibility are picked up and corrected.

Finally, Rocketdyne operates what are known as flight test support stands. These are engine test stands which have been equipped with operational ground support equipment insofar as feasible. Our past problems have been less of a technical nature and more a matter of finding out what things to do rather than how to do them. Recognizing the harmful effects of poor human engineering, consultants to Rocketdyne have produced a Human Factors design manual for support equipment. Classes in human factors principles are conducted regularly by a qualified expert who also approves all MSE design layouts.

Of more pressing interest are the more technical obstacles that confront us immediately.

• **Big rocket MSE**—The physical size of some of our new engines, for instance Rocketdyne's 1.5 million-pound-thrust F-1 single-chamber *Nova* engine being developed for NASA, poses some unusual handling and transport problems. Since it is desirable to position the engine at several different angles during the process of fabrica-



EQUIPMENT used to remove *Thor* engine and ready it for trip to maintenance area.

tion, special handling equipment must be provided in the shop. With regard to transport, there are definite size limitations relating to bridge and tunnel clearances as well as allowable or desirable load width on the highways.

Special consideration will also have to be given to the limitations of highway, rail, air and water transport. At the test stand or launching site, too, the handling problems incident to installation and removal of the engine are not to be dismissed lightly.

The size of certain of the engine control components presents problems. We are used to thinking of engine propellant valves as being something smaller than a breadbox that one man could pick up and carry. This is by no means any longer the case, and special handling and protective gear must now be provided for them.

Again because of size, decontamination equipment for these large engines must be correspondingly scaled up to provide higher pressures and higher flows of solvents, and purge gases. Thrust chamber protective covers and closures, heretofore considered minor design problems, now require careful comparative analysis and design study in order to arrive at configurations which actually do protect the engine and yet are made up of subsections small and light enough that special handling equipment is not especially required for them too.

Happily, increased size has not resulted in increased difficulty of engine checkout or in complexity of checkout equipment. In fact, the simplicity of this particular engine has considerably reduced checkout requirements as compared to current production engines. With some new engines, however, checkout equipment has been complicated somewhat by the addition of new systems such as helium cryostats.

The *Saturn* vehicle being developed for ARPA by the Army Ballistic Missile Agency, and for which Rocketdyne is developing the booster propulsion, employs a cluster of eight engines similar to those now used on the operational *Jupiter* missile. Fortunately, again, clustering presents no particularly new support equipment problems. Engine installation gear may be a trifle more difficult than for an IRBM, but the "any position, plug-in" engine imposes no new requirements on checkout or servicing equipment.

On the other end of the scale, some of the new engines now being developed by the industry for application to upper stages, have thrust chambers which are extremely lightweight. Special handling and protective devices are required.

The new silo launcher configurations, now projected for various weapon systems, impose no significant hardships on the design of engine support equipment, but may possibly exert a larger influence on the support devices associated with the rest of a weapon system, such as propellant loading gear or missile handling or missile checkout equipment.

• **Space support needs**—Let us take now a very brief glimpse at some of the anticipated problems of the future. The trend seems to be toward higher pressures in missile pneumatic and hydraulic systems, possibly up to 8000 psi.

This will require the development of greatly improved fittings and hoses capable of satisfactory performance and safety at these higher pressures for use in fluid systems.

Enormous size and expenses of first-stage boosters for some of the currently contemplated space vehicles makes it extremely desirable, probably economically mandatory, to develop booster recovery techniques. What new support requirements will be thus generated is not yet known, but it can be foreseen that ships or landing fields and communication systems will be required and also engine cleaning and overhaul facilities. The cost, in the opinion of the writer, will be fully justified by the dollar savings in booster hardware.

The same applies, of course, to the recovery of the man, or men, in a space vehicle. The extent and cost of the ground support required will be large, but this is critical to putting men in space. With manned vehicles, it may be necessary to protect the pilot from the noise developed by his vehicle's engines, especially at blast-off. And it may be possible to ameliorate this condition by means of special support equipment, the nature of which we can now only guess at.

The potential effects of storable propellants upon support equipment appear to be beneficial. Propellant transfer will be a less frequent operation and it will no longer be necessary to employ topping techniques during holds. The use of storables actually forces a reduction in checkout and in maintenance operations, as it is usually not practical to exercise valves and control components for purposes of checkout or to remove and reinstall components from a propulsion system when the missile tanks are already full. Other simplifications are also inherent.

For instance, the propellants are hypergolic and need no special ignition systems for starts, or restarts aloft, and, consequently, ignition system checkouts are eliminated. About the only new problem that storables introduce is that of propellant leakage detection and the disposal of propellants thus lost.

• **Simplification trend**—High-energy propellants, on the other hand, pose very difficult support problems. Liquid hydrogen requires special liquefaction storage, transportation and line-transfer equipment because of its extremely low boiling point (minus 420°F). Liquid fluorine has the same disadvantages plus some extremely difficult materials problems. Passivation and cleanliness requirements force the development of new handling items.

Simplification characterizes future trends in rocket engine support. Vastly simplified engines both in being and projected will require very little checkout. New techniques of induction-brazing plumbing will virtually eliminate leaks and the need for leak-test equipment.

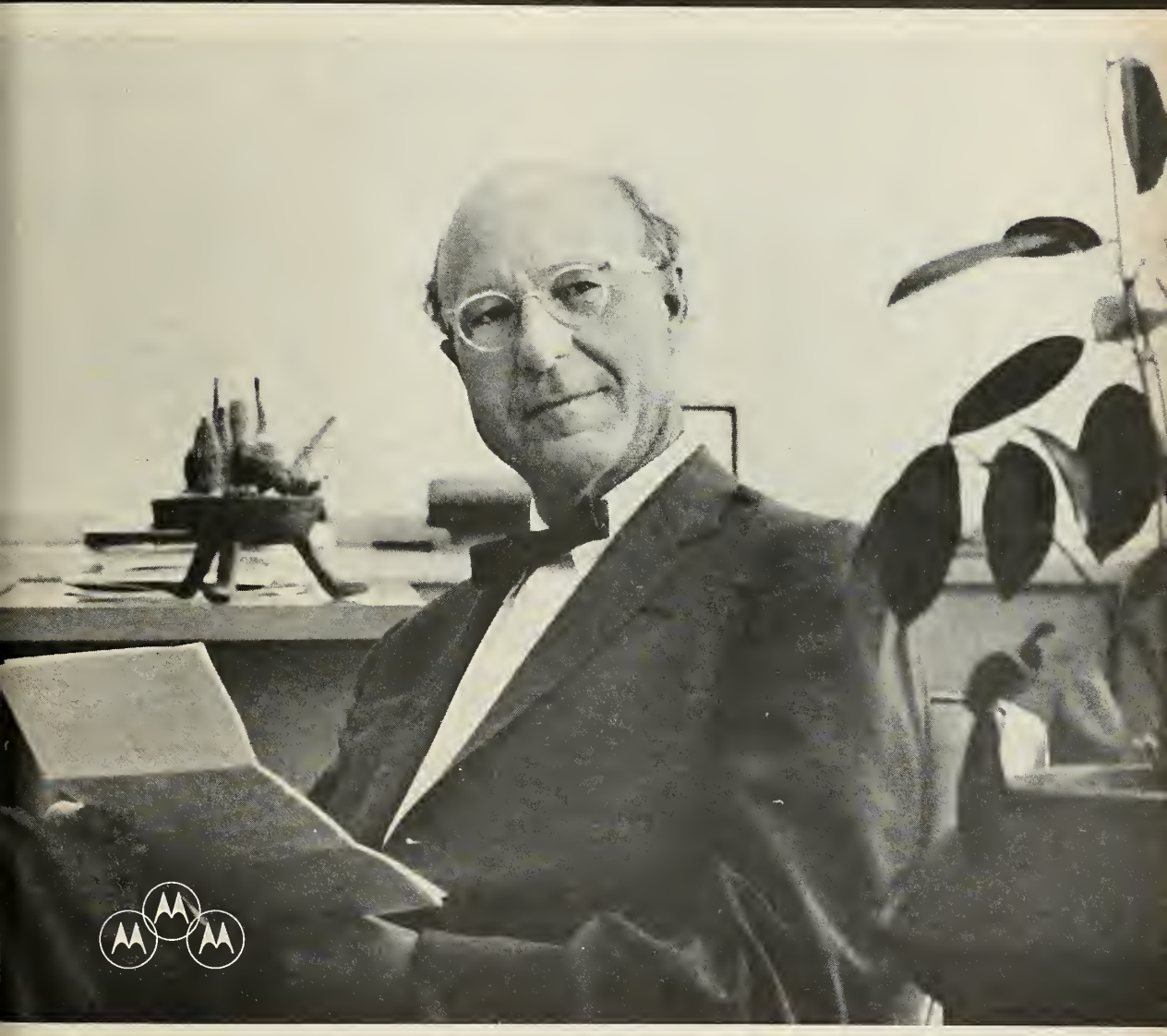
Simpler components will foster simplification of support gear. Hypergolic igniters and burst diaphragms, for instance, cannot be checked out and hence do not generate supporting devices. Equipment for cold checking in the field will also disappear as it is becoming safer and safer to assume that a component assembled per print with parts that are dimensionally correct will function properly under all conditions for which it was designed. Highly sophisticated items like servo valve analyzers will fade from the operational scene.

Future engines will be capable of being flushed, purged and preserved while in any position, eliminating special handling and rotating gear now in use. The utter simplicity of new engines and almost complete lack of an electrical system may eliminate automatic checkout of engines.

Technical breakthroughs can and must be made by the designers of airframe hardware, guidance systems, engines and the researchers in fuels, materials and futuristic propulsion systems. To be sure, support equipment designers will make use of the new knowledge and techniques thus gained by their less earthbound brethren in order properly to support the winged things of the future. Missile support (and space support), however, will hold up its end by making "conceptual" breakthoughs—researching the new ways in which men in space must be supported and maintained alive until they and their vehicles are successfully recovered intact.

MOTOROLA MILITARY ELECTRONICS CAPABILITIES REPORT:

Strategic Deployment of Technical Personnel



Dr. Daniel E. Noble, Executive Vice President, Motorola, Inc.

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Pre-cooling To Eliminate Countdowns?

Retractable cooling jacket is suggested to prevent cryogenic boil-off; ICBM bases require 25 T/D LOX-liquid nitrogen plants

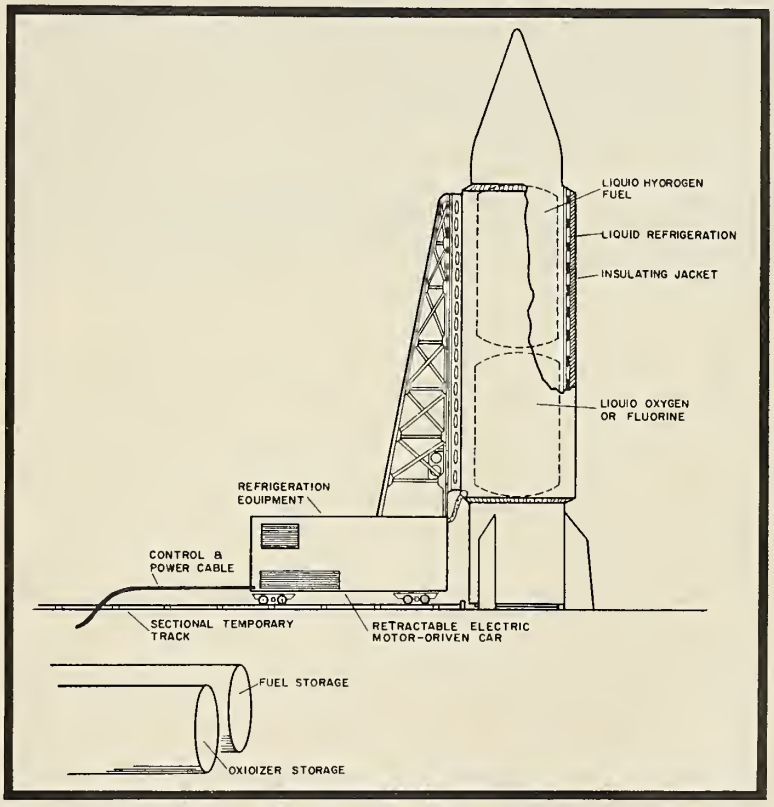
by James A. Snyder

ALLENTOWN, PA.—Among the disadvantages associated with high-performance cryogenic propellants is the long countdown period. This remains after such other difficulties as mobile production and handling have been overcome.

One method of drastically reducing or even eliminating the countdown time would be fabrication of a retractable, refrigerated missile jacket. This device would pre-cool the missile prior to fueling and then maintain both the fuel and the oxidizer in a slightly subcooled condition in the missile, thus eliminating boil-off. The jacket could be removed just before launching. Different zones of the jacket could be held at different temperatures to accommodate the particular fuel-oxidizer combination in use at the time. The system would assure the presence of the exact amounts of propellant necessary at the precise instant of launching.

Since the airborne cryogenic equipment contained in the missile would be at low temperature, the possibility of thermal shock as a source of malfunction would be eliminated.

It is doubtful that this adaptation will be made to the present generation of vehicles, but it shows great promise for future high-performance equipment. Meanwhile, advances have been made in adapting the production and handling of cryogenic propellants to field conditions.



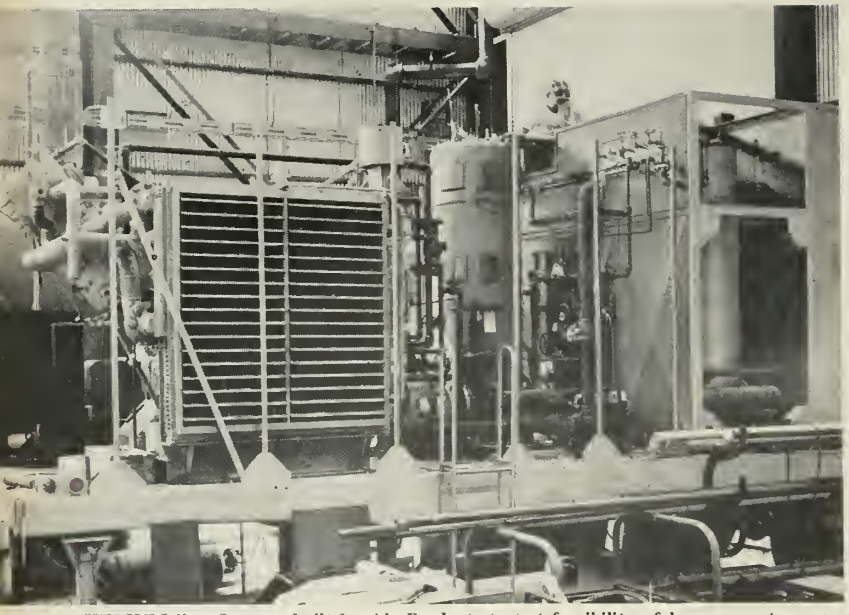
RETRACTABLE refrigerated missile jacket could assure right amount of launch fuel.

• **Mobile LOX systems**—The *Redstone* missile—being highly mobile—required a LOX generating plant which could be built into military type semi-trailer vans, and able to meet all the normal military requirements such as terrain, climatic conditions, gee-loading and air transportability. The plant employs the use of a somewhat standard high pressure cycle and produces 5 tons per day (T/D) of liquid oxygen.

In field use, the only support raw material needed is diesel fuel for the engines driving the compressors. These units generate their own electricity for auxiliary purposes. LOX or liquid nitrogen is withdrawn from the appropriate liquid storage tank aboard the trailer and is transported to the missile in a military type, 9 T/D LOX trailer. This trailer has a self-contained

About the Author

James A. Snyder is manager of the Government Projects Division of Air Products Inc. Holder of an MS degree in mechanical engineering from Columbia University, Snyder is closely associated with LOX and liquid hydrogen production in both large permanent plants and mobile support systems.



HELIUM liquefier was built by Air Products to test feasibility of long-range transportation of the material. The next few years will bring heavy work in this field.

liquid transfer pump which pumps the product directly into the missile.

The *Jupiter* system, with considerably larger demands than the *Redstone,* required the development of a liquid oxygen-liquid nitrogen producing plant having total liquid capacity of 20 tons per day. Once more, the mobility concept prevailed and in this instance it was necessary to use four semitrailer vans to house the essential equipment. Again, all of the military vehicle requirements applied. Two air source trailers are needed, along with a third housing air purification and heat exchanger equipment.

The fourth contains the control room, expansion turbine, distillation column and plant storage tanks. In field use, LOX or liquid nitrogen is transferred from the generating plant to a 4000-gallon military-type liquid semitrailer. A sufficient number of trailers to fill one missile are hauled from the generating plant site to the actual launching site where the product is transferred from the trailers to the missile by means of a separate transfer pump.

The required suction head for the LOX transfer pump is provided through pressurization of the liquid in the trailer by coils located on the underside of each trailer. Appropriate filtering equipment is used to avoid the introduction of mechanical particles into the missile itself.

• **Transporting by air**—Other major missiles in our arsenal employ the concept of a semi-permanent or permanent base, such as the *Thor, Atlas* and *Titan* programs. The LOX generator concept then changes from one of extreme mobility to one of air transportability for these semi-permanent or permanent locations. For this service, a 25 ton-per-day liquid oxygen-liquid nitrogen generating plant was developed with the main power source being either diesel engines or electric motors. Again, the plants are designed so that the main support requirement will be easily available. A high-pressure cycle similar to the *Redstone* is used, except that more refinements such as expansion engines and more effective control systems are employed to provide a plant having a greater over-all economy.

In all instances, the plants are designed to be operated and maintained by military personnel. All components, including the building, form convenient packages for air transportation. In these bases, LOX is moved from the generating area to the launching area by means of 4000-gallon semitrailers. The storage tanks are generally 28,000 gallons and pumping from the storage tank to the missile is accomplished by means of a pressurization system. High-pressure storage bottles are filled with vaporized LOX at a pressure of approximately 3000 psig, and an elaborate control system is employed to fill the missile quickly with LOX and to keep it topped with sub-cooled LOX during the pre-launching period.

• **New standards**—As the missile program developed and the equipment and systems became more complex, new requirements for quality control became apparent. Commercial standards of cleanliness and purity were no longer satisfactory. As a result, a hydrocarbon analyzer was developed and forms a part of the scientific equipment associated with each of these installations. It is used to detect contaminants in the fractional parts per million range which, if concentrated, could cause explosions.

Similarly, mechanical contamination became a problem. It was necessary to develop new standards of cleanliness for all LOX handling equipment. A system had to be devised for protection against the introduction of the contaminants during the various rehandling operations. There is still no universal agreement among the missile manufacturers on this point, but generally filters capable of removing mechanical particles down to a minimum of 10 to 40 microns are used.

Another specific missile development is storage tank decontamination. A device has been developed which will allow periodic removal of either soluble or non-soluble contaminants by means of adsorption techniques without the necessity for discarding the contents of the tank.

• **Liquid Hydrogen**—Now that the security veil which has surrounded the liquid hydrogen program has been lifted, it is possible to discuss some of the outstanding developments in this field. Liquid hydrogen is the most promising new fuel in the missile business today.

Users feel that the increased handling problems are more than offset by the remarkable high performance of this fuel. In contrast to liquid oxygen, liquid hydrogen has a boiling point of –423°F., a critical temperature of –400°F., and a freezing point only 14° below its boiling point. This very light liquid has a density of only .58 pounds per gallon and a latent heat of only 389 BTU's per pound-mol compared to that of 2932 BTU's per pound-mol for oxygen.

Thus it can be seen that the liquid is very cold, that it will occupy large volumes on a weight basis, and that it has a tendency to boil away at a much faster rate than the familiar liquid oxygen. However, its specific impulse when used with LOX is approximately 365, as compared to a specific impulse of approximately 270 for RPI and LOX. Of the known chemical fuels and oxidants, this impulse is exceeded

only slightly by the combination of hydrogen and elemental liquid fluorine.

A hydrogen production and liquefaction facility is necessarily complex. The basic source of hydrogen is crude oil, with additional hydrogen being extracted from water during the chemical processing which takes place in the hydrogen gas generation portion of the plant. The hydrogen is liquefied by first being cooled to liquid nitrogen temperatures by means of a nitrogen refrigerant system and further cooling in a hydrogen refrigerant system—with final refrigeration being supplied through mechanical expansion devices especially developed for this application.

Large-scale production of this important chemical has proved to be safe and economical. The price of product on a per-pound basis is well below that of some of the more common storables such as hydrazine.

After production, the liquid hydrogen is stored in vacuum insulated storage tanks which have been developed to a state of perfection so that only a very small loss rate (a fraction of 1% per day) is experienced. It is, however, necessary to transfer this product through vacuum insulated transfer lines as opposed to bare or non-insulated lines for LOX or liquid nitrogen. These lines require precision manufacture to maintain the high vacuums, less than one micron, required for successful operation.

Special shielding techniques to eliminate infrared radiation into the product had to be developed. Hydrogen is transferred from the storage area either by direct pipeline or with the use of large liquid semitrailers developed especially for this service. Safety techniques have been developed to the point where it is possible to transport the product over long distances on public highways. However, generally speaking, the economics of the situation indicate the desirability of the location of the production liquefaction plant at or near the missile firing site.

In addition to its use as a chemical fuel, hydrogen has been selected as the ideal propellant for use with the nuclear rocket engine. No new techniques in handling or storage of this fuel are needed for the nuclear missile program.

• **Liquid fluorine**—Because of a shortage of funds for development last year, the liquid fluorine program did not receive the amount of attention which would normally have been indicated by the technical progress made in this field. Next to ozone, elemental liquid fluorine is the most powerful chemical oxidizer known. It has a normal boiling point of –306°F., a critical temperature of –207°F., and a latent heat of 2952 BTU's per pound mol. Thus, excepting for its extreme chemical activity, it is in its physical respects, very similar to oxygen. In addition to being extremely active chemically, it is lethally toxic and thus requires very special handling.

Elemental fluorine is produced by the electrolysis of HF, and various chemical and physical techniques or combinations thereof are employed to remove the impurities carried over from the electrolytic process.

The high toxicity of the element increases the complications in storing and shipping. For instance, the outer shell of a fluorine storage and transport tank contains an intermediate shell which surrounds the inner fluorine tank.

The space between the intermediate and inner shells is filled with liquid nitrogen which is allowed to boil at its normal temperature, –320°F., thus maintaining the fluorine itself in a subcooled condition. This means that fluorine can be handled with these loss-free containers, thus preventing escaping gases and the resulting attack on people or materials.

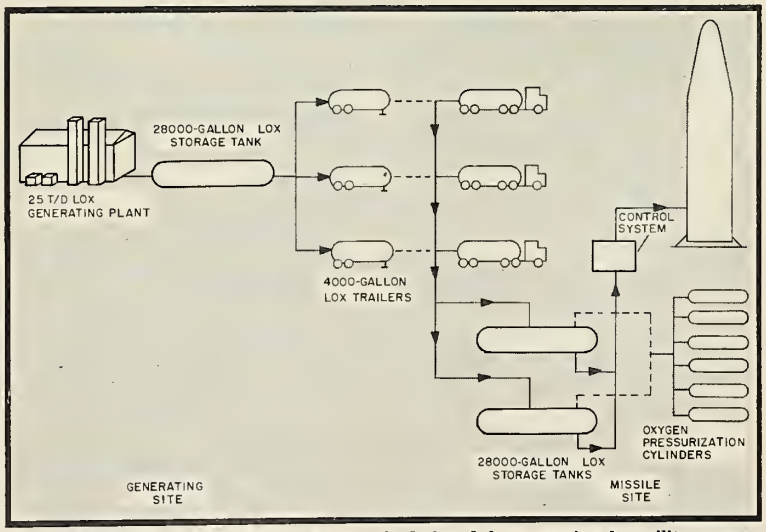
One of the major problem areas in this program has been the development and selection of materials suitable for containing the fluorine under the various operating conditions likely to be encountered. The materials used in handling equipment must often be passified, that is, they are first exposed to a weak fluorine solution which forms a chemical film on the surface of the metal, thus protecting it from attack by the stronger fluorine itself.

Because of the extreme hazards associated with the transporting of this material, it is considered better to locate the production sites as near to the use sites as possible. It is anticipated that activity in this field will increase greatly during the next few years.

• **Future needs**—It is certain that further improvements will be made in the manner in which the liquid propellants are transferred from their storage areas to the missile itself. For example, research is being done on various high-capacity pump systems. Various transfer systems are now being used and it would appear that one superior system will emerge.

The use of the extremely cold cryogenic materials such as liquid hydrogen or liquid helium has required the development of superior insulations and, more important, the application of these insulations to the appropriate tank or line configurations. Several manufacturers are developing proprietary insulations with performances many times better than the familiar perlite-vacuum low-temperature insulation technique. Generally, these new materials successfully shield against infrared penetration while retaining their low-conduction characteristics.

Finally, the area of helium liquefaction will receive much additional attention and development during the next few years. A helium liquefier was developed primarily for feasibility work. This program will demonstrate the practicability of long-range transportation of liquefied helium. This will, of course, greatly reduce transportation costs, as well as the size and bulk of the equipment required for transportation. As more helium becomes available for missile use, liquid storage and pumping systems will be developed as well as the recondensation apparatus necessary to conserve this very scarce element.



LOX SYSTEM for *Thor, Atlas* and *Titan* is designed for operation by military crews.

Space Support Market On the Rise

NASA's support outlay has been limited so far because its vehicles have been modified missiles— but hundreds of millions may be spent in the '60's

by Paul Means

WASHINGTON—The nation's fledgling space program is creating a new market for the missile industry—a market for space vehicle support equipment.

How fast the market grows will depend entirely on the progress of the space program. Though only about $30 million was spent by NASA this year on new space support equipment, the amount spent per year could grow into the hundreds of millions during the next decade.

Space vehicle support equipment is the instruments and tools that test, move, set up, check out, launch, track and control the space vehicle. It does not necessarily remain on the ground. Space stations used for launching vehicles into deep space would be support equipment. So would the equipment needed to support space vehicles and their crews on the moon and other planets.

The market is curtailed presently because most space vehicles in use are modified missiles which use equipment already in existence. *Jupiter-C, Juno, Atlas-Able* and *Thor-Able* all use the support equipment developed for their missile prototypes. The only current space vehicle that was developed from the ground up as a space vehicle with its own equipment is *Vanguard.*

Many of the newer space vehicles, such as *Centaur* and *Vega,* are also adapted from missiles and will use existing equipment. *Scout,* operational next summer, will be the first space vehicle since *Vanguard* needing its own support equipment.

But as newer space vehicles come off the drawing board, the market will increase for space vehicle support equipment of a type that will hardly resemble missile support equipment.

The support equipment needs of space vehicles are radically different from those of missiles. A missile must be easily serviced, rapidly moved, and quickly implaced, fueled and fired. Space vehicles, on the other hand, are fired one at a time from the same launching pad at non-strategic bases, under clinical conditions, at unhurried, opportune times.

Support equipment designed for advanced space vehicles must be capable of moving large, heavy and fragile components, of handling the most toxic and radioactive fuels, of firing rockets developing millions of pounds of thrust, and of tracking, telemetering, and sending commands so complex as to be undreamed of in the military missile world.

Specific support needs of space vehicles are:

• **Tracking, telemetering and ground command stations**—as space vehicles achieve the capability of changing course or orbit upon signal, and of travelling millions of miles from earth, the need will arise for more powerful and more complex ground stations.

Estimated NASA-ARPA cost for such equipment during the next few years is from $50 million to $75 million per year.

Thirty million has already been spent for the east-west Minitrack fence used originally in the *Vanguard* program. Over $3 million has been allocated for a similar fence in Alaska, the northern United States, and Canada, to track satellites in polar orbits.

NASA plans to bolster its deep space tracking in the near future by constructing two more of the multi-million dollar Goldstone 85-foot parabolic dishes. And the demand for deep space tracking apparatus will increase as space vehicles achieve the capability of probing farther into space.

Man-in-space will place a heavy burden on industry to come up with the type of supporting ground electronic equipment that will keep him safe and in control of his vehicle. Original estimates for the Project *Mercury* tracking range is over $15 million, with $5,250,000 going for a tracking, communication and radar acquisition network in Southern Texas.

Further into the future, the electronic supporting equipment needed for space stations, and moon and planet launching bases should provide the electronics industry with a sizable market for years.

• **Test and launch equipment**—As missiles become smaller and more compact, space vehicle boosters will become larger and heavier. This places special requirements on the types of test stands and launch equipment that must be used.

Saturn, the first of the large space vehicle boosters, will be over 200 feet high and will weigh 580 tons at liftoff. To provide for its needs, a special 175-foot test tower is being built at ABMA, and a 305-foot self-propelled service stand will be built at the launching site.

Types of equipment this tower will need include fire protection facilities, personnel safety devices, heating and air conditioning systems, lightning protection, elevators, cranes, and generators.

These requirements give an idea of the immense and complex type of equipment needed to launch the large future space vehicles. The six million pound thrust cluster *Nova,* and space boosters still on the drawing board, will even be larger.

• **Check-out equipment**—Some of the newer propellants to be used in space vehicles, such as liquid hydrogen, and liquid flourine, are going to require exacting and safe check-out equipment. The problems of checking out boosters propelled by nuclear reactors, ion, plasma or photon energy, have hardly been approached.

• **Moving equipment**—How do you move a booster over 200 feet long and weighing hundreds of tons? Unless you dismantle the vehicle, and reassemble it at the launch area, you must devise some way of flying it, moving it across land, or floating it down rivers intact.

• **Man-in-space**—Before man occupies a space station, or installations on the moon and the other planets, a great deal of research must be done to establish what sort of support equipment he needs. Space stations and moon stations must be built on the ground that will match the rigors of space environment. Millions of dollars will be spent for research on this type of support equipment.

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Who Should Be Prime to Design-Build?

Big steel fabricators dispute role of missile makers in constructing rocket stands

by M/R Staff

WASHINGTON—Construction of a 2400-ton, 310-foot-high missile service gantry involves problems vastly different from those encountered by engineers in the design of bridges and conventional structures.

The $4-million tower being built for *Saturn's* 1.5 million-pound-thrust must be able to accommodate a 240-foot missile and provide for its safe servicing, checkout, and launch and for the comfort and convenience of the missile crews.

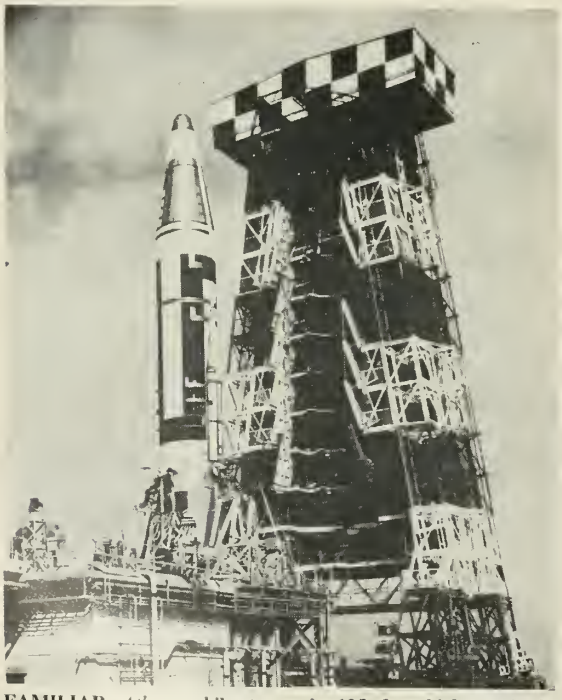
Such a structure is practically a city in itself. It contains its own power station, elevators, air-conditioning, fire-protection, intercom, water, air, hydraulic, and lighting facilities, complex operating controls, and lightning protection. And the entire structure must be "portable"—that is, be capable of being moved under its own power to a safe distance during launch.

There are two opposing schools as to who should be the prime contractor on the design and construction of such structures. One—typified by **Kaiser Steel**—holds that the design, fabrication, and erection of the basic structure and its mechanical components should be in the hands of firms with a long background in construction and heavy equipment fields.

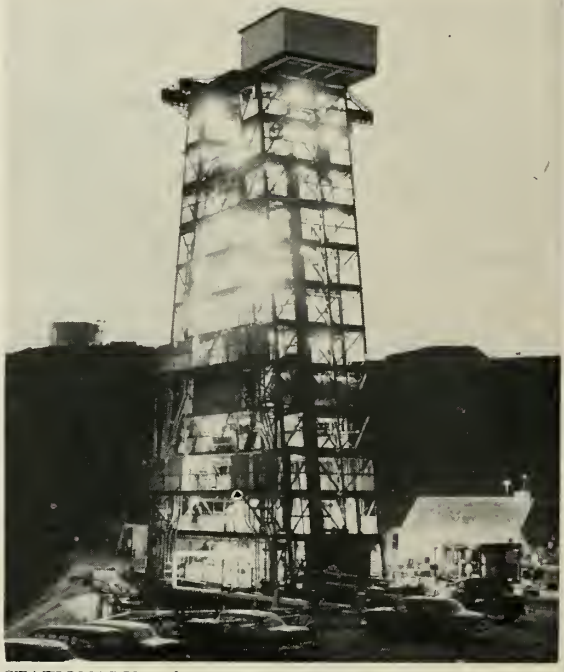
The construction firm feels that the missile contractor's participation should be limited to those areas and to the extent governed by functional requirements imposed on the service tower by the missile itself.

The other view is that the missile prime should have full cognizance and control over all support equipment, including the towers. They hold that the gantry is basically a simple steel structure whose fabrication and erection is straightforward and should be bid competitively and built from the engineering firm's designs and specifications.

• **Money keys procedure**—The steel fabricators in this young but thriving



FAMILIAR *Atlas* **mobile tower is 135 feet high. It backs away to a safety area when the missile is ready for firing. Kaiser Steel designed and built the first model.**



STATIONARY *Atlas* **engine testing stand was Kaiser's first. They collaborated with Convair on its research and design. Convair controlled support in** *Atlas* **program.**

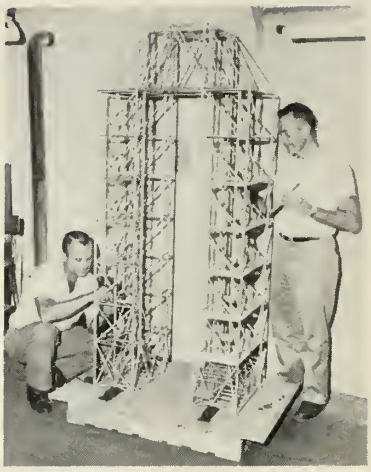
as usual, money talks . . .

Space Age industry counter that big test stands and gantrys are as tricky to build as missiles, and require a specialized engineering talent to cope with the never-ending stream of modifications. Says N. M. Schroeder, Kaiser support equipment project engineer, speedy incorporation of changes is most effectively accomplished "by the 'design-build' contractor working in close harmony with the missile designer."

Actually, procedure is determined by who has control of the money. In the case of the *Atlas* program, **Convair**, the missile prime, had control over the entire weapons system. They could, and did, award a design-build contract to Kaiser Steel for the Sycamore Canyon static test facility and two mobile service towers. Later, Convair awarded a contract for 14 of the towers—modified to allow for horizontal checkout —to **U.S. Steel**.

In most cases, however, responsibility for support construction for Army and Air Force missiles is held by Army Corps of Engineers. (Bureau of Yards and Docks has similar cognizance for the Navy.)

Government policy is that design and construction be handled by separate firms. Generally, a contract is let to design the structure to governmental specifications based on missile requirements. After the design has been approved, another contract is let for construction of the facility.



SCALE MODEL of *Saturn* tower. Kaiser engineers first built 80-inch model to study fabrication and operation.

This procedure, although sometimes ponderous, provides a check and balance. It also offers a measure of guarantee that all will be done according to Hoyle.

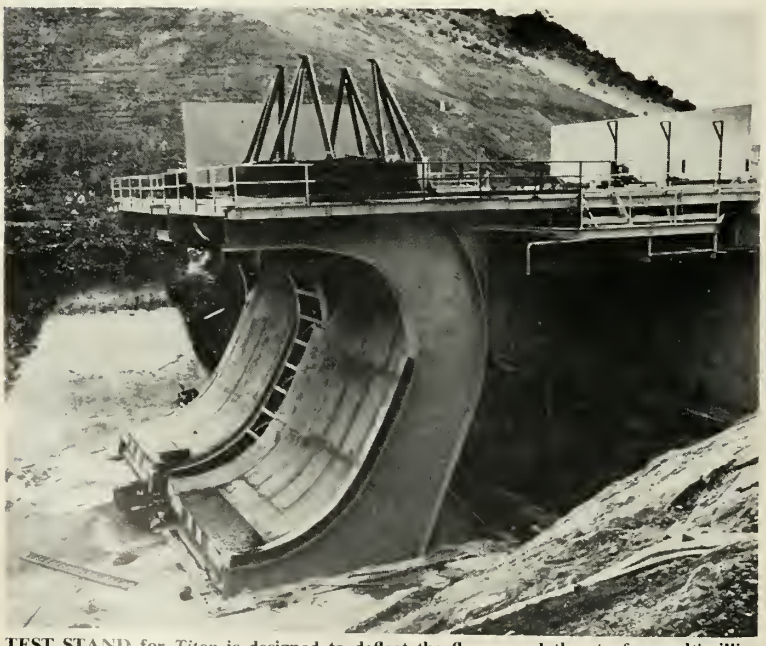
• **Objections raised**—Many in the industry feel, however, that the firm doing the design work can logically do a better job on the construction. In any case, the bulk of missile gantry work is done under Army Engineers procedures.

As in many other phases of missile development, some odd situations are sometimes created in the procurement jungle. As an example, **Aerojet-General** was awarded contracts to construct two 1.5 million-pound-thrust test stands at Edwards AFB. In their capacity as an A&E firm, this would arouse no particular question.

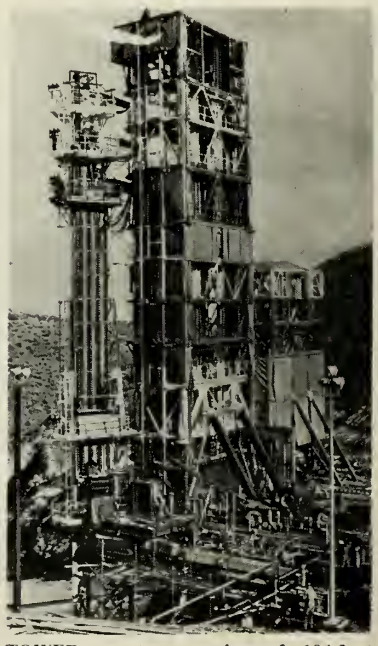
However, **North American**, the prime, objected strenuously since Aerojet-General is one of their main competitors in the propulsion field. According to reports, other A&E companies also objected.

It appears likely that most of the future test and launching gantries will be built under the established procedures of the Corps of Engineers—especially since procurement policies are getting away from the weapon system concept which gave the prime contractor cognizance over the entire missile system.

Much can be said for both sides in the controversy, but the primary objective, of course, is that our missile and space programs have the support structures equal to their job when and where they are needed.



TEST STAND for *Titan* is designed to deflect the flames and thrust of a multimillion horsepower motor. Many construction companies feel that equipment like this should be built and erected largely by firms with construction background.



TOWER structure consists of 104-foot missile erection and service tower plus 52-foot tower for second stage.

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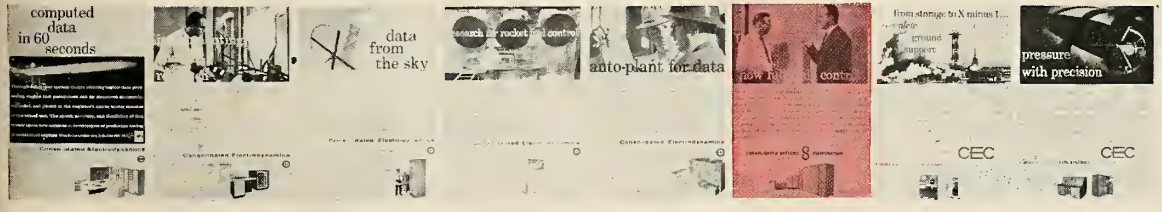

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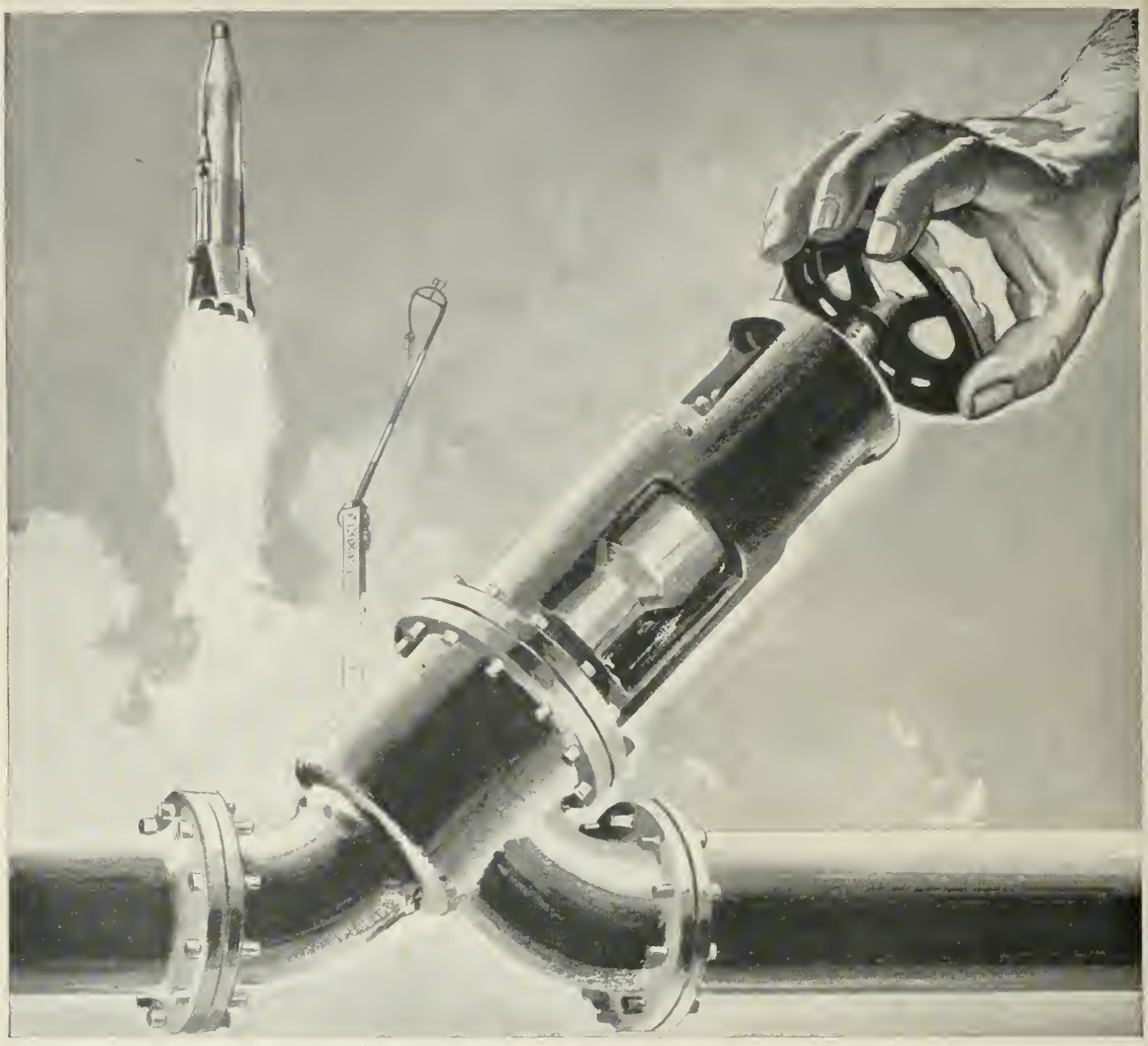

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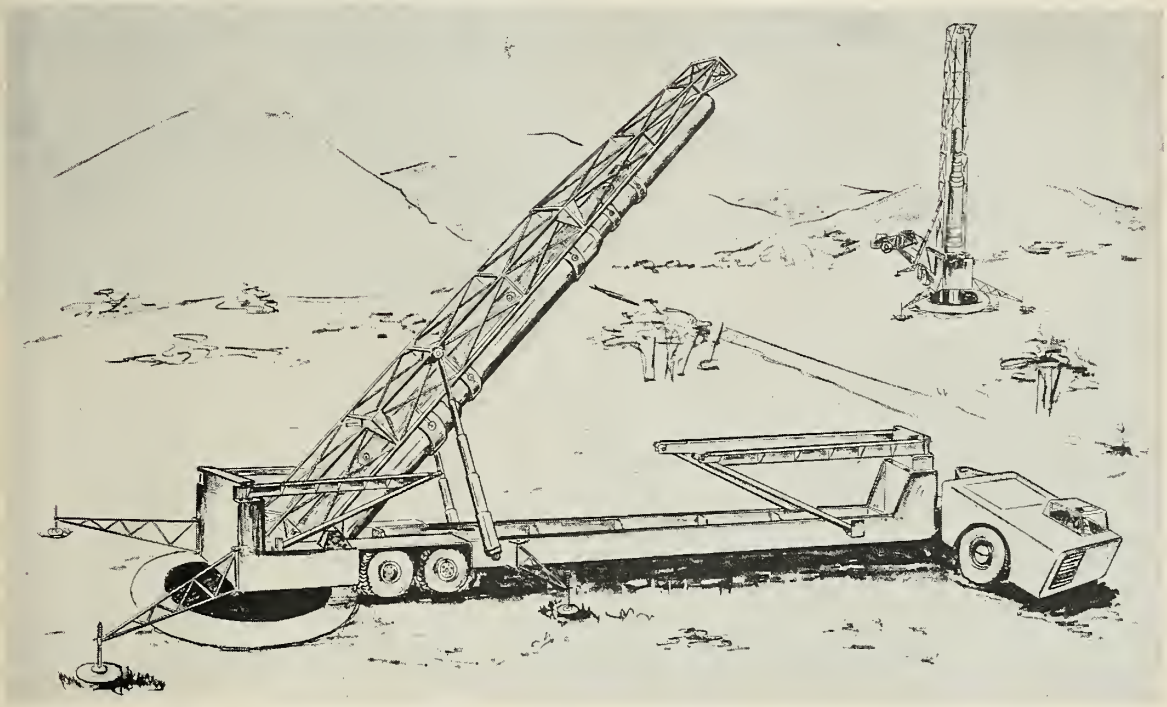
Minuteman Handling Must Be Delicate



by Jay Holmes

WASHINGTON—Handling of the **Boeing** *Minuteman,* America's flexible intercontinental missile, will be a major challenge to support equipment makers.

The finely-balanced and structured weapon, with its sensitive guidance gear and solid-propellant grain, must be able to move over rough terrain in remote areas or on trains to fulfill its mission of "mobile" instant retaliation. Furthermore, it must be taken out of its hard base at intervals for checking and recycling of propellant.

The missile, due to be operational in 1962, will be transported in ready-to-fire condition. This is to provide maximum readiness, since only the thermonuclear warhead will be installed at the underground launch site. The *Minuteman* concept of widely dispersed launch facilities, most of them ready to fire at any given time, will provide assurance that at least some of our retaliatory weapons will escape destruction even after a surprise attack.

The lightweight skin of the rocket case is a major difficulty in transporting *Minuteman.* The skin, just strong enough to hold the combustion pressure, must not even be scratched, lest it be weakened by notch sensitivity. Bending loads must not be imposed. Temperature must be rigidly controlled.

To deal with this dilemma, **General Electric** proposes a missile carrier and loader powered by direct current electric motors. A gasoline engine generator would supply current. Electric motors have no gears to shift while the carrier is accelerating or decelerating, and while the hoist is transferring the missile to and from the silo. There are no sudden jars.

In a further effort to keep the ride smooth, all wheels will be equipped with hydraulically operated brakes as a supplement to dynamic braking. And on either side of the carrier's pivot center, a trunion provides three-point support that eliminates any twisting or bending while the missile is raised or lowered into position.

The versatility of the electrical system allows performance to be altered to suit any changing requirements and to furnish power for auxiliaries. One of these needs is temperature control, provided by a combination refrigerator-heating plant with a blower.

One 70-foot carrier has already been produced by **Utility Trailers,** Los Angeles, for *Minuteman.*

Boeing, associate general contractor for assembly and test of *Minuteman,* and a rocket engine company probably would operate the assembly and recycling facilities. The Air Force is reported to be studying sites in Nebraska, Kansas and Iowa, among others, for their location. Although it is presumed that the launching bases will be relatively close to the assembly facilities, their locations will be secret.

It will be fairly easy to hide launch facilities because they will be much simpler and smaller than those for *Atlas* and *Titan,* the liquid-fueled ICBM's. *Minuteman,* stored in a camouflaged silo, will be launched by remote control from an inconspicuous building nearby. Personnel and ground support facilities will be few.

Autonetics Division of North American Aviation has the *Minuteman* guidance contract. **Avco** is making the reentry nose cone. **Thiokol** is developing the first-stage propulsion, with limited backup by **Aerojet-General.** Aerojet and Thiokol have second-stage development programs stressing different technological approaches. Aerojet is working on the third stage with **Hercules Powder Co.** developing a parallel program stressing a different approach.

Last week, **Data-Control Systems Inc.** announced receipt of a $750,000 contract from Boeing to develop the FM/FM ground station telemetry system for the *Minuteman* test program.

In Fiscal Year 1960 alone . . .

$550 Million for ICBM Facilities

Here's an authoritive account of the complex and constantly changing requirements of the nation's most massive design and construction program.

by Lt. Col. Charles B. Alexander, Jr., USAF and Fred E. Ressegieu

Los Angeles—From its Ballistic Missile Division (ARDC) here, the Air Force supervises and directs the largest design and construction program in the United States today—the preparation of bases and launch facilities for the country's rapidly increasing arsenal of intercontinental ballistic missiles.

In the fiscal year just concluded, the Air Force committed approximately $200 million to the program for construction of facilities, making a total of $480 million to date. The FY 1960 budget passed by Congress includes a figure of approximately $550 million for ballistic missile facilities. BMD handles directly the design of all these facilities; the Army's Corps of Engineers is BMD's principal constructing agency.

Because it is vital that bases be ready as soon as the ICBM's are available, their design and construction is being accomplished concurrently with development of the missile. Growth and change are inevitable as the missiles approach operational status, and changes in the facilities must keep pace during both design and construction. Close control and integration by BMD makes this possible.

Col. William E. Leonhard is BMD's Deputy Commander for Installations. His organization manages the design of test, training and operational facilities for the ballistic missile program, using selected architect-engineers for the actual design.

BMD's responsibility continues during the construction phase. Changed requirements must still be coordinated with the missile contractors and the facility designer and incorporated into the launch buildings during construction. Col. Leonhard accomplishes this through his own field offices at each construction site.

Construction of missile launch facilities is now under way at eleven Air Force bases in the United States. The Department of Defense appropriations bill for 1960 provides increased funds for speedup of missile programs, specifically for *Atlas* and *Minuteman*.

After receipt of a design assignment, the Architect-Engineer's first concern is to accumulate the information necessary for him to proceed. This includes design criteria from the missile designer, design and operational criteria from the Air Force, construction agency design standards, and specific information pertaining to the site, such as soils, topographic and real estate data.

• **Complexities**—Most complex of these by far is the first—the design criteria from the missile designer. In designing missile facilities, the construction engineer finds himself involved in an engineering problem of new dimensions. Inherently complex, the missile and supporting equipment must be sheltered in a facility designed to withstand overpressures, ground shock, and radiation from nuclear attack.

Understandably, the criteria from the missile designer is provided in considerable detail. It consists of design documents accompanied by drawings specifying critical dimensions, clearances, and arrangement, as well as power and other utility requirements, temperature, humidity, shock and similar physical limitations. Interfaces between the facility and the missile are specified or suggested. The detailed requirements of propellant storage, handling, and loading are particularly critical. All of the necessary information to assure that the facility will properly support the weapon system is supplied to the A-E after check and approved by the Air Force.

Criteria originating with the Air Force include those of the Strategic Air Command based on operational needs. Design specifications assure incorporation of the latest technical improvements, by-products of studies and research conducted by BMD as well as their experience with other missile systems. Of considerable importance are the "austerity" criteria which assure that completed designs contain no frills and meet minimum essential standards for the use intended.

ALEXANDER

RESSEGIEU

About the Authors

Colonel Alexander is Assistant for Technical Requirements, WS-107A-1, Facilities Division, AF Ballistic Missile Division, ARDC. He is responsible for validation, correlation and approval of these requirements for launching and support of the Atlas and integration of these requirements into design criteria. A native of Macon, Ga., and a graduate of Macon University, he was an Air Force intelligence officer in Europe in World War II.

Mr. Ressegieu is Manager of Defense Projects, Power and Industrial Division, Bechtel Corporation. He is a graduate of West Point and has an AM in civil engineering from Cornell. He retired from the Army with the rank of colonel after 20 years' experience including service as District Engineer in St. Louis. From 1954 through 1957, he was Chief of the Plans and Programs Division in the Office of the Army Chief of Research and Development. Since joining Bechtel in 1958, he has been involved in ICBM facilities designing.

NEW DRAWING by a Bechtel Corp. artist shows blast-off of now operational *Atlas* from a hardened launching site, still in construction stage.

Information pertaining to the site is received from SAC, A-E studies and the construction agency concerned through arrangements made by BMD.

• **Constant change**—Few of the criteria listed above are static; arrangements must be made for orderly incorporation throughout the design of continually changing requirements. Most critical and complex, and most subject to change, are those criteria provided by the missile system contractor. While changes can be effected by formal changes to the original criteria document, transmitted through BMD, more often than not the urgency of time will require a short cut.

During a major design program, representatives of the Architect-Engineer may be physically located at the missile system contractor's plant, and representatives of the missile contractor similarly stationed at the A-E's design office. Through this close technical liaison, changes in the missile system are immediately known to the facility designer and their impact on the facility design can be calculated. Any required changes are of course subject to BMD approval.

Panels of experts are available for discussion and consultation on specific areas of classified information such as effects of nuclear weapons, blast waves, radiation, ground shock.

Systems technical direction and coordination of the many technical requirements of integration of the several weapon systems is handled by Space Technology Laboratories (STL) acting as agent for BMD.

• **Conception and review**—In the design of missile launching facilities one of the first steps is delineating the basic concept to be followed.

The Architect-Engineer prepares a concept based upon the total criteria and presents it to BMD, usually using a series of charts which show general arrangement of equipment and buildings in plan and section views as well as proposed treatment of some of the more unusual problems.

At this presentation, BMD, SAC, STL, and other key groups can evaluate the concept and direct changes if required prior to approval, so that detailed design can proceed.

After approval of the concept, the Architect-Engineer prepares the preliminary design, which includes drawings, outline specifications of equipment and materials, and engineering calculation. This is thoroughly reviewed by AFBMD, an engineering review conference is held, and BMD directs any changes to be incorporated into the final design. Further conferences are held with SAC, the designers of the missile, and the designers of its support equipment; the design proceeds to its final phase embodying the requirements for operation of the missile and of its supporting components.

Final design of the facility is submitted and again reviewed. Every detail is gone over with a fine-tooth comb; new developments are incorporated. Design drawings and specifications are then modified and passed to the constructing agency.

Design work, however, does not come to a halt with the award of a construction contract; any change which occurs during development of the missile or its support equipment must be reflected in design of the facility. Major changes affecting the construction contract are handled by change orders to the contractor. Other changes or clarifications of the drawings and specifications are handled by BMD's field representative, who continuously checks on construction to see that it is completed on schedule and in strict accordance with the design, including such changes as may be developed in the field or in the change orders.

• **Tough requirements**—The requisites of a good Architect-Engineer for missile facility design work are stringent.

The work includes structural, architectural, civil, electrical, and mechanical engineering and drafting and preparation of specifications. While much of the work is like that performed on any large and difficult engineering project, there are important differences involving special skills and organizational flexibility and adaptability.

Most of the designs must protect men and equipment against nuclear blast and radiation and still allow the bird to be launched on command. Protection of structures, men, and equipment from the tremendous ground shock requires designers with the best possible background in such problems.

Since resistance to a nuclear attack necessitates underground design, problems in soil mechanics become extremely critical. Ground water is a problem in some areas; in others there is the opposite problem of obtaining an adequate electrical grounding grid and a suitable source of water.

Particular skills are required for designing cryogenic systems. Special equipment and design are required to meet their unique problems. The techniques of normal temperature piping, valving, control, and liquid transfer are inadequate; even materials of construction are different. Carbon steel, for example, is brittle at these low temperatures and cannot be used for pipe, valves, pumps, or vessels.

Schedules are tight and become even tighter as design progresses. A finished design of one part of the facility may be nullified overnight by developments in the weapon or its components and must be redesigned. To meet the schedules, checking must proceed continuously and simultaneously with design; flexibility is the keynote. Coordination of all phases must proceed rapidly, with constant intercommunication among all government and civilian groups.

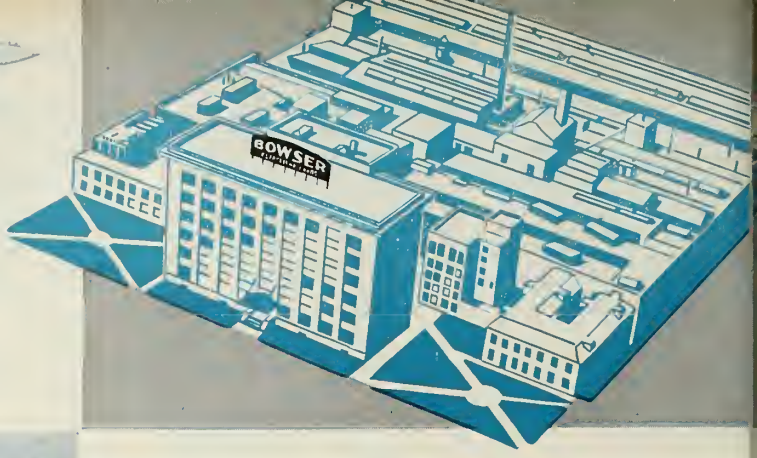
• **Nine at a time**—An operational squadron for the *Atlas* ICBM can simultaneously fire nine missiles—grouped three to a site or totally dispersed, with only one to a site.

Training bases are built to be as nearly like operational sites as possible, insofar as actual equipment and arrangement are concerned. The term "Hollywood Hard" has been coined to describe these installations which simulate the "hard" operational bases, the main differences being that the hard bases are underground and have more massive concrete structures.

Each missile is housed in a Launch and Service Building. This building contains, in addition to the missile, all the auxiliary equipment required to raise and fuel the missile, arm it, and check and set its guidance system. The whole

(continued on page 76)

FROM *Concept* TO *Application*



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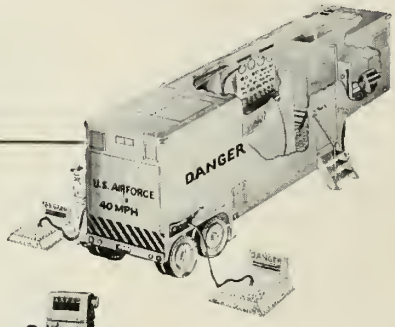

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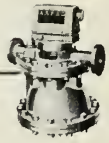

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Packaging Influences MSE Concepts

How the growing utilization of 'packs' is boosting missile/space reliability and maintenance and cutting costs

by Edsel F. Moffitt

AKRON, OHIO—The most obvious consideration in the design of missile support equipment (MSE) or a support system is that the functional requirements of the missile, aircraft or other vehicle be met.

These functions are often defined through specifications which set forth in definite terms requirements that must be met in regard to a specific operational capability. However, there are other, less obvious considerations that have a major influence on design.

Included in this category are factors such as reliability and ease of maintenance which are often dealt with in comparatively general terms in specifications. To this list should also be added ease of logistic support and versatility—adaptability to use in multiple applications or several programs. Versatility borders on and is closely associated with standardization, still another consideration in design and development of missile support systems or components.

• **Packaging is basic**—These considerations—operational capability, reliability, maintenance, logistics, versatality, and standardization—are obtained or lost to some degree through the factor of "packaging": that is, how the system, sub-system, or major component is put together or assembled.

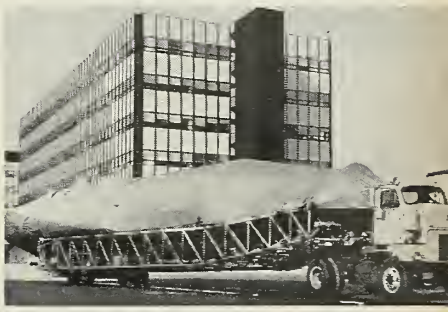
Packaging is a basic element in working out a system. In some cases it may very well *be* the system. Generally, however, packaging means assembling into a functional entity various detail equipments or components for performing related or complementary functions. Examples of this type of package might be vehicles such as trucks, trailers, track vehicles. A semi-trailer in which is installed telemetry, communication, or test equipment illustrates the idea of packaging. Other examples are transportable housings or shelters.

The criteria for packages, or "packs," of this nature may also be applied in a sub-level; for example, a console of equipment installed in a trailer or shelter. Further application may be made even to the level of "black boxes" installed in a console. It is obvious, however, that greater benefits are obtained in the first level, where the greatest quantity of material is involved.

Missile launching systems, communication systems, command control, and tracking systems are candidates for the application for packaging technique. It can also be applied to servicing equipment for missiles, rockets, VTOL aircraft and the more conventional aircraft. A notable example of its use is the *Mace* ground support system produced by **Goodyear Aircraft Corporation.** This system utilizes a building block principle; the equipment is packaged into "packs," and when various combinations of these "packs" are assembled the required operations of the missile from assembly, through transport and checkout, to launch can be performed.

What is obtained by packaging? What is gained by the systems engineer in utilizing the packaging technique or basing a missile system on a type of building block organization? The advantages discussed below might be considered as criteria for developing missile support equipment. (They are not necessarily listed in order of importance.)

• **Versatility**—The capability of applying an item of equipment to various systems or of having application to various functions in a given system may be illustrated by communication equipment installed in a transportable shelter. The basic shelter itself can be a further example; in the case of the *Mace* system the same basic shelter is used in several applications.



PACKAGED *Atlas* ICBM leaves Convair plant at San Diego on specially built trailer for delivery to Cape Canaveral.

• **Transportability**—Packaging into units also provides ease of transportability, a boom to the military because it facilitates movement required by tactical and training operations.

• **Flexibility**—A packaged system also gives flexibility—the capability of composing arrangements of equipment in various theaters of operation to meet various tactical conditions. This in part is accomplished by the building block principle.

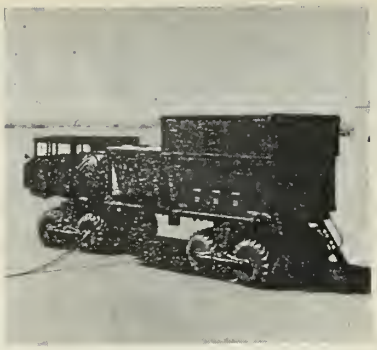
• **Maintenance**—Maintenance of a support system in the field is eased through application of packaging. The maintenance problem is reduced to a simple matter of replacing component packages whenever failure occurs. Various levels of maintenance may be established—a complete shelter or trailer may be replaced, a change of cabinet made, or a black box changed in a cabinet. As a result, down time is reduced, and fewer and less skilled personnel are necessary.

Sending "packs" back to the depot permits factory level of service and/or overhaul, providing a high level of skill along with more tools and facilities. Usually this means field equipment is in better condition; frequently it also saves money.

In several missile systems a Contractor Maintenance Service is provided

About the Author

Since his graduation from the University of Louisville in 1946 with a BS in Mechanical Engineering, Edsel F. Moffitt has spent more than 12 years in the design of various structural and mechanical components or support equipment for aircraft and missiles, as well as other lightweight structures such as radar antennas. During the past six years he has worked in the area of missile support equipment design at Goodyear Aircraft Corp.



EXAMPLE OF packaging equipment into housings is typical pack, at left, built by Goodyear Aircraft for *Mace* program. At right, packs mounted on all-purpose truck.

by the prime equipment producer or other contractor to the military organization. Through this arrangement the contractor in effect provides a depot maintenance capability with the backing of a manufacturing organization. As an illustration, consider as a pack a railroad car launcher for a ballistic missile. For maintenance the car may be replaced, routed directly back to the depot or factory, serviced or repaired, and placed in usable supply again. The result—reduced field down time and a higher level of maintenance service.

• **Supply**—Packaging permits flexibility of supply; units can be easily transported, stored and relocated if necessary. Instead of inventorying and stocking a group of sub-assemblies, the user relies on a specific operational entity, supplied in a package. And equipment of this type is ready to operate with a minimum of servicing upon reaching operational site; no installation is required and no time-consuming check out is necessary. Again the resultant savings are apparent in the reduction of personnel and skill levels required at the operational site. And there's reduction in down time of a particular function or system.

"Packs" facilitate any central supply systems that might be established, such as that now incorporated in the *Mace* program. Here the Missile Automatic Supply Technique (MAST) uses an electronic computer tranceiver in global hook-up to keep tabs on all components for the *Mace* system. Computers instantly figure inventories and issue signals to warehouse points or manufacturers in seconds, providing whatever orders are necessary for production and/or shipment of needed components. A supply system of this nature, coupled by air transport with the capability of quick setup on the operational site, provides a short supply time, from material source to operation, not heretofore obtainable.

The advent of widespread use of air transport has brought a new approach to maintenance and supply; the time required to transport from using organization to depot maintenance point or supply point and back to using organization is no longer a controlling factor in the cycle. And packaging simplifies air transportability and thereby further reduces the time cycle.

It should be noted that packaging for operational advantages also provides in effect a shipping container; boxing, crating or much of the other processing for shipping is eliminated. In the case of relatively small missiles, consideration has been given to shipping in a container which may then be used as the launcher.

• **Erection**—Savings of a packaged system are reflected not only in operational maintenance and supply, but in the simplified initial construction or setting up of the site. Manpower requirements over and above normal operating personnel are reduced or eliminated. This is particularly significant because many operational sites are located, or are subject to relocation, in remote corners of the world. Again, the reduction of personnel reduces major problem of logistics.

• **Reliability**—Packaging will tend to enhance reliability, since installation and checkout will be conducted at the factory where conditions are more favorable for applying reliability techniques. Reliability of detail components will increase because the equipment may be installed and completely checked out in its operating environment. This is particularly significant with the installation of electronic equipment into shelters or van trailers. And reliability in this case will also be aided by the fact the equipment may be shock-mounted to reduce the possibility of damage in shipping or handling.

• **Types of installations**—Several types of operating installation or complex may profit from adoption of a packaging concept. Fixed installations obviously will benefit from the concept's flexibility, simplified maintenance, ease of supply, ease of erection and increased reliability. Ease of installing, removing, or servicing the missile or other flight vehicle is also of importance to a fixed installation.

In an installation of the type planned for the *Minuteman* missile, these factors would save both time and funds; with a complex of a great number of missiles, the ease of these operations results in great cost saving. This of course applies to the servicing of both the missile and the support equipment. Even more importance may be attached to the time factor when missiles such as *Minuteman* must be kept on an "alert status." Packaged equipment also will enhance standardization of equipments and components for use in various installations or locations.

Semi-fixed installations can be obtained through the packaging technique without the investment demanded by a completely fixed installation. A missile Operations Center "pack" similar to that used in the *Mace* program, for example, will provide facilities for control of an operation without the expense of a permanent concrete and steel structure. And much of the investment in a site using packaged components can be salvaged when the site is abandoned. This situation is noticeable in a satellite program, such as Project *Mercury*, where tracking and communications equipment may be set up in far flung locations. Upon completion of the program, the equipment can be salvaged; at any time during the program, the site may readily be relocated. Furthermore, "packs" permit operation in relatively unprepared terrain or geographical environment; this results in savings in time and money.

Mobile systems of course benefit most from the packaging concept. All the above noted advantages are applicable to the mobile system.

Shipboard installations also reap the benefits of the package concept. Often the same equipment packages can be used interchangeably on both ship or shore; but even though the installation cannot be identical or interchangeable, packaging has merit on a shipboard installation. It tends again to reduce installation and checkout time, reduce skill levels required on board, and ease logistics. Transfer at sea may be simplified by transferring a complete package rather than a quantity of detail items of equipment.

• **Concept application**—Although this discussion primarily relates to missile support, it is interesting to note other areas where packaging concepts have been applied. Particularly is this apparent in the vehicle to be supported itself. We see the advent of packaged fuels; missile stages and/or sections are packages; much thought is presently being given to escape capsules or pack-

ages; commercial application of the concept is being made in the aircraft industry—a notable example is the DC-3 baggage handling system.

This discussion is based on equipment considerations only and does not take into account operational requirements such as mission. Operational requirements may override or overrule certain of these equipment considerations, but the latter generally tend to support or complement the former.

Missile support equipment must be considered or designed along with the flight vehicle or overall system, if maximum realization of the benefits of packaging are to be obtained, MSE development must start early in the system conception. The close relationship between MSE and the missile can be seen in the case of automatic test equipment for checking out of the guidance system. The *Atlas* Transporter developed by **Goodyear Aircraft Corporation** is an additional example of the influence the missile characteristics had on the handling equipment.

Support equipment is also influenced by training requirements and use. Experience has shown that equipment often gets its heaviest use in training and not in operation. Therefore, life consideration should be based in part on training. Also, the configuration of the equipment might well be affected by training requirements. The packaging concept would receive greater emphasis in cases where training could not be conducted at the same site as tactical operations, for instance, a case in which troops and equipment had to leave some heavily populated area and train at an established or designated missile range.

Costs naturally are a major factor in designing MSE; one way of reducing them is through mass production techniques. These techniques are difficult to realize in a field where quantity requirements for specific items are relatively low; nonetheless, they are goals to strive for.

One way to progress here is development of custom equipment by use of standardized (off shelf) components packaged into sub-packages.

The most notable illustration of this concept is the automobile industry, where the basic automobile is produced in several series such as standard, deluxe and custom, but all are variations of the same basic product.

But what about the size of the coming rockets? Will this not defeat the trend toward packaging? The answer rests in the fact that the limiting factor in moving to larger and larger items has been the "state of the art." As the "state of the art" moves forward so does the capability of performing with larger equipments.

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Automatic Test Equipment Solves Logistic Nightmare

With a potential market of nearly one-half billion dollars, this facet of support equipment has an assured future . . .

by George A. Peck

ROCHESTER, N.Y.—Out of the military requirements of the missile industry has grown a new product with a tremendous future—Universal Automatic Test Equipment. In an industry growing like Topsy, its early evolution was predestined as the only solution to a profusion of complex and sensitive test devices.

Due to the multitude of missile and aircraft weapon systems, the variety and form of specialized test equipment has become a logistic nightmare. Add to this the continuing need for highly skilled technicians to maintain this gear, hindered by a rapid turnover rate in the Armed Forces, and you have an economic problem of vast proportions.

Over $1.5 billion of defense money will be spent on ground support equipment for missiles and aircraft in fiscal 1960. Of this amount, from 10% to 30% of every program will be spent on electronic MSE, creating a potential market of $150 million to $450 million for this type of equipment.

The military thus faces the continuing need to initiate economies by (1) simplifying logistics, (2) reducing the necessary skill levels, (3) reducing the sheer numbers of operators, and (4) increasing reliability.

The most logical answer to this problem is standardized test equipment, automatically self-checking with built-in fault location capabilities, and flexible enough to be adapted with a minimum amount of engineering development to any existing or projected weapon systems. The logic behind this concept is readily apparent:

• **Standardized test equipment** is necessary to reduce the logistics problem of replacement parts supply. A reduction in the variety of such gear also simplifies the task of training operators. Besides, the flexibility gained cuts the engineering costs for new weapon systems and permits faster delivery of operational equipment.

• **Automation** allows for greater speed of checkout. In one typical operation a 12-hour manual testing procedure was reduced to less than 5 minutes by automatic means—a reduction ratio of 150 to 1 in operational time. An additional advantage exists in that machines do not become fatigued, bored, or try to cut corners. Therefore, testing reliability is greatly enhanced.

• **Self-checking** of the equipment assures (1) that these checks will be made and (2) that no testing time will be wasted by the use of a faulty tester. This increases reliability and establishes a higher confidence level in systems marked for operational use.

• **Fault location** techniques built into the tester lower the skill levels necessary for maintenance technicians. The capability may be utilized to troubleshoot both the tester and the system under test or either one, depending upon the system complexity.

• **Flexibility,** as used here, depends upon the amount of standardization feasible. Considering a basic controller-programmer as the truly universal test system, flexibility means that by the addition of adaptor modules providing unique stimuli to the systems under test, the basic unit might be used for testing a wide variety of weapon systems. Thus, by merely changing tape programs and switching adaptor modules a number of systems may be checked out by the same basic unit at the same location.

• **Configurations**—There are many forms which automatic test equipment may take, but the most logical of these is the modular, or "building-block," form. The major advantage of this configuration is potential growth capacity. By simply adding drawers of circuitry, capabilities can be extended to provide for greater needs in data handling and to include tests completely new in nature.

The basic comparator-programmer circuits may be standardized to the point where libraries of such elementary designs are established. Mounting these circuits on standard-sized printed

About the Author

George A. Peck is vice president and general manager of the Electronics Division of the Stromberg-Carlson Division of General Dynamics Corporation.

He was graduated from Clarkson College of Technology with a BS in Chemical Engineering in 1937. He joined Stromberg-Carlson in 1942 as engineer-in-charge of the Materials Laboratory. For a short time in 1951, he was on leave from Stromberg-Carlson, serving as vice president in Charge of Manufacturing of Standard Cable Corporation, Chickasha, Oklahoma. He returned to Stromberg-Carlson as production manager of the Radio-Television Division, and continued in that capacity until August, 1955, when he was appointed vice president—manufacturing. In January, 1957, he was advanced to his present position.

circuit cards will provide rapid replacement parts which may easily be reduced in value to the class of "throw-away" items.

The use of completely solid-state, transistorized circuitry provides greater ease of packaging, better accessibility for maintenance, and smaller size and weight. The use of semiconductors also increases reliability and the ability to withstand changing environmental conditions.

Miniaturization to micromodules or the use of cryogenics is probably not necessary and far too expensive in the present state-of-the-art. Besides, these techniques will not as yet meet military specifications.

Standard programming codes are being devised which are compatible with the variety of available read-in and read-out methods in use today. These codes are adaptable to fast, simple preparation techniques by technicians of low skill levels.

• **Environmental conditions**—The physical configuration and complexity of automatic test equipment today is largely determined by where it is used. For instance, use on the flight line calls for mobile, van-mounted gear; fixing pads require operations—center blockhouses; depots need bench-mounted racks; and factories call for production line settings.

In the near future, the intermediate echelons will develop a need for integrated and highly mobilized units for field usage. These will take the shape of trailers and smaller, self-propelled vans. Whatever the use, flexibility in packaging to meet a variety of environmental and operational conditions is a prime requirement.

Test equipment built in the past has had to comply to such specifications as MIL-T-945A, Mil-T-5148B and, currently, to the more stringent Mil-T-21200. These are still rigid enough to assure capability of the equipment during nuclear attack. However, there are few, if any, automatic test equipment units in the field today which meet fully the environmental requirements of these specifications. More work is certainly necessary along these lines.

• **Current problem areas**—The most pressing problem of automatic test equipment design, paradoxically, is not concerned with the tester itself, but with the system it must test. Very often, weapon systems are designed and built before any thought has been given to testing them, so that adequate test points are totally lacking. Waiting until the last minute to procure test equipment then calls for a crash program to make the system operational.

The necessity for proper test points usually calls for system modifications, which not only slows down the program, but also often has a degrading effect on performance. Then too, limited design time on the tester necessarily deters those engineers from putting forth their best possible efforts. The biggest penalty paid, however, is the lost chance to design fault isolation techniques into the integrated system and, thus, the need for much more exotic adaptor modules to achieve this capability.

The available test point situation is not quite as bad with newer equipments as with the old. System designers are now aware of the problem and are changing their philosophy, but old equipment in use is virtually inaccessible by automatic methods.

Adaptor design is also becoming more sophisticated as military demands for standardization are now being extended to this area. One of the prime requirements today is for a universal programmable stimulus generator.

At first glance, it would seem rather ridiculous even to attempt to build a generator ranging across the spectrum from DC to cosmic frequencies. Upon investigation, however, it becomes apparent that each requirement actually calls for a fairly narrow range of frequencies.

Therefore, what the Military really seeks is a family of such programmable stimulus generators, each member representing a small segment of the spectrum, programmable to a series of specific frequencies. Even these aren't devised overnight, but work is presently well along in providing these production-unit adaptor modules.

Never absent are the problems of time and money. Research and development absorb huge quantities of both, but are of prime necessity. However, the pressures of military needs and competitive advantages sometimes stifle the use of advanced techniques throughout the industry. The limited use of existing, highly reliable, solid-state test equipment at present is a good example.

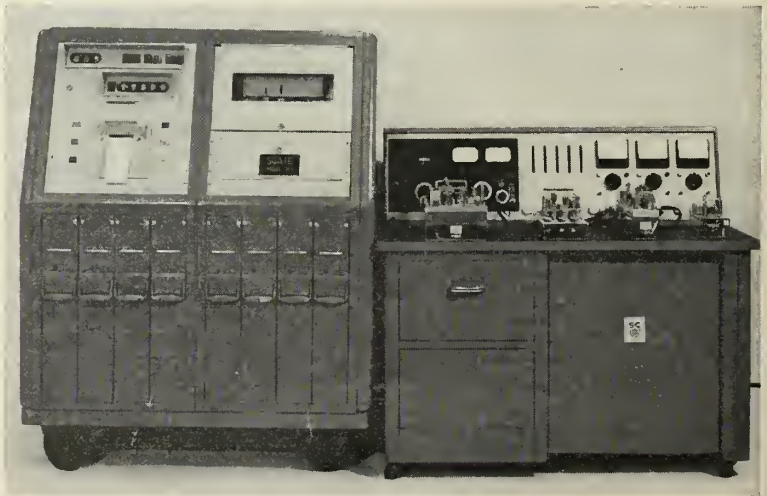
• **Limitations**—The potential of automatic test equipment is practically limitless. However, there is always the question of when it is *feasible* to use automatic test equipment. It is then a question of economic limitations, not engineering limitations.

Thus, the restrictions are basically those of time and money. Automatic test equipment must be utilized for checking out complete systems if it is to be used economically. Even depot use doesn't pay unless the system is extremely complex or testing encompasses production quantities.

Modification of the unit under test

Stromberg-Carlson's SCATE

TYPICAL OF many existing advanced automatic checkout systems is Stromberg-Carlson's SCATE. It is completely solid-state and modularly constructed for flexibility in adaptation. Stromberg-Carlson recently received a $500,000 contract extension from Bell Telephone Laboratories to adapt SCATE for testing the complex *Nike-Zeus* guidance system.



is not a limitation except to the extent that this would affect the adaptor modules. Punched tape permits easy revision of the prescribed limits and test procedures. Magnetic tape poses somewhat more of a problem, due to bit density, but is still not a major difficulty.

Operational speed sometimes presents a problem. The biggest limiting factor of speed is the operation sequence of the unit under test. Read-in and read-out modules often are not compatible, but faster methods are currently available at the cost of further system sophistication.

Physical problems limiting operation speed are largely those of switching techniques. Besides the sheer bulk of numbers of test points which often must be monitored, some type of electromechanical switching is currently the basic method used. This means is much too slow and inefficient.

In the more advanced forms of automatic test equipment, this has been replaced by a transistorized, solid-state switching matrix. Further research and development is also being carried on along these lines to offer a more complete solution.

• **The cost picture**—The price of automatic test equipment at first glance appears expensive. Spending $75,000 to $100,000 for a basic unit and another $50,000 to $200,000 for the appropriate adaptors uses up a million-dollar procurement budget fairly fast. However, the four or five test systems this will provide not only solve more than their share of problems faster, but will also be available as basic units for the next test system requirement that weapon developments bring.

Thus, the universality of the equipment spreads depreciation over a longer period. In essence then, to the savings in time, training, manpower and reliability, we also may add the savings of continued value through adaptability. Because of its flexible design, obsolescence losses may be diminished by the simple replacement of redesigned modules.

A trend is developing for the use of automatic test equipment in other industries besides missiles and aircraft MSE. Such areas as communications systems, data handling networks and ground radar station centers are proving to be fertile markets. Thus, as production of the basic units increases, the cost will logically be decreased.

Price of the adaptors will not be reduced as much, due to the higher design costs, but will decline somewhat as a library of more standardized and programmable adaptor modules is accumulated. Any integration into the test system of special-purpose computer capabilities or other such sophistications necessarily will add to cost.

• **Future outlook**—The future sales outlook for the automatic test equipment industry is excellent. As we move toward manned space-flight, systems become more and more complex. Advanced communications systems, navigation aids and flight simulators and controllers are coming off the drawing boards at a fantastic rate.

Networks of these systems will not be able to tolerate down-time. Constant monitoring and standby equipment is a basic necessity. Alarm systems to switch in standby gear and trigger off fault isolation subroutines in the permanent monitors will be required to assure rapid replacement of faulty components. Life and failure prediction techniques will have to be built into the periodic maintenance tests to monitor system degradation. All this will require millions of dollars of automatic test equipment.

The major challenges facing the industry are basically those of development. A listing of the more important factors poses an ambitious program for producers' consideration:

• The test philosophy must be instilled in systems designers who may then build equipment *capable* of being universally and automatically tested.

• The test philosophy must also be integrated into the Armed Forces logistics system to reduce down-time by assuring supply of replacement components.

• Less expensive basic tester units must be built which are still adaptable to changing requirements and have a potential for growth as systems needs expand.

• The use of fault-isolation techniques should be increased. This reduces the need for trained technicians. However, it should only modify the complexity of the equipment to the point where service technicians may begin manual testing at a function or on a module.

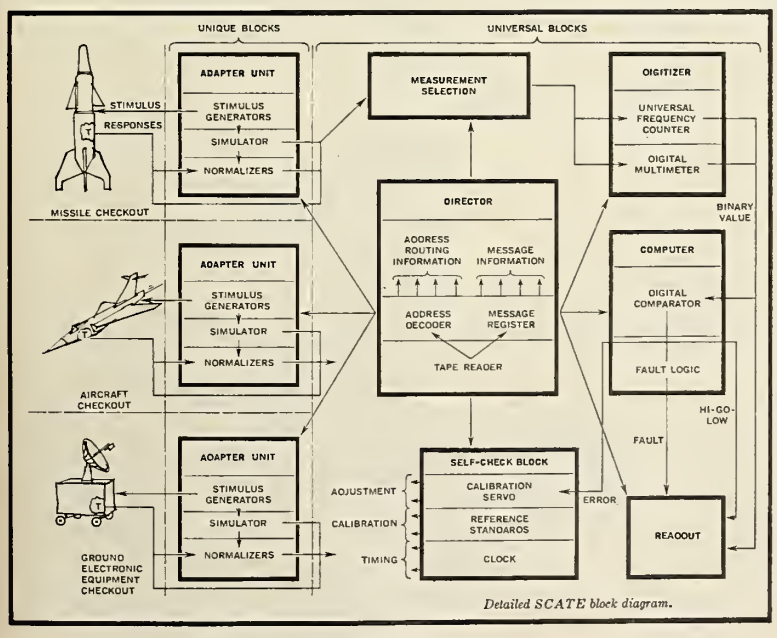
• More universal programmable-type adaptors should be designed.

• Test equipment should be made more flexible and reliable. Sophistication and complexity leads to less flexibility and less reliability.

None of this may be accomplished adequately without primary definition of systems needs by the Armed Forces. Through the cooperation and suggestions of the industry, a well integrated plan of specifications can be written to determine the best possible solution to this problem. Without such coordination, only the chaos of a multitude of specialized equipments can result, causing inefficiency and extraneous expense.

A problem exists and a solution is readily available. Although automatic test equipment is beset by minor difficulties and limitations, these are far outweighed by the advantages of economy of men, money and time which it offers.

The future is bright. Automatic test equipment is the only rational answer to current systems' complexity and future designs hold forth only more complexity. The market for this new universal product is thus assured.



Detailed SCATE block diagram.

SAGE Guides Interceptor Missiles

Here is an exclusive account of a single computer's role in replacing manual ground control to meet a hypothetical air attack

by Lawrence R. Jeffery

LEXINGTON, MASS.—SAGE's basic mission was to provide a centralized, complete, and timely picture of the air situation over a large area. This mission has grown as the reach of our missiles and manned interceptors has outstripped the range of a manual Ground-Controlled Intercept site using a single radar set.

To improve substantially the GCI radar coverage would require an enormous increase in its transmitted power, and the long-range radar returns would be limited by the earth's curvature to high-altitude aircraft. SAGE (Semi-automatic Ground Environment) sidesteps these limitations by using a digital computer (the AN/FSQ-7) to combine data from widely separated radars and construct a composite situation display, as a large map is produced by piecing aerial photos together.

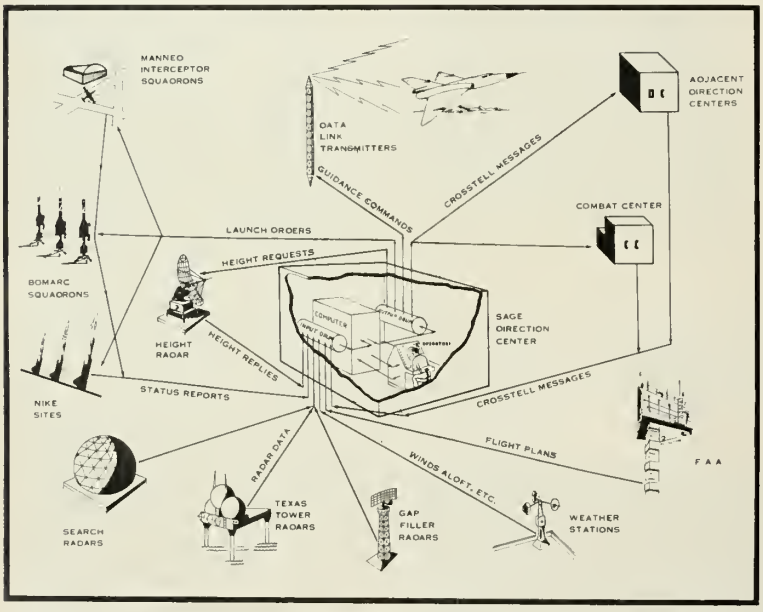
A network of SAGE direction centers (DC's) using these computers is spreading rapidly across the country. Each computer communicates automatically with dozens of external sources such as radars, missile and manned interceptor bases, radio sites, and weather stations. Computers in adjacent DC's communicate directly with each other and with those at higher headquarters.

Nearly all SAGE data processing is done by the computer, setting human operators free to make the important decisions and cutting detailed operator coordination to a minimum. To follow the operators' instructions, the computer senses the settings of up to 5000 console switches every 2.5 seconds. To portray the air situation, it generates about 200 different types of displays requiring 20,000 characters, 18,000 points, and 5000 lines.

As the nature of the air threat and our defense weapons provided against it have changed, SAGE has been required to accept greater responsibility. The computer, too, is handling tasks far beyond its original assignment.

• **Alerting the system**—We can see the system components at work by following a hypothetical *Bomarc* interception. Let's begin by supposing that the early-warning network has reported many heavy penetrations by unidentified aircraft and CINCNORAD has alerted all air defense units.

At McGuire Air Force Base, in the big windowless concrete cube housing the SAGE DC for the New York Air Defense Sector, maintenance crews are tuning up the standby computer. They replace any of its 20,000 tubes which do not pass margin tests, for this machine must be ready to take over if the operational AN/FSQ-7 breaks down. The senior director, responsible for the center's operation, has ordered

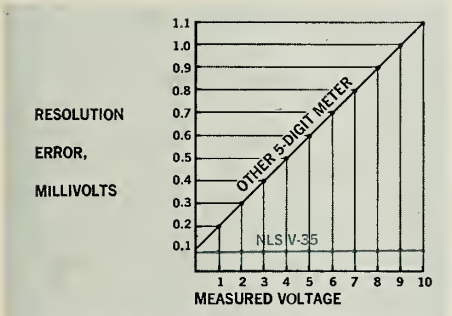


DIRECTION center communicates automatically with external sites by using digitally-coded data on voice-band-width circuits. The computer is coupled to computers of nearby centers and directly connected to console displays in its own center.

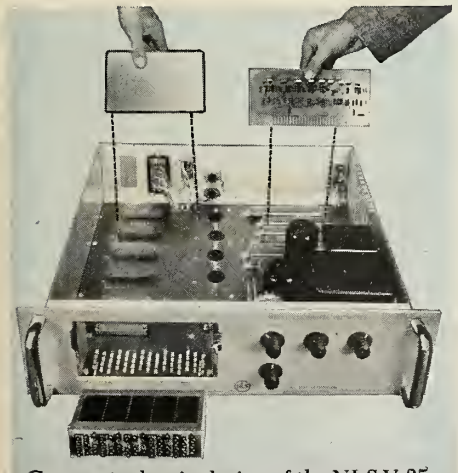
About the Author

Lawrence R. Jeffery is associate head of the Design Department of the recently-formed MITRE Corporation at Lexington, Mass. He has been engaged in design and development work on the SAGE system since 1954 when he obtained a staff appointment at MIT's Lincoln Laboratory. He earlier worked on computer design at Raytheon and for several years taught mathematics and television engineering in Chicago. He received his M.S. in mathematics from the University of Chicago in 1953.

FIRST DIGITAL VOLTMETER WITH THE FACTUAL FIFTH FIGURE



This chart shows the significant resolution error that results in other five-digit meters as compared to the NLS V-35 with the *factual fifth figure.*



Compact, plug-in design of the NLS V-35

The All-Transistorized NLS V-35

Here for the first time is a *true* five-digit voltmeter with a factual fifth figure. Increased accuracy of *full* five-digit resolution — 0.001% — results from the new mathematically perfect logic of the NLS V-35.

Other five-digit digital voltmeters require "desensitizing" to prevent oscillation of the least significant digit. This results in a resolution error of three to nine digits in the upper portions of each range as graphically displayed in the chart to the left. This comparison clearly shows the increased accuracy of the NLS V-35, made possible by full five-digit resolution.

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NLS V-35 Specifications

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operators to their consoles, where the air picture will be displayed and their various actions taken. Following the orders of the sector commander, the senior director has taken the "wartime" switch action on his console, telling the computer that nuclear weapons may be fired. His area of responsibility extends from the Boston Sector on the north to the Ft. Lee Sector on the south and from the Syracuse Sector on the west out to sea as far as his radars can search.

Next to the Syracuse DC is the 26th Air Division Combat Center, having command responsibility over the Boston, New York and Syracuse sectors. The combat center also contains a digital computer (the AN/FSQ-8), which maintains direct, automatic communications with the subordinate direction centers.

• **Tracking the target**—Many hostile aircraft are soon pouring into the East Coast sectors. We will follow one —let's call it Raid Able—as it penetrates the New York Sector and is engaged. Raid Able, we will suppose, has just entered the coverage of the heavy radar on Montauk Point, Long Island, on a course slightly north of west.

The AN/FST-2 data processor at the site converts the radar echoes from Raid Able into a digital message specifying the range, azimuth, and time of the report. Less than a second after the observation, the message is transmitted to the DC. There, the coded return is automatically recorded on a magnetic input drum, which acts as a kind of reservoir for data from all of the Sector's radar sites. The drum stores the data until the computer is ready to use it.

At the proper points in its operating cycle (called a frame), the computer transfers the input data from the drum into its 65,000-register ferrite core memory, clearing the drum so it can be filled with more input data.

The computer then goes about its other jobs. First it converts the new radar data from the ρ, θ form in which it was received into the sector's common x,y coordinate system. Each aircraft track carried by the system is then extrapolated ahead and its position compared with the positions of the new returns. Where a return is sufficiently close to a track, the computer labels it as "correlated" with the track, and will later use it to correct the track's position and velocity.

Since our Raid Able is just entering the system, its returns do not correspond to any of the tracks carried by the computer. Such "uncorrelated" data is saved for use in an automatic track initiation process. The computer also presents these uncorrelated returns on the situation displays (a 19" Charactron cathode ray tube developed by **Stromberg-Carlson**) of the track initiator and track monitor consoles for possible manual action.

Nothing further will happen to Raid Able for about 15 seconds, until the Montauk radar has again swept the eastern sky. In the meantime, the computer:

(1) Updates the positions of all established tracks;

(2) Identifies newly established tracks;

(3) Receives and decodes automatic input messages from *Bomarc*, *Nike*, and manned-interceptors bases, adjacent direction centers, the Syracuse Combat Center, weather stations, and height finders;

(4) Updates its weapon availability tables;

(5) Makes new data entries in its table of winds aloft;

(6) Selects weapons for use against unpaired hostiles and transmits launch orders;

(7) Makes guidance computations for airborne weapons;

(8) Prepares and transmits data-link messages to weapons;

(9) Prepares and transmits weapon and target data of interest to adjacent direction centers and the combat centers;

(10) Transfers air situation and status information to "safe-data storage" in the standby computer;

(11) Prepares air situation and tabular information displays for the more than 100 operator consoles in the surveillance, identification and weapons rooms;

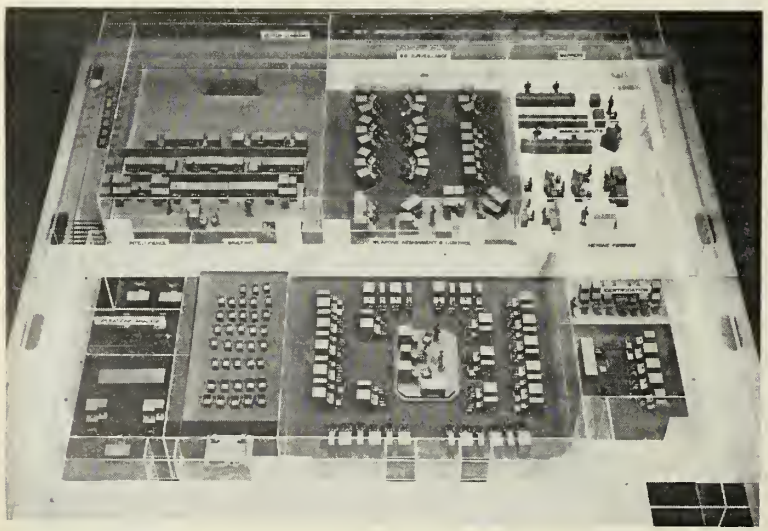
(12) Reads, interprets, and acts upon the console switch actions taken by the operators.

As with any digital computer, the SAGE machine carries out these tasks in accordance with a sequence of instructions (called the program) prepared and stored in the computer's memory perhaps many months earlier. Although each step, or "instruction," accomplishes only one simple arithmetic or logical transaction, very complex processes can be carried out by suitable sequences of those basic operations. The computer's enormous capacity results from its ability to perform more than 100,000 such operations every second.

The next two scans of the Montauk radar bring in still more data on Raid Able—data so spaced in distance and time that the computer, by means of the automatic initiation logic in its program, will recognize these uncorrelated returns as a new track. A position and a velocity are next computed, and Raid Able is entered in the machine's track table as:

Track number B207
Speed ..... 480 Knots
Course ..... 285°
Altitude ..... Unknown
Flight-size ..... Unknown
Identity ..... Pending

Now that Raid Able is an established track, the tracking program will



FOURTH FLOOR of the direction center contains separate operational rooms for air surveillance, identification, weapons assignment and control, and command functions. Altogether there are more than 100 operational positions.

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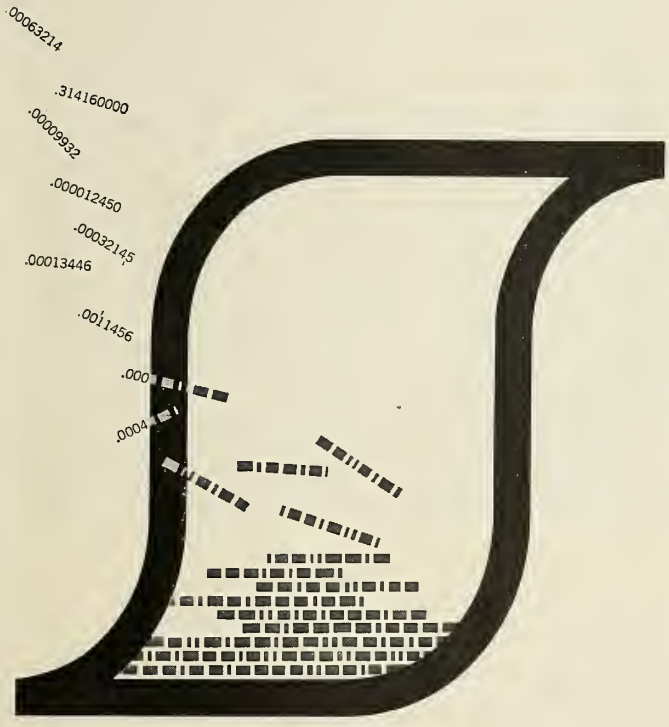

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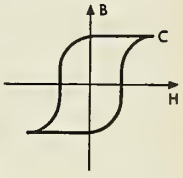

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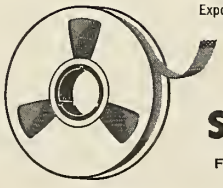

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periodically attempt to correlate with it any new radar data near it. When a return is found sufficiently close to B207's predicted location, it will be used to correct the track's position and velocity.

Since B207 is a new track, the computer places it near the top of the "height priority" table and soon sends a height request message to one of the semi-automatic height finders (AN/FPS-6) at Montauk. The message causes the height finder to slew automatically to the proper azimuth. The operator measures the target's elevation angle and presses a button to send this data back over the phone line to the SAGE computer. The reply reads:

Track B207
Altitude 43,000
Flight Size 1

• **Identifying the target**—While Raid Able's height and flight size are being determined, the computer adds track B207 to the situation displays in the air surveillance room. In the identification room, the track is displayed with a special attention device, and an audible alarm is sounded in the identification officer's (IDO's) console. The computer also displays to the IDO the positions of nearby commercial flight plans. Since these do not appear to correlate with the track, and since we are already under attack, the IDO presses the follow buttons:

B207
Identify
Hostile
Activate

The activate button tells the computer to read the console's switches. In the computer's memory and on the situation displays throughout the DC, the identity of track B207 is changed to H, for hostile. Now the weapons room enters the air defense picture, and increased activity is focused on track B207.

• **Committing a *Bomarc***—On a dais in the weapons room, next to the senior director, sits the senior weapons director, in charge of all activities in the room. Surrounding the dais are four teams, each headed by a weapons director responsible for committing weapons to targets.

After a weapons director has committed a weapon, the subsequent interception is monitored by one of the five intercept directors on his team. Each officer in the room uses a situation display console, and has an enlisted technician to assist him.

The time soon comes, in the computer's frame, when it must spend a half second or so on the selection of new weapons. It cycles through the list of "hostile" tracks, comparing the number and capabilities of the weapons committed against a track with a standard previously specified by the senior weapons director. When it comes upon any hostile not adequately covered, the computer removes it from the table and acts on it. Track B207 will be one of these.

To select a weapon (or weapons) for use against B207, the program examines each of the sources. The F-106 squadron at Suffolk is the first to be considered. The squadron data table indicates that five aircraft are available on five-minute alert and that the standard armament load for the day is GAR-3 and GAR-4 missiles.

A final-turn tactic is chosen, with combat speed and other tactical parameters appropriate to that armament combination for the speed and altitude of this particular target.

Similarly, the computer picks out an interceptor flight profile (cruise speed and altitude, etc.) to match the geometry of the problem. Next the machine predicts the location of the intercept point and calculates the time-to-go to intercept. This turns out to be twelve mintues.

Finally it determines that this interceptor will require 5400 pounds of fuel to climb to altitude, cruise out, accelerate to combat speed, make the intercept, and return to base. More than this amount of fuel is on board, so the intercept is within range. The Suffolk squadron is therefore listed as a possible weapon source against B207, with a time-to-go of twelve minutes.

Similar computations are performed for the other four interceptor squadrons accessible to the New York SAGE sector and the *Bomarc* squadrons at Otis, Suffolk, and McGuire. The availability status of *Nike* batteries in the Boston and New York AA defense complexes are also checked, and earliest intercept points are predicted. A seven-minute time-to-go is shown by the Suffolk *Bomarcs*, and this is substantially shorter than can be obtained against this target with any of the other weapon sources. The computer therefore selects (still tentatively) the Suffolk *Bomarcs* for use against track B207. This entire selection process, including all of the computations for all the weapon sources, occupies the machine for less than one-twentieth of a second.

Based upon the location of track B207, the computer selects weapons director No. 2 to be responsible for it, and notifies him with an attention display. The display also indicates the computer's recommended course of action (i.e., fire a *Bomarc* from Suffolk) and the predicted intercept point corresponding to that choice.

The WD indicates his concurrence by pressing a button on his console (if he did not agree, he could choose an alternate weapon source). Within a few seconds, the computer transmits a "fire" message to launcher No. 31 at the Suffolk *Bomarc* squadron. Seconds later, the booster ignites and the missile rises from the launcher. When it reaches altitude the *Bomarc* levels off and cruises under the power of its ramjets.

An automatic message flashes from the launcher to tell the SAGE computer the *Bomarc* is airborne. The computer assigns track number AB15 to the missile. By this time it also has selected one of the WD's five intercept directors to assume responsibility for the mission.

The selected intercept director's situation display shows the locations of Hostile B207 and Missile AB15 and the predicted intercept point. Both the missile and the target are now being tracked and a series of guidance computations will steer the missile and periodically up-date the predicted intercept point.

• **Guiding the missile**—The guidance computations take into account the target's position, speed, heading and altitude, the missile's position, altitude and speed, and the velocity of the wind (weather data in its memory). From these inputs it computes:

(1) Missile mid-course heading
(2) Missile attack heading
(3) Time-to-go
(4) Seeker azimuth orientation
(5) Seeker elevation orientation
(6) Location of intercept point.

When the computer notices that target speed, heading, or altitude has changed significantly, the computations are repeated. It takes about one-fiftieth of a second to perform them once.

The computer then codes necessary command information into the proper format for transmission. It also must consider the location of the missile in relation to all of the data link transmitter sites in the sector and select the site from which the missile will receive the strongest signal. A digital address for the selected site and the address of the missile (AB15) are added to the message, which is then recorded on the computer's output drum.

Like the magnetic input drum, the output drum acts as a kind of reservoir, but in reverse. The computer fills it up quickly with outgoing messages such as the data-link commands for all weap-

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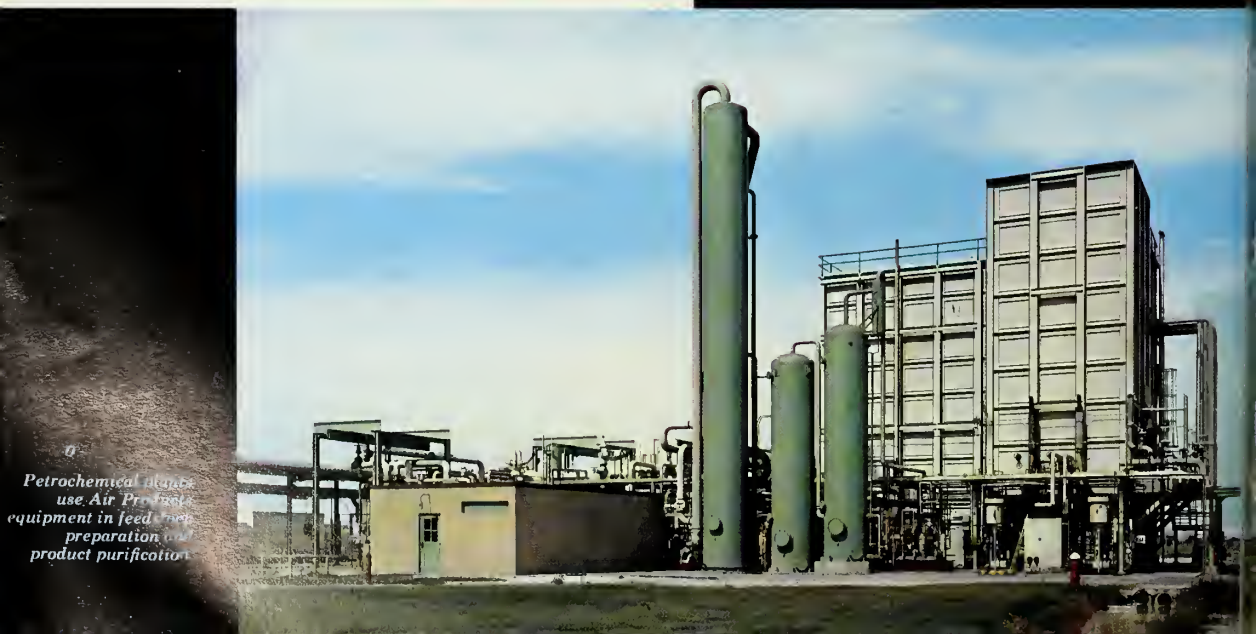

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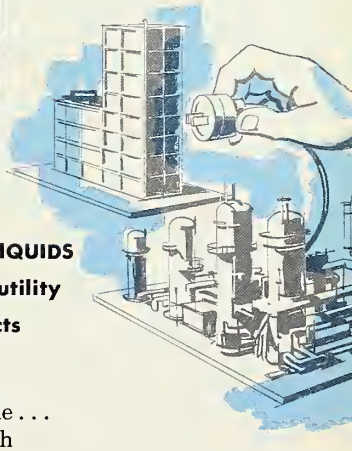

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ons. Then, while the computer is doing other jobs, the drum "slowly" doles out its data to the phone lines. It will be empty by the time the computer has more information to record on it.

When the message for AB15 is placed on the phone line to the data-link network, the appropriate data-link site recognized the address, accepts, and radiates the message in a fraction of a second. AB15 receives the message and makes the necessary adjustments in its course.

• **Handover**—When time-to-go is down to about four minutes, the course of track B207 shifts still more to the north, and the predicted intercept point drifts across the sector boundary. Raid Able is apparently headed for Boston, and his present course will soon carry him into the Boston Sector.

Accordingly, the New York computer places a special symbol about this track's display, alerting operating personnel that it is about to be transferred, and sends a "crosstell" message to the Boston computer, giving data about the track and the missile paired with it.

Boston almost immediately begins tracking the target with data from its own radars and notifies New York that the transfer has been made. Missile AB15 is still in the New York Sector, where it is being tracked and guided.

As Missile AB15 nears the border, the controlling intercept director is alerted and the New York computer dispatches a crosstell message containing the missile's position, speed, heading, altitude, fuel remaining, and tactical parameters. Boston's computer selects an intercept director to monitor the rest of the mission.

New York drops out of the picture by transmitting a final data-link message to *Bomarc* AB15, commanding it to re-tune its data-link receiver to the frequency of the Boston network.

Boston now has complete responsibility for guiding the missile to its interception point. It tracks, computes the intercept, and transmits guidance commands. When the missile's seeker is activated, the missile turns to its attack heading. AB15 is now a few miles from the hostile, a few thousand feet above it, and on a collision course.

The radar seeker is aimed directly at the target and scanning. When the seeker locks on, the missile dives, and its proximity fuse detonates the warhead at its closest approach to target.

The stoppage of radar and beacon returns from the target and missile tells the Boston computer that the mission is accomplished. On the machine's recommendation, an operator in the Air Surveillance Room takes a switch action to erase AB15 and B207 from the computer's active memory.

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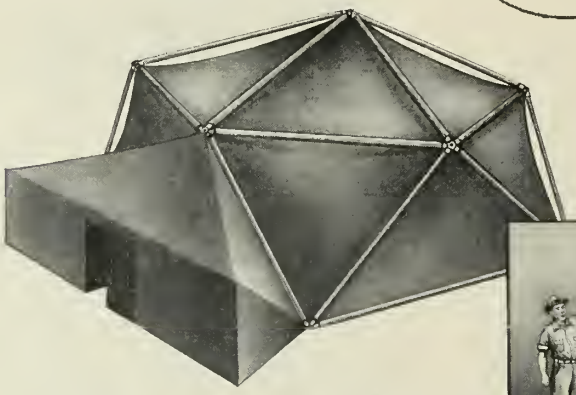

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BMEWS—A Billion-Dollar Investment To Fulfill One Objective

America's electronics giants unite to give us 15-minute advance warning of ICBM attack

by Charles D. LaFond

MOORESTOWN, N.J.—The Ballistic Missile Early Warning System (BMEWS) is a billion-dollar product of an evolution of national defense weapon systems. The concept is an accumulation of new ideas fostered by a need for protection against modern weapons —weapons which have surpassed available defensive hardware and destroyed our former complacency. An unusual part of the evolution is its very brief time span.

Early in 1958 the Air Force announced that the **Radio Corporation of America** has been designated as prime contractor for the design and construction of the BMEW system. Because of the rapid development of ICBM's, it had become necessary to construct a high-powered, long-range radar system having a series of forward sites at northern locations to detect any enemy missiles that might be launched toward the United States or Canada.

A polar projection immediately reveals why the forward sites had to be located in northern regions; the shortest missile trajectories from the USSR to the United States are across the polar area. Typical approximate distances to principal U.S. cities include 3000 miles to Los Angeles from Siberia, 4000 miles to Chicago from Siberia, and 4500 miles to New York City from northwest Russia. All of these distances are well within the range limits of present ICBM's.

Early plans for the system called for three high-powered radar stations in northern latitudes plus a central computer and display facility in the continental United States. The latter was located at the North American Air Defense Command at Colorado Springs.

Two sites have been definitely established; Clear, Alaska, and Thule, Greenland. The third site reportedly will be established somewhere in Scotland (this final selection is currently under negotiation with the British, following the survey of eleven potential sites).

FIG. 1—Artist's conception of a typical BMEWS site layout. The huge plastic sphere surrounding the tracking radar when mounted on the radar building will tower to the height of a 15-story office building.

BMEWS has one primary objective: to provide at least a 15-minute warning following the detection of a mass ICBM attack. This warning will alert military forces and furnish information to civil defense agencies. Thus it complements the DEW Line, which is designed to detect aircraft and air breathing missiles.

Tentatively, an $822.7-million ceiling has been set by the Secretary of Defense for BMEWS implementation. This includes Sites 1 and 2 and the U.S. control facility. An additional $98 million (estimated) will be needed to

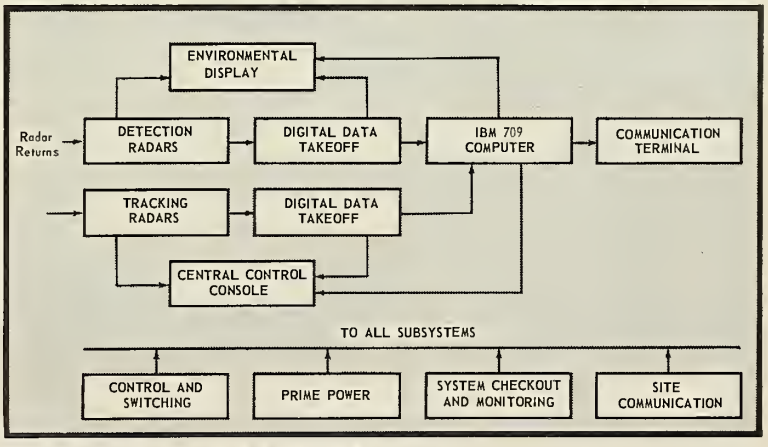


FIG. 2—Major elements of the BMEWS system.

complete Site 3. Because of the joint utilization of this site (Scotland), the British will probably contribute an estimated $21.7 million of the total required.

An estimated $91 million of the total above will be utilized for rearward communication facilities from Sites 1 and 2.

The original letter contract award to RCA was for $200.1 million. **Western Electric Company,** under separate Air Force contract, received $30.8 million as prime contractor for rearward communications. It has been estimated that up to the initial operating date of the system, RCA will have been awarded a total of $440 million and WECO a total of $85.7 million.

In developing BMEWS, RCA is supported by several major subcontractors, including the **General Electric Company, Sylvania Electric Products,** and the **Goodyear Aircraft Corporation.** Construction will be accomplished by U.S. Army Corps of Engineers.

Such a combination of talents and facilities indicates the complexity of the system as well as the typical teamwork that exists within American industry on defense contracts.

The BMEWS system will be linked with the Command Headquarters at Colorado Springs through a communications network being constructed under a separate contract by WECO.

• **Evolution of complex systems**—H. W. Phillips, RCA manager of BMEWS Operations Administration, has stated that approximately 80% of the products and services furnished to present-day weapon systems by the electronics industry were not available as recently as 10 years ago. This is not surprising, he said, when we consider the evolution of the weapon system concept itself and the rapid development of new electronic and mechanical components.

Only since the early days of World War II have we seen the results of advanced development and application of such techniques and equipments as jet propulsion, nuclear and thermonuclear weapons, atomic power, missiles, satellites and similar advanced systems.

During World War I, weapon systems, as we now interpret the term, were unknown. Officers evaluated battle situations and issued orders to men who took action with manual weapons—rifles, bayonets, machine guns, and artillery. As a result, military operations were slow and inefficient by our present standards.

Shortly before and during World War II, techniques and equipment were refined so that effective electronic weapon systems became a reality. The first system of this kind involved anti-aircraft weapons. These were controlled manually or semi-automatically, based on information obtained from sound and optical trackers, search-lights, computers and gun directors. Unfavorable weather seriously hampered operations, however, and searchlights revealed the position of anti-aircraft units.

The development of radar radically changed the system. Detection became possible under all weather conditions and at ranges of several hundred miles. The next step electronically united the radars, computers, and guns for accurate fire control. This, then, was a simple integrated weapon system.

Many other achievements occurred during World War II that led to complex weapon systems: advanced jet aircraft engines were developed; guided missile work began; advanced fire control systems were developed for ground, shipboard, and airborne applications; and nuclear energy was harnessed as a weapon and as a source of power.

Since the end of World War II, some of the greatest advances in the defense program have been accomplished in the electronics field. Radars, computers, and communication equipment have been greatly refined. Transistors, printed circuitry, and microminiature modules have contributed tremendously to our superior electronic equipment. Undoubtedly, said Phillips, the development and application of miniaturized electronic components is helping us to maintain our position as a world leader in perfecting complex weapon systems.

• **Design configuration**—In the final configuration, it is contemplated that BMEWS will feature RCA-designed tracking radars and General Electric detection radars. The detection radars are being developed in conjunction with the Lincoln Laboratory of Massachusetts Institute of Technology and ARDC.

Together, these radars will detect and track an invading missile as it appears above the horizon. With the aid of a high-speed electronic computer and associated equipment being provided under subcontract by Sylvania Electric Products, altitude, speed, and trajectory of the target will be established.

The Goodyear Aircraft Corporation, as one of the three major subcontractors, is responsible for the design and production of the tracking radar antenna pedestal assemblies and the 140′ diameter rigid spherical radomes to protect radars.

Fig. 1 shows a possible layout of a BMEWS site. The sizes involved are impressive. The huge plastic sphere surrounding the tracking radar antenna when mounted on the radar building will tower to the height of a 15-story

PORT OF EMBARKATION

In the decade of missilery ahead, prime contractor capability must go far beyond the requirements of hardware design and manufacture. New experience and facilities are now required in the increasingly critical launching phase—from ground handling and testing to countdown and data control.

Martin's Cocoa Division is the first organization of its kind devoted exclusively to this specialized area. Accomplishments have already established new operational standards at Cape Canaveral, one of the two U.S. ports of embarkation for the major space events of the decade ahead.

An example of the latest development in electronic fail-safe launching equipment is the new Martin Master Operations Control [MOC] system, which automatically monitors count-down procedures in the test firing of research and development-type TITAN missiles. With equipment such as this, TITAN launchings have achieved unheard-of performance reliability.

office building. The detection radar antennas each have more area than a full sized football field. These are stationary —scanning action is accomplished by moving a beam mechanically or electromechanically.

Technically, it is significant that the system required increasing the range capability over the present radars, such as those used on the DEW Line, by a factor of 10 to 1. This could be done theoretically by increasing power by a factor of 10,000, but this is well beyond the feasible economic limits. The second approach was the construction of much larger radar antennas to obtain increased range by concentrating the energy in a narrower and a more efficient beam.

In addition to the necessity for providing longer range so that early detection is possible, it is also necessary to provide frequent coverage of the area being observed so that targets cannot slip through without detection. This is accomplished by developing the best compromise between pulse rate and pulse length.

• **Reliability**—According to R. H. Baker, program reliability manager at RCA, one of the overriding considerations in connection with the design, development and production of BMEWS is the high reliability requirement. In order to afford full protection, it is essential that the system be capable of staying on the air continuously.

The required reliability, said Baker, is being achieved through careful application of thoroughly developed reliability techniques in connection with the development of the system concept, the physical design of the hardware, and the production and installation of the equipment.

• **Operation**—Fig. 2 is a functional chart showing the major elements of the system and their relationship to each other.

The "Data Take Off" provides a fundamental part of the system capability by furnishing preliminary detection information and transforming analog radar returns to digital form. The tracking and detection radars require separate data-take-off equipments because of the differences in the generated signals.

The site computers are known as "track initiation and prediction" computers. Two IBM solid-state digital computers make up this duplex, which is operated on a real time basis (computer operations are concurrent with the events on which information is being generated).

Target trajectories are computed from the digitized target information and the computed trajectories are compared with known courses and charac-

(continued on page 78)


Atlas Beams
U.S. Peace Plea
WASHINGTON, Dec. 19 — The voice of President Eisenhower, broadcasting from the Atlas satellite in space, today was heard in a dramatic Christmas message calling for peace on earth.
As the San Diego-built rocket raced overhead at 17,000 miles an hour the communications system flashed these words:
"This is the President of the United States speaking. Through the marvels of scientific advance, my voice is coming to you from a satellite circling in outer space.
"My message is a simple one. Through this unique means I convey to you and to all mankind America's wish for peace on earth and good will toward men everywhere."
Mr. Eisenhow... plans to transmit ... the Yule... world th... expre... Ch...
field test engineers
If you are a versatile, practical minded engineer with a true flair for excitement, Convair Astronautics would like to discuss with you the opportunities now available at its test bases. There is no sight quite like the mighty ATLAS as it rises majestically into the sky. The dramatic future of test base work will include "space shots" to the moon, orbiting of other planets, as well as the much talked about Mercury "man in space" program.
If you have an engineering degree or a sound engineering background suitable for missile test firing, Convair Astronautics would like to qualify you for one of the specialties listed below:
Mechanical Engineering Pneumatics, hydraulics, propulsion, systems and mechanical ground support equipment.
Electronic Engineering R.F. communications, instrumentation, flight control and guidance systems, airborne telemetry and test equipment.
Most important requirement for these positions is versatility — that blending of education and experience which equips engineers to think in terms of hardware under field conditions. Openings exist at Cape Canaveral, Fla.; Vandenberg AFB, Santa Maria, Calif.; Edwards Rocket Base, Boron, Calif. and Sycamore Canyon, San Diego, Calif.
In New York area call EL 5-7970
Write to Mr. T. W. Wills, Engineering Personnel Administrator, Department 130-90
CONVAIR/ASTRONAUTICS
Convair Division of
GENERAL DYNAMICS
5624 Kearny Villa Road, San Diego, California

mostly for building and support . . .

PMR Plans to Spend $256 Million

The nation's largest missile and space vehicle range includes only base from which polar launches can be made, will be heavily used by services and NASA.

M/R Staff Report

POINT MUGU, CALIF.—Over a quarter of a billion dollars is planned to be spent during the next few years to develop the nation's largest missile and space vehicle range.

And most of this money will be spent for construction and missile support equipment.

The Pacific Missile Range—run by the Navy with the **Bendix Corp.** and the **Texas Transportation Corp.** as prime range contractors—is already the largest range in size (65,000 acres of water and land). Present and future expenditures will give it the most extensive facilities.

PMR is really four ranges:

- The Inland Range—which stretches eastward from Tonopah, Nev. to Dugway Utah, tests short range surface-to-surface missiles;
- The Sea Test Range—extends 500 miles south paralleling the California coast and is used for testing short-range air-to-air and air-to-surface guided missiles and medium-range surface-to-surface missiles;
- The IRBM-ICBM Range—centered at Vandenberg AFB extends thousands of miles over the Pacific, allows long range tests with maximum telemetry and safety;
- The Space Range—at Point Arguello, is the nation's only range having the unique geographical advantage allowing polar orbiting satellites to be fired with complete safety.

PMR presently employs 6500 and has a yearly payroll of $35 million. By the end of FY 1960, over $151 million will have been spent on the base. During the next few years, a total of $256 million will have been spent. The final figure may be in the billions.

Like its sister bases—the Atlantic Missile Range run by the Air Force and White Sands run by the Army—PMR is used by all four services and both space agencies. Base Commander Rear Admiral Monroe has as his Deputy Commanders representatives of the Army, Navy, and Air Force, and soon will have a Director from the National Aeronautics and Space Administration.

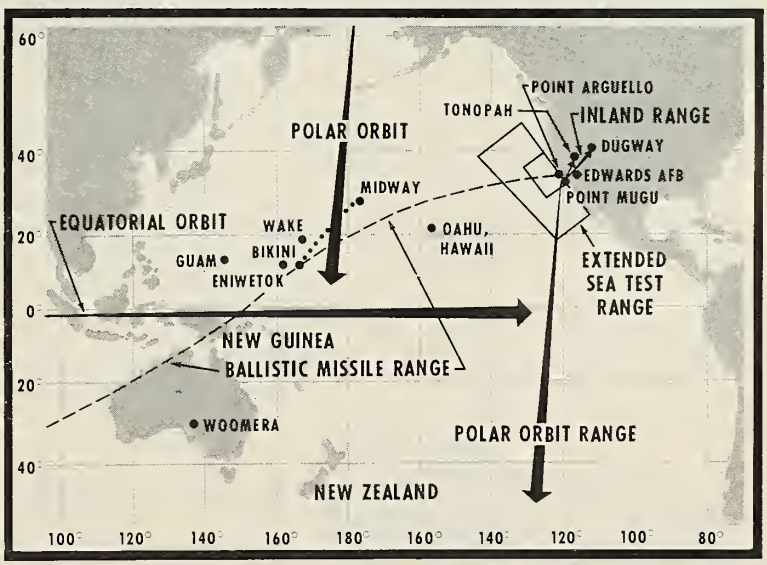
What does PMR intend to spend its quarter of a billion dollars on? The primary market will be for construction. Buildings, fuel storage, high explosive magazines, facilities, frequency control facilities, warehouses, and additions to many existing but inadequate facilities.

Missile support equipment needs range from mobile instrumentation stations, vehicles, and towers, to the various small electronic components that form the guts of any missile test center.

PMR does not duplicate the work of AMR or White Sands. AMR was constructed as a research and development center for long range guided missiles, and White Sands performs the same function for shorter range air-to-air, surface-to-surface and surface-to-air guided missiles.

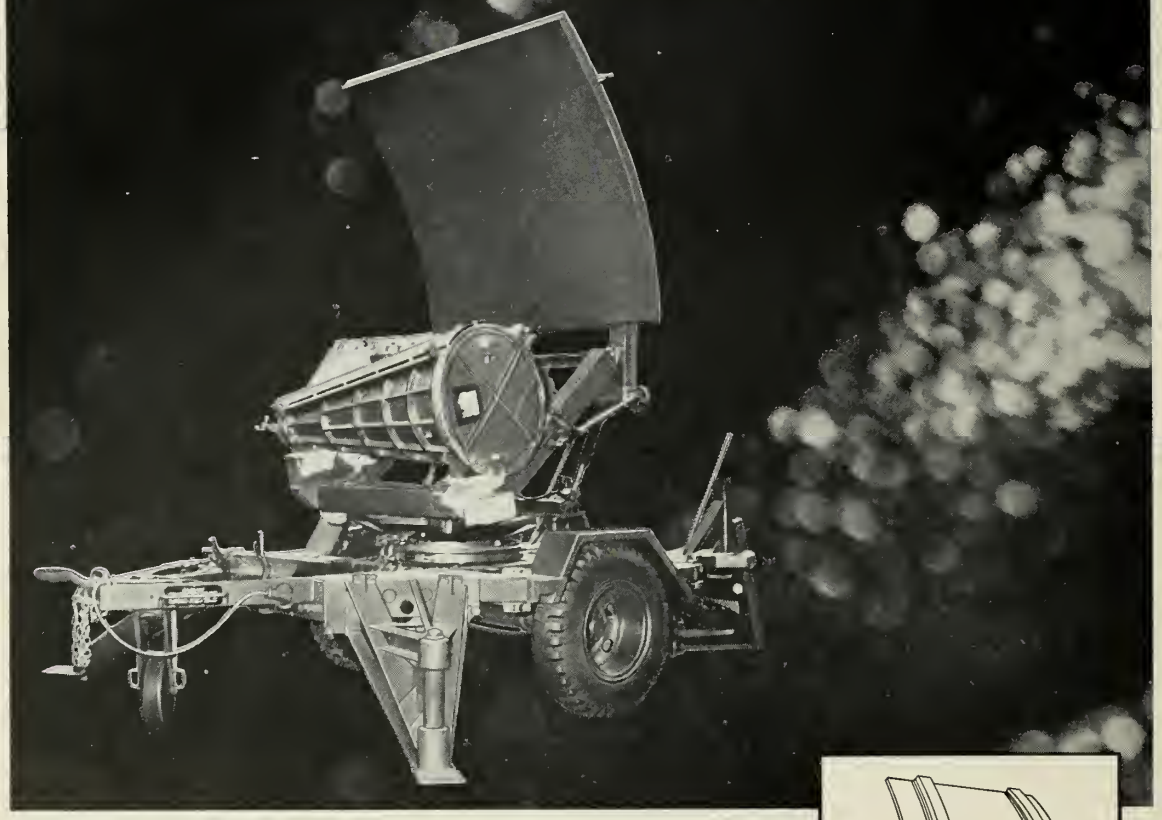
Except for *Polaris* and other Navy missiles, PMR is used for training crews to fire the missiles once they become operational.

The Point Arguello space range, as was explained before, carries out a function that no other launch base can. It is the only base that can put a satellite safely into a polar orbit—there is nothing between Point Arguello and the South Pole except water. This provides an excellent fall-out area for the booster and also a large safety area for destruction of vehicles which do not go into proper orbit.



ACTUALLY four ranges in one, the vast Pacific Missile Range already includes Inland Range in Western U.S., Sea Test Range south from California, IRBM-ICBM Range from Vandenberg AFB west, and Space Range at Point Arguello.

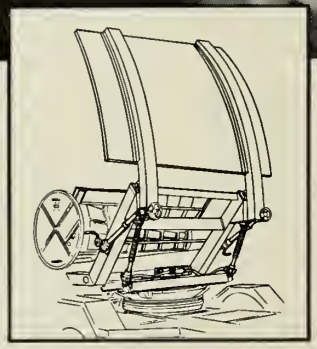
Diversified electromechanical systems capability



AiResearch Actuation Systems For Portable Radar represent a typical electromechanical systems application in ground support equipment. Two types of AiResearch actuation systems are now in production for the Army's mobile trailer-mounted ground radar unit. They consist of a manually operated antenna folding storage system and an electrically powered antenna elevation system.

Designed to operate under the most severe environmental conditions, this type of electromechanical system can operate on 60 cycle A.C., 400 cycle A.C., or 28 volt D.C. Other suggested applications include: *missile launchers, missile ground handling and support equipment, armored vehicle fire control and ballistic handling systems, and mobile communications equipment requiring servoed actuating systems.*

AiResearch leadership in the development and production of electromechanical equipment for aircraft, ground handling, ordnance and missile systems of all types also includes such recent examples as spoiler servo control systems, magnetron and Klystron tuning devices, and safe-arm mechanisms for missile igniting. We invite you to submit a problem statement of your electromechanical requirements.



U.S. Army Signal Corps ground portable radar unit operated with two AiResearch electromechanical actuation systems.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

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Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

Because of its peculiar needs, the Army's *Nike-Zeus* anti-missile missile will be tested at PMR.

PMR grew from the early Navy missile base at Point Mugu which was set up in 1946 to test short range missiles for use with the fleet. Early missiles developed at Mugu were the *Loon* (modified German *VO1*) and the surface-to-surface *Lark*. These missiles were the forerunners of the Navy's air-to-surface *Bullpup*, air-to-air *Sparrow's I* and *III*, and the surface-to-surface *Regulus I*.

The reason that Point Mugu and the surrounding area stretching 90 miles north to Point Arguello was picked to become the largest missile and space vehicle range were: (1) it offered more launching room for long range missiles and could launch satellites into polar orbits; (2) launches could be conducted in complete secrecy; and (3) there were no inhabited areas within 10 miles of the facility, offering greater safety to the civilian populace.

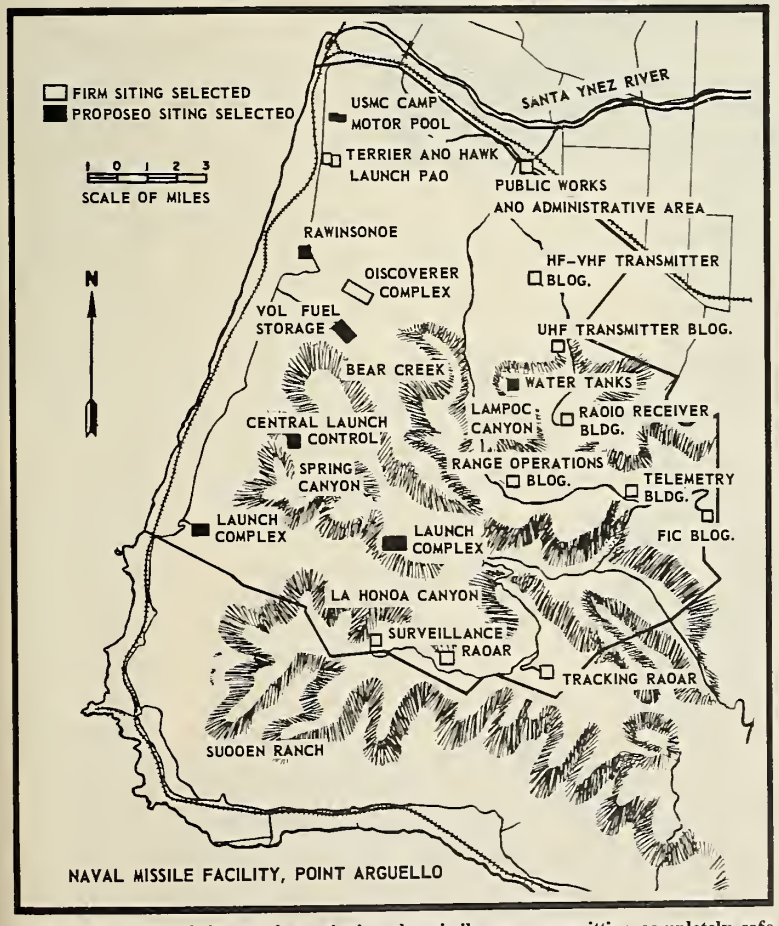
Point Arguello, originally the Army's Ft. Cooke, was brought into the PMR complex in 1958.

The three biggest installations already constructed or under construction at PMR are the *Thor, Atlas* and *Titan* complexes. Eight *Thor* pads are nearing completion and three *Atlas* pads are ready to handle the nation's first operational ICBM.

Joining these complexes in the future will be installations for the *Minuteman*, the *Nike-Zeus*, and for the larger NASA space vehicles, such as *Centaur, Vega, Saturn*, and *Nova*, now under development.

NASA, which has not used PMR in the past, intends to make extensive use of it in the future. Joining ARPA satellites launched from PMR will be NASA polar orbiting satellites and communications satellite.

An integral part of the space operation, when built, will be the equatorial launch site tentatively slated for construction on Manus Island in the Admiralty Islands Group.



POINT ARGUELLO boasts the nation's only missile range permitting completely safe launching of satellites into polar orbit. South of the point is nothing but open water, providing fall-out area for booster and room to destruct erratic birds.

ICBM Facilities

(continued from page 47)

fuel system and all the cryogenic systems are located here.

The missile is stored in a horizontal position, attached to a motor-driven erection boom with which it can be raised to a vertical position. When the missile is vertical, boom clamps are withdrawn and the boom is moved away from the missile so as not to interfere with launching.

The vertical missile sits directly over a concrete flame pit which curves away to deflect flame and hot gases from its vicinity. The terrific heat energy released into this pit when the engines fire is almost beyond imagination; alloy steel melts like butter unless cooled by large volumes of water. Hence, steel flame deflectors are not economical for operational sites and concrete deflectors have been designed to ablate without harmful deterioration.

In normal readiness, the missile will be stored horizontally with roof and flame pit exit doors closed against blast effects of a possible enemy missile. All liquid fill lines are capped, and air intake and discharge openings have blastproof covers which will automatically close whenever an external blast occurs and will remain closed until the danger has passed.

• **"Buttoning up"**—Connected to the Launch and Service Building by a tunnel is the Launch Operations Building, containing the Control Room and communications equipment and the electric power generating equipment, as well as sleeping quarters for the operating crew and air conditioning, electric power generation, cooking, and domestic water facilities. Everything is on an austere basis but complete in every detail; the operational crew can "button up" in complete isolation from the outside world except by telephone.

During an alert, or during exercise of the missile, all crew members are withdrawn into the Operations Building for protection against operational hazards. From here, they can carry out a complete countdown and launching by remote control.

Each complex is self-sufficient during the "button-up" period, retaining its capability to strike back even though all power lines are knocked out in the area, all water supplies cut off, all roads blocked or destroyed, and all local communications inoperative. And each individual complex is located far enough away from every other complex so that any conceivable multi-megaton thermonuclear bomb which might knock out one missile would be too far away to adversely affect others.

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FIG. 3 (at left)—Recently completed near New Jersey Turnpike just east of the Camden-Philadelphia area, is a prototype of similar installations to be constructed in the Far North. The dome will provide protection for huge antennas inside. It was fabricated by Goodyear Aircraft. FIG. 4 (at right)—Artist's cutaway drawing shows in-location installation at a Far Northern site of BMEWS tracking antenna and supporting pedestal being fabricated by Goodyear under a multimillion-dollar RCA contract.

teristics of satellites, aurora, meteor trails, etc. The computers then make strategic decisions in designating tracking radars to cover specific targets on which more information is required.

Finally, they are capable of formulating messages for transmission to the display in the Zone-of-the-Interior. The information from the detection and the tracking radars is fed into the two computers simultaneously.

One computer performs the more detailed computation and acts as the active computer. As answers are generated they are transmitted on through the system for evaluation and in parallel are fed into the second, or standby, computer for a correlation check.

The second computer is operated on a simplified program so that it will have an answer ready for comparison with the answer generated by the active computer.

Correlation, of course, is a relative matter and is based on whether or not the answers agree within specified limits. If a variation is noted that is beyond the specified tolerance, the built-in checking capability of the computers is put into operation and also the system checkout equipment checks each computer automatically to determine which one is in error. Proper corrective action can then be taken.

BMEWS is provided with a comprehensive and completely automatic checkout and monitoring system. This system according to RCA is believed to be the most extensive automatic checkout and monitoring system that has been built up to this time. The principles being used have all been proved in a similar system built by RCA for the *Talos* Ground Launch System. This system has been in operation successfully for about 1½ years.

One major advantage of the checkout system is that it makes possible the isolation of a malfunction without the necessity of system shutdown.

Signals from the checkout and monitoring system are fed into BMEWS and then at specified monitoring points the outputs are compared against reference outputs generated by the checkout and monitoring system. Variations that are out of specified tolerances indicate problem areas requiring further check.

At the Zone-of-the-Interior facility, the data from the forward sites will be decoded, evaluated, modified by other intelligence and displayed. This action provides the basis for evaluation of the potential threat and the determination of whether a decision for action is required.

• **Engineering problems**—It is impractical to provide a detailed description of all of the major elements of the BMEWS system, but a few of the specific engineering problems that have been encountered can be discussed.

The first problem encountered was with the radome. It had to be capable of withstanding winds as high as 185 miles per hour and temperatures as low as minus 65°F. Since it is installed on top of a building, the coefficient of drag is higher than would be the case for a radome installed on the ground. The drag coefficient for a radome installed in the usual fashion is about 0.38. The coefficient of drag for the BMEWS radome is 0.657 or almost 1¾ times as great.

Wind tunnel tests made on the model of the radome developed that the total lift could be almost 1.4 million pounds, total drag could be nearly 1.14 million pounds and the overturning moment could be over 58 million foot-lbs.

The radome is of sandwich construction with skins made of reinforced plastic impregnated fiberglass with a phenolic impregnated paper core. The

panels are hexagonal in shape, 6" thick, and about 6' across. It takes 1,646 of them to make one radome. The panels will be bolted directly together without any additional framework or structual support.

Fig. 3 shows how the panels are fastened into final radome form. The elimination of structual support reduces the transmission losses by a factor of approximately 10. This is a highly desirable end result. More important still, the bore sight error will be less than 0.3 mils. However, the elimination of the frame introduces certain mechanical design problems. The principal one is to reach the best compromise between tension and shear loading of the bolts. The influence of the heavy wind loadings is not only a major factor in this connection but also in connection with the design of the non-rigid base ring made as a part of the building structure to support the radome.

The low-temperature environment was also a serious problem to reckon with in connection with the design of the detection radar reflector. Welded structures made of conventional structural steel are subject to failure at low temperatures. A transition of the physical properties of the metal occurs and causes a serious reduction in strength. To assure adequate strength to withstand the heavy wind loadings under the extreme low temperature conditions it was necessary to utilize a nickel steel with suitable low temperature properties.

Fig. 4 shows an artist's conception of the tracking radar reflector radome, and building. The total weight of the rotating mass is over 200,000 pounds. When it reverses direction, the deacceleration and acceleration take place at about 25°/sec., which imposes a loading of nearly 1 g.

Considering that the center of gravity of this rotating mass is about 85' above ground it is obvious that mechanical problems would be involved in designing the pedestal assembly, drive mechanisms, gears, bearings, support and the pedestal base itself. The main bearing in the pedestal which carries the load is designed to be capable of continuous operation for at least a ten-year period.

One of the phenomena that causes difficulty in far-north construction is permafrost (frozen earth below a certain ground level that maintains its frozen state). Since there is a thaw during the summer season, it is necessary to use non-frost-susceptible material (referred to as NFS) where buildings are to be constructed. It is necessary to use the NFS so that the heat from the buildings will not melt the permafrost and thereby cause the buildings to settle.

Large plastic tents are used during the cold weather to permit construction work to continue. The tents are kept inflated by pumping in heated air, which also makes it possible for the work to be performed under reasonably tolerable conditions.

• **Test installation**—An engineering-test and personnel-training installation is being constructed at Moorestown, New Jersey (Fig. 3). It will house a complete tracking radar and will have installed for protection of the radar one of the 140' diameter radomes.

Included as part of the test installation will be other parts of the complete system that are associated with the operation of the tracking radar. This will include the high power transmitting apparatus for probing the distant sky, and the high speed computers for calculating speed and direction of an approaching ballistic missile.

Two types of radar transmitters currently are under development: a triode and a klystron amplifier. Following extensive tests, one will be selected for multiple procurement and use at the sites.

Earth's attraction for an apple?

Free fall in relativistic space?

A complex meson field?

Built-in return power for project Mercury?

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Division of General Motors, Indianapolis 6, Indiana

Army Establishing Missile Support Base in France

by Anthony Vandyk

CHATEAUROUX, FRANCE—The U.S. Army plans to establish a European Inventory Control Point here for supply and maintenance support of certain guided missile systems furnished to NATO nations.

The Inventory Control Point will be incorporated in the NATO Maintenance Supply Service Center which has been established at Chateauroux. This center is currently managed by the U.S. Air Force but it probably will be turned over to NATO in the middle of 1961.

At the moment all missiles and their support equipment supplied from the U.S. are shipped by ocean surface transportation except for certain high-priority items as some special equipment. In these cases air transportation is used. USAF officials believe the outlook is good for increased emphasis on supply by air.

Today there are relatively few U.S. missile units in Europe. The U.S. Air Force has only three missile bases —all located in West Germany. The missile units are under control of the 38th Tactical Missile Wing, headquartered at Sembach Air Base Germany, and include the 587th Tactical Missile Group at Sembach, the 586 TMG at Hahn Air Base, and the 585th TMG at Bitburg Air Base.

The 587th TMG is presently transitioning to the **Martin** TM76 *Mace* as replacement for the Martin TM61 *Matador*. The 586th and 585th will eventually transition from the *Matador* to the *Mace*, but dates for conversion have not been announced.

No plans have been announced for additional U.S. Air Force tactical guided missile bases in Europe.

• **Willing Suppliers**—Publicly, at least, there are no plans for the U.S. Armed Forces or any of the NATO nations receiving U.S. missiles to have support equipment manufactured in Europe. The main reason is that it would be too costly to produce the small quantities required to support existing facilities.

Nonetheless, the European aircraft industry, which is suffering badly from lack of orders, would welcome an opportunity to get into this field. Industry officials hope the offshore procurement program may be extended to this area.

They point out that contracts such as those involving the production of F-86s by Italy's **Fiat** and F-84 spares by France's **Sud Aviation** proved that the European industry can do a good job in building U.S. equipment under license.

Officials at Chateauroux believe that European industry may get involved with U.S. missiles first in the overhaul and maintenance field, rather than in license production. At the moment the USAF has contractors in most of the countries of Europe overhauling and maintaining piloted aircraft, their engines and components. This system has saved the U.S. taxpayer money as well as giving needed work to the European aircraft industry. Its exension to the missile field would be logical.

New Missile Buildings Rise on Both Coasts

New buildings are rising for missile makers on the East and West Coasts. **Lockheed** has signed a construction contract for the first $2,500,000 unit of its new electronics division headquarters at Newport Beach, Calif. **Microwave Associates Inc.** has begun construction of a $750,000 expansion of its facilities in Burlington, Mass. And **Rantec Corp.** has broken ground for a $100,000 building, the first stage in a three-year expansion of its Calabasas, Calif., plant.

Puget Sound Bridge and Dry Dock Co., Seattle, a wholly owned Lockheed subsidiary, and **Diversified Builders Inc.,** Paramount, Calif., will be joint general contractors on the Lockheed job. It provides for about 100,000 square feet of construction, which will be the nucleus of a major scientific and production center on a 200-acre triangle near Upper Newport Bay. The schedule calls for occupancy late next summer.

VAPPI Construction Co. of Cambridge, Mass., will build the Microwave addition, scheduled for completion next spring. A new 17,000-square-foot wing will be added to the building housing the firm's semiconductor and tube operations, and a new 32,000-square-foot structure will be built for research and production of microwave radar components.

PROBLEMS OF SATELLITES AND SPACE OPERATIONS; Lecture series, Office of Naval Research, April-July 1958. Order PB-151410 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 111 pps. $2.50.

The lectures, presented to the ONR research staff and representatives of other Government agencies from April to July 1958, concern problems associated with manned satellites and space operations.

Talks were given by Donald H. Menzel, director of the Harvard Observatory, on problems of the space age; Homer E. Newell, Jr., superintendent of the Atmosphere and Astrophysics Division, Naval Research Laboratory, on objectives of space research; Gerald M. Clemence, scientific director at the Naval Observatory, on Space navigation and celestial mechanics.

John P. Hagen, director of Project Vanguard at NRL, on satellite tracking; N. Whitney Matthews, head of the Applications Branch, Solid State Division, NRL, on satellite payload optimization; Fred L. Whipple, director of the Smithsonian Astrophysical Observatory, on astronomy and space operations.

Jerome B. Wiesner, director of the Research Laboratory of Electronics at MIT, on space communications; and Hugh L. Dryden, deputy director of the National Aeronautics and Space Administration, on the work of the NASA.

HIGH TEMPERATURE PRINTED CIRCUITRY; G. H. Young, C. H. T. Wilkins Etc. Quarterly report No. 4 on Computer Components Fellowship No. 347. Order PB 136 579 from Library of Congress, Photo-duplication Service, Publications Board Project, Washington 25, D.C. 41p. Microfilm, $3.30, photocopy, $7.80

Findings of the program on high temperature printed circuitry are summarized briefly, and the several techniques for circuit fabrication are evaluated in the light of the 200°C temperature specification for this year and the 750°C specification for the coming year.

The conductivity of silver enamels has been found to remain high with silver contents as low as 26%. Platinum resistor films were found to have a linear temperature coefficient of resistance from 28 to 500°C, with a change in resistance of plus 18% over this temperature range.

Boron carbide thermistor films are stable in air above 750°C, but crack when temperature cycled between 200 to 300°C. Silicon carbide and zirconium carbide enamel resistor were successfully formed using suitable wetting agents.

Irreversible increases in resistance were observed in testing vacuum deposited gold-palladium resistor films to 500°C.

FLIGHT FORGINGS

BY CAMERON

WHEN DEMANDS ARE CRITICAL

The Cameron split-die forging process has created a new concept in forged components that fly. Parts which must handle new extremes in temperature and mechanical stress are now in routine production at Cameron. As an added benefit interesting economies result from savings in the critical materials, often in short supply, which are specified for these important parts.

Our facilities are complete through every production phase. We melt many of our own special alloys, bloom, forge, heat-treat, and perform machining operations when required. Each of the shapes below was a problem when presented to our Special Products Division. They are now current production items, adding to our ever-increasing list of extreme service solutions.

Forging of a Refractory Throat for Missile
Material: Tantalum 90%
Tungsten 10%
Outside Diameter of Large End: 6.25″
Height: 4″
Outside Diameter of Small End: 5.25″
Weight: 42.25 lbs.

Forging of Turbine Rotor Stub Shaft for Nuclear Jet Engine
Material: A-286 Steel
Outside Diameter of Cone End: 33.687″
Outside Diameter of Shaft: 10.375″
Height: 44.875″
Weight: 1150 lbs.

Forging of a J-93 Front Turbine Shaft for Aircraft Gas Turbine Engine
Material: Waspalloy
Diameter of Conical End: 23.38″
Diameter of Hub End: 6.50″
Length: 27.68″
Weight: 430 lbs.

Forging of a Liner — Exit Cone Missile
Material: Unalloyed Arc Cast Molybdenum
Diameter of Large Conical End: 10.50″
Height: 12.89″
Diameter of Small Conical End: 6.75″
Weight: 104.5 lbs.

If your forging demands are critical, write, call, or come by —

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IRON WORKS, INC.
SPECIAL PRODUCTS DIVISION
P. O. Box 1212, Houston, Texas

A simple method of attaching lead wires to high temperature printed ceramic circuits using properly formulated enamels is also described.

EFFECTS OF BRIGHT POINT LIGHT SOURCES ON LOW LEVEL IMAGE ORTHICON DETECTORS; R. K. H. Gebel, WADC. Order PB 151587 from OTS, U.S. Department of Commerce, Washington 25, D.C. $.50.

Treated in this pamphlet are causes and corrections of the high brightness point source effect in orthicon tubes.

The conclusion was reached that halo and ghost produced by redistribution of secondary electrons in a military tube should be avoided if possible, since they appeared to show nonexistant targets. The present glass target plate should be replaced with a faster target having insulated metal plugs.

By incorporating this assembly in an isocon arrangement no "overfloating" of the charge which results in the loss of low intensity background information, because of high intensity point sources, should occur.

TRACKING OF A MOVING TRANSMITTER BY THE DOPPLER EFFECT; Thomas Skinner. Order No. PB 139 909 from Library of Congress, Photo duplication Service, Publications Board Project, Washington 25, D.C. 23p. microfilm, $2.70, photocopy, $4.80.

This report considers the feasibility of tracking a moving transmitter, in particular, an artificial earth satellite, by measurements of doppler shift only.

Although it is shown to be possible to track a transmitter moving on an arbitrary course, unless sufficient prior knowledge of the motion is available the computational procedures are impractically involved.

With this in mind, two restricted types of motion are considered, constant velocity and two-body central field motion. The former is analytically very simple, and the latter is a reasonable approximation to the motion of an artificial satellite.

AN INVESTIGATION OF THE MECHANICAL PROPERTIES OF CERMETS AS RELATED TO THE MICROSTRUCTURE; Ira Binder and Robert Steinitz. Order No. PB 151 722 from OTS, U.S. Department of Commerce, Washington 25, D.C. 95 p. $2.25.

Seven different test groups were formulated, using 60 TiC-40 Ni as the test material, comprising changes in original particle size, processing procedure, and controlled binder addition.

Each test group was heated in seven different fashions. Each test batch so obtained was tested for physical properties and its microstructure was investigated. The microstructures were correlated with changes in physical properties.

OXIDATION OF EXPERIMENTAL ALLOYS; Joseph C. Richmond and H. Richard Thorton. Order No. PB 151741 from OTS, U.S. Department of Commerce, Washington 25, D.C. 19p. $.50.

Tests were conducted on five newly devoloped high-temperature alloys to determine their oxidation resistance.

Measured was the average depth of external oxidation and maximum depth of oxide penetration on specimens placed under stress in air under varying temperature conditions for an equal time.

The changing weight of samples oxidized in air at high temperatures was continuously recorded for up to 100 hours. All of the alloys conformed reasonably well to the parabolic rate law in the weight-gain oxidation tests.

RADIO TRACKING OF EARTH SATELLITES; Pickard and Burns, Inc. Order PB 139915 from Library of Congress, Photo Duplication Service, Publications Board Project, Washington 25, D.C. 141p. microfilm: $7.20, photocopy: $22.80.

This report includes; Satellite orbital data, application of orbital data, instrumentation for doppler frequency measurements and analysis, laws of satellite motion, energy relations and orbital velocity, and perturbations of satellite motion.

Nerve Cell Research Urged for 'Decision-making' Guidance

Armed Forces Chemical Association also hears of need for work in dielectric behavior in space

by John Judge

WASHINGTON—Living nerve cells may yield clues to developing a bio-electronic space vehicle guidance system with "decision-making" capability.

Alton E. Prince, a chemist in the Wright Air Development Center materials laboratory, said intensive nerve cell research is indicated as the result of the recent discovery of the synthesis of "giant" protein molecules.

He told the Armed Forces Chemical Association 14th annual meeting that "with more knowledge concerning the molecular structure in the living cell, the synthesis of polymeric chains which would be responsive to an electrical signal, select the necessary information and make a decision, is a necessity." He believes such materials ultimately would find wide use in space guidance systems.

Prince said it can be anticipated that the fundamental aspects of space age chemistry will not change much from the present or the past. The products of space age chemistry will depend, as in the past, on the ingenuity of the scientists in their laboratories. It is certain that, in time, some of the laboratories will actually be space vehicles.

"It seems probable that there will be less room for the extreme individualist in a corner of a laboratory by himself, because teams of people with great differences in training and experience even now are required to solve existing problems. This is true because nearly half a lifetime is required to gain training and experience to formulate sound concepts for future needs," he said.

Another fundamental problem that can develop is that attempts will be made to place the new knowledge gained from space exploration into categories already established for our own little earth. It is believed that the exploration of the space and its contents will yield facts which do not at all fit into our preconceived, inherited and firmly established categories of the past, he added.

Need for increased chemical research in structural materials capable of functioning in an environment of 2000°F to 5000°F was stressed by Claude Kniffin of ARDC. He pointed out that few presently available materials are fully satisfactory, especially for extended periods of service. The day of the multiple use of single materials in aerospace vehicles structure is definitely over, said Kniffin, and the trend is toward composite items such as sandwich structures and surface coatings.

Future performance requirements envision temperatures up to 10,000°F and if these are to be met, progress must be made in two simultaneous yet slightly divergent directions. The materials themselves must be provided and the data currently available must be collected, evaluated, and disseminated so that more effective application can be made.

• **Vacuum research needed**—Much of the present knowledge of dielectric materials has been developed in the light of terrestrial conditions, reported Nelson A. Terhune of the Army Signal Research and Development Laboratories. But little is known about their behavior in outer space. Evaporation is greatly enhanced by the absence of atmosphere, said Terhune, and the material can be effected in two ways.

Ablation of the substance or a change in its composition due to the loss of a more volatile component may become serious in a relatively short time. And the other effects will be caused by the removal of the absorbed gases always present under normal conditions.

Dr. Wilbur A. Riehl of the Army Ordnance Missile Command called for new and improved corrosion inhibitors, compatible paints for marking and coating shipping containers and additives as partial catalysts in high-energy liquid fuels. The Army expert suggested the possible use of scavengers or "getters" in removing fuel contaminants.

• **Energetic binders**—Future research in high-energy solid propellant technology should be directed toward chemical reactions that produce low molecular weight gases at reasonable flame temperatures. Dr. Evan C. Noonan of the Naval Ordnance Laboratory said this path may produce delivered impulses in the neighborhood of 300 I_{sp} with solids.

He suggested that, due to the demands for high elongation at maximum strength for case bonded propellants, energetic binders might be substituted for part of the oxidizer in composite grains.

Martin Devine of the Naval Air Material Center reported new dry film lubricants have been developed which are stable through a temperature range of —300°F to 750°F. He said they will permit ball bearing lubrication for periods up to 240 hours.

The compounds, inorganic in nature, will function immersed in liquid oxygen. Based on their chemical structure, the stability in nuclear radiation and at low pressures should be satisfactory. It is anticipated that such lubricants will eliminate excess weight, increase reliability of operation and provide new mission capabilities.

Research in high-temperature plastics was discussed by Dr. Lewis W. Butz of the Office of Naval Research. He said program objectives include development of information concerning the range over which properties can be varied by changing the details of structure and the providing of new inorganic plastic compositions.

WESTERN GEAR CAN SUPPLY THE SOLUTIONS

To insure the reliability of the missile, its positioning must be accurately and cautiously handled. No matter what mode of transportation, truck, rail, air or water, there are Western Gear precision drives and related equipment engaged in the touchy and delicate task of handling the mighty "birds." Moreover, Western Gear's extensive experience and facilities enable the company to effectively handle your system requirements.

For complete information on our capabilities and facilities, write on your letterhead for Bulletin 5900.

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5921

Battery Omission

To the Editor:

It surprised us that your article "Batteries Retain Their Power Role" (M/R, Aug. 24) failed to mention our company as a leading manufacturer of nickel cadmium batteries. We probably have sold more (such) batteries, in a wider number of applications, in this country, than all the other . . . manufacturers combined.

NICAD developed and introduced both the pocket plate and sintered plate nickel cadmium storage batteries to the United States. We have sintered plate batteries in the *Tartar, Terrier* and Norair T-38 trainer as well as in "design in" phases of a number of missiles and other classified military projects. Our pocket plate batteries are used extensively in many military and nonmilitary applications, including missile ground support: DEWLINE, WHITE ALICE and USAF GLOBECOM installations. Nearly 1000 major U.S. merchant ships are equipped with NICAD batteries . . .

Ralph W. Gage
Sales Promotion Manager
NICAD Division
Gould-National Batteries, Inc.
Easthampton, Mass.

M/R apologizes for inadvertently omitting NICAD, decidedly a leading manufacturer in the battery field.—Ed.

Full Names in Future

To the Editor:

In M/R of Aug. 31, we noticed a misleading detail in your article on Avco's Dr. Arthur Kantrowitz. You say "a policy change after the war switched Avco to civilian-market emphasis and it acquired Bendix and Crosley. Largely because of distribution problems, Avco sold Bendix to Philco in 1956 . . ."

To the best of our knowledge, **Bendix Aviation Corp.**, as such, has never been any part of Avco Corp., by acquisition, agreement or any other means. It is true that Bendix Aviation and Bendix Washing Machine Activities were founded by Mr. Vincent Bendix, but at no time was there any connection between the two activities, due to the fact that Mr. Bendix had disassociated himself from Bendix Aviation Corp. prior to any interest on his part in the Bendix Washing Machine Activities.

We feel that your statement . . . incorrectly presents the present position in the aviation and missile fields enjoyed by Bendix Aviation Corp.

E. A. Carpenter
Marketing Manager
Special Products
Red Bank Division
Bendix Aviation Corp.
Eatontown, N.J.

M/R regrets not specifying that the company involved in the acquisition was the firm now titled Bendix Home Appliances Inc.—Ed.

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HIGH PRESSURE HOSE FOR AIRCRAFT AND MISSILES

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SUPER "T-HP" Teflon* HOSE

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Withstands tests more severe than MIL-H-8788

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- Available with swivel elbows that can be rotated without disturbing the wire grip lock.
- Stratoflex High Pressure Fitting combines the exclusive Pressure Activated Gland Seal and the assurance of crimp design.
- Shelf life practically unlimited.
- Available in two styles of high temperature fittings. Combination of stainless steel and carbon steel, or corrosion resistant all stainless steel fittings.

Hose assemblies are factory assembled from stock with straight, 45° and 90° fittings. Other angles or connections are made to your specifications. WRITE FOR BULLETIN S-7 TODAY!

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SF7-9

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DUNLAP

Dr. W. Crawford Dunlap, Raytheon Mfg. Co. scientist, has been named editor-in-chief of "Solid State Electronics," a new international publication dealing with transistors and other solid-state devices.

Dr. Dunlap, director of semiconductor research for Raytheon, is the United States representative heading a five-man board of editors from the United Kingdom, Europe, Japan, the Far East and one to be appointed from the U.S.S.R.

Prior to joining the company in January of this year, he was supervisor of solid-state research at Bendix Aviation Research Laboratory and a consultant and research physicist with General Electric Co.

Frederick D. Dodge has been elected chief engineer of Minneapolis-Honeywell's Missile Equipment Division, designers and producers of missile launching and checkout equipment.

Prior to joining the division in 1958, Dodge held various engineering positions at Brown Instruments Division.

John N. Monroe, formerly president of Monroe Laboratories, has joined the Guided Missile Division of Firestone Tire & Rubber Co.

Monroe, a specialist in conceptual guidance and detection systems, stellar tracking and optics, previously was associated with Northrop Corp. and The Martin Co.

DODGE

MONROE

LEVESQUE

Russell J. LeVesque has been appointed manager of the Printed Circuit Department, Technical Products Division of Packard-Bell Electronics.

LeVesque has had more than 16 years experience in the electronics industry including ten years of supervision and design at Northrop, two years with North American Aviation as design engineer and electronic designer for two years with Hughes Aircraft Co.

Mrs. Donald R. Quarles, who has long been associated with aviation matters through her husband, the late Assistant Secretary of Defense, has joined FAA as Confidential Assistant to the Chief of Office of Public Affairs.

LINVILLE

Thomas M. Linville, manager of the Research Operation Department of General Electric's Research Laboratory, has been named a member of the National Research Council and will represent the American Institute of Electrical Engineers in the NRC's Division of Engineering and Industrial Research.

Linville, who joined GE in 1926 has served in his present position since 1953. He has specialized in design and development of motors and control systems, engineering administration, engineering education and holds seven patents.

engine power BY CATERPILLAR

THEY DEPEND ON CAT DIESEL POWER TO KEEP AIR FORCE ATLAS MISSILE ON TARGET

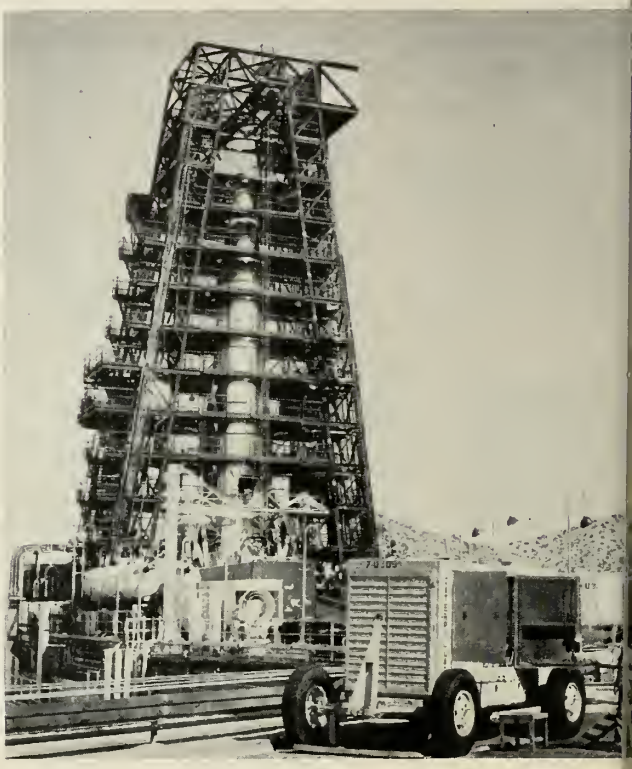
Calibration of the delicate electronic system of an Atlas missile requires a portable power source with unusually accurate control of voltage.

Down-range tracking stations need a power supply that can be depended upon in *any* emergency.

Both requirements are met by Caterpillar Diesel Electric Sets. Caterpillar Diesel Engines in these sets are extremely efficient 4-cycle engines which operate on any fuel from JP-4 through No. 2 furnace oil. They start easily, pick up load quickly and can be maintained and operated by unskilled personnel. Parts—and service—are available all over the Free World.

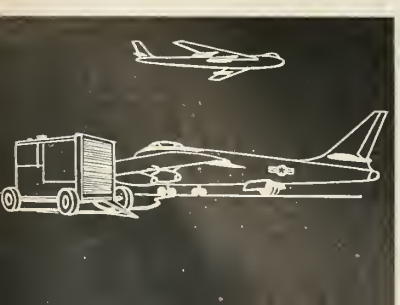
These are some of the reasons why you will see so many Caterpillar Electric Sets used for primary and standby power at our missile bases and other military establishments. They are used to supply power for testing, for starting jet engines, for radar warning systems, for lighting, heating and other base living facilities.

Free booklet. Get the full story on the advantages of Caterpillar Diesel Electric Sets. Write to Engine Division, Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

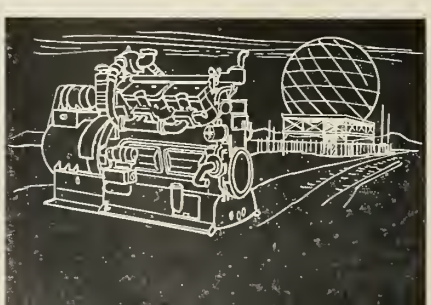


At Edwards Air Force Base in California, power for testing the precision electronic control circuits of the Atlas missile is supplied by two Cat D375 Diesel Electric Sets. They meet the triple requirement of portability, dependability and accurate control.

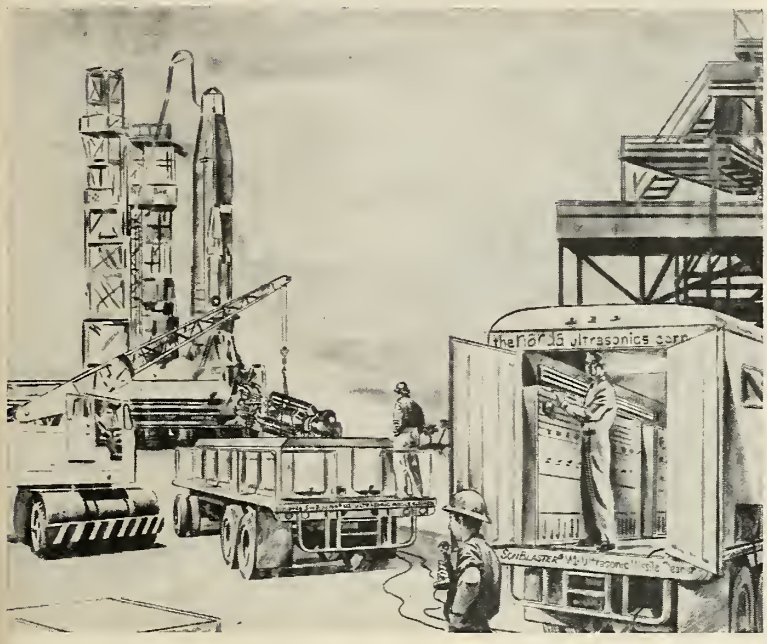
JET ASSIST. Caterpillar Portable Electric Sets supply dependable power for starting jet engines and for calibrating control systems.



ALONE. Without benefit of people to look after them, Cat Electric Sets furnish power for gap filler sites in our aircraft warning system. They are used at larger bases, too.



ENDURANCE. At Air Force Bases in the Atlantic, Cat Electric Sets have run over 20,000 hours without overhaul, while supplying 63,000 kwh a month.



Mobile Missile Cleaner Available

The **Narda Ultrasonics Corp.** recently introduced the new M-1 Ultrasonic Missile Cleaner—a fully self-contained mobile missile cleaner for use at launching pads and at missile assembly plants.

The flat bed trailer is 24 feet long and supports a transducerized tank measuring 20 feet by 6 feet by 3 feet deep. This tank requires 30 kw input.

The transducers are paired in 1 kw modules for easy field maintenance and replacement. The trailer is towed by a power tractor of the cab over the engine type.

Twelve of Narda's G-25001 generators are installed in the rear of the air-conditioned van. The van is equipped with all of the necessary cables and maintenance facilities.

In addition to missile cleaning equipment, Narda has developed the SonBlaster DVC—3000 "Jupiter," a two-stage ultrasonic vapor degreaser.

Circle No. 225 on Subscriber Service Card.

LOX Manifold Features Automatic Change-over

Liquid oxygen cylinders can now be manifolded with a new manifold introduced by **Linde Co.**, Division of the **Union Carbide Corp.**

Used with four Linde LC-3 liquid oxygen cylinders, the new Oxweld M-40 provides an uninterrupted supply of 12,000 cubic feet of oxygen. More than 48 conventional high-pressure cylinders would be needed to supply the same amount of oxygen. And, the new unit occupies only a fraction of the space required for an equivalent high-pressure cylinder supply.

The new manifold is expected to find widespread use as a replacement for many existing systems of high-pressure cylinder oxygen supply.

Automatic change-over from one bank to another is an important feature of the new Oxweld M-40. As the supply in one cylinder bank is depleted, the manifold automatically continues to supply oxygen from the other bank. This feature provides a continuous, uninterrupted supply which is important in many industrial applications and vital in hospital use.

The new Oxweld M-40 manifold is flexible. Standard models are supplied for use with four or two Linde LC-3 cylinders arranged in two banks.

The M-40-2 two cylinder manifold is designed for hospital service. A five-cylinder emergency standby manifold for gaseous cylinders and a junction box assembly for connecting both manifolds to a hospital piping system are available for use with the M-40-2 manifold.

Circle No. 226 on Subscriber Service Card.

Exhibit Demonstrates CO_2 Liquid Equipment

Pure Carbonic Company and **Wyle Manufacturing Corp.** cooperating on a project to show the advantages of carbon dioxide (CO_2) liquid as a cooling agent for environmental testing have developed a traveling exhibit mounted on a 40′ flatbed trailer to demonstrate products directly at the plant sites of missile/aircraft components manufacturers.

Pureco, a division of **Air Reduction Company, Inc.,** is a major nation-wide producer and distributor of CO_2 and CO_2 supply systems, and Wyle is a

leading manufacturer of environmental equipment designed to use CO_2 liquid for low temperatures.

The CO_2 liquid for the demonstrations is provided in two storage units: a stationary six-ton unit and a half-ton mobile unit. These units, typical of those made available by Pureco, provide storage without loss over an indefinite period.

CO_2 liquid is piped from the storage units to a Wyle portable servo temperature conditioning unit. This unit

← Circle No. 3 on Subscriber Service Card.

converts simple insulated enclosures of virtually any size into automatically controlled high/low temperature chambers. Temperature range is −100°F to +400° F, and any selected temperature is automatically held to within plus or minus 2° F. Temperature conditioned atmosphere is circulated through test enclosures via six-inch diameter fiber glass insulated hoses.

One of the insulated enclosures with which the temperature conditioning unit is demonstrated is a chamber fitted over an oil film vibration slip table to provide temperature environments during vibration testing. The slip table, recently placed on the market by Wyle, consists of a large granite block with an extremely flat, highly polished top surface. A slip plate, mounting the test specimen, is placed here. The flat surface holds the vibration accurately in one plane, virtually eliminating cross-talk problems.

To show the use of the temperature conditioning unit with large test chambers, an end section of one of Wyle's radically new foam-insulated, weatherproof walk-in chambers has been fitted with special doors and instrumentation, permitting demonstrations of the rapid temperature pull-downs possible with Pureco CO_2 liquid.

Also included in the exhibit is a Wyle chamber which features self-contained temperature control and utilizes CO_2 liquid by direct injection into the chamber.

Recent breakthroughs in equipment design, together with today's wide availability of CO_2, make this medium one of the most practical and efficient for low temperature tests. Through the use of the trailer exhibit, the companies intend to make potential users aware of the full potentialities of CO_2 as a cooling agent.

Circle No. 227 on Subscriber Service Card.

Homing Devices Improved By Refrigerant Spray

Sensitivity of "homing" devices in the guidance system of missiles and rockets is being improved by spraying "Freon" refrigerant into an electronic eye no larger than a thimble, to maintain its temperature at a frigid 114 degrees below zero. The refrigerant is manufactured by the **E. I. DuPont de Nemours.**

Heart of the electronic eye is a sensitive deposit of photo-conductive lead sulfide, lead selenide, or lead telluride—not much larger than the head

LOW LEVEL INPUT AMPLIFICATION

- *1,000,000:1 rejection ratio at 60 cps*
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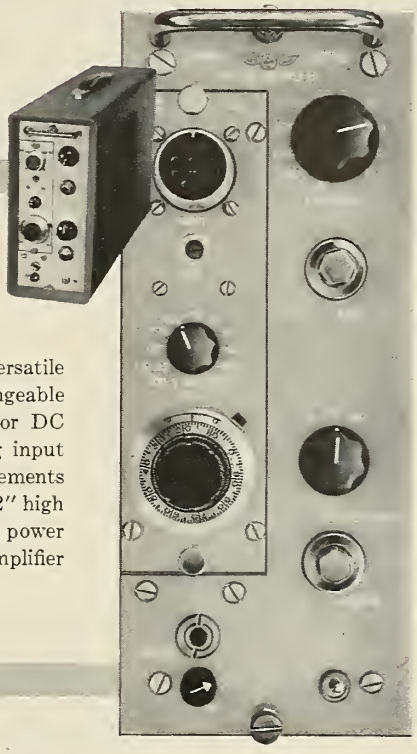
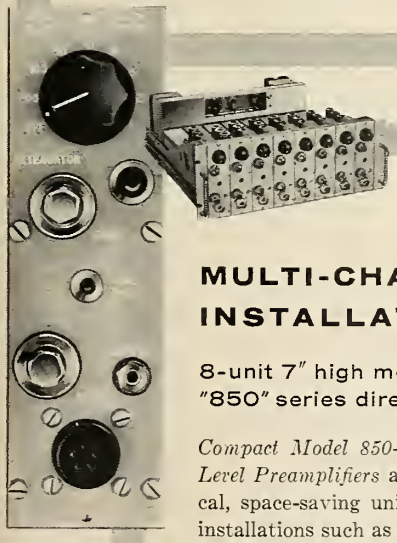


INDIVIDUAL SET-UPS

portable, self-contained unit amplifier

The Model 350-1500 Low Level Amplifier provides extremely versatile measurement of low level signals through use of two interchangeable plug-in circuits — one for thermocouple applications, another for DC strain gage work (other plug-ins now in development). Floating input and isolated output make the 350-1500 useful when signal measurements are made in the presence of large ground loop voltages. The 10-1/2" high x 4-3 16" wide 350-1500 may be used individually with its own power supply to drive a 'scope, meter, optical element, etc. or as a preamplifier in 6- or 8-channel 350 series recording systems.



MULTI-CHANNEL INSTALLATIONS

8-unit 7" high modules for "850" series direct writers

Compact Model 850-1500A Low Level Preamplifiers are economical, space-saving units for large installations such as aircraft and missile development and test facilities where many recording channels are used to monitor strain gage and thermocouple outputs. Required 440 cps chopper drive voltages can be supplied for up to 16 channels with the *Model 850-1900 MOPA*.

SPECIFICATIONS

	350-1500	850-1500A
Sensitivity	20 uv input for 1 volt output, or 10 chart div. with Sanborn recorder; X1 to X2000 attenuator	100 uv input for 1 volt output, or 10 chart div. with Sanborn recorder; X1 to X200 attenuator
Input	Floating, can be grounded	
Input Impedance	100,000 ohms	200,000 ohms
Output	Floating or grounded (independent of input)	
Output Impedance	350 ohms	
Output Capabilities	±2.5 volts across 1000 ohm load	
Bandwidth	DC – 100 cps (3db)	
Linearity	±0.1% of full scale	
Common Mode Performance	120 db for 60 cps and 160 db for DC with 5000 ohms unbalance in source	
Noise	2 uv peak-to-peak over a 0 to 100 cps bandwidth	
Drift	±2 uv for 24 hours	
Gain Stability	±0.1% for 24 hours	

(specifications subject to change without notice)

Complete specifications and application data are available from Sanborn Sales-Engineering Representatives in principal cities throughout the United States, Canada, and foreign countries.

SANBORN COMPANY
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. . . new missile products

of a pin. This is mounted in the nose of the missile or rocket and performs much like a human eye, scanning the area ahead of the weapon.

In operation, a small electrical current flows through the lead compound. Because it is photo-conductive, its impedance or electrical resistance varies with the quality and amount of light to which it is exposed.

When infrared rays—from the exhaust of an enemy plane ahead of the missile, for example—pass through the protective window of the scanning eye to the lead compound, they cause a voltage change across the cell.

This minute change then can be amplified in the electronic equipment to which the cell is attached, to control mechanical energy to operate various parts of the weapon's guidance system so that it automatically "homes in" on the target.

Spectral response and sensitivity of the lead compounds vary with the temperature at which they're held, with both increasing at lower temperatures, and that's where "Freon" refrigerant enters the picture. A simple capillary tube jets a controlled amount of "Freon" into the thimble-size sensing unit. As the refrigerant gas expands it has the ability to absorb large amounts of heat from the lead compound and maintain its temperature at a pre-determined level—114 degrees below zero in the case of one unit using "Freon-13" monochlorotrifluoromethane. A variety of "Freon" refrigerants, each with a different boiling point, offers guidance system designers a wide choice of operating temperatures which can help adjust the spectral response of the lead compound to desired levels.

Although three types of energy are involved (light energy received through the scanning eye, being converted to electrical energy in the electronic components, then to mechanical energy in the power guidance system), response of the entire guidance system, when properly adjusted, is almost instantaneous. In fact, its "quick as a wink" action might be likened to the human body's reaction to a sudden flash of light. Here the eye transmits the increased light intensity to the brain, as electrical signals which are converted into mechanical energy to cause the eyelid to blink or close. The principal difference is that the mechanical "eye," instead of trying to shut out the light, just opens wider to "home in" on the target.

Aside from its cooling advantages, "Freon" refrigerant is particularly adaptable to use in such complicated

electronic equipment because it is nonflammable, nonexplosive, noncorrosive to metals and other materials used in construction of the delicate parts, and has outstanding electrical properties.

Circle No. 228 on Subscriber Service Card.

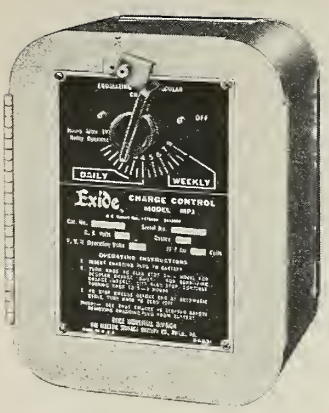
Charge Control Unit Extends Battery Life

A new, completely automatic unit just introduced by the **Exide Corp.** helps to prolong the high-capacity working life of electric industrial truck batteries by providing proper change control.

Insuring a full-charged battery for peak truck performance on every shift, the new MP-3 Exide Charge Control Unit also eliminates the danger of overcharging the battery.

The MP-3 automatically controls the battery charging equipment as it brings the battery to a full state of charge, and then automatically terminates the charge.

Designed to control both regular daily charges and weekly equalizing charges, the MP-3 requires no attendance or resetting, regardless of the length of the normal charging time.



Interconnected with the charging equipment, the MP-3 initiates the charging process when the control indicator of the electric timing switch is dialed. A unique spring-pin metal stop above the control indicator on the door of the case makes it simple to pre-set the unit for a normal three or four-hour daily finishing charge. The stop also can be lifted to move the control indicator to the six or eight-hour weekly equalizing-charge positions.

Vital to the control function of the unit is the Exide TVR temperature-compensated voltage relay, mounted inside the case. When a battery on charge reaches 2.37 volts per cell at 77 degrees Fahrenheit, the relay operates to reduce the charging rate and/or start the electric timer. The bi-metal strip on the relay armature has differing expansion coefficients to compensate for temperature changes.

The MP-3 is designed to control modified constant potential battery charging. A control circuit also is provided in the unit to operate an external auxiliary relay when two-rate charging is used.

The Exide unit can be mounted readily with two screws or bolts in a vertical position on the charger or on a wall. Lead-in wires from the charger can be pulled inside the case and connected to the terminal strip after the unit is mounted. The vital components can be removed easily and replaced without demounting the unit.

Assembled in a gray hammertone steel case, the MP-3 is 6¼ inches wide, 8-1/8 inches high and 4-1/8 inches deep. The control indicator extends 7/8

of an inch beyond the piano-hinged door.

MP-3 Exide Charge Control Units can be selected for charging specific-sized batteries ranging from 6 to 60 cells. They are available at low cost from the manufacturer of Exide-Ironclad and Exide-Powerclad motive power batteries.

Circle No. 229 on Subscriber Service Card.

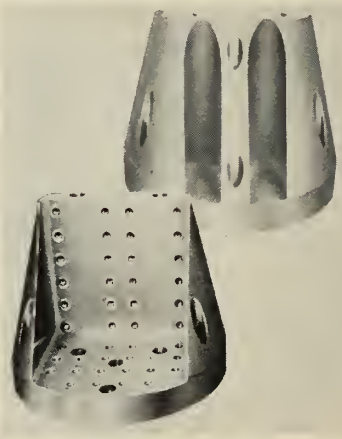
New Resonant-Free Test Fixture Developed

A new environmental test fixture that is resonant-free during normal use and may be used to mount test specimens during vibration, shock and acceleration tests has been designed by the Avco Research and Advanced Development Division.

The T-type fixture was designed to convey only the desired environment and is made of cast magnesium. It is capable of testing specimens in three mutually perpendicular axes, simultaneously. The fixture is essentially resonant-free below 2,000 cycles.

Use of the new rigid test fixture allows standardization of fixtures for vibration exciters, shock machines and centrifuges. The Avco scientists say that the fixture also has exceptional response characteristics in that the transmissibility factor does not exceed 1.10 up to 2,000 cps. This gives accurate transmission of input with no amplification.

Only minor adjustments are required for testing different specimens.



Components may be tested in each of three mutually perpendicular planes of motion by moving the test specimens to a different axis.

Called the Multi-purpose Environ-

mental Test Fixture, it is available in a small size used with a 1,500 g-pound exciter and a larger size for use with a 5,000 g-pound exciter. The smaller size has a dimensional capacity of 6 x 6 x 4½ inches with a weight capacity of up to 6 pounds. The larger type has a dimensional capacity of 12 x 12 x 9½ inches and weighs up to 25 pounds.

Circle No. 230 on Subscriber Service Card.

Tiny Metal-to-Metal Seals Solve Hydraulic Problems

Temperature and pressure problems arising out of the increasing development of miniature hydraulic pumps and valves have been met by the production

of a new series of tiny metal-to-metal seals by the **Harrison Manufacturing Co.**

Designated as Harrison K-Mini/Seals, the miniature seals are designed for applications requiring outside diameters smaller than ¾ inch. Standard sizes range down to ¼ inch.

Extensive testing indicate the seals are suitable for use in temperatures ranging from minus 300 degrees F. to plus 1200 degrees F. Zero leakage has been recorded in these tests at 6000 psig.

Like the other two series of seals, the K-Face/Seal and the K-Boss/Seal, the miniatures are re-usable, the re-usability factor depending upon the care and application of seating and re-seating.

Circle No. 231 on Subscriber Service Card.

Rocker Arm Has Missile Qualifications

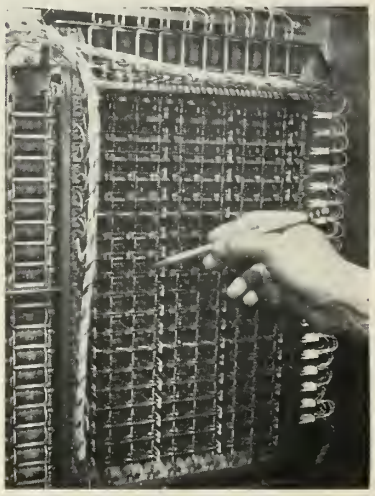
PITTSBURGH—A special stainless steel rocker arm is helping to make and fire missiles.

Automation in business and industry is also being made more feasible and more accurate through the adaptability of small but efficient switches of AM-350 stainless steel.

The stainless steel is used as an in-

tegral part of the crossbar switch made by **James Cunningham Son & Co.** This switch is a component of electrical computers and automatic programming equipment that requires high speed selection or scanning of multiple sources of information.

About 100 million cycles under load is demanded of the spring and rocker arm assembly of stainless steel.



This special steel is made by **Allegheny Ludlum Steel Corp.**

At the rate of 50 cycles per second, an individual crossbar switch can sample, select or translate data from as many as 1200 input points and relay the electronic information to reading or monitoring devices. The switches are often set up in relays to increase the number of input points.

Engineers designing the crossbar switch wanted a material that would work under greater stress loads than that previously used.

Circle No. 232 on Subscriber Service Card.

Gaussmeter Measures Flux Density

A new direct-reading gaussmeter, designed to measure direction and magnitude of flux density, has been designed and developed by **F. W. Bell, Inc.**

The new instrument is useful also in plotting flux paths, measuring flux leakage and performing other functions in the design and testing of electronic equipment. The unit has a carrying handle which doubles as a storage place for the probe, protecting the probe tip when not in use. A push-button on the probe itself facilitates use

by energizing the unit for quick readings.

Operating on the Hall Effect, the Bell Gaussmeter (designated Model 100) uses as its sensing element a thin wafer of high-purity indium arsenide with a temperature coefficient of 0.1%. The smallness of this element (.019" thick and .125" wide) permits insertion of the flat probe tip into very narrow air gaps. The active area of the sensing element is equal to a circle of .0625" diameter. High gradient fields can thus be measured easily in confined spaces. The sensing element is non-magnetic and does not disturb the field being measured.

A convenient scale selector on the front panel gives gauss readings in three scales: 0 to 300, 0 to 3,000 and 0 to 30,000 gauss. "Balance" and "null" adjustments are not required on the front panel. The instrument will read DC flux in the presence of a strong AC field, rejecting the AC field and giving strong, continuous readings as long as the probe is held in a constant magnetic field. Measurements are indicated on a linear meter scale. No amplifier is used.

The power supply is a built-in 4½-volt battery, drawing current only when the push-button is depressed. A convenient cord hanger on the rear panel holds the 5-foot cord furnished with the unit. Dimensions of the unit are: 10-1/8" wide, 4-3/8" deep over all, and 7½" high over all. The unit weighs 5 pounds. The finish is a dark grey baked-on enamel. Front panel trim is in anodized aluminum.

F. W. Bell, Inc., reorganized in June of this year and known formerly as American Electronics, Inc., announces also that probes and test fixtures for special applications are available on special order.

Circle No. 233 on Subscriber Service Card.

Solid-State Repeaters Aids Distorted Signals

The Trepac Corp. of America has announced a new line of teleprinter coupling repeaters designated the Diamond Trepac 560 Series.

Designed around the Trepac solid-state relay widely used for keying teleprinters, the new repeaters represent a simplification and operational improvement over the bulky, expensive, delicate repeaters previously used. The absence of moving parts (except for one mercury relay), electron tubes, and operational adjustments practically eliminates maintenance and repair problems.

The units operate from either 115-volt 60-cycle power or 12-14 volts DC, and require only 15 ma in "line-closed" condition. The repeater contains a rechargable standby battery which enables the unit to operate independently for three months after failure of the external power source. Location of the unit with respect to battery or ground terminations or any particular part of a telegraph line or loop is not critical.

Diamond-Trepac repeaters are said to be immune to many signal defects that incapacitate old-style units. The repeated signal emerges clear, clean and consistent (even when the input signal contains heavy asymmetric distortion) at modulation rates up to 200 bits per second. The repeater is remarkably immune to interference,

change in signal levels, and load variation.

NEW VICKERS® Packaged Valve Assembly accelerates – decelerates Thor Missile Erector smoothly without ratcheting.

Operating Pressure	3400 P.S.I.
Proof Pressure	4500 P.S.I.
Burst Pressure	7500 P.S.I.
Temperature Operating Range	−65°F to +150°F
Filtration Nominal	10 Micron

Smooth control of the Thor erecting cylinder is accomplished by a new Vickers' packaged valve assembly. This assembly provides regulated acceleration-deceleration throughout the erecting cycle without compounding structural vibrations. Despite varying external loads and temperatures, firm positive control is maintained as the missile's center of gravity passes over the pivot point.

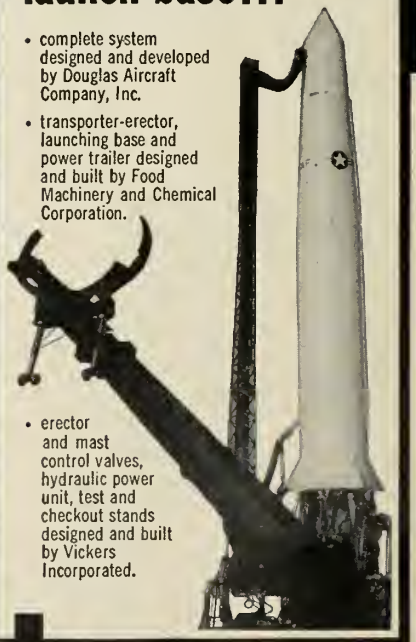
This "system engineered" valve is another example of the special ability of the Vickers Marine and Ordnance Department to solve difficult ground support problems. An integrated package, this new valve consists of a metering-type, modulating flow control that is pressure compensated for a fixed pressure differential. An integral, motor-actuated, 4-way directional control regulates starts and stops in mid-cycle.

Now in production, this valve can be used to control a broad range of accelerations, decelerations and overrunning loads merely by varying combinations of orifice sizes and spool configurations. Horsepower input can be adjusted to meet onsite power availability. Valve output can be controlled electrically, mechanically or hydraulically. Mounting flexibility permits valve installation directly on the hydraulic cylinder.

All units are factory pre-tested, interchangeable and require no external lines except to pump and tank. They are built to meet the most demanding reliability requirements.

THOR missile on launch base...

- complete system designed and developed by Douglas Aircraft Company, Inc.
- transporter-erector, launching base and power trailer designed and built by Food Machinery and Chemical Corporation.
- erector and mast control valves, hydraulic power unit, test and checkout stands designed and built by Vickers Incorporated.



If this valve offers a solution to your problems, call Waterbury, Connecticut, PLaza 6-3684 (TWX: WBY 160) for more complete information. Write for a free copy of Bulletin 5303 "Vickers Oil Hydraulics for Missile Systems."

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Marine and Ordnance Department
WATERBURY 20, CONNECTICUT

Hydraulic Products for Marine and Ground Defense Applications

MO-219

DISTRICT SALES OFFICES: DETROIT, MICH. • EL SEGUNDO, CALIF. • BERKELEY, CALIF. • WASHINGTON, D. C. • WATERBURY, CONN.

Each repeater is bi-directional. Pilot lamps indicate the direction of transmission. Repeater modules are 5¼" high, 3¼" wide, and 14" deep. Five such modules may be mounted in a 19" rack or seven in a 24" rack, using standard accessory trays. Completely-wired bays, accommodating up to 50 units per rack, are available.

Portability, immunity from signal distortion or fluctuation, freedom from maintenance, and the standby battery feature make these repeaters ideal for use in remote, unattended locations. Their high speed capabilities assure their performance in the faster teletypewriter and data transmission circuits of the future.

All units are compatible with each other, and with existing standard equipment, and may be included in complex conference networks.

Circle No. 234 on Subscriber Service Card.

Thermometer Is Smaller Than Pencil Eraser

A resistance thermometer, half the size of an ordinary pencil eraser and designed for extreme accuracy and high temperature operation, is now available for immediate delivery from **Minco Products, Inc.**

The model S-22 provides reliable

operation from −100°F. to +500°F. It has a resistance of 470 ohms at 32° F., which varies at the rate of about 1 ohm per degree F. The unusually small mass and size (.156" dia. x .281" long) results in rapid response to transients and changes in temperature. The tiny platinum sensing element is plotted for maximum environmental capabilities, dielectric and mechanical strength.

A unique attachment of the lead wires provides a minimum of 5 lbs. pull strength. The stainless steel case will withstand a minimum of 5 lbs. compressive force from a rigid load.

Calibration accuracies of plus or minus ¼%, ½%, and 1% are available from stock. Curves, points, and/or equations are available with each unit.

Circle No. 235 on Subscriber Service Card.

New Cycle Timer Is Totally Enclosed

Haydon Division of **General Time Corporation** announces the availability of an improved cycle timer known as Series AC-42, which is a totally enclosed, motor driven switching device for use in the control of vending machines, hand dryers, photocopying equipment, etc.

The timer, which the manufacturer describes as being extremely rugged and compact, repeats a set cycle or

sequence of switching operations as long as the motor circuit is energized. If desired, the motor can be wired through switch contacts to limit rotation to one cycle. The wide choice of speeds and availability of "Torque-Rated" motors make possible many timing intervals.

The unit incorporates one SPDT switch and has a housing of molded phenolic, offering a rigid, dust tight construction that will assure reliable performance under adverse ambient conditions.

According to the manufacturer, all terminal and blade configurations are heavy gage spring brass without welded or staked joints. They are held positively in place by locating bosses and slots molded permanently in position, eliminating any shifting of blade position during installation and operation.

All series AC-42 Cycle Timers are equipped with amp "Ark-Les" quick disconnect type terminals for rapid, easy hook-up and ready replacement of or repair.

Circle No. 236 on Subscriber Service Card.

Automatic Compressed Air Dryers Now Available

Desomatic Products, Inc. are now in production on two sizes of small, inexpensive compressed air dryers for drying small quantities of compressed air, from 1 to 25 SCFM, with inlet pressures up to 125 psig and inlet temperatures up to 120°F.

This dryer is fully automatic, using a small amount of heat for reactivation. The components are simple—only two moving parts, a timer and solenoid type 4-way valve.

The desiccant towers are of the throw-away type and easily replaced by breaking couplings, loosening screw, pulling out plug-in heaters and replacing with a new tower. Heaters are permanently imbedded.

The desiccant and heaters will last several years under normal operation. There are built-in dust filters thereby assuring clean, dry air at dew points down to −60°F. or below.

Uses are dry air supply for controllers and instruments, precision air gauges, coaxial cables and wave guides, and small unit processes or machine operations where dry air is essential.

Circle No. 237 on Subscriber Service Card.

The man:

. . . a top missile scientist at White Sands, N. M., missile range where preliminary *Nike Zeus* tests take place. He is a key member of the highly specialized military-civilian team that is putting this agile anti-missile missile through its development stages.

When *Zeus* goes on active duty, it will follow Douglas *Nike Ajax* and *Hercules* missiles into service with the North American Air Defense Command. And it will be maintained by Army personnel assisted by Douglas field service men who have extensive experience in the *Nike* program.

The mission:

. . . anti-missile defense. *Zeus* will roar out from emplacements around cities and industrial and military areas to intercept approaching enemy ICBM's . . . or bombers.

CLASSIFIED

The missile:

. . . *Nike Zeus* is being developed by Douglas under a Western Electric-Bell Telephone program. System will include electronic detection gear to pick up enemy ICBM's at extreme range and then guide *Zeus* out to destroy them. Vital statistics: CLASSIFIED.

Depend on **DOUGLAS**

The Nation's Partner in Defense

propulsion engineering...

By M/R STAFF

Propulsion chemists . . .
and engineers can work faster, get more work done easier, thanks to a new shorthand developed for chemists and metallurgists by a U.S. Department of Commerce chemist. Gregg-type symbols represent all common words, arrangements and radicals, and much specialized terminology. The developer of the system, James Kanegis, is now Chief of the Chemical Section of Commerce's Office of Technical Services. Formerly he was a National Bureau of Standards metallurgist. Kanegis made news in 1957 when his 14-year-old daughter, Brenda, co-authored (with her father and Dr. Roger Gilmont) an American Chemical Society national meeting paper on cooking with glycerine.

Cryogenic, oxidize, catalyze, enthalpy . . .
are a few of the words of special significance to missile chemists that Kanegis has included in his chemical-metallurgy shorthand. There are also special symbols for these: organometallic, analine, pyrophoric, exothermic, modulus, stoichiometric, and over 1500 others. The system is based on a few fundamental symbols that cover realms of thought in chemistry. Specific words are modifications of the symbols. Therefore, it is not necessary to memorize the whole word list. There are symbols for all the important professional societies, and for the names of major chemical firms. Kanegis even has anticipated one very special need of the missile industry—he has included a curlicue to represent "Pentagon."

'Change of state,' and 1600 other phrases . . .
are symbolically represented for the convenience of propulsion chemists. Some of the others: Characteristic property, coefficient of thermal expansion, corrosion resistance, heat of combustion, nondestructive test, products of combustion, reaction kinetics, solid fuel, thermal expansion.

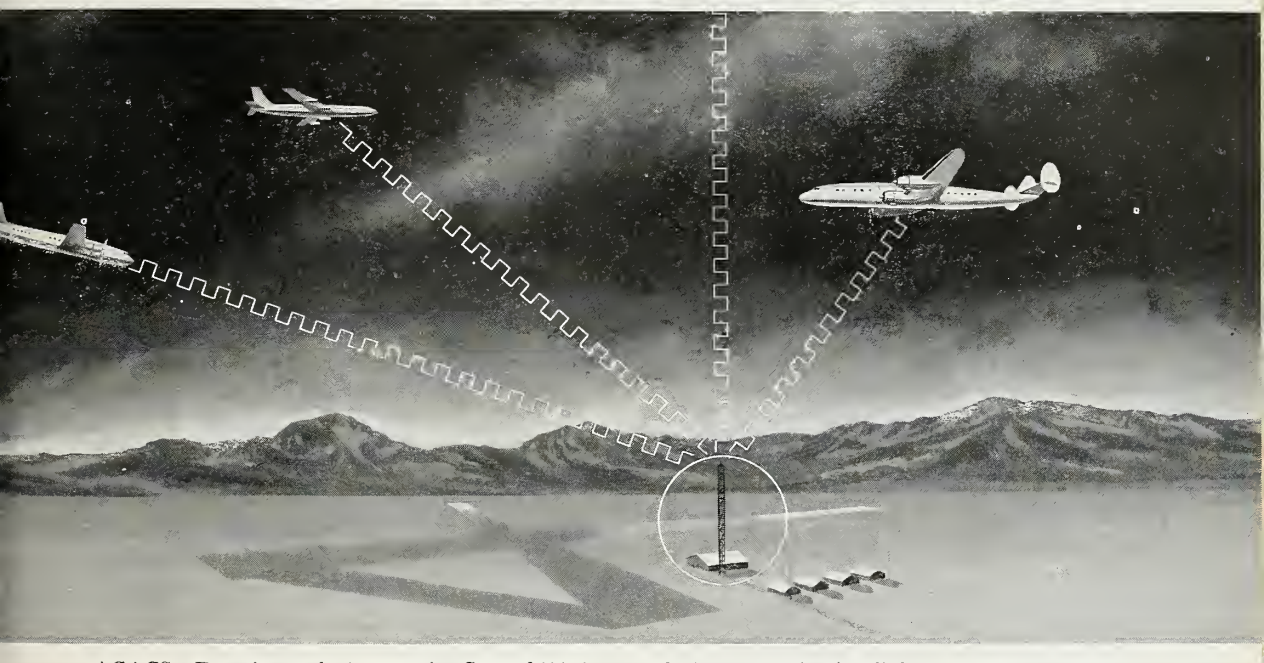
A short course in chemistry. . .
and one in metallurgy are presented in the Kanegis approach to teaching his chemical shorthand. This part is probably skipped by chemists, but is suggested by Kanegis as a means of upgrading clerical personnel to the point where they are much more valuable. The short courses, as they appear in a monograph Kanegis prepared some years ago (and has continually updated) will not make a chemist of a secretary. The subject matter is technical, but emphasis is on the forms and idiosyncrasies of technical expression. The form used is the Gregg shorthand, and Kanegis suggests prior study of conventional Gregg before tackling his chemical and technical shorthand. (He welcomes comments addressed to his home: 3907 Madison St., Hyattsville, Md.)

New missile fuel facilities . . .
are going on stream almost every month. Firms are breaking ground for others almost like clockwork. Here's the fall roundup. **Industrial Air Products Company's** LOX plant at Boise, Ida., is starting up. **American Potash & Chemical** is increasing capacity of its Aberdeen, Miss., sodium chlorate plant—a starting point for various perchlorate oxidizers. **Air Reduction Pacific Co.** (Air Reduction Co., Inc.) expects to have its 30-ton-per-day LOX and nitrogen plant in operation at Richmond, Calif., late this year. **Olin Mathieson** still is in the missile-aircraft picture despite Air Force high-energy fuel cancellations—O-M is opening up new facilities at Brandenburg, Ky., for propylene oxides and glycols, starting points for many fuel chemicals. **American Potash & Chemical's** lithium chloride facility at Henderson, Nev., is on stream—much of the output can go into lithium perchlorate, super oxidizer in solids.

new wings for words

AGACS

pronounced "AJAX"



AGACS, Experimental Automatic Ground/Air/Ground Communication System is a new concept in Air Traffic Control Communications to meet the accelerated pace of increased air traffic. Primary objectives are efficient usage of frequency spectrum, added safety through increased reliability and reduced burden to pilot and controller, and adaptability to all classes of aircraft. AGACS provides compatibility with existing ground and airborne communication equipment, selective addressing of information, and a minimum number of frequency changes during flight. The system utilizes two-way time division data transfer over existing ground and air communication links to provide an automatic, mutual exchange of information. The airborne facilities display to the pilot the last significant Air/Ground and Ground/Air message quantities, while the controller may recall from central memory-storage equipment the last Air/Ground and Ground/Air message quantities for display. The AGACS program is still in the developmental stage. In August, 1959, RCA provided initial models of both airborne and ground equipments for the Bureau of Research and Development of the Federal Aviation Agency for extensive experimentation and flight tests.

RCA Tmk(s) ®

RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS

CAMDEN, N.J.

Circle No. 47 on Subscriber Service Card.

He has brainstorms ...to order

He's one of a group of AMF scientists who develop solutions to the utterly original problems of modern defense and human penetration of space. He doesn't build *better* mousetraps. His business is completely new kinds of traps for mice that have never been caught.

Examples: A method of recovering potable water from human waste fluid, the major source of water in a sealed space vehicle... Methods of analyzing the effects of a nuclear blast on the earth's crust, how it changes the character of soil and rock, how its shock is propagated, what sort of building structure will withstand it... Platforms on which will be mounted primary standards calibration instruments for missile guidance systems. These platforms must be so vibration-free that natural earth movements must be compensated for. Platform vibrations are limited to millionths of an inch ...A method of predicting temperatures in missile nose cones upon re-entry.

Single Command Concept

These samples of creative ingenuity reflect the resourcefulness AMF brings to any assignment.

AMF people are organized in a *single operational unit* offering a wide range of engineering and production capabilities. Its purpose: to accept assignments at any stage from concept through development, production, and service training... and to complete them faster...in

- *Ground Support Equipment*
- *Weapon Systems*
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- *Range Instrumentation*
- *Space Environment Equipment*
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AMF

In engineering and manufacturing AMF has ingenuity you can use... **AMERICAN MACHINE & FOUNDRY COMPANY**

Circle No. 48 on Subscriber Service Card

——more about the missile week——

● **Edwards AFB, Calif.**—A **Boeing** *Minuteman* test vehicle shot skyward from an underground silo for the first time Sept. 15. The three-stage ICBM reached 200 feet above the ground before its flight was checked by a nylon cable attached in a noose to its nose. The first stage carried only enough solid propellant to launch the missile from the silo. The other two stages were dummies.

● **Washington**—Soviet Premier Khrushchev indicates it may be a long time before the Russians try to land a man on the moon. "We value human lives," he said at the National Press Club last week. He said Russia would consider shooting a man moonward "when the technical possibilities have been achieved. And that has not happened at this time."

● **Washington**—NASA Administrator Dr. T. Keith Glennan declared that Russia's successful moon shot would not cause any major change in the U.S. space effort.

● **Huntsville**—Dr. Wernher von Braun, director of development for the ABMA, sees Russia staying far ahead of the U.S. in space. "We have the brains, the resources, the capability, but we are hampered by continuous evaluations, justifications, re-justifications instead of progressing in our development in space projects." Added von Braun: "If Russia stops immediately we could catch them in one, two or three years."

● **Moscow**—Television observation of the moon and planets via satellites and rockets is next on the Soviet space program. Echoing Khrushchev's Washington statement, officials said that no manned flights would be attempted until the safe return of human passengers was assured.

● **Washington**—Wilfred J. McNeil, 58, resigned last week as Defense Department comptroller—effective Nov. 1. He will become president of the Grace Steamship Line.

● **Washington**—President Eisenhower signed the $1.4 billion military construction money bill. The bill—cut nearly $200 million below what the President requested—includes $550 million for construction of ICBM bases.

● **Cape Canaveral**—An Army *Jupiter* carrying frogs and 14 pregnant mice and other NASA experiments in its nose began to falter seconds after launching Sept. 15 and was destroyed. The IRBM developed engine trouble the day before—only a few hours before Premier Khrushchev arrived for his U.S. visit—and the downrange launching was understood to have been postponed for at least two weeks. Then the launching was suddenly put back on schedule for the next day.

● **Cape Canaveral**—The last missile of the much-troubled pioneer *Vanguard* series failed to ignite during a launching attempt in the early hours of Sept. 15. The *Vanguard* carried a 100-pound payload. Its launching was postponed indefinitely.

Shell-Casting Method to Cut Casting Time, Cost

LAVERNE, CALIF.—**Mercast Corp.** last week announced perfection of a new method of shell-casting of metal, which it said would allow faster casting and lower cost for many missiles, aircraft and electronic components.

A company spokesman said the new process, called "Ceramercast," allows the casting of configurations too large and too complicated for the existing processes that make use of lost-wax molds and frozen mercury. It makes possible precision castings of components that now must be produced by machining.

Semiconductor Output Being Increased by RCA

Radio Corporation of America is building a 120,000-square-foot plant at Mountaintop, Pa., near Wilkes-Barre, to expand its production of mesa transistors and silicon semiconductors. Plans call for manufacturing to start in mid-1960 with the employment of "many hundreds" by the end of the year.

The company estimates the semiconductor industry will have sales totalling $350 million in 1959. By 1965 they will approach $650 million a year.

Melpar Inc., a subsidiary of **Westinghouse Air Brake Co.**, is constructing a $2.4 million facility at its Falls Church, Va., headquarters to step up its electronic output. The building will be finished a year from now . . . With some floor space idle at its Dallas Plant, **Temco Aircraft Corp.** is now offering "instant manufacturing" capabilities to other firms through a new Industrial Division . . . **The Martin Co.** has created a new electronics division at Denver headed by G. Howard Teeter. . . . A 6000-square-foot refractory metals fabrication plant being erected by **Sylvania Electric Products Inc.** at Towanda, Pa., is scheduled to be ready early next year . . .

FIRST OPERATIONAL *Atlas* **fired by SAC troops at Vandenberg AFB on Sept. 9 is shown at blast-off in an official Air Force photo. It landed near Wake Island, 4300 miles west.**

Atlantic Research Buys Jansky & Bailey from GC

For a "substantial" amount of cash and stock, **Atlantic Research Corp.**, Alexandria, Va., propellant manufacturer, has purchased the Washington, D.C., electronics and communications firm from **General Communication Co.**, Boston.

ARC also acquired in the transaction 16% of the outstanding GC stock with a 5-year option to acquire a total of 25%. Dr. Arch Scurlock, ARC president, also becomes a member of the GC board.

Red Moon Hit Shows Guidance Prowess

by Paul Means

WASHINGTON—The Soviet Union launched a moon rocket on Sept. 12—three days before Premier Khrushchev's visit to the U.S. (as predicted by M/R Aug. 17, page 9).

The rocket's achievement gave further testimony to the accuracy of Soviet space vehicle guidance, the ability of Soviet space boosters to lift heavy payloads, and the capability of Soviet rocket engines to achieve specific desired velocities.

Early computations indicate that *Lunik II* had an injection arc error of only 1.5 seconds and a deviation from planned cutoff velocity of less than plus or minus 25 feet per second.

By comparison, a *Vanguard* can have an injection arc error of 1.5 degrees and still go into orbit. An *Atlas* ICBM can have an injection arc error of 10 seconds and a velocity cutoff error of 50 feet per second and still be effective.

As Dr. Herbert F. York, DOD R&E chief remarked last week, it is an easier guidance problem to hit the moon than it is for an ICBM launched from New York to hit Moscow. But, accepting the Soviet statement that they aimed for the center of the moon, and comparing the probable error (approximately 500 miles) to an ICBM trajectory of 6000 miles, the ICBM would have to miss the center of its target by less than 1½ miles to do as well.

There are other factors—such as re-entry (the moon has little atmosphere) and the report that the Soviet rocket was said to have had fourth-stage guidance—which do not make the two situations comparable.

• **Strong evidence**—In contrast to *Lunik I*, there was no doubt this time that *Lunik II* was launched and that it traveled very close to the moon. Major tracking installations in the free world—including the mammoth radio telescope at Jodrell Bank, England, and the 85-ft. parabolic dish at Goldstone, Calif.—locked on to the rocket's transmitter and received strong, usable signals.

A U.S. scientist theorized that the Soviets could have designed a clock mechanism for the rocket's transmitters which would have turned off the signals at the time the Russians said the payload would hit the moon. An overwhelming number of rocket experts disagreed, pointing out that it would have almost been impossible to fake the Doppler shift or acceleration change in the signals that was noted by Jodrell Bank when the rocket came within the moon's gravitational field.

Final proof of the Soviet success will come when the signals recorded by Jodrell Bank are fed into a computer.

Also in dispute was a statement by Vice President Richard M. Nixon that the Russians had failed three times in the two weeks preceding Sept. 12 to launch a moon rocket. Though U.S. intelligence and radar stations may have picked up three rocket failures, astronomical conditions were not favorable for a moon shot during much of this period.

• **New fuel used?**—Judging from the Soviet description of its trajectory and payload, *Lunik II* apparently was a sister vehicle to the earlier Russian moon rocket. One Soviet scientist hinted, however, that the new rocket used a new fuel combination. The vehicle was probably launched at the Russian base northeast of the Aral Sea. (See M/R, Sept. 7, p. 21.)

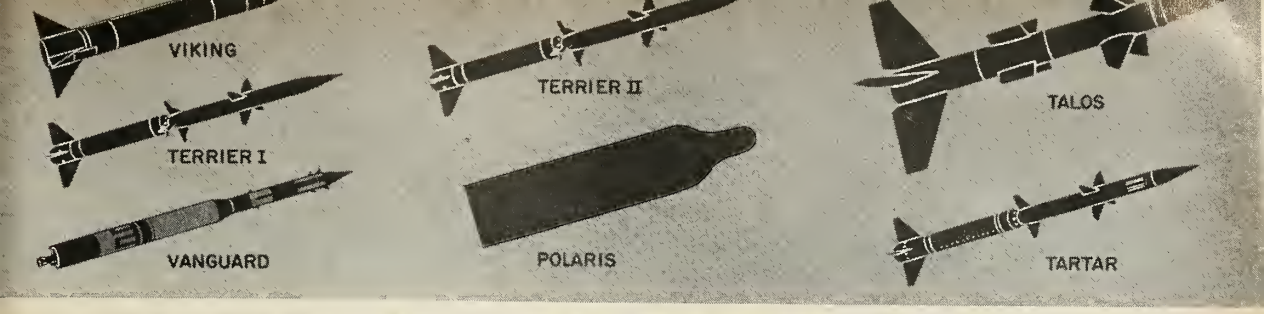
The final stage and payload contained 780 pounds of scientific instruments, small rockets and a guidance system, and pennants bearing the Russian coat of arms.

The instruments included radiation experiments designed to reveal more information about the earth's charged particle belts, the earth's magnetic field, cosmic rays, micrometeorites, and about interplanetary gas.

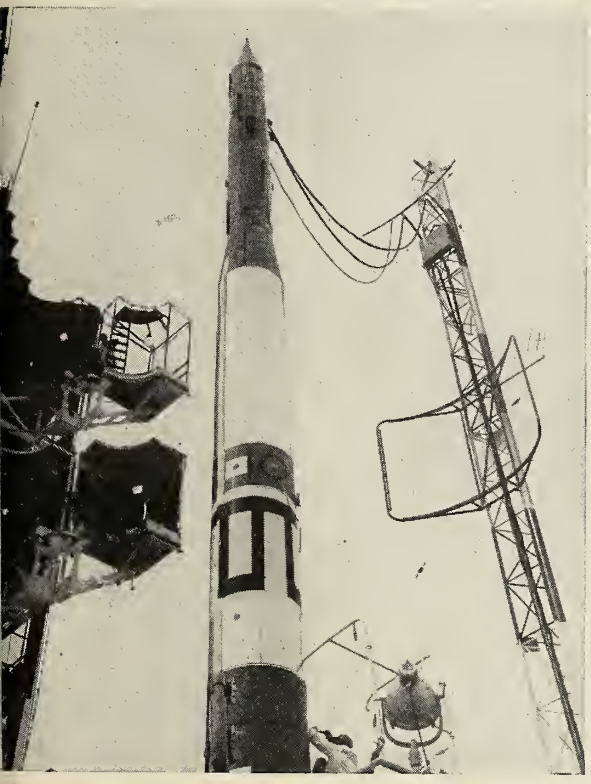
The capsule was said to have carried a special radio circuit called a "moon altimeter" which, when switched on just before impact, was to supply information about changes in the rocket's altitude relative to the surface of the moon. Judging from the weak signals Jodrell Bank received before impact, it is doubtful that this instrument yielded information.

Like *Lunik I*, *Lunik II* released a sodium cloud at about 88,000 miles. The director of the Abastuman Observatory of the Georgian Academy of Sciences reported his team took 12 photographs of the cloud, one of which was released to the Western press.

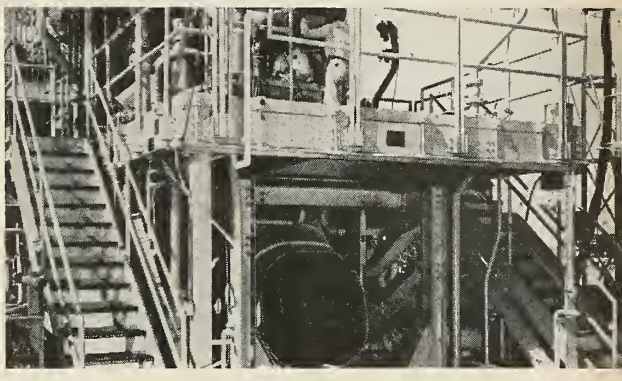
Prof. Yugi Kalinin, Russian specialist on terrestrial magnetism, said that the rocket would also help verify that the liquid core of the earth is the source of its magnetism. The moon is known to have no liquid core, and if no signs of magnetism were recorded when the rocket approached the moon, the hyphothesis would have a stronger basis.



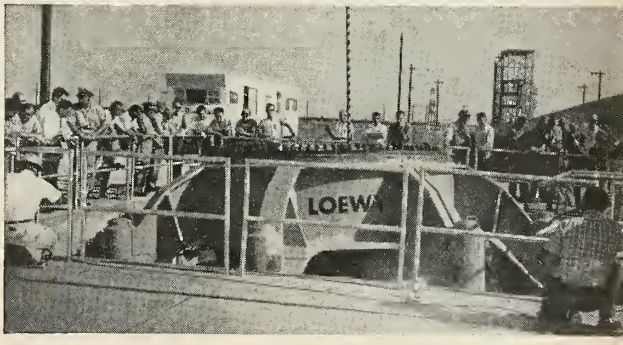
Loewy-Hydropress has been engaged in building handling, stowage and launching systems for these rockets and missiles.



Vanguard rocket being readied for launching on March 17, 1958.



Testing and firing installation for Viking and Vanguard rockets.



Ship motion simulator for test-firing U.S. Navy's guided missile "Polaris" under seagoing conditions.

Loewy ground handling and launching systems in successful operation and in progress

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Loewy-Hydropress has also been chosen to design systems for the protection, handling and launching of surface-to-air supersonic missiles and missile components for the Navy's first nuclear-powered cruiser, *Long Beach.*

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west coast industry . . .

By FRANK G. McGUIRE

Considerable irritation is being expressed by newsmen over their handling during the recent operational *Atlas* shot at Vandenberg AFB. Following a statement at the AFA meeting in Florida that the launching was scheduled for September 9, USAF here declined to confirm or deny that the date was accurate, and would not permit reporters to cover the shot. Finally, one and a half hours before launch time, the press was notified in Los Angeles that it could cover the event. Driving time from LA to VAFB is three and a half hours. Celebrations planned by **Convair** and the Air Force were reluctantly cancelled, following orders from Assistant Defense Secrectary Murray Snyder that the shot be closed to the press. No reason was given for the orders.

Electronics Capital Corporation . . .

has made five appointments to its executive staff. The three-month-old company furnishes capital and management to electronics and allied firms capable of associating in special groups to bid on government contracts. Clarence A. Wetherill, senior technical officer, was formerly chief engineer at **Stromberg-Carlson;** Elliot Lewis, assistant to the president, organized and directed the PR department at **Ramo Wooldridge;** Harold M. Gruener, senior management services officer, previously was executive VP and general manager of **Intertectics Corp.;** Daniel I. Fellers, controller and financial planning officer, joined ECC from his post as assistant professor at San Diego State College; and Wilford D. Willis, assistant general counsel, was formerly contract administrator for the **Convair** 880 program.

Meletron Corporation has split . . .

into two separate corporations owned by the same stockholders, and retaining George A. Starbird as president of both. The **Meletron Corp.** becomes a sales and engineering firm, transferring all production activity to the newly-formed and wholly-owned subsidiary, **Pressure Switch Corp.** Richard L. Shelton, comptroller for three years, becomes vice president and manager of PSC. Sales for the year ending July 31 were $1,750,000.

Lockheed's hourly-paid employes . . .

have received a cost-of-living bonus amounting to 2¢ - 3¢ per hour, depending on job held. Maintenance electricians get the 2¢ raise, and all other hourly-paid employes receive the 3¢ raise.

No subcontracting worries in Russia . . .

according to George P. Brubaker, president of **Brubaker Electronics** and VP of **Telecomputing Corp.** "Major plants in Russia are completely self-contained," he said, "and handle all the minor work that we would subcontract out. When something rolls off the line over there, it's ready to go to work." He predicted that the USSR will soon lead the United States in steel production, and possibly in oil production. "The United States is on an economic island," he stated, "and will soon face the question: 'How long can we trade with ourselves?' There might be benefits in trading with the USSR."

Houston Fearless Corp. reorganization . . .

recently approved by the California Corporation Commission, has brought a powerful management group to the company. Noah Dietrich, former Howard Hughes financial associate, Emmett Steele, ex-**Litton Industries** military sales head, and Richard Woike, Eastern financier, are expected to take the company into much bigger things. The firm says it is now "up to our ankles in military electronics, and will soon be up to our necks." Barry Shillito, former **Hughes Aircraft** Sales Director, joined the 30-year-old company this month, and he will reportedly be followed by additional management talent. HF is paving the way for a number of acquisitions soon, in the areas of advanced military and industrial electronics, with emphasis on communications and guidance.

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contracts

NAVY

$30,000,000—**Raytheon Manufacturing Co.,** for advanced submarine sonar equipment.

$9,400,000—**Texas Instruments, Inc.,** for airborne radar systems.

$360,000—**ACF Industries, Inc., Avion Division,** for production of radar beacons for use in testing *Corvus* air-to-surface missiles.

$245,000—**Electro-Mechanical Research, Inc., Ascop Division,** Princeton, N.J., for four mobile self-propelled FM/FM telemetry trucks.

$200,000—**Telemeter Magnetics, Inc.,** Los Angeles, for a core memory.

$107,000—**Syracuse University,** for research in high-energy physics.

$44,490—**Purdue Research Foundation,** for studies pertaining to arc plasma.

$42,411—**Dunlap & Associates,** for research in connection with *Tartar* weapon system.

ARMY

$4,900,000—**Aerojet-General Corp.,** Azusa, Calif., for surveillance drone systems.

$3,900,000—**Kaiser Steel Corp.,** for tower for *Saturn* project.

$2,697,117—**North American Aviation, Inc., Rocketdyne Division,** Canoga Park, Calif., for research and development.

$2,000,000—**Raytheon Manufacturing Co.,** Waltham, Mass., for engineering services on the *Hawk* missile.

$1,893,432—**Blount Brothers Construction Co.,** Montgomery, Ala., for construction of *Bomarc* facilities at Langley AFB, Va.

$1,676,814—**Douglas Aircraft Co., Inc.,** Santa Monica, Calif., for maintenance and operation services for the *Nike-Hercules* anti-aircraft missile.

$1,641,714—**Bell Aircraft Corp.,** Buffalo, N.Y., for a visual surveillance system.

$1,634,762—**Purvis Construction Co.,** Yardley, Wash., for construction of a radar site at Sundance, Wyo.

$102,238—**Tung-Sol Electric, Inc.,** Newark, N.J., for electron tubes. (Two contracts.)

$97,908—**Radio Corp. of America,** for study and development of a calculating light modulator.

$68,064—**Radio Corp. of America, Electron Tube Division,** for electron tubes.

$31,501—**Western Electric Co.,** N.Y., for *Nike* spare parts and components.

AIR FORCE

$73,400,000—**Avco Corp.,** N.Y., for research and development on *Titan* nose cone.

$36,700,000—**Avco Corp.,** N.Y., for *Minuteman* nose cone.

$29,209,851—**General Electric, Missile and Space Division,** Philadelphia, for production of *Thor* IRBM nose cones.

$9,000,000—**Burroughs Corp.,** for thirty-six SAGE air defense units.

$5,200,000—**Sperry Gyroscope Co.,** for radar sets.

$5,000,000—**Martin Co.,** Orlando, Fla., for work on *White Lance* air-to-surface guided missile.

$4,500,000—**Radiation, Inc.,** Melbourne, Fla., for development of airborne telemetry system for *Minuteman.*

$1,059,300—**Dynamics Corporation of America,** for twenty portable radar antennae groups.

$500,000—**Electronic Specialty Co.,** Los Angeles, for electronic fusing timers for the *Genie* air-to-air missile. (Subcontract from **Douglas Aircraft Co., Inc.**)

$300,000—**Marquardt Aircraft Co.,** Ogden, Utah, for services in connection with the testing engines used on the *Bomarc* missile.

$182,000—**Boller & Chivens, Inc., Joseph Nunn & Associates,** S. Pasadena, for satellite tracking camera.

$150,000—**National Research Corp.,** Cambridge, Mass., for high-energy solid propellant missile fuels.

$95,550—**Raytheon Co.,** Waltham, Mass., for electron tubes.

$61,000—**Convair Division of General Dynamics Corp.,** for development of X-ray standards for determining the strength of steel castings.

$42,761—**Yale University,** for research on kinetics of Uninolecular and Halogen atom reactions.

$40,000—**Amperex Electron Co., Division of North American Phillips Co., Inc.,** for electron tubes.

$30,700—**University of Minnesota,** for continuation of research in gaseous electronics.

$27,202—**University of Wisconsin,** for research on Addition and Displacement Reactions with Unsaturated Hydrocarbons.

MISCELLANEOUS

$14,500,000—**General Dynamics Corp.,** for its part in nuclear electric power plant at Peach Bottom, Pa.

$2,000,000—**Advanced Technology Labs,** for nuclear power reactor research and development.

Explore new areas at IBM in

MATHEM

At IBM, creative mathematicians are discovering important, new applications of mathematics in the electronic computer field. Long before actual construction of IBM's unique Magnetic Character Sensing Machine, for example, mathematicians were at work on a mathematical model, testing both the over-all design and the logic circuitry needed for character recognition. In another project, mathematicians employed large-scale computers to simulate, in a matter of weeks, eight years of engineering work which have yet to begin. Currently under study are vehicular penetration problems involving thousands of variables. Projects of this sort demand keen, discerning minds. If you have a flair for creative mathematics, you're the man we want to talk to.

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moscow briefs

by Dr. Albert Parry

The model of Pioneer IV, seen by Professor Georgi I. Pokrovsky at the American exhibit in Sokolniki, impressed this outstanding Soviet rocket expert as "made quite well." Writing in *Sovetskaya Aviatsia* of his impressions, Dr. Pokrovsky states that since Americans "succeeded in maintaining radio communications with this construction at a distance of more than 600,000 kilometers," this U.S. satellite of the sun "doubtless represents an achievement of American instrument-making." But he criticizes the small size of *Pioneer IV*, "so small that it could serve as a desk ornament." He writes: "These dimensions apparently are not accidental. They are due to the weak force of American rockets which still are not able to hurl heavy enough machinery into outer space." He compares the lag in American rocket size and strength with the tremendous payloads of the Soviet *Sputniks* and *Lunik*.

Pokrovsky also comments on the model and photos of our *X-15* as studied by him at Sokolniki. He complains that the U.S. exhibit told him of the *X-15* "essentially less than is already known from the world's technical press." He notes that the *X-15* "has not as yet even once flown on its own rocket motor."

Professor Georgi I. Pokrovsky is not only a doctor of the technical sciences, but also a major general in the engineering-technical branch of the Soviet armed forces and, since 1947, on the faculty of the famous Zhukovsky Military Air Academy in Moscow. In technical literature he is known particularly for his book on *Guided Effect of Explosion*, written as early as 1942. Since 1957 he has written and published extensively on Soviet ICBM's. Professor Georgi I. Pokrovsky is not to be confused with Professor Alexis V. Pokrovsky, who is among the chief trainers and observers of dogs used in Soviet rocket shoots.

No Red missile base on Ruegen, says *Krasnaya Zvezda* as it reveals that East German Communist authorities recently took a group of West German newspapermen on a tour of that strategic Baltic Sea island, to prove to them that, despite reports in the Western press, not a single Soviet rocket installation existed anywhere on Ruegen. The tour took "nearly a day," the daily organ of the Soviet ministry of defense writes, but "instead of any rocket bases" there were on the island resting facilities for summerfolk and nothing else.

The memory of the Russian who was among the first to work out equations of motion of bodies with variable mass, and thus originated some of the fundamentals of the rocket propulsion theory, is now being honored in the Soviet Union. The 100th anniversary of the birth of Ivan Meshchersky was marked in August in the Soviet press and from the Red lecture pulpit. "It Is to His Labors that *Sputnik* Owes Its Existence," proclaimed a headline in *Komsomolskaya Pravda* on the occasion of Meshchersky's centenary. A professor at the St. Petersburg (now Leningrad) Polytechnic Institute, Meshchersky worked out and published his equations in the period 1897-1904. By 1959 his *Collection of Problems in Theoretical Mechanics* has gone through more than 20 editions.

A new monument to another Russian rocket pioneer was recently unveiled at the North Caucasian spa town of Kislovodsk. This is a memorial to Friedrich A. Tsander, a Lett from Russia's Baltic shore, who in 1908 began his rocket studies and experiments at the early age of 21, six years before he was finally graduated as an engineer from the Riga Polytechnic Institute. He was an ardent disciple of Tsiolkovsky. After the Soviet revolution, Lenin himself talked to Tsander, encouraging him in his rocket work and space-ship dreams. Tsander was a founder of one of the first Russian rocket societies, GIRD (Russian initials for the Group to Study Rocket Propulsion). Its members under his guidance built one of the first Soviet liquid-fueled rockets. Tsander died in Kislovodsk in 1933 at 46 before he could see this rocket's launching (it was fired successfully on November 25 of that year). The monument unveiled in Kislovodsk last month is tipped by an exact reproduction of Tsander's rocket.

Tsander is also remembered for his proposals to use aluminum and magnesium as rocket fuel.

Latest Soviet rocket joke circulated by irreverent Russians in Moscow—Question: "Why was Nicholas Bulganin like a rocket?" Answer: 'Because he launched Khrushchev into orbit but burned up himself."

Digging for *Titan*

Details of Work on A Hardened Complex

VANDENBERG AFB, CALIF.—Mine "mucking" and burrowing techniques are being used by construction engineers to dig a hardened *Titan* ICBM complex here.

They were employed to push

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MITRE, organized under the sponsorship of the Massachusetts Institute of Technology with a staff nucleus composed of the men who developed the SAGE System, is now expanding its Radar Systems and Techniques Department. The principal function of this department will be the development of advanced detection systems and techniques applicable to the nation's future air defense.

The work being performed by this department will afford the serious engineer or scientist an opportunity to apply his skills in areas that range from conceptual realization to proof of feasibility.

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through personnel access tunnels carrying piping, cabling, missile support connections and water between the missile silos, propellant terminal, equipment terminal, powerhouse and command control center. These units are all interconnected by tunnels ranging from 10 to 12 feet in diameter.

Usual clam-shell or drag-line methods could not be used in the excavation of the 43-foot diameter missile silos to a depth of 160 feet. Contractors instead employed a mucking machine with a half cubic yard toothed scoop, which bored the holes in the ground. Concentric ring pattern of dynamiting (with the center ignited first to prevent excess edge rock breakoff) was employed against shale.

The mucking machine dumped excavated material into a hopper which was hoisted to the surface by a 25-ton crane for disposal. With this system, **Daniel, Mann, Johnson and Mendenhall and Associates,** architectural and engineering group in charge of the project, reports excavation on a 'round-the-clock basis proceeded at the rate of 6 feet every 24 hours.

Silo shoring included 6 WF 25 beams, 6 x 6 x 10/10 electrical-welded wire mesh and gunite. DMJM says "the gunite proved to be more economical than steel sheeting and eliminated the necessity of grouting between the sheeting and the rock wall to fill the voids."

When tunnel openings were made later in the silo walls, instead of using only a jackhammer, the contractor drilled holes in the gunite at 12-inch centers and exploded one stick of dynamite every 30 inches. The silo walls are eight inches thick and 5000 psi in strength.

Silo walls were slip-formed in much the same manner as a grain silo, but with two big differences: 1) only one form was used for the inner wall face and, 2) a cylindrical, three-level slip form was suspended from steel rods attached to 20 cables equally spaced around the hile.

Ready-mixed concrete was poured at a rate of up to one-foot per hour at points where wall inserts did not slow down the operation. During pouring cycles pneumatic jacks pulled the slip form up the steel rods.

Surprisingly enough, the silo excavation required only up to seven men during preparation for blasting, and only two or three during the mucking cycle. Three men were on the crane and one on a dump truck.

Northwood Co., sub to general contractor **Matich-Sundt,** performed the excavation operation.

—when and where—

SEPTEMBER

Standards Engineering Society, 8th Annual Meeting, Investment in Survival, Somerset Hotel, Boston, Sept. 21-22.

Instrument Society of America, 14th Annual Conference and Exhibit, International Amphitheatre, Chicago, Sept. 21-22.

Airwork Corporation, Operations and Maintenance Symposium, Millville, N.J., Sept. 23-24.

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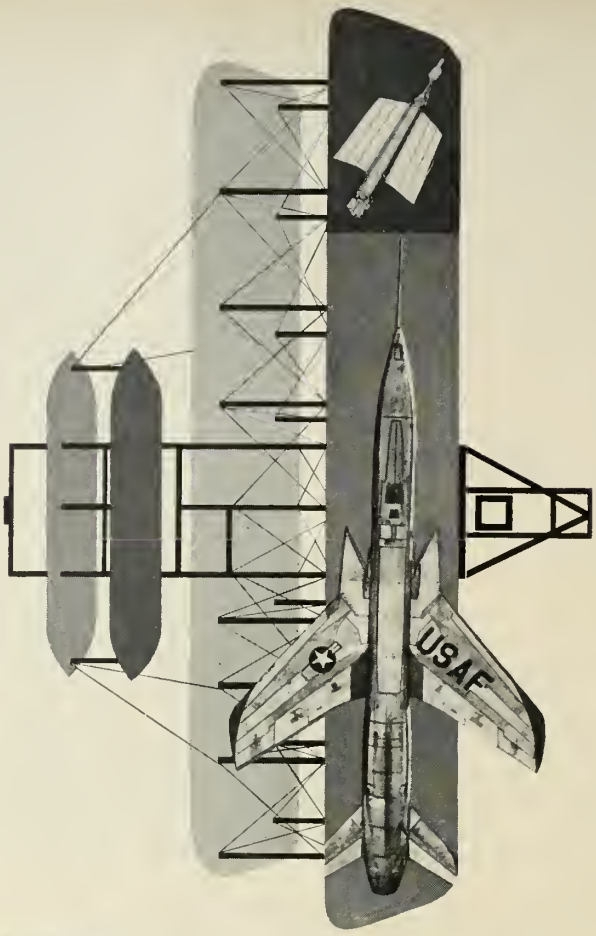

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Advertiser's Index

EMPLOYMENT SECTION

Management—Major Support Problem

There are job openings these days—or soon will be—for several hundred young men in an absolutely new career field. The educational qualifications are exacting but not unusual. The experience has only been available in the past year or so. The techniques have to be learned mainly on the job.

The position? Missile Base Management Engineer.

The number one problem in the missile field today is that of managing the support systems. The scope of these systems runs from ten-penny nails to steel tubes 10 feet in diameter. It includes packaging and shipping, transportation, handling and automatic checkout, refrigerants, hydraulic and electric systems, storage and transfer of highly explosive fuels, valves, tubes, transistors—nuts and bolts. The missile support field utilizes and must have the talents of the architect engineer, the electronics engineer, chemical engineer, electro-mechanical engineer, mechanical engineer and construction engineer.

The duties of the Missile Management Engineer? To bring all of these component parts and skills together.

There is very little understanding today on the part of the public, Congress, the military and space agency—even industry itself—of the cost and complexity of the missile base management problem.

Consider the ICBM, either *Titan* or *Atlas*. Here is a missile built at a cost of approximately $2 million. A squadron of nine is moved to a base which cost $45 million to construct and another $45 million to equip. There the giant missile sits, pre-targeted, ready for its fuel, ready for its hydrogen warhead, linked by dozens of slender arteries to dozens of support systems which once—only once—may bring it to life. The time could be next month or next year, two years or five—or never. But if the call comes and at whatever time, every one of the thousands of parts in this vastly intricate system must work instantly and must work perfectly.

Only now and only barely are we beginning to realize that the missile base and the missile support equipment are simply extensions of the missile itself. A rifle bullet is made and fired from a gun, a shell from artillery, a rocket from an airplane. A manufacturer makes them according to specifications and there his responsibility ends.

With the big ballistic missile, the equivalent firing or launching mechanism must be designed concurrently with the missile. A company building a missile engine must know if that engine is going to be installed while the missile is vertical or horizontal—because while building the engine it also has to design and build a sling which can install it. And, just incidentally, how do you install a multi-megaton thrust engine in a missile approaching the size of the Washington Monument?

By the very nature of the situation, much of the ballistic missile support equipment has to be tested in the field. Much of it has been virtually built or rebuilt there. For example, we learn that in the first 30 days of construction of the *Atlas* base at Cheyenne, 70 change orders were passed down to the Corps of Engineers building the base. These orders simply reflected either changes in the missile itself or changes in a major piece of support equipment.

In another instance a company installing the communications system at a missile base so underestimated the difficulties of the job that they sent "desk" engineers to manage it. After some weeks of trying—including attempts to lay coaxial cables across dirt roads used by bulldozers—the company threw in its "red necks." Used to field conditions and to improvising, they got the job done.

No one in particular is at fault—just the circumstance that no one foresaw the magnitude and the complexity of the job which still has to be done. The military and industry are now learning the missile base facts of life, now beginning to understand that at an ICBM base the air conditioning, the power supply, the access tubes to checkout equipment—all of these and thousands of other parts and subsystems are just as important as the bird itself.

This missile base management job is an exercise in intricacy, a test of ingenuity, skill and vision, a bag of worms. And its solution is the most important problem facing industry and the military today if the ICBM is to take its place in the deterrent arsenal of the nation.

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NEW PRODUCT BRIEFS

RANSISTOR COMPUTERS. Two new -transistor computers, one to serve all businesses and the other to cope th the tremendous paperwork load of dustrial giants, were announced re-ntly by the Radio Corporation of merica. The RCA 502 and RCA 504 e said to broaden the scope of the CA 501 electronic data processing sys-m. Until now, the 501 system had ilized only the RCA-503, the medium-ale computer. With this pair of addi-nal 'brains,' RCA believes the effi-ency of the RCA 501 system has been tended to meet virtually any data ocessing situation. According to RCA okesmen, the all-transistor RCA-501 stem using the 503 computer was de-loped originally to bring full-scale ta processing to the medium-sized m.

cle No. 225 on Subscriber Service Card.

ENERATING SETS. The entire new line Diesel-Engine-driven Electric Generat-g Sets, recently announced by D. W. nan & Sons Inc., is described and illus-ted in an attractive 2-color folder re-ntly issued by the Minneapolis firm. ese heavy-duty Diesel Sets provide a pendable continuous source of elec-city for all types of rugged opera-ns . . . oil fields, heavy construction es, mining camps, railroads and light nstruction jobs, too. And in emer-ncy power applications where low-vola-e Diesel fuel is preferred over gasoline, ese new Onan Diesel electric plants ovide quick-starting auxiliary power hospitals, institutions, radio & TV sta-ns, hatcheries, motels, microwave in-llations and military requirements. ecifications and illustrations of these mpact, powerful Diesel sets, in sizes nging from 3,000 to 6,000 watts (air-oled) and from 10,000 to 230,000 tts (water-cooled) are included in the page folder. Diesel-driven marine elec-c generating plants are also described are a complete selection of acces-ies and controls.

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ECISION COUNTERS. A line of sim-fied design precision counters which said to completely eliminate transfer sks or shades and have no interrupted aring to complicate operation is ing offered by Chicago Dynamic In-stries, Inc., Precision Products Divi-n. Series AD-1 counts hours, degrees, s, minutes, etc. and returns to zero, n repeats. Because these units do not unt in multiples of 10, they are ideal for applications where the counter must repeat from zero with continued rotation after a count other than 99,999,-9999, etc. such as 359 degrees, 6300 mils, 23 hours, 59 minutes, etc. Type 1400 degree counters read through 359.9° to zero and repeat with continued rotation. Type 1401 mil counters read through 6399 mils to zero and repeat with continued rotation. Both types are bi-directional and add with clockwise rotation of the input shaft. Both types have an operating temperature range —60°F. to +165°F and meet MIL-E-16400-B and applicable parts of MIL-STD-167.

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COMBUSTION TERMINATION. By rapidly lowering the pressure in solid propellant gas generators such as those used in rockets, a valve by the Aero Supply Co. valve terminates combustion in the gas generator. The valve, No. 33-2258-000, is hydraulically operated and is designed so that it may easily be modified as to line sizes and configuration.

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TRANSFORMER SERIES. An all-new 2 KVA series has been introduced to complete the range between the 1 KVA and 3 KVA Powerstat variable transformer types by the Superior Electric Co. Called the 126-226 Series, these compact, functionally designed variable transformers are available in open, enclosed, fused, cord-plug and enclosed terminal models; single, two-and three-gang types; manually-operated and in 5, 15, 30 and 60 second motor-driven assemblies. They feature zero waveform distortion, excellent regulation and high efficiency. The commutator surface is rhodium-plated for smooth operation and long life. Terminals accommodate push-on connectors, lug, wrap-around or soldered connections. Output voltage can be limited to line voltage or to 17 percent above line voltage. Single units in the 126 Series are for use on 120 volt, 1-phase lines and ganged units for 240 volt, 1-or 3-phase duty. Ratings are 12.5 amperes on constant-current loads and 18.0 amperes on constant-impedance loads. Single units in the 226 Series are for 240 volt, 1-phase lines and ganged units for 480 volt, 1-or 3-phase service. Ratings are 6.0 amperes on constant-current loads and 9.0 amperes on constant-impedance loads.

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MISSILE LITERATURE

FILTER MATERIALS. A two-page, two-color, 8½ by 11 in. bulletin describing seven basic filter element materials and various series of filter assemblies and replacement elements is now available from the Bendix Filter Division, Bendix Aviation Corp. The bulletin illustrates each of the filter element materials with two photographs, including photomagnifications. The materials discussed provide particle size control from ½ to 250 microns in temperature ranges from minus 350F to plus 1500F. Nine different filter assembly and replacement element combinations are also illustrated with photographs.

Circle No. 200 on Subscriber Service Card.

EPOXY RESIN. Processes for insulating transformers to meet the grades of MIL-T-27A with scotchcast brand epoxy resin are outlined in a new eight-page booklet issued by the Minnesota Mining and Manufacturing Co. Sections of the booklet deal with background on MIL-T-27A, transformer 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. The booklet is intended as a guide to the construction of transformers to military specifications, their design and special techniques which have been successful in meeting such specifications.

Circle No. 201 on Subscriber Service Card.

RADIATION SOURCES. A 12-page brochure has been put out by Nuclear Systems Division of The Budd Co. detailing its capabilities to provide radiation sources for irradiation research, radiography and teletherapy. The publication illustrates and describes Nuclear Systems radioisotope encapsulation facilities—its hot cell has a 50,000 curie capacity—its training courses for new customers, and its lines of radiography, teletherapy and irradiation sources.

Circle No. 202 on Subscriber Service Card.

GAS TURBINES. A 12 page booklet issued by General Electric describes the new J85, a compact, lightweight turbojet designed to power subsonic and supersonic missiles, drones, and small-to-medium size piloted aircraft. Included is information on engine design, performance, test progress and current applications on Northrop's T-38 "Talon" trainer and N-156F "Freedom Fighter," the McDonnell GAM-72 decoy missile and Northrop Q-4B Supersonic target drone.

Circle No. 203 on Subscriber Service Card.

DATA PRODUCTS. A quick-reference catalog on Benson-Lehner data products defines the term "record reader" and discusses the various types of record readers produced by the Corporation. The catalog discusses special purpose record readers which are used to convert information recorded in pictorial or graphic form into either digital or proportional analog resistance form. The catalog also describes various types of automatic plotting machines used for graphing business, military, and scientific data from a variety of inputs including punch-cards, punch-paper tape, magnetic tape, manual keyboard and the outputs of automatic data handling systems.

Circle No. 204 on Subscriber Service Card.

INPUT SCANNER. A new bulletin d tailing specifications and features of multiple point input scanner is now ava eble from the KIN TEL Division of Co Electronics. The bulletin describes t KIN TEL model 453M scanner, an e tremely flexible and versatile input d vice designed for any application whe a number of signals must be scanne Up to 400 individual points can scanned by the model 453M and wi a 453S slave unit attached, 1000 poi may be scanned. Channel numbers a displayed on a 3-digit readout in nu erals 1⅛" high. Switching is acco plished by electromechanical stepp that advance each time the inp reaches null balance. Complete inf mation on operation, application a available accessories for the model 45 are included in the bulletin. Specifi tions covering the scanner's controls, c play and timing are listed in detail

Circle No. 205 on Subscriber Service Ca

PACKINGS. A revised catalog issu by the Greene, Tweed & Co., prese in detail what Palmetto self-lubricati packings are and describes their adv tages and applications on pump r and shafts and valve stems. The t opens with a description of the four c ferent stranded forms of Palmetto s lubricating packings and their constr tion methods. The booklet's data inf mation includes calculator tables weights and lengths, and order instr tions. Each one of the 29 Palmetto s lubricating packing types is illustrat and described. Details include rec mended service, uses, temperature lim sizes, standard packagings and pri One page is devoted to a compreh sive applications chart which pinpoi the correct type of packing for e type of service. Molded Packings Sheet Packings are also illustrated.

Circle No. 206 on Subscriber Service C

THERMOCOUPLES. A newly revis fully illustrated Catalog, EN-S2, of complete information about Leeds Northrup's full line of thermocouples a thermocouple components and access ies, and available on request. The p lication lists and describes standard semblies in protecting tubes and w for general applications; speciali thermocouples and assemblies for lab atory and industrial applications, and extensive line of bare and insula thermocouple wires, replacement ments, ceramic insulators, metal ceramic protecting tubes, wells, term heads and extension leadwires. Rec mendations are given on the choice use of thermocouples and assemb and on the limitations of protecting t and well materials.

Circle No. 207 on Subscriber Service C

PRINT, PLOT SCALER. A new desc tive bulletin covering the firms M ADRS2-5 Print-and-Plot Scaler is nounced by the Victoreen Instrum Company. The bulletin, Form 302 outlines the features of the instrum which is described as being desig for accurate digital and analog reac of spectrographic equipment. In a tion to giving suggested applicati the illustrated bulletin details speci tion and performance data.

Circle No. 208 on Subscriber Service C

Avco "primes" America's newest peacemaker — Newest weapon in America's atomic defense is the Navy's submarine-launched missile, Polaris. The critical job of making sure the Polaris detonates on time and on target was handled by Avco's Crosley Division. Arming and fuzing for the Polaris—like the recent development of the Air Force's Titan nose cone—is typical of Avco's role in U. S. missilery.

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DATASYNC is a new breakthrough in data recording capability . . . combining multi-channel Magnetic-Tape with Optical "Panoramic Video" Picture Data, on a single "Datasync" Film for immediate and reliable self-synchronized "Quick-Look" capability, only minutes after recording!

The **Convair** Division of General Dynamics is producing this Airborne Frequency Monitoring and Interference Control Airplane which carries 51 antennas and uses **Datasync** Equipment to record Panoramic Video optically, plus a "Steno-track" of the intercom conversations between technicians in the aircraft, and between the aircraft and the ground station controls, together with independent recording of time-base signals, etc.

The basic design of this Aircraft is planned for down-range checking at all missile test and launching ranges. It may also be used for checking the functional and electronic environment of DEW Line installations and other defense system ground installations equipped with such components as SAGE "Texas Towers" and "P" Sites.

Datasync performance and reliability are guaranteed by Berndt-Bach's experience in manufacturing Electronic-Optical Recording Equipment since 1931.

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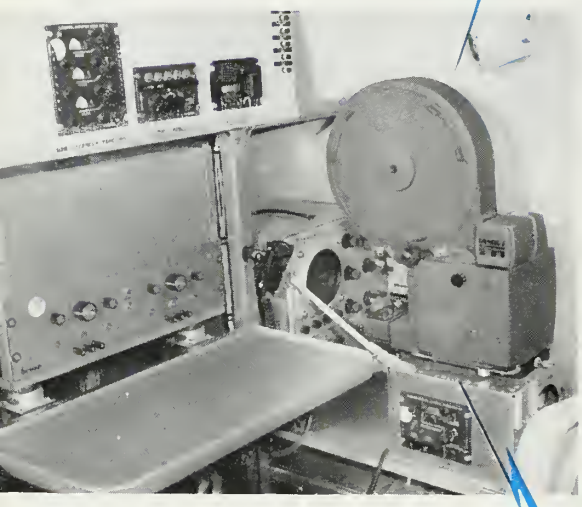

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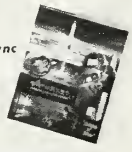

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