OCTOBER 12, 1959

PLASMATRON TESTS
FOR X–15 NOZZLE

missiles and rockets

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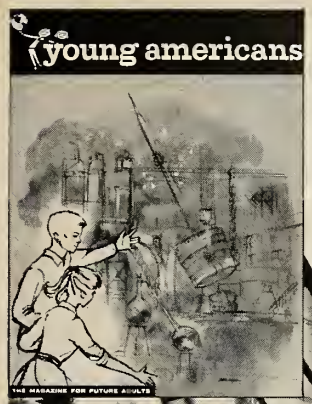

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Propulsion .....MICHAEL LORENZO
Industry .....JAMES J. HAGGERTY, JR.
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missiles and rockets

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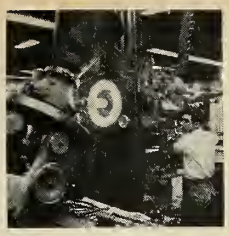
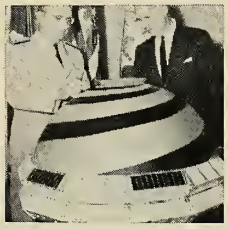


COVER: Ceramic-coated metal used in the exhaust nozzle of the *X-15* engine built by Thiokol Chemical Corp. is subjected to temperatures well in excess of the 5000°F it must withstand.



ANTENNA system of *Transit* R&D model is studied by Rear Adm. K. S. Masterson, Assistant CNO (Development) and Assistant Navy Secretary (R&D) J. H. Wakelin, Jr. See story starting on p. 16.

ARMY'S Michigan Ordnance Missile Plant near Detroit, run by Chrysler, turns out *Jupiters* and *Redstones*, employs 10,000. Auto firms are working to bring in more missile work. See p. 18.

TITANIUM'S first big use in missiles was this 50-lb. helium bottle for the Convair *Atlas*. Titanium and plastic are making inroads in steel's near-monopoly for solid motor cases. See p. 29.

OCTOBER 12 HEADLINES

ASTRONAUTICS ENGINEERING

U.S. Reg. Pdg.

ASTRIONICS

NEW MISSILE PRODUCTS

THE MISSILE WEEK

U.S. Reg. Pdg.

DEPARTMENTS

COMMUNICATIONS...

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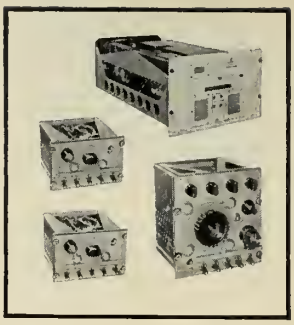

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Washington Countdown

IN THE PENTAGON

Stiffening of ASW . . .

defenses is not far off. **Minneapolis-Honeywell's** *Asroc* is scheduled to be deployed aboard ships beginning next year. Some of the Navy's big new destroyers are expected to get the anti-submarine missile first.

• • •

Deployment of *Subroc* . . .

isn't too much further away, either. The **Goodyear** torpedo-missile is expected to be operational in not much more than a year. It will be put on nuclear-powered submarines for firing from regular torpedo tubes. The Thresher —scheduled to be launched in January, 1961 —is expected to get *Subroc* first.

• • •

***Discoverer VII's* launching . . .**

now is scheduled for later this month. ARPA planned to launch the R&D satellite late last month . . . then postponed the shot to make further studies. The new launching will be another attempt to recover a capsule from orbit. Again no wildlife.

• • •

A hot new project . . .

has been added to ARPA's portfolio. The highly classified effort is a costly one and is expected to become more so. It is understood to involve both space and the environment of earth.

• • •

Killing enemy satellites . . .

is one of the latest weapon requirements laid down by the Pentagon. The new weapon would be a satellite sweep system capable of finding and destroying enemy satellites. **Motorola** is making a study for the detection system.

• • •

Where the budget ax falls . . .

next is the question of the moment in all three services. The atmosphere may have been best expressed by an official who, when asked if *Dyna-Soar* might be in jeopardy, said: "I don't think so. I looked in on the project officer yesterday and he hadn't hung himself."

The shakeup of ARDC . . .

may not be the end of Air Force readjustments at the present time. It may lead to a complementary shakeup in the Air Materiel Command.

At NASA

An about-face . . .

appears to be in the works at NASA. Informed sources say the agency plans to speed up its programs because of the *Luniks*, and is preparing a supplemental budget for Congress to okay to cover the added cost. NASA earlier this year told Congress it had as much money as it could spend wisely.

• • •

Feverish efforts . . .

already are underway to get another *Atlas-Able* rocket ready to launch a moon-orbiting satellite late this month or early in November. If NASA misses that date, a launching will be attempted in late November. The planned moon-orbiting shot had to be called off early this month after the only *Atlas-Able* that NASA had available exploded.

• • •

The first *Little Joe* . . .

launching is recorded as a complete success. The Project *Mercury* test vehicle's booster, launcher and destruct mechanism performed exactly as planned. The next of five more launchings will test the performance of the *Mercury* capsule during recovery.

AROUND TOWN

A French space program . . .

is expected to get under way shortly. All French non-military R&D is now under the direction of one man—Pierre Piganiol. And he is understood to be planning to spend francs first on space.

• • •

Some of the reports . . .

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

. . . Loud and long demands for Pentagon reorganization are a sure thing in the coming months.

. . . The next Russian space feat probably will be a soft landing on the moon.

. . . *Samos*—the ARPA-Air Force reconnaissance satellite project—is not showing as much promise as had been hoped.

Industry Countdown

MANUFACTURING

Scaled-up 10-million-lb. . . .

thrust solid booster is being pushed by **Thiokol.** Company studies show it would be feasible to fabricate at launch-site a 107-ft.-long, 20-ft. diameter vehicle weighing just under 3-million pounds fueled. The huge motor would cost (after development) $3,769,000—about one-third as much as a comparable-size booster by alternative methods. Chief hitch: development might cost $100 million.

• • •

Look for major switch . . .

to non-nuclear warheads for missiles. DOD's strategists see a need for highly effective conventional explosives to maintain the Nation's security if there is nuclear disarmament agreement with Russia or if a nuclear stalemate is reached. R&D of new explosives will be required to yield a "big punch" from a relatively small missile package.

• • •

Big competitor to hydrofoils . . .

as the Navy's high-speed submarine killer is Britain's Hovercraft. **National Research Development Corp.** reps are now in the U.S. telling armed forces how the ground cushion effect vehicle would be less expensive to build than hydrofoils, will go faster (90 knots vs. 45 knots) and doesn't have the deep draft problems of a surface craft.

• • •

X-ray standards . . .

will be established for strength of steel castings by **Convair** for the Air Force. The company did a similar job on aluminum and magnesium castings.

PROPULSION

Lack of million pound . . .

deadweight calibration facilities at National Bureau of Standards is seriously hampering U.S. development of multi-meg-thrust rocket engines. The present 111,000-pound maximum means several steps in calibrating big load cells with consequent loss in accuracy. Design of a suitable unit is in process, but the $1.5 million required to build is unavailable.

• • •

Nuclear systems division . . .

has been established at Van Nuys, Calif., by **Marquardt Corp.** . . . **Republic Aviation** is now using adhesives to join the inner and outer shells of missile engine casings.

• • •

Sea-level propulsion tests . . .

and inadequate telemetry flight data are being blamed for many missile failures. AF Arnold Engineering Development Center says it is overcoming some of these problems with high-altitude test cells.

• • •

Helium shortage . . .

could put the *X-15* engine program in a bind, although tests are proceeding on schedule. AF is now rationing the gas, which is used to pressure *X-15* fuel lines. **Thiokol's Reaction Motors Division,** Denville, N.J., is averaging two tests a day and in the past three years has run 2400 static firings of the engine.

ASTRIONICS

Nighttime recovery . . .

of missile nose cones and space capsules may be possible through discovery that fluorescent dye markers are heat absorbers and can be detected by infrared. In daytime detection range of 1 mile or so is inferior to visual and/or radio beacon methods.

• • •

Permanent missile impact . . .

location center is now under construction by the Navy at Kaneohe Marine Air Station, Hawaii. The center will track *Atlas* training shots from Vandenberg AFB which are aimed in vicinity of Wake Island.

WE HEAR THAT—

Miniature missile parts . . .

made of dissimilar metals are being welded by **Emmco Development Corp.,** Brooklyn, N.Y., with a new electrical "fridg-flash" process . . . The new Carteret, N.J., plant of **American Metal Climax Inc.** will produce germanium for the electronics industry . . . **F. J. Stokes Corp.,** Philadelphia, is building a $250,000 cold-wall vacuum heat-treating furnace for **Convair.** It will be used for heat treating alloy steels at temperatures up to 2150°F. . . . **Leeds & Northrup Co.** has opened a new $2-million research center at North Wales, Pa. . . . A research and development subsidiary will be opened in Florence, Italy, by **Melpar, Inc.,** Falls Church, Va.

More About the Missile Week on Page 43

AiResearch gas turbine completes 5,000 start cycles

Reliability Record Achieved Under Tough Test Conditions

Air Force trailer-mounted MA-1A starter cart with improved AiResearch GTC 85-20 gas turbine unit.

AiResearch engineers inspecting improved AiResearch GTC 85-20 gas turbine unit after successful 5,000 start cycle test.

A world performance record for small gas turbine reliability has been established by this improved AiResearch GTC 85-20 unit . . . 5,000 start cycles. During each start cycle the turbine was brought to peak load twice, with a shut down time of only five minutes. This is equivalent to two main engine starts per cycle.

Throughout the entire test only routine maintenance was necessary plus replacement of one generator brush. AiResearch gas turbines now in production incorporate the improvements made in this newly tested unit.

Pneumatic power source for the Air Force's trailer-mounted MA-1A starter cart, the engine was torn down under supervision of Air Force personnel from Wright Air Development Center. It is now undergoing further tests upwards of 10,000 start cycles.

This intense product improvement in gas turbine reliability is matched only by AiResearch versatility. The world's largest manufacturer of lightweight turbomachinery, AiResearch has designed, developed and produced more than 8,500 gas turbines of all types vital to military and commercial ground support as well as auxiliary and prime power applications. Your inquiries are invited.

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How Lockheed-built satellites are

Making space travel safe for man

Before man can be sent into the emptiness of space, we must know how to protect him against the hazards of weightlessness and cosmic radiation—and how to bring him safely back to earth.

The United States is using every scientific means to solve these problems. The satellites in the Discoverer program of the Advanced Research Projects Agency—Lockheed-built Agena vehicles—are one of the means to achieve this end.

ARPA's Discoverer program is being executed by the Air Force's Ballistic Missile Division, ARDC. Lockheed's Missiles and Space Division is prime contractor and system manager of a team that includes Douglas, General Electric and Bell.

The Agena is by far the nation's largest satellite now in orbit—19 feet long, 5 feet in diameter. It weighs almost a ton when in orbit.

It was designed to be put into polar orbit—the most difficult of all to achieve. Four Agena satellites have been placed in completely successful polar orbits; more are on the way.

As it circles the globe every 90-odd minutes, the Agena radios home to its tracking stations more than a hundred measurements of the space phenomena it encounters and monitors its own performance.

Trickiest part of the job is recovering the space capsule. Most satellites tumble and twist as they hurtle through their orbits at about 18,000 miles an hour. The Agena can stabilize itself on orbit and position itself at the exact 60° angle to earth that's necessary to separate the re-entry capsule.

The capsule's retro-rocket slows it to safe speed for re-entry, then drops away. A parachute floats the capsule earthward for aerial recovery by specially modified planes.

Each time an Agena satellite is launched, manned space travel comes closer to reality.

Agena satellite is America's most advanced orbital vehicle today—first in the world to achieve a polar orbit. Agena's nose section contains a combined re-entry vehicle and recovery capsule.

Boosted into space by the 150,000-pound thrust of an Air Force Thor missile, the second-stage Agena satellite is powered into orbit by its own liquid-fuel rocket engine of 15,000 pounds thrust.

Once in orbit, the Agena satellite radios back to its tracking stations more than a hundred measurements of its performance and of the conditions it encounters as it circles the earth at 18,000 mph.

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MISSILES AND SPACE DIVISION

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RAMJET PROPULSION TESTING

RYAN FIREBEES STAR AGAIN AT SECOND "WM. TELL" MEET

The Air Force has selected Ryan Firebees as the exclusive targets for Project "William Tell II"—the second annual world-wide weapons meet to use free-flying jet targets for the purpose of testing pilots, planes, and missiles.

The Ryan Firebee—America's most widely used jet target and the hit of "William Tell I"—provides the most economical and realistic means of maintaining air defense weapons at combat readiness. Firebees stay "on station" for extended periods—permitting numerous attack sorties. And they can be used over and over again.

Pitted against the Firebees will be the top Air Defense Command squadrons, flying Convair F-102, Lockheed F-104, Northrop F-89 and North American F-100 interceptors. They will fire deadly Falcon and Sidewinder guided missiles and Genie (atomic-type) rockets.

The advanced, new transonic Q-2C Firebee—now in production for the Air Force—has already set world's records by flying faster (mach .95), higher (59,800 feet), and longer (99½ minutes).

Ryan has led the field in the design, development, and production of jet target missiles for more than ten years. The Firebee is another outstanding example of Ryan's skill in blending aerodynamics, propulsion, and electronics knowledge to produce a superior product.

RYAN OFFERS CHALLENGING OPPORTUNITIES TO ENGINEERS

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Ryan Aeronautical Company, San Diego, Calif.

Air Force, NASA May Bid for ABMA

Uncertainty clouds the future control of Redstone but there's confidence it will stay in business regardless of ownership; some welcome idea of AF takeover

by an M/R Correspondent

HUNTSVILLE, ALA.—With the Air Force taking "eventual" control of all space transportation, who will boss the Army team which pioneered America's venture into outer space?

That's the big question in Huntsville today, and no one seems to know the answer—not even Secretary of Defense Neil H. McElroy.

McElroy told a former Huntsville newsman in Tokyo last week that "special and urgent examination" is being given by the Defense Department to utilization of the Redstone Arsenal space team headed by Dr. Werner von Braun.

He also gave a hint as to how the decision might go: "The basic approach is that these fine, capable people must be used to the best advantage of United States programs on space and advanced techniques. The best way will be worked out. It may be a combination of work for the military and the National Aeronautics and Space Administration. Exactly how this will be done is being given special and urgent examination."

• **Pulling and hauling?**—Authoritative speculation here and in Washington is that there's likely to be a behind-the-scene tug of war between the Air Force and NASA, although the latter agency reportedly has some doubts as to its ability to fund the 5500-man ABMA at its present level.

Officially, NASA has said that it has no plans to renew its bid of a year ago to take control of ABMA facilities, but the recent Pentagon space program reshuffle may have changed that.

Sen. John J. Sparkman (D-Ala.) says that the issue may eventually have to be decided by President Eisenhower. Another source says it may be decided by the National Space Council, slated to meet in Washington later this month.

Not all of the talk concerns NASA or the Air Force. Some strong Army boosters are hoping that the Army will be allowed to continue operation of ABMA, contracting services to the other branches and agencies. But they admit this is a faint hope at best.

The people most directly affected by any change—the members of the ABMA team itself—are not talking. Washington reportedly has put the clamp on any public comment, and too, there's a general "wait and see" attitude on the part of team members, including Von Braun. "We might be talking about our future bosses if we said anything about anybody," one laboratory chief said.

• **Quick recovery**—News of the ARPA reshuffle caused an initial shock, which quickly dispersed with immediate reports that ABMA would continue to operate, whoever had control.

It was quickly pointed out that of the total force of 22,000 employes at Redstone, only ABMA's 5500 would be involved in the shift. Employes of the Army Rocket and Guided Missile Agency and the Ordnance Guided Missile School would not be affected. And even some of ABMA's 5500 will surely remain with the Army. ABMA is developing *Pershing* and still has some *Jupiter* and *Redstone* work, along with its major of *Saturn*. Also, several space assignments, including a series of *Redstones* for Project *Mercury* and two *Juno II* space probes, are in the ABMA mill.

Another major factor in easing local concern was the point that ABMA's centralized, unique and compact facilities are unequalled anywhere in the nation, and "they cannot be moved." Examples are the huge 15-story static test stand already modified for the *Saturn* cluster, and the expensive and complex laboratories and test buildings especially designed for development of large rocket vehicles, along with their experienced technical force.

• **Change for the better?**—Apparently, the space team is ready to accept a change in management. Many of them have considered a change inevitable since Secretary of Defense Charles E. Wilson's roles and missions order of Nov. 26, 1956, when he took the Army out of long-range missile operations.

And there is quiet talk that a change will be for the better, especially if the uncertainty of the past three years—during the Air Force-Army controversies—is ended. From the few qualified comments which can be heard, there appears to be some genuine hope that the Air Force will move in and turn the team loose full force on outer space problems.

There are some, especially among the former German members of the team, who have expressed a hope that they could work on "peaceful" projects for space exploration, possibly under NASA. But they voice a fear that NASA couldn't fund their efforts as well as a military service might.

• **The community's stake**—The question of control is of primary interest to all of Huntsville, and not just the ABMA members. The city, with a population of about 70,000, has a substantial economic stake in the space effort. In addition to the Arsenal employes, there are several thousand on the payrolls of satellite industries, such as **Chrysler Corp.**, which has a force of about 800 here to render engineering services. **Brown Engineering Co.** has about 650 doing a similar job, and most of the efforts are centered around ABMA.

However, contractors not expected to be affected, except affirmatively, are those like **Thiokol Chemical Corp.**, which employs about 2000 at its Redstone Division, and **Rohm & Haas Chemical Co.**, which has about 250 employes. Both firms do development work for all three armed services.

Only one official spoke out against the transfer. The city's colorful mayor, R. B. Searcy, said "It is incredible to me . . . that the Army has been kicked out of the space field. The whole world knows that the U.S. Army put up the first free world satellite, put the first made-in-the-U.S.A. satellite around the sun, and kept the free world in the race for space.

"As a reward for this magnificent and indisputable record, the Department of Defense not only umpires the Army out of the ball game, but steals the balls as well."

despite recent failure . . .

Transit System Is Due By Early '61

Navigation satellites needed to launch Polaris and ALBM's; new failures could delay program because of money shortage

by James Baar

WASHINGTON—The vitally important *Transit* navigation satellite is still expected to be the nation's first military satellite system despite last month's launching failure.

However, another failure in a row at this time could throw it months off schedule unless more money or boosters from some other project are thrown into the program.

The ARPA-Navy *Transit*—like the bulk of the Pentagon's space and missile programs—is slowed by money shortages. At best, additional funds would bring the system to operational status months sooner. At worst, they would guarantee that it would be operational on schedule.

R&D *Transit* is more than five times the size of planned operational models, to provide redundancy. Antennas are painted on its skin, and its waist is girdled by 12 banks of solar cells. Rear Adm. K. S. Masterson, Deputy CNO for Development, and James H. Wakelin, Jr., Assistant Navy Secretary for R&D, examine satellite.

The early development of *Transit* is no accident. It will play an important part in the *Polaris* system as well as later in the launching of **Douglas** *ALBM's* from bombers.

The first *Polaris*-launching submarine is scheduled to be on station in the last months of next year—possibly as early as September. The *Transit* schedule calls for having the first prototype satellites in orbit only a few months later.

The first spiral-striped *Transit* test satellite was scheduled to go into orbit last Sept. 16. However, the third stage of the *Transit Thor-Able* booster failed to ignite and the 265-pound satellite with the stage attached crashed in the Atlantic southwest of Ireland.

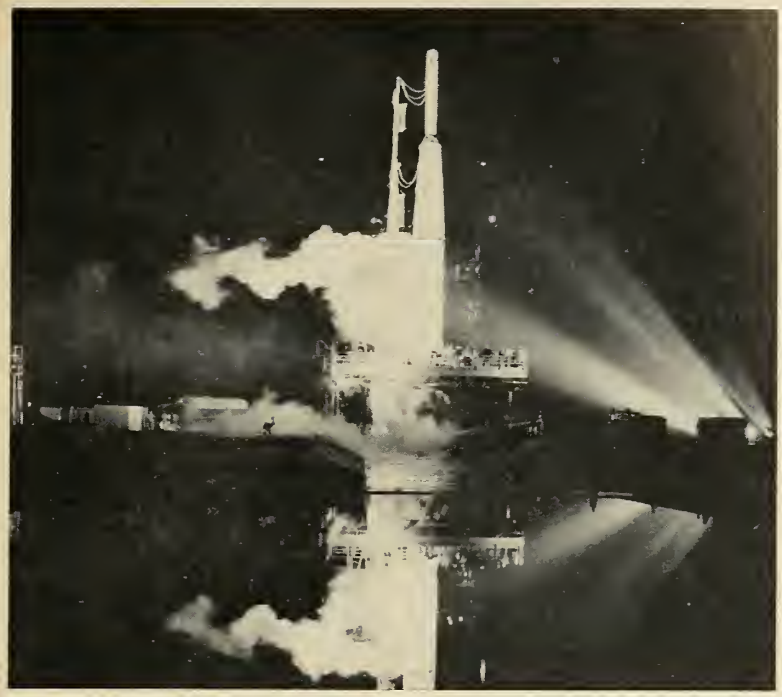
Monitoring stations picked up some data from the satellite's two transmitters during its brief flight. But they only received enough to encourage top scientists in the program in thinking that the design appears feasible.

• **Scanty funding**—The next launching now is scheduled for late winter. Two or three more shots with backups would be spread out during the rest of next year. Finally, two prototype 50-pound *Transits* probably would be launched during the first half of 1961 if the schedule is maintained.

The transit program probably will be turned over to the Navy about the time the prototypes are launched.

In all, ARPA expects to spend about $20 million on the program during the next two fiscal years. That makes it one of the cheapest of the military satellite systems. For example, the *Samos* reconnaissance satellite has a $100 million budget in FY 1960.

Obviously, the *Transit* budget provides slim room for making up for



Thor-Able **three-stage rocket is being used in the** *Transit* **program to launch the satellites into 400-mile orbits. The next launching is scheduled for late winter.**

losses. Additional funds would have enabled ARPA to attempt another launching this fall rather than wait until nearly the end of winter.

• **What it will provide**—The final *Transit* system will involve four 50-pound satellites probably placed in about 400-mile orbits. They will have a life-span of about five years.

A ground station will transmit to the operational *Transits* their exact orbits for each 24-hour period. The data will be stored on magnetic tape in digital computers and transmitted continuously on two stable frequencies.

A ship will be able to obtain the data from one of the satellites at any time over special receiving equipment. There will be no need to interrogate the satellite.

The ship's receiving and computing equipment also will be able to measure the Doppler shift of the satellite's signal, thereby enabling the ship's navigator to know his precise distance from the satellite. This combined with exact knowledge of the satellite's orbit will give the navigator a precise fix on his position.

The system will provide all-weather, global navigation. Navigational fixes obtained from it eventually will be better than two-tenths of a mile—about as precise as the **Sperry** Ships Inertial Navigation System (SINS) developed for *Polaris* submarines.

This also is more than coincidence. *Transit* will provide a precise check point for SINS which must be corrected periodically because of gyro drift.

• **Aiding** *Polaris*—*Polaris* submarines on station will be able to pick up fixes from *Transits* without surfacing. However, a whip antenna must be exposed. Such antennas can be sent to the surface on small floats or even buoyant antennas can be used.

Such precise fixes only become important for plotting trajectories prior to launching missiles. Otherwise, much less precise navigation systems are more than adequate.

Similar fixes would be important for bombers carrying *ALBM's* and surface ships if they are used to carry *Polarises*.

The *ALBM* launching problem is more complex than the problem presented by ships because the high speed of bombers introduces a new factor. One solution is the possible greater miniaturization of computers so that a computer of sufficient capacity to handle the problem can be installed on the planes.

Some officials hope to have *ALBM*'s for deployment on B-52's and B-58's by the end of 1962. Air-breathing **North American** *Hound Dogs* are expected to be deployed on B-52's next year.

Therefore, the major defense role of *Transit* is clear.

In no case will its failure to be developed on time badly cripple part of the nation's future retaliatory forces. But certainly it can be said that much assurance for the accuracy of those forces rests on the development of a small spiral-striped ball weighing only 50 pounds.

NATO Nations Lack Space Funds, Would Like *Scouts*

AACHEN, GERMANY—Europe's lack of funds for any major space exploration programs was pointed up here recently during a round-table discussion of the NATO Advisory Group for Aeronautical Research and Development (AGARD).

The chairman, Dr. Theodore von Karman, and several other speakers indicated that under the circumstances it would be desirable to use NASA's *Scout* vehicle for European space research work.

Dr. M. Freson, of Belgium, suggested to the AGARD symposium that a working group be set up to help small nations with their space projects. Dr. van der Holst, of the Netherlands, said his country's main effort in space research is in the field of astronomy and astrophysics.

Dr. Hugh L. Dryden, NASA Deputy Administrator, disclosed that in 1960 his agency will launch 100 *Aerobee* high-altitude research rockets, in addition to firing a large number of five-stage *Javelins* under the re-entry heat research program. Later, Dryden said, NASA will begin a program involving *Iris*, a vehicle capable of carrying a 160-pound payload to an altitude of 200 miles.

Largest Radio Telescope Is Nearing Completion

SAN DIEGO—The world's largest radio telescope—an installation measuring two miles long and 800 feet across—will be able to locate space noise with greater accuracy than ever before. Located in a desert dry-lake bed 90 miles from San Diego, the system is to be completed in about three months.

Convair Division scientists, who built and operate the massive complex, have observed bursts of solar radiation on outer fringes of the sun's corona.

Using the earth as its "pedestal", such a huge telescope could be built as a movable parabolic reflector only at the cost of many billions of dollars. The system operates at a frequency of 26.3 mc and has a fan-shaped beam width of about one-fourth degree. It will be able to look billions of light-years into space and is expected to help astrophysicists answer many of the questions concerning the emission of radio noise by stellar bodies.

First of a series . . .

Michigan Seeks Missile Comeback

M/R regional survey shows Nation's top arsenal in Korean War has slumped from defense picture; motor companies push hard for missile contracts

by William E. Howard

DETROIT—Much soul-searching is going on in Michigan these days. In the midst of a general upsurge in missile/space production and research in the Great Lakes area, the state inexplicably finds itself far out of step.

Just six years ago, during the Korean War, more than 42% of Michigan's population—some 2,694,000—was employed in factories. Michigan companies held the highest percentage (17.2%) of defense contracts in the nation. **General Motors** alone had $1.9 billion in military work and 95,000 defense workers, highest for any single corporation in the country.

Today, Michigan's share of military contracts has shrunk to a vestigial 3.2%—half of what it was last year. GM's defense business has plunged to about $390 million this year and much of it is being done outside the state. In mid-September, unemployment stood at a depressing 275,000—9.4% of the total work force. Upwards of 150,000 of this number were defense workers.

What's the matter? What can be done to improve the state's economy? These questions have had Congressmen, state officials and economists muttering to themselves for months. They also have been speaking out loud, demanding help from the Federal government, and, perhaps more important, suggesting direct action within the state.

An M/R survey of prominent Michiganders concerned with the problem shows they feel, generally, that manufacturing interests have been too slow to move into the missile/space field. These manufacturers lost ground while they were wholly occupied turning out conventional armaments during the Korean War. Small firms elsewhere in the country during those years were moving into the new rocket and electronic technologies.

When the dramatic switch to missiles started right after the war, many Michigan companies were left at the post. Today they are struggling uphill to win a share of the market. And there is a spreading conviction that the state's economic future lies in space technology.

In a study "What's Ahead for Michigan," the W. E. Upjohn Institute for Employment Research says: "Although Michigan has not done as well as other areas in aircraft and missile parts industries, their good growth prospects plus the need for accurate machining to close tolerances for many of the parts required by these industries suggest that Michigan may be able to secure a larger share of this business . . ."

A survey by Sen. Philip A. Hart (D-Mich.) shows the state's tooling and machining industries have been hardest hit in a downward trend that started in 1957 and is continuing. Geared for mass production, chiefly in the automotive field, the many manufacturing facilities have been slow to shift over to small-scale production of highly specialized items required in rocketry.

• **Short-changed**—What bothers Hart and other members of the Michigan Congressional delegation is a firm conviction that their state is getting short shrift from the Federal government under special programs for awarding defense contracts.

For example: although the state's unemployment is 12% or higher in Detroit or Flint, Hart says Michigan ranks ninth in the value of contracts awarded under the labor surplus area provision of the Defense Act. Against $13.6 million allocated to New York, which was tops between July 1, 1958, and March of this year, Michigan received a paltry $1.5 million under the Office of Civil Defense Mobilization program.

In the Small Business Administration set-aside program, New York again led the states, receiving $435 million between July of last year and

CHRYSLER-OPERATED U.S. Army Michigan Ordnance Missile Plant near Detroit turns out *Jupiters* and *Redstones* on parallel production lines employing 10,000 workers.

April, 1959. Hart says Michigan was 10th—getting just $58.7 million. His survey shows that out of a possible 1500 small businesses capable of participating in the SBA program, actually only 80 received any benefits.

"The hard figures demonstrate only too graphically that these programs are a total failure as far as Michigan is concerned," an economic advisor to the senator told M/R.

"We know that around 90% of defense contracts are negotiated. So it is patently obvious in our case that all the crowing about designating defense work by areas comes after the fact—not before. Otherwise Michigan would be gettting more of it."

Hart feels, too, that there has been a poor utilization of universities, R&D firms and other scientific facilities in the state. The University of Michigan, which participated with **Boeing** in developing *Bomarc*, for instance, has only a few hundred thousand dollars in research contracts—including $267,000 with the Army.

• ***Jupiter* finished?**—While the Wolverine State's missile picture is not entirely framed in gloom, there are several large question marks as to the future.

Take the Air Force *Jupiter* IRBM and Army *Redstone* 200-mile surface-to-surface missiles. **Chrysler Corp.** is prime for both and today is facing the prospect of a complete washout of both programs. The Army wound up *Redstone* buying on June 30 and the Air Force has reached the "buy-out" stage on *Jupiter*.

NASA in August ordered eight *Redstone*-type boosters worth about $3 million for the *Mercury* man-in-space project and is thus keeping the program alive. There has been considerable speculation that either *Redstone* or *Jupiter* may be purchased in quantity as a target for the Army's *Nike-Zeus* A-ICBM—if the Defense Department decides to move ahead with a full-scale *Nike-Zeus* program. This decision is expected before the end of the year.

The Army's Detroit Ordnance District—major missile procurer in Michigan—says a total of $477.8 million has been obligated for both *Redstone* and *Jupiter*, which was an Army missile until it was transferred last year to the AF.

Chrysler has 10,000 employed at its missile division. Its 1559 suppliers and 13 subcontractors employ another 17,100, making a total of 27,100 persons working on Army missiles in the state.

By the end of FY 1960, the Ordnance District says, "total funds awarded to missile contractors by the District will be a half-billion dollars." Just how this money will be distributed over the the next nine months has not been divulged.

The District also has been making substantial buys of missile support equipment. But Sen. Hart's survey shows that much of the mobile equipment purchases—largely because of diversification within the automobile industry—is going to plants outside the state.

• **The brighter side**—The outlook is promising for the state's other prime missile system, the $100 million air-to-air Navy *Eagle* being primed by **Bendix Aviation's** Ann Arbor division, which employs several thousand persons. One drawback is that much of the major work presently is being subcontracted outside the state. But opportunities are being created for local vendors.

Borg-Warner Corp.'s Ingersoll Division at Kalamazoo is turning out metal motor parts for *Nike-Hercules* and JATOS. And it is engaged in substantial support work.

Dow Chemical Co., Midland, developer of the first die-castable alloy of the magnesium-thorium group for service above 500°F, is a principle subcontractor for the *Nike-Zeus*. A major producer of missile/space basic materials, Dow recently formed a new division at Midland for fabricating magnesium, aluminum and other metals.

Aeroquip, located at Jackson, is expanding its plant facilities and is building a special laboratory for testing advanced missile components developed at its engineering center. These include flexible hose assembles, detachable reusable fittings and self-sealing couplings.

Ford Motor Co. is planning to back up at Detroit its new **Aeronutronic Division** at Glendale, Calif., which is prime for the Army's *Shillelagh* short-range surface-to-surface missile and hopes for "large-scale participation in the nation's space and missile programs."

Things are looking up, too, in astrionics. **Burroughs Corp.,** employer of several thousand persons at its Detroit headquarters, recently acquired a $9 million follow-on contract for 36 additional SAGE computer units. This brings Burroughs' total SAGE business to $155 million. The company has made 58 installations of its AN/FST-2 data processing and computer devices throughout the continental United States for the semi-automatic ground environment system for air defense. A network of some 200 separate installations is planned for the system. Burroughs also has the guidance for *Atlas* under a $77 million AF contract.

Last month **Lear Inc.** dedicated its new $5-million instrument manufacturing facility at Grand Rapids. The 172,000 square foot plant doubles the company's operation there and brings employment to 3500. Lear is a principal subcontractor for the *Nike-Zeus's* stable platform and is a precision component supplier of several other missile guidance systems.

AT LEAR'S INC.'s new instrument plant in Grand Rapids, workers build gyros in specially designed "clean rooms."

Many officials are looking hopefully at General Motors to help the state make a comeback in missile/space systems. GM's principal missile activity today is in its **AC Spark Plug** Division at Milwaukee, where the all-inertial guidance for *Titan, Thor* and *Mace* is being manufactured in a $100 million-a-year operation.

In a bid for more missile business, GM earlier this year moved Harold R. Boyer, head of the Cadillac Tank Plant at Cleveland, into the newly-created post of director of military production.

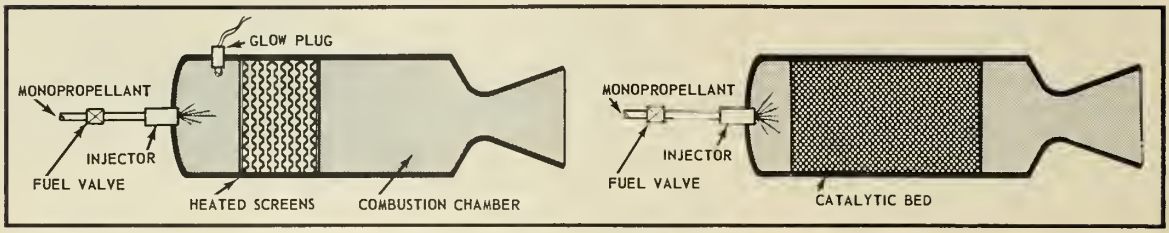
Since the changeover, GM has developed a major proposal with **RCA** for a multimillion-dollar mobile railroad launching platform for the **Boeing** *Minuteman*. Several other teams are in the competition.

GM also has several smaller proposals in the fire and wants to become a prime missile/space systems contractor in the future.

In Michigan today moves are afoot to make manufacturers, particularly smaller ones, more aggressive in the search for new missile business. As one economist puts it: "I think it is pretty evident that for the past several years many of our companies have grown accustomed to being handed business. They have to wake up and get reoriented to selling their capabilties in the missile field."

Demand for Non-Pyrotechnic Ignition

Electric, torch, hot spot, catalytic and hypergolic systems find many uses in repetitive starts—Part II of a two-part series



TWO FAMILIAR types of non-pyrotechnic ignition systems. Left: The hotspot or heated wall ignition. Right: Catalytic bed ignition. Biggest advantage of these types over pyrotechnic devices is their capability for repetitive starts and need for less special handling.

by Frank G. McGuire

LOS ANGELES—Although pyrotechnic devices pretty well dominate in the ignition of modern missiles and rockets, there's a big market for a wide variety of other approaches—electric systems using spark plugs, glow plugs, inductive and capacitive methods; torch systems; hot spot (heated wall) systems using glow plugs, heat sink, low-voltage AC or DC, and torch igniters; and the catalytic and hypergolic systems.

This demand is expected to continue, because pyrotechnics, appropriate as they are in ignition, have a number of disadvantages: they can provide only single, not repetitive, starts; they require special handling and inclusion of safe/arm devices; they have limited storage life; they are, to some degree, sensitive to temperature; and they offer only a short period of operation.

The other systems described below are employed to get around some of these shortcomings—especially to supply repetitive starts.

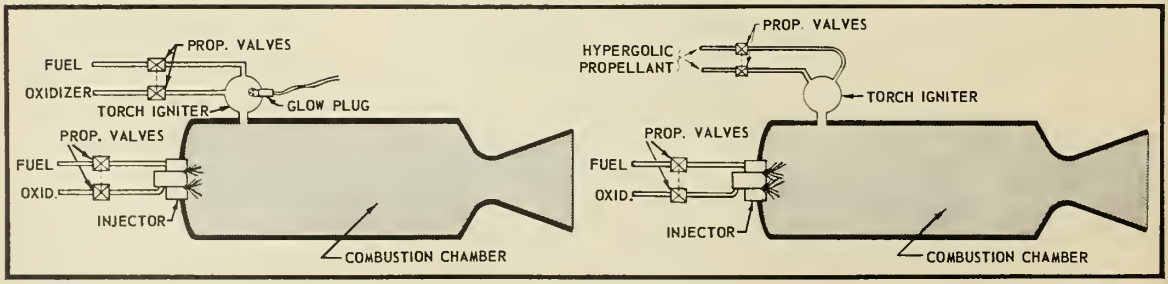
• **Electrical systems**—Electrical ignition systems have, of course, been used in aircraft, automotive and rocket systems for years. Because they must operate continuously in some systems, their weight has been accepted in the design of vehicles. But problems arise from the nature of their operation: erosion and fouling of electrodes, erosion of breaker points, timing, high-voltage insulation and radio interference are some of them.

The development of diesel engines brought forth the glow plug as a method of ignition. The low voltage used in a glow-plug system sidesteps the high tension problems of spark plug systems. Jet engine systems, although not requiring timing of a spark, pose other problems in common with reciprocating engines, as well as additional difficulties brought by high-altitude ignition and severe weight limitations.

Even more stringent requirements have been introduced into missile and rocket systems by the extreme environmental and operating characteristics of these vehicles. They need lower voltage, lower weight, both extremely high- and low-pressure starting systems, and special types of igniter units. Each system has its own requirements.

A continuous development program betwcen electrical ignition system manufacturers and **Aerojet-General Corporation** resulted in a number of improvements that enabled electrical systems to meet the needs of rocket engines. Some of the ignition system manufacturers included **B G Corp., General Lab Associated Corp., G.L.A. Inc., Champion Spark Plug Co., Auburn Spark Plug Co., Bendix Aviation Scintilla Division,** and **AC Spark Plug Co.**

Among the many improvements



REPRESENTATIVE OF THE torch ignition systems are, left, bi-propellant starter, and, right, hypergolic propellant starter. Many types of gas generators use these systems to ignite and decompose the monopropellant fuel. Disadvantage of hpergolic ignition is the restriction on fuel types.

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were reduction of weight from 2-3 pounds to 3 to 11 ounces; improved low-tension systems (high tension being 5000 volts and above, low tension being 2000 to 3000 volts); development of capacitor discharge systems to prevent plug fouling; development of better semi-conductor spark plugs; improvement of glow plugs and their high-temperature sealing methods; development of anti-fouling spark plugs and high-tension systems.

Semi-conductor gap plugs were developed to obtain a longer arc by using a larger gap between the electrodes; good semi-conductor plugs have a resistance of between 200 and 2000 ohms. Application of a surge voltage across the electrodes will ionize the surface of the semi-conductor and the area of air surrounding it, providing a path for follow-through current to burn off and ignite accumulations of carbon and fuel between the electrodes.

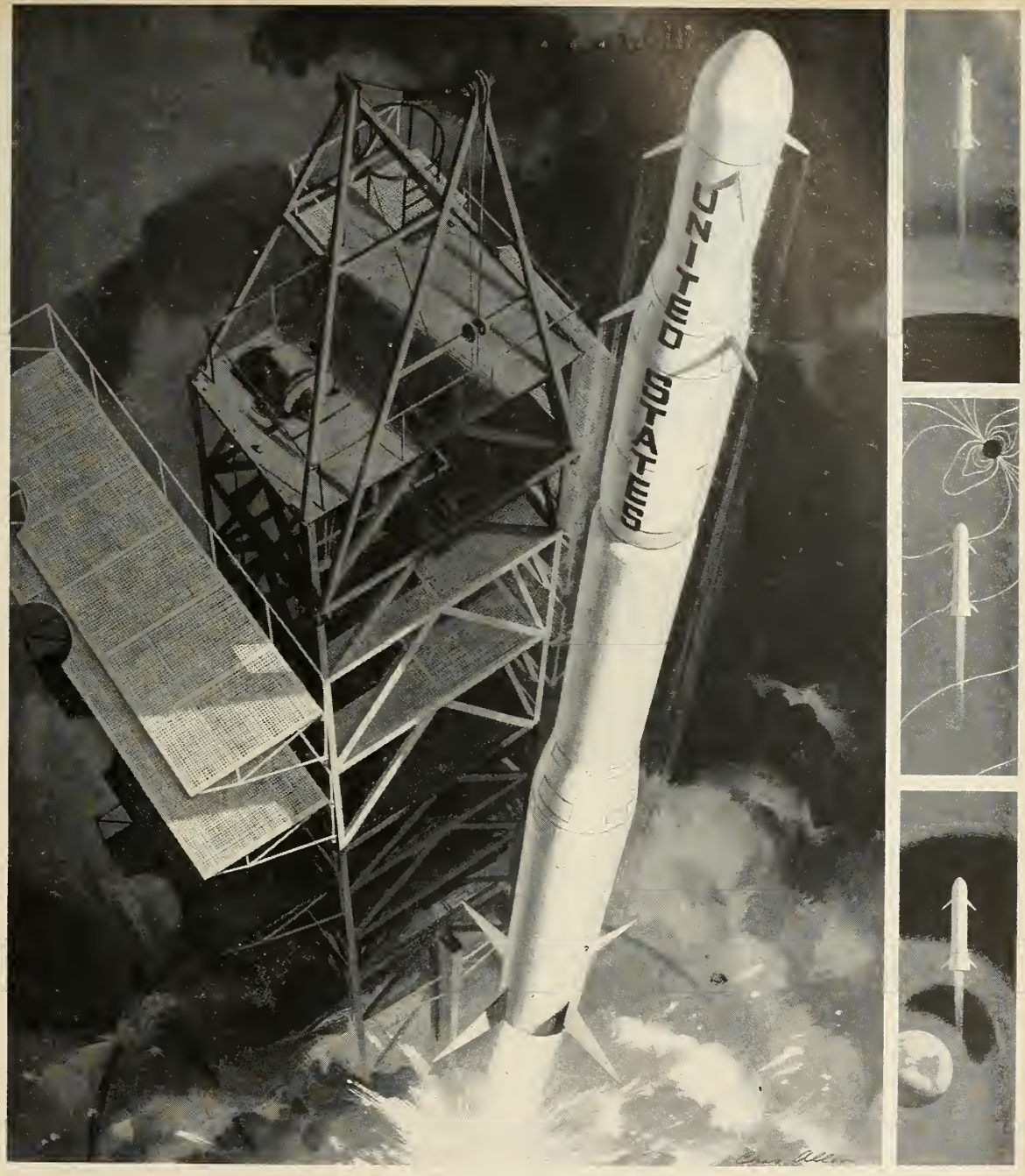
• **Glow plug igniters**—Two types of glow-plug igniters are in use—with shielded and unshielded elements. Glow plugs have the advantages of repetitive and continuous operation, low weight and small construction, and a good thermal mass for ignition source. Their disadvantages are element burnout, low response time, lower temperature than spark ignition, and, unless shielded, susceptibility to fouling or shorting.

The shielded-element type offers the advantage of invulnerability to fouling or shorting and is protected from high chamber pressures. The unshielded element, on the other hand, offers faster response and higher ignition temperature source, and dissipates more wattage than the shielded-element glow plug.

• **Torch ignition systems**—These miniature rocket engines, so to speak, require propellants, valves, a combustion chamber, and an igniter. They are most often used in restarting operations of a large rocket engine or in heating the catalytic bed of a monopropellant engine. Many types of gas generators use this type of ignition to ignite and decompose the monopropellant fuel.

Such bi-propellant starter systems may use the main engine's fuel and oxidizer, or it may have its own supply. Some others use air for the main engine oxidizer and then utilize an injection of starter fuel and electrical ignition for starting.

A hypergolic-propellant torch starter can use either of the main engine propellants and a separate oxidizer or fuel that is hypergolic with one of the main engine propellants. Either or these may be used on monopropellant engines, since it takes additional heat to start the catalytic action or decompose the monopropellant. Spark and glow plugs have limited heat to decompose



NASA'S SCOUT WILL MARK A TRAIL FOR MAN TO FOLLOW

Scout is designed to explore paths into space . . . at low cost. The inexpensive, 70-foot research rocket will go after vital space measurements that require sounding after sounding. National Aeronautics and Space Administration scientists will use the vehicle to launch the satellites and probes that measure the ionosphere, map magnetic fields and gauge radiation. Chance Vought's job is to assemble *Scout's* four stages, build its airframe and launching tower — holding to low cost and high reliability standards. *Scout* will make many of the hundreds of space soundings NASA already has scheduled. From this rocket's well-blazed trail, scientists may unlock secrets that will pave the way for extended manned space flights.

AERONAUTICS | ASTRONAUTICS | ELECTRONICS | GENESYS CORP. | RANGE SYSTEMS | RESEARCH

CHANCE VOUGHT
DALLAS, TEXAS

supporting decomposition . . .

TORCH IGNITER by Aerojet-General uses gasoline, air and a spark plug. Units of this type are widely employed to restart big rocket engines.

such large volumes of monopropellants.

A given chamber pressure must be reached in the torch igniter before the propellant valves of the main engine can be opened for main engine operation.

• **Hot spot (heated wall) igniters**—Monopropellant rocket engines offer the greatest opportunities for applications of this method. The system is usually started by glow plugs, torch igniters, or preheated chambers. The propellant is usually metered into the chamber in small quantities until the hot spot or heated wall becomes an adequate heat sump to support continuous combustion.

In small engines, the glow plug is an adequate heat sump, but in larger engines, an additional heat source must be provided to insure continuous decomposition during starting transients. Stainless steel wire-mesh screens and cermet pellets or catalytic screens may be used in conjunction with stainless steel screens to insure decomposition of the monopropellant.

Typical monopropellants using this type of ignition are unsymmetrical dimethylhydrazine ($C_2H_8N_2$), N-propyl nitrate ($CH_3CH_2CH_2ONO_2$), ethylene oxide (CH_2CH_2O), and others.

• **Catalytic ignition systems**—A combination of catalytic beds and heated wire screens supporting the decomposition of a monopropellant characterize this method. When a 90% hydrogen peroxide (H_2O_2)/10% water (H_2O) propellant is used, the catalytic bed consists of silver-plated stainless steel wires.

Slow response time is a major objection to these ignition systems. This time may vary from 0.015 to 0.060 seconds and is considerably affected by motor size, propellant flow rate and chamber pressure. On small engines (compact, simple, efficient control engines) this type of ignition is excellent if the slow response time is tolerable.

• **Hypergolic ignition systems**—A very desirable, but limiting, method of rocket engine ignition utilizes hypergolic propellants. It limits the designer's choice of propellants, and requires strict handling procedures. Engines using hypergolic fuels must have precise start and shutdown procedures, to prevent occurrence of high starting and shutdown pressures in the combustion chamber and the injection system. These problems are also present in non-hypergolic systems, but not to such a great extent.

Ignition Systems for Missiles

Igniter System	Types	Methods of Initiation	Applications	Starting Use	Advantages	Disadvantages
Pyrotechnic	A. Black Powder B. "Alclo" Pellet C. "Alclo" Flare	A. Low Voltage Bridge Wire Squib B. High Voltage Explosive Wire Squib	A. Ignition of Solid Propellants 1. "Jato" assisted take off rockets 2. Solid rocket engines (Polaris, Minuteman, etc.) 3. Gas generators (solid) B. Bi-Propellant Liquid engines 1. Titan thrust chambers 2. Gas generators C. Monopropellant Liquid Engines 1. Rocket engines 2. Gas generators	Reliable Single Starts Non-Repetitive	A. High Reliability B. High Altitude Starts C. Fast Starts Without Shock Transient using "Alclo" Pellet type igniter D. Low Power Electrical Ignition System E. Large Area Coverage	A. Single Start B. Special Handling During Transportation and Installation C. Requires "Safe arm" Devices D. Limited Storage Life—5 years E. Temperature Sensitivity F. Short Duration
Electric	A. Spark Plugs 1. Air Gap 2. Semi-Conductor B. Glow Plugs 1. Open Element 2. Closed Element	A. Inductive 1. D.C. Supply 2. A.C. Supply B. Capacitive 1. D.C. Supply 2. A.C. Supply	A. Bi-Propellant Liquid Engines 1. Rocket Engines 2. Torch Igniters 3. Gas generators (APU) B. Mono-Propellant Liquid Engines 1. Air Turbo Rockets 2. Ramjets 3. Gas generators (APU) 4. Liquid Assisted Take Off Engines 5. Rocket Engines 6. Turbojets	Single and Repetitive Starts	A. Reliable Single Starts B. Longer Duration C. Safe Handling (non-explosive) D. Good Shelf Life E. Re-Usuable with Proper Maintenance F. Small Element G. Simple Electrical System using Glow Plugs	A. Can be Fouled or Shorted B. Indefinite Starting Time C. Heavy System (spark plug) D. Un-Reliable Restart E. Requires more Power than other Systems F. Sensitivity to Chamber Pressure (spark plugs) G. Sensitivity to Arc over of insulation, Shorts and High Altitude, and High Humidity Conditions H. Slow Response Time (glow plugs only) I. Some Systems Require Shielding for Radio Interference

Hypergolic-slug starting systems for engines, torch igniters, and catalytic-bed heaters are typical applications of this kind of system. Sequencing and metering of propellants are critical and require suitable care and control to insure smooth starting conditions.

Missiles using hypergolic ignition include *Corporal, Able,* some models of *Aerobee-Hi,* the *Bomarc* booster, some *Nike* boosters, and a number of liquid rocket sleds.

• **General trends**—In general, ignition systems for large rocket engines apparently will fall into two categories—single shot systems, which will mostly use pyrotechnic ignition; and restart systems, which will tend toward hypergolic ignition.

For smaller engines and control verniers, the trend will be toward pyrotechnic and glow-plug ignition for single-start systems, and toward hypergolic or catalytic ignition for restart systems.

Advanced starting systems being investigated for future use are: hypergolic ignition by use of hypergolic buttons or coatings, and chemical additives; electrical, by use of conductive films; and pyroforic fuels.

Each system has advantages and disadvantages; tailored to a particular propulsion system, each will do the job. Indications are that no one ignition system will ever be universal in its application.

Limits on Electrical Propulsion

PHILADELPHIA—The power supply weight problem will probably eliminate the electrical systems of propulsion for all but orbit-trimming or attitude-control maneuvers and, possibly, extremely high-energy flights to the outer planets.

The Institute of Radio Engineers last week heard Dr. Jerry Grey of Princeton say that at least two of the basic problems of the ion rocket, beam neutralization and accelerating electrode erosion, have not really been solved at the present time and that practical operation of any of the high-energy magneto-fluid mechanics devices has yet to be demonstrated. He said:

"These represent the only classes of high specific-impulse electrical devices; the other, the low specific-impulse electrical types such as arc plasma jet, colloid or dust rocket, etc., cannot compete weightwise with advanced nuclear heat-transfer rockets in the 1000 second regime."

Dr. Grey added that it was likely that these advanced nuclear rocket systems would reach operational status at least about the same time as an equivalent electrical system.

New Air Force Ranks?

WASHINGTON—Pentagon Air Force enthusiasts celebrated the turning over of all space transportation to the Air Force by drawing up a proposed list of new ranks befitting the Space Age.

Here is the list as amended by security wags:

Galacteer, Four Star; Liftenant Galacteer, Three Star; Majoris Galacteer, Two Star; Solardeer, One Star; Planeteer, Colonel.

Liftenant Planeteer, Lt. Col; Orbiteer, Major; Rangeer, Captain; 1st Liftenant, 1st Lt; 2nd Liftenant, 2nd Lt.

Stageman, CWO; Jr. Stageman, WO; Senior Blasteer, CMS; Jr. Blasteer, SMS; Blasteer, M/Sgt.

Chief Nozzleman, T/Sgt; Jr. Nozzleman, S/Sgt; Padman 1st Class, A/c; Padman 2nd Class, A/2c; Padman 3rd Class, A/3c; and Basic Padman, Basic Airman.

There will be no restriction on a member of the Women's Space Force to keep her from reaching the rank of Galacteer provided she is prepared to go that far. (AF Regulations restricted women to the equivalent rank of Planeteer.)

Igniter System	Types	Methods of Initiation	Applicatians	Starting Use	Advantages	Disadvantages
Torch	A. Bi-Propellant with Electrical Ignition B. Hypergolic Slug	A. Ignition with Spark Plugs or Glow Plugs B. Acid Slug Introduced by Valving or Burst Diaphragm	A. "Boot-strap" Ignition of large Bi-Propellant Rocket Engines B. Ignition and Heating of Catalyst Beds and Heat Sinks of Monopropellant Engines 1. Gas generators 2. Rocket Engines 3. Air-Turbo Rockets 4. Liquid Assist. Rockets	Single and Repetitive Starts	A. Repetitive Starts B. Smooth Starts C. Large Heat Output D. Long Duration E. Large Area Coverage	A. Heavy System B. Requires Separate Fuel System and Electrical Components C. Reliability Reduced by Complexity of System D. Expensive
Hat Spot ar Heated Wall	A. Glow Plug B. Heat Sink	A. Low Voltage AC or DC B. Torch Igniter	A. Mono-Propellant Rocket Engines* B. Auxiliary Power Units* C. Air Turbo-Rocket Gas Generators* *Using Mono-Propellants That do not Decompose by use of a Catalyst	Single and Repetitive Starts	A. Repetitive Starts B. Simple System (glow plugs) C. Fair Durations	A. Limited Application B. Requires Large Heat Sinks for Large Units—Heavy C. Slow Response D. Possibility of Fouling
Catalytic	A. Catalytic Bed B. Catalytic Bed + Heat Sump C. Catalytic Bed + Regenerator or Preheater	A. Pre-Heating B. Glow Plug C. Catalyst D. Torch E. Hypergolic Slug	A. Monopropellant Rocket Engines B. Auxiliary Power Units C. Attitude Control Rocket Jets	Single and Repetitive Starts	A. Repetitive Starts B. Simple System C. Fair Duration D. Good Control (Throttling)	A. Limited Application B. Shutdown Due to Contamination or Burn out of catalyst bed C. Slow Response D. Heavy Motor
Hypergolic	A. Hypergolic Propellants 1. Liquid 2. Solid + Liquid B. Hypergolic Slug 1. Oxidizer 2. Fuel	A. Propellant Valves B. Slug 1. Valved 2. Burst Diaphragms 3. Coating (solid)	A. Bi-Propellant Rocket Engines B. Hybrid Rocket Engines C. Mono-Propellant Engines D. Gas Generators	Single and Repetitive Starts	A Repetitive Starts B. Simple System C. Reliability Good D. Fast Response	A. Dangerous Propellants B. Requires Accurate Valve Sequencing to Obtain Smooth Starts and Shut Down C. Storage Problem on Many Propellants

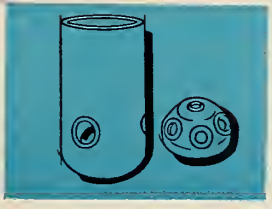
industry . . .

GARLOCK'S UNIQUE POSITION in the missles industry may be of infinite value to you.

ACCEPTANCE: Right now Garlock is supplying rocket motor components for various phases of development and production of seven different missiles. **FLEXIBILITY:** Garlock has the people, the equipment, and the experience to swing into prototype production on short notice, and to follow this with full-scale production as needed. **DIVERSIFIED ABILITIES:** Garlock is thoroughly familiar with the design and manufacture of components from a wide range of basic materials—metals, rubber, phenolics, fluorocarbons and other plastics. **COMPLETELY INTEGRATED STAFF:** Garlock's product design, tool design, pilot manufacturing and production staffs are completely integrated for efficient handling of a project from start to finish. Garlock engineers will work to your design—or with you in developing designs. Write or call Military Products, The Garlock Packing Company, Palmyra, New York. GARLOCK

FILAMENT WOUND ROCKET MOTOR CASES made by exclusive Garlock method results in structure much lighter and stronger than steel.

MISSILE PARTS FROM INERT MATERIALS include newly developed asbestos-phenolic compound for nozzles . . . nose cones of fluorocarbon plastics.



INSULATION FOR SOLID FUEL ROCKET MOTORS made by Garlock is rubber-like compound which encounters gas velocities of Mach 3, temperatures to 5500°F, prolonged ambient temperatures of 300°F.

Garlock components are presently used in the development and production of:

Vanguard	Minuteman	Super Tartar	Polaris
Super Vanguard	Nike Hercules	Terrier	

Ion Rockets Lead in 'Exotic' Propulsion

BOSTON—The progress of ion and plasma research in space flight applications was the subject of the only open session at the Second Symposium on Advanced Propulsion Concepts, jointly sponsored by **Avco**-Everett Research Laboratory and the Air Force Office of Scientific Research.

The ion rocket emerged as most likely to reach flight test capabilities first, based on current state-of-the-art development.

T. M. Littman of **Rocketdyne** said that although the feasibility of obtaining thrust from ionic, plasma jet and magnetohydrodynamic devices has been demonstrated, none of the systems has been proven practical from an engineering standpoint.

The Symposium featured a panel discussion moderated by Dr. Arthur Kantrowitz, Director of the Avco-Everett laboratory and member of the M/R Advisory Board. The panel included Brig. Gen. B. G. Holzman, Commander of the Air Force Office of Scientific Research; Brig. Gen. H. A. Boushey, Director of Advance Technology, USAF; Col. Robert W. Christy, Commander, 644th Missile Squadron, Vandenberg Air Force Base; Dr. Horace N. Gilbert, economist, California Institute of Technology; Dr. Thomas Smith, historian, University of Oklahoma, and Clarke Newlon, Executive Editor of MISSILES AND ROCKETS.

The abstracts of papers given in the session on Ion and Plasma Research are presented as a service to M/R readers. Further information may be obtained by contacting either the authors or the editorial office of MISSILES AND ROCKETS.

Magnetohydrodynamic Acceleration of Slightly Ionized, Viscously Contained Gases, G. Sargent Janes and James A. Fay, Avco-Everett Research Laboratory, Everett, Mass.

The various physical and aerodynamical factors affecting the design of a steady flow MHD accelerator having viscous containment and crossed electric and magnetic fields are considered for the case of a slightly ionized gas. These include the effects of tensor electrical conductivity, ion slip, current diffusion, frozen flow and leaving losses, magnetic field and electrode losses, and viscous boundary layer losses. Some of the effects are also applicable to the case of a completely ionized gas. This may be the more interesting case, but it is not considered in detail. A particular example portraying most of these effects is presented for the case of a slightly ionized gas.

The Colloid Rocket: Progress Toward a Charged-Liquid-Colloid Propulsion System, Robert D. Schultz and Lane K. Branson, Aerojet-General Corporation, Sacramento, Calif.

Theoretical and experimental research is described leading toward a space propulsion system in which microscopic oil droplets are produced with a high positive charge and accelerated electrostatically to exhaust velocities of over 50,000 mph with I_{sp} of over 2200 seconds. This type of rocket system may prove to be of considerable value for controlling the orbit of an earth satellite, for earth-moon missions and possibly for deep space exploration such as a Mars or Venus probe.

A Detonation Wave Hypersonic Ramjet, W. H. Sargent and R. A. Gross, Fairchild Engine Division, Deer Park, N.Y.

This report examines the performance of a hypersonic ramjet having a detonation wave combustion process. Flight speeds from Mach 2.5 to Mach 10 are investigated. Engine performance characteristics are presented and compared with those of a conventional ramjet.

Pulsed Plasma Accelerator, Thomas L. Thurson, Research Center, Borg-Warner Corporation, Des Plaines, Ill.

The various types of pulsed plasma accelerators using a Lorentz force for acceleration are examined. The Bostick source, the rail type gun, the Avco coaxial shock tube, and the Kolb shock tube are presented and the experimental difficulties of each are discussed. The simplicity and fair reliability of pulsed plasma accelerators are the main advantages of the system for use in space propulsion.

A Critical Evalution of the Ion Rocket, T. M. Littman, Rocketdyne, Canoga Park, Calif.

A critical evaluation of the current status and future potentialities of the ion rocket is presented. Comparison is made, insofar as possible, with both conventional rockets and other electrical propulsion schemes. It is concluded that the ion rocket is unique among the advanced systems in its relative simplicity, high efficiency, wide range of applicability and early availability of a low-power flight model.

The Production and Study of High Speed Shock Waves in a Magnetic Annular Shock Tube, Richard M. Patrick, Avco-Everett Research Laboratory, Everett Mass.

A magnetic annular shock tube has been used to produce magnetically driven shock waves with very high velocities. Experiments were carried out with this device with two magnetic field configurations ahead of the shock front in the direction of motion of the shock. In the second configuration the magnetic field ahead of the shock had its principal component in the plane of the shock front and a small component in the direction of motion of shock. The continuum radiation emitted by the shock-heated plasma was measured with photomultipliers. The use of probes to measure the change in the local magnetic field in the shock front was investigated. With the second configuration, shock velocities in excess of 4 x 107 cm/sec were measured in hydrogen. For these high speed shock waves, a shock thickness was obtained from measured rise times of the emitted visible radiation. These shock thicknesses are thinner than the mean free path in the shock-heated plasma, an observation which agrees with a theoretical prediction.

The Arc Jet, Dr. Gabriel M. Giannini, Avco-Everett Research Laboratory, Everett, Mass.

Space flight propulsion studies definitely indicate that for practically all space missions electrically driven rockets offer a substantial saving in mass over chemical rockets. If these studies are limited to satellites and moon missions, they show that the most advantageous I_{sp} is in the 2000 to 3000 second range. Thus, the arc jet becomes suitable for this type of application. The paper presents the results of typical mission studies and outlines the analytical and experimental work conducted to develop the plasma jet as a means of propulsion. The results of various phases of the program are presented and discussed in the order they were obtained. On the basis of these results a plasma-propelled space ship appears feasible.

Cesium Ion Motor Research, R. C. Speiser and G. R. Dulgeroff, Rocketdyne, Canoga Park, Calif.

Experimental studies with cesium surface ionization devices operated as miniature ion motor configuration are discussed. Such studies cover many of the phenomena of significance to the development of practical sized ion motors even though conducted on a small scale. The results indicate that the system can provide adequate current densities for electrostatic ion propulsion at moderate temperatures, and no major technological "break-through" is necessary for the development of a practical cesium surface ionization motor.

Charged Droplet Experiments, Charles D. Hendricks, Jr., Ramo-Wooldridge Consultant, University of Illinois.

The paper describes the experimental techniques by which charge-to-mass ratios and drop size of the individual droplets were measured. Broad distribution were found for radii and charge-to-mass ratio. The charged oil droplets were obtained through use of a small hollow needle raised to a high potential.

Titanium, Plastic Rocket Cases Gain

But steel holds near-monopoly in choice of material for solid cases because of its low cost and wealth of experience in handling

by Jay Holmes

WASHINGTON—Titanium, laminated plastic and aluminum are challenging steel's near-monopoly in the supply of materials for solid rocket motor cases.

Steel still holds the edge, primarily because of its low cost and the wealth of knowledge about its properties. But the day may come when booster and second stages will be made of these newer materials.

What are the demands placed on a material for rocket cases? First, of course, it must be strong. Second, it must be light. Third, it must be at least relatively inexpensive; we may be willing to pay a little more for greater performance, but there is a limit to every budget.

There is a fourth requirement that isn't as easy to express in numbers. That is reliability—we want a rocket case we can depend on.

Steel is the strongest material available. But it is also one of the heaviest.

FIRST TITANIUM used on a large scale for missiles was this 50-pound helium bottle in Convair *Atlas*. Aluminum bottle would have weighed 80 lbs., steel 125.

Its density ranges from .27 to .28 lbs./cu. in. This compares with .16 for titanium, .098 for aluminum, and as low as .072 for filament-wound glass fiber bonded with resins.

The best measure of these two factors together is the strength-to-weight ratio. Strength is measured in pounds per square inch strain that can be withstood without rupture—the ultimate tensile strength. Density is measured in pounds per cubic inch. Thus the ratio comes out in inches.

Take, for example, a steel with tensile strength of 240,000 psi. If its density is .27 lbs./cu. in., the strength-to-weight ratio would be 890,000 inches.

• **Toward "magic million"**—The rocket maker's aim in the last few years has been to better this ratio—to get it up to the so-called "magic million." Much progress has been made in steels: better alloys have been developed; better heat-treating processes have been developed, such as that announced last month by **Research Development Corp. of America** (M/R, Sept. 28, page 10); welding has been improved to the stage where when rocket cases burst in tests of their ultimate strength, the burst no longer occurs at the welding seams.

Furthermore, such processes as the strip-winding technique developed by **Ryan Aeronautical Co.** have raised the ratio still higher. Ryan says it can get ultimate stress up to the neighborhood of 300,000 psi with this method.

But titanium and plastics may be able to do as well in a single leap. **Titanium Metals Corp. of America** reports it has developed an alloy with 190,000 psi ultimate yield strength. This would put the strength-to-weight ratio in the area of 1,200,000 inches. A simple aging process, TMCA says, can increase the strength to 200,000 psi for a ratio of 1,250,000.

With the glass fiber-resin combination, the figures are even more amazing. **Hercules Powder Co.** says its Young Development Division has developed a material with ultimate

strength of 135,000 psi and density of .072 lbs./cu. in. This gives it a strength-to-weight ratio of more than 1,800,000.

Aluminum is in there pitching, too. Although its figures don't show up as well as plastic and titanium, **Alcoa** reports an alloy with strength-to-weight ratio of about 830,000—which compares favorably with steel.

• **Solid battleground**—The scene of battle is the lower stages of the big new solid-fueled missiles: the Air Force **Boeing** *Minuteman*, the Navy **Lockheed** *Polaris*, and the Army **Martin** *Pershing*. The decisions are made by case fabricators, propulsion contractors, primes and the services themselves. Design engineers propose choice of material—but cost accountants dispose.

Laminated plastics made the first inroads in steel's domination. Hercules produced a small, high-performance rocket that was used as the final stage of last year's Air Force *Pioneer* moon shots. The rocket was adapted as the third stage of last month's successful *Vanguard III*. Hercules now proposes to use a similar bird, scaled up somewhat, as the third stage of *Minuteman*.

Titanium is being tested for the lower stages—the second stage of *Polaris* and both stages of *Pershing*. Wright Aeronautical Division of **Curtiss-Wright** is making two prototype titanium *Polaris* cases for **Aerojet-General. Pratt & Whitney** is making the *Pershing* cases for **Martin-Orlando.**

Early this year, a titanium fourth stage carried *Pioneer IV* into an orbit around the sun—the first object to be pushed by American rocketry out of the earth's gravitational field. The switch from steel to titanium made it possible to add two pounds—about 20%—to the payload.

• **The money bind**—But the question of cost has raised its ugly head in the *Pershing* program. The Army has a budget even tighter than those of the other services. Mill titanium costs something like $7 a pound, compared with about $1.50 for vacuum-melted steel. For this reason, the Army has tentatively decided to scrap the *Pershing* titanium program. The decision will not be final for a few weeks, but with the current bind on Army money it is hard to see how it can be reversed.

Another factor in Army thinking on *Pershing* is the theoretical 200-mile range limit on Army weapons. Even with a steel case, *Pershing's* range approaches 700 miles. You don't have to be privy to military secrets to be able to figure that the range would be substantially extended by a switch to titanium.

• **Other uses**—Elsewhere in missiles, titanium already is making struc-

THOR
MACE
TITAN
HAWK
ATLAS
NIKE B
BOMARC
NIKE ZEUS
SPARROW I
SPARROW II
SPARROW III
NIKE HERCULES
SIDEWINDER
REGULUS II
VANGUARD
PERSHING
BULL PUP
POLARIS
CORVUS
FALCON

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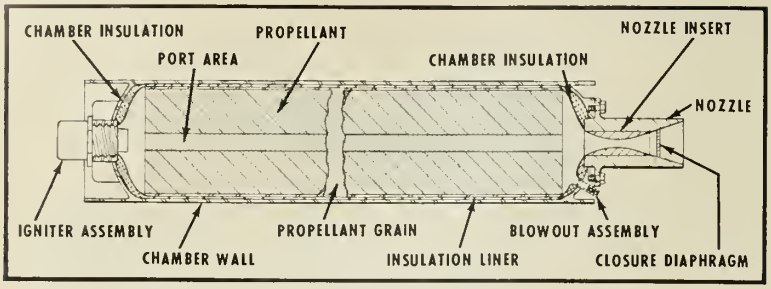
heat-resistance less important . . .



THE BATTLEGROUND: A typical solid rocket propulsion unit.

tural inroads. The first use of the metal on a large scale was in the liquid-fueled **Convair** *Atlas*. Spherical helium bottles, ranging in diameter from 16 to 24 inches, were made of titanium after original studies showed one type of bottle could be produced at 50 pounds. Weights for other metals were aluminum, 80 pounds, and steel, 125, TMCA reported.

The alloy chosen for the *Atlas* job was so-called "6-4"—titanium plus 6% aluminum and 4% vanadium. This is an alpha-beta combination: Alpha titanium has a close-packed hexagonal atomic structure; Beta titanium has a body-centered cubic lattice, that is, the atoms are stacked in array corresponding to the corners of regularly stacked cubes, with an additional atom at the center of each cube.

Recently, TMCA introduced an all-beta titanium alloy, with 13½% vanadium, 11% chromium and 3% aluminum. The alloying ingredients increased the density to 0.17 lbs./cu. in.

Beta titanium gains considerably in strength by simple aging at temperatures between 800 and 900°F. It need not be quenched, as in normal heat-treat processes. TMCA spokesmen say this provides a manufacturing economy that partly offsets the raw material cost.

• **Participation**—TMCA, jointly owned by **National Lead** and **Allegheny Ludlum,** is the largest producer of mill titanium and the only integrated producer of both raw titanium sponge and mill products. Other titanium mill producers are **Mallory-Sharon, Crucible Steel,** and **Republic Steel.** Other sponge producers are **Union Carbide Metals Corp., du Pont, Dow Chemical,** and **National Distillers.**

Compiling a list of the firms interested in laminated plastic glass fiber for rocket cases would be a herculean task. Some of those in the field are **Lamtex, Thompson Fiber Glass, Continental Diamond Fibre, Haveg Industries,** and **Zenith Plastics,** a subsidiary of **Minnesota Mining and Manufacturing,** in addition to Hercules.

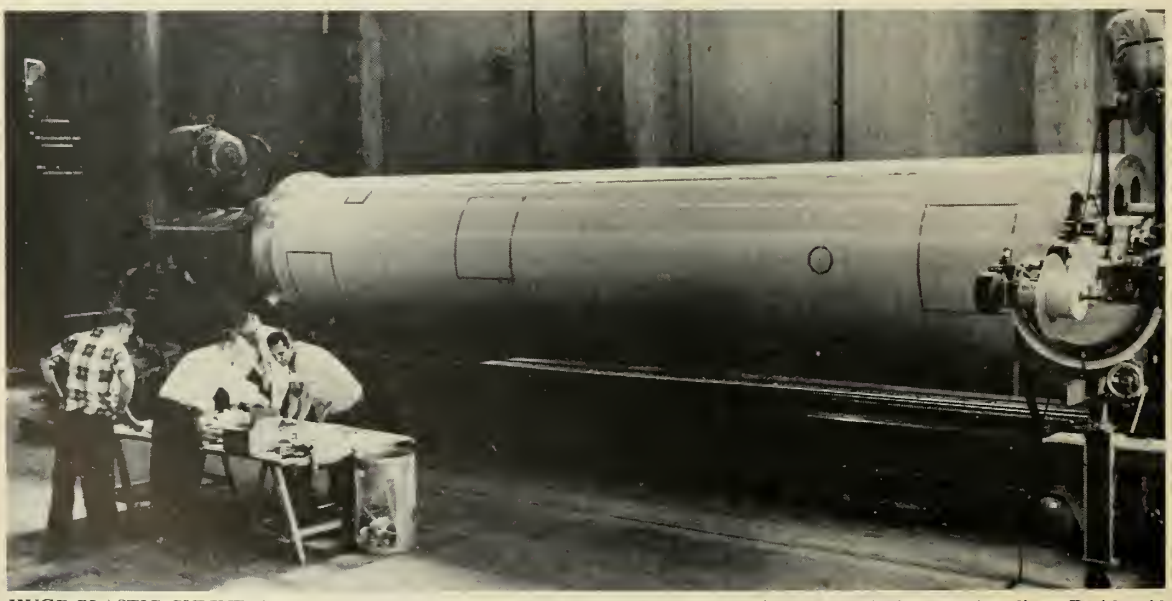
Recently, Zenith delivered a plastic cylinder 25′ long and 57″ in diameter to Lockheed. Zenith said it was the largest reinforced plastic cylinder ever made. The cylinder, a shipping container liner, weighed less than 1000 pounds and replaced a metal cylinder. Zenith said the production of the cylinder demonstrated that large missile cases also can be made of such material.

Lamtex says it has made plastic cases for *Nike-Hercules, Bomarc, Little John, Pershing* and *Minuteman* at one-half the weight of similar structures in steel.

Filament-wound motor cases consist of about 80% glass fiber and the rest plastic—usually epoxy resin. The fiber is wound at high tension around a mandrel while the resin is applied in a pasty condition. Two winding systems almost at right angles to one another prevent the fiber from separating laterally.

Hercules winds one filament in a system nearly parallel with the cylinder axis. The other is circular. The near-axial filaments can be passed over an end shape to provide closure.

• **What about heat?**—A question often raised about both titanium and plastic cases is their resistance to high temperature. Actually, this is less important today than formerly. Modern



HUGE PLASTIC CYLINDER was recently delivered to Lockheed by Zenith Plastics for use as shipping container liner. Zenith said the fabrication proved the possibility of making big plastic rocket cases.

solid fuel grains are excellent thermal insulators. Since they burn from the center out, the case itself is not heated until the last instant. If it fails at that moment, the failure doesn't matter, since the rocket already has provided its full quota of propulsion. However, the case itself provides additional insulation. It is actually possible to touch a small plastic rocket a moment after firing without burning your hand.

Both titanium and plastic claim an advantage over steel in their corrosion resistance—a factor particularly important for weapons such as *Polaris* and *Minuteman,* which must be stored for long periods of time in places where they might to subject to rusting or attacks by salt water.

The biggest objection to plastic has been its tendency to absorb water from the atmosphere when stored over a long period. This might tend to weaken the structure.

Titanium's major headache has been notch sensitivity—the tendency of a high-strength, heat-treated metals object to weaken in spots where a notch or indentation has been cut into it. Steel has notch-sensitivity problems too, but some steelmen say the problem is even greater with titanium. Titanium spokesmen vigorously deny this.

However, the greatest barrier to the immediate use of these newer materials for rocket cases is the concept of "historical reliability." So much more is known about steel and its properties that users can predict with greater confidence what it will do under every sort of condition.

Furthermore, the Air Force and Navy feel that the nation's survival may depend on development of some kind of *Minuteman* and some sort of *Polaris* as soon as humanly possible. And so orders have gone out to develop these two weapons with a bare minimum of new concepts. Such refinements as titanium or plastic rocket cases will have to wait until later.

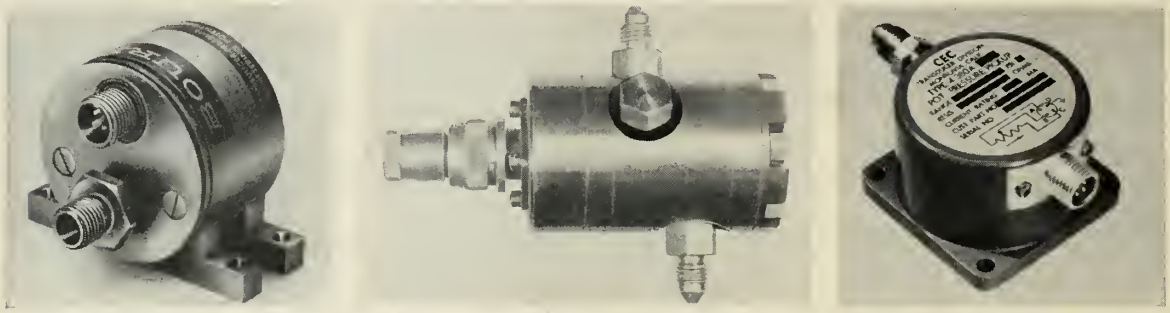
Gauge Is Sensitive to One-millionth of an Inch

SEATTLE—A unique "Mag-Ray" gauge—developed at **Boeing's Aero-Space Division**—is so sensitive that it can indicate difference of one-millionth of an inch. One portion of the dual instrument measures capacitance changes, the other the intensity of beta-ray reflection.

The gauge was developed for such measurements as plating thicknesses on *Bomarc* missile timer discs—where both nickel and rhodium platings must be measured. Future applications include measurement of ceramic coatings, paint, and other thin films.

Healthy Transducer Market Promises Even Greater Future Potential

M/R survey shows that the industry is dominated by fewer than 10% of the manufacturers



TRANSDUCER DEVELOPMENTS are reflected in these products. Left: Bourns Laboratories employs an unusual Bourdon tube movement for operation to 35G at 200 cps vibration. Crescent Engineering transducer, center, has a sensitivity of 100 millivolt 1 volt full-scale. CEC model has withstood 100 G shock.

by Charles D. LaFond

WASHINGTON—Only a handful of companies carry the lion's share of the annual $90-million transducer market today. But—just like the better mousetrap—the field has an even greater money potential for manufacturers who come up with solutions in vital problem areas.

The role of transducers in missilery and astronautics principally involves support equipment. Upon transducers falls the task of providing the means for faithfully reproducing a multitude of variable quantities that must be measured.

To do this, each transducer—regardless of function—must impose a negligible load on the variable under measurement. And—above all—the response must be free of all other variables being experienced by the tested system.

As in many other fields of the missile industry, these criteria have created new needs: better environmental testing, new materials to withstand high-g acceleration and shock, high temperature, vibration and corrosive atmospheres.

Production techniques are dictated by the required product quality and costs are restricted by competition. M/R has located over 130 companies in this country alone actively producing from one to seven basic types of transducers. But, who are the leaders in the field and what is being accomplished?

As already indicated, a few manufacturers are dominating multi-million-dollar business. But other companies now nibbling at the outer edge could at any time secure a larger piece with a significant breakthrough in any one of the problem areas.

Statham Instruments, Inc., reports that it is carrying about 10% of the whole transducer business. Principal products are pressure transducers, accelerometers, and load cells of the unbonded strain gage type. Significantly, a company spokesman says missiles are accounting for a much larger share of the total market than aircraft flight test applications and wind tunnel investigations combined.

Baldwin-Lima-Hamilton Corporation's Electronics and Instrumentation Div. until two years ago held the patent for bonded strain gage transducers. Although they licensed a few outside corporations to produce them for limitated applications, BLH controlled the whole market.

The company estimates the total missile market for load cells and pressure cells at $2 million and $10 million, respectively. Seventy-five per cent of the load cell business is theirs, although they have only about 5% of the pressure cell market.

The Garrett Corporation's AiResearch Manufacturing Co. has been developing and producing transducers for over 10 years. Their principal field has been the external environments for flight testing missiles, drones, and aircraft.

They have also exerted great effort in developing devices for use in controlled flight regimes for space vehicles during atmospheric exit or re-entry.

In 1950, the company produced

Transducer Breakthroughs Needed Now

To help manufacturers build the proverbial "better mousetrap," this M/R survey has revealed some of the products needed tomorrow:

- *For use with associated missile servos, a feedback potentiometer for operation in 1000°F temperature environment.*
- *A 2-to-5-volt high output strain gage for direct coupling to telemetering subcarrier without amplification.*
- *A digital output transducer for test use.*
- *Vastly improved magnet wire, lead wire, and potting compounds to withstand all the severe environments and rapid environmental changes experienced by tomorrow's missiles and spacecraft.*

what it feels was the first ". . . true, servoed, force-balance transducer for Mach number and altitude." Since then, AiResearch believes, it has led the field in the production of this type transducer. In one application alone, engine pressure ratio indicators, more than 10,000 systems have been built, said a company spokesman.

AiResearch also stated that it built the first force-balance, multiple output Mach and altitude transducers. More than 10,000 of these are now employed in aircraft and winged missiles.

Another manufacturer prominent in the air data transducing field is **Minneapolis-Honeywell Regulator.** The company carries a complete line of units ranging from very accurate force-rebalance transducers to low-cost, lightweight, direct-driven air data devices.

Principal manufacturer of piezoelectric accelerometers is believed to be **Gulton Industries, Inc.** In addition, the company stated that it carries a very complete and diversified line of transducers for industry and the military.

Crescent Engineering and Research Co. is a leader in the production of AC electro-mechanical transducers—linear differential and variable permeance and reluctance types.

Consolidated Electrodynamics Corporation's Transducer Division has made inroads on the chamber-type unbonded strain gage pressure transducer market. The company has applied its effort toward developing units covering broad pressure ranges (100-10,000 psi) wide high temperature operation (−320° to 2000°F), and high-g shock (100 g) and acceleration.

It is not possible to list all of the other 130-odd transducer manufacturers, but here is a summary of some of the important producers.

- **G. M. Giannini & Co., Inc.**—accelerometers, low- and high-pressure transducers, probe and vane types for temperature, pressure, pitch and yaw.
- **Bourns Laboratories, Inc.**—position and pressure transducers.
- **Colvin Laboratories, Inc.**—low to medium pressure devices.
- **Standard Controls, Inc.**—bridge, unbonded, pressure transducers.
- **Taber Instrument Corp.**—bridge, bonded, pressure transducers, an extensive line for liquid and gas.
- **Vinson Manufacturing and Sales Co.**—all types of motion transducers.
- **Kearfott Co., Inc.**—accelerometers and temperature sensors.
- **Arnoux Corp.**—temperatures sensors.
- **Wallace O. Leonard, Inc.**—accelerometers, flow and pressure transducers.

Types of Transducers

Von Nostrand's Scientific Encyclopedia, Third Edition, defines a transducer in its more narrow sense as a ". . . device capable of being activated by waves from one or more transmission systems or media, and of supplying related waves to one or more other transmission systems or media."

Briefly, there are three general classifications for transducers based on their electrical pickup configurations: inductance, resistance, and output voltage. All are variable.

The resistance types employ either bridge or potentiometer circuitry. The output voltage types use the piezoelectric effect (generation of an electrostatic voltage by crystal compression).

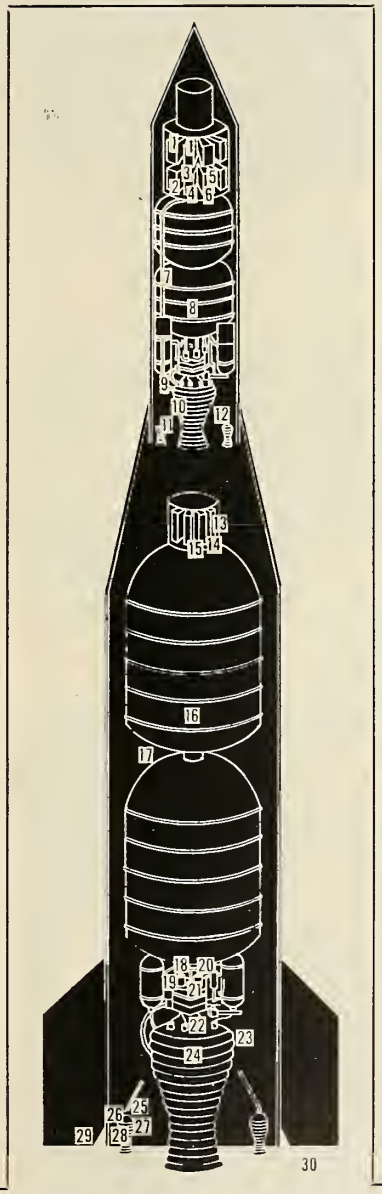
In missile-telemetry applications, principal functional types of transducers are used to measure the following: acceleration, position or motion, force, pressure, strain, temperature and vibration.

- Acceleration—Accelerometers use either a change of inductance or resistance to translate linear or angular accelerations into usable measurement data. The response is seismic in producing a proportional voltage output.
- Position or motion—Transducers are available for indicating an angular position or angular or linear motion. Either a variable inductance or potentiometer type can be used. The former employ a rotating shaft to alter inductance and is used to register small torque or short linear distances. The latter finds greater application for high-frequency motion—either angular or linear.
- Pressure—Changes in fluid pressure are translated by differential pickups employing changes in inductance or resistance. From here on it is difficult to generalize with brevity for there are different ranges requiring different pressure-indicating techniques.

For low, medium, and broad-range transducers, a two-chamber, diaphragm type is used with an "E-coil" inductor rigidly mounted and serving as one wall in one chamber.

Inductance in the E-coil is changed with pressure differentials between the two chambers by means of a high-permeability material in a pad secured to the diaphragm.

Transducers of this type handle pressures ranging from 0.4 psi to 3000 psi. They are limited by case construction and the application of unequal



PREPARED BY Crescent Engineering and Research Co., this typical missile configuration indicates the variety of transducer applications in a single vehicle.

(1) Autopilot system, (2) propellant ratio control system, (3) translator, (4) rotary transducer (pickoff balance transducer), (5) HC-250-4E linear transducer (programmer), (6) HC-265-4E linear transducer, (7) tank differential pressure transducer and indicator system, (8) pressure transducer (propellant motion), (9) velocity transducer (actuator feedback damping), (10) linear transducer (sustainer autopilot feedback), (11) rotary transducer (vernier actuator telemetering pickoff), (12) rotary transducer (vernier gimbal autopilot feedback), (13) linear transducer (programmer), (14) linear transducer (programmer), (15) linear transducer (programmer, (16) pressure transducer (propellant motion), (17) tank differential pressure transducer, (18) pressure transducer (propellant ratio), (19) pressure transducer, (20) rotary transducer (propellant valve pickoff), (21) rotary transducer (valve position pickoff), (22) rotary transducer (booster gimbal pickoff, ground monitoring), (23) booster actuator linear transducers, (24) pressure transducer (autopilot actuator feedback damping), (25) rotary transducer (gimbal autopilot feedback), (26) linear transducer (vernier ground monitoring instrumentation), (27) linear transducer (vernier actuator servo pickoff), (28) linear transducer (vernier actuator servo pickoff), (29) rotary transducer (control surface pickoff), (30a) ground installation test transducers (linear transducer position pickoffs-tank, engine, etc., ground test), (30b) linear transducer (signal comparator ground test).

pressures to the two chambers. Mechanical detents may be employed, but only on one side, as a protection against sudden overload.

For altitude, a modified unit is employed. It uses an aneroid cell instead of the diaphragm with magnetic pad (mu-metal) attached. Operation is otherwise similar.

For a somewhat limited range from 600 to 3000 psi, a bourdon tube and an E-coil inductor are used. The magnetic pad is secured to the tube, and the whole is encased. Pressure applied to the open end of the tube causes it to bend with a resultant change in coil inductance. A correction factor is necessary with any change in altitude, although the error is slight (less than 1%).

• Force—Mechanical force transducers, dynamometers, are varied and have broad application. A typical type consists of an E-coil mounted in one elastic ring and a mu-metal pad secured to another ring diametrically opposite the E-coil. With this arrangement, both tension and compression can effect a power translation by changing coil inductance.

• Vibration—Because of the frequencies involved, transducers using the piezo-electric effect are common for vibration pickup. They vary greatly in shape, size, and capability. Outputs of the order of 8 millivolts (rms)/g (peak) can be produced with a frequency range of from 5 to 2000 cps. Outputs require voltage amplification.

• Temperature—Two types of temperature-indicating sensors are in general use: thermocouples and variable resistance. For rapid response (0.1 sec.) the thermocouple and a voltage amplifier are used. The variable resistance type device has slower response, but greater sensitivity. Used as one active arm of a resistance bridge oscillator, a change in temperature unbalances the bridge circuit and modulates the oscillator.

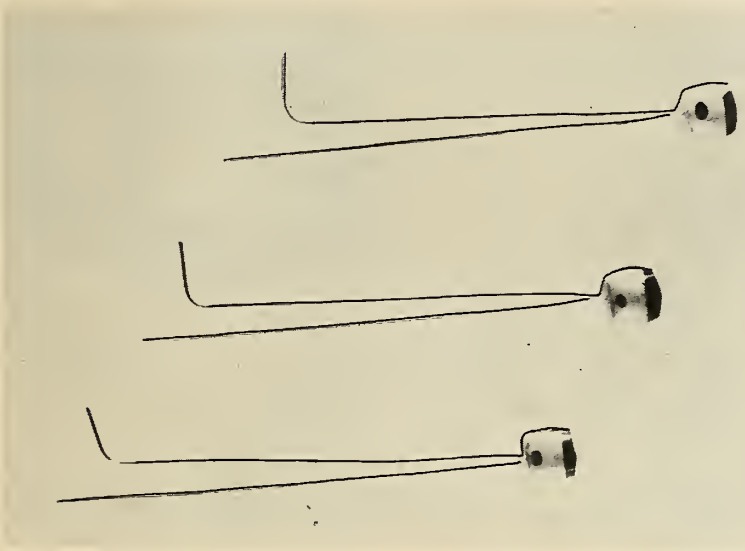
The physical configuration for temperature sensors are extremely varied. Minute sizes are avaliable for insertion into hydraulic systems; grid types for insertion in gas flow streams, etc.

• Strain—Workhorse of the transducer industry is the strain gage, which employs resistance bridge circuitry and falls generally into two principal groups —bonded and unbonded.

Most widely used is the bonded type, developed and patented by **Baldwin-Lima-Hamilton.** The SR-4 gage finds application in measurement of forces ranging from micropounds to megapounds.

The bonded strain gage enjoys a peculiar advantage: it can measure

(Continued on page 48)



Cheaper Selenium Diodes Produced

Designed for volume applications where high reliability, low cost and small size are key factors, new subminiature plastic-encapsulated selenium diodes—priced at only 15 to 35 cents in production quantities—have been developed by **Radio Receptor Company, Inc.**, subsidiary of **General Instrument Corporation**, and are available for immediate delivery.

Capable of operating in ambient temperatures from –50°C. to 100°C with derating, the new Radio Receptor diodes come in eight types, with peak inverse voltage ranges from 50 to 400 volts, at 12.5 ma. Maximum case length is only .380 inches for the 50 and 100 volt units up to .480 inches for the 400 volt type.

Protected from atmospheric conditions by the plastic encapsulation, the new diodes are color coded for simple identification. Bent pigtail and red dot on body of the diode give positive lead indication. The diodes are stated to be priced at least 20 per cent less than nearest comparable units, in quantity. Applications cover a wide range from computers, business machines, arc suppressors, power supplies, etc., to consumer products such as radio and TV sets, hearing aids and electric games.

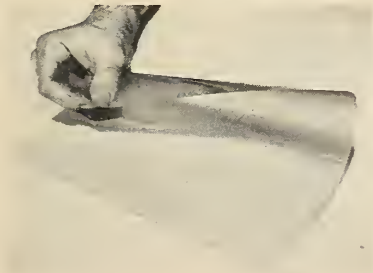
Radio Receptor Company
240 Wythe Avenue
Brooklyn 11, N.Y.

Laminated Plastics Available in New Grades

Two new general-purpose grades of Dilecto epoxy-impregnated, glass base laminated plastics are available from **Continental-Diamond Fibre Corp.**

Designated as GB-28EV-2 and GB-16EV-2, the grades are similar except that GB-16EV-2 is made from a finer weave cloth that permits its use in thinner laminates and for finer machining. Both materials are available as plain sheets or as Di-Clad copper-clad sheets for printed circuit applications.

These new grades are designed for electrical insulation applications requiring high reliability in severe service conditions. In such use they offer low electrical loss properties and good arc resistance and dielectric strength as shown in Table I. Dilecto GB-28EV-2 and GB-16EV-2 also feature excellent tensile and impact strength and good compressive strength. Both grades designated as NEMA G-10 laminates and meet requirements for MIL-P-18177B, Type GEE. Their fabricating qualities are good, with GB-16EV-2 slightly better for close tolerance machining.



The new grades are available in sheet sizes of 38-in. by 42-in. and 38-in. sq.

In thickness, GB-16EV-2 is available in 0.010 in. to 1/8 in. inclusive and GB—28EV-2 ranges from 1/32 in. to 1 in. inclusive. GB-28EV-2 is also available as rolled tubing in sizes from 2 to 12¾ in. ID and 2½ to 13½ in. OD with a minimum wall thickness of ¼ in.

Continental-Diamond Fibre Corp.
Newark, Del.

Transistorized Oscillator Feeds Low Power Units

A millivolt transistorized oscillator, developed by the **Hoover's Electronics Co.** makes it possible to feed the output of low level transducers (such as thermocouples, strain gauges, accelerometers) directly into the Hoover subcarrier oscillator without d-c amplification.

The advantages of eliminating the separate d-c amplifier are fewer packages, with a resulting saving in bulk and weight, lower power consumption, and the elimination of one possible source of error which has plagued telemetering in the past.

D-c common mode rejection is

conservatively rated at 10^7 within ± volts of ground. This permits the oscillator to be used with bridge circuits for measuring the voltage between two points in the bridge, without the oscillator's being affected by a voltage from one point to ground.

Floating input terminals eliminate problems which often result from a common ground among several components.

The subcarrier oscillator contains an internal voltage regulator. As a result of carefully designated circuits, its only power requirement is +26 volts. The distortion of the output signal is

limited to less than 1% by a bandpass filter which also prevents interference with adjacent channels.

The unit is produced to IRIG specifications of frequencies and deviations for channels 5 through 18 and A through E.

Hoover Electronics Co.
110 West Timonium Rd.,
Timonium, Md.

Silicone-Teflon Magnet Wire Operates at +250°

Anaconda Wire and Cable Company has produced Silicone-Teflon Magnet Wire with nickel-plated copper conductors. This is an organic film-coated magnet wire for continuous operation at 250°C.

The Silicone-Teflon Magnet Wire is being used successfully in transformers, solenoids, miniature relays and motors. Experimental transformers wound with Silicone-Teflon were subjected to sufficient load to maintain an average conductor temperature of 250°C and operated continuously for 11,000 hours without failure. Peak temperatures were estimated to be as high as 275°C.

Additional properties of Silicone-Teflon include: low dielectric constant and dissipation factor. Its outstanding flexibility and adherence permits it to be handled in the same manner as conventional film-coated wires. It has excellent resistance to solvent attack by most acids, alkalies and hydrocarbons.

Anaconda Silicone-Teflon wire is available in round sizes, No. 15 AWG through 36, in both single and heavy film thicknesses.

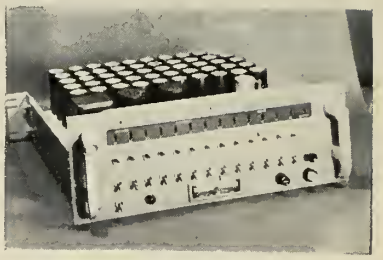
Anaconda Wire and Cable Company, Dept. EFL
25 Broadway
New York 4, N.Y.

Time Reader Features Simplicity

Vitro Laboratories has produced a magnetic tape search unit, the Vitro Model 1060 Automatic Time Reader, which compares the timing or index track of a magnetic tape with switches set to designate the beginning and end of tape sections of interest. Control signals are generated at these times to effect print-out or other desired action.

A "presensing" feature permits generation of the Start and Stop signals precisely at the beginning of a frame of interest and prior to reading time or index code for that frame.

The unit is composed of transistorized, plug-in modules mounted along with the power supply on a 16 inch deep chasis secured to pull out sides for mounting in a standard 19" track. A 7 x 19 inch front panel on the chassis contains the operating controls.



Vitro Laboratories
200 Pleasant Valley
West Orange, New Jersey

Sweep Generators Produce Watts of Power

RF Sweep Generators are now available that will produce watts, rather than milli-watts of power. The new instruments, covering the frequency range from 20 to 1000 mc, are manufactured by **Telonic Industries, Inc.**

Four Telonic Sweep Generators are included in the new line of highpower instruments. Models SP-103, SP-104, SP-105 and SP-106 cover center-frequency ranges of 20-100 mc, 100-250 mc, 250-500 mc, and 500-100 mc respectively. Sweep widths are variable from near zero to over 20% of the center frequency.

The high-power line of Sweep Generators incorporates new concepts in the design of swept RF generators. The two low frequency instruments employ inductively tuned oscillators, while the other two are designed with cavity-tuned oscillator circuits. All oscillators use high-power tubes in order to produce the specified output of over 15 volts RMS into 50 ohms (4-5 watts).

The high-power output is held constant within ± 5% over the maximum sweep width by use of AGC circuits controlling the oscillator B+ voltage.

For load isolation, 3 db pad is provided between the oscillator and the output jack. In addition, there is a vernier attenuator with a range of approximately 0-10 db. Display linearity is better than 1.2:1. Source VSWR for the Telonic instruments is normally below 1.3:1. The sweep rate is fixed at line frequency, 50 or 60 cps. The oscillator is cut off during the return trace in order to provide a zero base line on the oscilliscope image.

The new instruments include the Telonic Birdy-By-Pass Marker system,

which provides panel-front jacks for adding beatnotes or birdies to the signal after it has passed through the circuit under test. An external signal of approximately 0.1 volts may be used, or plug-in crystal-controlled marker units may be added to the basic instrument as optional accessories. Provisions are made for up to four "C" type Telonic Markers or two "CDH" type plug-in units.

Telonic Industries, Inc.
Beach Grove, Ind.

Angular Force Balance Accelerometer Available

An angular force balance accelerometer is now available from the **Donner Scientific Company.**

Chief applications for this type of instrumentation are related to missile and aircraft flight dynamics. Pitch, yaw and roll accelerations can be monitored giving information that in some cases eliminates the requirement for more expensive gyro devices. In addition to ballistic and aerodynamic applications, these instruments have been used for various commercial/industrial applications and in ground support equipment.

For instance, visualize a huge radar antenna, perhaps six feet in diameter being oscillated by servo motors at a precise rate. Now introduce wind gusts. Donner angular accelerometers have been used to monitor and to control such devices. They "sense" the gust and feed corrective signals to the antenna servos resulting in the smooth tracking operation of these giant electronic "eyes."

The Donner angular accelerometer operates as a subminiature servo system responsive to input angular acceleration about the sensitive axis. The basic accelerometer consists of a seismic system and associates position-error detector, a restoring mechanism, and a servo error signal amplifier. Under the action of angular acceleration, a force is generated on the seismic system which tends to develop a displacement.

As movement takes place the position-error detector and servo amplifier generates a rapidly increasing feedback signal which is returned as current through the restoring mechanism. With minute deflection of the seismic system, the electro-mechanical servo action of the accelerometer results in automatic balance between the input force proportional to acceleration and the feedback force proportional to current in the restoring coil of the accelerometer. The restoring current, or the voltage it develops across a fixed load resistor, is the electrical output of the instrument.

Donner Scientific Co.
Concord, Calif.

missile business . . .

By WILLIAM E. HOWARD

Missile contractors in search of new markets—particularly in electronics—should keep an eye on the Army Signal Corps. This agency currently is placing contracts at the rate of $500 million a year. At the moment, it has outstanding 10,000 contracts valued at a total of more than $2 billion. And it has an "open door" policy for new suppliers.

One angle of interest to small business concerns . . . is the corps' "small business specialist" who maintains a list of recent awards to successful bidders. This list may be reviewed by anyone seeking subcontracts. The list and other contract information is available at:

Headquarters U.S. Army Signal Supply Agency, 225 South 18th St., Philadelphia 3, Pa.; Midwestern Regional Office, U.S. Army Signal Supply Agency, 615 West Van Buren St., Chicago 7, Ill.; Western Regional Office, U.S. Army Signal Supply Agency, 125 South Grande Ave., Pasadena 2, Calif.; U.S. Army Electronic Proving Ground Procurement Office, U.S. Army Signal Supply Agency, Fort Huachuca, Ariz.; U.S. Army Signal Supply Agency, Ft. Monmouth Procurement Office, Fort Monmouth, N.J.; and the Washington Procurement Office, U.S. Signal Supply Agency, Room 2603 Main Navy Bldg., Washington 25, D.C.

Practically all production and industrial . . . preparedness measure contracts are placed by USASSA headquarters in Philadelphia. These include first time production upon completion of development, and technical representative contracts for the maintenance of field equipment. There is a New York regional branch office of USASSA headquarters, incidentally, at 46th and Northern Blvd., Long Island City 1, N.Y.

The Midwestern Regional Office has sole procurement responsibility for approximately 40,000 items of communications and electronic equipment—from antennas to telephones. No contracts are awarded at Western Regional Office. Its mission is purely to administer contracts with firms in the states of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

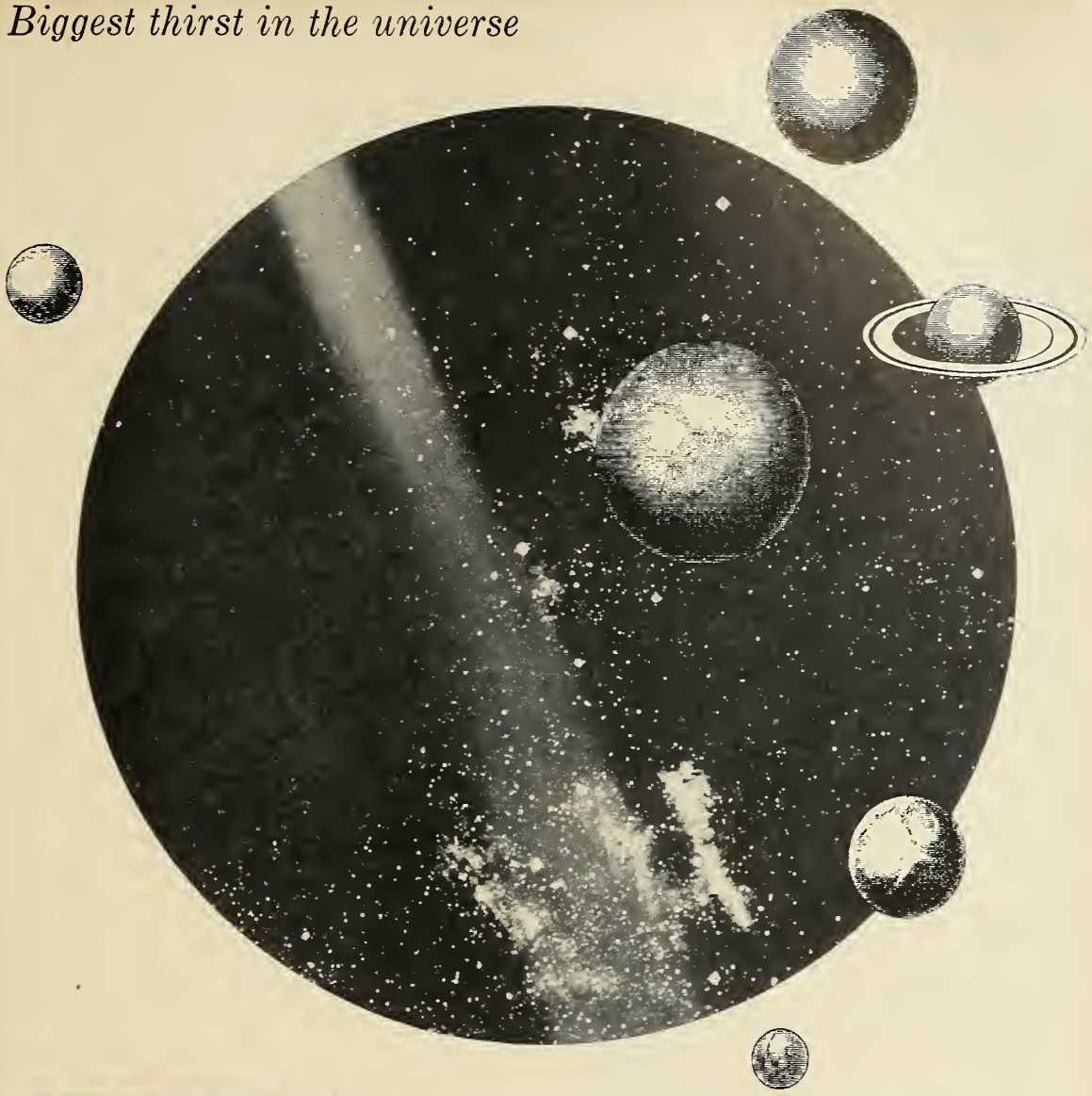
Special equipment contracts for its own operation . . . are placed and administered at Fort Huachuca. The hot one in the bidding stage now is for a $30-million electronic environmental and missile drone range at the Arizona installation. The contract, to be awarded after Jan. 1, will be for equipment to find out what happens to combat electronic equipment when it is massed on a battlefield. The Army figures that one pentomic division will have more than 15,000 pieces of electronic gear concentrated in a 60 square mile area and there are acute interference problems.

Fort Monmouth processes prime R&D contracts . . . in communications, radar, surveillance, electrical and electronic components. The initiating agency is the U.S. Army Signal Research and Development Laboratory at Fort Monmouth. Support and housekeeping items are purchased by the Fort's Support Purchases Branch.

No production or military spec contracts are placed by the Washington Procurement Office. Its job, primarily, is to buy standard commercial communications equipment and other services for agencies located in Washington. The Signal Corps also lets contracts for installations and maintenance through the U.S. Army Alaska Communications Systems, 550 Federal Office Bldg., Seattle 4, Wash.

New company divisions . . .
Convair Astronautics has set up a Base Activation Department under Alfred P. Higgins to facilitate organization and management of the logistic support for *Atlas* bases. And **Republic Aviation** has established an Economic Research and Corporate Planning Division headed by Edward Stone. The division will research markets, says Stone, and also "advise on the possibilities of corporate acquisitions."

Biggest thirst in the universe



Each 6,000,000 pound thrust rocket ship now being planned for manned interplanetary exploration will gulp as much propellant as the entire capacity of a 170 passenger DC-8 Jetliner in less than 4 seconds! It will consume 1,140 tons in the rocket's approximately 2 minutes of burning time. Required to carry this vast quantity of propellant will be tanks tall as 8 story buildings, strong enough to withstand tremendous G forces, yet of minimum weight. Douglas is especially qualified to build giant-sized space ships of this type because of familiarity with every structural and environmental problem involved. This has been gained through 18 years of experience in producing missile and space systems. We are seeking qualified engineers and scientists to aid us in these and other projects. Some of our immediate needs are listed on the facing page.

Dr. Henry Ponsford, Chief, Structures Section, discusses valve and fuel flow requirements for space vehicles with Donald W. Douglas, Jr., President of **DOUGLAS**

MISSILE SYSTEMS ■ SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND HANDLING EQUIPMENT

Kenneth Dollinger of Sanders Associates, Inc., has been designated project manager of the target seeker development for the *Eagle* missile. Prior to Bendix Aviation Corp.'s project seeker award, he was manager of a systems section for Sanders.

Dollinger, who joined the company seven years ago following several years of design and development work on missiles, has contributed prominently to advances in seeker systems, countermeasures, navigational devices and missile guidance. In addition to laboratory investigation, development, design, construction and flight testing, he participated in the initial design plans for development of the *Eagle*.


DOLLINGER

Dr. Nicholas A. Renzetti has been named chief of field tracking and instrumentation, and **Dr. Melvin Gerstein** has been appointed chief of the combustion research section of the California Institute of Technology Jet Propulsion Laboratory.

Renzetti was formerly associated with the Naval Ordnance Test Stations at China Lake and in Pasadena, where he supervised research and development of missile aerodynamics, trajectory determination and other areas of rocket research. At JPL he will be in charge of all deep space tracking stations and the technical communications between these facilities and the laboratory. He has written eleven technical papers and is a consultant to the Air Pollution Foundation, the Naval Ordnance Test Station and General Motors Research Division.

Dr. Gerstein was formerly assistant chief of the Propulsion Chemistry Division, Lewis Research Center. At JPL he will supervise and conduct research in the fields of combustion, chemical reactions in flow systems, and chemical reactions in the atmosphere of the earth and other planets. He has authored 25 technical papers and is well known both here and abroad for his work in laminar flame propagation and on high-energy fuels for air-breathing aircraft.

Frank Manov, formerly chief scientist to the Allied Air Forces in Central Europe and most recently a senior technical staff member at Space Technology Laboratories, has joined Electro-Optical Systems as supervisor of a newly formed satellite and space defense studies group.


MANOV

Manov was a senior member of a group responsible for systems engineering and technical direction of the *Atlas, Titan* and *Thor* missiles and a major contributor to recent anti-satellite studies by the Air Force.

Eugene T. Fleischhauer has joined the engineering staff of Poly-Scientific Corp. as senior mechanical engineer, directing special projects for airborne military products.

He was formerly associated with Experiment, Inc., Horace J. Smith, Jr., Inc., and for a number of years with Ordnance Research and Development.

Dr. William L. Whitson, internationally-known authority on space satellite systems, has been named a vice president of Daystrom, Inc.

Dr. Whitson was formerly deputy scientist of ARPA, supervising research and development of military space systems and ballistic missile defense. He was previously associated with the Operations Research office of Johns Hopkins University, the Union Carbide Co.'s Oak Ridge National Laboratory and the Radiation Laboratory at the University of California.


WHITSON

J. E. Brister has been elected to the newly created position of coordinator-defense materials for Union Carbide Plastics Co., division of Union Carbide Corp.

Brister, who joined the company in 1933 as a technical representative, has held positions as manager of the Wire and Cable Division, and department manager, Molding and Extrusion Materials, and most recently served as product general manager-Polyolefins.


BRISTER

Dr. C. G. Harman, with more than 25 years in both basic and applied research, has been appointed senior scientist for Gladding, McBean & Co. He is the author of more than 50 scientific and technical publications, holds many patents, has been affiliated with Battelle Memorial Institute and Locke Insulator Corp. and most recently headed the ceramic department of Horizon, Inc.

Data-Control Systems, Inc., has elected **Raymond A. Runyan** vice president of research and development in telemetry and associated fields.

Runyan, one of the original founders of the company, has written several papers in the telemetry field and directed the development of the line of voltage controlled oscillators, calibrations and ground subcarrier discriminators. He has been associated with Boeing Airplane Co. in the development of non-destructive metal testing equipment, did research on airborne signal processing equipment for Aerophysics Laboratory of North American Aviation and previously designed wind tunnel instrumentations for both United Aircraft and NASA.

The following appointments have also been announced:

Morris Plotkin, formerly with the Naval Air Development Center, Johnsville, Pa., has been named chief of analysis at Auerbach Electronics Corp.

Dr. James Q. Brantley has been named vice president and director of research at Radiation, Inc., replacing Lloyd R. Everingham, who recently resigned.

Robert T. De Vore, former public relations director for the Instrument Society of America, has been named public relations director of Electronic Industries Association.

R. E. "Tim" Dahlin has been appointed sales representative for Transue & Williams Steel Forging Corp., to serve Texas, Oklahoma and southern Kansas.

Republic Electronics Industries Corp. has announced appointment of **Louis F. Lucci,** formerly of Airborne Instrument Laboratories, to the newly created post of assistant purchasing agent.

Alanson W. Parkes, Jr., well known in aviation through 30 years' association with the Aircraft Radio Corp., has been elected president of Ballantine Laboratories, Inc.

Donald C. Harris, previously regional sales engineer for Sperry Semiconductor Corp., has been named West Coast sales manager for National Semiconductor Corp.

David Shapiro has been named to represent Vertol Aircraft Corp. and its subsidiary, Allied Research Associates, on the West Coast.

Sperry Gyroscope Co.'s Sunnyvale Development Center has named **A. W. Lindh** industrial relations superintendent.

Henry Lehne has been elected a senior vice president of Sylvania and will have overall responsibility for electronic systems operations.

Ivan Dornbush has been appointed general manager of Technology Instrument Corp. of California.

Brig. Gen. J. A. Barclay has been named acting deputy commanding general of Army Ordnance Missile Command, Redstone Arsenal, replacing Brig. Gen. J. M. Colby, who has retired.

Lehigh A. Taylor, former RCA marketing executive, has joined Southwestern Industrial Electronics Co. of Houston, in the newly created post of vice president of marketing.

——more about the missile week——

• **Groton, Conn.**—Dummy *Polaris* Missiles are now being test-launched from the George Washington, the nation's first nuclear-powered fleet ballistic missile submarine. Initial firings are being conducted while the sub is tied up in the Thames River at the **Electric Boat Division** of **General Dynamics Corp.**

• **Paris**—In the wake of the formation of SEREB (Societe D'Etudes et de Realisation D'Engins Balistiques) by eight French companies to develop missiles and space vehicles, suggestions are now being advanced for the creation of joint research centers by European nations to work in the space field. SEREB was legally organized last month with a capitalization of $1.5 million.

• **Washington**—The AF Air Research and Development Command is now in the process of being reorganized into four functional divisions to cut "substantial time" off the development cycle. These are: the already existing BMD at Englewood, Calif., which will remain under the command of Maj. Gen. Osmond J. Ritland; a new Wright Air Development Division which will consist of the present directorate of systems management and major elements of the Wright Air Development Center; a new Air Force Command and Control Development Division to be established at Hanscom Field, Bedford, Mass., and including elements of the existing AF Cambridge Research Center; and an AF Research Center which will be established in the Washington area and will include the AF Office of Scientific Research, European office of ARDC and other elements of the command engaged in basic research.

• **Washington**—Dr. Herbert York, Pentagon R&E director, conceded that Soviet ICBM's are more reliable than the *Convair Atlas*. York said Russia has been able to develop a more reliable ICBM than the United States because the Russians started work on it earlier.

• **Cape Canaveral**—The Air Force successfully launched three big missiles in 14 hours. An *Atlas* carrying a new fast-re-entry nose cone roared more than 6000 miles down the Atlantic Missile Range Oct. 6. A **Douglas** *Thor* followed it 11 hours later for some 1700 miles. Meantime, an RAF crew launched another *Thor* from Vandenberg AFB, Calif.

• **Ann Arbor, Mich.**—The Navy completed construction of a $600,000 radio telescope that ranks first in the world in the quality of its reception. The telescope—located at the University of Michigan's Peach Mountain Radio Astronomy Observatory—is designed to listen to solar flares and pick up radio emissions from interstellar hydrogen gases in other galaxies.

• **Washington**—Lt. Gen. Bernard Schriever, chief of ARDC, predicted that space between 500 and 25,000 miles from earth will be the "most likely theater" of operations for manned spacecraft well into the future. He also predicted development in the next several years of rockets capable of transporting "very small groups" of men between continents.

• **Washington**—The government announced significant contracts in the fields of nuclear rockets, AICBM's and tactical missiles. NASA is negotiating a $1-million, three-year contract with **Lockheed Aircraft's Nuclear Products Division,** Atlanta, for experiments in connection with a new nuclear rocket system. The research will determine behavior of possible nuclear rocket materials, including liquid hydrogen, at extremely low temperatures while being exposed to radiation. The Army let $188 million in contracts to a **Western Electric** contractor team for R&D on the *Nike-Zeus* AICBM. ARPA and ARDC awarded **Cornell University** a contract to design and build a 1000-foot diameter spherical antenna to be installed in Puerto Rico for anti-missile research. Cost: $4.5 million. **Martin** received a $24-million contract for continued engineering activities on development of the solid-fueled *Pershing* 700-mile surface-to-surface missile.

• **Mare Island, Calif.**—The USS Theodore Roosevelt—third of the nation's growing fleet of *Polaris* launching nuclear-powered submarines—slipped down the ways at Mare Island Naval Shipyard. The ship was the first of the 5400-ton *Polaris* subs to be launched on the Pacific Coast.

• **Dover, N.J.**—The Naval Air Rocket Test Station here has developed a new group of high-energy rocket monopropellants—the two best—"Tallulah" and "Caves." The latter is considered the more stable, weighing more than 95 pounds per cubic foot.

Mergers & Expansions

Ford Motor Co. is opening an advanced R&D facility at Boston headed by Dr. Eric Durand . . . Across the country at Los Angeles, **Perkin-Elmer Co.** of Norwalk, Conn., is opening another advanced R&D operation which will require a staff of 100 . . . **North American Aviation** has completed purchase of its full interest in **Astrodyne Inc.,** McGregor, Tex., from **Phillips Petroleum** . . . **Marquardt Corp.** is adding a $1.2 million building at its Pomona, Calif., division . . . **Lewyt Mfg. Corp.** has been purchased by **The Budd Co.** . . . **Chance Vought** is modernizing its heat treating facility at Dallas to handle refractory metals . . . A new semiconductor plant is being put up at Holmdel, N.J., by **Bendix Aviation Corp.** . . . **Sylvania Electric** plans to construct a 32,000-square foot computer component manufacturing plant at Santa Cruz, Calif., next month . . . Overseas, **Garrett Corp.** has established a subsidiary in Geneva . . . **Burtonwood Engineering Co.,** Lancashire, England, has been acquired by **U.S. Industries Inc.** . . . and at Edinburgh, **Ferranti Ltd.** has expanded its inertial navigation instruments laboratory.

contracts

NASA

$54,650—**Avion Div., ACF Industries, Inc.**, Paramus, N.J., for radar beacons.

$47,400—**Gustav Hirsch Organization, Inc.**, Columbus, Ohio, for installation and connection of electrical equipment for reactor facility at Plum Brook, Sandusky, Ohio.

NAVY

$4,700,000—**North American Aviation, Inc., Autonetics Div.**, for additional autonavigators for *Polaris*-carrying submarines.

$1,650,401—**Philco Corp.**, Philadelphia, for technical professional services of electronics field engineers.

$1,250,000—**Packard-Bell Corp.**, for production of airborne radar recognition sets.

$124,435—**Electronics of Clearfield, Inc.**, Clearfield, Pa., for 91 oscilloscopes.

$95,288—**Remington Rand Univac Div. of Sperry Rand Corp.**, St. Paul, Minn., for technical professional services of electronics field engineers.

$79,845—**Telemetering Corp. of America**, Sepulveda, Calif., for services and material to manufacture sonar telemetering system.

$79,685—**Hewlett-Packard Co.**, Alexandria, Va., for H-P model 150A 10mc oscilloscopes, cabinet mount.

$52,203—**Clevite Corp.**, Electronic Research Div., Cleveland, for developing and evaluating a high-temperature dielectric material for capacitors.

$25,985—**Sperry Rand Corp.**, Long Island, N.Y., for technical professional services of electronics field engineers.

AIR FORCE

Aerojet-General Corp., Azusa, Calif., for the design and fabrication of four *Astrobee-500* sounding rockets. Amount not disclosed.

Daystrom, Inc., for production of power control and marginal checking distribution equipment to be used in the SAGE program. Amount not disclosed.

$15,500,000—**Federal Electric Corp.**, Paramus, N.J., for nonpersonal services to operate and maintain and necessary supply support for the White Alice communication system in Alaska.

$15,200,000—**International Business Machines Corp.**, for five SAGE computers.

$5,268,000—**Continental Electronics Manufacturing Co.**, Dallas, for additional super power radar transmitters for use with BMEWS surveillance system.

$1,500,000—**FXR, Inc.**, Woodside, N.Y., for manufacture of additional DC line type modulators used with the AN/FPS-35 radar set which becomes a part of SAGE. (Subcontract from Sperry Gyroscope Co.)

$714,112—**Machlett Laboratories, Inc.**, Springdale, Conn., for various electron tubes.

$300,000—**General Precision Laboratory Inc.**, Pleasantville, N.Y., for components of AN/APN-102 doppler radar sets, spare parts, maintenance tools and test equipment and related data.

$80,150—**Central Electronics Manufacturers**, Danville, N.J., for various electron tubes.

$57,739—**Microwave Electronic Tube Co., Inc.**, Salem, Mass., for various electron tubes.

$44,890—**Ampex Corp.**, Newton, Mass., for recorder/reproducer for instrumentation.

$35,000—**Catholic University**, Washington, D.C. for studies concerning the structure and motion of molecules.

$28,000—**Columbia University**, for conducting a broad investigation of electronic computer-control systems.

$26,372—**Oregon State College**, Corvallis, for performing an investigation of light emission characteristics during early stages of microwave plasma formation.

$25,000—**University of Minnesota**, for conducting basic research in gaseous electronics.

$17,000—**Yale University**, for investigation of various properties of liquid helium.

ARMY

$188,402,905—**Western Electric Co.**, New York, for continued research and development of the *Nike-Zeus* anti-missile missile.

$24,000,000—**Martin Co., Orlando**, for continued engineering work on the *Pershing* solid-propellant surface-to-surface missile.

$2,177,684—**Aerojet-General Corp.**, Azusa, Calif., for 686 *Hawk* missile rocket motors.

$2,154,000—**Chrysler Corp.**, for services and parts for the *Jupiter* missile.

$2,067,138—**General Electric Co.**, Phoenix, for digital computation facility operation.

$1,727,717—**Burroughs Corp.**, Detroit, for production of classified communications units.

$1,313,615—**Sperry Rand Corp.**, for amplifiers to be used in the *Nike-Zeus* development program.

$1,288,211—**Litton Industries of California**, for improvements in the Missile Master systems.

$251,808—**Harvey Aluminum, Inc.**, Torrance, Calif., for study on weapon systems.

$174,462—**Douglas Aircraft Co. Inc.**, Santa Monica, Calif., for *Nike* repair parts.

$127,820—**Central Electronic Manufacturers**, Denville, N.J., for various electron tubes.

$86,183—**Westinghouse Electric Corp.**, Pittsburgh, for investigations leading to the development of photomission solar energy converters.

$67,973—**Tung-Sol Electric, Inc.**, Livingston, N.J., for various electron tubes.

$50,000—**Electro-Optical Systems, Inc.**, Pasadena, Calif., for research and development on concentrators.

$46,811—**Commercial, Hicksville, N.Y.**, for feasibility study of an electric timer for use in rocket and guided missile adaption kits.

$43,519—**Electro-Optical Systems, Inc.**, Pasadena, Calif., for research and development work toward investigation of composite or stacted variable energy gap photovoltaic solar energy converters.

$41,268—**Washington University**, St. Louis, for continuation of research on allergic contact dermatitis: Induction of skin sensitivity by low molecular weight substances.

$35,740—**Eagle-Picher Co.**, Miami, Okla., for investigation of integrally composed variable energy gap photovoltaic solar energy converter.

$32,747—**Bulova Research and Development Laboratories, Inc.**, Woodside, N.Y., for study, design and fabrication of nine prototype accelerometer monitors and micro-miniaturized 3-speed synchro assemblies utilizing size 8 synchros for the ground equipment to be used in the *Jupiter* guidance system.

$26,070—**Resdel Engineering Corp.**, Pasadena, Calif., for receivers and local oscillators.

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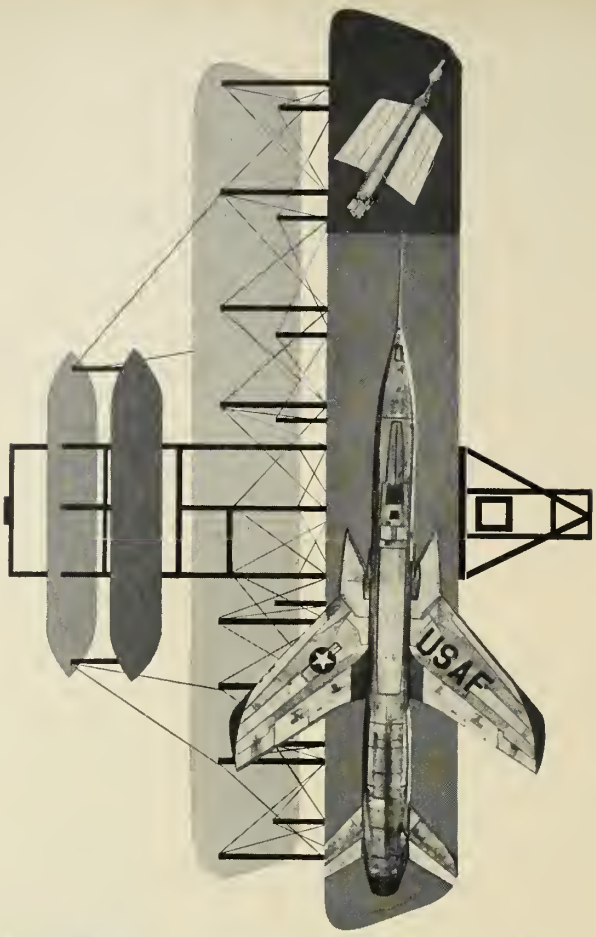

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REPUBLIC AVIATION
FARMINGDALE, LONG ISLAND, NEW YORK

Lunik Orbit Is Longest Yet

by C. Paul Means

WASHINGTON—The Soviet Union apparently succeeded last week in using the moon's gravity force to put *Lunik III* into the most elongated orbit any man-made satellite has achieved.

Present calculations indicate that *Lunik III* will travel over 350,000 miles from earth at apogee and come within 9,000 miles at perigee.

If the as-yet-undisclosed instruments in the Soviet satellite function properly, they will give the first systematic observation of the space between earth and moon. Repeated crossings by *Lunik* of the charged particle belts enveloping the earth should allow scientists to draw a fairly complete and accurate map of these belts. With its orbit extending 100,000 miles (estimated) outside the moon's orbit, the satellite may uncover new phenomena.

• **No moon orbit**—The Russian satellite did not actually orbit the moon. Though the moon's gravitational pull did slow the vehicle, turn it around and head it back again towards earth, the moon will be long-gone by the time the satellite recrosses its orbit path.

Estimated period of the satellite is 18.232 days, with approximately 13 days of the orbit spent outside of the moon's orbit path. Life-time of the satellite is indefinite, though its orbit will be affected by the moon every time it comes within close proximity to it.

The satellite did come close enough to the moon to have taken a crude picture of its back side. The Russians have not announced whether or not *Lunik III's* payload was so equipped, or whether the equipment worked.

Lunik III was launched at approximately 5 a.m. Sunday, Oct. 4, Moscow time. It performed differently than the two earlier Soviet moon rockets in that its speed was purposely slower so that it would be attracted by the moon's gravitational pull.

The soviet approach to moon orbiting as demonstrated by *Lunik III* is markedly different from the American plan, which will attempt to slow its *Atlas-Able* rocket's payload to the desired velocity by firing a retro-rocket.

Unlike the two previous *Luniks, Lunik III* did not emit a sodium cloud to aid visual tracking. Speculation is that this mechanism failed to function.

The satellite was powered by chemical batteries replenished by solar cells. The transmitters were turned off in order to save battery power when the satellite was not over Soviet territory. For this reason, U.S. tracking installations have not been able to track it.

Soviet reports said the undisclosed instruments in the satellite were performing "satisfactorily" and that temperature and measuring instruments indicated normal readings of 77 to 86°F and 1.35 atmospheres.

Lunik III made its closest approach to the moon, according to Soviet sources and the world's largest radio telescope at Jodrell Bank, England, at 5:16 p.m. Tuesday Moscow time, when it was approximately 4375 miles from the earth's satellite. The moon was 228,300 miles from earth at the time.

• **Mysterious changes**—Although Jodrell Bank has been able to record most of the signals emitted by the Russian satellite, they will not be able to decode them unless the Russians give them the key. They have not done this in the past.

The scientists at the big English radio telescope were somewhat mystified by the change in the satellite's 183.6 megacycle transmitter's signals during the two-hour transmission period when the payload was closest to the moon.

For the first 20 minutes, according to Jodrell Bank, there was a steady series of 15-second signals separated by 15-second gaps. This was followed by a series of bleep-bleep pulses for 80 minutes, after which the tone returned to the original pattern.

Missile Firepower To Be Shown Off at AF Meet

TYNDALL AFB, FLA.—Air Force jets from around the world later this month will demonstrate the firepower of three air-to-air missiles—the *Sidewinder, Falcon* and *Genie*—at the nine-day annual World Wide Weapons Meet.

The Air Defense Command predicted the first passes alone in the nine days of aerial competition will result an overall score of nearly 90% kill—compared to the 10% kill scores considered good only a decade ago.

North American F-100's and **Lockheed** F-104's will fire the **Philco-GE** *Sidewinders*. **Convair** F-102's will fire the **Hughes** *Falcons*. **Northrop** F-89's will fire the **Douglas** *Genies*.

Both heat-seeking GAR-2 *Falcons* and radar-guided GAR-1 types will be used.

Interceptors throughout the meet—nicknamed William Tell I—will scramble and be vectored to their targets—Q2A *Firebee* drones. Planes carrying TV cameras will provide judges and observers with closeups of engagements.

Reds Urge UN-Sponsored World Space Conference

UNITED NATIONS, N.Y.—The Soviet Union has proposed that the UN junk its existing space committee and set up a UN-sponsored international conference of scientists to pool knowledge secured from space exploration.

In a speech before the 82-member General Assembly, Soviet Deputy Foreign Minister Vasily V. Kuznetsov maintained the Russian stand that the UN committee for peaceful uses of outer space is stacked with Western nations, and hence does not ensure equality in the balance of Communist and "neutral" countries.

He added that establishment of the committee "hindered the start of genuine international cooperation in using outer space."

As an alternative, he proposed: "Taking into account the benefits in exchange of experience in the field of scientific research and accomplishments for a more rapid progress in exploring outer space. The Soviet Government intends, in particular, to put forward the proposal to convene under UN auspices an international conference on exploring outer space."

Czechoslovakia and Poland also hold to the Soviet stand in refusing to participate on the West-dominated committee. The United Arab Republic and India declined joining the committee at its formation on the grounds that its work would be useless and unrealistic without Soviet participation. Because of the Russian opposition, the committee has not been effective.

Early *Little Joe* Test Is Called Full Success

WALLOPS IS., VA.—Man came one step closer to space last week as the *Little Joe* booster rocket passed a firing test with flying colors.

The launching, propulsion and destruct systems all were tested successfully, according to National Aeronautics and Space Administration spokesmen.

The rocket carried aloft a cast-iron model of the Project *Mercury* space capsule which will eventually house the first astronaut. Future tests will carry instruments, then animals, as the program develops. Although last week's mock capsule and rocket were destroyed according to plan 2½ min. after firing, later capsules will be recovered.

. . . TRANSDUCERS

(continued from page 36)

either tension or compression; the unbonded can measure only tension. Sensitivity of most units is the order of 2 millivolts output per 1 volt input, full load.

• **Today's problems**—Problem areas today are much the same as they were a few years back. The need for instruments and materials to operate at higher temperatures, higher g's, in varied and extreme environmental conditions continues, as does the need for more miniaturization and higher reliability.

Increased research must be applied in many fields to meet the expanding parametric horizons.

Gulton Industries feels that there are still two major problems in the refinement of high-intensity microphones —more specifically temperature and vibration. The former limits operating temperature levels. Vibration is a problem because, at low levels, the sound generated by vibration has to be excluded.

To overcome the temperature problem, piezo-electric materials hold forth the best promise since they are now able to operate with stability up to 525°F. Capacitance-type units, on the other hand, are subject to sensitivity changes at elevated temperatures.

The Navy has indicated several urgent needs requiring technological breakthroughs.

It wants a feedback potentiometer designed for use in 1000°F environments. In the past, potentiometers in missile servo systems have broken down at this range; not only does resistance change, but expansion causes binding and solder melts. Space limitations prevent adequate insulation use.

The Navy also wants a strain gage transducer capable of developing an output of from 2-to-5-volts, with direct coupling to a telemeter subcarrier, and without requiring amplification.

Here, the need is for significant weight reduction and reduced circuitry.

Another development long awaited is the digital-output transducer. Many are working in this area, but results have been meager.

To be really useful, the digital output must be an integral characteristic of the transducer. Analog signals currently developed are susceptible to amplitude error pickup. In giving a simple "yes" or "no" response, a digital use inherently would be less error-prone.

• **The future**—The need for more and different and better transducers appears assured. As some of the problem areas are solved, the distribution of the transducer-market pie may

change. Many feel that the missile industry has paved the way for an even greater market in the whole industrial field.

Kearfott Co., Inc. has achieved certain success in developing ferrite magnetostrictive transducers for echo-ranging equipment. Both commercial and military applications are extremely broad and will increase, but continued study will be required.

Vinson Engineering believes that eventually variable reluctance and differential transformer transducers will replace a large portion of the potentiometer market.

Statham Instruments is applying much of its research effort toward developing the concept of a "zero-gage-length" transducer. This is for the distant future. For the near future, Statham is happy with its high-sensitivity ¼-volt output unbonded strain gage transducer, which requires no amplification and has minimum commutation and noise level. They too see a reduction ahead in the potentiometer market.

Another area which shows promise for the future is the application of semiconductors to the transducer field. **Westinghouse Electric Co., Victory Engineering Co.,** and **Bell Telephone Laboratories** are but a few of the many companies active in basic research projects in developing solid state transducers of all types. Strain and temperature sensing devices are receiving the greatest amount of effort.

when and where

OCTOBER

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

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

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

CORRECTION

The University of Denver's Conference on Hypervelocity Projection Techniques will be held Oct. 20-21, 1960—not 1959, as previously reported by M/R. Pertinent papers are invited.

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

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

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

ADVERTISER'S INDEX

EMPLOYMENT SECTION

CLASSIFIED

Outworn Concept of 'Clobberation'

In the military and in industry these days, long-range planners are spending many long hours over desks and drawing boards trying to find the answer to a question which will affect the lives of every man, woman and child on earth: In the world's arsenal of weaponry, what comes after the intercontinental ballistic missile?

To many, the answer comes in two parts and requires some basic philosophical explanation.

The first-generation ICBM consists of the near-present *Atlas* and the *Titan*. On the way and programmed for 1962 is the second generation, the *Minuteman*. There will be no third generation; in this category of massive retaliation there will simply be refinements, improved guidance, smaller packages and bigger warheads—growing to some 2000 times as powerful as the only nuclear bombs ever dropped in anger.

And somewhere along the line, as the size and accuracy of these and other ballistic weapons improve and as the stalemate of destruction becomes more certain, man will know more and more surely that his old idea of war is outmoded. A world conflict based on devastation, like the horse and buggy, has been overtaken by events.

The concept of clobberation is no good. No one wants to destroy the world.

There is some evidence that the wily Russian may have come to this realization ahead of us; his softening attitude, his reasoned words would seem to indicate it. But since we know by their deeds and declarations that the Communists have no thought of forsaking world domination, we can be sure that the conflict will continue in one way or another.

In the process of abandoning the concept of clobberation (although the present stalemate may be with us for a long time) we turn to other logical possibilities, to the answers arrived at by the planners. Not necessarily in order of likelihood or importance, they are:

1. A struggle to influence and even control men's minds.

2. A race to control space or to deny that control to an enemy.

If we abandon clobberation as a massive weapon, we in effect give up the attempt to control or destroy man physically. The logical next step would be to try to control his mind. This is not a novel idea, of course, but it has never been attempted on the scale possible with today's scientific approaches.

An invisible tranquilizing gas, for instance, spread periodically over a nation could make its people more amenable. In this field of chemical and biological warfare there are dozens of possibilities. The trouble to date has been impracticality of delivery, but this may change.

Another possibility is the computer approach to propaganda. While propaganda is nothing new, reducing it to a near absolute science might be. The known attitudes and reactions of a people, fed in massive quantity into a modern computer, could produce virtually certain answers as to what it takes to influence them, individually and collectively, in what way and to what point.

These are some of the conceivable approaches to thought control. Others almost unbelievably weird are still in the basic research stage.

We are more concerned, however, with the planners' second suggestion as to what may replace the clobberation concept—the race for space. This is not some dream of the future; it is in progress now—and the Russians are both leading and gaining.

Successes in the race for space have great force, of course, in influencing men's minds. They capture the imagination; their prestige value is incalculable. In a more practical way, they lead toward future control of communications, space experiments, travel, and—conceivably—even the weather.

In a more predatory way, they could break the military stalemate. There is a subtle but terrible difference in being told that the enemy has a force of missiles aimed your way—and in knowing that he has satellite weapons hanging over your head. With such an advantage, the enemy would not have to resort to clobberation, only to the threat of it—blackmail.

Each step in our struggle to conquer space is important, not so much for its immediate value as for its potential. Whether the step is taken by the military or by a civilian agency is not important—an achievement by either can be converted to the use of the other. We have lost two major battles to the Russians, *Sputnik* and *Lunik*.

The recent moon orbit may be a third. In our drive to match and excel the Russians, we can afford duplication of effort, even triplication. We can afford backup and multiplication of effort. In fact, there is almost nothing conceivable that we cannot afford rather than the apathy of effort which would permit Russia to win the race and deny us access to space.

CLARKE NEWLON

(left) Navy POLARIS AX-1 flight test vehicle at beginning of launch. Lockheed's POLARIS fleet ballistic missile is more than a year ahead of original schedule.

(below) Nation's first successful re-entry tests were conducted with the Lockheed X-17.

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engine power
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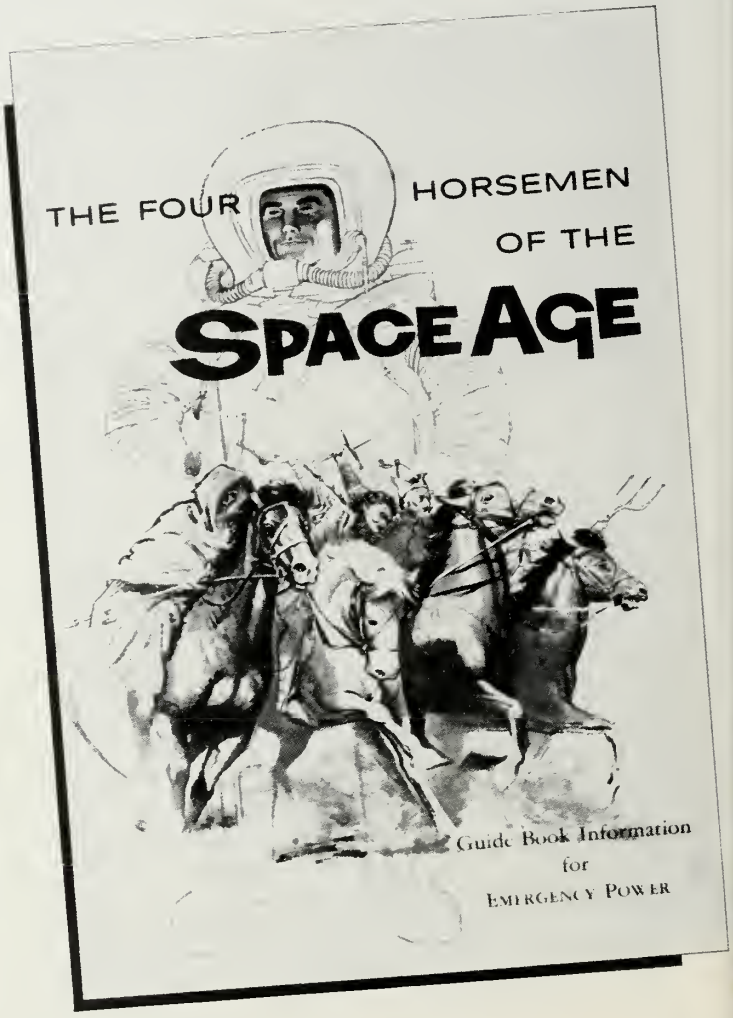
What can cause utility power interruptions?

Who needs protection against power outage?

What kinds of standby power are there—and which is best for your application?

What things to consider when you plan standby power installation?



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