JANUARY 4, 1960

missiles and rockets

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Missiles and Rockets Volume 6 Number 1

Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington 5, D.C. Wayne W. Parrish, *President;* Leonard A. Eiserer, *Executive Vice President & General Manager;* Fred S. Hunter, *Vice President & Editorial Director;* A. H. Stackpole, Eric Bramley, Robert R. Parrish, *Vice Presidents.*

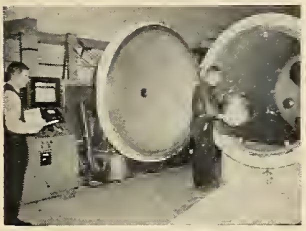
Printed at the Telegraph Press, Harrisburg, Pa. Second class postage paid at Washington, D.C., and at additional mailing offices.

Subscription rates: U.S., Canada and Postal Union Nations—1 year, $5.00; 2 years, $8.00; 3 years, $10.00. Foreign—1 year, $10.00; 2 years, $18.00; 3 years, $26.00. Single copy rate—$.50. Subscriptions are solicited only from persons with identifiable commercial or professional interests in missiles and rockets. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., M/R, 1001 Vermont Ave., Washington 5, D.C. Please allow 4 weeks for change to become effective and enclose recent address label if possible.

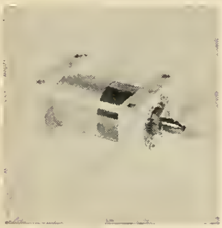
missiles and rockets
MAGAZINE OF WORLD ASTRONAUTICS

30,700 copies of this issue printed

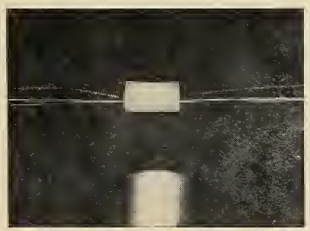
COVER: The Air Force is now stepping up its training program at Vandenberg AFB, Calif., for ICBM launching crewmen. A special report, with pictures, begins on p. 12.



NEAR-VACUUM conditions of 100-mile altitude are duplicated in this test chamber at Army's Signal Research and Development Laboratory. A report on growing vacuum technology starts on p. 16.



TRANSDUCER problems are being solved with introduction of units like this Model CP-40 pickup by PACE Engineering Co. For a survey of recent progress in this field, see p. 20.



CYLINDER of Teflon 7 TFE resin retained general shape after 117 sec. in Bunsen burner flame. Its manufacturer, DuPont, has raised the insulation's effective operating temperatures as result of testing. See p. 23.

Washington Countdown

IN THE PENTAGON

1960 R&D launchings . . .

scheduled by the military services include:
. . . The Air Force's *Discoverer IX* about mid-January.
. . . The second ARPA-Navy *Transit* navigational satellite in February.
. . . The first ARPA-Army *Courier* communications satellite about April-May.
. . . The first Air Force *Samos* reconnaissance satellite about June.
. . . The first two *Midas* early warning satellites by about June.

• • •

The Army's missile arsenal . . .

is expected to receive two new operational missiles this year. Number one: The surface-to-surface **Emerson** *Little John* which replaces the **Douglas** *Honest John*. Number two: The surface-to-surface **JPL Sperry** *Sergeant* which replaces the **Firestone** *Corporal*.

• • •

Some 40 more *Polaris* shots . . .

are scheduled this year before the Navy plans to put the first operational missiles on station in the nuclear-sub George Washington. So far 45 of the **Lockheed** *Polaris* test vehicles have been launched.

• • •

The coming threat . . .

of air-breathing air-to-surface missiles launched from Soviet bombers will be met, the Army believes, by the **Western Electric** *Nike-Hercules*. The *Hercules* has already been successfully tested against air-launched supersonic jet drones.

• • •

AT NASA

NASA will ask . . .

Congress for about $30 million in extra funds for FY 1960 almost as soon as the new congressional session gets underway. The supplemental request—about $8 million more than Congress cut from NASA's budget last year—is urgently needed for Project *Mercury*. Some also will go to development of **Pratt & Whitney's** liquid hydrogen *Centaur* engine.

• • •

The search for cash . . .

to support *Mercury* already has forced NASA, temporarily at least, to ax two programs and divert their funds. One is advanced studies on rendezvous capability—$3 million. The other is studies on orbiting laboratories—$2 million.

Meantime, the new NASA budget . . .

for FY 1961 still is being held at about $730-million—plus funds for *Saturn* and the tentatively acquired Army Ballistic Missile Agency. Critics complain that the proposed budget will not speed up current programs and will start few new ones.

• • •

Soaring costs, unrealistic estimates . . .

are plaguing the space agency. For example: *Mercury* now is expected to cost about $100 million more than estimated a year ago.

• • •

Saturn's first static test . . .

firing may come in March. That's the ABMA team's target date—about the time when Congress will be determining how much to spend on the program. However, the test of the big booster—originally scheduled for last December—could be delayed until summer if technical snags arise.

• • •

ON CAPITOL HILL

First blood . . .

in the sweeping congressional investigations into the nation's lagging space program is expected to be drawn by the House Space committee. It tentatively plans to begin four to six weeks of hearings at 10 A.M. on Jan. 18. First witness: Probably Secretary of State Herter. The question: How is running second to Russia in space hurting U.S. foreign policy? (See this issue, page 11.)

• • •

The long-awaited Hébert report . . .

on the House investigation of the so-called "munitions lobby" is now expected to be out about mid-January. Publications of the report and accompanying legislative recommendations has been held up by technical publication difficulties.

• • •

AROUND TOWN

Some of the "reports" . . .

heard around the nation's capital:
. . . The **Western Electric** *Nike-Zeus* AICBM is being fired against jet target drones in early test shots.
. . . The United States is cool to French requests for technical assistance in developing nuclear-tipped IRBM's.
. . . Russia is lining the Soviet-Red Chinese border with missile bases.

Industry Countdown

MANUFACTURING

None too cheery 1960 . . .

is forecast by AIA President Orval R. Cook for the missile/aircraft industry. He sees the increasing trend toward R&D contracts continuing to adversely affect earnings. Profits of the 12 major airframe companies, Cook notes, slid substantially in the first nine months of 1959; total for the 12 was $44.6 million compared to $105.8 million for the same period in 1958.

• • •

Cook blames the decrease . . .

in profits mainly on contract cancellations and stretchouts, economic limitations and "proportionately more R&D contracts than production contracts." According to AIA figures, the total backlog of the major companies has dropped $1.1 billion in less than a year—from $13.2 billion on Dec. 31, 1958, to $12.1 billion on last Sept. 30.

• • •

Last major buy . . .

of *Lacrosse* surface-to-surface missiles will be made in the last half of FY 1960 by the Army. They will be purchased from **The Martin Co.** to equip the last three of seven planned battalions (four missiles each). Future buys will be replacements only.

• • •

Crew training . . .

for launching the **Douglas** ALBM probably will be conducted by the Air Force at Vandenberg AFB, Calif., where ICBM crews are being schooled now.

• • •

Belgium's Army is replacing . . .

its 90 mm cannons with *Hawk* anti-aircraft missiles. And the country's Air Force has lopped off three pursuit squadrons with the installation of *Nike* batteries.

PROPULSION

Lighter and more powerful . . .

Atlas engine will be delivered soon to the Air Force by **Rocketdyne.** The new MA-3 system consists of two low-altitude boosters, a high-altitude sustainer and two small verniers. Weight was reduced by substituting fibreglas for metal banding around booster combustion chambers. Components have been cut by 15% through new controls which permit the fuel to operate engine sequencers.

• • •

Pad damage . . .

apparently was superficial in the explosion of an advanced *Polaris* motor on an **Aerojet-Sacramento** test stand Dec. 15 . . . *Polaris* is said to be having liner problems causing case burnout.

• • •

Minuteman nozzle erosion . . .

is being studied by Aerojet-General, using a liquid rocket which can be cut off at any point—an advantage not possible with a solid rocket.

ASTRIONICS

Changes in plans . . .

and soaring costs are expected to add several million dollars to NASA's world-wide *Mercury* tracking range, originally estimated at about $27 million. **Western Electric** is now negotiating the contract at Langley Research Center.

• • •

Mergers & Expansions . . .

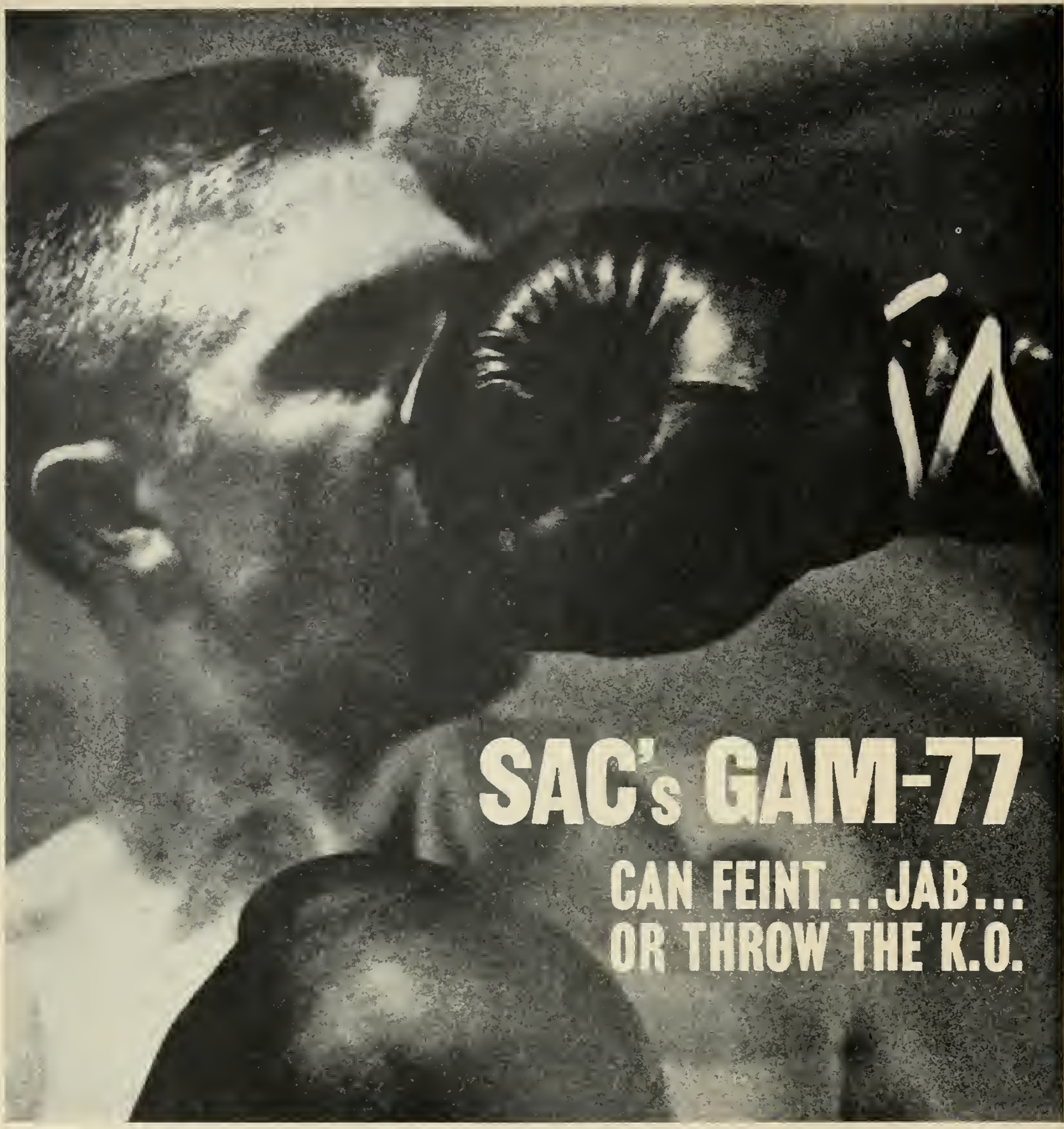
Midwestern Instruments, Tulsa, Okla., has agreed to become a division of **Textron Electronics** . . . A new $500,000 plant is being built at Anaheim, Calif., by **Photocircuits Corp.** of Glen Cove, L.I. . . . **RCA** is consolidating its Washington operations under one roof—a newly-leased building—as of March 1 . . . and **Technology Instrument Corp.** of California has opened a new environmental test lab at Newbury Park, Calif.

WE HEAR THAT—

Aerojet-General is buying . . .

radio and television station **WRC**, Washington, D.C., from **NBC**—a real switch in the usual diversification pattern . . . Britain may sell its Short *Seacat* anti-aircraft missile to the German Navy . . . Team of **American Machine & Foundry** and **American Car & Foundry** is expected to be named winner of the competition for the mobile railroad launching system for the **Boeing** *Minuteman* ICBM . . . The **Hamilton Standard Division** of **United Aircraft Corp.** is purchasing a 50% interest in **Microtecnica Inc.,** Turin, Italy.

More About the Missile Week on Page 48



GAM-77 HOUND DOG air-to-surface missiles give SAC's B-52G intercontinental bombers the versatility of a champion boxer. Even while the aircraft carrying the GAM-77 missiles is airborne, a new target can be selected. Then reaching out at supersonic speeds after launch, the GAM-77's can flatten opposition for the bomber to deliver its own Sunday punch...or independently destroy the primary target. These jet-powered missiles vastly increase the striking power of the giant Boeing B-52... give it a triple-punch capability.

Guided by a self-contained inertial autonavigator—set before launch by the B-52's crew—the GAM-77 can't be jammed, can't be decoyed. The GAM-77 Hound Dog was designed and is being produced for the USAF by the Missile Division of North American Aviation.

MISSILE DIVISION

NORTH AMERICAN AVIATION, INC.

Downey, California

many-angled attack . . .

Congress Takes Up Missile/Space Lag

Some seven congressional committees expect to begin probing the nation's programs this month; pace will increase as election nears

WASHINGTON—Angry and worried congressmen this month will begin digging into the nation's lagging space and missile programs in one of the most exhaustive series of investigations in recent years.

At least seven committees in the House and Senate will attack from a score of directions the problems posed by Russian space supremacy and missile might.

The men and military officers charged with running the U.S. space and missile programs will pass before the committees in a parade that is expected to last for months.

The atmosphere of the hearings—already supercharged by the importance of the issues at stake—will become ever more electric as the 1960 presidential election campaign increases its pace.

• **Block from White House?**—The White House may attempt to cut the ground from beneath the investigations.

President Eisenhower is understood to have directed before leaving on his overseas tour that officials be prepared when he return to lay before him the entire East-West space situation. Some officials have interpreted this as a prelude to announcing a somewhat bigger and faster-moving space program in the President's State-of-the-Union address.

However, congressmen concerned about continuing Soviet space triumphs contend that words and half-way measures will not be enough either to overtake Russia or dull the edge of the congressional investigations.

• **The lineup**—The seven committees expected to take the lead in the investigations are: the Senate and House Space Committees, the Senate and House Armed Services Committees, the Senate and House Appropriations Committees and the House Military Operations Subcommittee.

The House Space Committee is expected to open its hearings first on Jan. 18—the day the President will send his annual budget message to Congress. The opening witness probably will be Secretary of State Christian Herter. He will be asked how being a second-class space power is hurting our foreign policy.

Others expected to be called in rapid order are Defense Secretary Thomas S. Gates, NASA Administrator T. Keith Glennan and the members of the Joint Chiefs of Staff. The hearings are expected to run four to six weeks. Then the committee will swing into extensive hearings on the NASA authorization bill for its FY 1961 budget.

The Senate is expected to begin its hearings by the end of the month, probably with the Senate Space committee taking the lead. However, Senate Democratic Leader Lyndon B. Johnson may decide to have the Senate Preparedness Subcommittee—which he also heads—conduct the initial investigation.

Meantime, the Armed Services and Appropriations Committees in both houses will begin digging into the space and missile programs under their own special jurisdictions.

The House Appropriations Committee hearings will be closed. However, the others will be mostly open. The House Military Operations Subcommittee is expected to postpone opening any hearings until it sees which areas might be more thoroughly explored.

In all of these hearings, congressmen will be asking variations on four overriding questions:

- Why are we behind Russia in space?
- Do we have a strong enough military machine?
- What more should we do?
- Who is to blame for the lag?

The questions have been asked many times in the past. Congress is going all out this time to get some straight answers.

Basic Questions

The nation's space and missile programs will undergo one of the greatest workings over by Congress in recent years.

The White House may attempt to cut some of the ground from beneath Congress by announcing some new programs this month, before the investigations even start. But the attempt isn't given much chance of success.

The basic questions that Congress will ask are:

Why are we behind Russia? What can be done about it?

And intermixed with it all is the heady atmosphere of a presidential election year—and the juicy question: Who is to blame?

All are old questions. Congress is seeking some new answers.

AF Training 14,000 ICBM Crewmen

Combat missilemen now fill pipeline; industry and Air Force develop radical techniques for schooling Atlas and Titan crews in factories and on the pad

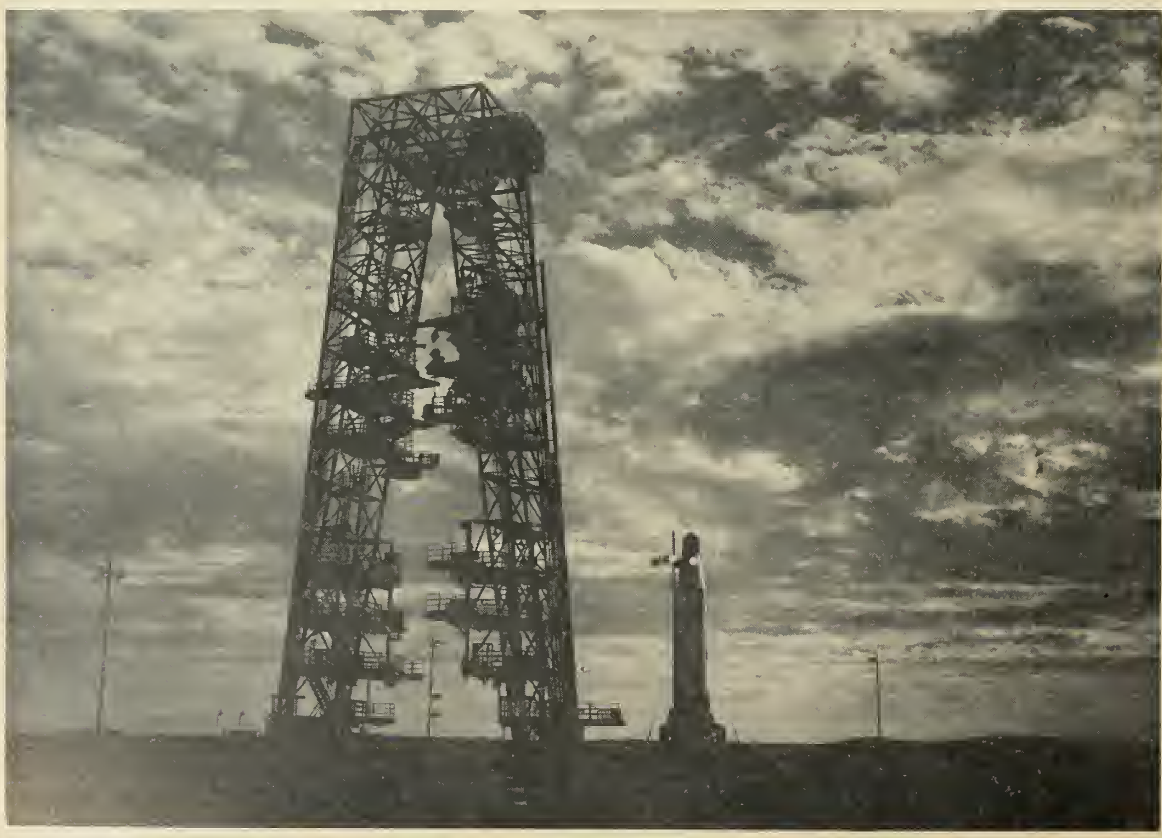
by James Baar and William E. Howard

VANDENBERG AFB, CALIF.—The Air Force today is moving swiftly into the wholesale—yet meticulous—training of 14,000 hand-picked officers and men in the exacting art of launching combat ICBM's.

These trainees will become an entirely new breed of earthbound "airmen" who will man the nation's first 180 *Atlas* and *Titan* missiles—20 squadrons—at wartime readiness around the clock. In the next few years, their ranks will be swelled by the future crews for hundreds of fixed and mobile-based *Minuteman* ICBM's.

On all of these missilemen will rest the final, enormous responsibility of ensuring that night and day the retaliatory missile-might of the Strategic Air Command is "in the green."

Time already is closing in. This year some 600 men must be fully trained and prepared to take over operational control of the 564th Strategic Missile Squadron at Warren AFB, Cheyenne, Wyo. This unit will man a complex of six *Atlases* now nearing completion. And it will be followed within a few months by a second opera-



OPERATIONAL *ATLAS* PAD where ICBM missilemen are training before being sent to man bases across the nation.

tional unit—the 565th SMS—at Warren.

The exact number of ICBM crewmen scheduled to pass through Vandenberg in this first year of full-scale training is classified. However, the base is ready now to handle several thousand men at one time.

Since the activation of Vandenberg a little over two years ago, the main effort in the ICBM training program has been directed at building up a cadre of Air Force men to become the permanent teaching force. Until the present, the program has had to rely heavily on industry contractor personnel to instruct the cadre at the three operational gantry-type pads of the 576th SMS, which is both a training and an operational squadron.

The Air Force hopes very soon to take over the pads with a complete "blue suit" capability and retain only a bare minimum of contractor instructors.

These operational ICBM's—the nation's first—will be supplanted later this year by a complex of three aboveground emplacements in which birds of the *Atlas D* series are stored horizontally and erected only for launching. This complex, similar to the six-missile complex being completed at Warren AFB, will be called the 576th "B" SMS.

ICBM training is broken down into three major phases:

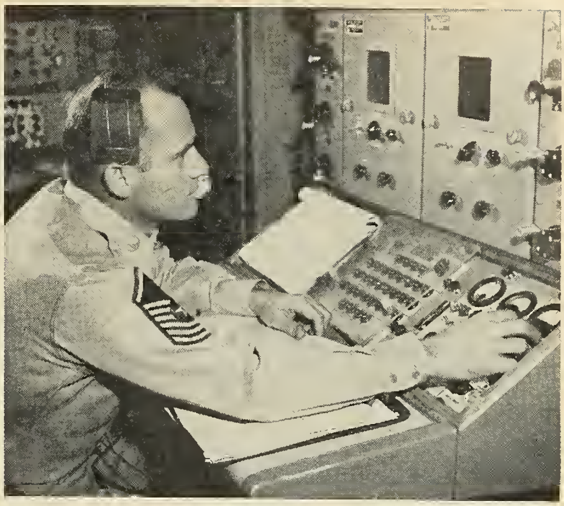
- Up to three months at factory schools learning, as one launch control officer puts it: "From blueprint to component, system by system how the whole bird is put together."
- Up to three months "on the pad" at Vandenberg learning how to operate and maintain the weapon and to be able to launch one within 15 minutes.
- Periodic retraining.

Every launch crew is supposed to take part in some degree in a live firing before taking up its vigil at a combat emplacement in the American mid-continent. It is indicative of the status of the program that only one such training shot has been held so far. That was last September. The tempo should pick up shortly.

- **Three shifts**—The men to make up five *Atlas* launch crews arrived on the base Jan. 1. More are coming in daily. Within weeks, the Air Force expects to be training 10 crews at a time here on a three-shift basis.

Conducting the first phase schools for *Atlas* are the prime, **Convair Astronautics; General Electric** (re-entry vehicle and radio inertial guidance); **Burroughs Corp.** (ground computer); **American Bosch Arma** (all-inertial guidance); **Rocketdyne** (propulsion); and the Air Training Command.

The *Titan* lineup includes **The**



TRACK ANALYST at console supervises hundreds of precise adjustments as an *Atlas* roars towards its target. He is one of the first of *Atlas* trainees who are being formed into training cadres.

TECHNICAL ADVISER to the launch control officer works at his post at the launch analyst console. Men spend long days at launch pads, long nights studying.

RATE ANALYST makes rounds of 11 cabinets checking on rate subsystems during countdowns. Besides hard work and ever-changing courses, missilemen face housing shortages at rapidly expanding Vandenberg.

handpicked for challenge . . .

CONTROL ROOMS, such as this one built for *Thor* training, enable all training operations on launching pads to be followed by training directors.

EACH TRAINEE, each training problem, is monitored on display boards.

Martin Co., the prime; **Avco Mfg. Co.** (re-entry vehicle); **American Machine & Foundry** (erector); **Bell Telephone Laboratories/Remington Rand** (guidance); **Aerojet-General Corp.** (propulsion).

Boeing Airplane Co., the prime for *Minuteman*, so far is running the only contractor school for this solid-fueled ICBM. Others are expected to start up later this year or early in 1961.

A missile training squadron—the 395th—has been activated here for the *Titan* program and work is well along on the equipping of an underground silo launcher where the first "molemen" will be trained.

• **Improvising**—For the whole ICBM training program officers frankly admit "we have to write and re-write the book as we go along." Improvements are continually being programmed into the bird, changing operational procedures, the manuals for maintenance and many times the number of men needed to operate the weapon.

The Air Force even has had to set up an entirely novel Directorate of Training to coordinate the program, which it calls "integrated weapons systems training."

Atlas Launch Crew

An *Atlas* launch crew today has evolved into a unit of 13 men. They include:

A launch control officer, missile system analyst, power distribution system technician, missile electrician, three missile maintenance technicians, a missile engine mechanic, ground support equipment specialist, propulsion system technician, guidance system analyst and hydraulics technician.

The crew for a radio inertial guidance unit is comprised of 18 men:

A guidance control officer, track analyst, track transmitter specialist, track receiver specialist, track data processing specialist, two track antenna servomechanism specialists, rate analyst, rate transmitter specialist, exercise analyst, exercise simulation specialist, exercise recorder specialist, digital computer analyst, digital computer systems specialist, digital computer electromechanical specialist.

In the all-inertial system the guidance crew has been reduced to just four men:

A guidance control officer, automatic tracking radar specialist, automatic tracking radar technician and electronic computer maintenance specialist.

The number of men in the launch section is not changed by the introduction of all-inertial guidance.

This directorate, a part of the 1st Missile Division and the only one in SAC, has four divisions: missile training, surveillance, standardization and collateral (supporting personnel). Contractor personnel and civilian construction and technical service people also operate under the directorate.

Today the pipeline for *Atlas* crews is full, and the selection and training for *Titan* missilemen is partially complete. Training for *Minuteman*—still two to three years away—is just getting organized.

Chosen for their brains and special skills, these crewmen are considered the "cream" of the Air Force. They have been plucked from SAC bomber crews all over the world; communications and maintenance outfits; from Tactical Air Command *Matador* and *Mace* missile squadrons; SAC command posts; the Pentagon; and even from the U.S. Naval Academy.

Most are seasoned and dedicated Air Force career men who look upon the ICBM not only as a necessary weapon in the Nation's arsenal, but as a personal challenge. Many feel this is but an interim evolution before once again they cut free from the earth —and head into space.

Indeed, Maj. Gen. David Wade, commander of the 1st Missile Division at Vandenberg, has said: "These vital (missile) programs . . . represent SAC's first step into the realm of space."

• **Training grind**—Selection of *Atlas* crews began in January, 1958. Thousands of personnel records were screened and the men hand-picked. Now that they are in the program, practically every move they make is carefully watched. Their standard of performance has to be high or they are washed out.

Says Lt. Col. James B. Vogeler, Jr., chief of the missile training division in the Directorate of Training, "Training is just as important as the hardware itself. The people must be trained before you have a weapon system."

Training for the missileman is an all-consuming grind from beginning to end.

At Vandenberg, the classroom for the most part is the launching pad itself. Here the missileman puts what he has learned—and continues to learn—to the test. Here also the missileman is integrated into a crew that learns to work as a team and will be sent out to an operational squadron as a team.

The school day at Vandenberg is split into three shifts, each eight hours long. But the trainees often continue to work on problems at their pads long after their eight-hour day has ended.

About 85% of their time is devoted to training on equipment. Only 15% is for briefings, critiques of their work and procedural training.

This grind for *Atlas* crews lasts anywhere from two to 12 weeks depending on a missileman's job. Launch crews and guidance crews train for 12 weeks at Vandenberg alone. Re-entry vehicle men train for six weeks. Maintenance management men train for only two.

This does not include prior training at industry and ATC schools. For example, launch crew missilemen undergo two months of advance training before arriving at Vandenberg.

Present scheduling calls for graduating crews from Vandenberg in time for them to arrive at their operational launch pads to take part in the installation and checking out of its equipment.

As one training officer puts it: "Our missilemen will participate in building their own house."

Nor does training stop here.

• **A new breed**—Present plans call for continual proficiency training at the operational launching sites and the periodic return of crews to Vandenberg for retraining. Moreover, individual crew members will be brought back to Vandenberg from time to time to take part in actual launchings.

The end product is an entirely new kind of military man. The combat missileman is not only an operations man or only a maintenance man: He is both.

The problem of training such a military man would be very great under any circumstances. There are no guides; no textbooks; no long experience. This is why the whole training program is being fashioned from scratch. But this is only part of the problem.

The basic difficulty is that the missileman is being trained for a weapon that is continually evolving. Today's texts are old-hat tomorrow. Trainees complain that what they learned during their pre-Vandenberg lectures no longer applies to the equipment they find on the launching pads. Sometimes the equipment is being installed as they arrive.

This is no temporary situation the Air Force must live with. The nation's security demands that missilemen be trained while their missiles are still being developed and improved. This is true now of *Atlas*; it soon will be true of *Titan*; and still later it will be true of *Minuteman*.

• **How big a crew?**—The most glaring example of this is the size of an *Atlas* crew itself. No one can say today what will be the best size for the crews that will man *Atlases* two years from now.

Originally, an 18-man guidance crew and a 13-man launch crew fired the first operational *Atlas* from Vandenberg last September. The typical guidance crew now has been cut to four. Further reductions are expected.

This has already been the history of the *Thor*, which helped set the pattern for *Atlas*. Originally 12-man RAF crews fired one *Thor* in training here. Now three men can launch a single *Thor*.

Moreover, most of these changes in the size of crews have come about without the experience of having to man large numbers of missiles at widely dispersed sites. This is expected to bring about further changes in crew requirements.

• **"A lot to think about"**—The type of officers and men chosen for this pioneering assignment come from a wide variety of backgrounds—some technical, some not.

Col. John J. Easton, commander of the 576th Strategic Missile Squadron, which fired the first operational training *Atlas*, is a former chief of the Electronic Data Systems Planning Division and director of administrative services at SAC Headquarters. Technical Sgt. Bruce Pottoroff, a missile system analyst technician in Easton's squadron, is a 24-year-old high school graduate. Vandenberg is the only technical service school that he has even attended.

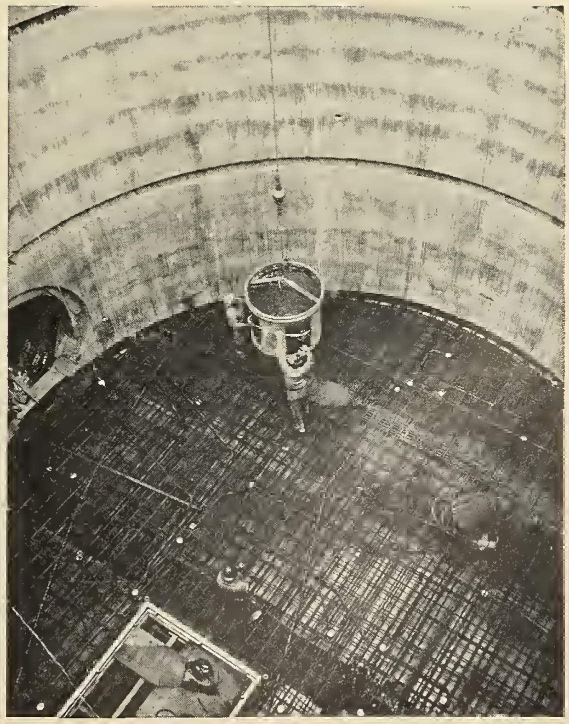
Enthusiasm and dedication among the trainees is extremely high.

Sgt. Donald Scearce, a 27-year-old missile system analyst technician who graduated from *Matadors* to *Atlases*, decribes his job as continually challenging.

"There's something new every day," he said. "They can send me anywhere as long as I stay with missiles."

Then there is another feeling—the feeling of awe for the job itself.

As Capt. Albert Ford, a 42-year-old launch control officer, put it: "There's a lot to think about when you have your finger on the button."



TITAN silo soon will have erection mechanism installed. Here Air Force will start on-site training of "molemen" late this year. Silo is 163 ft. deep.

Vacuum Knowledge Is Slim But Growing

Unlimited pumping capacity of space is detrimental to most of the substances on earth; vacuum technology is being expanded to meet demand for test facilities

by John F. Judge

WASHINGTON—A sudden surge in the re-creation of the vacuum of outer space in large chambers is increasing the dimensions of an old market—environmental test facilities.

The demand for such equipment has been growing for several years, and the first chambers are now emerging from production lines. It is now possible to test the effects of ultrahigh vacuum on full-scale structures.

The surprising consequences of extremely low pressure on most of our common structural materials, and our meager knowledge in the area, generated this expansion in vacuum technology.

• **Vacuum consequences**—The vacuum effects on materials can be considered under two general categories.

The first is the evaporation of the substance itself, or of a volatile component. Briefly then, the usefulness of a material is a function of its vacuum vaporization coefficient.

In essence, molecules leaving the surface do not have the opportunity of collision that exists in the presence of an atmosphere, which would return them to the surface.

Such molecules may be considered as lost. In space, unlimited "pumping capacity" insures the continual sublimation of an exposed solid surface.

The second general effect is the removal, total or partial, of the absorbed surface gas layer which covers all materials under sea-level conditions.

The result is all out of proportion to the material change involved. Such things as creep-rupture time and friction in metals are known to be significantly changed. There are other subtle effects.

Considering the "hard" vacuum of space alone, apart from the aspects of temperature, radiation and micrometeorite impact, a host of problems are immediately apparent.

The essential points to remember are (1) the important effects are produced long before appreciable quantities of a material evaporate or sublime, and (2) the time of exposure.

Mechanical properties are affected by the atmosphere in which the determination was made. Dr. M. R. Achter of the **Naval Research Laboratory's High Temperature Alloys Branch** has explored creep-rupture and fatigue behavior of alloys at high temperatures. In a report presented to the Sagamore Conference on Space Materials, the Navy scientist said that at high stresses and lower temperatures, creep-rupture lives were longer in vacuum than in air.

But he found the reverse happening at lower stresses and higher temperatures. The proposed mechanism involved two competing processes, strengthening by oxidation and strength reduction due to the lowering of the surface energy.

N. J. Wadsworth and J. Hutchings have shown that the density of a surrounding gas affects the fatigue life of certain metals.

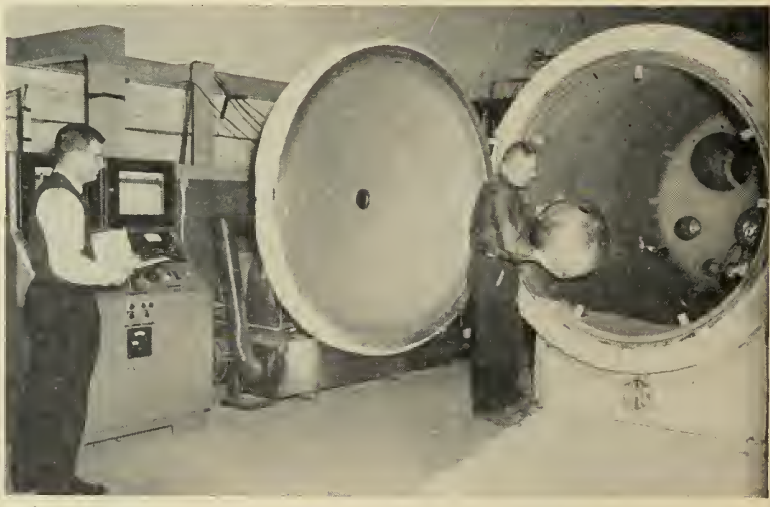
The second general phenomenon, that of the removal or formation of the absorbed gas layer, is believed to be involved in both operations.

Reduction of surface sublimation from metals and alloys may be accomplished through coatings of inorganic oxides. Still, there are indications that there are other, more complex effects in this area.

Plastics face a rougher future in space. Because of their organic nature, they have higher vapor pressures and consequently sublime much more readily than metals or other inorganics. Plastics formed from the polymerization of pure materials fare somewhat better than those employing a plasticizer. Silicone polymers are in a class by themselves in vacuum endurance.

• **Lubrication**—The problem of lubrication in the hard vacuum of space has top priority. Conventional lubricants disappear in short order and the clean surfaces remaining will quickly seize or weld together.

Solid lubricants have their short-



TEST CHAMBER at Army's Signal Research and Development Laboratory, Fort Monmouth, N.J., duplicates near-vacuum conditions found 100 miles above the earth.

comings. The most familiar, graphite, is useless because it depends upon trapped water vapor for its lubricity. Molybdenum disilicide seems to offer some promise but there is the question of bonding. And there is always the time factor.

Silver plating is another method of providing a friction-reducing surface, but the process is difficult and expensive. There are many companies interested in both short- and long-term vacuum lubrication. This is a good indication that the idea of hermetically sealing all motors and moving parts involves bigger problems than development of good vacuum lubricants. This is in addition to the obvious weight considerations encountered in such encapsulation.

• **Some benefits**—Another consideration is in the vacuum effect on overall structures. Designers have always allowed for atmospheric damping on vibrating structures.

Professor B. J. Lazan, head of the Department of Aeronautical Engineering of the University of Minnesota, explained that atmospheric damping is difficult to describe without accounting for other energy dissipation effects within a structure.

The absence of an atmosphere introduces many complex problems, to be sure; but the scientist pointed out that flutter, some acoustical fatigue, and other aeroelastic excitations disappear in a vacuum.

This "mixed blessing" occurs in other areas in vacuum environments. The absence of oxygen has its beneficial effects on materials as does the lack of other gases and vapors commonly present in our atmosphere.

The absence of gravity is one more credit factor in material applications. Gears and bearings will be loaded primarily by the torque or force they must transmit to overcome inertia, and by their own frictional drag. Of course, additional problems of lubrication exist, but some conditions are improved because of the vacuum.

How does one go about learning more of the physical aspects of a vacuum?

It is fairly obvious that laboratories are not going to be hurled into space in the near future. Probes and instrumented satellites can and do supply a great deal of information but there is a basic limitation involved.

This drawback stems from a cardinal rule in the gathering and interpreting of scientific data—that of successfully isolating or controlling variables in order to trace the results accurately to an originating stimuli.

To instrument a satellite to provide this type of service would be extraordinarily expensive and actually unjustifiable if there are other means to provide the necessary answers.

• **Environmental testing**—The immediate problem confronting us is the effect on available materials of the environment in the region extending several hundred thousand miles from the earth. This involves primarily the question of "how" not "why." But reaching this immediate objective may very well involve a great deal of basic fundamental theory.

This basic work can best be done on earth in environmental test chambers.

The task of bringing the vacuum of outer space into the laboratory is less difficult than it might superficially seem. While the density-equivalent pressures in space are thought to be in the area between 10^{-11} and 10^{-15} mm mercury or lower, for many purposes the simulated vacuum need not be anywhere near this.

Radiant heat transfer studies might be made under conditions much less stringent than those necessary for certain friction data.

• **Vacuum chambers**—The recent history of vacuum chambers is that of a constant search for larger vessels with higher pumping capacity. The production of high vacuums (10^{-7} mm Hg) has been readily possible for many years. A typical high-vacuum system involves a backing pump; a water vapor collector, to prevent water from entering the back up pump; a diffusion pump; a cold trap, to prevent vapor from the diffusion pump from entering the vessel; and finally, the evacuated vessel.

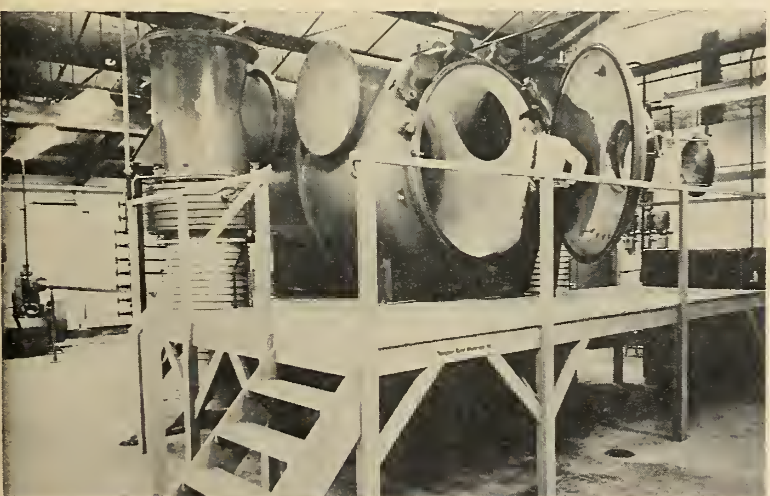
After the physical plant is provided, certain procedures and methods are followed to insure successful operation. There can be no leakage to the outside atmosphere, and only low-vapor-pressure oils and greases are used in lubricating and sealing the system. Gases absorbed on the walls of the system are removed to a certain extent by "bake-out"—heating the entire system as much as possible while operating the pumps.

For most applications, the above system is sufficient. But in simulating outer space to determine effects on materials, more sophisticated and complex systems are necessary. Investigators at the University of Illinois recently reported that samples under study in a standard vacuum apparatus of 10^{-6} and 10^{-7} mm Hg capacity became surface-contaminated with foreign matter in 20 minutes. This contamination was enough to halt the experiment. When the scientists used special systems which maintained a vacuum of at least 10^{-10} mm Hg, there was more than a thousandfold improvement.

The Illinois scientists suggested that air contamination of some surfaces is important even in the best standard vacuums.

The investigators pointed out that much of the present information on the surfaces of solids may be of little scientific value.

They said practical data on the nature of "clean" surfaces may be so limited as to prove dangerous when space flight is attempted. This is presumably based on the assumption that much of the work carried out in high vacuums has been extrapolated into the ultrahigh-vacuum area for comparison purposes. While the investigation of "clean" surfaces is admittedly more involved with the kinetics of surfaces, and is difficult to perform unless extremely efficient vacuums are em-



CHAMBER built by NRC Equipment for Ramo Wooldridge can provide a vacuum of about 10^{-5} mm Hg in one hour. It's designed for general and ion engine testing.

ployed, the fact that contamination existed where none was expected might lead one to examine earlier results in other areas more closely. The same vacuum level or less was probably maintained when other effects were under study.

• **Evacuation techniques**—The actual pumping equipment is not the whole story of evacuation. At extremely low pressures evacuation is a function of the design of the entire system—including outgassing and surface absorption effects.

Only a few representative pumping techniques will be described here since the field is extremely large and complex.

• Diffusion—Based on the concept of Langmuir, diffusion pumps fundamentally involve the capturing and removal of gas in the evacuated chambers by a flowing vapor stream. Molecules of the gas to be removed usually enter the pump by random thermal motion.

Theoretically capable of pressures to 10^{-10} mm Hg, diffusion pumps contaminate ultrahigh-vacuum systems. Better oils and the incorporation of other techniques reduce this tendency.

• Getter pumps—The familiar use of getters is in the final exhaustion of lamp bulbs. High-vacuum getters such as barium and titanium are in present use. Other materials fit special applications. Since a chemical reaction is involved, getters have no effect on the inert gases.

• Electronic Pumping—This technique involves using electromagnetic forces to move gas particles. The high equipment cost and the necessary special power supply are inherent disadvantages.

• Ion—Gettering pumps—A combination of electronic and getter pumping, this system eliminates some of the disadvantages of each but produces some new ones. It is not too effective on inert gases and requires complex controls, reducing operational reliability.

• Mechanical pumps—Evacuate by imparting high directional speed to gas molecules by impact on a high-speed surface. Although capable of producing clean vacuums, these pumps present the usual difficulties of fast-moving machinery.

The utilization of cold traps, condensation and absorption techniques in combination with the above systems, or in other methods, is possible. But space does not permit a thorough evaluation of their applications here.

• **Measuring the vacuum**—Accurately determining the pressure of a chamber below 10^{-7} mm Hg is a complex task. A wide variety of gauges available, and the subject is too broad and comprehensive to detail here.

The problem is not only the presence of residual gas, but also its nature and chemical makeup. To provide even more complexity, some gauges also act as pumps.

On the other hand, measuring systems have been developed for special applications that are so sensitive that the leakage of helium from the air into the system through its glass walls produced an appreciable rise in pressure.

Vacuum gauges fall into four general groups—Mechanical, Liquid Manometer, Heat Conductivity and Ionization.

Some of the firms involved in their production are **Consolidated Electrodynamics Corp., Vecco Vacuum Corp., NRC Equipment Corp.** and **Lebold**, a German firm.

The subtle and far-reaching effects of the space vacuum on materials are but vaguely understood. The main obstacle has been the fabrication of suitable facilities. Indications are that this barrier is rapidly falling and the research being conducted at such firms as the **National Research Corp, Jet Propulsion Labs, Space Technology Labs, Lockheed Aircraft, The Martin Company, Convair, Astravac Corp** and many others will clarify the list of man's space-compatible materials.

Pack Pressing Makes Better Domes

COATESVILLE, PA. — Solid-rocket motor casing domes are pounded into shape by a novel fabricating technique —"hot pack pressing."

Created by the **Lukens Steel Co.**, the method produces extreme uniformity of thickness and freedom from decarburization, and eliminates heat scale.

In pack pressing, a disk of high-strength alloy sheet is sandwiched between two circular plates of mild steel, after being sprayed with a parting compound. The coating substance is intended to prevent metal-to-metal contact during the forming; it also acts as a high-temperature lubricant.

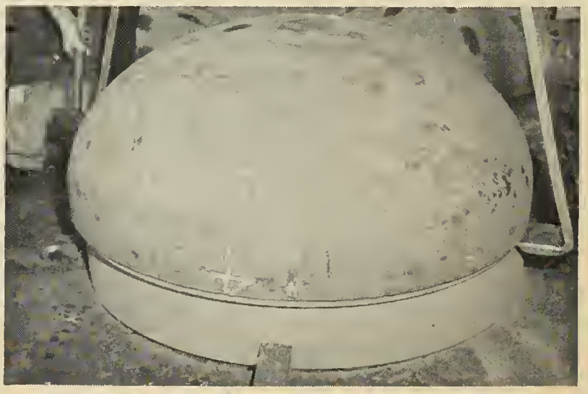
The cover diameters are identical to each other but slightly larger than the dome disc. The covers are welded together around the edges except for a small vent hole which releases trapped air and gases during heating.

This "pack" is heated to around 1600°F and placed on a hydraulic drawing press. The dies are compound. A ring-type hold-down is fastened to the main press platen. A central ram in the platen mounts a secondary cylinder to which is fixed the contoured punch.

Actual drawing is carried out in a series of steps with a reheating of the pack following each phase. This is necessary because the alloys are sensitive and must be maintained in a narrow temperature range. After the final pressing, the pack is allowed to cool, the welded edge is trimmed off and the covers are separated.

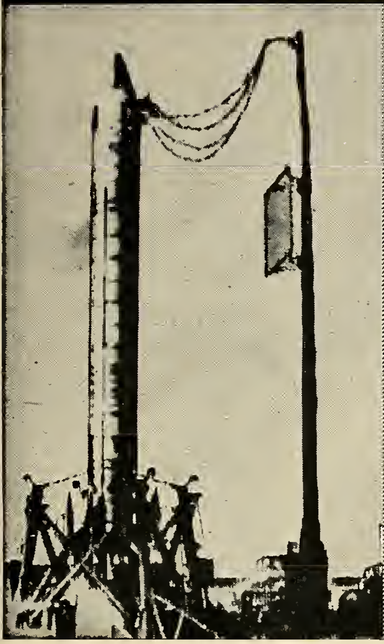
The process is flexible and can be applied to many materials, including beta titanium. The same tooling can be used to press heads of dissimilar gauge —in one case from 0.060" up to 0.300".

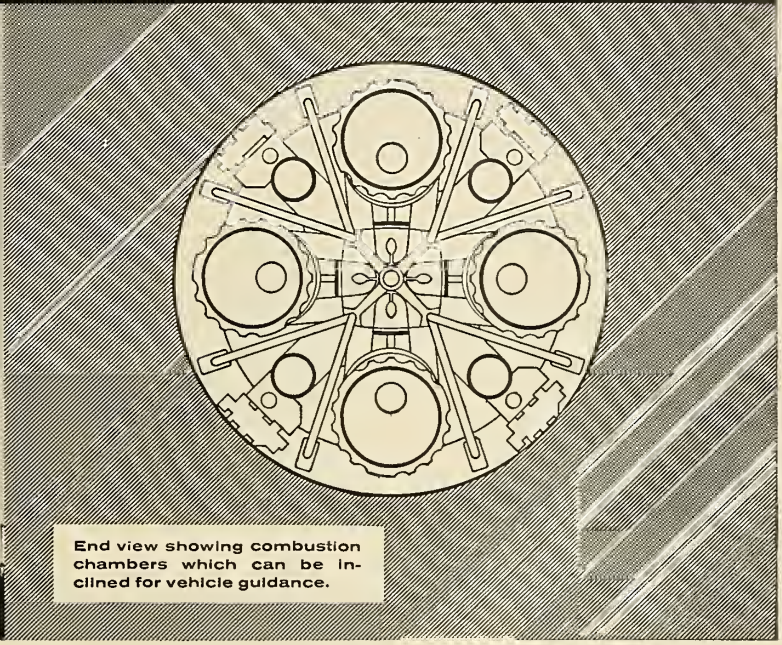
There are no special requirements in choosing cover plates, other than that they be amenable to hot pressing and have fairly smooth surfaces. The exact pressing cycle is governed by the characteristics of the material involved, as is the physical strength to which the finished head may be heat-treated.



STRIPPING of top cover from finished dome shows the scale-free edge of the dome and (below its visible edge) clean appearance of bottom cover.

Gamma rocket engine delivers 19,000-lb thrust outside the earth's atmosphere–for a weight of under 700lb . . .





End view showing combustion chambers which can be inclined for vehicle guidance.

...ANOTHER ENGINEERING ADVANCE BY BRISTOL SIDDELEY

One of the largest manufacturers of motive power units in the world, Bristol Siddeley Engines Limited produce the Gamma. A liquid propellent rocket engine, the Gamma delivers 16,400-lb thrust (7,438 kg) at sea level rising to 19,000 lb (8,618 kg) outside the earth's atmosphere for a total engine bay weight of under 700 lb.

The Bristol Siddeley Gamma has four gimbal-mounted combustion chambers which are hydraulically actuated for vehicle guidance. Each combustion chamber is fed with propellents by its own turbopump unit and the four units are joined at the centre by a common manifold. The Gamma burns hydrogen peroxide (HTP) with kerosene and uses silver-plated nickel gauze as a catalyst to decompose the HTP into oxygen and superheated steam.

Gamma powers Black Knight

The Bristol Siddeley Gamma powers the Saunders-Roe Black Knight, Britain's highly successful space research vehicle. The Gamma has proved itself to be exceptionally reliable. In fact, in all firings to date Black Knight has never failed to start, and has reached a height of over 500 miles above the Woomera rocket range in Australia.

Since Bristol Siddeley's rocket division began work in 1946 it has developed a wide range of rocket components. By combining these components in single or multi-chamber layouts, thrust requirements from 500 lb up to very high figures, can be met.

BRISTOL SIDDELEY ENGINES LIMITED

BRISTOL AERO-INDUSTRIES LIMITED, 200 INTERNATIONAL AVIATION BUILDING, MONTREAL 3, CANADA

Circle No. 2 on Subscriber Service Card.

Breakthroughs on Transducer Front

Since M/R's October list of urgently needed developments, manufacturers have revealed answers to some problems and progress on others

by Charles D. LaFond

WASHINGTON—Long-awaited transducer breakthroughs have been revealed which will have great impact on the missile industry. Among these are digital-output transducers and 5-volt dc direct-output pickups.

The rapid advances in transducer development reflect the phenomenal growth of this important part of the industry. Only two months ago (Oct. 12 issue), M/R published a roundup of this market and detailed four principal problem areas. All have since been solved to some extent and researchers indicate that complete solutions are near at hand.

(Indicative of the growth in transducer application is the recent announcement by the Instrument Society of America that it has initiated a program to prepare and publish regularly a "comprehensive compendium of up-to-date information on all known transducers." The ISA also intends to provide a current bibliography of source material and a listing of manufacturers. Publication of the first volume is due in January 1961. The program is the result of a two-year ISA study.)

The four problem areas indicated by the M/R survey concerned the much-needed development of:

- A digital-output transducer for test use.
- A 2 to 5-volt high-output strain-gage transducer for direct coupling to telemetering subcarrier without amplification.
- A feedback potentiometer for operation in 1000°F environments.
- Vastly improved magnet wire, lead wire, and potting compounds.

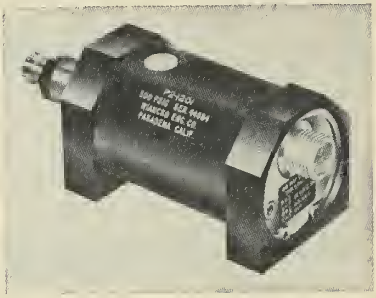
The extent to which these problems have been solved can be described only within the tight limits of military security and company proprietary restrictions. Several of these devices are currently in use on major weapon systems.

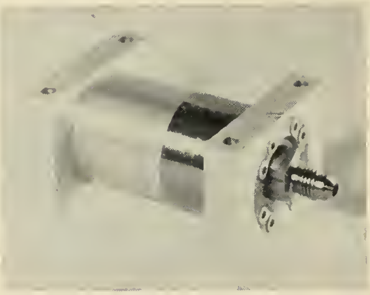
NEW TRANSDUCERS

Two digital-output transducers have been developed and tested for a myriad of applications by **BJ Electronics Division** of **Borg-Warner Corp.** Until recently, both types have been under security wraps; even now, only one can be described.

This is a miniature, rugged high-precision pickup which uses a vibrating wire as its principal component. Output is a frequency modulated signal, eliminating the need for conversion from analog voltages.

Called a Vibrotron Transducer, the device has performed successfully in extended use on *Atlas*, *Redstone*, and other missiles. Essentially, it consists of a tightly-stretched wire (force equivalent to 200,000 psi) anchored securely at one end and terminating on the other end at a highly sensitive moving diaphragm. Changing the position of the diaphragm alters the natural frequency of the wire—much as tuning a violin string modifies its pitch.





TWO 5-VOLT DC output variable reluctance pressure transducers: above, type P2-1201 unit by Wiancko Engineering Co.; below, model CP-40 pickup by PACE Engineering Company.

When the device is used as a pressure sensor, a similar technique is applied. A short non-magnetic wire is secured in the field of a permanent magnet. Transverse vibrations are induced by an oscillator circuit attached to the wire.

As long as the current through the wire is at a frequency other than the natural frequency of the span of wire, a relatively constant impedance exists in the wire—that is, it is practically a pure resistance. But as the natural frequency of the wire length is approached the impedance changes rapidly. At the exact natural wire frequency, a phase shift occurs and the wire suspension becomes a resonator.

Successful operation from 3 to 25 kc has been demonstrated under severe environments.

A few of the applications of the Vibrotron Transducer, according to the company, include the measurement of acceleration, flow-rate, force, torque, and velocity.

At least two manufacturers are now producing 0-5 v dc direct-output transducers.

The **Wiancko Engineering Co.'s** dc pressure transducer is a variable-reluctance pickup combined with a solid-state carrier oscillator and ring demodulator. It was developed for telemetering, static test stand, and data systems; gage, absolute, and differential models are available.

Standard units operate in a temperature range from −65° to 165°F, but Wiancko says this can be extended to 250°F. Response to vibration is less than 1% error for 25 g up to 2 kc. The units, weighing about 11 ounces, will withstand shock up to 50 g without damage, and pressure ranges are available up to 10,000 psig.

PACE Engineering Co. has produced similar units using a dc-energized carrier-demodulator. Its variable reluctance transducers deliver 0-5 v dc, full scale. Input voltage (25-30 v dc) is regulated.

The 18-ounce units are stable in a temperative range of from –65° to 180°F and will withstand 35 g from 50 to 2000 cps. Stability is ± ½% over an 8-hour operating period. Pressure ranges are available from 5 to 1500 psi in gage, absolute, and differential models.

Consolidated Electrodynamics Corp. has developed two pressure transducers for continuous operation at 700°F without cooling. These are unbonded strain-gage types and together cover a range from 15 to 5000 psi. With a special cooling adapter, one of these (operating in the higher pressure range) can be modified for operation up to 2000°F.

To meet the extreme environmental conditions to which the **North American** *Hound Dog* air-to-surface missile is exposed, CEC produced a potentiometer transducer to withstand 10 g for sustained periods and at vibration frequencies up to 2 kc. Temperature range of the pickup is –65° to a 300°F maximum. Maximum static acceleration or shock is 100 g in any axis. Response to static acceleration is less than 0.01%/g.

Transducers now in advanced development at CEC include:

- A highly stable pressure pickup designed for rocket test stand use. Range extends above 700°F at pressures from 0 to 10,000 psi. Sensitivity can be adjusted and bridge unbalance set to better than ± 1%.
- Using refractory metals (instead of noble metal alloy) with stable electrical and mechanical properties, strain gage transducers for use in temperatures up to 1000°F. Part of this program is the development of a helium leak-tight feed-through seal for use at 1000°F, which will permit wider selection of strain wires.

A new 2.2-ounce gage pressure transducer for telemetering is now available from **Bourns, Inc.** The miniature potentiometer unit uses a Bourdon tube as the pressure sensing element. Pressures ranges through 5000 psig are available. Units feature low hysteresis, small temperature and vibration error up to 212°F and 5 g from 10-1000 cps.

Pacific Electro-Kinetics has developed a new linear, variable, differential-transformer transducer for temperature sensing. The ½-inch dia. probe is available in various lengths up to 17 inches.

Operating in a temperature range from –100°F to 350°F. input voltages may vary from 6.3 to 24 volts, depending on model.

A 6-ounce infinite-resolution pressure transducer is now available from **White Avionics Corp.** for control, telemetry and propulsion systems. A potentiometertype pickup, it will withstand 50 g at a 3-kc vibration frequency. Pressure ranges are 0-15 to 0-300 psi.

MAGNET WIRE

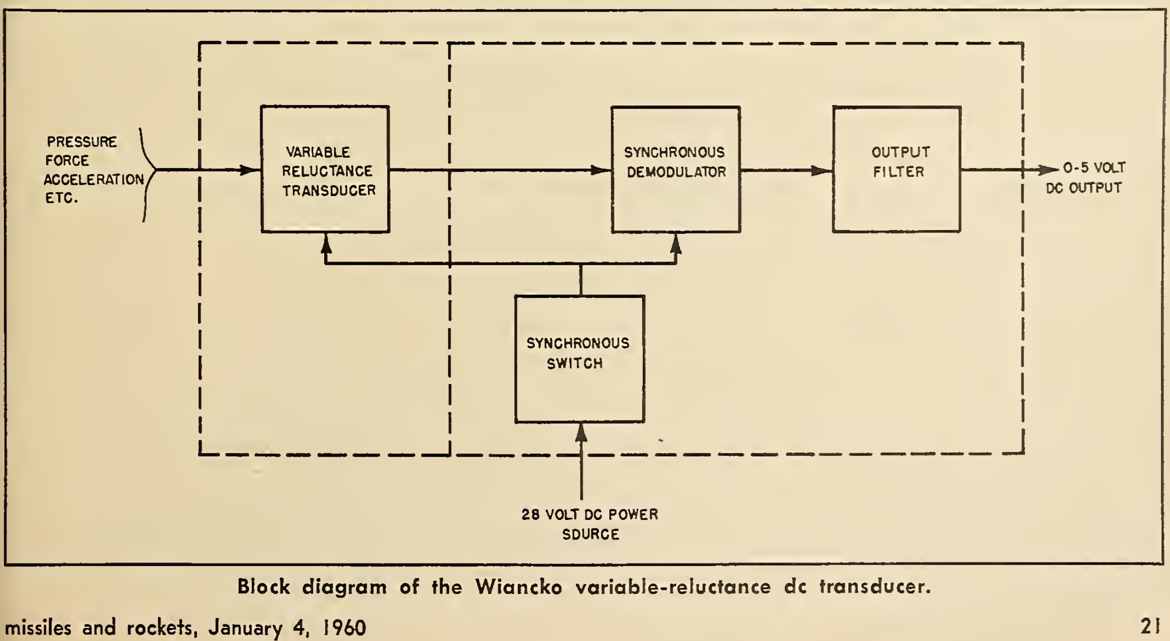
Efforts by industry to develop better insulated magnet wire have been intense in the past five years. Environmental requirements for devices employing magnet wire are not only demanding; they are constantly increasing throughout the missile industry. Application for these products is broad in the transducer field. A look at some current research and development will show progress to date and who is performing the work:

- **Epoxy enamel**—A broad range of epoxy-resin enamel magnet wire has been produced by **Anaconda Wire and Cable Co.** For use in moderately high temperatures (up to 400°F), the company line now extends over all wire sizes—round, square, and rectangular cross-section. Tests have shown it will withstand severe thermal shock, provides good chemical stability, and is compatible with other insulations.

In its manufacture, epoxy enamel has the characteristics of good reproducibility, coating ability, and long storage life.

Furane Plastics, Inc. also has proven long-time (500 hours) thermal stability of epoxy enamel at temperatures up to 400°F. For short-time use in missiles and rockets, maximum operating temperature is considerably higher, according to company researchers.

- **Teflon**—For very high temperatures, tests by **I. E. du Pont de Nemours & Co.** and the Navy's Bureau of Ships have shown that Teflon TFE- and FEP - Fluorocarbon resins provide necessary characteristics for wire insulation at temperatures of 842°F and above. Different types and sizes of wire have been investigated with equal success.
- **Pigmented polyester**—At the **Westinghouse Research Laboratories,** researchers have been investigating pigmented polyester magnet wire for use in temperatures up to 1000°F. Very satisfactory performance has been ob-



Block diagram of the Wiancko variable-reluctance dc transducer.

tained at 600°F, and short-term success has been achieved above 1000°F. To test thermal shock, units have been exposed to a cycling from −65°F to 600°F. Results have been satisfactory, but tests are still in progress.

• **Ceramics**—Ceroc HT and Ceroc ST, also by du Pont, are ceramic coatings cemented to wire by the action of silica and alumina gel. The former provides adequate performance up to 482°F; the latter is good up to 572°F.

Georgia Institute of Technology has been working since 1953 in ceramic research. In 1957, under an Air Force contract, it participated in a program to develop an insulation for use from −85°F to 1500°F. All other desired characteristics were similarly rigid including a 10,000-hr. life expectancy.

The required insulation has been found by using aluminum oxide, provided by anodizing aluminum coated copper wire. For repeated use in temperatures at 1500°F, either a ceramic organic coating or colloidal silica are used as sealers.

• **Strip windings—Aluminum Co. of America** has been developing aluminum wide-strip windings for electromagnetic devices. The idea is not new, but many production problems had to be solved to make its use economically attractive.

Thinner insulations can be used to permit higher space factors (70-95%). Since there are no buried turns, inner hot spots are avoided. Another great advantage, according to Alcoa, is the labor saving resulting from automation.

• **Encapsulants**—This is a tough research area. So far it looks as though no single matrial provides all the needed characteristics.

There are some problems with epoxy resins, but they, too, vary with the particular compound. Many have been found which provide high dielectric strength (sometimes even increased strength) at temperatures up to 450°F on a long-time basis. **Epoxylite Corp.** has made advances, but intense research is still in progress.

Bell Telephone Laboratories, Inc. has performed comprehensive tests on alumina powder as a potting material. Results have shown many advantages in its use: it withstands temperatures above 1800°F, does not expand or contract with wide temperature excursions, does not cure or vulcanize, is light in weight and low in cost.

Dielectric gel, a silicone potting compound, developed by **Dow Corning,** has several advantages, particularly for encapulating coils and other windings. It offers very high insulation resistance, low stress, and high resistance to physical shock. Tests have indicated at least 1000-hr. life at temperatures around 400°F.

Bunker Takes Over *Titan*

BALTIMORE—In an additional move to strengthen management of the *Titan* program, **Martin Company** announced this week that all aspects of the project are being consolidated into a single integrated division with headquarters at the Denver plant where the missile is being built.

MISSILES AND ROCKETS on December 28 reported that the firm would tighten liaison between various divisions working on the program, but the company denied that such a change had been ordered by the Air Force.

George M. Bunker, Chairman of the Board, on January 4 will assume the title of general manager of the *Titan* program and will take personal charge of integrating and coordinating the production, testing and launch activities. H. W. Merrill will be vice president and assistant general manager of the overall program under Bunker.

The recently organized *Titan* base activation division, headquartered in Denver, will be incorporated in the new organization with its present head, V. R. Rawlings, serving as manager of this phase of the *Titan* project. Also included in the new set up will be all *Titan* pre-flight and launching activities at Cape Canaveral.

In announcing the integration, Bunker said development of the *Titan* has now reached the stage where "we are convinced that, with a proper concentration of effort on our part, 1960 will go down in Air Force annals as 'the year of the *Titan*' and that this 'second generation' ICBM also will establish a firm place for itself in the nation's burgeoning space program."

Air Force and **Space Technology Laboratories** (M/R, Dec. 21, p. 43) completed a re-evaluation of the program and pronounced it technically sound, but questioned Martin management.

Fiberglas Blocks Cut Weight of Nuclear Shields

WASHINGTON—Nuclear shielding systems that eliminate the need for the handling of heavy materials have been developed by the **General Nuclear Corporation.**

The shielding is composed of hollow fiberglas blocks, which are filled with lead, water or concrete to provide the specific type of protection required. Stanley H. Clark, president of the firm, explained that virtually any shielding substance can be incorporated into the fillable, interlocking blocks.

Before filling, the blocks are lightweight and consist of two basic and three compound sizes. Each part of a compound block can be filled separately.

Microwave System Adds To Mobility of Antennas

MILLIS, MASS.—Development of a mobile, microwave, passive-reflector system that eliminates the necessity of rigidly-fixed booster stations was revealed by the Electronics Division of **The Gabriel Company.** The "pie-plate"-shaped reflectors redirect microwave energy in almost any desired direction, the company says.

In conventional reflector systems, the passive reflector is used to change direction of transmitted microwave energy from vertical to horizontal, and vice-versa, with a paraboloidal-reflector antenna located directly below the reflector.

The new system permits location of the transmitting antenna anywhere within 1200 feet of the passive reflector, according to Gabriel. Obvious advantages are that reflectors can be easily located and serviced in formerly inaccessible areas, and the microwave system can be aligned by positioning either the paraboloidal antenna on the ground or the passive reflector aloft.

NRL Process Prevents Columbium Oxidation

WASHINGTON—A self-healing, heat resistant metal coating has been developed by the Naval Research Laboratory. The process is designed to prevent the oxidation of columbium.

Tests have shown that alloys of columbium can retain their characteristics at temperatures up to 2,200°F in an oxygen environment if coated by the NRL process. Columbium ordinarily crumbles to dust when exposed to oxygen at these temperatures.

Based on zinc, the coating actually forms an alloy with the columbium. At high temperatures, zinc is released, forming a protective "envelope" on the surface of the part. It rapidly repairs flaws and is plastic, preventing bare spots from developing when the base metal is subjected to stresses.

The usual coating procedures can be utilized. Industry is currently evaluating the process to determine its practicality in high temperature component fabrication.

Tests Point to Higher Teflon Range

INSULATION resistance of Teflon coverings remained in the megohm range at high temperatures until thickness was sufficiently reduced by decomposition. Photo at left shows Sample 1a before and after test. Despite some thermal erosion, coating integrity was still maintained after ten minutes at 454°C. Insulation was maintained for more than 30 seconds (center); did not decompose until after 60 seconds (right). Photos at far right show construction of Sample 2 and results of 4½-minute exposure at 538°C. Slight thermal expansion is indicated by dark area.

WILMINGTON, DEL.—Acceptable operating temperatures of Teflon electrical insulation may be considerably extended thanks to testing recently completed at **DuPont's** Polychemicals Department here.

The tests were conducted to re-evaluate the ability of the TFE-fluorocarbon resins to withstand the constantly increasing requirements for higher-temperature environments in missile and aircraft applications. Present recommended continuous service limitation of 260°C (500°F) has precluded use of this plastic in many instances where its many desirable characteristics made it preferable to other coverings.

Findings show that insulation resistance remains within usually acceptable limits (50 megohms/1000 ft.) until decomposition of the covering takes place. Some samples held up for several minutes at temperatures of 538°C (1000°F). Results differed according to type and configuration of insulation, temperature rise rate, peak temperature, and exposure time.

Basic conclusion reached by DuPont Researchers H. B. Barrett and J. C. Reed, was that the insulation resistance of Teflon remains in the megohm range even at temperatures much above the transition temperature (327°C, where the resins change from a crystalline to an amorphous state). They also found that the resins retain an appreciable degree of elastic strength equivalent to a high-modulus rubber, a fact not generally known.

The DuPont tests consisted of a series of electrical resistance measurements made at temperatures from 300 to 650°C (572 to 1202°F). They covered the insulating properties of the TFE-resins used as wire insulation conforming to specifications of MIL-W-16878 Type E and MIL-W-7139. Samples used were randomly selected from commercial material. They included:

Sample 1a—MIL-W-16878 Type E AWG #22 (7/30 stranded) silver-plated copper wire with 10 mils Teflon 6 insulation.

Sample 1b—Same as 1a except nickel-plated copper conductor.

Sample 1c—Four strands AWG #30 solid platinum wire inserted in a tube of 10-mil wall thickness Teflon 6.

Sample 2—MIL-W-7139 AWG #22 (7/30 stranded) silver-plated copper wire with 19 mils Teflon 6 insulation covered with 9 mils glass serving impregnated with Teflon 30 in turn covered by 10-mil glass braid impregnated with Teflon 30.

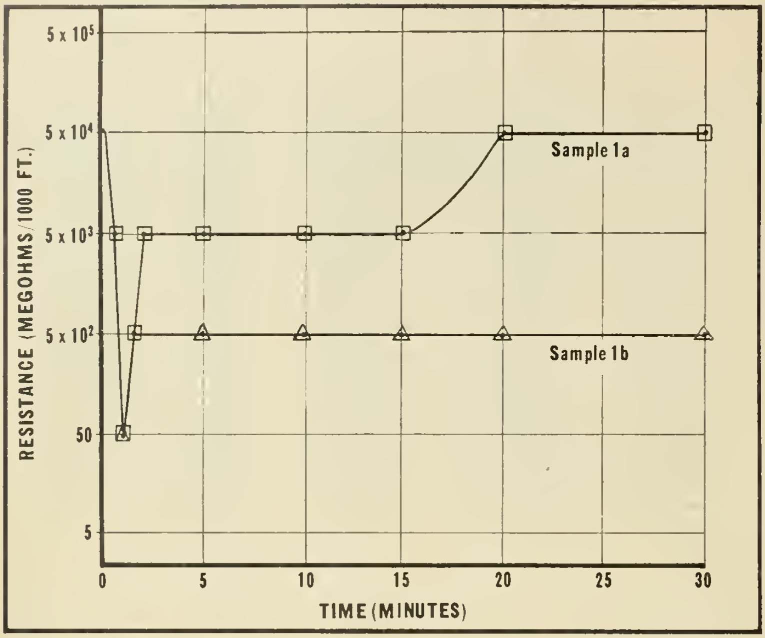
Sample 3—AWG #18 (19/30 stranded) silver-plated copper conductors with 16 mils Teflon 6 insulation (MIL-W-16878 Type EE). (Six of these wires were covered with a 30-mil jacket of Teflon 6 to form a cable.)

Sample 4—Two 0.020-in. diameter platinum wires spaced 0.020 in apart in a cylinder of Teflon 7.

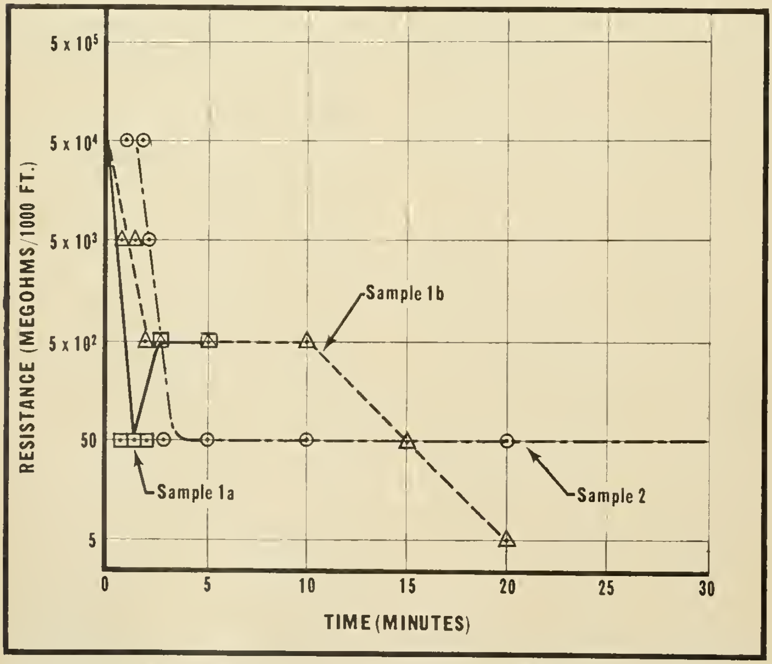
• **Test procedure**—Resistance checks were run with two-foot samples of the insulated conductor wrapped in aluminum foil and placed in an electric furnace. The foil served as a ground for leakage current measurements. The conductor, carrying a test voltage of 500 vdc, was kept at the prescribed temperature for 30 minutes, or until the insulation broke down and the circuit shorted.

Measurements were also made with the same setup under a constant temperature rise of 10°C/minute. Beginning at 200°C, the conductor ambient was raised until the sample shorted.

CYLINDER of Teflon 7 kept shape after almost two minutes in gas flame. Insulation provided high resistance for three minutes at temperatures up to 519° C.



TESTS AT 400° C and 500 vdc show good resistance even beyond 30 minutes.



AT 500° C, Sample 1a shorted at 8 min.; 1b at 22 min. Sample 2 lasted for 45 min., when the thickness of the insulation was materially reduced by decomposition.

In a third series, a molded cylinder of Teflon 7 containing two lead wires—separated by 0.02 in. of insulation—and a thermocouple was held in a gas flame until one of the leads shorted.

Values for insulation resistance were computed from the leakage currents obtained and converted to megohms per 1000 feet, as generally required by specifications.

• **Results**—Most test samples showed a characteristic initial decrease in resistance within a 2-3 minute period from the start of the test, as shown in accompanying graphs. This decrease was usually followed by a partially—and sometimes completely—restored equilibrium value, except at 500°C.

The reason for this decrease could not be completely explained by the researchers. The most acceptable theory advanced to account for the phenomenon was that some conductive volatiles accumulated on the insulation or evolved through it during pre-test exposure at room ambient. Evolution of the suspect volatiles appeared to be complete after the 2-3-minute period and equilibrium attained. The fact that the equilibrium resistances were different for the various samples was explained as an indication of different levels of ambient pickup of conductive volatiles due to non-standardized preconditioning procedures.

In general, the significant results of the tests indicated that Teflon-insulated conductors could be successfully used for short periods at temperatures far exceeding standard specifications. These new findings could prove particularly valuable in missile applications where short-duration temperature extremes are likely to be encountered.

• **Navy tests**—In a parallel research program conducted by DuPont for Bureau of Ships, Teflon also showed up well for use at high temperatures. This work—described at the recent National Conference on Electrical Insulation by J. J. Casey, Bureau of Ships, and J. P. Shoffner, DuPont—compared the high-temperature performance of Teflon TFE- and FEP-resins with other insulation materials. Results showed Teflon superior in many respects.

Primary objective of the tests was to determine the thermal life of representative materials. Standard hookup and interconnecting wire constructions were exposed to temperatures ranging from 200 to 500°C for periods up to 500 hours. After thermal aging, samples were electrically tested for failure by a high-pot dielectric test. A sample passing the dielectric test was returned to the oven for continued high-temperature aging and retested periodically to determine life expectancy at the higher temperatures.

A significant fact, noted by the authors, is that test voltages used (twice rated plus 1000 volts) were those specified by MIL-W-16878 for unaged wire. Consequently, the level of acceptance was appreciably higher than required by existing military specifications and the resultant data proportionally conservative.

Representative samples of the most widely used airborne electrical insulations were used in the tests: polyvinylchloride, monochlorotrifluoro-ethylene, silicone rubber, and Teflon TFE- and FEP-fluorocarbon resins.

Three series of tests were conducted based on cyclic performance in combinations of 1) heat aging, 2) heat aging with modified NAS-703 bend test, and 3) modified NAS-703 heat resistance test. The MIL-W-16878 dielectric strength test for unaged wire served as the measure of acceptability or rejection following each conditioning cycle. A minimum of 10 samples of each construction were sampled.

• **Conclusions**—Briefly, the conclusions advanced by the Casey-Shoffner paper are these:

(1) Teflon wire insulation can be specified for short-term exposure at 400°C with a life expectancy of 60 hours and for higher temperatures with proportionately shorter life.

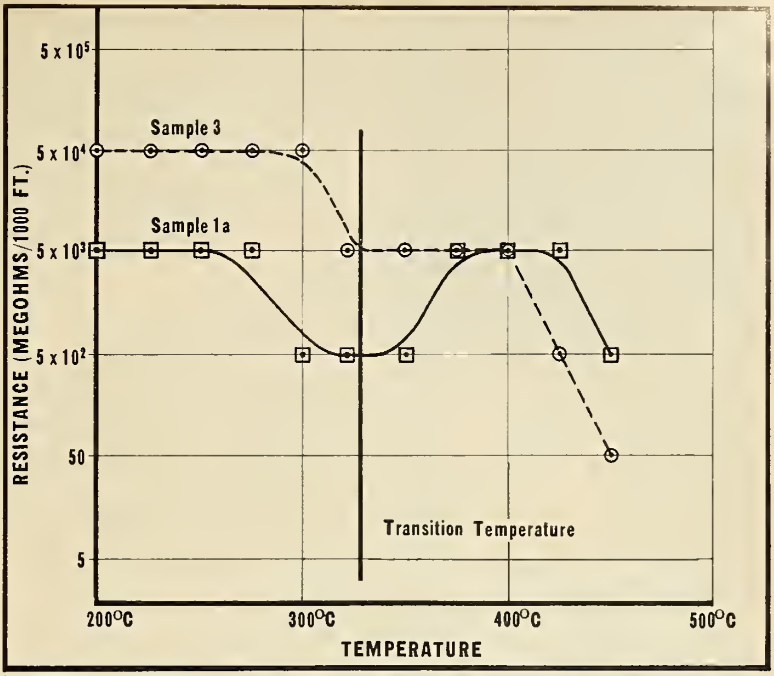
(2) Teflon can be specified for continuous rating in the 250-300°C range in lieu of the current 200°C limitation specified by MIL-W-16878 for prolonged service.

(3) These data, and independent BuShips evaluation, indicate that Teflon 100X FEP resins will meet MIL-W-16878 requirements of Type E and EE wire. Plans are to include this resin in the specification as the existing Type E and EE constructions and uprate the TFE resins from their present position. A new letter designation for this higher temperature construction is probable.

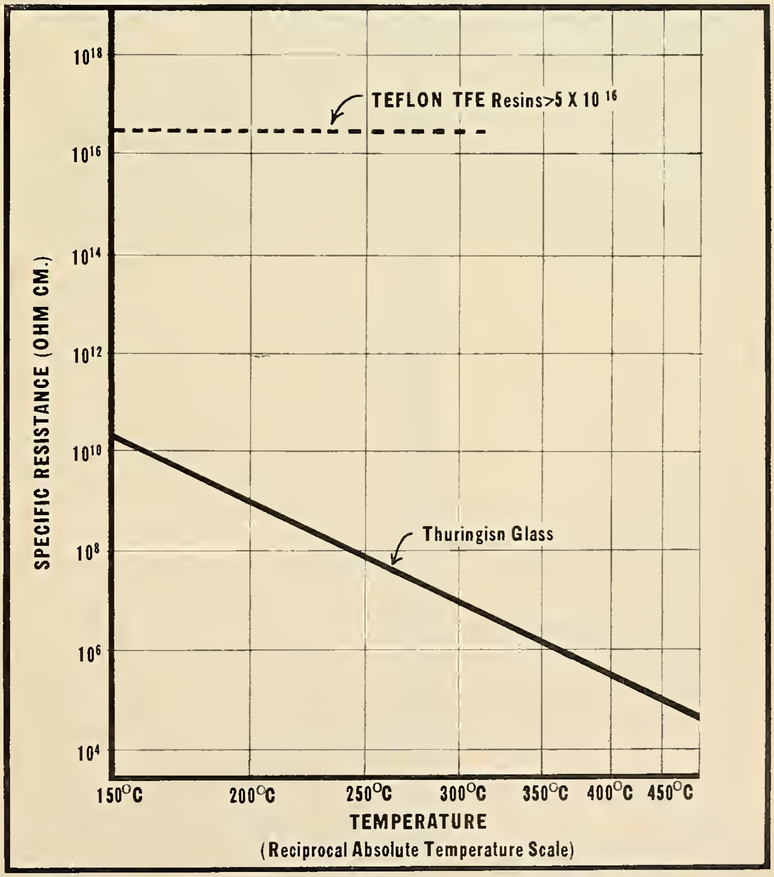
(4) Silicone rubber compounds and Teflon FEP resins significantly exhibit similar electrical and mechanical properties at elevated temperatures. The immersed dielectric test indicates a possible unsuitability of silicone rubber in applications where moisture exists.

(5) The superior combination of properties of Teflon—significantly high temperature resistance to cut-through, unsurpassed dielectric properties, and near-ideal chemical resistance—indicate its noteworthy advantages over the other materials tested.

(6) The use of Teflon-insulated wire is feasible for short time endurance at temperatures of 450°C and above. Such applications include missiles, launch site instrumentation, ground support cable, atmosphere re-entry vehicles, and many others in high-speed short-range aircraft launching facilities.



UNDER CONSTANT rise (10° C/min.), marked decrease in resistance starts near 300° C, continues to minimum at transition temperature. Values remain acceptable more than 20 min.



TFE-RESINS show specific resistance values considerably over those of glass.

French Show Missile Test Ship

by an M/R Correspondent

PARIS—The French Navy has publicly demonstrated its missile testing ship Ile d'Oléron. A former cargo vessel, the Ile d'Oléron was reconverted in 1957-1958 under sponsorship of the Centre d'Essais et de Recherches des Engins Spéciaux (CERES) of the French Navy. It has been used in testing since early 1959.

The ship is equipped with launching ramps for **Nord-Aviation** *CT-10/CT-20* target missiles. It has completed the testing of the subsonic experimental surface-to-air *Maruca* system which is used for the development of the *Masurca* surface-to-air weapon system. The *Masurca* will be on the French training ship/helicopter carrier Jeanne d'Arc, which will be commissioned in 1963, and on a missile launching cruiser to be commissioned in 1964. Construction was authorized in the 1960 budget.

The *Masurca* can be described as a French equivalent of the *Terrier*. The French say that it is less costly than its U.S. counterpart. The solid-propelled surface-to-air system should be operational in 1962. It weighs 1.5 tons, has a range of about 25 miles and Mach 2-2.5 performance. Testing will begin in October.

The Ile d'Oléron is also used to test the *Malafon* surface-to-under water anti-submarine weapon system which will equip the La Galissonnière, an escorter of the T-47 class. The La Galissonnière will become operational next summer. The French Navy has other ambitious plans: it is already beginning to suggest that the French solid-propelled IRBM, whose construction has been decided by the French Government, should be installed on atomic-powered submarines which would become part of the French strike-armoury to which General de Gaulle has recently assigned worldwide strike capabilities.

Atlantic Research Runs Materials Testing Service

ALEXANDRIA, VA.—A routine testing service for materials applicable to rockets and missiles has been established by the **Atlantic Research Corp.**

High-temperature tolerance tests and high-velocity gas flow resistance determinations utilizing both standard solid propellants and new, high-impulse aluminized propulsion systems are part of the facility.

ARC's Pine Ridge propellant plant is fully integrated for manufacturing and testing. It now occupies 600 acres, and facilities are being added at the rate of over a half million dollars annually.

The materials testing facilities are already being used by a number of producers. Similar work has been done for various government agencies under an approved security system.

Medaris Predicts Step-up In Activity at Redstone

HUNTSVILLE, ALA. — Even with ABMA's transfer to NASA, a net increase in investments and employment for Redstone Arsenal is being predicted for this year by Maj. Gen. J. B. Medaris, retiring Redstone Chief.

The Army, he said, will continue all of its current operations at Huntsville. And "while ABMA may lose a substantial number of its people to NASA, it will retain much of its competence in national procurement, military training and systems management. Some of the personnel losses must be replaced, in order to have a continuing research and development element."

Also, he reported, certain additional projects will be transferred to ABMA, giving the Agency even broader responsibilities than it has had in the area of weapon systems.

Summarizing the Arsenal's growth since his arrival four years ago, Gen. Medaris pointed out that;

- The Arsenal budget has grown from $471,700,000 in 1956 to more than $2 billion today.
- Employment rose from 9048 to 21,936 in the four-year period with payroll figures jumping from $39,-860,000 in 1956 to a 1959 figure of about $137 million.
- The government's investment in land and facilities, excluding equipment, has grown from $70,441,000 to $133,385,000 with another $27 million in construction now under way.

NBS Improves Retriever

WASHINGTON—An improved model of a high-speed document retrieval device has been developed by the National Bureau of Standards. The machine, developed for the Patent Office and Navy Bureau of Ships, examines binary coded patterns describing filed documents. Code and document images are on 35-mm microfilm which is read by the machine at the rate of 2400 pages per minute. Documents selected through code recognition are copied photographically without slowing the film.

The '50's—Rocketry Comes of Age

by Heather MacKinnon

WASHINGTON—While the next 10 years should be known as the Decade of Man-in-Space, 1950 through 1959 will be recorded in the pages of astronautical history as his preparatory years.

In this brief period, the world exploited the little known field of rocket technology which first showed its real military and astronautical significance with *V-2* experiments in the early 1940's.

But in the 1950's, families of military missiles were developed; many saw actual operational use toward the end of the period. Whereas at the beginning of the decade the emphasis was on manned aircraft, 1959 closed with the decided shift of emphasis to the missile as the major carrier vehicle for war.

At the mid-point of the decade, planning for orbiting the world's first artificial earth satellites began. And the Space Age dawned to an awakening world with the musical beep from *Sputnik I* on Oct. 4, 1957.

In the following pages, MISSILES AND ROCKETS recounts some of the major events of the 1950's. All could not possibly be listed because of space limitations, but it is hoped this chronology will be of benefit to readers.

1950

Jan. 24: Air Force established a separate Research and Development Command with Maj. Gen. Gordon P. Saville as deputy chief of staff.

Feb. 6: Navy's *Mighty Mouse*, air-to-air rocket, was successfully tested.

Feb. 18: The Air Force announced that it had fired a 12,00-lb. guided bomb and a 500 mi. self-propelled guided missile—no other data disclosed.

April 1: The missile team headed by Dr. Wernher von Braun, designer of the German *V-2*, was moved from White Sands to Redstone Arsenal, Huntsville, Ala.

April 11: General Electric's *"Hermes Project,"* a case-bonded solid-fuel engine which could go "further and faster" than the German *V-2* was revealed. Thiokol was also a contributor.

May 11: Army revealed *Loki*, a ground-launched rocket to seek out and destroy enemy aircraft up to 12 miles altitude.

May 11: A 106.4 mi. altitude record for U.S. single-stage rockets was set by a Navy *Viking*, fired from a ship to be used for cosmic ray research.

June 13: The Department of Defense assigned range responsibilities to the armed services: Army: White Sands, N.M., Proving Ground and nearby Holloman Air Force Base at Alamagordo; Navy: Point Mugu, Calif. Air Force: Long Range Proving Ground at Banana River, Fla. (now called Cape Canaveral).

July 24: A German *V-2* (14 tons) with a (700 lb.) *WAC Corporal* was fired at the Army Long-Range Proving Ground; the first stage climbed 10 mi., separated and was radar-exploded; the *Corporal* traveled 15 more miles.

1951

Jan.: Convair received *Atlas* contract, which had been cancelled in June, 1947.

June 21: The Martin TM-76 *Matador* made its first flight at Cape Canaveral, using for the first time the "down range" facilities in the Bahama Islands.

Aug. 8: The Navy *Viking* climbed a record 135 miles at White Sands, with a top speed of 4100 mph.

Sept. 3: The International Astronautical Federation was formed by scientists of 10 nations at the 2nd International Congress on Astronautics to coordinate responsibility on flights to the moon and planets. Predicted within the decade: a 50-ton earth satellite traveling 18,000 mph orbiting earth at an altitude of 300 miles.

Sept. 19: Navy revealed that it had been testing underwater missiles at TVA Hiwasse Dam for as long as nine years.

Oct. 4: A $25-million Navy contract went to the Sperry Corp. for a guided missile plant near Bristol, Tenn.

Nov. 26: A 10-year agreement was made by the U.S. and Dominican governments for track and control bases to be built in the Dominican Republic.

1952

April 1: Navy announced production of three new guided missile types for service next year: the *Terrier* (Consolidated Vultee); the *Regulus* (Chance Vought); and the *Sparrow I* (Douglas).

May 27: Ryan Aeronautical Co. receives a contract from Aerojet Engineering Corp. for production of rocket engine components developed by Aerojet.

June 27: Northrop began six-month training course in guided missiles.

June 30: President Truman signed a bill authorizing $19 million for NACA laboratories involving further construction and new equipment.

July 15: BuAer chief announced that the first ship-to-surface guided missile would be placed in service this year.

Dec. 16: The U.S. Navy again sent a *Viking* up 135 miles at White Sands, and revealed that it had launched rockets from balloons in the geomagnetic North Pole area for cosmic ray research.

1953

Jan. 23: Guided Missile Committee was created by Aircraft Industries Association to handle collective problems in research, design, construction and testing of missiles.

Feb. 9: Grand Central Aircraft Co. established a Rocket Division at Pacoima, Calif., to develop and produce solid-propellant rocket motors and complete missiles, including one under contract with the Army Ordnance Corps.

March 30: The first details on the *Regulus* missile were disclosed by the Navy. In production at Chance Vought, the 30-ft. missile is to be capable of supersonic speed.

Aug. 4: Evidence that Russia was rebuilding former German rocket bases on the Baltic was presented at the International Astronautical Congress.

Aug. 7: Dr. Wernher von Braun assured the IAF that U.S.-developed propellants were capable of shooting a rocket into satellite orbit for a space station.

Sept. 9: Secretary of Defense Charles E. Wilson appointed Trevor Gardner to head a committee to eliminate interservice competition in development of guided missiles.

1954

Jan. 11: The existence of the *Rascal* guided missile was officially confirmed by Bell Aircraft Corp., but no details were released.

Jan. 15: Air Force announced that two *Matador* squadrons would be sent to West Germany for NATO defense.

May 24: The Navy *Viking* set another record with a 158-mi. climb, top speed 4300 mph at White Sands, N.M.

May 27: Pres. Eisenhower signed $5-million expansion bill for NACA to be used in research for ICBM fuel and high-speed seaplane fighters.

Sept. 29: Chrysler received its first missile contract from the Army—$22 million to build the *Redstone*.

Oct. 9: $500 million was added to the current year's budget for the guided missile program. (In FY 1950 through '54, $700 million was spent.)

Dec. 1: The Navy received the Boston and Canberra, converted to become the world's first true guided-missile ships, using *Sparrow I*, *Terrier* and *Regulus* which were in the hands of the fleet at this time.

Dec. 27: Lt. Col. John P. Stapp rode a rocket sled at Holloman Air Force Base at 632 mph and stopped 1½ seconds after attaining the land speed record.

1955

Jan. 17: Hughes Aircraft made first deliveries of new E-9 fire control system to enable Northrop F89D's to use guided missiles.

Jan. 20: Navy let $16-million contract to Chance Vought Aircraft for *Regulus* guided missiles.

Mar. 6: Air Force Chief of Staff Twining reported that ICBM's were receiving priority in the AF program because of known Soviet progress and possible bases in China. North American's *Navaho*, Northrop's *Snark* and Convair's *Atlas* programs accelerated.

Mar. 14: DOD officials announced that guided missile spending would reach $518 million in FY '55 and $674 million in '56.

Mar. 18: USAF-North American Aviation Corp. contract for long-range *SM-64* missile (formerly designated *B-64*) revealed.

Mar. 23: At IRE convention, speakers disclosed work on instrumentation for devices to be launched by the Rockaire technique, which called for the launching of missiles from high-altitude aircraft as a probable first step to establishing a space radio transmitter.

Mar. 28: Bell Aircraft Corp. revealed that it was supplying the rocket engines which would power *Nike*.

Apr. 20: Details of *Aerobee-Hi*, a new high-altitude research rocket, were revealed.

May 31: NATO officials investigated use of *SS-10*, a French-produced guided missile for air-to-air or air-to-ground missions.

July 1: A six-month training course on the *Corporal 2* guided missile was inaugurated for a small group of British Army personnel to become instructors for British Army units using American missiles.

July 20: The first pre-production order by the Canadian Government was placed for an air-to-air missile.

July 31: The USSR disclosed plans for a satellite, and hired 120 German scientists.

Aug. 1: The White House announced that the U.S. also planned to launch a small unmanned satellite (to be about the size of a basketball) sometime after July, 1957.

Aug. 2: The Navy announced that it was receiving *KDU-1*, a target drone version of the *Regulus* missile from Chance Vought.

Oct. 7: The prime contract for a major part of earth satellite program jointly sponsored by the Army-Navy-Air Force was awarded to the Glenn L. Martin Co. General Electric was to provide the rocket engine.

Nov. 2: The Fairchild *Petrel* was entering operational stage, according to Adm. Arleigh A. Burke, Chief of Naval Operations.

Dec. 13: Aerojet-General was announced as the subcontractor to build the second-stage rocket propulsion system for Project *Vanguard* by Navy and Glenn L. Martin Co.

Dec. 20: Wilson reported the FY '57 would have a record $1 billion for development and production of guided missiles, over the $750 million in FY '56. He also predicted an ICBM with a nuclear warhead within the next 5 years.

1956

Jan. 6: Pres. Eisenhower in his State of the Union message noted the increasing importance of long-range missiles and nuclear-powered aircraft. $1.275 billion was scheduled for FY '57 production of guided missiles with an additional $1.43 billion for military research and development.

Jan. 10: Gen. Taylor, Army Chief of Staff, reported that the Army was "putting everything we've got into IRBM's." The Navy also disclosed that the IRBM was receiving priority, while the Air Force, concentrating on the ICBM, maintained that "know-how" for the IRBM would be achieved simultaneously.

Jan. 13: An AF *Snark* was flown 2000 miles from Cape Canaveral, achieving a 30,000-ft. altitude.

Jan. 13: Army Secretary Brucker disclosed that an electronic "missile master" to detect enemy planes and missiles and coordinate all *Nike* batteries in an entire target area was now in operation. Taylor added that the *Nike* "could destroy anything."

Jan. 26: The Air Force awarded Aerojet-General Corp. a $9-million contract for facilities for the pilot production and production testing of liquid rocket engines.

Feb. 9: Air Force Secretary Donald A. Quarles denied that missiles would be decisive for at least 5 years, and that the ICBM was the "ultimate weapon"; he hinted at an interceptor missile.

Feb. 16: Ryan's *Firebee* remote-controlled jet drone was pronounced operational.

Feb. 23: A new office of Deputy Director-Ballistic Missiles was created in the Directorate of Procurement and Production by the Air Material Command.

Mar. 20: Martin Co.'s scientific breakthrough allowed *Vanguard* to be the first liquid-fuel rocket design to be controlled without fins, according to a Navy announcement.

Mar. 27: Defense Secretary Wilson appointed Esso President Eger Murphree his "missile czar," and revealed that Convair's *Atlas*, Martin-Denver's *Titan*, and Douglas Aircraft's *Thor* were all in the development stage.

Apr. 2: AF fired *Snark* a distance between 1500 to 5000 mi. from Patrick AFB, Fla.

Apr. 3: Navy's program to procure guided missiles would jump from $126 million in FY '55, $238 million in FY '56, $353 million in FY '57, according to Navy Sec. Thomas.

Apr. 4: *Petrel* was fleet operational, according to Navy officials.

Apr. 30: A House subcommittee heard that guided missiles, which accounted for 20.3% of the AF's FY '57 budget might climb to 35% by 1959.

May 3: Plans were disclosed by the AF and Convair for a $41-million guided missile facility at Sorento, Calif., ostensibly for work on *Atlas*.

May 18: The development of a new high-altitude research rocket known as the *Asp*, for Navy's BuShips was announced by Horning-Cooper, Inc.

June 20: Announcement that the Navy had a solid-propellant rocket underway was confirmed by Missile Chief Murphree.

June 22: The Japan Center Meteorological Observatory announced that the USSR had exploded a missile-borne H-weapon at a 22 mi. altitude.

June 23: Adm. Burke warned of Russian missile launching subs as a real threat.

June 27: Senate Armed Services committee rejected an AF request to set up four *Talos*-equipped anti-aircraft bases, but approved Army plans for expansion of the *Nike* program.

July 24: Navy Guided Missile Director disclosed that by 1961, 89 ships would be equipped with surface-to-air missiles.

Aug. 8: The largest U.S. test stand for rocket motors was completed at Redstone Arsenal, slated for *Jupiter* IRBM.

Sept. 18: ARDC disclosed it had a research rocket which could accelerate to 5000 mph in about two seconds.

Oct. 5: The Martin Co. announced that *Lacrosse* was in production for the Army.

Oct. 11: NACA disclosed that four-stage research rockets had hit speeds of 6864 or Mach 10.4.

Oct. 16: Navy planes received *Sidewinder*.

Nov. 2: DOD officials announced that the Boston, first guided missile cruiser, would be dispatched to the Mediterranean to join the Sixth Fleet.

Nov. 26: Secretary of Defense Wilson ruled on U.S. service jurisdiction in the missile program. Army restricted to development and operation of missiles having up to 200 mi. range, missiles for "point" defense against air raids and for tactical support of ground forces. Existing systems: *Nike I*, *Nike B*, and *Talos*. Air Force—Sole responsibility for the development and operation of surface-to-air missiles for "area" defense, ICBM's and IRBM's—existing IRBM, the *Bomarc*. Navy—Ship-based missiles, "suited to accomplishment of its assigned functions." Marine Corps—May adapt others for its use.

Dec. 3: The first known guided missile-launching destroyer, the Gyatt, was commissioned at the Boston Naval Shipyard. Its principal weapon, the *Terrier*.

Dec. 4: The AFL-CIO formed an "Aircraft and Guided Missile Industry Joint Committee," in Washington, D.C.

Dec. 8: The first test rocket for a U.S. satellite, a three-stage *Viking* considered a 45' scale model of 72' *Vanguard*, attained an altitude of 125 miles and a speed of 4000 mph. The rocket carried a "minitrack" radio transmitter which was ejected at 50 mi. and tracked.

1957

Jan. 9: Navy awarded $27 million contract to Bendix for *Talos* anti-aircraft guided missile.

Feb. 7: Ryan's *Firebee* drone set new altitude and endurance records by soaring 53,000 mi. and remaining on remote control for 1 hr., 44½ min.

Mar. 26: First *Lacrosse* came off production line.

Apr. 23: Details of North American's X-15 were revealed for the first time.

May 16: Production contract for *Bomarc IM-99* interceptor missile was signed between AF and Boeing Airplane Co.

May 28: Navy and Martin Co. announced new air-to-surface missile, the *Bullpup*, was undergoing Navy evaluation.

June 5: Army announced that a *Jupiter* mid-range missile was fired 1500 miles, limit of its designed range, and to an altitude of 250-300 miles.

June 12: Raytheon Mfg. Co. was named prime contractor of entire *Hawk* weapon system by Army.

July 1: International Geophysical Year began.

July 2: Air Force ordered into mass production the country's first military missile of intercontinental range, the *Snark*.

July 11: *Navaho* missile program cancelled by Air Force.

Aug. 26: Soviets announced firing of *TR-3*, a huge ICBM, and claimed that their *TR-2* (IRBM), was in production and undergoing advanced testing.

Oct. 4: The Soviet Union launched *Sputnik I*.

Oct. 23: *Vanguard* flew to a 109 mi. alt., at 4250 mph.

Oct. 23: A four-stage, 1900-lb. research rocket was launched in a rarified atmosphere from a balloon-borne launcher 100,000 ft. over Central Pacific.

Oct. 24: *Thor* fired at Cape Canaveral.

Nov. 1: *GAM 63, Rascal* became operational with SAC at Pinecastle AFB, Fla.

Nov. 3: *Sputnik II*, carrying the dog Laika, launched by the Soviet Union.

Nov. 4: Navy awarded a $62-million contract to Lockheed Aircraft Corp. for developing *Polaris* IRBM.

Nov. 7: Pres. Eisenhower announced that there are 38 types of US missiles in operation or development, with *Falcon, Sidewinder, Sparrow I, Rascal, Nike-Ajax, Terrier, Corporal, Honest John, Matador* and *Regulus I* operational.

Dec. 6: *Viking* rocket failed on pad.

Dec. 17: *Atlas* made first flight at Canaveral, flying 500 miles.

1958

Jan. 4: *Sputnik I* disintegrated.

Jan. 31: The first American satellite, *Explorer I*, launched.

Feb. 5: Trial firing of *Vanguard* test satellite failed at Canaveral.

Feb. 7: ARPA created.

Mar. 5: *Explorer II* launching fails.

Mar. 17: *Vanguard I* satellite launched, life expectancy of perhaps 200 years.

Mar. 26. *Explorer III*, U.S. satellite, went into orbit around earth.

April 13: *Sputnik II* plunged to earth.

April 23: *Thor-Able* containing a mouse in its nose cone was launched from Cape Canaveral in a re-entry test, but fell short of its goal and was not recovered.

April 28: A *Vanguard* fired by the Navy at Cape Canaveral failed to reach required speed to orbit and burned up in re-entry.

May 1: Details on the Van Allen belt were disclosed by Dr. James Van Allen.

May 15: *Sputnik III*, Soviet satellite, started orbiting earth.

May 18: A *Jupiter* missile was fired 1600 miles and the nose cone was recovered.

May 27: *Vanguard II* made a normal takeoff, but incorrect angle carried it only 2000 miles to burn up in re-entry.

June: *Nike-Hercules* became operational.

June 26: Another *Vanguard* failed.

July 9: A second *Thor-Able* was launched, traveling 6000 miles.

July 23: A *Thor-Able* made another successful 6000-mile flight, although the nose cone was lost.

July 26: *Explorer IV*, fourth U.S. satellite, successfully launched.

Aug. 1: A nuclear weapon believed capable of prematurely triggering the warhead of an oncoming ICBM was exploded by the U.S.

Aug. 6: Rocketdyne division of North American announced an Air Force contract for a 1,000,000-lb.-thrust engine.

Aug. 7: A *Bomarc* defense interceptor was launched by remote control 1500 mi. away, but failed to find its target.

Aug. 12: *Talos* "bagged its prey"—the first missile to hit Lockheed's specially developed *XQ-5*, a supersonic ramjet drone.

Aug. 17: First AF lunar probe ripped apart by an explosion 77 seconds after launch.

Aug. 24: *Explorer V* missed orbit.

Aug. 27: The Soviet Union sent two dogs to an altitude of 281 miles and safely returned them to earth.

Sept. 7: Great Britain's *Black Knight* launched to an altitude of over 300 miles.

Sept. 24: The first meeting of the newly created NASA held, with Dr. T. Keith Glennan as administrator.

Sept. 17: *Regulus II* fired for first time from a submarine at Navy's Point Mugu.

Sept. 17: *Vanguard* fell back on pad after firing, was saved.

Sept. 26: *Vanguard* fired, did not attain orbit and burned on re-entry.

Oct. 11: *Pioneer I*, first successful space probe, launched from Cape Canaveral.

Oct. 15: Rocket ship *X-15* unveiled for first time.

Oct. 22: *Beacon*, intended U.S. satellite, failed when last two stages did not fire.

Nov. 6: Army completed *Redstone* testing with a perfect 250-mile shot.

Nov. 8: *Pioneer II* climbed 1000 feet, then fell.

Nov. 28: *Atlas* made its first successful test flight in a 6325-mile trip, landed within 30 miles of its target.

Dec. 6: *Pioneer III* launched, presumably disintegrated after reaching speed of 24,-000 mph.

Dec. 13: Space monkey Gordo made trip in *Jupiter* with no untoward effects, but float mechanism failed and nose cone was not recovered.

Dec. 16: Two *Thor* shots successful.

Dec. 17: Project *Mercury* got its name, and Rocketdyne was awarded contract for engine with up to 1.5-million pounds thrust.

Dec. 18: An *Atlas* missile launched and put into orbit under code name of Project *Score*.

Dec. 18: Navy cancelled *Regulus I*.

Dec. 19: President Eisenhower's Christmas message beamed from Project *Score*—the first voice in space?

Dec. 20: White Sands Long-Range Proving Grounds announced missile range firing record—2000 "hot" firings in one year.

1959

Jan. 2: Defense officials indicated FY '60 budget would begin major integration of long-range missiles into weapons arsenal and replace manned aircraft on a large-scale by '60, '61.

Jan. 2: USSR launched *Lunik I*, into a solar orbit.

Jan. 4: Vandenberg Air Force Base and the Pacific Missile Range were officially ready for firings.

Jan. 9: Administration repeatedly rejected USAF proposal to expand ICBM squadrons from 13 to 20 despite warnings of growing gap with USSR.

Jan. 17: *Atlas* flew 200 miles.

Jan. 19: The U.S. Navy announced that it had developed a rocket engine and control system deemed flexible enough for manned flights and moon landings, operable by single hand lever. The engine would use 2 fuels igniting on contact, fed from pressurized containers that eliminate complex pumping systems.

Jan. 20: The first operational-type *Polaris* firing was successful on an 800 mi. test at Cape Canaveral.

Jan. 21: *Atlas-Score*, 8700-lb. U.S. satellite, destroyed in reentry.

Jan. 22: The first *Jupiter* tactical model was fired from Canaveral 1700 miles and hit its target.

Jan. 23: *Thor-Able* fails.

Jan. 28: 110 candidates were selected in the first screening for Project *Mercury*.

Feb. 4: The U.S. was believed able to monitor ICBM countdowns, launchings and above atmosphere flights by radio-radar devices based around the USSR.

Feb. 17: *Vanguard II* launched by the U.S., to last more than 10 years.

Feb. 20: NASA awarded $105 million in contracts for '59 projects (15 satellites to be launched.)

Feb. 26: First *Titan* was successfully fired a limited range at Cape Canaveral.

Feb. 28: *Discoverer I*, 1450-lb. U.S. satellite, launched from Vandenberg.

March 1: "Poor man's rocket," *Scout*, was announced by NASA and AF.

March 3: *Pioneer IV*, U.S. 13.4-lb. lunar space vehicle, was launched, (after four failures), missed its intended trajectory by a fraction, and shot past moon to orbit sun.

March 5: *Discoverer I* presumed burned up on re-entry into atmosphere at an unknown point.

April 8: U.S. recovered first *Thor-Able* nose cone after 5000-mi. flight from Cape.

April 13: *Discoverer II* launched by U.S., a 1610-lb. satellite, from Pacific Missile Range into polar orbit.

April 13: *Vanguard* launching failed when payload and 3rd stage fell into ocean after only 500 sec. flight time.

April 26: *Discoverer II* fell, capsule was not recovered after timer malfunctioned ejecting capsule in vicinity of Spitzbergen Islands instead of Hawaii, the intended impact area.

May 15: Lt. Gen. Bernard A. Schriever, Commander of ARDC, unveiled first re-entry vehicle ever to be recovered after a full intercontinental range flight, built by GE of Avco's Avcoite.

June 3: *Discoverer III*, U.S. satellite, launched; second stage, which was to go into orbit, fired—but officials doubted its success.

June 22: *Vanguard* satellite fired, but a faulty second-stage pressure valve caused failure and rocket plunged into Atlantic Ocean some 300 miles northeast of Atlantic Missile Range.

June 25: *Discoverer IV* failed due to insufficient velocity.

July 16: *Explorer*, launched by *Juno II*, was exploded by the range safety officer when it tilted sharply due to failure of power supply to guidance system.

July 18: Navy's *Corvus* fired successfully in first test.

July 21: *Atlas* nose cone was successfully recovered.

Aug. 7: *Explorer VI*, U.S. "paddlewheel" satellite was launched by a *Thor-Able III*.

Aug. 13: *Discoverer V*, U.S. Satellite and nose cone re-entry capsule, launched from the Pacific Missile Range goes into orbit, although capsule was not recovered because of a malfunction.

Aug. 14: *Beacon* attempt at launching U.S. satellite failed because of premature fuel depletion in booster and malfunction in attitude control system for upper stages.

Aug. 17: A sodium flare was lighted 150 mi. above earth from a *Nike-Asp* research rocket at Wallops Island to study direction and velocity of wind and rate of diffusion of matter in upper atmosphere.

Aug. 19: *Discoverer VI* satellite launched.

Aug. 27: *Polaris* successfully launched for first time.

Sept. 9: *Big Joe*, test version of astronauts, capsule, rocketed 1500 miles into Caribbean and was pulled out in "extremely good condition."

Sept. 12: *Lunik II*, Russia's 858.4-lb. package, impacted on the moon.

Sept. 16: A *Jupiter* launched from Cape Canaveral, destroyed by a range officer after fishtailing, carried 14 pregnant mice, 2 frogs and other biological specimens.

Sept. 16: A full-sized *Minuteman* ICBM model was fired from an underground silo.

Sept. 16: *Discoverer V* fell.

Sept. 17: *Transit I*, U.S. satellite attempt failed to achieve orbit.

Sept. 18: *Vanguard III*, U.S. satellite launched for an estimated 30-40 year life. Complete *Vanguard* program.

Oct. 4: *Lunik III*, Russia's translunar earth satellite began photographing trip around moon.

Oct. 13: *Explorer VII*, U.S. *Juno-II*-launched satellite went into orbit with a life expectancy of 20 years.

Oct. 14: "Paddlewheel satellite." *Explorer VI* ceased transmitting.

Oct. 14: First test flight of *Nike-Zeus* antimissile bird was made.

Oct. 20: *Discoverer VI* fell.

Oct. 21: President Eisenhower decided to bring the Army Ballistic Missile Division, Huntsville, Ala., with Von Braun and his team under NASA. Decision subject to Congressional action.

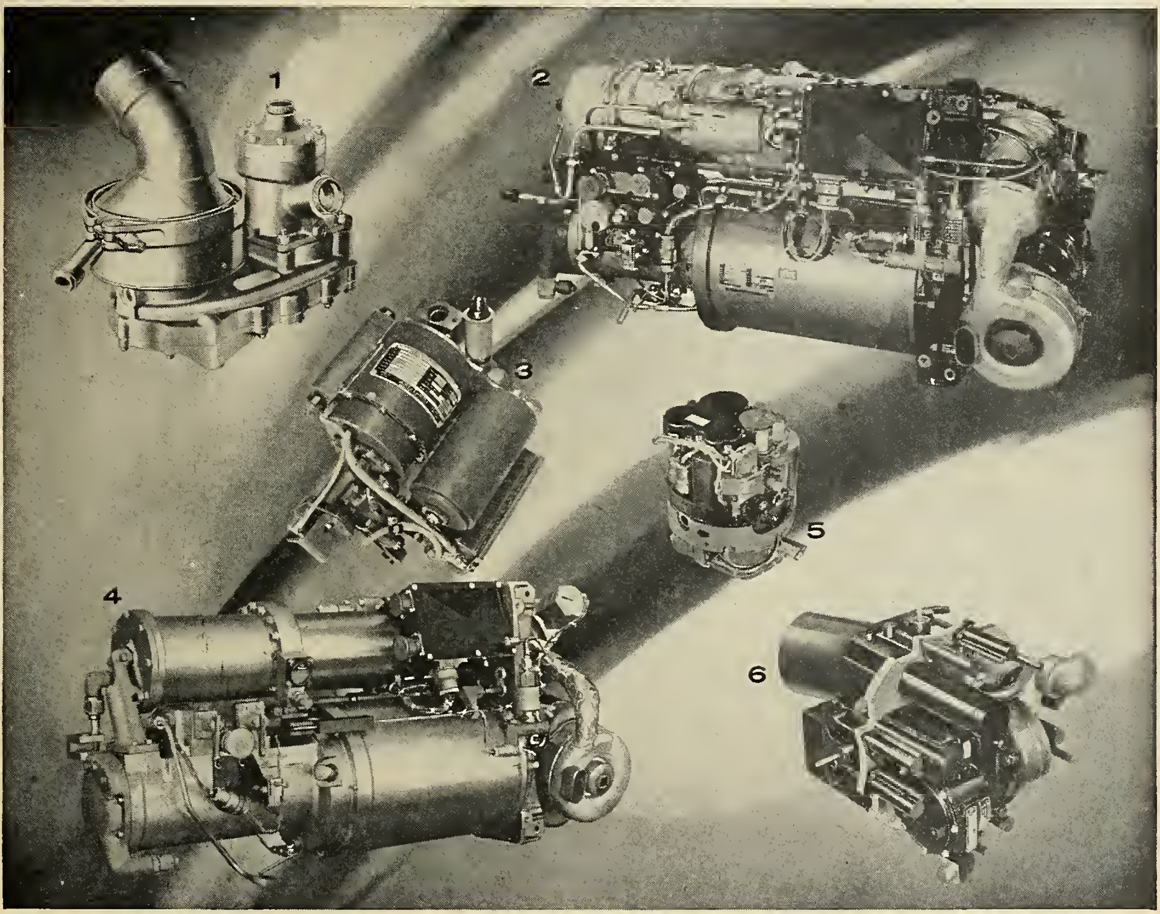
Nov. 7: *Discoverer VII* satellite went into orbit, but re-entry capsule was not released because of a failure on the electrical system. Expected life—2 weeks.

Nov. 11: Air Force announced decision to go ahead with *Dyna-Soar* program.

Nov. 26: *Atlas-Able* test vehicle explodes, dashing hopes for another U.S.-satellite and recapture of prestige.

Dec. 13: NASA cancels the $65-million *Vega* space vehicle program.

DELIVERED—thousands of missile APUs



1. Solid propellant—hydraulic output 2. Liquid propellant—hydraulic and electric output 3. Solid propellant—electric and mechanical drive output 4. Liquid propellant—hydraulic and electric output 5. Solid propellant—hydraulic and electric output 6. Solid propellant—hydraulic, electric and steering outputs

AiResearch has designed, developed, manufactured and delivered thousands of missile accessory power units. Extremely reliable and lightweight, these various solid and liquid monopropellant APUs are completely self-sustaining within the missile system. Designed to minimum space and weight requirements, they are built to withstand high G loading and severe temperature extremes.

The several units pictured above provide hydraulic, electrical and/or steering surface control depending on the customer's requirement. Delivered horsepower ranges from 1.2 to 35 h.p. over hot gas operating durations from 30 seconds to 20 minutes. Electrical regulation is maintained as closely as ±½%. A significant advance in missile APUs is unit #6 pictured above. This package represents the first integrated hydraulic and electrical power unit providing a steering surface actuation system.

These tailored systems utilize the extensive hardware experience and complete laboratory, test and production facilities of AiResearch needed for quick and efficient quantity production of complex APU systems. AiResearch is the world's largest and most experienced manufacturer of lightweight turbomachinery—the key component of its APU systems. Your inquiries are invited.

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

 Circle No. 1 on Subscriber Service Card.

Camera Measures Missile Accuracy

WOOMERA, AUSTRALIA—A miniature one-shot camera, less than two inches in diameter, is being used here to measure missile accuracy. Mounted in the missile's nose section, the camera was developed to measure the attitude of a missile relative to its target and vector miss-distance. It can also photograph the ground or horizon to indicate missile attitude relative to the earth.

Designed and developed by the Weapons Research Establishment here and manufactured by **Fairey Aviation,** the WRECISS (WRE Camera Interception Single Shot) has a field of view of 186 degrees. Two of the units mounted back-to-back give full 360-degree coverage.

The camera can measure miss-distance to an accuracy of 5% and missile-to-target attitude to approximately ±1 degree. Relative to ground axes, attitude can be measured to ±1 degree in pitch and roll and, by reference to the sun, to ±3 degrees in heading.

The WRECISS is triggered by a 45-150 volt electrical impulse from either a proximity fuze or from an error-signal voltage from the guidance system as the missile passes its target. Exposure time is 0.3 msec. About 30% of the cameras can be reused after recovery after replacement of the expendable firing lever.

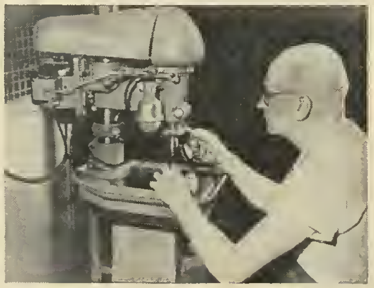
Circle No. 225 on Subscriber Service Card.

Drill Press Has Speeds to 12,000 rpm

A new 14-inch Hi-Speed Drill Press, with speeds up to 12,000 rpm, has been introduced by **Rockwell Manufacturing Co.'s** Walker-Turner Division.

Engineer for high speed, small hole drilling where precision and sensitivity are needed, the new press is ideal for manufacturers of specialty parts, electronic devices and similar equipment. It is recommended for all drillable materials, particularly precious metals, phenolics and non-ferrous metals such as aluminum, brass and copper.

Drill breakage and work spoilage is reduced by a counterbalanced quill that



eliminates quill drop at break-through on through holes.

Vibration-free, accurate operation is assured by preloaded, lubricated-for-life ball bearings with a 14-spline "floating" sleeve drive. This sleeve drive includes a taper-hole mounted spindle pulley, lapped quill, etc.

The press is available in single spindle models or with any number of spindles in multiple spindle set-ups. Both single spindle or multiple spindle models come with production table, No. 72-¼-inch key chuck and choice of single, three phase or D. C. 1/3-horsepower motor.

Circle No. 226 on Subscriber Service Card.

Potentiometer Available With Special Shaft Flanges

Gear coupling to the highly accurate Series 2 "Vernistat" precision a. c. potentiometer may be obtained with special shaft flange versions of the components introduced by the Vernistat Division of the **Perkin-Elmer Corp.**

The main feature of these special

units is a precision shaft coupling assembled with the Vernistat to obtain maximum mechanical accuracy in coupling the component to other elements in a system. Three mounting holes and an accurate machined slot locate a gear on the Vernistat shaft.

Characteristics of the Series 2 Vernistats include linearities from ±0.05%, output impedances from 45 to 470 ohms, input impedances from 65,000 to 200,000 ohms, and extremely low phase shift. The ten-turn Vernistat operates at 130 volts at a nominal 400-cycle input.

The a. c. potentiometer is a combination of a tapped autotransformer and a precision interpolating resistance element. The component finds widespread use in precision military servos for inertial guidance, analog computers, and simulator systems.

In addition to standard linear versions, the Vernistat design enables the components to be constructed to generate nonlinear functions with extremely high conformity (e.g. sine 0 - 360° can be provided with a conformity deviation not exceeding ±0.25%).

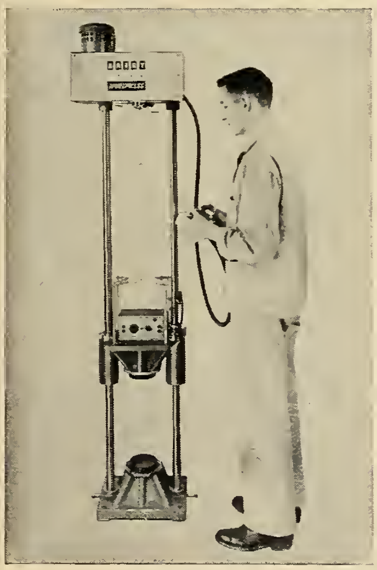
Construction features include class 5 ball bearings, centerless ground shaft, and accurately machined size 18 aluminum housing.

Circle No. 227 on Subscriber Service Card.

Shock Testing Machine For Small Components

Barry Controls Inc., announces development of the 16750 Varipulse Shock Machine, specifically designed for production and laboratory testing of small electronic, electromechanical and mechanical components.

Fourth of a series of shock testing



machines, Type 16750 accommodates test specimens weighing up to twenty pounds and occupying an eight-inch cube. It provides accurate and repeatable half-sine, saw-tooth, and square waves.

The same pulse is reproducible in test after test and from one machine to another, eliminating the confusing variety of test results obtained from older type sand-drop equipment.

Like others of the Varipulse line, the 16750 utilizes the gravity free-fall principle for simplicity, economy of operation, and minimum maintenance. A remote push-button control and a disconnect interlock provide safety features for the protection of the operator.

The 16750 Varipulse requires only a 110-volt power source—no gas or hydraulics involved. No special foundation is needed. The machine may be operated manually or automatically for any of the specified shock pulses. When the resilient pads for half-sine pulses are used, the elevator table is mechanically caught at the peak of rebound to assure a single, undistorted pulse.

Circle No. 228 on Subscriber Service Card.

Miniature Tape Recorder Has Space Applications

A new model of miniature tape recorder designed for reliable operation over wide temperature range under extreme shock and vibration conditions has been announced here by engineers of the **Leach Corp.'s Special Products Division.**

The recorder is already in use by the U.S. Air Force Geophysics Research Center at Bedford, Mass., on space probe projects, and by **Goodyear Aircraft Co.** on tests of the *Subroc* missile.

Developed especially for use in space vehicles where critical conditions prevail, the model known as the MTR-1200 can also be put to various military, commercial and industrial uses, company engineers said.

The MTR-1200 is completely self-contained and requires only external power for operation. It features all metal surface recording heads, modular construction and ease of operation. The unit can be driven in either direction and contains an end-of-tape sensor.

Tape length choice offers either 650 feet of 1 mil Mylar tape or over 800 feet of ¾ mil pre-tensioned tape of either ½" or 1" width.

Circle No. 229 on Subscriber Service Card.

Low-Cost Centrifuge Has One Percent Accuracy

A new rotary centrifuge featuring moderate accuracy and very low cost is announced by **The Gyrex Corporation,** Santa Monica, Calif. Designed to provide production departments with a small instrument capable of fast testing

at pre-set accuracies, the Gyrex G-RATER operated up to 100 g of acceleration force in a number of standard speed ranges.

Basic accuracy of the instrument is better than 1% in terms of RPM. Two matched objects larger than 3" cube and 5 pounds weight can be tested in three axes on the standard booms. First models of the G-Rater have useful book radii of 12 inches. Eight slip rings are standard.

Start and stop times of the machine between zero and full speed at full load can be varied down to 2 seconds, approximately.

Circle No. 230 on Subscriber Service Card.

Electronic Gauge Measures All Coating Thicknesses

Coatings of any type and thickness can now be measured quickly and accurately with an electric micro-guage and comparator called the Elcotector, now available for the first time in the U.S., from the Supply Division of **Ferro Corp.**

In addition to measuring metallic

and non-metallic coatings on any dissimilar bases, the unit will also compare the hardness and grades of metals and other materials.

The unit operates on the eddy-current principle by making use of the fact that the electrical characteristics of a coil are influenced in proportion to the conductivity of the materials being measured. Housed in an aluminum desk-type cabinet 12"x8"x8", the instrument may be operated at 100/115, 220/230 or 240/250 volts A.C., 50/60 cycles.

The Elcotector is manufactured in England by the **East Lancashire Chemical Co., Ltd.,** who also manufacture a small pocket size thickness gauge called the Elcometer which measures coating thickness by the magnetic principle.

Circle No. 231 on Subscriber Service Card.

Absolute Pressure Switches Operate at High Temps

A line of absolute pressure switches capable of continuous duty at temperatures from –65 to 1000°F has been introduced by **Consolidated Controls Corporation,** a subsidiary of **Consolidated Diesel Electric Corporation.**

The switches are intended for use in locations where high temperatures do not permit the use of standard pressure switches as in hot spots near aircraft and missile engines or where air friction at high speeds raises temperatures abnormally.

They are used to provide electrical signals at predetermined pressure levels in such media as air, oxygen, steam, and hydraulic and other aircraft fluids.

Currently available are units for operation at any pressure in the range of 20 to 200 pounds per square inch absolute, with proof pressures to 375 psi absolute. The accuracy of the operating point is within 10% for most models over the entire temperature range. The differential between make and break of the electrical contacts on increasing and decreasing pressure is 2 psi maximum.

Electrical contacts are rated for 1 amp resistive at 28 volts dc. They are furnished in a single-pole, single-throw configuration to either make or break the circuit at the desired pressure.

Units are built to withstand the vibration requirements of MIL-E-005275B, Procedure I, extended 1,000 cycles per second, 10 g. Shocks of 40 g have no effect on the switches.

The pressure inlet port is in accordance with MS33656-3 or to meet special requirements. Electrical connection is by means of sealed ceramic terminals.

Units are mounted by a strap around the body or by a suitable bulkhead type port.

Ability to withstand high temperatures is achieved through all-welded construction of Inconel and Inconel-X.

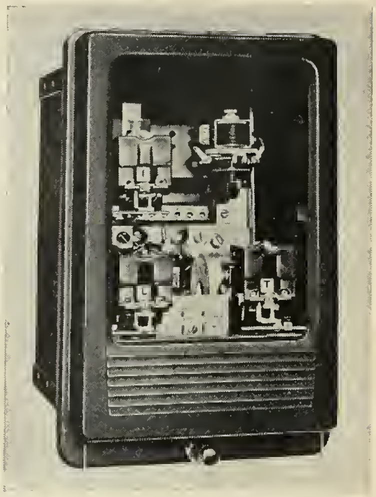
Circle No. 232 on Subscriber Service Card.

Relay Gives Motor Protection From Overloads

A new relay (type COM-5) for complete motor protection from very light to heavy overloads is now available from the **Westinghouse Electric Corp.** The relay provides protection by combining several elements to more closely match the motor heating curve.

From minimum pickup to 175 percent of tap value setting, an alarm is sounded and an operator is allowed five to ten minutes to remove the trouble. With medium overloads, the COM-5 gives normal time delay tripping protection. The relay provides for instantaneous tripping on heavy fault current.

In the past, a number of indepen-



dent relay packages were required for complete motor protection. Now, with the new COM-5 relay, a more convenient and versatile package is provided.

Circle No. 233 on Subscriber Service Card.

New Literature

LAMINATED PLASTIC. 20-page catalog available from the **Cadillac Plastic & Chemical Co.** describes its lined laminated plastic sheets, rods and tubes lists available grades and properties, illustrates typical applications and gives fabricating and finishing information. Special features of each grade are noted. More than 50 laminate grades are described. Included are phenolics, melamines, epoxies and silicones with paper, asbestos, canvas, cotton, nylon and glass fabric bases. Copper clad laminates for printed circuits are included. Size ranges in all grades are shown.

Circle No. 200 on Subscriber Service Card.

TEST EQUIPMENT. A four-page shortform catalog and five individual flyers describe **Cubic Corp.'s** transistorized test equipment, power measuring equipment and microwave instrumentation. The new literature includes the shortform (Bulletin 500-T), giving brief descriptions, and the individual specification sheets, giving complete data.

Cubic Model 500 Waveform Generator, a portable signal source which supplies trigger pulses, variable width gates, square waves and clipped sawtooth signals of continuously variable repetition rate and amplitude. Bulletin 510-T.

Cubic Model 504 Transistor Curve Tracer, a fully transistorized instrument for rapid evaluation of PNP and NPN Junction Triodes, which offers an eight-curve presentation, single-curve selectivity and dual input matching. Bulletin 520-T.

Cubic Model 701-B Klystron Power Supply, a compact power supply for use in development work, microwave research, production test, VSWR determination and attenuation measurement. Bulletin 530-T.

Cubic Model 100-X peakpower Test Set, a precision instrument useful for direct-reading peak power measurements of amplitude-modulated X-band sources, as an X-band signal generator with a metered power output and as a wide band crystal-video receiver. Bulletin 540-T.

Cubic Model Mc-1B Calorimetric Wattmeter, instrumentation for calibration and check-out of magnetrons and radar systems, commonly used by government and industrial laboratories as standards against which to check power-generating and power-measuring devices. Bulletin 550-T.

Circle No. 201 on Subscriber Service Card.

FM/FM TELEMETRY. **Tele-Dynamics Inc.** has just released a 24-page two-color brochure, Number 936, which describes a new line of ruggedized airborne FM/FM telemetry components. Transistorized voltage-controlled subcarrier oscillators for conventional signal voltage ranges, fractional volt ranges, and millivolt ranges are described. A compact oscillator mount, a miniature transistorized wideband amplifier, and a crystal-stabilized FM transmitter round out the equipment line-up. The brochure includes detailed electrical, environmental, and physical characteristics in addition to outline drawings.

Circle No. 202 on Subscriber Service Card.

FLAME CUTTER. An eight-page catalog on **Air Reduction's** latest addition to its line of flame-cutting machines has just been issued. Designated the Linagraph, this machine is of pantograph design and is suitable for straight line and shape cutting on eight-foot steel plate used in medium duty production. The catalog discusses in detail the design, construction and operation of the Linagraph. Liberally illustrated with photographs it explains the principal features of this automatic gas-cutting machine such as centralized operator control, pantograph design, motorized torches and its adaptability to various tracing devices.

Circle No. 203 on Subscriber Service Card.

SHAFT ASSEMBLIES. The **F. W. Steward Corporation** has issued a new catalog of its standard flexible shaft assemblies and over 180 variations which may be ordered directly from their catalog.

Circle No. 204 on Subscriber Service Card.

ASTROLOG

A status report on U.S. missiles and rockets and all space vehicles presently in orbit

★ Indicates change since November 9 edition

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
SPACE VEHICLES			
★AGENA (Air Force)	Lockheed, prime; Bell, propulsion	1700-pound satellite after burnout	Used in Discoverer program; larger model to be used with Atlas under development; NASA also will use to take place of cancelled Vega
★ATLAS-ABLE (NASA)	STL, prime; GE/Burroughs, Arma, guidance; Rocketdyne, Aerojet-General, ABL, propulsion	Orbit 200-lb. vehicle around moon or send into deep space	No shots scheduled
★CENTAUR (NASA)	Convair, prime; Pratt & Whitney/JPL, propulsion	Soft-land 730-lb. on moon; first liquid hydrogen engine; 30,000-lbs. of thrust	First test flight in 1961
COURIER (ARPA-Army)	Army Signal Corps, prime	Delayed repeater communications satellite	R&D; satellite in advanced stage; first to be launched in spring
DECREE (ARPA)	No contract announced	24-hour instantaneous repeater satellite	R&D
★DISCOVERER (ARPA-AF)	Lockheed, prime; GE, re-entry vehicle	Thor-Agena launchings of early stabilized satellites	Of first 8 launched, 5 stabilized in orbit; ejected capsules not recovered
★DYNA-SOAR I (Air Force)	Boeing, space craft and systems integrator; Martin, propulsion	Boost-glide orbital space craft; first space bomber; Titan booster	R&D; first glider flights from Edwards AFB by 1962
JUNO II (NASA)	ABMA/Chrysler, prime; Ford Instrument, guid.; Rocketdyne/JPL, prop.	Early deep space booster; small payload	Five more shots planned
★MERCURY (NASA)	NASA, prime; McDonnell, capsule	First manned satellite	Capsule testing being conducted; manned capsule launching by REDSTONE down Atlantic; program slipping
MIDAS (ARPA-Air Force)	Lockheed, prime	Early-warning satellite; detect ICBM launchings by infrared before birds leave pad	R&D; first launchings from Cape
MRS. V (ARPA)	No contract announced	Manueverable, recoverable space vehicle; also known as DYNA-SOAR II	Studies; future of project in doubt
NOVA (NASA)	Rocketdyne, prime; Rocketdyne, propulsion	Clustered 6 million lb. booster	Early R&D on 1.5 million lb. engines
ORION (ARPA-Air Force)	General Atomic	Space station launched by series of atomic explosions	Feasibility studies under way; tests may be attempted
★SAMOS (ARPA-Air Force)	Lockheed, prime	Reconnaissance satellite; formerly Sentry	R&D; stabilization already achieved in DISCOVERER series; first test launching scheduled this spring
★SATURN (ARPA-Army)	Army Ordnance Missile Command, prime; Convair/Pratt & Whitney, propulsion; To be transferred to NASA if Congress approves	Clustered 1.5 million lb. thrust booster; liquid TITAN or scaled-up liquid hydrogen engine second stage; CENTAUR third stage; second stage may be changed by NASA	Timetable in doubt. Under current schedule, 3-stage SATURN would be first launched late 1963 earliest; under crash program, late 1962.
★SCOUT (NASA)	Chance Vought, prime; Minneapolis-Honeywell, guidance; Aerojet-General/Allegany/Thiokol, propulsion	Four-stage satellite launcher; 200-300 lb. payload in orbit	Operational this summer; Air Force also to use for research
STEER (ARPA)	GE-Bendix, prime	Polar-orbiting instantaneous repeater satellite	R&D

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
SUZANO (ARPA)	No contract announced	Space platform to be used as base for staging and other missions	Feasibility studies; no funding
★TACKLE (ARPA)	No contract announced	Polar orbiting communications satellite	R&D
★THOR-ABLE (NASA)	STL, prime; Rocketdyne/Aerojet-General/ABL, propulsion	Early deep space booster	Sun orbit shot in January
THOR-DELTA (NASA)	STL, prime; IT&T, guidance; Rocketdyne/Aerojet-General/Allegany,prop.	Put 65-lb. satellite in orbit around moon	R&D; first flight early this year; to be used in TIROS program
★TIROS (NASA-Navy)	RCA-Army Signal Corps, prime	Meteorological satellite; TV pictures of cloud cover	R&D; three launchings this spring
★TRANSIT (ARPA-Navy)	Lockheed and Johns Hopkins Laboratory, prime	Navigational satellite	First shot almost complete failure because final stage didn't operate; next shot in February
TRIBE (ARPA)		Family of space launching vehicles	Planning
★X-15 (NASA-AF-Navy)	North American prime; Thiokol, prop.	Rocket plane; 3600 mph; flight at edge of space	Two powered flights; one plane damaged in landing

MISSILES & ROCKETS

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
ABLE (Navy)	Avco, prime	ASW surface-to-underwater; 500 lb. solid; conventional	Deployed on destroyer escorts
ASROC (Navy)	Minneapolis-Honeywell, prime	Surface-to-underwater; solid rocket torpedo; nuclear	R&D; operational Jan. 1961
ASTOR (Navy)	Westinghouse, prime	ASW underwater to underwater; rocket torpedo; nuclear	R&D
★ATLAS (Air Force)	Convair, prime; GE/Burroughs, Arma, guidance; Rocketdyne, propulsion; GE, re-entry vehicle	ICBM; more than 5500-mile range; liquid; nuclear	38 military launchings: 22 successes, 8 partial, 8 failures; 2 scientific launchings: 2 successes. Squadrons at Vandenburg
AUTOMET (Army)	No contract announced	New solid tactical missile	R&D; test vehicle stage
★ALBM (Air Force)	Douglas, prime; Nortronics, guidance; Aerojet, propulsion	Air launched ballistic missile; more than 1000-mile range; solid; nuclear	Design study stretched out
ARM	No contract announced	Anti-radar missile	R&D
★BOMARC-A (Air Force)	Boeing, prime; Westinghouse, guidance; Marquardt, propulsion	Ramjet surface-to-air interceptor; liquid; 200 m. range; Mach 2.7; nuclear	A model operational at McGuire AFB, N.J.
★BOMARC-B (Air Force)	Boeing, prime; Westinghouse, guidance; Thiokol, propulsion	Ramjet-solid, surface-to-air; Mach 2.7; more than 500 m. range; nuclear	Late development
★BULLPUP (Navy)	Martin, prime; Republic, guidance; Thiokol (Reaction motors), propulsion	Air-to-surface; 4-mile range; conventional 250-lb. bomb; new model has pre-packaged liquid	Deployed with Atlantic and Pacific Fleets; bigger model under R&D; Air Force buying modified version
COBRA (Navy)	No contract announced	Anti-ship radar missile	Early R&D
★COBRA (Marines)	Boelkow Entwicklungen, West Germany, prime; Daystrom, U.S. distributor	24.6-pound anti-tank missile; 1 mile range; 191 mph speed; solid propellant	Marines evaluating for purchase; already operational with West German troops
CORPORAL (Army)	Firestone, prime; Gilfillan, guidance; Ryan, propulsion	Surface-to-surface; 75-mile range; liquid; nuclear	Deployed with U.S. & NATO troops in Europe
CORVUS (Navy)	Temco, prime; W. L. Maxson guidance; Reaction Motors, propulsion	Air-to-surface; pre-packaged liquid; radar homing; about 100-miles range	First successful test July 18, 1959
CLAYMORE (Army)	No contract announced	Anti-personnel missile	R&D
★CROW (Navy)	No contract announced	Air-to-air missile	R&D; has been flight tested
DAVY CROCKETT (Army)	In-house project at Rock Island, Ill., arsenal	Surface-to-surface; solid; bazooka launched; sub-kiloton nuclear warhead	R&D
EAGLE (Navy)	Bendix, prime; Sanders, guidance; Aerojet propulsion	Air-to-air; 100-mile range; nuclear; for launching from relatively-slow aircraft	Early R&D
FALCON (Air Force)	Hughes, prime; Hughes, guidance; Thiokol, propulsion	Air-to-air; 5-mile range; Mach 2; solid; conventional	GAR-1D & GAR-2A & GAR-3 operational; GAR-4 & GAR-9 under R&D; GAR-9 work slowed
GENIE (Air Force)	Douglas, prime; Aerojet-General, propulsion	Air-to-air; unguided; 1.5-mile range; nuclear	Operational
GIMLET (Navy)	No contract announced	Air-to-surface; unguided; considered highly accurate	R&D

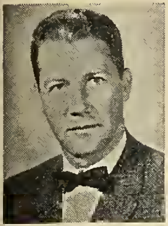
PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★HAWK (Army)	Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion	Surface-to-air; 20-mile range; solid; conventional; designed to hit low-flying planes	Operational; units training for early deployment to Europe and Far East; advanced Hawk under development
HONEST JOHN (Army)	Douglas, prime; Hercules, propulsion	Surface-to-surface; unguided; 16.5-mile range; nuclear	Operational; deployed in Europe
HOUND DOG (Air Force)	North American, prime; Autonetics, guidance; Pratt and Whitney, propulsion	Air-breathing air-to-surface; 500-mile range; Mach 1.7; turbojet; nuclear	Nearly operational; to be launched from B-52G intercontinental bombers
★JUPITER (Army)	Chrysler, prime; Ford Instrument, guidance; Rocketdyne, propulsion	IRBM; liquid; nuclear	To be deployed with Italian troops in Italy and used as AICBM target drone; 27 launchings: 20 successes; 5 partials; 2 failures
★LACROSSE (Army)	Martin, prime; Federal Telecommunications Laboratories, guidance; Thiokol, propulsion	Surface-to-surface; highly mobile; 20-mile range; solid; nuclear	Operational; 4 units being trained; 3 more planned for 1960; to be deployed in Europe and Far East
LITTLE JOHN (Army)	Emerson Electric, prime; ABL, propulsion	Surface-to-surface; unguided; 10-mile range; solid; nuclear	Operational this year; units training with it
LOBBER (Army)	No contract announced	Surface-to-surface; cargo carrier; 10-15 mile range; also can drop napalm	Studies
LULU (Navy)	No contract announced	Surface-to-surface; nuclear	R&D
MACE (Air Force)	Martin, prime; AC Spark Plug, guidance; Allison, propulsion	Air-breathing surface-to-surface; more than 650-mile range; turbojet & solid; nuclear; B model has 1000-m. range	Being deployed with U.S. troops in West Germany
MATADOR (Air Force)	Martin, prime; Thiokol/Allison, propulsion	Air-breathing surface-to-surface; 650-mile range	Being turned over to West Germans; also deployed in Far East
★MAULER (Army)	Convair; prime	Surface-to-air; IR guidance; field weapon	R&D
★MINUTEMAN (Air Force)	Boeing, major contractor; Autonetics, guidance; Thiokol, propulsion first stage; No decision other stages	2nd generation ICBM; solid; mobile; nuclear	R&D. Expected to be operational by late 1962 or early 1963; to be installed in hardened sites and made mobile on trains or trucks; tethered full-scale test vehicles successfully fired from silos
MISSILE A (Army)	No contract announced	Surface-to-surface; 65-70 mile range; solid	Design studies
NIKE-AJAX (Army)	Western Electric, prime; Western Electric, guidance; Hercules Powder, propulsion	Surface-to-air; 25-mile range; Mach 2.5; solid & liquid; conventional	Deployed in U.S., Europe & Far East
NIKE-HERCULES (Army)	Western Electric, prime; Western Electric, guidance; Hercules & Thiokol, propulsion	Surface-to-air; 80-mile range; Mach 3+; nuclear	Rapidly replacing NIKE-AJAX
★NIKE-ZEUS (Army)	Western Electric, prime; Bell Telephone, guidance; Thiokol and Grand Central, propulsion	Anti-missile; 3-stage; 200-mile range; solid; nuclear	R&D; major components being tested; first tests against ICBM's to be in PMR; first launched ZEUS fell apart in flight Aug. 26; second successful but short of programmed range, first and second stages ignited; third partial success—second stage failed to ignite
★PERSHING (Army)	Martin, prime; Bendix, guidance; Thiokol, propulsion	Surface-to-surface; solid; 700-mile range; nuclear	R&D; to replace REDSTONE; test launchings in spring at Cape Canaveral
★POLARIS (Navy)	Lockheed, prime; GE, guidance; Aerojet-General, propulsion	Underwater and surface-to-surface; solid; 1500-mile range; nuclear	45 launchings of test vehicle; 30 successes; 12 partial; 2 failures; launched from surface ship Aug. 27, 1959; expected operational late 1960; 900-m. range vehicles under test at Cape Canaveral
RAVEN (Navy)	No contract announced	Air-to-surface; about 500-mile range	Study
★REDEYE (Army)	Convair, prime; Atlantic Research, propulsion	Surface-to-air; 20-lb. bazooka-type; IR guidance; solid; conventional	R&D
REDSTONE (Army)	Chrysler, prime; Ford Instrument, guidance; Rocketdyne, propulsion	Surface-to-surface; liquid; 200-mile range; nuclear	Deployed with U.S. troops in Europe
★REGULUS II (Navy)	Chance Vought, prime; Sperry, guidance; Aerojet-General, propulsion	Surface-to-surface; turbojet & solid; 500-mile range; nuclear	Deployed aboard U.S. submarines; used as target drone
SERGEANT (Army)	JPL/Sperry, prime; Sperry, guidance; Thiokol, propulsion	Surface-to-surface; solid; more than 75-mile range; nuclear	Production. To replace CORPORAL this year
SHILLELAGH (Army)	Aeronutronics, prime	Surface-to-surface; lightweight; can be vehicle-mounted	R&D; expected to be operational mid-1960's

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★SIDEWINDER (Navy)	GE-Philco, prime; Avion, guidance; Naval Powder Plant, propulsion	Air-to-air; IR guidance; 6-7-mile range; conventional	Deployed with Navy and Air Force; all-weather type under development
SLAM (Air Force)	No contract announced	Surface-to-surface; low-altitude; supersonic; nuclear-powered ramjet; nuclear	Study-R&D
SNARK (Air Force)	Norair, prime; Northrop, guidance; Aerojet-General, propulsion	Surface-to-surface; 5500-mile range; solid and turbojet; Mach .9; nuclear	Deployed at Presque Isle, Maine
★SPARROW III (Navy)	Raytheon, prime; Raytheon, guidance; Aerojet-General, Thiokol, propulsion	Air-to-air; 5-8-mile range; Mach 2.5-3; solid and pre-packaged liquid; conventional	Operational with carrier aircraft; earlier SPARROW I obsolete
SU8ROC (Navy)	Goodyear, prime; Kearfott, guidance; Thiokol, propulsion	Underwater or surface-to-underwater; 25-50 mile range; solid; nuclear	R&D
SUPER TALOS (Navy)	No contract announced	Seagoing anti-missile missile; possible AICBM	Early R&D
SS-10 (Army)	Nord Aviation, prime	Surface-to-surface; primarily anti-tank; 1600-yards range; 33 lbs. solid; wire guided; conventional	Operational with U.S., French and other NATO and Western units; battle-tested in North Africa
SS-11 (Army)	Nord Aviation, prime	Surface-to-surface; also helicopter-to-surface; 3800-yard range; 63 lbs.; wire guided; conventional	Operational. Under evaluation by Army.
TALOS (Navy)	8endix, prime; Farnsworth/Sperry, guidance; Bendix/McDonnell, propulsion	Surface-to-surface; 65-mile range; solid & ramjet; Mach 2.5; nuclear	Operational aboard cruiser Galveston
TARTAR (Navy)	Convair, prime; Raytheon, guidance; Aerojet-General, propulsion	Surface-to-air; 10-mile range; Mach 2; 15 feet long & 1 foot in diameter; solid dual-thrust motor; conventional	Many test firings in Pacific; expected deployment 1960 as primary armament of guided missile destroyers; production
TERRIER (Navy)	Convair, prime; Reeves/FTL, Sperry, guidance; ABL, propulsion	Surface-to-air; 10-mile range; Mach 2.5; 27 feet long; solid; conventional	Operational with fleet
★THOR (Air Force)	Douglas, prime; AC Spark Plug, guidance; Rocketdyne, propulsion	Surface-to-surface IRBM; 1500-mile range; liquid; nuclear	Operational; 4 bases set up in England; one planned for Turkey. 56 military launchings: 37 successes; 11 partial; 8 failures; 22 scientific launchings: 19 successful, 2 partial; 1 failure
★TITAN (Air Force)	Martin, prime; Bell, Remington Rand, guidance; Aerojet-General, propulsion	Surface-to-surface ICBM; 5500-mile range; liquid; 90 feet long; nuclear	6 launchings test vehicles: 4 successes; 2 failures; program slipping
WAGTAIL (Air Force)	Minneapolis-Honeywell, prime	Air-to-ground; low-level; solid; designed to climb over hills and trees	R&D
ZUNI (Navy)	Naval Ordnance Test Station, prime	Air-to-air, air-to-surface; solid; unguided rocket; 5-mile range; conventional	Operational

SATELLITES

SATELLITE	COUNTRY	STATUS
EXPLORER I (30.8 lbs.)	U.S.	Launched 1/31/58, est. life 3-5 years. Orbits earth, perigee: 224 m., apogee: 1573 m., period 114.8 min. (Discovered Van Allen Belt)
VANGUARD I (3.25 lbs.)	U.S.	Launched 3/17/58, est. life 200-1000 years. Orbits earth, perigee: 409 m., apogee: 2453 m.
SPUTNIK III (about 3.5 tons)	Russia	Launched 5/15/58, est. life, 13 mo. Orbits earth, perigee: 135 m., apogee: 1167, period: 106 min., inclination to equator: 65.3°. Speed, at perigee: 18,837, at apogee: 14,637 mph.
LUNIK I "MECHTA" (3245 lbs.)	Russia	Launched 1/2/59. 8elieved to be in orbit around sun on 15 mo. cycle.
VANGUARD II (20.7 lbs.)	U.S.	Launched 2/17/59, est. life 10 years +. Orbits earth but is "wobbling," perigee: 347 m., apogee: 2064, period: 125.85 min., inclination to equator: 32.88°.
PIONEER IV (13.40 lbs.)	U.S.	Launched 3/3/59. Orbits sun, and achieved primary mission, an Earth-Moon trajectory.
EXPLORER VI "PADDLE-WHEEL" (142 lbs.)	U.S.	Launched 8/7/59, est. life 10 months +. Orbits earth, perigee: 156 m., apogee: 26,357 m., period: 12½ hours, speed: at perigee 23,031, at apogee: 3126 mph., inclination to equator: 46.9°.
VANGUARD III (about 100 lbs.)	U.S.	Launched 9/18/59, est. life 30-40 years. Orbits earth, perigee: 319 m., apogee: 2329 m.
LUNIK III (about 614 lbs.)	Russia	Launched 10/4/59, orbits earth-moon; took first picture far side of moon; est. perigee: 30,000 m., apogee: 291,000 m.
EXPLORER VII (91.5 lbs.)	U.S.	Launched 10/13/59, est. life 20 years, orbits earth, perigee: 341, apogee: 679.
★DISCOVERER VIII	U.S.	Launched 11/20/59, est. life-short, perigee: 116, apogee: 913.

Vinton D. Carver has been named assistant general manager of Litton Industries Electron Tube Division. He will be in charge of all division operations, reporting directly to **Dr. Norman H. Moore.** Prior to joining the firm, Carver was vice president and general manager of the Pacific Division of Farnsworth Electronics Co.



CARVER

Arthur O. Wolf has been named manager of Spectron, a department of the Transducer Division, Consolidated Electrodynamics Corp.

Wolf joined the transducer division in May of this year as an administrative assistant. Previously, he spent 15 years with the Navy as a pilot and as a ground maintenance, administrative, and public information officer.

Dr. Harry E. Robbins has been selected to be a research engineer with Lessona Corp. (formerly Universal Winding Co.).

He was previously associated with the National Aniline Division of Allied Chemical Corp. as a group leader in the fiber research and development group. Prior to that, he was a supervisor in the technical department at Celanese Corp. of America.

John R. Curran, former vice president in charge of engineering, has been elected divisional vice president and general manager of the Hammel-Dahl/Foster Engineering Div. of General Controls Co., manufacturers of control valves, regulators, safety and reducing valves and flow tubes for petrochemical, atomic energy, power station, missile applications.

Curran joined the Hammel-Dahl Co. in 1945 as chief design engineer. When the company was purchased by General Controls two years ago, he was a member of the firm's board of directors and vice president in charge of engineering and sales.

Dr. Raymond R. Bouche, an authority on the calibration of vibration instrumentation, has been appointed manager, Standards and Analysis Dept., Endevco Corp. He will be responsible for transducer and electronics test procedures, maintaining electrical-mechanical standards and design of special test equipment. Dr. Bouche was with the National Bureau of Standards, Washington, D.C. for nine years, working in the field of shock and vibration measurement. He is recognized for his wide range of technical papers published in the past several years.

BOUCHE

A. H. Andrews, formerly senior engineer with Marconi, Montreal, has joined CBS Electronics as an engineering specialist in electron tube research and development.

He also served as a research engineer with Ferranti Ltd., England, where he was engaged in klystron development. Prior to that he was a cyclotron control engineer with the Nuclear Research Laboratories at the University of Liverpool.

Lockheed Missiles and Space Division has announced the following personnel changes:

Dr. Wayland C. Griffith, former associate director, has been elevated to assistant director of research and **Robert H. Gibson** has been appointed to the newly created post of production and services manager of the Navy's *Polaris* fleet ballistic missile. He was formerly stationed in Washington as assistant to the *Polaris* missile system manager.

Maurice Tucker has been named associate director of research for spacecraft and missiles and **J. R. Weiner** to associate director of information processing and computers.

Vadim N. Martinovitch has joined Stavid Engineering, Inc., as an engineering consultant in high-power modulator and radar systems design.

Martinovitch was formerly senior project engineer at FXR, Inc., where he was engaged in the manufacture of custom-made test equipment, high-power modulators and development of high-power pulsed radar transmitters. Earlier, he was an electrical design engineer at Vitro Corp. of America.

MARTINOVITCH

Dr. Norman A. Baily, an experienced radiation physicist, has joined Hughes Aircraft Co.'s nuclear electronics laboratory as a senior staff physicist. He is investigating medical and radiological applications of linear accelerators and detection devices.

Dr. Baily was formerly chief scientist for the department of radiation therapy at the Roswell Park Memorial Institute, and prior to that was scientific advisor to the Air Force on the effects of nuclear explosions on personnel and equipment and base defense problems due to special weapons.

John W. Smith has joined the ordinance division of Minneapolis-Honeywell Regulator Co. as assistant to **Clyde A. Parton,** vice president and general manager of the division. Smith was formerly associated with Collins Radio Co., where he served in various engineering capacities, most recently as engineering department head for communications systems.

SMITH

The following appointments have also been announced:

Miniature Precision Bearings, Inc., has named **Harry E. Gabriel** head of its newly opened Western Technical Center and sales office in Los Angeles. **Robert R. Pierson,** who has had extensive experience in bearing application and design work at MPB's home plant, will be in charge of the laboratory.

Carlo V. Bocciarelli has been appointed director of Philco Corp.'s research division, in charge of the basic science and technology department.

Frank B. Jewett, Jr., executive vice president, has been elected president of Vitro Corp. of America, succeeding **J. Carlton Ward, Jr.,** who has been named chairman of the board of directors. **Charles S. Payson,** the retiring board chairman, has been elected to the new office of chairman of the executive committee of the board of directors.

Thiokol Chemical Corp. has approved the addition of vice presidents **Dr. Harold W. Ritchey** and **Josepb C. Jorczak** to the board of directors.

Tung-Sol Electric Inc., has announced the election of **Frank J. Ebringer, Barton R. Lester** and **Dr. R. Burton Power, Jr.,** as vice presidents of the firm.

Donald C. Beem, formerly in charge of quality control at Owens Labs, has been named senior design engineer in charge of design and development of solid-state power supplies of the special products group of Spectrol Electronics Corp.

Lorn A. Bailey, former engineer with the Long Lines Dept. of American Telephone & Telegraph Co., has joined Page Communications Engineers, Inc., as a senior staff engineer.

Howard Cary, president of Applied Physics Corp., has been elected to Varian Associates' board of directors.

John M. Van Dam has been named general manager of the western division of Aeroquip Corp.

Glenn Cata has joined Electro-Optical Systems, Inc., as a senior engineer in the space defense systems division, where he will be engaged in preliminary systems design.

Malcolm F. "Mal" Brown, Jr., has been named to the newly created post of assistant to the vice president of engineering at Resdel Engineering Corp.

ADVANCES IN SPACE SCIENCE, Volume I. Edited by Frederick I. Ordway, III, ABMA. Academic Press, New York and London. 411 pp. $12.

This series was conceived for scientists and engineers working in the various related fields of astronautics.

It is designed to permit them to keep abreast of research and developments in their own specialties and other branches. The series is edited with the aim to the importance of the subject to the development of astronautics, the state of the art and current need and interest.

Subjects surveyed include: "Interplanetary Rocket Trajectories," "Interplanetary Communications," "Power Supplies for Orbital and Space Vehicles," "Manned Space Cabin Systems," "Radiation and Man in Space," and "Nutrition in Space Flight."

The volume also contains a proposed Decimal Classification System for Astronautics. Its purpose is to give the field a useful tool for filing references, technical papers and other material.

TIME, TACTICS, AND TECHNOLOGY, 1959 Kermit Roosevelt Lecture Program, presented by Lieutenant General Arthur G. Trudeau. Dept. of the Army pamphlet 70-15.

The research and development effort being made in the free world is covered in a series of lectures presented to British Military Schools. Emphasis is on the importance of time, tactics, science and technology.

The four lectures covered: "Research and Development-Crucible for the Future," "New Dimensions in Tactics, Weapons, and Material," "Men, Machines, and the Battlefield," and "Science and Technology."

SCIENTIFIC MANPOWER 1958, papers of the Seventh Conference on Scientific Manpower. National Science Foundation, 1951 Constitution Ave., Wash, D.C.

The report is the third in a series of annual summaries of developments relating to scientific manpower.

It contains the papers of the annual Scientific Manpower Conference held during the meeting of the American Association for the Advancement of Science.

Partial contents include: "Trends in Industrial Requirements for Scientists and Engineers," "Requirements of the Federal Government for Scientists and Engineers," "Influence of Government on the Demand for Scientists and Engineers" and "An Analytical Model for Studies of the Recruitment of Scientific Manpower."

GUIDE TO THE SPACE AGE, by C. W. Besserer and Hazel C. Besserer. Prentice-Hall, Inc. 320 pp. $7.95.

More than 5000 words and phrases are defined in this comprehensive presentation of terminology of missiles, rockets and astronautics. Terms are alphabetically arranged, extensively cross-referenced and many are illustrated by figures and tables.

Purpose of the book, according to the authors, is to help standardize the specialized language, and secondly, to present the material in a form that will be of value to technical and non-technical people.

JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, Volume 63A, No. 3, Physics and Chemistry; Volume 63C, No. 2, Engineering and Instrumentation, and Volume 63D, No. 3, Radio Propagation. Order from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Vol. A, published 6 times per year, $4 for annual subscription; Vol. C, published quarterly, $2.25 per year, Vol. D. published 6 times per year, $2.25 annual subscription.

The Physics and Chemistry volume includes: "Multiple ionization of rare gases by electron impact," "Thermal degradation of polymers at high temperatures," "OH in the solar spectrum."

Volume on Radio Propagation includes papers on "Path Antenna gain in an exponential atmosphere," "Pattern systnesis for slotted cylinder antennas," and "A method for measuring local electron density from an artificial satellite."

ON THE THEORY OF A NON-STEADY RADIATION FIELD, V. V. Sobolev. Translated from Astronomicheskiy Zhurnal (USSR). Order 59-17527 from SLA Translation Center, The John Crerar Library, 86 East Randolph St., Chicago 1, Ill. Microfilm, $2.40. Photocopy, $3.30.

The equation describing the change in intensity of the radiation along a ray is given, together with the equation relating the energy emitted by an element of volume in the medium to the energy absorbed by that element.

From this the differential equation can be obtained to determine the function which is the ratio of the coefficients of emission and absorption.

ATOMIC ENERGY IN AVIATION. Yu N. Sushkov. Translated from Atomnaya Energiya v Aviatsii (USSR). Order 59-11921 from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. $.75.

Basic principles of nuclear-powered aircraft design are described in layman's terms.

The heating of the air by means of the heat-exchange principle is the major deficiency of atomic engines. It could be eliminated by mixing the air with gaseous, liquid, or powdered nuclear fuel which in the neutron flux in the reactor core would undergo fission and liberate heat in the entire volume of air.

Experimental prototypes can be expected in the near future.

RESEARCH ON LIQUID METALS AS POWER TRANSMISSION FLUIDS, part II, R. C. Kumpitsch, General Electric Co. for WADC, U.S. Air Force. Order PB 151876 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 196 pp. $3.

The behavior as a hydraulic fluid of liquid metal NaK-77, a eutectic alloy of sodium 23% by weight and potassium 77% by weight, was observed over the temperature range 80 to 1000°F and at cyclic pressures of 15 to 3000 psi. Bearing and construction materials and static seals were tested for effectiveness in NaK-77 under the same conditions.

Among the results, a single piston pump operating in an inert atmosphere "glove box" pumped NaK-77 to pressures of 3000 psi at 1000°F and delivered a cyclic flow rate of 0.02 GPM.

Tests identified carbide materials as most compatible in NaK-7. A high-pressure (3000 psi) and temperature (1000°F) test loop was designed to test feasibility of liquid metals for power transmission and control systems. It circulates NaK-77 at a flow rate of 1 GPM.

HETEROGENEOUS CONSTRUCTION FOR MISSILE FUSELAGES, A. T. Zahorski, for WADC. Order PB 151881 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 136 pp. $2.70.

New "heterogeneous" type fuselage structures are said to provide significant structural weight savings in missiles because there are more design options in providing paths for resisting internal forces.

The greatest advantage of heterogeneous structures is said to exist where aerodynamic heating is a factor. Other advantages over conventional designs include lower cost of fabrication and functional accessibility.

A model of a proposed fuselage was fabricated and performed satisfactorily in burst, bending, and supersonic wind tunnel tests. A full-size fuselage section of the new design is reported to have shown a 45% weight savings over a current missile fuselage. Specifications for fabricating prototype fuselages are given.

The report contains a summary of present structural design philosophies and traces the need for, and the development of, the heterogeneous concept.

SPRAY FORMATION AND BREAKUP, AND SPRAY COMBUSTION, A. E. Fuhs, Air Force Office of Scientific Research. Order PB 151645 from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. 132pp. $2.75.

A survey of the literature in the field of liquid spray behavior is given in this two-part report.

The first part discusses means for atomizing liquids. Mechanisms for jet and sheet breakup under the various environments of non burning media are probed. Subsequent distributions and the behavior of liquid drops in sprays are examined, and the application to rocket motors of sprays formed by impinging jets is considered in some detail.

The second part deals with sprays associated with the combustion process. First considered is the mixing of propellants. The empirical laws of evaporation are reviewed, both for single droplets and for sprays.

Finally, an examination of spray combustion leads to the conclusion that the combustion process is quite complex, since it involves the interaction of many physical and chemical rate processes.

propulsion engineering . . .

By JAY HOLMES

A neat hypergolic igniter . . .

for a liquid hydrogen-liquid oxygen engine is suggested by NASA's Dr. Walter T. Olson. Ignition is a bigger headache here because both fuel and oxidizer are cryogenics and must be heated well above ambient before they can be set off. At full flow, enough propellant mixture can accumulate in a fraction of a millisecond to destroy the combustion chamber on ignition.

To solve the problem, Olson suggests a small supply of liquid fluorine, which is hypergolic with hydrogen. As soon as the flame is lit, oxygen can be fed into the fluorine and gradually built up to full flow. Meanwhile, the fluorine is reduced gradually and cut off when hydrogen-oxygen combustion is going full blast. Thus a small liquid fluorine tank and a couple of valves do the ignition job. The system has worked well on a laboratory scale at NASA's Lewis Research Center, Olson told the American Institute of Chemical Engineers recently.

Handling is the biggest problem . . .

involved in using fluorine, the ultimate oxidant. Many metals, such as stainless steel, copper, brass, monel and aluminum can be used for piping if they are kept scrupulously clean.

But only metal-metal seals can be used. Fluorine reacts furiously with almost every organic compound known. Teflon is not attacked chemically but it has poor physical properties at cryogenic temperatures. Thus it can be used for O-rings and valve packings only if it does not come in direct contact with the liquid. Olson said no one has ever developed a completely satisfactory liquid fluorine pump.

Because of development progress to date, he rates hydrogen-oxygen as the most promising of the high-energy chemical fuel systems. If unexpected difficulties come up in the handling of liquid hydrogen, Olson sees the hydrazine-fluorine combination, only a few points behind hydrogen-oxygen in specific impulse, as "a string to our bow."

Promotion for Dr. Harold Ritchey . . .

is announced by **Thiokol Chemical Corp.** Ritchey, vice president of the American Rocket Society, now is vice president in Charge of Rocket Divisions, one of three major divisions of the company. He had been Vice President and Technical Director.

New ideas are still scarce . . .

in the designing of propulsion systems, some military missilemen complain. When someone brings out a new gimmick, everyone in industry rushes to imitate it, instead of trying to develop something better. Despite the general acceptance of the need for rapid change in rocket technology, these sources say there is still wide unwillingness to investigate novel methods.

No 1960 price rise . . .

is expected in average raw chemical prices, despite the upward pressure on the overall price index. Competition, rising volume and constant technological improvement have kept chemical prices down over the last decade despite rising costs of almost everything else.

As one example, the average of **du Pont** prices has actually declined since 1949. The company reports its own price index stood at 104 in 1949 and was on the way up. By 1951, it rose to 112; it hit a plateau and started down in 1954. In November, 1959, it was down to 103.4, a little below the level of a decade ago.

Of the raw materials supplied to the missile/space market, some will rise and some will fall in 1960. But the outlook is that any major cost rise will be in labor, processing costs or overhead, not in raw materials.

letters

Easily Discouraged

To the Editor:

Extensive efforts to photograph the backside of the moon set the writer to contemplating the possibility of turning the moon around, i.e. setting up a rocket to spin the moon around.

The project was abandoned when the slipstick showed that it would take a rocket with 1.7 million-billion pounds force, blasting for one year, to turn the moon around halfway.

R. B. C. Newcomb
Testing Engineer
Douglas Aircraft Company
2302 Pearl Street
Santa Monica, Calif.

A Handle for ALBM

To the Editor:

You may be interested to know that your magazine is read and enjoyed even by humble little clerk-stenos (Civil Service) in the far-off Pacific. The office in which I work (M&S Division, Ordnance Office, HQ USARPAC), at Ft. Shafter, Honolulu, receives M/R regularly and I latch onto it eagerly . . .

In the Sept. 21 issue, I noted an item mentioning that the Air Force wanted a catchy name for its air-launched ballistic missile, presently referred to as *ALBM*. Just for kicks, I began a list of all the names of rockets, missiles and satellites. Apparently the Greek, Roman and Norse gods and heroes have been just about exhausted.

So I skipped down to medieval times and wondered about the names *"Crusader"* and *"Lance."* Have they been used yet? And what about the winged horse *"Pegasus"*? . . . However, maybe the AF would prefer one more modern, say *"Stingaree"* . . . Personally, I like *Lance* the best . . .

Oh yes . . . another thought. When they've quite run out of names, they might start on the Bible. There's mighty *Samson*, you know.

Space happily yours,
Frankie B. Krzympiec
2234 Citron, Apt. O
Honolulu, Hawaii

Safety Plea from Distaff

To the Editor:

That was a splendid program (for national space objectives) you outlined in the Dec. 14 M/R editorial.

And there are some of us wives here at the Cape who would like to see your energetic campaign extended to include the design of missiles that don't explode . . .

. . . A panic program will only kill our husbands . . .

Ruth Garvin
112 E. Park La.
Cocoa Beach, Fla.

Soviet Moon Studies

Two groups of Soviet scientists have independently arrived at the same conclusion that the moon's surface is not dust-covered as has been widely accepted.

N. N. Sytinskaya of the Main Astronomical Observatory in Leningrad concludes that the visible lunar surface is composed of strongly porous, striated materials, like volcanic slag in structure. Other scientists at the Khar' kov Astronomical Observatory hold that the moon is covered with disrupted tuff-like rocks with scattered large-grain volcanic ash. Both studies present a final concept of a covering of a porous, sponge-like material, sharply striated and fragmented, very probably with sharp spikes and deep furrows.

Sytinskaya believes that this peculiar structure originated in the explosions accompanying the impact of meteorites on the lunar surface. This "meteor slag" theory is confirmed by the determination of such low values of the possible lunar atmospheric density that even micrometeorites can reach the lunar surface with cosmic velocities.

The conclusions were derived through the parallel application of several different physical methods, according to the Soviet Astronomicheskiy zhurnal, Vol. 36, No. 2, 1959.

High Strength Metal

A new material twice as strong as steel and three times as strong as aluminum has reportedly been developed by the Soviet Union, according to G. Solganik. (Yunyy teckhnik, No. 9, 1959.)

"SVAM," as the Russians call it, will be used in manufacturing industries as well as chemical, petroleum and electrical engineering, and can be combined with plastics to provide a light, strong and rigid lining material for building construction.

Vanadium Added

Vanadium added to copper and aluminum in small quantities will produce superior metals without impairing their abilities, according to Soviets Ye. M. Savitskiy and U. K. Driysemaliyev.

Copper with 0.3 to 1.0% vanadium added will improve all its mechanical properties without impairing its electrical conductivity. Addition of 7.97% V to Cu increases its hardness from 42 to 75 kg/mm^2. Addition of 3.29% V increases the tensile strength of Cu from 21 to 33 kg/mm^2. Plasticity of Cu-V alloys with a low vanadium content is higher than of pure Cu, they report.

The hardness and electrical resistance of Al increases with addition of V—up to 0.4%—with no substantial change in its other physical and mechanical properties. (*Vestnik Akademii nauk Kazakhskoy SSR*, No. 7, 1959.)

In another reputed Soviet "breakthrough," titanium has been successfully introduced into titanium-bearing stainless steel in a new alumino-thermal method. Instead of adding titanium in the form of ferrotitanium, it is used in the form of ilmenite concentrate containing approximately 42% TiO_2. The concentrate is mixed with aluminum powder, iron ore powder, and lime powder in respective amounts of 38, 19, 4, and 4 kg per ton of steel, followed by the addition of lime and fluorspar in order to thin the formed high-alumina slag. (*Metallurg*, No. 10, 1959)

Coder Design

A method of designing coders, taking into account spectrum characteristics of the signals to be transmitted and using automatic control of transmission speed, has been proposed by Russian electronics specialists.

The new method would eliminate delays in telemetering processes caused by the use of optimum coders which limit high-speed telemetry. Working on a principle similar to human reactions, telemetering systems using this method can reportedly operate with any type of modulation, though width, time and code modulation types are preferred for efficiency in terms of either narrow frequency bands or increased operating speed. (Avtomatick i telemekhanika, No. 10, 1959)

New Satellite Information

Recent information in a Soviet news journal states that the rocket-carrier of each of the Soviet earth satellites greatly exceeded 4 tons.

Instruments in Sputnik II weighed 508.3 kg; maximum height of the apogee in the launching period was 1671 km, and the initial period of revolution was 193.75 min. The satellite lasted 162 days, in which it made 2370 revolutions.

Sputnik III, launched May 15, 1958, weighed 1327 kg including its rocket carrier, and its last stage weighed 1½ tons. Maximum height of the apogee in the period of launching was 1880 km, and the initial period of revolution was 105.95 min. The satellite has completed more than 7000 revolutions and is still orbiting the earth.

Rocket launching according to the Nauka i zhizn', (No. 10, 1959) is being conducted in the "moderate latitudes" of European USSR and on the Franz Josef Islands, in "equatorial latitudes," and near the village of Mirnyy in Antarctica from on board the diesel-electric powered ship "Ob."

Millimeter-Wave Radiation

A paper by K. A. Barsukov recently published in a Soviet technical journal gives as theoretical analysis of processes in an ideal system for radiating mm-wave oscillations and counting fast particles.

Writing in the *Ahurnal eksperimental'noy I teoreticheskoy fiziki* (Vol. 37, No. 4, 1959), Barsukov outlines a system consisting of a particle accelerator and a cylindrical waveguide made of conducting material and filled with two homogeneous dielectrics whose dividing boundary is perpendicular to the z-axis.

When a charged particle travels at high speed parallel to the main axis of the waveguide, it produces two electromagnetic fields inside the waveguide as a result of crossing the boundary between the two dielectrics. According to Barsukov, the integral effect when a number of particles participate is that these two fields are sustained.

The first field is bounded by the particles and is of no immediate interest, while the second has a spatial configuration and generally produces a system of waves propagating along the z-axis of the waveguide.

Theoretically, a very high-frequency field can be produced by particles hitting the boundary surface ("transition radiation") and the magnitude of the field is proportional to the energy of the particles.

Priority Red Projects

A list of 271 top-priority Soviet projects announced by TASS includes: a plate-rolling mill for the Magnitogorsk Metallurgical Combine; the first part of the cold-rolled-sheet mill for the Novyy Lipetsk Plant; a powerful sheet mill for the Il'icha Plant in the Stalino region; and the West Siberian, Karaganda, and Cherepovets Metallurgical Plants. (Promyshlenno-ekonomichesy a gazeta, Nov. 15, 1959.)

soviet affairs . . .

By DR. ALBERT PARRY

Lithium instead of sodium . . .

is suggested in Moscow as a better element to use in triggering off the so-called "artificial comet-clouds" for future *Lunik* and *Sputnik* shoots. In his article "The Cosmic Lighthouse," printed in *Znanie—Sila,* V. G. Kurt praises the role of sodium in the recent *Lunik* performances, yet points out certain of its weaknesses.

'Not an ideal material' . . .

for a rocket's vapor tail, after all—the Soviet scientist says of sodium. Kurt, who is a staff member of the State Shternberg Astronomical Institute, points out that there is too much sodium in the sun, and that therefore the solar spectrum has gaps in ray emission where lines of sodium go through "as if the solar atoms of sodium at these particular points of the spectrum have sucked the energy away." The artificial comet tail of a *Lunik* utilizes the sun's energy from only the bottom of these gaps, and this tapped energy is a mere 5% of the normal energy of the uninterrupted spectrum.

'Shamefully too little!' . . .

exclaims Kurt. He goes on to recommend lithium as an element which is almost absent from the sun and can well serve as material for "the outer-space lighthouse." He emphasizes the fact that the sun contains some 200,000 times less lithium than sodium. Thus the solar spectrum has practically no gaps caused by lithium, and this makes lithium 20 times brighter than sodium. It is also three times lighter in weight than sodium—quite an advantage, since "each kilogram of lithium has three times as many atoms." We know that each atom of sodium disseminates one quantum of light per second. With more atoms in lithium, there is still greater brightness in a *Lunik's* lithium tail than in a sodium tail. All in all, the advantages of lithium are reckoned by Kurt as 40-fold over those of sodium.

Visual observation . . .

of a lithium cloud-tail is difficult, he concedes. Yet he emphasizes that modern photo-materials have a great sensitivity in this particular kind of picture-taking. A lithium comet-cloud can be observed with the same photo-cameras which have so far been developed for sodium comet-clouds of the *Luniks.* "All you have to do," Kurt remarks, "is install a different kind of light-filter." Future spaceships will be easily traced from the earth, he predicts. By arranging for the discharge of lithium clouds in a pattern, all along the route of a spaceship, man's impending journeys into the cosmos will be photographed in their entirety.

Who originated Soviet comet-clouds? . . .

Professor I. S. Shklovsky claims in *Komsomolskaya Pravda* that he and his staff were the first to try these "global scientific experiments," as he calls the sodium tails released by the *Luniks.* A well-known astrophysicist, in charge of the Shternberg Institute's Laboratory of Radio-Astronomy, Prof. Shklovsky relates that back in 1958 he and his assistants sent up "a geophysical rocket," which at the height of a little more than 400 kilometers released a prearranged cloud of sodium, its color golden-orange, its size "equal to the distance between the widest divergent stars of Ursa Major." The Moscow *Trud* reveals that the 70 photos taken last September of *Lunik II's* sodium cloud by the observatories of Baku, Alma-Ata, Tbilisi and other Soviet cities were sent to Dr. Shklovsky in Moscow for close study.

The latest lithium idea . . .

may well be also Shklovsky's, as Kurt is one of Shklovsky's two chief assistants. The other is V. F. Yesipov. Watch for these names in the Soviet press as more *Luniks* or *Sputniks* are shot into space, each with its special lithium or sodium vapor cloud-tail.

missile business . . .

By WILLIAM E. HOWARD

One of the drafters of the Renegotiation Act believes there are some sound reasons today for revising his creation—and making it less painful for defense contractors. Indeed, Sumner Marcus—writing in the current *California Management Review*—implies that renegotiation might well be done away with altogether.

Here are some of the arguments advanced . . .

by Marcus, who notes that conditions have changed since the last version of the law was passed in 1951, when the objective was to recapture excess profits and to prevent unfair pricing:

• A much smaller percentage of the economy is involved in defense business, making it easier to arrive at fair pricing through regular market processes. (This is not necessarily true of the large expenditures for missiles and aircraft concentrated in one industry, he says, but military agencies are more efficient and experienced now than they were at the start of World War II. And usually there is more time for investigation and negotiation—as well as more efficient procurement techniques.

• Renegotiation can be self-defeating. Incentive-type contracts today "are likely to be more effective than renegotiation" in reducing the cost of an item to the government because they can avoid initial commitment to a fixed price.

• Savings claimed by the Renegotiation Board can be misleading. They fail to take into account what renegotiation proceedings cost the companies involved. This cost is reflected in tax collections. In addition, if the Renegotiation Board conducted its proceedings like other Administrative agencies, recoveries would be substantially smaller.

If industry has to live with renegotiation . . .

Marcus suggests modifying the sting by: 1) establishing more precise criteria for determining what constitutes excess profits; 2) requiring a statement by the Renegotiation Board setting out the important issues involved; and 3) changing Tax Court procedures.

The Marcus appraisal may well be a rallying point for a drive to revamp the law in this session of Congress.

A report just out shows delays are still plaguing . . .

the Renegotiation Board. As of last June 30, the end of FY 1959, there was a backlog of 1359 cases assigned to regional boards or pending before the full board. An undetermined number of others had not yet been assigned.

During the year, 1161 new assignments were made and 1400 were completed. Of these, 141 determinations of excessive profits were made with this result: 119 bilateral agreements between the Board and contractors allowing for the recovery of $34 million out of a total of $60 million. The Board's expenses amounted to $3 million.

From scraps of paper—Christmas money . . .

Three ingenious **Rocketdyne** employes—K. E. Walden, D. A. Meyers and J. M. Agnew—designed and developed a machine which salvages remnants of expensive oscillograph record paper (used for taking data during rocket engine static testing) by splicing them together without damaging the data surface.

For this invention the three split $7275—largest suggestion award in the company's history.

NAVY

$22,600,000—**The Martin Co.**, Orlando, for additional production of *Bullpup* air-to-surface missiles.

$1,593,505—**Kearfott Co., Inc.**, subsidiary of General Precision Equipment Corp., Little Falls, N.J., for an unspecified quantity of precision gyros and accelerometers for use in connection with the *Polaris* program. (Subcontract from General Electric Co.).

$1,300,000—**Summers Gyroscope Co.**, Santa Monica, Calif., for spring-wound gyros destined for use in the *Bullpup* missile.

$400,000—**International Telephone & Telegraph Corp.**, for services on communication facilities in the San Francisco area.

$196,985—**Beckman Instruments, Inc.**, Fullerton, Calif., for atmosphere analyzer.

$65,000—**University of California**, for research on antennas and radiation.

$50,000—**Avco Corp., Research and Advanced Development Div.**, Wilmington, Mass., for exploratory research on the vaporization of solids.

$47,170—**University of Wichita**, for research on wind tunnel tests of ground effect machine models.

$37,000—**Martin Co.**, Baltimore, for research in biophysical aspects of photosynthesis.

$34,000—**Educational Testing Service**, Princeton, N.J., for research to analyze inter-group relations under systematically varied conditions.

$32,250—**Franklin Electronics, Inc., Communications and Control Division**, for high-speed data conversion and magnetic tape storage system.

$25,000—**Foster D. Snell, Inc.**, New York City, for research and development of a satisfactory sprayable and strippable material for use as a protective coating for aircraft, missiles and rockets.

AIR FORCE

$115,000,000—**North American Aviation, Inc., Autonetics Division**, for continued development, fabrication and test of the inertial guidance and flight control system, including ground support equipment, for the solid-fuel *Minuteman* ICBM.

$15,000,000—**Westinghouse Electric Corp.**, for radar systems capable of providing three-dimensional warning information six hours after air delivery to their sites.

$250,000—**Packard Bell Electronics Corp.**, for design, development and production of a multi-channel, ground-air-ground radio receiver.

$96,272—**Marks Oxygen Co., Inc.**, Augusta, Ga., for oxygen.

$59,908—**Electro-Mechanical Research, Inc.**, Sarasota, Fla., for telemetry ground station to be used in support of Project *WS-133A*.

$40,898—**Southern Illinois University**, for research directed toward experimental and theoretical investigations of informational feedback with respect to disrupted speech communications.

$28,800—**University of Hawaii**, Honolulu, for analysis and interpretation of satellite meteorological data gathered over equatorial, tropical and subtropical regions.

NASA

$30,959—**Research Inc.**, Hopkins, Minn., for infrared heating equipment for 3.5-ft. hypersonic wind tunnel.

ARMY

$3,540,500—**North American Aviation, Inc.**, for design and development of motors. (Two contracts.)

$3,000,000—**Western Electric Co., Inc.**, New York City, for repair parts for improved *Nike-Hercules* equipment.

$2,350,214—**Raytheon Co.**, Waltham, Mass., for three sets of *Hawk* missile field maintenance test equipment.

$2,298,247—**California Institute of Technology**, for research and development of guided missiles.

$1,249,500—**Radio Corp. of America**, Moorestown, N.J., a supplemental contract for R&D on the down-range anti-missile program.

$1,148,263—**Swanson & Youngdale Construction Co.**, Minneapolis, for construction of a guided missile assembly building and storage at Fairchild AFB, Spokane, Wash.

$500,000—**Chrysler Corp.**, Detroit, in connection with the *Jupiter* program.

$471,786—**Western Electric Co.**, for *Nike* spare parts and components. (Three contracts.)

$431,970—**Hayes Aircraft Corp.**, Birmingham, Ala., for engineering services, ground support equipment, fabrication and maintenance services in connection with *Saturn*.

$394,950—**Western Electric**, for *Nike* spare parts and components. (Two contracts.)

$316,141—**Arnoux Corp.**, Los Angeles, for services and material required for design, fabrication and installation of a ground fixed FM/FM, PAM/FM, PIM/FM telemetering data acquisition and display system.

$243,200—**Southern Constructors, Inc.**, Rossville, Ga., for construction of rocket fuel storage area and utilities for the propulsion engine test facility, Arnold Air Force Station, Tenn.

$188,920—**Raytheon Co.**, Andover, Mass., for replenishment repair parts for the *Hawk* missile system. (Two contracts.)

$129,000—**Machlett Laboratories, Inc.**, Springdale, Conn., for electron tubes.

$117,610—**Lockheed Missiles and Space Div.**, for basic studies on a new technique for harnessing solar energy.

$87,311—**Pioneer Chemical Co., Inc.**, Long Island, N.Y., for rocket engine fuel.

$80,959—**Smithsonian Institution**, Washington, D.C., for satellite tracking program.

$77,000—**Sperry Utah Engineering Laboratory Div. of Sperry Rand Corp.**, for repair parts for guided missiles.

$59,812—**Harvey Aluminum, Inc.**, Torrance, Calif., for production and engineering study.

$47,897—**Allegany Instrument Co., Inc.**, Cumberland, Md., for a ballistic computer system.

SENIOR ENGINEERS & SCIENTISTS

General Electric's Missile & Space Vehicle Dept. Building New $14,000,000 Space Research Center

17 miles from Philadelphia, Near Valley Forge Park

Back in 1956 this General Electric organization outgrew its quarters in Schenectady, N. Y. and moved to Philadelphia. Since then its research and development staff has increased 5-fold. A new move is fast becoming imperative and will be met by the $14,000,000 Space Research Center now under construction on a 132 acres site near Valley Forge Park. This construction will feature unique facilities, to be utilized in a long-term program, to expand the activities in the realm of space research and the development of space vehicles and systems—areas in which MSVD has already contributed so many notable advances:

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- the FIRST measurements in space of earth's magnetic field and infrared radiation
- the FIRST meteorological information from space
- the FIRST organic plastic ablation material for nose cone re-entry protection capable of withstanding temperatures from 5,000 to 13,000°F

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Write in confidence to: Mr. Thomas H. Sebring, Div. 73-WA

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DIVERSITY OF ADVANCED PROGRAMS NOW UNDER WAY AT MSVD INCLUDE:

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- STEER—a communications satellite to provide global military radio communications.
- Study programs in the area of accessory space power for a variety of missions, including chemical, nuclear and solar energy sources, electrolytic fuel cells and thermoelectric and thermionic converters
- Studies for three of the nation's space agencies to develop more accurate "space maps" than have hitherto existed to guide rockets and manned flights to the moon and planets

A well qualified scientist or engineer is likely to find advanced work going on at MSVD on almost any field of space research of special interest to him.

A campus-like setting is planned for the new Space Research Center which General Electric's Missile and Space Vehicle Department is building close to historic Valley Forge Park. Situated at the junction of the Schuylkill Expressway and Pennsylvania Turnpike, the Center will be easily reached by engineers and scientists living in the Philadelphia area and in southern New Jersey.

Japanese to Get *Nikes*

by an M/R Correspondent

TOKYO—The Japanese Defense Agency has decided to begin equipping the country's self-defense forces with *Nike-Ajax* ground-to-air guided missiles beginning in FY 1961.

Japan's *Nike* program will come under the jurisdiction of the Ground Self-Defense Force as a result of a compromise between it and the Air Self-Defense Force.

The two services feuded for some time over control of the *Nikes*. The Defense Agency decided in favor of the army at an interservice conference in Tokyo on Dec. 22.

Conferees chose to establish the *Nike* battalions because of the prevailing opinion that Japan's aerial defense would be inadequate even with adoption of 180 Lockheed F104J Starfighters plus 20 F-104D jet trainers.

The Defense Agency will send 271 selected personnel to the *Nike* school at Fort Bliss, Tex., in July, 1960, to begin two years of training. When they return to Tokyo, they will form the nucleus of four *Nike* battalions in the Ground Self-Defense Force.

The four battalions are expected to be set up by the end of March, 1963.

Japanese and U.S. officials are believed to have reached an informal understanding that missiles—plus all firing equipment necessary for one battalion—will be loaned to Japan without charge under the U.S.-Japan defense pact.

The first *Nike-Ajaxes* will be delivered to Japan when the first group of Japanese trainees returns in the summer of 1962. At that time, the U.S. Government will equip a full *Nike* battalion for Japan.

The first batch of Japanese trainees will consist entirely of Ground Self-Defense Force personnel, but subsequent groups will include Air Self-Defense Force members.

Explorer VII Performance Pleases NASA Scientists

WASHINGTON—The *Explorer VII* satellite is performing well and yielding significant data, according to NASA scientists.

The 92-lb. space vehicle—in orbit since Oct. 13—has been transmitting data since that time on seven major experiments. Preliminary results—some not yet fully analyzed—indicate much new information as well as substantiation and fill-in on data obtained from previous satellites.

Dr. Josef Boehm, ABMA, stated that *Explorer VII* has "achieved remarkable progress in space technology." Other members of the NASA team were equally enthusiastic.

Dr. Homer Newell, NASA, emphasized that much credit for the project's success can be attributed to cooperation between team members from ABMA, NASA, State University of Iowa, University of Wisconsin, NRL, **Bartol Research Foundation, Martin Research Institute,** Army Signal Corps, **Bulova Watch Co.,** and **Hoffman Electronics.**

No experiment could be singled out as more significant than others. Considerable new data has been obtained on radiation belts and cosmic rays. Temperature control experiments have worked well. Mechanics of the satellite operation have all proved satisfactory. All payload equipment has performed up to specifications.

Three-Dimensional X-ray Used for Parts Inspection

SAN DIEGO, CALIF.—Stereoscopic X-ray examinations discover flaws which may escape normal quality control procedures.

Engineers at the **Convair Division** of **General Dynamics Corp.** perfected the three dimensional inspection method. Two X-rays of the same piece, taken at slightly different angles with conventional equipment, form the basis of the system.

The plates are then inserted in two modified X-ray film viewers in which two mirrors are set at a 45-degree angle. The observer sights across the "V" formed by the mirrors and manipulates them to superimpose the images of the negatives.

Due to the slightly different angles at which the shots were taken, the observer "sees" the image in depth. The system permits the examination of such things as fine wires in encapsulated parts. It has been used to check out many *Atlas* components.

Parts ranging in size from a thumb tack to 289 sq. in. in cross-sectional area can be studied.

more about the missile week

• **New York—Material Service Corp.,** of Chicago, an $84-million-a-year producer and supplier of building materials, concrete products and coal, has merged into **General Dynamics Corp.** The merger agreement calls for an exchange of 2,064,516 shares of a new issue of GD Convertible preference stock, without par value, for 57,532 shares of Material Service common.

• **Washington**—The Internal Revenue Service has adopted unchanged a proposed regulation killing tax exemption on money spent for "propaganda" advertising or "lobbying" activity to defeat legislation. The new rule continues as deductible expenditures for "good will" advertising and dues to trade associations—unless a "substantial part" of the dues are earmarked for lobbying and propaganda-type advertising.

• **Washington**—The Democratic Advisory Council recommends a new military concept in which the Air Force would be divorced from participation in "limited wars" to insure they would not turn into an all-out nuclear conflict. The Army and Navy would take over the job of fighting small wars.

• **Washington**—Federal Aviation Agency Administrator Elwood P. Quesada told M/R his agency is engaged in R&D of air traffic control for manned spacecraft re-entry. He said research is in Phase 3 of FFA's program, which has about 15% of the agency's funds.

• **Groton, Conn.**—The USS George Washington SSB(N)-598—first U.S. fleet ballistic missile submarine—was commissioned Dec. 30. The 380-foot, 5400-ton sub is the first of nine designed to fire 16 *Polaris* IRBM's. It's scheduled to be operational this year. Constructed on a crash 72-hour-week schedule, the George Washington was built from an attack submarine hull cut apart in the middle and extended to accommodate the missile tube section.

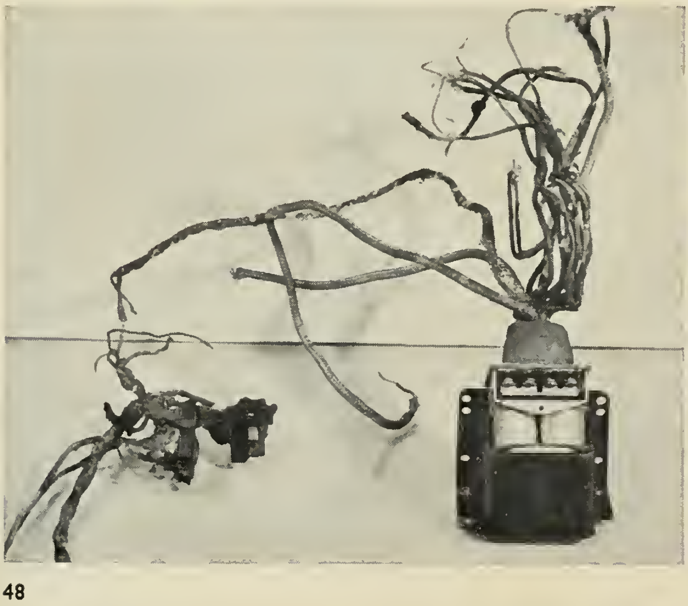
• **Groton, Conn.**—Navy's first fully transistorized fire control system will be installed in the newly commissioned *Polaris* submarine, George Washington. The complex system, made extremely compact with advanced miniaturization and packaging techniques, contains more than 15,000 transistors. Centered around a brain of both analog and digital computers, the system will provide accurate data to launch and guide the missile to its target.

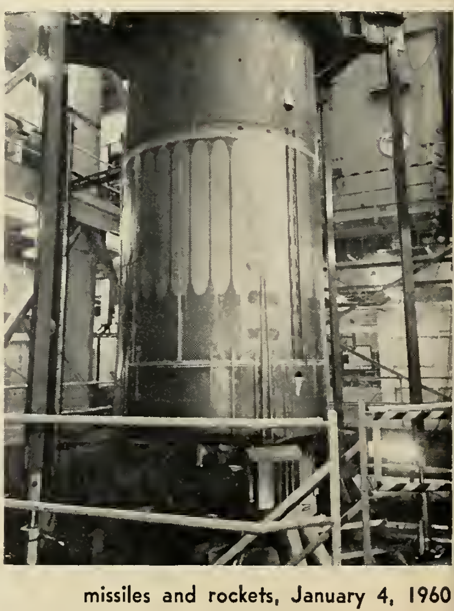
• **New York**—A new five-minute radio program, "Today in the Space Age," is being launched over a local station this week by **American Bosch Arma** to aid in the company's advertising campaign for recruiting engineers and scientists.

• **Washington**—Major missile contracts: The Omaha District Corps of Engineers has awarded **Keenan Pipe & Supply Co.,** Denver, a $4-million contract for 2056 pressure vessels for ICBM fueling systems and a $2.7-million contract to **Compu Tyne,** Hatboro, Pa., for ICBM propellant loading valves . . . **The Martin Co.,** Orlando, has received a $22.6-million follow-on award from the Navy for *Bullpup* missiles . . . and **Martin-Orlando** has awarded a $1.3-million follow-on contract to **Summers Gyroscope Co.** for spring-wound gyros for use in the *Bullpup*.

TITAN Failure Simulated in Lab

VERTICAL TEST laboratory at Martin-Denver has successfully duplicated the accidental triggering of *Titan's* safety destruct system which resulted in destruction of a *Titan-C* Dec. 12 at Cape Canaveral. Cause was chattering of an electrical relay. First-stage fuel tank, loaded and weighted to equal complete 110-ton bird, had hydraulic jacks to simulate 300,000-pound engine thrust. Explosive hold down bolts were fired releasing all forces as they occur at lift off, producing same chatter. Relay has been relocated and safety system redesigned to prevent recurrence.





Advertisers' Index

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some straight talk to engineers aiming at management

from General Electric's Defense Systems Department

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Should Ike Be Space Project Officer?

The National Space Act is a remarkable document.

It rather ridiculously made the President of the United States project officer for the nation's space program.

It created a National Aeronautics and Space Administration on the basis of program and not function—an action probably unique in major U.S. legislation.

It established a National Space Committee and a Military Liaison Committee, neither of which is effective—certainly not in the way Congress intended them to be.

Making the President responsible for Space is a little like making him responsible for oceans—or land. As the highest U.S. official and chief of the Executive Branch he presumably would have that responsibility anyway. But the National Space Act, probably in an effort to emphasize its own importance, gives him such duties as surveying and developing the program, designating responsibilities, effecting cooperation and resolving differences between agencies involved. Added to his normal duties—as Chief of State, Commander-in-Chief of the Armed Forces, etc., etc.—this seems a little too much.

The Act says NASA shall "plan, direct and conduct aeronautical and space activities." (Activities peculiar to the military are excepted.) This may be fine as a proclamation but it is difficult to follow in actuality because it is programmatic instead of functional. NASA should, let us say, have the function of *exploring* space for peaceful purposes. And if later the Department of Commerce, as an example, wants to utilize a weather satellite in forecasting, Commerce needs no special legislation to include the cost of such an operation in its budget. That is already provided because furnishing weather information for the country is a function of the Department of Commerce.

The National Space Council consists of: the President, who is chairman; Secretary of State; Secretary of Defense; Chairman of the AEC; President, National Academy of Science; Director, National Science Foundation; President, Illinois Institute of Technology, and the Administrator of NASA. Reportedly it does very little actual counseling, and this seems understandable. Many of the members are not qualified as space experts. And, more important, they have other, overriding commitments which hardly allow them to give much time or thought or understanding to the problem of competing in space.

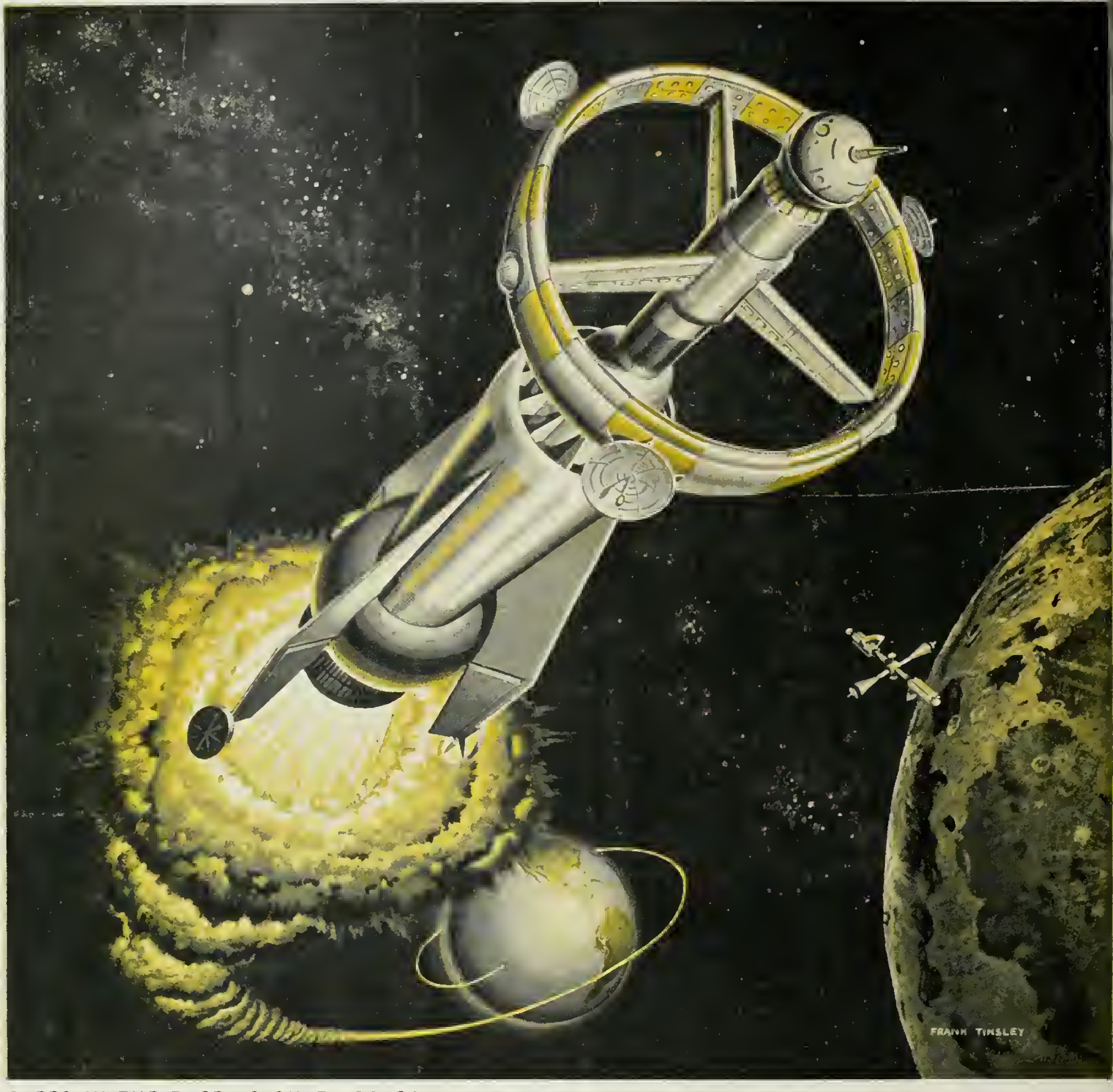
The Civilian-Military Liaison Committee is headed by a chairman named by the President and consists of representatives of the military and NASA. The Act reads that "The Administration (NASA) and the Department of Defense, through the Liaison Committee, shall advise and consult with each other on all matters within their respective jurisdictions relating to aeronautical and space activities and shall keep each other fully and currently informed with respect to such activities."

It may be one of the foibles of the American system—or perhaps just human nature—but the top people in both NASA and the military will not trust the Liaison Committee with any matters of real importance. The result is that the Committee is frequently the last to hear of significant projects or events, and usually finds itself dealing with comparative trivia.

It is not too surprising that the National Space Act leaves more than a little to be desired. It was slapped together hurriedly in the summer of 1958 when the Russians had already orbited three *Sputniks,* including one dog and kennel. Senator Lyndon Johnson, in a recent address to the Wright Day dinner, hinted that his space committee and the Congress might find some changes necessary.

We suggest a long, hard look—with some realistic revisions of the law to produce a workable system. We also suggest a new project officer.

CLARKE NEWLON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