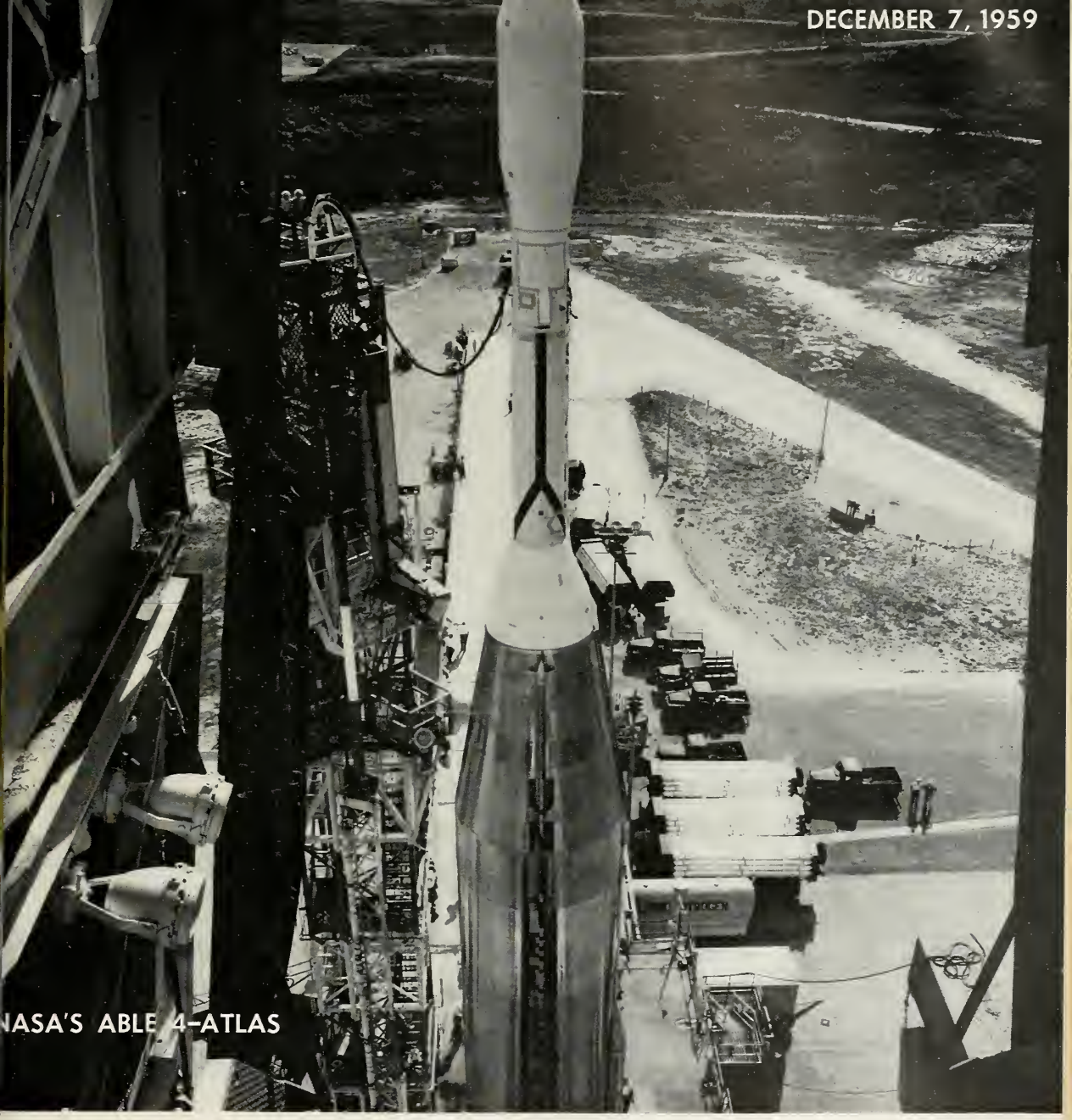
DECEMBER 7, 1959



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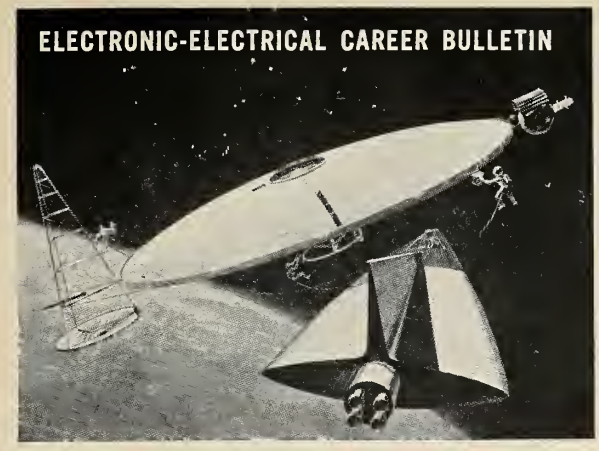
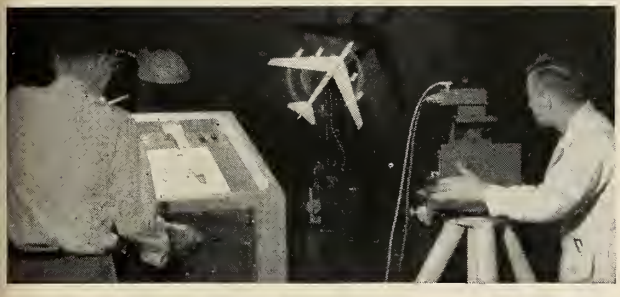
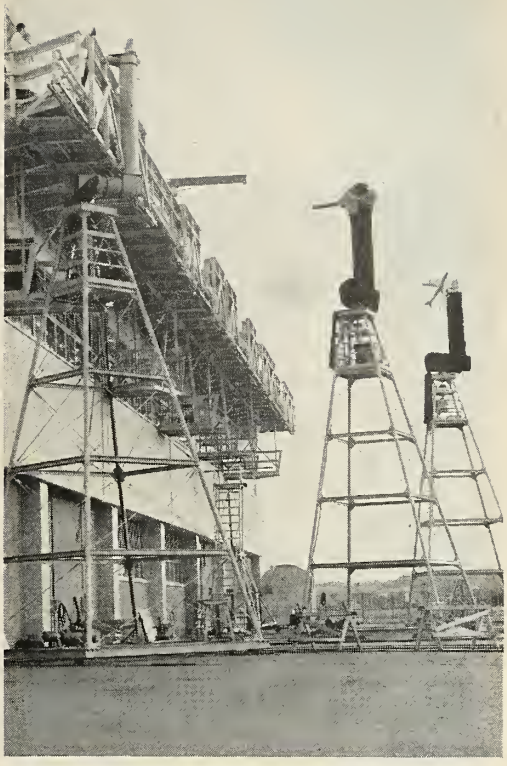


MARS VEHICLE. Drawing, based on Boeing study, of space vehicle designed for launching from orbiting platform for reconnaissance flight to Mars and return. Lunar, orbital and interplanetary system studies, and expanding programs such as the advanced Minuteman solid-propellant ICBM, are typical of challenging, long-range assignments Boeing offers electronic-electrical engineers.



DARK TUNNEL. View in 100-foot dark tunnel, part of extensive Boeing infrared research and development facilities. Boeing investigations include use of infrared, visible and ultra-violet techniques for use in communication, navigation, detection and guidance at altitudes above tropopause. IR systems, inertial navigation, electrical power systems for satellites, shockwave radiation and refraction and irdome heating are other areas of assignments open at Boeing.



ANTENNA PATTERN RANGE, with movable towers capable of handling models up to 1000 pounds. Boeing has openings in ECM antenna development, and in gas, solid and liquid dielectric research, as well as large-aperture antennas for ASMs, orbital vehicles and airborne warning systems. Other openings are available in instrumentation, missile guidance and control.

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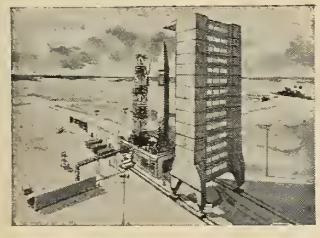
COVER: Ill-fated *Atlas-Able* vehicle is shown on launching pad at Cape Canaveral prior to unsuccessful moon shot attempt on Nov. 26. An assessment of where the failure leaves U.S. space program starts on p. 30.

MASSIVE solar converter of Hoffman Electronics is indicative of growing emphasis on energy conversion for both military and industrial applications. See story on p. 22.

ARTIST'S conception of the 120" diameter Spin Forge machine which Hufford Division of the Siegler Corp. expects to have in operation by next July. It will be world's largest. See p. 27.



TALLER THAN a 16-story building will be this steel gantry tower (shown in artist's drawing) being built at Cape Canaveral by Convair. Picture shows *Vega* in launch position.

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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DECEMBER 7 HEADLINES

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ASTRIONICS

NEW MISSILE PRODUCTS

THE MISSILE WEEK

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At missile sites, at air force bases, at airports, at radar outposts, you will find Caterpillar Electric Sets furnishing dependable electric power. Any quantity of electric power—for any purpose—can be supplied by Cat Electric Sets. Write for our new booklet, "Guide Book on Emergency Power." Engine Division, Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

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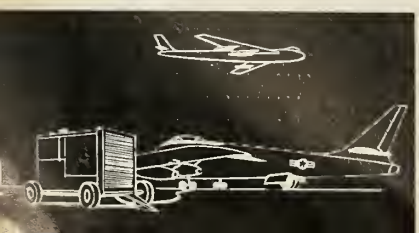
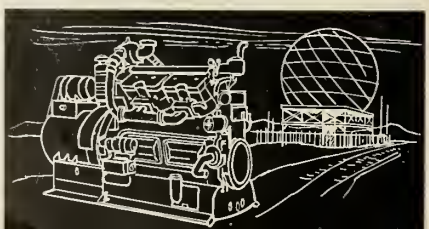


RADAR BASE Caterpillar Electric Sets furnish pawer far gap filler sites in aur aircraft warning system . . . serve larger bases, taa.



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Additional features of the "950" Series include: common power supply, built-in MOPA, front and rear inputs, easily serviced plug-in circuit cards, adaptability for use with other readout devices, availability in 4-, 6- or 8-channel models. When many channels are constantly in use for floating or grounded high gain inputs the simplified 958-1500 design assures dependable operation, yet at much lower "per channel" cost.

Complete details are available from Sanborn Sales-Engineering Representatives located in principal cities throughout the U.S., Canada and foreign countries.

SPECIFICATIONS—Model 958-1500 System

INPUT	100,000 ohms, all ranges, floating and guarded.
LINEARITY	±0.4%
SENSITIVITY	10, 20, 50, 100, 200, 500, 1000 and 2000 uv per chart div
COMMON MODE REJECTION	100 db, min. dc
FREQUENCY RESPONSE	0-100 cps within 3 db at 10 div peak to peak. 0-50 cps within 3 db at 50 div peak to peak.
NOISE	¼ div peak to peak maximum.

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Washington Countdown

IN THE PENTAGON

Operational *Hound Dogs* . . .
are scheduled to be deployed first with the 72nd Bomb Wing at Ramey AFB, Puerto Rico. Some of the **North American** air-launched missiles may already be at the base.

• • •

The magic phrase . . .
"stretch out" is the key to military R&D planning within the ever-tightening defense budget. Rather than kill programs, the services will try to conduct a holding operation if at all possible in hopes that a new administration in 1961 will bring policy changes.

• • •

Booming range business . . .
is expected to continue at the Army's White Sands Test Range despite Army's exit from the space business. Some days the rate of firings at the desert range reaches one every 15 minutes.

• • •

ICBM dispersal plans . . .
around Cheyenne, Wyo., call for deploying **Convair** *Atlases* in hardened sites spread over some 11,000 square miles. The layout is similar to the ICBM complex around Salina, Kan.

• • •

Project *Caesar* . . .
the Navy's latest operational submarine detection system, is considered far from what is needed to meet the mounting threat of Soviet missile-launching subs. However, R&D for ASW will continue to be strapped for funds in the new budget.

• • •

Tactical missile shortages . . .
among U.S. Army units in the Far East are causing increasing concern. The reason: The buildup of the tactical missile stockpile of Red China.

ON CAPITOL HILL

Contract renegotiation . . .
will undergo another working over in the new session of Congress—but probably not until spring. A major congressional report on government renegotiation policies under present legislation isn't expected to be completed before then.

A major airing . . .
of the *Nike-Zeus* AICBM program and the whole anti-missile missile defense problem is expected to be ordered by at least one congressional committee. Quite a number of congressmen are reported to find the problem very disturbing—particularly in an election year.

AT NASA

Man in 'space' around Christmas . . .
now appears to be only hope—and a slim one at that—for saving last vestiges of America's disappearing space prestige. NASA plans to send one of the astronauts on a 100-mile flight up (and 100 miles down the Atlantic range) in a capsule atop a *Redstone* this month or next.

• • •

First *Mercury* flights . . .
are far off. New postponements have pushed them back to 1963. This will create an age problem which may eliminate the older astronauts. Lt. Col. John Glenn, the oldest, is 39.

• • •

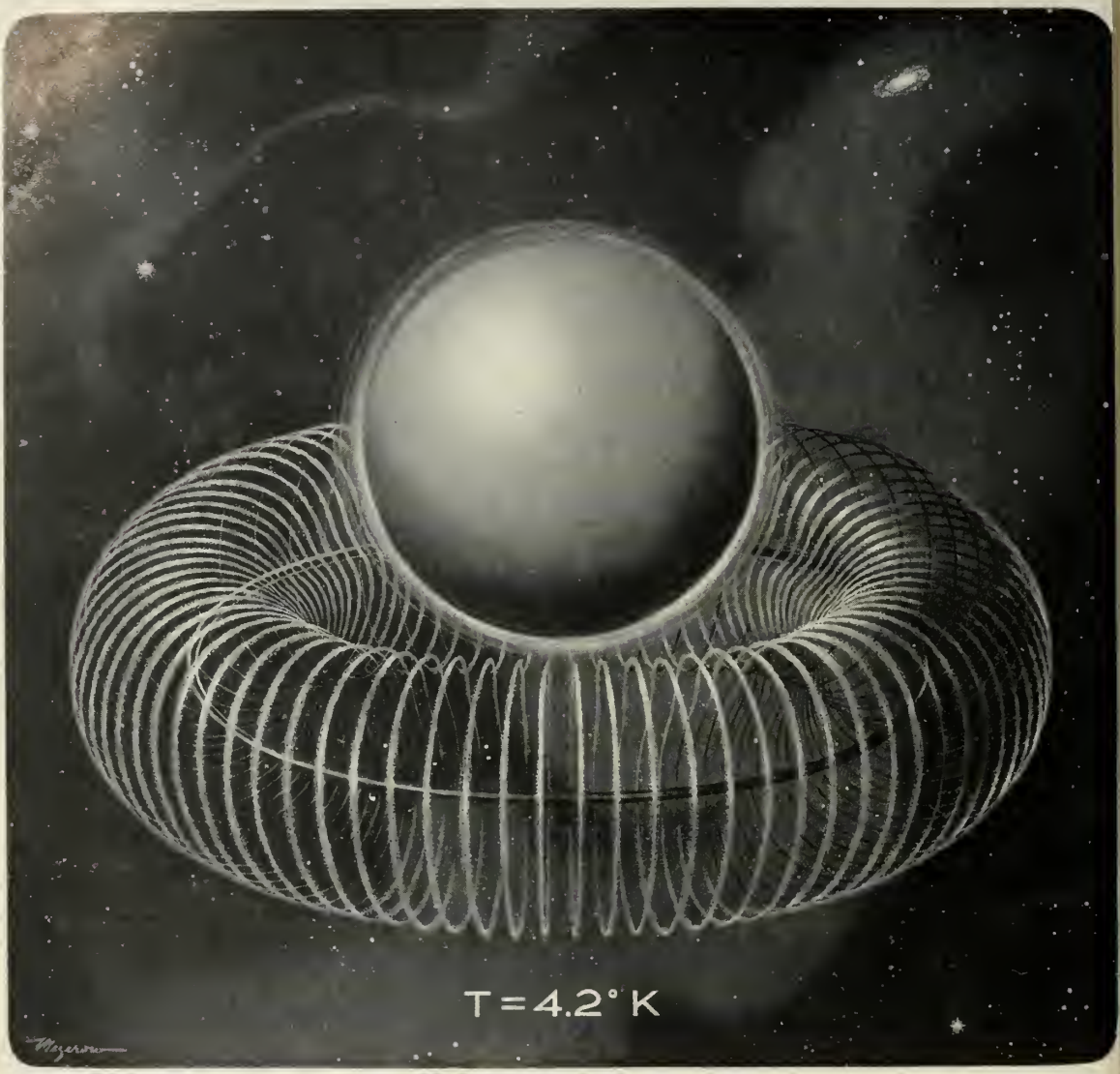
***Vega* also is in trouble . . .**
The *Atlas* upper stage, which was supposed to be ready next year, now is not scheduled to be operational until the spring of 1961. This is only three months ahead of the high-energy, hydrogen-burning *Centaur*, which is supposed to replace *Vega*.

ALONG EMBASSY ROW

Japan's *Typhoon I* . . .
is a camera-armed rocket being developed to photograph typhoons in order to determine their direction and size. The rocket can also be used for general long-range weather reconnaissance work.

• • •

Norway's *Tern* . . .
an anti-submarine missile, is being studied by the Navy for possible purchase. The missile homes on its target with sonar.



THE CRYOGENIC GYRO

A fundamentally new type of gyroscope with the possibility of exceptionally low drift rates is currently under development. The design techniques used in conventional electro-mechanical gyros appear to have been largely exploited. A break-through is needed, and the cryogenic gyro may well provide it.

The cryogenic (liquid helium temperatures, in the range of 4°K) gyro consists of a superconducting sphere supported by a magnetic field. The resulting configuration is capable of support in this manner as a result of a unique property of a superconductor. Exceptionally low drift rates should be possible. This cryogenic gyro has performance potential unlimited by the constraints of conventional electro-mechanical gyros.

This is just one example of the intriguing solid state concepts which are being pioneered at JPL for meeting the challenge of space exploration. In addition to gyro applications, superconducting elements are providing computer advances and frictionless bearings. The day of the all-solid-state space probe may be nearer than one realizes.

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the missile week

Industry Countdown

MANUFACTURING

Puzzler to industry . . .

is Navy's decision to go ahead with a surface-type tender for its long-range nuclear-powered *Polaris* submarines. Many observers feel the fleet ballistic missile subs should have a submersible tender—one that would be difficult for the enemy to track either by air or water. One expert close to the problem tells M/R the Navy wanted an underwater tender, but couldn't find a shipyard that could build it. But the real reason may be cost. The contract for a surface tender awarded **Newport News Shipbuilding & Drydock Co.** recently was for $28.7 million. An underwater tender probably would cost nearly three times as much.

• • •

France's space program . . .

is due for some funding soon. Money is being sought from the French Assembly to allow the National Fund for Scientific Research to carry out space research.

• • •

Various plastics . . .

are being screened for possible use in the *Mercury* man-in-space program by the **Cincinnati Testing Labs Division** of **Studebaker-Packard.** CTL has a new test facility near Cincinnati which can check materials at 4200°F and speeds up to Mach 2.5.

• • •

Several European . . .

nations are expected to buy the British counterpart of the U.S.'s *Sergeant*—the **English Electric** *Blue Water*. Australia is already buying **Bristol/Ferranti** *Bloodhound* anti-aircraft missiles, giving another boost to Britain's growing missile industry.

PROPULSION

Pre-packaged liquid . . .

motor for the improved **Martin** *Bullpup* air-to-surface missile will be interchangeable in the airframe with the present solid motor. This new version is now in production and is expected to be operational with the fleet shortly.

• • •

Combination ramjet-rocket . . .

engine has been patented by the Navy (U.S. 2,912,820.) Combustion heat of the rocket, which is ignited first, burns away a partition before the ramjet cuts in—allowing both chambers to use a common nozzle.

Solid-fueled engine . . .

will be developed by **SEREB** to power France's intermediate range ballistic missile.

ASTRIONICS

Gyro manufacturers . . .

are urging the military to ease up somewhat on rigid specs to reduce costs. Some point out that less than 20% of newly-made gyros meet specs—and against some specs there are yields of 1 in 60.

• • •

Electrostatic gyros . . .

by **Minneapolis-Honeywell** are expected to replace floatation-type gyros in about the fourth stage of the development of SINS (ships inertial navigation system) for *Polaris* submarines.

• • •

Astronertial guidance . . .

is almost certain to be favored over pure inertial system for extended space probes, according to some industry experts. They see the market expanding in the next 3-5 years for the astronertial system. It will correct continuously for gyro drift—and hence is more accurate.

WE HEAR THAT—

The Navy is going . . .

to automatic checkout systems for *Polaris* missiles in a big way. One of the large contractors is **Nortronics** . . . **Fairey Aviation** has a British government contract for new missile development work following cancellation of its *Orange William* anti-tank missile . . . Paris probably will be selected as the site for the International Astronautical Federation's Academy of Astronautics . . . Several Iron Curtain countries are among the 54 nations invited to display their wares at the first International Air and Space Exposition to be held at Los Angeles April 14-24 . . . **Nuclear Materials and Equipment Corp.** has a new process for applying tenacious films of gold directly to substrates without any intermediate steps . . . The "bomber gap" will widen if the Air Force goes ahead in FY 1961 with plans to close or consolidate 15 bases—before the slack can be taken up by more ICBM bases . . . Two **IBM** 705's and one **Burroughs** 220 computer at Norton AFB are handling missile logistics, including 56,000 *Atlas* parts, 35,000 *Thor* parts, and 41,000 *Titan* parts.

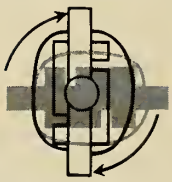
More About the Missile Week on Page 43

Pedigree of a Hound Dog

The guidance and control system of America's HOUND DOG missiles—best of breed—has a pedigree 13 years long. Created by Autonetics, the HOUND DOG's inertial autonavigation system sends this supersonic air-to-surface missile from mother-ship to target anywhere in the world, in any weather. Equipped with an invulnerable sense, HOUND DOG extends the retaliatory effectiveness of SAC's B-52G bombers by hundreds of miles.

Against a 13-year background of blue-ribbon winners, Autonetics is now producing in quantity and at low cost the N5G autonavigator. This is the pedigree that makes the GAM-77 HOUND DOG missile performance "best in show."

DID YOU KNOW?...



At Autonetics, navigation gyros are made so precisely that it would take over 40 years for one to precess one complete revolution.

Inertial navigation by Autonetics

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USE LOTS OF TAPE?

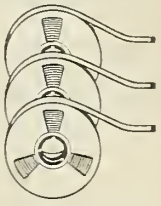
"SCOTCH" BRAND Instrumentation Tapes cut operating costs

Let's develop our own small theory of relativity. For everything's relative, after all—even economy. Clearly, an economy effected now and *corrected* later is no economy at all. In instrumentation tape, there's only one genuine economy—reliable performance. And in performance, the last two words for any acute tape-user are "SCOTCH" BRAND.

First to last, "SCOTCH" BRAND Magnetic Tapes offer uniformity and reliability—born of the experienced 3M technology that created the first practical magnetic tape and continues to advance the art of tape-making day by day.

But let's look at economy from another viewpoint —in terms of some things around the periphery that might not come so readily to mind—storage, use, waste, and time saved.

What other kind of record is so permanent it may last a lifetime, yet requires so little space for storage? Three reels of "SCOTCH" BRAND like those at the right "contain" 30 million characters. What other medium serves input, output and memory functions at such high speeds? Accepts both digital and analogue data?



What other kind of record is not *consumed*, even when it is used? "SCOTCH" BRAND Magnetic Tape is run and rerun for analysis, erased and used again, permits retaping with corrections, editing and new data.

Last, but far from least—in these days when time is money, what other medium speeds up data acquisition, reduction and control programming in a way that keeps critical projects rushing forward at full tilt? Or cuts production lead time and human error to a point where a 1000% saving may be realized?

At any cost, "SCOTCH" BRAND Magnetic Tapes would be a good buy. And in every application, "SCOTCH" BRAND Tapes offer that greater economy —reliability. "SCOTCH" BRAND High Resolution Tapes 158 and 159 let you pack more bits per inch, offer extra play reels. "SCOTCH" BRAND Sandwich Tapes 188 and 189 end rub-off, build-up, cut head wear to an absolute minimum, show little wear in 50,000 computer passes. "SCOTCH" BRAND High Output Tape 128 offers top output at low frequencies, even under ambient temperature extremes. "SCOTCH" BRAND Instrumentation Tapes 108 and 109 offer top performance at lowest cost.

Where there's no margin for error, there's no tape like "SCOTCH" BRAND Magnetic Instrumentation Tape. For details, write Magnetic Products Div., 3M Company, Dept. MBW-129, St. Paul 6, Minn., or mail the reader inquiry card.

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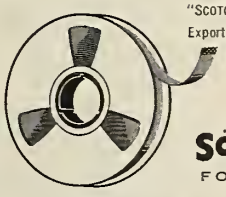

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when and where

DECEMBER

American Institute of Chemical Engineers, 52nd Annual Meeting, Sheraton-Palace Hotel, San Francisco, Dec. 6-9.

Classified Symposium on The Plasma Sheath, Its Effect on Communication and Detection, Electronics Research Directorate, Air Force Cambridge Research Center, Boston, Dec. 7-8.

American Management Association, Defense Market Briefing Session, Ambassador Hotel, Los Angeles, Dec. 7-9.

Chemical Specialties Manufacturers Association, 46th Annual Meeting, Washington, D.C., Dec. 7-9.

Southwest Society of Aircraft Materials & Process Engineers and Dallas-Fort Worth Branch, American Electroplaters' Society, Hotel Texas, Fort Worth, Dec. 7-9.

American Institute of Electrical Engineers and National Electrical Manufacturers Association, National Conference of the Application of Electrical Insulations, Sheraton Park Hotel, Washington, D.C., Dec. 7-11.

Institute of Environmental Sciences, N.Y. Metropolitan Chapter, Technical Symposium and Product Exhibition, "Instrumentation for the Environment," Henry Hudson Hotel, New York City, Dec. 10-11.

23rd Wright Brothers Lecture; "High Temperatures in Hypersonic Flow—Physical Principles and Experimental Techniques," Natural History Bldg., Smithsonian Institution, Washington, D.C., Dec. 17.

American Chemical Society, Industrial and Engineering Chemistry Division, 1959 Christmas Symposium "Mechanisms of Interfacial Reaction," Shriver Hall, Johns Hopkins University, Baltimore, Dec. 28-29.

JANUARY

Sixth National Symposium on Reliability and Quality Control in Electronics, IRE, EIA, AIEE, ASQC, Statler-Hilton Hotel, Washington, D.C., Jan. 11-13.

Society of Plastics Engineers, 16th Annual Technical Conference, Conrad-Hilton Hotel, Chicago, Jan. 12-16.

American Astronautical Society, Sixth Annual Meeting, Statler-Hilton Hotel, New York City, Jan. 18-21.

Institute of the Aeronautical Sciences, 28th Annual Meeting, Hotel Astor, New York City, Jan. 25-28.

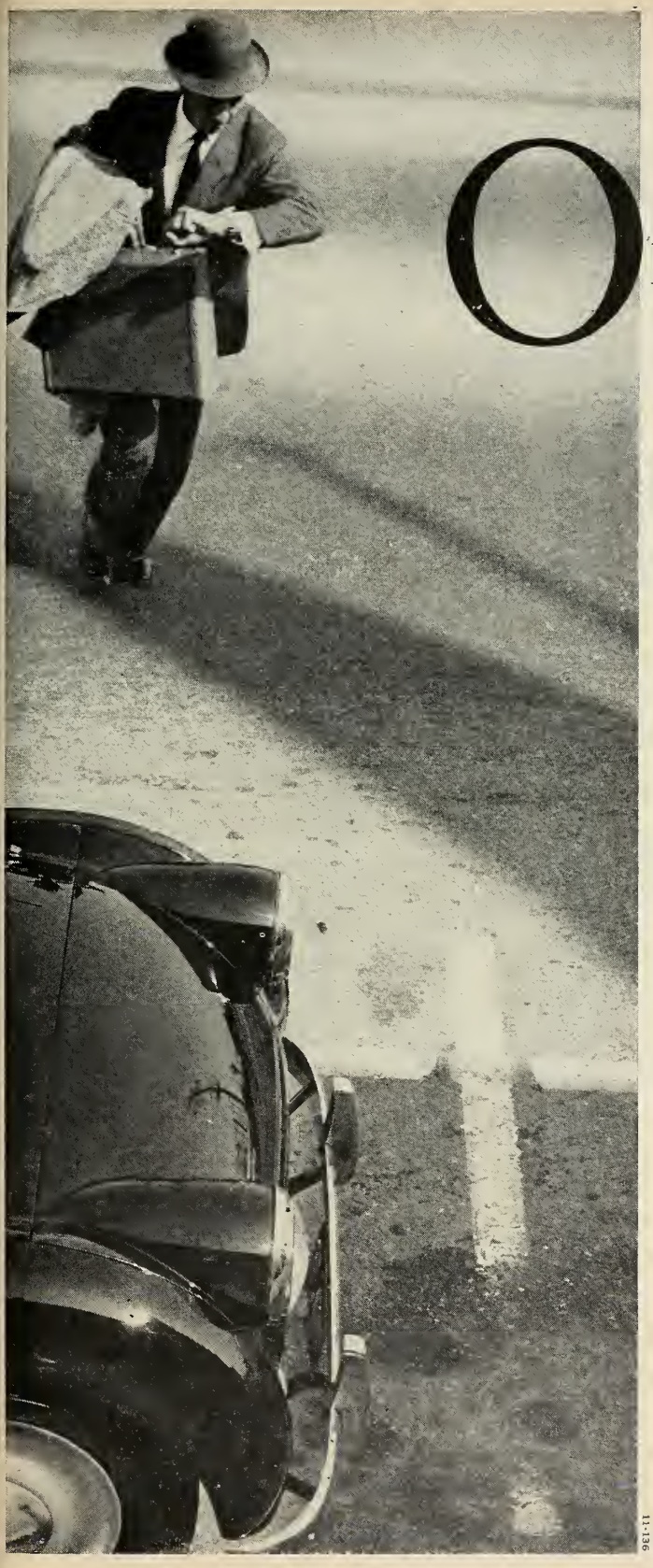
Seventh Annual Western Spectroscopy Conference, Asilomar, Pacific Grove, Calif., Jan. 28-29.

American Rocket Society, Solid Propellants Conference, Princeton University, Princeton, N.J., Jan. 28-29.

FEBRUARY

Chemical Institute of Canada, Toronto Section, Symposium on Gas Chromatography, Seaway Hotel, Toronto, Ont., Feb. 1.

Instrument Society of America, Houston Section, Instrument-Automation Conference and Exhibit, Rice Hotel and Sam Houston Coliseum, Houston, Feb. 1-4.



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"Application of Computer Simulation to Production System Design," a paper by Allen J. Rowe, is available upon request. Send request to Dr. Rowe at SDC.

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RAYTHEON MISSILE SYSTEMS DIVISION

Soviet Rockets Exploit German Technology

Sacrifice ease of fabrication, production for reliability of the V-2; Reds research H-F propulsion

by Donald J. Ritchie*

DETROIT—The Russians had a great interest and capability in liquid rocket engines as far back as 1937. So it is unfair to say that all their rocket capability stems from German sources.

Nevertheless, it is accurate to state that Soviet engineers and scientists have taken the German technology and exploited it to its fullest extent.

At the end of World II, the Soviets took over much of German industry, including the tooling for the *V-2* rocket engine. By continuing the manufacture of the *V-2* engine and firing a great many of them, the Soviets have achieved extremely high reliability.

It is well known that experience and usage is the most important single factor in determining the reliability of an engine—or for that matter any other component of a vehicle system. T. Keith Glennan, National Aeronautics and Space Administrator, said recently that the Soviets have probably tested their big workhorse rocket as many times as the total of all tests of big American rockets.

The Soviets sacrificed ease of fabrication and production for the proven reliability of the *V-2* engine—developing ever higher thrusts and better performance without varying the basic type of engine.

The largest known operational Soviet rocket engine is the *R14A*, a scaled-up *V-2* that generates 264,000 lbs. of thrust at sea level. A pair of *R14A* engines, totaling about 528,000 lbs. of thrust, was used as the first stage of dog-carrying *Sputnik II*.

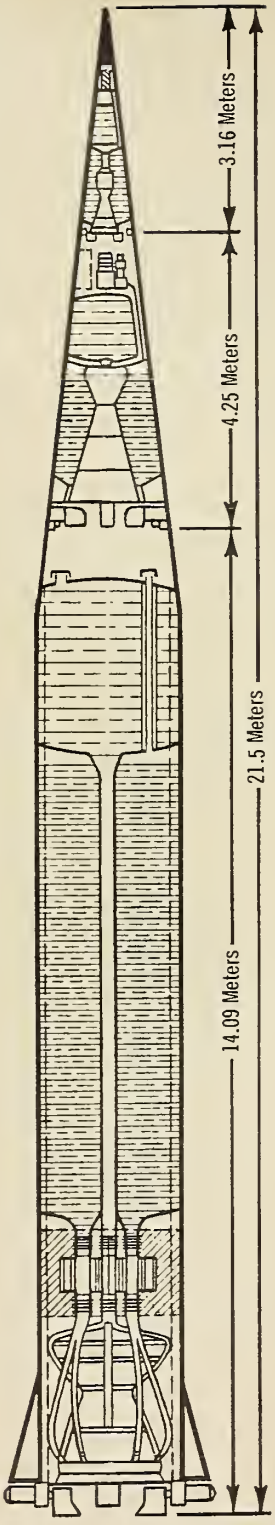
Sputnik I used a pair of the slightly smaller *R14* engines, each with about 220,000 lbs. of thrust. *Luniks I, II* and *III* made use of a cluster of two *R14* engines and two solid-fuel *Golem-3* engines, each with 88,000 lbs. of thrust, for total thrust of about 560,000 lbs.

The Soviets also are known to be hard at work developing nuclear propulsion and high-energy chemical rockets burning hydrogen and fluorine. They have discussed an H-F rocket with a sea level thrust of 281,000 lbs. of thrust as booster for a relatively small vehicle. However, this obviously could be used as a high-energy upper stage of a much larger vehicle system.

In nuclear propulsion, the Soviets have published basic data from which we can infer their interest in a rocket with 550,000 lbs. sea level thrust based on a 13,200 megawatt reactor using liquid hydrogen as a working medium.

Soviet authors, like our own, also have published many highly futuristic propulsion ideas. However, to get a better idea of Soviet progress, it is best to treat it historically.

• **First Red rocket**—V. P. Glushko designed the *ORM-65* engine in 1936. It used nitric acid and kerosene as propellant, developing a thrust that varied from 342 to 386 lbs. It was first successfully flown on a soaring glider on Feb. 11, 1939. Its specific impulse was 210 seconds.



ULTIMATE CHEMICAL propellant combination—hydrogen and fluorine—is exploited in this rocket described in a recent Soviet propulsion textbook.

** Donald J. Ritchie, a project mathematician in the Research Laboratories Division, Bendix Aircraft Corp., gathered material for this article by studying hundreds of books and periodicals in the Russian language.*

Large Soviet Liquid Rocket Engine Characteristics

Engine Designation	Soviet V-2	R-10	R-14	R-14A
Sea Level Thrust, pounds	55,000	77,000	220,000	264,000
Vacuum Thrust, pounds	66,500	90,500	262,000	298,000
Chamber Pressure, psi	220	289	850	882
Fuel	75% Alcohol 25% Water	75% Alcohol 25% Water	Kerosene	Kerosene
Oxidizer	Lox	Lox	Lox	Lox
S. L. Specific Impulse, seconds	210	211	242	250
Vacuum Specific Impulse seconds	253	248	288	282
L*	113	113	...	...
Propellant Flow Rate, pounds/second	262	365	910	1056
Nozzle Efficiency Factor	0.973	0.973	0.973	0.973
S. L. Thrust Coefficient	1.32 (1.28)	1.405 (1.367)	1.51 (1.47)	1.56 (1.52)
Vacuum Thrust Coefficient	1.59 (1.55)	1.65 (1.608)	1.80 (1.75)	1.76 (1.71)
Area Ratio	3.42	4.5	16	10
Throat Diameter, inches	15.75	15.75	14.92	15.8
Exit Diameter, inches	29.1	33.4	59.8	50
Chamber Diameter, inches	36.3	36.3	...	...
Nozzle Length, inches	34.35	45.5	115.5	88
O/F Ratio	1.23	1.23	2.28	2.28

Later the Russians developed the *ZhRD R-3395* for use as an aircraft jato rocket, using nitric acid and aniline, with a thrust of 2640 lbs. Other characteristics of the jato engine are: propellant flow rate, 14.1 lb./sec., specific impulse 188 sec., chamber pressure 396 psi, throat diameter 2.52" exit diameter 5.12", pump feed system and engine weight 125.3 lbs.

After World War II, they modified the German "Walter" engine to use as a fairly high-thrust, throttable aircraft engine. This uses hydrogen peroxide of 80% strength and hydrazine as propellant, producing a thrust varying from 440 to 3300 lbs., with a specific impulse of 190 sec. Its other characteristics are propellant flow rate 17.2-4 lb./sec., chamber pressure 58.7-279 psi, throat diameter 3.31", exit diameter 6.42", pump feed system and engine weight 286 lbs.

Today, there are four primary types of large liquid rocket engines in the Soviet Union. They are the Soviet version of the German *V-2*; an improved *V-2* called the *R-10*; a scaled-up *V-2* called the *R-14*, and an improved version of the latter called the *R-14A*.

The engines were designed respectively for 25, 35, 100 and 120 metric tons of thrust—which in pounds are 55,000, 77,000, 220,000 and 264,000, The *V-2* and *R-10* both operate on watered alcobol and liquid oxygen. The *R-14* and *R-14A* use LOX and kerosene. Table I presents the characteristics of these large engines. In Table II may be found the Soviet rocket vehicles and their powerplants.

The German *V-2*, operating at a chamber pressure of 220 psi, generated 55,000 lbs. of thrust at sea level and 66,500 lbs. in a vacuum. Its specific impulse is 220 seconds. This was improved in the *R-10* to produce 77,000 lbs. at sea level and 90,500 lbs. in vacuum.

The Russians developed the *R-10* easily by using a heavier gauge steel for the combustion chamber, increasing the pressure from 220 to 289 psi and slightly lengthening the nozzle. The area ratio was expanded from 3.42 to about 4.5 to achieve the same coefficient of thrust variation as the engine proceeded from sea level to vacuum conditions. Thrust diameter was maintained but the exit diameter was increased from 29.1" to 33.4". The nozzle efficiency factor remained at 0.973.

• **Performance demands**—As the need arose for much higher thrust liquid rocket engines, a German-Russian team proceeded to design and develop the *R-14* engine, which produces 220,000 pounds of thrust at sea level and 262,000 lbs. at altitude, using a chamber pressure of 850 psi.

The sea level specific impulse of the *R-14* is 242 sec. It is believed that the dry weight is about 2400 lbs. An area ratio of 16 was chosen, which yields a nozzle length of nearly 115", compared with the 45" of the *R-10*.

The *R-14* engine, improved 20% in performance, is designated the *R-14A*. It generates 264,000 lbs. of thrust at sea level, and 298,000 lbs. at altitude with a chamber pressure of 882 psi. The sea level specific impulse of this engine is about 250 seconds.

The area ratio chosen for the *R-14A* is about 10, which yields a nozzle length of 88". The throat diameter is almost identical to the *R-10* engine and has an exit diameter of 50".

In contrast with U.S. practice, the Soviets have retained high values of L* and a multiple cup injector design rather than the U.S. flat plate injector. Furthermore, the propellant turbopumps have been used without change on the Soviet version of the *V-2* engine and the Soviet *R-10* engine. Indications are, however, that the *R-14* engine series uses separate propellant pumps for fuel and oxidizer with a three-pressure cooling system.

The flat plate type construction of the liquid engines has been used throughout all of the operational Soviet engines. However, indications are that research has been carried out on tubular helical wound thrust chambers. It should be remembered that Herman Oberth, a German scientist at Peenemunde during World War II, recommended the use of a wound tubular rocket thrust chamber as a more efficient combustion chamber design.

It should be noted that a cluster of seven of the improved *V-2* engines at 70,560 lbs. of thrust will give a total sea level thrust of 494,000 lbs. This total thrust is very close to the take-off thrust claimed for the *T-3A* booster vehicles.

At the recent American Rocket Society convention in Washington, Soviet scientists denied that they are building more powerful rockets than they now have. However, the reply given by Academician Anatoli Blagonravov was "not just now." Obviously, this leaves much room for maneuver.

• **Higher energy**—Just as in this country, rocketeers in the Soviet Union are interested in harnessing the hydrogen-fluorine reaction, which produces the maximum specific impulse possible in a chemical rocket (398 seconds, frozen equilibrium at sea level). The accompanying diagram shows a three-stage liquid rocket using hydrogen and fluorine as propellants which appeared as an illustration in a recent Russian book on jet engine and rocket propellants.

The first stage would use a large thrust chamber fed by three turbopumps, two of which feed liquid hydrogen to the engine, regeneratively cooling the rocket nozzle. The third and middle pump feeds liquid fluorine. The upper stages have the rocket thrust chamber imbedded in the liquid hydrogen tanks. Small liquid fluorine tanks are mounted on top of the thrust chambers. All stages use an external carbon vane system for control and guidance.

This rocket would have a total length of 70.5', and a diameter of 6.56'. The first stage is 46.2' long, while the two upper stages have lengths of 13.95' and 10.38' respectively. From the extremely small size of the payload in evidence, it seems apparent that this is only a conceptual design. However, it does not seem impossible that Soviet designers might be working on a hydrogen-fluorine rocket for upper-stage use.

Here are the characteristics of the H-F rocket given in the Soviet textbook: sea level thrust 281,000 lbs., vacuum thrust 330,000 lbs.. chamber

pressure 368 psi, sea level I_{sp} 362 sec., vacuum I_{sp} 426 sec., propellant flow rate 776 lbs./sec., nozzle half angle 18.5°, nozzle efficiency factor 0.9745, area ratio 5, throat diameter 26.5", exit diameter 59.2", chamber diameter 63.9", and nozzle length 51.8°.

• **Harnessing the nucleus**—Two Soviet authors, Sinyarev and Dobrovol'ski, presented a detailed analysis of the nuclear rocket engine in their 1957 book, "Liquid Rocket Engines." Although it is believed that their data is hypothetical, their thinking is undoubtedly an indication of the trend that Soviet nuclear development work will follow.

The authors conclude, just as American researchers have concluded, that atomic and molecular hydrogen provide the highest specific impulses of all working fluids available. They calculate I_{sp} of 822 sec. at 4000°K and 1045 sec. at 6000°K for molecular hydrogen, without dissociation, and 1105 sec. at 4000°K and 1350 sec. at 6000°K for atomic hydrogen, without recombination.

The authors imply that it would be possible to construct a reactor using uranium oxide and graphite operating at a temperature of 2100°K. On this basis, they present possible characteristics of a nuclear rocket engine weighing 66,400 lbs. and generating 550,000 lbs. thrust at sea level and 620,000 lbs. in vacuum.

A nuclear rocket meeting these specifications is obviously several years in the future, both for the Soviets and for this country. However, the characteristics presented for what they may be worth: reactor power 13,200 megawatts, operating pressure 1470 psi (100 atmospheres), average core temperature 3142°F, gas exit temperature 2942°F, nozzle expansion ratio 20, nozzle efficiency factor 0.973, nozzle half angle 12°, throat diameter 17.35", exit diameter 77.6", nozzle length 113", sea level I_{sp} 472 sec., propellant flow rate 1166 lbs./sec.

The low performance achieved in this powerplant is primarily due to the low fluid working temperature, which is a function of the structural materials available. If one can obtain materials that will stand up at higher temperatures, it is obviously a simple matter to let the nuclear engine heat up the hydrogen a little more and obtain higher performance.

If one assumes a vehicle with a take-off gross weight of 400,000 lbs., this 250 metric ton nuclear rocket engine is capable of placing 43.5 tons into a 300 nautical mile orbit. The useful load placed in orbit is approximately 3000 lbs. This is twice the mass that the *Saturn*, a three-stage chemical rocket vehicle, can place in a similar orbit with a launch weight of 1 million lbs. This points out the great advantage that even a modest improvement specific impulse gives to a rocket vehicle.

• **Futuristic schemes**—Soviet technical literature is rich with proposals for futuristic means of propulsion for space vehicles. Possibilities of ion propulsion, plasma propulsion, nuclear and thermonuclear engines, and photon propulsion, using a scheme of antimatter cancellation, have been considered. Proposals for using lightning balls and beamed electric power for propulsion have also appeared in the literature.

A photon rocket has been proposed wherein a particle and antiparticle accelerator feeds the focus of a large paraboloidal reflector. Matter is annihilated at the focus of the paraboloid, producing energy which propels the photon vehicle through space. The main components of this photon vehicle are the crew cabin, biological shield, nuclear reactor, fuel tank, particle and antiparticle accelerators. With such a vehicle, it is thought that speeds approaching the speed of light can be achieved.

The Soviet engineer and scientist have both the organization and the freedom to carry out research and development in the advanced areas of propulsion for space and travel. They are supported by a singleness of purpose—to put the Soviet Astronaut into space. The Soviet satellites and lunar probes ably point out the success of the Soviets in achieving their goals.

Soviet Rocket Vehicles and Their Power Plants

Vehicle	Weight (Pounds)	Thrust (Pounds)	Probable Engine
V-2	28,400	55,000	1 V-2 Engine
T-1	44,000	77,000	1 R-10 Engine
**T-2 1st Stage	132,000	268,000	1 R-14A Engine
2nd Stage	....	78,000	1 R-10 Engine
*T-3 1st Stage	176,000	440,000	2 R-14 Engines
2nd Stage	....	268,000	1 R-14A Engine
3rd Stage	....	78,000	1 R-10 Engine
T-3A 1st Stage	182,600	518,000	2 R-14A Engines
2nd Stage	....	268,000	1 R-14A Engine
3rd Stage	....	78,000	1 R-10 Engine
T-4 1st Stage	70,840	180,000	2 R-10 Engines
2nd Stage	....	52,800	1 V-2 Engine
CH-9 (Sputnik I)			
1st Stage	....	451,000	2 R-14 Engines
2nd Stage	....	264,000	1 R-14A Engine
3rd Stage	....	77,000	1 R-10 Engine
CH-10 (Sputnik II)			
1st Stage	....	528,000	2 R-14A Engines
2nd Stage	....	268,000	1 R-14A Engine
3rd Stage	....	77,000	1 R-10 Engine
Lunik I, II, III (CH-10)			
Booster	....	176,000	2 S.P. Golem-3 Engines @ 88,000 lb. T.
1st Stage*	184,800	484,000	2 R-14 Engines
2nd Stage**	113,300	410,000	2 R-14 Engines
3rd Stage	24,160	99,000	1 R-10 Engine

American Physical Society Meets at Case Institute

CLEVELAND—The first meeting of the American Physical Society held here in ten years attracted many of the nation's top physicists.

Meeting at the Case Institute of Technology, delegates delivered more than 150 scientific papers in sessions covering a wide spectrum of physical research: theoretical physics, neutron physics, cosmic rays, fission, magnetism and ferroelectricity, metals, semiconductors, paramagnetic resonance, cryogenics, and radiation belt measurements.

AEC Reports Successful Nuclear Reactor for Space

WASHINGTON—A light-weight high-temperature nuclear reactor for space vehicles has been successfully operated at design power and temperature. The SNAP Experimental Reactor, announced by John A. McCone, chairman of the AEC, weighs 220 pounds, without shielding, and is roughly the size of a five-gallon can. It produces sufficient heat to power a three-kilowatt mercury-vapor turbine generator.

The reactor was designed and built for the AEC by **Atomics International** division of **North American Aviation**. Components of a power conversion system to operate from the reactor have been developed by **Thompson Ramo-Wooldridge, Inc.**

X-Rays Opening Up Materials Analysis

Penetrating radiation should provide new market for the complete automatic inspection of all missile and rocket components

by J. D. Webster*

MILWAUKEE—Within the next few years, there will be an unprecedented expansion in the use of penetrating radiation in the missile and rocket field. Penetrating radiation has many distinct advantages. The most important of these are:

- It is non-destructive and at the intensity levels used does not alter the composition of the material examined.
- The instrument using the radiation need not contact the material.
- The characteristics of the material may, in most cases, be measured accurately regardless of physical state.
- Measurements may be taken quickly and accurately.

X-radiation figures importantly in component part manufacture, and in assembly and final test. It can be used to check the amount of fuel, to analyse the fuel itself, for analysis of high temperature metal alloys and for a whole host of related functions.

There are four basic classifications of quality control and analysis in the missile and rockets field:

(1) *Gaging*—Here the mass of the material and hence its thickness is measured by the absorption or scatterings of a beam of radiation.

(2) *Localization*—In this case any abrupt change in the absorption of the material such as would result from an occlusion or flaw is detected. This is similar to the gaging classification but is treated separately as special high resolution detectors are needed.

(3) *Structure analysis*—Here the radiation serves to "finger print" a compound by determining crystal structure that is unique to that compound.

*Manager, Industrial Sales
X-Ray Department
General Electric Company
Milwaukee, Wisconsin

(4) *Elemental analysis*—This permits the utilization of excited secondary radiation to identify certain elements with relative simplicity and at high speed.

These categories cover all uses of penetrating radiation as an inspection or control element in missile and rocket programs.

In specialized applications, through use of point detection devices, one is able to ascertain variations in density within a small area of a normally uniform dense object.

One of these x-ray detectors, a photoconductor cadmium selenide, currently is in use in a semi-automated rocket plant. Here the machine is fed 3.5″ rocket charges of cast explosive, and a multiple station mechanical scanning mechanism examines the rocket in its entirety. Each void in the cast charge exceeding ⅛ inch in volume is recorded in one of seven digital computers. When the total void volume exceeds safe limits, the defective region or zone is marked. The rate of inspection is approximately 300 an hour.

- **New system**—Sometimes, higher inspection rates are needed. To fill this need, a new high speed electronic scanning system has been developed, called TVX, which utilizes an x-ray sensitive television camera tube. Here the complete x-ray image of the material being inspected is projected on the face of the special pick-up tube.

Material analysis and penetration radiation dates back to 1912 but it is only recently that x-ray diffraction in missile and rocket work has moved from the research laboratory to the launching pad. Here this equipment serves as a fast and accurate analytical machine requiring only the services of a semi-skilled operator to interpret the data.

The operation is based on the principle that each compound in missiles and rockets has a distinctive crystalline structure which may be accurately determined by using a suitable source of x-radiation to measure the lattice constants. One example of its use as a process control is in determining the life and desirable characteristics of various elements of missile and rocket fuels.

Switching to elemental analysis, we find that one of the most promising innovations here is the x-ray emission spectrometer. The greater simplicity of the x-ray analysis method is due largely to the fact that the characteristic x-ray spectra are relatively simple, consisting of one or two lines while the optical may be made up of several hundred. By calibration with a known sample the intensity of the indication may be used to determine within one percent of relative accuracy the concentration of the element in the test sample.

In projecting future trends, there should be increasing widespread use of penetrating radiation due largely to the demands of continuous flow processes for high speed, non-contacting, accurate and non-destructive control devices.

In gaging, the low energy x-ray generator-detector system is coming more to the foreground. How far this trend continues depends on the ability to instrument to the tolerances required. Systems may be devised which conceivably may assure uniform density in free flow aggregates prior to processing. The x-ray scanning transducer opens up new areas for the complete automatic inspection of all missile and rocket components, limited in application only by the ingenuity of the designer. Material analysis, both as to structure and elemental content, will continue to grow.

Big Static Test Stand Completed at NOTS

CHINA LAKE, CALIF.—A horizontal rocket engine static test stand capable of handling engines of one million pounds thrust has been completed at the U.S. Naval Ordnance Test Station here.

The $650,000 installation was built primarily for testing of solid-propellant engines for the Navy *Polaris* ballistic missile.

The Navy says the stand is designed to provide a testing accuracy 400% higher than ever before achieved. The static test complex will be able to analyze propulsion characteristics to within .25% error, the Navy says, compared to 1% previously.

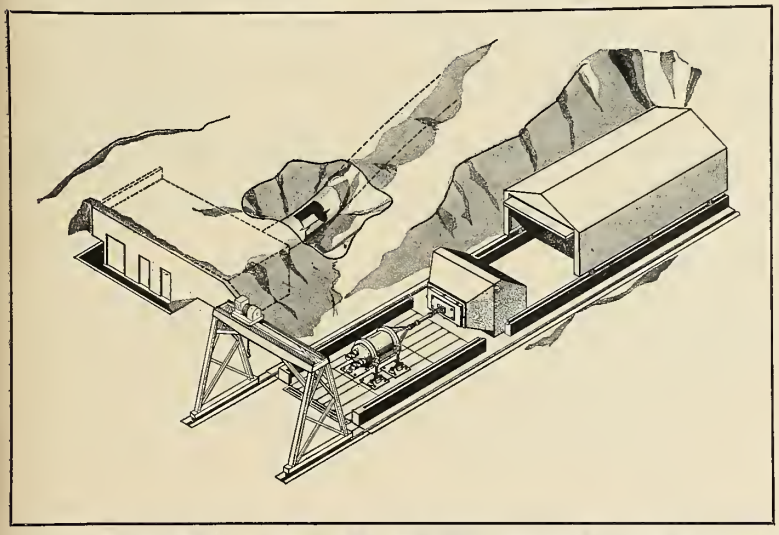
In addition to accommodating engines with an average thrust of one million lbs., the stand will be able to withstand peak loads of 10 million lbs. A test bay 35 feet long and 30 feet wide can accommodate rocket engines six feet in diameter, 30 feet long, and weighing up to 100,000 lbs.

The test complex is located in the Argus mountains.

In testing, the engine will be bolted horizontally to a steel platform, with its nose pushing against instrumentation which in turn will push against 12 inches of solid steel armor plate mounted on a concrete block 13 feet thick and 13 feet high.

A metal shed, which covers the test stand during early countdown to maintain temperature conditioning of the motor, moves away on rails prior to firing.

The firing control and instrumentation building is buried in a hillside a quarter of a mile distant and 37 feet higher than the test stand itself. Both analog and digital recording equipment is housed in this building.



NAVY'S new test stand at China Lake will accommodate engines with an average thrust of one million pounds and peak loads of 10 million pounds.

Infrared Symposium Indicates Field's Value

PASADENA, CALIF.—Infrared market may hit $5 billion by 1965, according to a prediction made at the secret Infrared Information Symposium held here under sponsorship of the Office of Naval Research.

The prediction was supported by turnout at the meeting, which drew more than 850 scientists from the U.S., Canada and Great Britain. Representatives of Army, Navy and Air Force also were on hand for the two-day symposium.

The gathering was the largest infrared information symposium ever held, exceeding expectations by 30%.

In addition to the estimate of $5 billion market by 1965, a spokesman for IRIS said IR should grow to a $500 million field within two years.

All sessions during the meeting were classified, but those who attended told MISSILES & ROCKETS the meeting was "extremely useful" and commented that "we've made some very good progress" in infrared.

While no data on the closed sessions was available, individual companies released some information simultaneously with the meeting.

Hughes Aircraft announced a new type of IR detector for tracking satellites and detecting ICBMs at "extreme" ranges. The detector is a copper-doped germanium crystal operating at liquid hydrogen temperatures and said to be six times as sensitive as existing detectors in the 8 to 25 micron range.

Hughes' new detector is responsive in microseconds to "very small" temperature changes, and the company feels it makes possible the detection of targets at extreme distances. A Joule-Thomson cryostat operating with hydrogen gas and liquid nitrogen was also developed in order to make the detector useful in rugged military equipment.

Subject matter of the classified sessions may be judged from the titles of some of the papers presented:

Low Card (Wright Air Development Center); Spectral Measurements of Missile Plumes (**Perkin-Elmer**); Measurements of Radiation Emitted by Ballistic Missiles During Re-Entry (**Barnes Engineering Co.**); Optical Radiation from ICBM Re-Entry Bodies (**RCA Service Co.**); Infrared Trackers for Ballistic Missile Defense (**Aerojet-General**); InSb Detector Development at the Royal Radar Establishment (RRE, Malvern, England).

Gaseous Infrared MASER Detector (Naval Supersonic Lab, **MIT** and **Block Associates**); Sky Backgrounds Produced by High Altitude Nuclear Bursts (AF Cambridge Research Center); The Infrared Transmissivity of Contrails in the 4 to 5 Micron Region (**Boeing Airplane Co.**); *Project Clinker* (Naval Research Laboratory); Visible and Infrared Spectral and Radiometric Measurements of Solid Propellant Rocket Motors (Boeing Airplane Co.); Missile Flash Measurements (**Ramo Wooldridge**); and Wide Angle Warning System (Santa Barbara Research Center).

Infrared-Tracker Development Progresses

BURBANK, CALIF.—In announcing recently the successful development of an infrared gunsight for West Germany's F-104G *Starfighters,* **Lockheed Aircraft Corp.** also revealed progress in the development of an IR tracking system for missile and aircraft.

Under a current Air Force contract, Lockheed will produce an IR tracking spectrometer to be used as a research tool for measuring target radiation spectral distribution. Observed data will be needed to produce a practical IR early warning unit.

Current schedule indicates that laboratory demonstration of the new unit will be possible within the next few months.

Ultimate goal is a system capable of locating and tracking an IRBM or ICBM within seconds after firing.

Energy Conversion Grows in Importance

New stress on space and potential commercial uses gives impetus to search for more and better ways to convert energy directly to electricity

by Hal Gettings

WASHINGTON—Tremendous strides made in the past few years in energy conversion—changing solar, chemical, and nuclear energy directly into electricity—indicate a growing field of intense interest to both industry and the military.

Recent advances—motivated by military requirements for space power sources in space, land, and undersea vehicles—show exciting potential for further progress. Direct conversion—just a few years ago thought to be neither technically feasible nor practical in usable amounts—has already been brought, in several cases, to the stage of working models.

Here is an area of research and development which would seem to be tailor-made for large segments of industry looking for new fields of endeavor. Increasing military interest—with consequent funding—and possibilities of tremendous commercial application offer an almost ideal combination.

Already at least 1000 companies are involved to some degree; there are estimates that the total may be 10,000 before long. This is no place for a bicycle-shop operation, however. Extensive research and development facilities staffed by experienced and capable people are required. Energy conversion cuts across many disciplines—physics, chemistry, thermodynamics, electronics, solid-state—and may even eventually lead to an entirely new breed of engineer.

In addition, a company needs in-house money to go along with military funding. Present programs indicate that most participating industries are at least matching government money. Several entirely company-funded programs involving large sums have produced significant results.

An interesting sidelight on the growing public interest in energy is the fact that at least one investment fund is devoted entirely to this field. Although the bulk of its $9 million investment is in conventional power sources, nearly 40% is devoted to companies involved in space power applications.

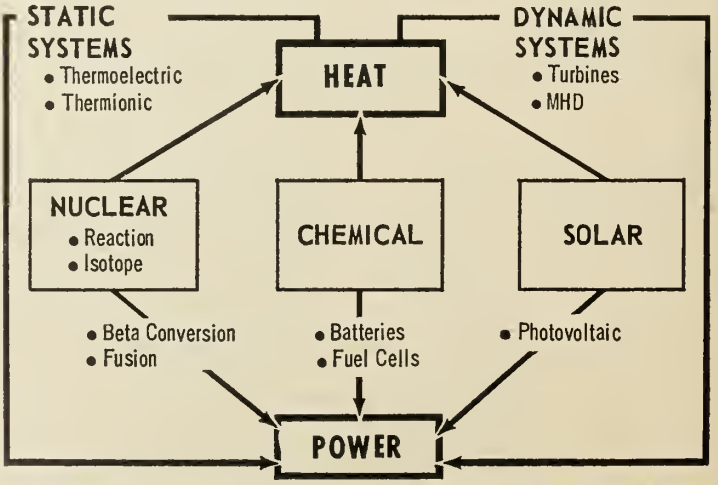
• **Military programs**—The energy conversion problem involves all the military services. New power sources are needed for space, for remote land operations, and for on and under the sea. Consequently, the entire Department of Defense is involved.

Efforts are under way to straighten out what looks, at first glance, to be a magnificent "can of worms." There is considerable optimism that the problems will be solved and that this may perhaps be one of the best-run and most productive military programs.

Research in this area is logically under the Research and Engineering Office of DOD. Total annual funding is now running close to $50 million; it is expected to be about 6% larger in fiscal 1960. Of this amount, $2.4 million is delegated to ARPA. Thirty-seven million dollars is allocated directly to the Army, Navy, and Air Force. About 50% of this is spent for basic research and the other half for applied research and end items. In addition, an estimated $10 million of DOD money is spent for engineering and production of new energy converters for satellite application.

Areas of energy conversion interesting to the military, exclusive of propulsion types, include photo-electricity and photo-chemical (solar systems), thermoelectricity, electrochemical (batteries and fuel cells), and thermionic emission.

Hopes for a concentrated and correlated push in this area lies mainly with the Interservice Group for Flight Vehicle Power. (This name will likely be changed since the field of energy conversion concerns not only flight but land and sea application. The Interservice Group (ISG) is directed by a steering committee with members from Army, Navy, and Air Force. Representatives from ARPA, NASA, and DOD R&E are associate members. Working areas are categorized into sev-



BASIC ENERGY may be converted into electrical power by both direct and indirect techniques. Direct conversion has now reached the working model stage.

eral working groups: advanced methods, batteries, chemical, combustion, electrical, mechanical, nuclear, and solar.

Operation of the ISG is based almost entirely on an informal working agreement. Its primary function is to effect interchange of information and assign work in the various fields among the services best qualified and most needing a particular application. The Navy's Bureau of Ships, for instance, has done extensive work in thermoelectrics, and is considered to have basic responsibility in this area. Army has been assigned fuel cells and solar cells. Air Force's main responsibility is in thermionics.

In spite of its theoretical perfection, the arrangement is not all sweetness and light. There is still a good deal of duplication and overlapping—desirable and otherwise—and perhaps a certain amount of jealousy and competition.

A particular problem is the fact that while all energy conversion is based on certain principles, the end use of the final device determines the direction that R&D must take to produce the end item. For instance, different systems might use the same basic thermoelectric generator but the final devices could differ significantly depending on whether their application was for land, sea, or space. This makes it much harder to assign definite responsibilities and areas to the various services.

One of the first items on ISG's agenda is to set up what will be called a "Power Information Center." It is intended to operate this Center on a contract basis; it will serve as a clearing house for information, conferences, and general administration of the program. The various military services will donate monies to finance it jointly, with later participation by AEC, NASA, and ARPA.

A meeting is being held this month to work out some of the details of the contract, expected to be let shortly after the first of the year. The contract will probably go to some university or non-profit research institution which already has the facilities and people necessary to carry out such a program.

The present chairman of this group is Arthur Daniel of the Army Signal Research and Development Laboratory; the contract for the information center will consequently be handled through the Army.

Another "unofficial" agency involved in this field is called the Advisory Staff for Aircraft Electrical Systems. This group is made up of representatives from various industries in the aircraft and missile fields as well as service representatives. It considers long-range weapons R&D programs and makes proposals for flight vehicle electrical power that will be required in the next five to ten years.

The last report, compiled this summer, goes far beyond aircraft requirements and covers, quite extensively, future requirements for the space and missile field. It emphasizes a strong recommendation for development of energy conversion processes for electric power for satellites. Although some of the recommendations appear to be very "blue-sky," it is estimated that everything suggested would be useful in the next two years—if it were available immediately.

• **Advanced Research Projects Agency**—Up until the present, ARPA has had primary responsibility for space power. This responsibility included formulation of programs and appropriation of money to the various services. However, since ARPA now is allegedly out of the space business, its future position appears somewhat fuzzy. Indications are that ARPA will assume a role of supervision for an advanced research program, leaving hardware development in the hands of the military forces.

Previously, ARPA had its own funds from DOD and appropriated them to various government agencies who did their own contracting. In Fiscal '59 the program involved $2.5 million; in '60 it was scheduled to be $3 million. It appears likely that some of the ARPA portion of the program will be turned over to the Air Force, which henceforth will administer the program as it applies to space.

• **National Aeronautics and Space Administration**—For Fiscal Year '60, NASA has responsibility for approximately $2.5 million for work in energy conversion. The bulk of this work is in solar cells and applications; the rest is on regenerative fuel cells. NASA expects shortly to inaugurate a solar-mechanical and solar-thermionic program and also give some support to photovoltaic techniques. It is expected that NASA will participate in the interservice group and their stated intention is to coordinate to preclude any duplication or overlap. The space agency's work is aimed directly at space requirements with interest primarily in systems of 1 to 300 lbs/kw for a few kilowatt power demand.

• **Atomic Energy Commission**—The AEC has its own budget appropriations, and most of the work in this area has gone into what is called the SNAP program. In Fiscal '59 this amounted to $13.1 million and in Fiscal '60, $14.3 million. This program has already produced some significant results. One so-called atomic battery, SNAP III, was first shown almost a year ago. Just last week a working model of SNAP II was displayed at the annual American Rocket Society meeting. This was a reactor capable of furnishing heat for production of three kilowatts electric power for space vehicles. It weighs approximately 220 lbs. without shielding and is fueled with enriched uranium. The SNAP III unit was a small isotope power device using a thermoelectric generator to produce small amounts of power.

• **Air Force**—The Air Research and Development Command has primary responsibility for carrying out the Air Force energy conversion program. In Fiscal '60 they had approximately $16 million to spend, and for Fiscal '61 will have an estimated $15 million. ARDC is involved in both basic research (AF Cambridge Research Center) and applied research (Ballistic Missile Division).

It is also understood that BMD will be responsible for programs turned over to the Air Force by ARPA. This has its problems, however, as well as inconsistencies. For one thing, BMD is under ARDC. For another, BMD at present has no technical management organization sufficient to carry out this program. It may be that the program at Wright Air Development Center and at BMD will be coordinated and enlarged to handle this technical management responsibility.

Present AF budget is divided on the following basis: solar, $4.5 million; nuclear, $2.5 million; nucleonics, $1.5 million; fuel cells, $1.3 million; fluids research, $1 million; advanced analysis $1 million; and a miscellaneous category of $4 million, most of which is actually for the B-70 and not applicable to the missile or space program.

The Cambridge Research Center will be managed by the Research Division of ARDC, which until the recent reorganization was the Office of Scientific Research. It is expected that it will probably be the end of this month before a firm program and mission assignment is set up—and possibly next spring before BMD is equipped to handle the program.

• **Navy**—The Navy's program of energy conversion is scattered among several agencies: Office of Naval Research, Naval Research Laboratory, BuShips and, to a small extent, BuWeap. Navy requirements are, of course, not in space but are in closely related areas as far as energy is concerned. It has in

(continued on page 42)

San Diego Is More Than LA Suburb

M/R survey finds area heavy in component manufacture and electronics work; some officials worry over reliance on military work

by Frank G. McGuire

SAN DIEGO, CALIF.—Often thought of by out-of-staters as a suburb of Los Angeles, this thriving city in southernmost California actually is, in its own right, a major factor in the Nation's aircraft/missile/space program.

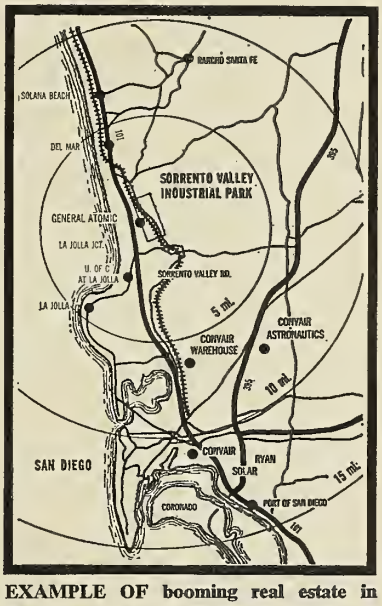
It has some of the largest aircraft and components plants in the world, the biggest concentration of naval strength on the West Coast, and a goodly portion of the electronics industry. Its workers have built the free world's first ICBM, some of the fastest U.S. jet fighters and drones, and what is billed as the fastest jet airliner in the world.

Greater San Diego has a population hovering around one million, ranking twentieth in the Census Bureau's list of standard metropolitan areas. Its population climbed 61% from 1950 to 1958. The 193-square-mile city has an an excellent climate—10 inches average annual rainfall and a daily temperature range of 54.5 to 70.2°.

• **Defense-dependent**—Of the 75,000 manufacturing employes in San Diego, 57,500 are in aircraft/missile payrolls—35,650 at **Convair Division, General Dynamics Corp.;** 11,050 at **Rohr Aircraft Corp.;** 6700 at **Ryan Aeronautical Co.;** 2200 at **Solar Aircraft Co.,** and the rest at other companies.

Many city officials have been decrying this lopsided dependence on aircraft/missiles and the military establishments in the area. "But for the success of the *Atlas* ICBM," says economist Eastman Hackney in *San Diego Magazine,* "San Diego still would be floundering in the doldrums of the 1957-58 recession." A number of study groups have been set up to find ways to diversify the area's expanding industry.

• **The run-down**—Convair, with its Astronautics and San Diego divisions,



EXAMPLE OF booming real estate in San Diego area is Sorrento Valley Industrial Park 10 miles north of city.

is the mainstay of the San Diego economy; the two divisions employ almost half the city's manufacturing workers. Other units of General Dynamics are **General Atomics,** at La Jolla, where 400 employes occupy a $10-million facility designated the John Jay Hopkins Laboratory; **Stromberg-Carlson,** which expects its SD facilities ultimately to be as big as those at its Rochester, N.Y., headquarters; and **Liquid Carbonic,** which has opened a new plant in the Kearney Mesa Area.

Convair (Astronautics) occupies a $40-million facility at Kearney Mesa, an area north and west of the city. The multi-unit plant is reputed to be "the largest, newest and most modern facility in the free world for integrated research, development and production of long-range missiles and space vehicles." Two six-story office and engineering buildings are coupled with an 834-foot-long factory building to provide this capability.

Rohr Aircraft Corp., the largest manufacturer of flight components, turns out bonded structures for the *Hound Dog* pylon, but has no other missile projects now underway. About 68% of Rohr's business is in commercial aircraft components.

Ryan Aeronautical Co., a $74-million-gross business in 1958, is deep in production of aircraft/missile components, jet target drones, electronics and navigation equipment, rocket engines and frames, as well as research and development work. Employment totals about 6700 with the great majority at the San Diego plants, located on a 48-acre site at the city's Lindbergh Field.

Ryan's drones have been almost standard items at air gunnery competitions including the recent William Tell II worldwide gunnery meet. To supplant its Q-24 drones, the company is producing the Q-2C version, capable of transonic speeds at over 50,000 feet altitude.

Explosive forming is another field in which Ryan is a leader; it is producing complex shapes to extreme tolerances with small explosive charges, and expects to put the technique to extensive use in component fabrication.

Lightweight steel structures, dubbed "MiniWate," are also being developed, with a view toward creation of extremely lightweight vehicles for aerial and space applications. The secret of the method lies in corrugation patterns.

Solar Aircraft Company, which recently closed its Des Moines facility, is working on advanced types of thrust chambers, nose cones, motor cases, valve systems, and other subsystems.

Some of the projects which Solar now has "in house" are for ARPA, NASA and various prime contractors on missile systems. The company aims

to establish as firm a role in the missile/space field as it has enjoyed in aircraft.

California General, one of the component producers in the area, has been turning out *Polaris* nozzles and other vital missile components at its Chula Vista plants. Experienced in working with refractory and exotic metals, CG has subcontracted on a number of missile projects.

Langley Corporation, specializing in hydraulic and pneumatic components, has been engaged in fuel and oxidizer handling and internal systems, cryogenic cleaning and various other services in the field. The 12-year-old company produced early-model *Atlas* fuel connections which have achieved operational status.

• **Small but able**—Electronics is a sizable business in San Diego, but not with the huge plants that characterize other electronic-industry areas. The great majority of electronics facilities here are relatively small, but their competence is reflected in their sales volumes.

Stromberg-Carlson produces four kinds of electronic products: equipment components (display tubes and deflection yokes, special purpose tubes, transistor and DC servo amplifiers); system components (airborne missile release computers); independent equipment (test devices for automatic checkout of missiles); and complete systems (high-speed editing, display and recording of computer information).

The San Diego plant of SC employs 400 people and occupies a 53,000-square-foot pair of buildings.

Electronics divisions within aircraft companies are a growing trend, and San Diego has its share of these. Convair, Ryan and other old-line aircraft manufacturers have gone into the electronics field and established facilities here.

Non Linear Systems, Inc., originators of the digital voltmeter, have occupied buildings located at Del Mar airport, a few miles north of San Diego. The company began operations about 1952, with production of the first digital voltmeter, and has been a leader in the digital instrument field. NLS has utilized plug-in modular construction and "no-needless-nines" logic in its products, in which the latter technique contributes to speed.

Daystrom Systems recently constructed a plant in La Jolla for production of automated systems, including power information, petroleum systems analysis, steel process control and nucleonics data collection.

Electro Instruments produces 80% of its products for inclusion in missile ground support equipment. The company turns out digital measuring instruments, graphic data recorders and precision amplifiers in a 43,000-square-foot plant on Kearney Mesa.

Hughes Aviation has entered the San Diego area electronics picture with the purchase of **Vacuum Tube Products Co.,** producers of special cathode ray tubes, storage tubes, vacuum measuring devices and other equipment.

Humphrey, Inc., suppliers of stabilizing gyros for rocket vehicles, also has in production a number of other instrumentation components for missiles. The company has enjoyed excellent growth in the field.

Cohu Electronics, a diversified company best known for its TV systems, has three divisions producing many types of amplifiers, meters, cameras (TV), remote controls, power supplies, hydrophones, sonar transducers, ultrasonic equipment, recorders, accelerometers, and a great number of other items.

The 15-year-old company consists of **Kin-Tel, Massa** and **Millivac** divisions, with the Kin-Tel division located in San Diego. Kin-Tel is one of the biggest names in closed-circuit television systems, although it also produces other items such as power supplies, amplifiers and various types of meters.

Cubic Corporation caused a flurry of stock activity in August when it issued over 100,000 shares of stock at $12 per share, which sold at $20 before the day's end. Producers of digital test equipment, data-handling systems and other electronic equipment, the firm sells 90% of its products to government agencies.

Kinetics Corp., located north of San Diego in Solana Beach, has climbed from 3 to 100 employees in less than three years. The six months period ending July 31 saw over $500,000 in sales recorded.

The company develops and produces telemetry equipment, including commutators and inverters. It was organized in February, 1957, and recently moved into a 20,000-square-foot plant.

Molectrics of San Diego, Inc., affiliated with an Inglewood firm of similar name, has been formed to engage in electrolytic machining and electropolishing of metals. The company will work principally on stainless steels for missile applications, as well as aluminum, titanium and chrome.

Stellardyne Laboratories, engaging in test of missile components, is a wholly-owned subsidiary of **Central Hadley Corp.** and has sales volumes over $1 million annually. The laboratory is one of the five largest environmental test labs in the country, despite the fact that it is just over two years old. It conducts more than 800 tests monthly, with missile components making up 80% of this volume. The company is diversifying into research activities, LOX cleaning and packaging, and other areas.

Real estate activities are booming throughout the San Diego area, with a number of industrial parks and other developments being promoted. One of the largest is Sorrento Valley Industrial Park, ten miles north of downtown San Diego. The valley will contain 780 acres of industrial tracts, straddling the Santa Fe Railroad's main line, and near the Route 101 freeway. The park lies within San Diego city limits and is served by local telephone and other utilities.

Kearney Mesa industrial park, being developed by the city, is a 450-acre tract lying between Convair-Astronautics and Montgomery Airport. **Narmco Resins & Coatings** has located in this tract, a supplement to its Costa Mesa facilities.

Devices Could Handle 300 Million Words/Sec.

NEW YORK—Electronic devices capable of handling information at the rate of 30 million words a second were reported here recently by a **Sperry Gyroscope** engineer at a meeting of the IRE Professional Group on Electronic Computers. At this rate all of the news material in 200 large daily newspapers could be transmitted in less than one second.

The new devices were created for developing computers and communications systems capable of handling large amounts of information at speeds at least 1000 times faster than large electronic computers currently in use.

Early use of these new high-speed techniques will probably be in systems simpler than computers, however. One possibility would be in a special communications system in which a message of 30 words could be transmitted in a millionth of a second. Such a system could transmit the complete message on a single radar pulse.

Another potential use is in a data reduction system involving simple operations such as correlating and counting where billions of events occur in an extremely short time.

Sperry scientists foresee this capability as a vital factor in future defense weapons in addition to providing a powful tool for accelerating advancement of science and technology.

Hufford: Spin-Forging Ahead

Firm will have 120″ diameter machine operating by next July; modification could give 150″ capacity; no help from the government

by Frank G. McGuire

LOS ANGELES—When the world's largest shear-forming machine—Hufford's 120″ diameter Spin Forge—goes into operation here next July, it will give the missile industry unprecedented ability to make structural sections having any surface of revolution.

Hufford Division of Siegler Corp. will use the giant to produce complex shapes as big as 120″ diameter and 300″ length. This will involve more considerations than metal working: a special power substation, a five-story building to house the machine, a 12½-foot-deep concrete foundation, and all the other complications involved in building and operating a 560,000-pound machine.

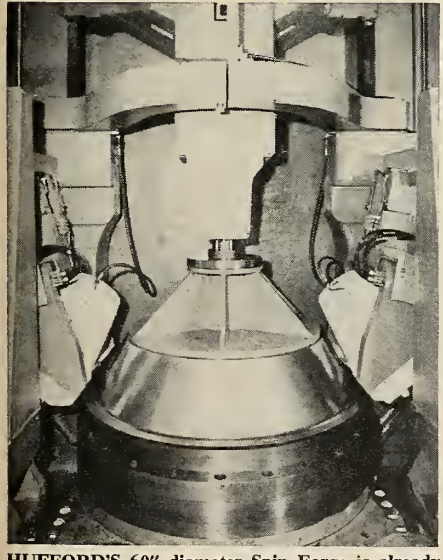
Despite estimates that the industry is not likely to require diameters over 120″, Hufford has designed a 150″-diameter potential into its new Spin Forge; it could be realized with little modification. The $1-million machine will be available to industry on a subcontract basis, and Hufford expects that the Spin Forge will be kept quite busy.

Materials for the 120″ unit will be about 60% steel plate and 40% steel castings. The costs are being borne by the company without government investment. Overall size of the Spin Forge is 310″ high, 440″ wide and 260″ deep, exclusive of the foundation dimensions.

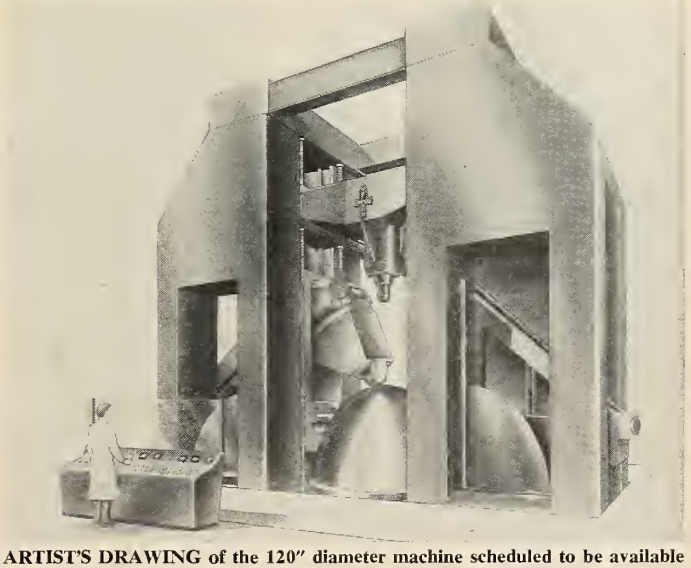
In order to accommodate the machine, Hufford will rebuild one of its present buildings into a five-story bay specifically designed for the purpose. Special mercury-vapor lights will be installed because standard lighting will not penetrate from the ceiling to the floor of the building. Reconstruction will cost $250,000.

• **How it works**—Control of the machine is accomplished through a hydraulic/electric system that is completely transistorized. It operates the Spin Forge through 360° on two axes. An electronic tracing head with stylus traces the template, and is coupled to an oil gear variable volume pump by an electro/hydraulic servo valve. This valve controls the output volume of the actuating system pump, and thus exerts control over the tool rings of the Spin Forge.

Two pump units are controlled by the double-axis tracer, one for vertical movement and another for horizontal movement. The tool rings are continuously synchronized. In conjunction with the spindle tachometer, the control system maintains a constant feed



HUFFORD'S 60″ diameter Spin Forge is already in operation turning out parts like this.



ARTIST'S DRAWING of the 120″ diameter machine scheduled to be available for subcontract work by July, 1960. A building is being rebuilt to hold it.

per revolution and a constant surface speed.

Heating elements within the mandrel can maintain the preform workpiece at up to 1000°F during the forming operation, in order to conduct the operation under the best metallurgical advantage. The Spin Forge is capable of applying one million psi to the preform during spindle operation from zero to 300 rpm.

Capable of turning a surface with varying wall-thickness, the 120" Spin Forge will maintain tolerances of .002". (Tolerances achieved on previous Spin Forge models were closer to .003".) Total power input will be about 2000 HP, supplied from the substation to be built by the **Edison Co.**

The most apt description of the Spin Forge process is that supplied by Dan W. Burns, president of Hufford: "It's just like clay on a potter's wheel —you place material on the spindle, rotate it, and work against it with tools during rotation." In operation, the Spin Forge handles metal as easily as a potter handles clay.

During production, a metal preform is placed on the mandrel and held in place by a vertical tailstock or hydraulic ram. The spindle is then rotated at speeds up to 300 rpm, and two massive tool-steel working rollers, exerting up to one million psi, move in to force the metal down and over the mandrel form. Under such great pressure, the metal "flows" and the grain characteristics change to provide superior alignment.

• **Many advantages**—According to Burns, one of the best features of the Spin Forge process is its ability to produce varying wall-thicknesses in sections like cones, hemispheres, cylinders, and paraboloid shapes. There are a number of other significant advantages: production of high-strength cylinders without longitudinal welds; improvement of physical properties of metals by simulating continuous forging; increasing tensile strengths by orientation and refinement of granular structure; revealing defects immediately, and revealing non-metallic inclusions in materials.

One of the non-physical advantages of the method is time saving. An example is fabrication techniques used in production of center-section structures for pressure vessels. A motor casing section made with the wrap-and-weld method, 100 by 50 inches, has a generally accepted production cycle of four hours. Roll forming the same section on a Spin Forge would require five minutes, plus handling time.

This 100-inch-long tube would be produced by placing a "doughnut" of metal on the Spin Forge mandrel, and by utilizing the tremendous force of the work rollers, cause the metal to "flow" vertically. A metallic ring 25" high, with a ¾" wall thickness and 50" inside diameter, would produce a 100" long cylinder with a 3/16" wall thickness. Finishing would be required only at the open ends, where welds might be desired.

Hufford, a 225-employe firm, was established in 1941, and has pioneered the Spin Forge process in the aircraft/-missile industry. The Spin Forge is currently being used in experimental production of first-stage engine forward domes for *Polaris,* which Hufford is making for **Aerojet-General,** propulsion subcontractor to **Lockheed.** The company is also making a limited number of *Polaris* equipment sections directly for Lockheed under a study contract.

Saturn booster bulkheads for propellant tanks are also being turned out on the Spin Forge machine at Hufford. A considerable number have already been delivered to the Army's Redstone Arsenal for fabrication.

Originally engaged only in production of stretch-forming equipment for the aircraft industry, Hufford has accounted for more than 85% of the world's stretch-wrap forming equipment and accessories.

Bureau of Standards Backs Plasma Study

WASHINGTON — A theoretical research study aimed at solving the basic problems in plasma physics is under way at the National Bureau of Standards.

The work is sponsored by the Air Research and Development Command. Part of it will involve establishing sound foundations for plasma theory.

A quantum theoretical generalization using the methods of quantum collision theory is being developed, and relativity considerations will be included later to arrive at a formulation which will apply to cases where electrons attain relativistic energies.

Wyman-Gordon Shows All-Beta Titanium Alloy

WASHINGTON—A 441-lb. closed-die forging of B120 VCA all-beta titanium alloy was shown here recently by the **Wyman-Gordon Co.**

B120 VCA also contains vanadium, chromium and aluminum. Wyman-Gordon said the alloy as forged develops 180,000-200,000 psi yield strength with 4% to 6% elongation. The 41.16" diameter forging was shown at the Eastern National Astronautical Exposition, held in conjunction with the American Rocket Society meeting.

The care and feeding of a missile system

It takes more than pressing a button to send a giant rocket on its way. Actually, almost as many man-hours go into the design and construction of the support equipment as into the missile itself. A leading factor in the reliability of Douglas missile systems is the company's practice of including all the necessary ground handling units, plus detailed procedures for system utilization and crew training. This complete job allows Douglas missiles like THOR, Nike HERCULES, Nike AJAX and others to move quickly from test to operational status and perform with outstanding dependability. Douglas is seeking qualified engineers and scientists for the design of missiles, space systems and their supporting equipment. Some immediate openings are described on the facing page. Please read it carefully.

Alfred J. Carah, Chief Design Engineer, discusses the ground installation requirements for a series of THOR-boosted space probes with Donald W. Douglas, Jr., President of DOUGLAS

MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ DC-8 JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND SUPPORT EQUIPMENT

Booster Scarcity Halts Space Effort

It will be two years before U.S. can match present Soviet space efforts, and many more years before it can hope to catch up

by C. Paul Means

WASHINGTON—The wake of Nov. 26's ill-fated *Atlas-Able* moon shot produced the public admission that the nation's belated, underfunded space effort has reached a dead end because no large boosters are left to get its ambitious projects off the ground.

The failure emphasized that the U.S. is at least two years away from matching present Soviet space feats, and past history has shown that the Russians will not stand still during this period. Present estimates indicate it could well be the latter half of the next decade before the U.S. space effort catches up.

A year-end inventory of the U.S. space program reveals these facts:

• All *Atlases* under production—the only boosters presently capable of lifting large payloads into space—are committed to military/missile space programs, and to the man-in-space program, Project *Mercury*.

• Lead time on new *Atlases* if ordered today is 18 months—15 months under a crash program.

• Scheduling is a great problem because only one *Atlas* launching pad capable of handling upper stages is in working order.

• Future U.S. space vehicles capable of matching *present* Soviet space feats—*Vega* and *Centaur*—will not be ready until the spring and summer of 1961 respectively.

• **$15 million down the drain?**—An example of NASA's present dilemma is the moon-orbiter project on which close to $15 million has already been spent.

Originally scheduled by ARPA, the moon orbiter's initial goal was to send a payload to Venus last June. This goal was set before scientists had determined the astronomical unit.

When the vehicle's payload was not ready by that time, NASA decided to orbit the moon with the payload in October. This attempt ended in late September when an *Atlas* Booster—the only booster given to the project—blew up during static test. The explosion also damaged one of the two *Atlas* pads capable of launching the booster with added stages.

NASA then became lucky when its meager inventory produced another *Atlas:* two *Atlases* were designated for Project *Mercury's Big Joe* experiment, but one proved to be enough. The second *Big Joe Atlas* was used for the belated Thanksgiving attempt.

NASA has another payload, but not another booster. It is therefore possible that the almost $15 million spent will go down the drain.

The space agency could divert an *Atlas* from Project *Mercury*, but to do so would further delay the important man-in-space program, already pushed back until 1963.

If NASA finds that Project *Mercury* could do with one less *Atlas*, it would take **Convair** approximately two months to modify the *Atlas* and place the three-stage **Space Technology Laboratories'** *Able* upper stage and guidance system on top, a Convair official said.

But even if an *Atlas-Able* were ready in two months, a launching pad would not be available. The one launching pad at Cape Canaveral capable of handling an *Atlas* with upper staging must also be used for military *Atlas* ICBM tests as well as for Project *Mercury*. Average time that a launching pad is tied up for one specific shot is four to six weeks.

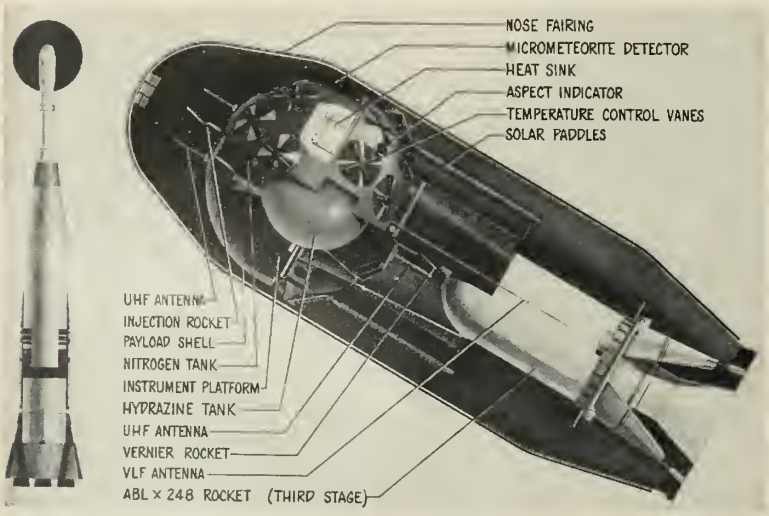
If NASA cannot spare one of its Project *Mercury* boosters, then it would have to scrape enough money out of its meager fund to buy more *Atlases*. It takes Convair 12 months to build one of the boosters, but lead time from order to launch is 18 months. This could be trimmed to 15 months on a crash program, M/R was told.

• **Marginal chances**—The final reason that an *Atlas-Able* will probably never be used to launch this particular moon-orbiting payload is that many NASA officials have serious doubts whether the vehicle could accomplish the mission.

The *Atlas-Able*—many in NASA say—is an interim vehicle that is being used as a stop-gap until *Vega* and *Centaur* come along and its chances of completing the moon-orbiting project are marginal. NASA is presently considering whether it is worth expending another *Atlas* booster and launch pad time to try again.

The cost of the *Atlas*, launch crew and launch expense would be about $4 million, bringing the total expense of the program close to $19 million. If NASA had to buy another *Able*, the cost would be greater.

One advanced concept for *Atlas-Able*, known as *Nomad*, has been sug-



PAYLOAD aboard unsuccessful *Atlas-Able* moon rocket.

gested, however. It would ultimately use a fluorine-hydrazine final stage which proponents say would place a 1100-1200 lb. softlanding payload on the moon within 18-24 months from project go-ahead.

With *Vega* and *Centaur* two years away from the launch pad, the U.S. space program for the immediate future—regardless of how much money Congress appropriates for space—is limited.

The only major upcoming shot is an attempt to place a *Thor-Able* (Dec. 10) into a sun orbit. This vehicle has the capability of sending information from as far as 50 million miles in space.

Shots planned for the next six months include:

- An attempt to send an astronaut 100 miles up and 100 miles down the Atlantic Missile Range atop a *Redstone;*
- Project *Tiros,* a *Thor-Able*-boosted meteorological payload which would take top-side pictures of the earth's cloud cover;
- Preliminary Project *Mercury* shots sending dead and animal payloads into orbit.

The latter half of 1960 will bring satellite orbit attempts with the new solid-fuel *Scout* and *Thor-Able's* successor, *Thor-Delta. Thor-Delta* conceivably could be useed for a moon-orbit attempt, carrying 100 pounds of payload, 35 pounds of which would be retro-rocket.

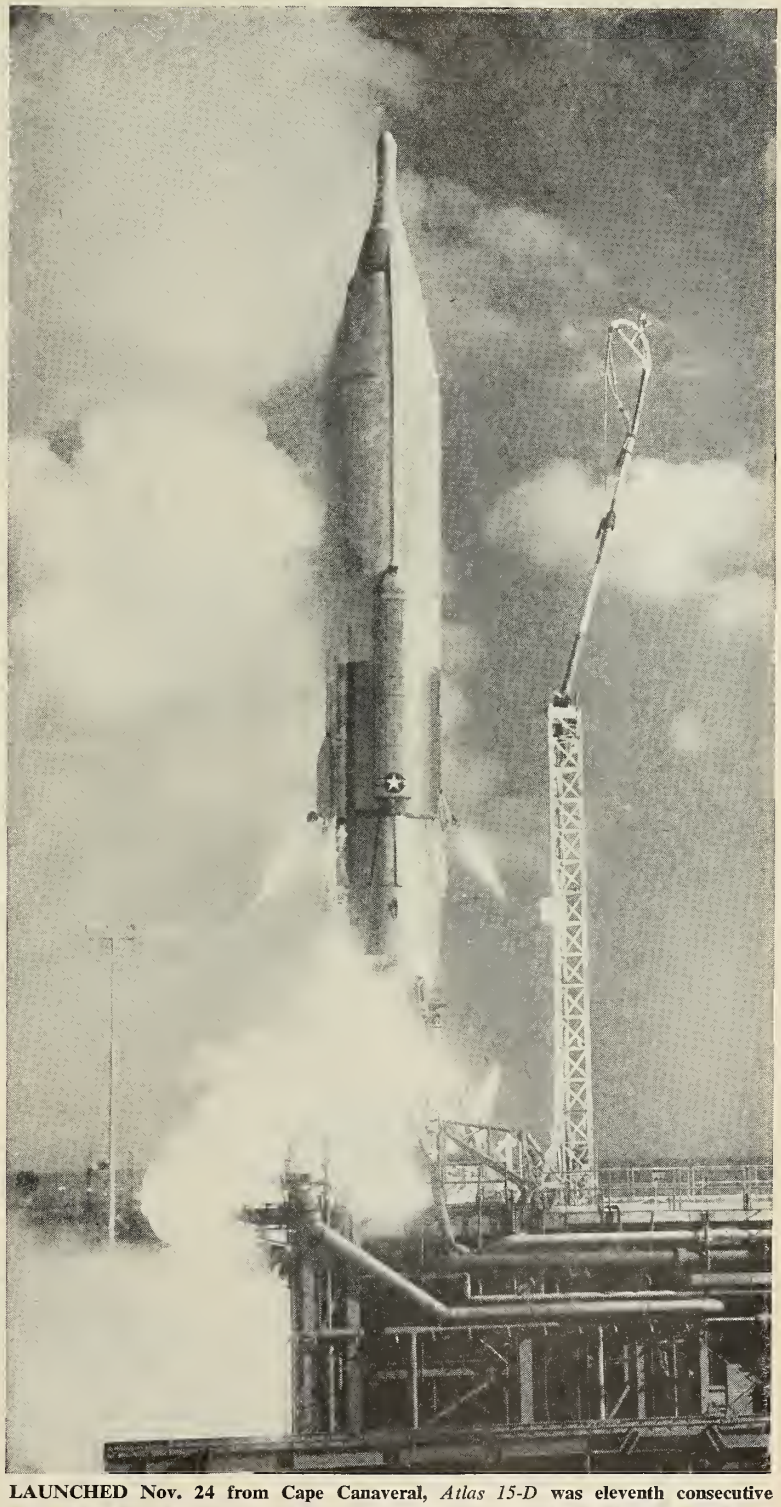
But until the *Vegas* and *Centaurs* are poised on the launching pad two years from now, no major space shots with the payload capability of *Mechtas II* and *III* will be attempted by this country.

One job the *Atlas-Able* or *Thor-Delta* will have to attempt is a Mars shot toward the end of 1960. The astronomical cycle for near planet probes is so long that the space agency will have to make the try with inadequate vehicles or wait many years.

- **Space program**—How can the United States overcome the present Russian space advantage? Most space authorities talked to by M/R reporters last week said the first hurdle is money. Our space program is inadequate now because of a lack of funds two years ago. Money spent now will not enhance our position until two years from now.

The M/R survey indicated that the four areas which should get the highest priorities are: nuclear rocket research; the development of liquid hydrogen-oxygen second-stage engines; Project *Saturn,* and systems affording a space rendezvous.

Blastoff of a Precious *Atlas*



LAUNCHED Nov. 24 from Cape Canaveral, *Atlas 15-D* was eleventh consecutive successful shot. In *Mercury* shoot, *Atlas 10-D* booster failed to separate but overall flight was so successful that NASA cancelled *Big Joe* operation. *Atlas* slated for second *Big Joe* was used on *Able* shot Nov. 26, giving Convair 12 successful and one partial success out of 13 shots since July 21.

Research-Core of the

Most powerful single chamber liquid racket engine ever built for manned flight—XLR-99—will drive the X-15

Test firing the XLR-99 . . . a major step in research supporting special design and production techniques.

North American Aviation Test Pilot, Scott Crossfield stands by the X-15—America's first manned space craft.

propulsion engineering...

By JAY HOLMES

The huge cost of big boosters . . .

has generated interest in the recoverable booster. And so schemes for recovery by parachute and glider are being discussed. There also is talk about recoverable ramjet boosters that would achieve part of the necessary velocity before a conventional rocket took over.

Obviously, a big saving is involved if the rocket—even a single stage—can be used again. This is likely to become a major consideration by the mid-60's, when we expect to be making frequent shots with multimillion-pound rocket systems such as *Saturn*.

But the savings may prove a mirage . . .

The cost of producing a single vehicle is often only a small part of the overall system cost. Development is usually the biggest item—at least until a few dozen vehicles are used. And so the savings on recovery of vehicles will only scratch at the overall expense.

On the other hand, making a vehicle recoverable adds to its complexity. This requires longer development time, and the cost of development largely depends on time involved. Thus the total cost could increase even though money is saved on recovering vehicles.

Reliability and performance also suffer . . .

when a vehicle is made recoverable. Reliability declines because the vehicle becomes more complex. Performance drops because the recovery system has weight. H. H. Koelle and H. F. Thomae of the Army Ballistic Missile Agency, Huntsville, Ala., have assumed in one calculation that recovery gear for a 1,941,000-lb. loaded booster would weigh about 30,000 lbs.—about 1½% of the takeoff weight.

Nevertheless, Koelle and Thomae concluded in a paper at last month's American Rocket Society convention, recoverable vehicles still may prove less expensive, if the annual firing rate is high. R. P. Buschmann of **Lockheed** reached the same conclusion about vehicles launched 100 times or more. David J. Jones and John O. Tearnen of **Convair Division, General Dynamics,** in the other paper given at the recoverable booster session, confined themselves to a finding that development of a rocket-powered winged booster is feasible.

This is more ammunition . . .

in support of the notion that we should settle on one big rocket and stick with it. Donald Ritchie's survey of Soviet propulsion (pages 17-19, this issue) indicates that the Reds have achieved fantastic reliability primarily by staying with one engine design and using it over and over again.

We could gain in reliability by doing the same—once we develop a booster with enough thrust to do the jobs we want to do in space. At the same time, we could take advantage of the recoverable booster concept. The money saved in recovery may make up for the additional cost of development.

New interest in ramjets . . .

has accompanied the talk about recoverable boosters. More than half of the launch weight of a LOX-RP rocket is oxygen. If air can do even part of the work, we may gain enough in performance to make up for the weight of the recovery gear.

A ramjet booster would take off horizontally. Lockheed's Buschmann suggests a vehicle fueled with hydrogen that burns in oxygen from the air and takes off from a 6000' to 8000' runway such as exists on present U.S. Air Force Strategic Air Command bases.

Perhaps the best measure of any such system is what Buschmann calls MOE, or "measure of effectiveness." The units of this parameter are dollars per pound of payload in orbit.

Portable Temperature Chamber Ready

An extremely accurate portable temperature chamber has just been announced by **Delta Design, Inc.** Temperatures can be maintained within ±0.2°F over a range of −100°F to +500°F. This close control is accomplished by a meter-relay in conjunction with a copper-constantin thermocouple.

The new 1060 Series includes a rack mounted model with test volume of 10″x7″x7″, two bench models with the same test volume, and a wide drawer model with test volume of 16″x7″x7″. Liquid CO_2 automatically cools three of the new chambers, while dry ice (solid CO_2) is used in the fourth chamber. Heating is accomplished by 650-watt electric elements.

The unit operates on 117 volts ac and contains a centrifugal blower to assure temperature uniformity throughout the test space, which is fully insulated with low conductivity inorganic fiber.

The liquid CO_2 cooled chambers, in addition to providing extremely fast temperature pull-down, can be programmed with a simple auxiliary timer to alternate between a high and low temperature. All chambers are constructed with stainless steel inner liners and are similar, except for control, to the Delta 6545 Series, which were introduced about a year ago. The new 1060 Series provides the utmost in convenience and accuracy in small temperature chambers.

Circle No. 225 on Subscriber Service Card.

Fluorinated Greases Available in Milled Form

Halocarbon fluorinated greases are now available in milled form for the first time. Milling makes available 100% polychlorotrifluoroethylene greases with conventional grease consistency, ranging from soft to medium, without the addition of any soap or silica thickeners.

A rust inhibitor is also offered for the first time in an inert Halocarbon grease. The Inhibitor, zinc chromate, is available in all series of the new milled form.

These greases, made by **Halocarbon Products Corporation,** are chemically inert, have high thermal stability, good lubricity, high dielectric strength, high density, and non-polar characteristics. Because of their chemical inertness the greases are extensively used as lubricants in missile propellant systems, particularly in those employing liquid oxygen, on launching rails and in liquid oxygen manufacturing equipment. The high density renders the greases useful as flotation media for inertial navigation systems. They are also utilized as coolants for high-power transmitting tubes and transformers.

The use of the Halocarbon greases in missiles prompted the inclusion of the rust inhibitor. The hot days and cold nights at both Cape Canaveral and Vandenberg AFB as well as the extreme cold of liquid oxygen, created severe condensation and rust problems with missiles on the launching pads.

The new milled greases are designated 25-10M and 25-20M. Those containing the rust inhibitor are 25-10MZ and 25-20MZ. They are available in 2 lb. polyethylene bags, for the clean filling of grease guns, in addition to the conventional containers in multiples of one lb.

Circle No. 226 on Subscriber Service Card.

Ultra-High Temperature Laminate Is Produced

A new grade of Dilecto laminated plastic designed for use in missiles and for other applications that require exceptional heat resistance, is announced by **Continental-Diamond Fibre Corp.** Made by impregnating graphite fabric with a heat resistant phenolic resin, the material is now known by the CDF lab designation N-104-84-2. It is still classified as a development item.

Pending further tests and patent investigations, Continental-Diamond Fibre Corp. is making laboratory sample quantities of N-104-84-2 available to companies that have a "DX-A2" Ballistic Missile Program priority. These samples are available in two forms: either laminated 6-in. squares in thicknesses up to ½-in.; or 3-in. dia. cylindrical moldings, made from macerated

impregnated fabric, in depths up to 2-in.

In laboratory ablation tests, a 6-in. square by ¼-in. thick sample of this new graphite fabric laminate was exposed to a 5000°F flame. It required more than 10 min. to burn through the sample, giving it a burn-through rate of less than 0.0005-in./sec. Typical burn-through rates for other materials are: 0.0017-in./sec. for phenolic im-

pregnated high silica glass; 0.002 to 0.003-in./sec. for phenolic impregnated felted asbestos and 0.004-in./sec. for phenolic impregnated glass cloth laminates.

Other physical and electrical properties of CDF's new Dilecto phenolic impregnated graphite fabric laminate are shown in Table I.

Circle No. 227 on Subscriber Service Card.

True FM Telemetry Transmitter Available

United ElectroDynamics, is in production on an FM transmitter for use in miniaturized telemetry systems.

Unit combines the best features of both transistors and vacuum tubes. All low-level and frequency-determining stages are transistorized to eliminate incidental FM noise produced by vibrating tube elements. Ruggedized subminiature tubes are used in the output stages. Unit is hermetically sealed for operation at all altitudes, and exceeds Mil specifications for salt spray and other missile environments.

This is a true FM telemetering transmitter, in which the frequency is modulated in accordance with the intelligence transmitted. Designated the TR-10, the unit has been flight-proven in a number of missile programs, and has been tested and certified in the laboratory.

The transmitter accepts inputs from and all other subcarrier oscillators operating in channels which meet MIL-STD-442. Power output is 2.5 watts in the 215-260 mc telemetering band, carrier frequency is crystal stabilized. Size: 4.25"x2.87"x1.53". Weight: less than 17 ounces. United also supplies small, efficient RF amplifiers which amplify the signals to 10 watts.

Circle No. 228 on Subscriber Service Card.

½ Amp. Fast Switching Silicon Diodes Available

A new series of high-current, high speed silicon switching diodes has been announced by **Sperry Semiconductor, Div. of Sperry Rand Co.**

Available in four voltages, the Series 1N690-1N693 diodes effect 0.8 usec switching of ½-ampere pulses and meet other stringent requirements of high current pulse circuits for high speed computer switching, pulse clamping, gating, blocking and diode logic circuits.

Designed for operation form −65°C to +150°C, these diodes also feature high forward conductance (400 ma at 1 volt) and low leakage (50 ua at 150°), and are especially suited for fast switching where current and temperature requirements are considerably in excess of the capabilities of germanium diodes.

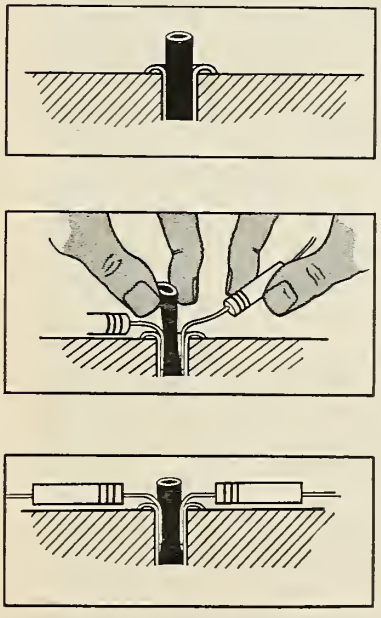
All units feature a maximum recovery time of 0.8 microseconds to return to 10K ohms when switched from a forward current 2 microsecond pulse of 500 ma to a reverse voltage of −50 volts, with a loop impedance of 1K ohm. Typically, these diodes will also switch from a 5 ma forward pulse to −40 volts (−30 volts for 1N690 diode) and recover to 100K ohms in 0.5 usec. (R_L = 2k, C_L = 10 u u f.)

Circle No. 229 on Subscriber Service Card.

Junction Cell Provides Fast, Solderless Connections

A new method of providing fast, solderless connections between wires and component leads has been developed by engineers at **Plastic Associates.**

The junction cell consists of a gold-plated eyelet and a long-wearing rub-



ber core (upper drawing). When the core is pulled upward, the rubber stretches, allowing wires to be easily slipped inside the eyelet. When released (lower drawing), the rubber core grips the wires or component leads, pressing them firmly against the gold-plated surface and establishing an electrical contact of essentially zero resistance.

Previous methods of providing fast, temporary connections of this type have generally depended on gripping the exposed wires between two opposing metal faces, as in the case of most clips, screw terminals and similar devices. This has caused trouble when the wires are of differing diameter since the larger wire "springs open" the holding device.

The new P/A junction cell solves this problem by gripping the wires between the metal surface of the eyelet and the soft, resilient rubber core. The rubber shapes itself around each wire, no matter what its size or shape. At the same time the rubber provides a firm gripping action that is essentially immune to vibration or shock.

Circle No. 230 on Subscriber Service Card.

Mobile Data Reduction Unit Contained in 40 Ft. Van

A mobile analog-to-digital conversion and data reduction system, contained in a 40′ semi-trailer van, has been developed by **Consolidated Avionics Corp.,** a subsidiary of **Consolidated Diesel Electric Corp.**

The system is capable of accepting up to 215 transducer output signals. It records the data in both analog and digital form and converts the input signals into a form suitable for data processing. A complete system recently delivered to the Army Ballistic Missile Agency is provided with a data storage medium which is compatible with the entry requirements of the IBM 704 computer.

The van is equipped with means for recording analog information on magnetic tape, strip chart graphic recorders and direct writing oscillographs, as well as on meters which provide visual readings.

A bar-graph oscilloscope provides a continuous visual display of 60 channels, enabling personnel to note what is taking place as the analog information is being commutated and converted into digital form at the rate of 600 samples per second. The digital data train is linearized digitally and along with time codes, decimal point location, channel identification and synchronization data, is recorded on magnetic tape, ready for feeding into a computer.

Data values for up to 20 channels may be printed out by direct playback from the digital magnetic tape. This is made possible by inclusion of tape search and editing facilities as well as channel and sample rate selection circuits.

A patch panel permits interconnection of any input signal to one or more recording instruments which may be operated simultaneously. The system may be operated from a control console in the van or from a remote location by removing a section of the console.

Circle No. 231 on Subscriber Service Card.

Polaris in 1960
Highlights of Final McElroy News Session

by Betty Oswald

WASHINGTON—The **Lockheed** *Polaris* will be operational at sea within a year, according to Defense Secretary Neil H. McElroy.

The retiring Pentagon chief told a farewell news conference last week that test results so far have supported the decision to continue production of the missile and construction of *Polaris*-carrying submarines.

The Navy missile will have initial operational capability on-station by the end of 1960, McElroy said, and after that there will be "one (produced) every four months for as far down the road as we can see."

He said the **Convair** *Atlas* ICBM program was also proceeding well. "We are satisfied that the *Atlas* is a proved weapon and are moving ahead vigorously to deploy it."

McElroy's letter of resignation, effective Dec. 1, was accepted by President Eisenhower, who presented him with the Medal of Freedom "in recognition of his outstanding service to his country and his dedication to his task."

The President immediately named Defense Undersecretary Thomas S. Gates, Jr., to succeed McElroy in the top Pentagon post.

• **Gap confirmed**—Despite his optimistic comments on *Polaris* and *Atlas*, McElroy stated that a missile gap in favor of Russia will exist from 1961 through 1962—and perhaps into 1963.

During this period, he said in answer to questions, "if they build what they could build, and if we build what we intend to build, we think they will have more missile capability."

On the positive side, in addition to *Atlas* and *Polaris*, McElroy cited the **North American** *Hound Dog*, being rapidly developed for use with **Boeing** B-52 bombers. He said *Hound Dog* now has a range of about 500 miles and does not interfere with the bomb-carrying capacity of the B-52.

McElroy did not mention the **Martin** *Titan* ICBM as a major factor in Pentagon planning. When asked to explain this, he merely said "it is intended that *Titan* will continue in the picture."

When he was asked why the U.S. did not buy more missiles to close the admitted gap, McElroy said "the first generation of any new weapon is going to be superseded mighty quickly by a much improved successor." For this reason, he added, the **Boeing** *Minuteman* solid-fueled ICBM is receiving

optimum funding and *Minutemen* are scheduled to be in place in 1963.

As for anti-missile defense, McElroy noted that, although a decision has been made not to produce the **Western Electric** *Nike-Zeus* AICBM in Fiscal 1961, the budget does include "a very generous support of a research and development program."

He reported substantial progress in development of surveillance drones for use in limited war. He said they go up and fly at a speed of about 200 miles an hour over a wide area, photographing what they see below. Then they come back to their point of origin and are landed by parachute, giving troops a chance to quickly examine the film and select targets.

• **Space report**—On the space front, McElroy conceded that there have been a number of disappointments. He pointed out, however, that the *Discoverer* project had achieved considerable success—even though none of its satellite capsules had yet been recovered.

"Of course," the retiring Cabinet officer said, "we would all like to put something around the moon. This happens to be in our civilian space program now. We would like to get up satellites that have special reconnaissance capabilities and keep them up there, and we would like to put satellites up that have special communications capabilities. I am sure that we will do that, and the programs are rolling along—in my opinion—very well."

Solar Energy Device Can Produce AC or DC Power

WASHINGTON—A new type of solar energy converter which can produce both alternating and direct current at high voltage has been developed by **International Telephone and Telegraph Co.** scientists. The device, shown for the first time at the ARS meeting here, is a ferroelectric converter. It operates by being alternately exposed to sun and shadow—as would occur in a spinning satellite. It could also operate by being heated by a thermonuclear or other heat source.

The converter unit is a ferroelectric ceramic sandwiched between charged plates. When heated, it transfers electrical energy to the plates, increasing the voltage. A single converter element, the size of a dime, can provide outputs of 1000 volts. Outputs of one million volts are theoretically possible with elements connected in series. ITT engineers calculate that the device is potentially able to provide better power output per pound than existing satellite power supplies.

Big Liquid Hydrogen Plant Proposed

by G. V. E. Thompson

LONDON—**Petrocarbon Developments Ltd.** has estimated the costs of producing liquid hydrogen and are considering erecting a manufacturing plant. In addition to its use as a rocket propellent and in the chemical process industries, liquid hydrogen would be of interest to the electronics industry as a refrigerating medium.

Hydrogen gas would be obtained at an average price of $280 per ton, the possible sources being by electrolysis of water, from petroleum refinery gases, or by refining various hydrocarbons with steam. Hydrogen from refinery gases is purer than that obtained by electrolysis and costs much less (around $150 per ton). However, the supply from this source would be insufficient and would have to be supplemented by reforming ($350 per ton hydrogen).

Petrocarbon have assumed a production rate of 16,000 tons per year and allowed $17 million for capital expenditure. Operating costs have been worked out for a pressure of 8 atmospheres and continuous operation. Power, steam and water, insurance, overheads, chemicals, etc., would cost about $3 million per annum; labour (50 men) and capital depreciation would bring the total to about $5½ million.

This size of plant has been determined by the probable consumption not of the hydrogen, but of the heavy water which could easily be produced by distilling the liquid hydrogen to separate the deuterium it contains, and then burning this. About 11 tons of heavy water could be obtained from 16,000 tons hydrogen (whatever its source) and would have a market value of $28 per pound.

Allowing for the value of the heavy water produced, liquid hydrogen could become available at about $600 per ton. To this sum must be added the expense of maintaining the material in liquid form during storage and transport; the price would still be economic for any firm using appreciable quantities of hydrogen. As a rocket propellant, of course, hydrogen is the most powerful of all fuels.

The proposed plant would use the Cascade process (cooling with a series of liquefied gases boiling at successively lower and lower temperatures) to reduce the temperature of the hydrogen gas to 85°K (—188°C). The coolants used would be liquid ammonia and nitrogen. Further cooling would be obtained by allowing part of the gas to expand through turbines, removing heat from the remainder. Eventually the hydrogen would be liquefied; further cooling would require the use of helium as a refrigerant.

A possible source of trouble is the presence of impurities in the hydrogen gas supplied to the plant. Gases such as nitrogen and methane become solidified and can then erode the equipment and deposit in heat exchangers. Laboratory liquefiers feature activated carbon purifiers for removing the impurities, but these are considered to be too expensive for the large-scale plant. Since the nitrogen concentration tends to rise rapidly on compression, the pressure is being restricted to 8 atmospheres absolute.

Heat economy is important, and the plant will be lagged with expanded plastics. Special attention will be paid to equipment handling gases at temperatures below —200°C. These will be placed within vacuum shields or surrounded with hydrogen itself. This is not the most effective insulant; nitrogen has a thermal conductivity only one-sixth of that of hydrogen, but suffers from the drawback that it deposits solid crystals at the temperatures under consideration. Liquid air is unsuitable because of the potential explosion hazard.

Long runs without maintenance are essential, for similar reasons. Metals suitable for use in the plant include copper, stainless steel and aluminum. The heat exchangers will be built of aluminum, to facilitate movement when they have to be removed for cleaning. After cleaning, it will be necessary to cool the exchangers down to operating temperature before replacement, and this will be done by including them in progressively cooler sections of the hydrogen line.

There are many problems to be solved in the detail design of the plant. These include the selection of the most efficient types of compressor and exchanger, fixing the sizes of the expansion turbines, etc. Allowance must be made for the appreciable shrinkage that will take place when the plant is cooled down to operating temperatures. Pipelines for transporting the liquid may be vacuum-lagged with an additional stream of liquid nitrogen outside the vacuum space.

Progress with *Black Knight*

Development work with the *Black Knight* experimental rocket has been proceeding at Woomera, Australia, and in its fifth firing a height of more than 450 miles was obtained. The velocity reached was more than ten times the speed of sound.

Firing again took place at night the primary object of the trial being to study the effects of re-entry on the nose cone. The rocket is said to have landed within the prescribed area very near the planned impact point; and next morning the Royal Aircraft Establishment recovery team were able to go direct to the landing spot.

Space Law Problems

In his annual lecture in the series "Current Legal Problems," Dr. Bin Cheng of University College, London said that whenever there was a new technological development it was accompanied by demands for a new system of law. There is, he said, no space law other than a projection of existing territorial laws in outer space.

He said it was unnecessary to create a new system of law; existing international law should be adapted to meet the new problems. Some scholars have suggested that laws for outer space should be based on moral principles but it was important to realize that there was no universal moral code on earth. There was no reason to suppose that man's social behaviour in space would be any different from that on earth.

Coating Advance

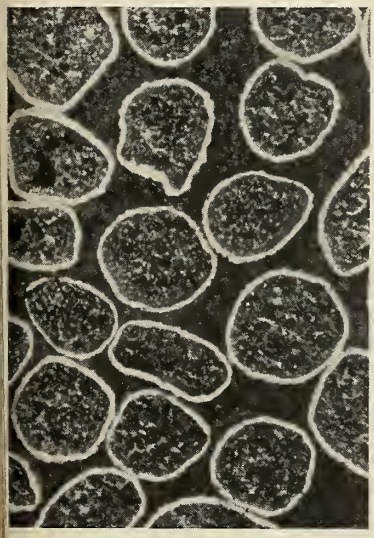
NUMEC Applies Metal To Ceramic Particles

APOLLO, PA.—Micron size particles of ceramics have been successfully coated with thin films of metal by scientists at **Nuclear Materials and Equipment Corp.**

The process is much broader in scope than the coating of ceramics. Arthur Weis, NUMEC's Customer Service and Contracts Manager, explained that the ceramic coatings can be applied to small particles of metals and that metal coated metals are possible.

The ceramic particles can be compressed and shaped or suspended in a plastic medium. The particles can also be applied to a surface by conventional means. Company spokesmen feel that deformation of the substrate in such a case would not be detrimental.

Weis said that the concept permitted the varying of the metal-ceramic



CROSS SECTION OF NUMEC'S nickle-coated uranium oxide in plastic medium (100X). Note uniformity of the film.

concentrations when and where needed with comparative ease.

The process enhances the high-temperature applications of ceramics and cermets by combining the properties of metals with the characteristics of the refractory substances.

NUMEC is primarily involved in production of enriched uranium fuels for reactors and is engaged in research and development projects relating to high-temperature materials. The company recently fabricated a small rocket nozzle from an alloy of metals and ceramics which withstood 2500°C for sixty seconds in a stream of hot gas.

Energy Conversion

(continued from page 24)

operation a coordinated and concentrated effort in energy conversion that has already produced significant results in thermoelectrics. Most of the Navy's money to date has come from ARPA, but with the new organizational setup it will probably be necessary to fund most of its projects in-house.

The Office of Naval Research power branch is responsible for coordinating the Navy effort. Its primary mission is to support basic research programs, mainly in materials. Current ONR funding amounts to about $600,000, spent on contracts to various universities, industrial and research organizations. The ONR program was started modestly in 1955 with basic research in fuel cells and thermoelectrics funded for $150,000.

Naval Research Lab works under ONR and acts primarily as a contractor to other Navy agencies as well as to other services. It supports material research and furnishes measurement facilities. The Lab's energy conversion branch works primarily in applied research and also concentrates on devices in several areas.

The big Navy effort is presently centered in the Bureau of Ships. Current funding totals around $3-3.5 million, with the bulk of this going to materials development. BuShips has concentrated in thermoelectrics and has seen considerable success in this program. They also have done some work in fuel cells. The Navy is primarily concerned in the program as a facet of work on the ultimate submarine. BuShips funds come from in-house R&D money as well as from other agencies such as ARPA and NASA.

Navy's Bureau of Aeronautics (or BuWeap) is just getting into the business. It is conducting investigations into the advisability of doing research in some of these areas and supporting work, but to date no money has been allocated. Interest is primarily in thermoelectric systems powered from propulsion heat and in heat storage devices. Some interest has been expressed in fuel cells.

• **Army**—Army's assignment in the interservice group has been primarily in fuel cell development and in solar cells. It contracts through several different agencies: Signal Corps, DOFL, Transportation Corps, European Research Office, Corps of Engineers, BuAer, ONR and WADC. Completed and current contracts run better than $2 million. Support for fuel cell research projects is set at an annual rate of around $500,000.

The Signal Corps has sponsored annual power sources research and development conferences since 1947. This conference first reported work on fuel cells in 1955. The 13th annual conference this year covered thermoenergy conversion, nuclear energy sources, solar energy, fuel cells, and batteries.

Army feeling is that conventional power sources such as primary batteries and engine generators no longer meet the needs of a modern Army. By 1965 they estimate that most of present conversion sources will be obsolete.

Although indications are, as pointed out before, that there may be much lost motion in the military's energy conversion program, there appears to be hope that much will be done in the next few years. There is certain to be increasing need for exotic power sources for missiles, in space, and for underwater applications. Parallel with the developments coming out of military programs will quite likely come developments for the commercial field. One scientist working in this area has stated that he would not be surprised to see within five years automobiles operated on fuel cells.

• **Washington**—NASA announced it would launch next spring a 100-foot-diameter inflatable aluminum-covered sphere into a 1000-mile-altitude earth orbit. Object is to test feasibility of a passive reflector communications systems on a global basis. Inclination will be about 50° to the equator and orbital period will be 120 minutes. Launch will be by *Delta* vehicle with three shots planned under code name of *Echo*.

• **St. Louis—McDonnell Aircraft** received a contract amendment to build six additional space capsules for Project *Mercury*. The new order brings the number of capsules ordered by NASA to 20.

• **Cape Canaveral**—*Thor* fired Dec. 1 carried movie camera to take first high-altitude color pictures of the earth. Capsule landed slightly short of the intended impact area and Air Force called off search 90 minutes after firing.

• **Washington**—Bureau of Naval Weapons—a merger of Bureau of Ordnance and Bureau of Aeronautics—went into operation Dec. 1, several months ahead of schedule. New bureau will get about 40% of Navy's budget and 70% of its R&D funds, along with some 204,000 military and civilian personnel.

• **Washington**—Defense Department said two high-powered radar units—one a modified **RCA** unit originally designed for BMEWS system, the other a **Raytheon** unit—will be used to detect and identify incoming missile warheads on an ARPA installation at Rol Namur Island in the Pacific. Experiments, using unarmed IRBM-type missiles launched from Johnston Island, goes under the title of Project *Defender*.

• **Washington**—NASA asked Congress for broad leeway to grant patents to industry on inventions developed through government-financed research. Aerospace Industries Association told the Mitchell Subcommittee of the House Science and Astronautics Committee present patent provisions in the Space Act deny NASA freedom to promote space technology as rapidly and efficiently as possible.

• **Paris**—Scientist Anatoly Blagonravov of the Soviet Academy of Sciences said Russia soon might build 60-passenger rockets and that present Soviet rockets are powerful enough for such craft.

• **Canberra**—The Australian Government announced it has decided to order the **Bristol Siddeley** Thor ramjet-powered *Bloodhound* surface-to-air guided missile. Sweden has also chosen *Bloodhound* for anti-aircraft defense.

• **Los Angeles**—NASA—although it will have about 20,000 people—will only be able to handle about 15% of its work in-house and industry will get the remainder. This estimate was made by Abe Silverstein, Director of Space Flight Development for NASA, at a meeting of the Institute of Aeronautical Sciences here. Silverstein told M/R no decision has been made on whether to use *Titan* or *Titan-C* for second stage of *Saturn*.

• **Ogden, Utah**—Air Force said production plant for first stage *Minuteman* motor would be built on **Thiokol** facilities near Brigham City. *Minuteman* assembly and repair facilities wil be built at Ogden, with **Boeing** operating this unit. A former ordnance plant adjacent to Hill AFB will be used for assembly of the missile.

• **Cape Canaveral—Tool Research and Engineering Co.** of Beverly Hills will build for **Kaiser Steel** a six-story-high, completely mobile launcher for 50-foot *Pershing* missile. TREC has contract for one unit, with follow-on contract possible.

• **New York—International Nickel Co.** announced development of a new family of very-high-strength steels containing about 25% nickel, which have yield strengths from 250,000 to 290,000 psi. Nickel content varies from 20 to 30% with smaller additions of titanium and aluminum.

• **Golden, Colo.—Coors Porcelain Co.** opened new facility for production of dense ceramic parts from beryllium oxide compositions.

• **New York—Schwarzkopf Development Corp.** announced new process for producing tungsten ingots with weights up to 200 lbs. Tungsten cylinders of about 8″ diameter and 8″ height are formed from powder in large-capacity presses. Blocks are sintered and forged at high temperature.

• **Dallas-Texas Instruments, Inc.** said the electronics industry's first all-solid-state, 400-MC beacon transponder, carried in a *Thor-Able* Sept. 17, responded from 1300 miles in space to an MIT Lincoln Laboratories Millstone radar which tracked the missile from horizon to horizon during 14 minutes of flight. Unit is capable of 40 hours continuous operation, weighs 6.3 pounds and occupies 0.058 cubic feet.

• **New York**—An **International Telephone and Telegraph Corp.** multiplier phototube used in a balloon ascent 15 miles above the earth on Nov. 28, converted into electrical signals the light reflected off Venus' impenetrable atmosphere. It amplified the signals two million times, producing data which indicated presence of water vapor.

• **Chicago—International Harvester Co.** offered to purchase **Solar Aircraft Co.** by an exchange of stock. Proposal calls for Harvester to offer Solar stockholders one common share of Harvester for each 2¾ common shares of Solar.

• **Washington**—Mergers, expansions, acquisitions: **Leach Corp.** purchased the **Electronics Division** of **Pendar, Inc.** . . . **Chromally Corp.,** White Plains, N.Y., acquired **Sintercast Corp. of America,** Yonkers, N.Y., producer of special tool materials, boron, tungsten and titanium compounds and nuclear reactor metals . . . **General Magnaplate Corp.,** Belleville, N.J., acquired **Eastern Testing Laboratories,** Corona, Long Island . . . **Thompson-Ramo-Wooldridge Products Co.** leased additional space in Beverly Hills which represents a 20% increase in the facility . . . **Douglas Aircraft Co.** announced establishment of an advanced research organization in Santa Monica . . . **General Dynamics Corp.** and **Material Service Corp.** of Chicago signed an agreement calling for merger of the latter into Dynamics as the Material Service Division, subject to approval by share owners.

• **Washington**—Late contract awards: Additional $5,250,000 order to **Westinghouse Electric Corp.** for initial work on launching systems for equipping four fleet ballistic missile submarines . . . A $270,000 contract to **Sylvania Research Laboratories** from **Aerojet-General Corp.** for development of refractory metals, alloys and compounds for solid fuel motors.

missile business . . .

By WILLIAM E. HOWARD

It will come as heartening news to some that the Air Force now is showing signs—after being designated the nation's military "space force"—of preparing to make a stiff fight next year for a realistic space program. And not merely as some sort of glorified handmaiden to NASA.

On the contrary—the AF may be battling NASA . . .

for top role when various congressional committees begin digging into such questions as why the U.S. is behind Russia and whether Soviet achievements have any bearing on the security of the nation.

Quite clearly, the AF is ready to challenge the whole Eisenhower doctrine that space belongs solely to "science." The first official expression opposing policy came a few days ago from Lt. Gen. Bernard A. Schriever, commander of ARDC, in a speech to the Aero Club of Washington. (Schriever, incidentally, admitted frankly that the speech had been well-laundered in advance by security review.)

Said Schriever: "We cannot afford to concentrate solely

on scientific explorations in space, and ignore its vast extension of the air as a theater of military operations. Our adversaries are not bound by either legal restrictions or moral law, limiting their exploration of space to peaceful scientific objectives.

"It is commonly accepted that their effort is a total one . . . to control any territory within their reach. For this reason, we cannot afford to set our military services apart from the scientific and industrial community, confining our use of the techniques and facilities which we have developed solely to the refinement of existing weapon systems."

This is a clear-cut statement of the issue—pure science vs. military use of space—that Congress and the Nation must come to grips with, if future programs are to have any perspective and objective. It is the hope of many in industry that this issue will be weighed against the broad perspective of history—which shows a consistent record of military technology moving ahead with almost every scientific advance. This may seem an obvious fact, but it appears to escape many leaders when they start peering into space.

One for the calendar . . .

After Jan. 1, four of **General Precision Equipment Corp.'s** seven divisions—**Kearfott, Librascope, Link Aviation** and **General Precision Laboratory**—will all be consolidated into one division. It will be called **General Precision Inc.**

One to watch . . .

The newly formed **National Electronics Facilities Organization Inc.** is an experiment in industrial teamplay. **Servo Corp., General Transistor Corp., Blount Brothers, Specialty Electronics Development Corp., Nytronics Group,** and **Technical Research Group** have united into a "super corporation"—NEFO—to bid as a prime on military contracts. Each company will retain its separate corporate identity and, as such, will still be competing with its teammates for subcontracts.

The group as a whole has a total of 4000 employes and assets amounting to some $25 million. And the blessing of Wendell B. Barnes, retiring head of the Small Business Administration, who said:

"I shall watch your progress with interest and trust that your example will be followed by many other such combinations."

people


SAINE

Dr. Vergil L. Saine, formerly assistant director, has been appointed director of solid propellant operations at the Ordill plant of Olin Mathieson Chemical Corp.

Dr. Saine joined the firm in 1951 and has held various positions in the technical and production departments relative to development and manufacture of rocket propellants, cannon propellants and supporting raw materials. He previously worked with Hercules Powder Co. and Carbide and Carbon Chemical Corp. in atomic energy research.


FARRIOR

Lockheed Missiles and Space Division has announced the appointment of **James S. Farrior,** nationally-known missile guidance expert, as *Polaris* missile system guidance manager. He replaces **A. F. Blight,** who assumes the position of *Polaris* internal systems manager.

Farrior was previously with the Army Ballistic Missile Agency, Redstone Arsenal, where from 1951 to this year he was chief of the navigation branch responsible for the *Redstone, Jupiter* and *Pershing* missiles.

R. B. Parkhurst, who has been vice president and manager of the Products Group of Hughes Aircraft Co., has returned to his position of vice president-manufacturing on the corporate staff, and **I. F. Richardson,** former director of programming, Airborne Systems Group, has been named manager of the Products Group. Before joining Hughes, Richardson was general manager of the Kansas City division of Bendix Aviation Corp.

Jack Parkin has been assigned corporate project responsibility for the *USD-5* surveillance drone being developed by the Fairchild Engine & Airplane Corp. for the U.S. Army.

Parkin was previously with Bell Aircraft where he was assistant project manager of the *Rascal* program, director of engineering of the Bell Avionics effort and more recently manager of the Bell Task Force, established to integrate the *Rascal* into Strategic Air Command operations.

He succeeds **Grayson Merrill,** who has been operating in the dual capacity of general manager of the Astrionics Division and corporate *USD-5* manager. Merrill will now devote his full effort to general manager-Astrionics.

Due to the recent expansion of the company, Feedback Controls, Inc., manufacturers of electronic components and systems for control and computation, has transferred **Rear Adm. William S. Harris** (Ret.) to the home office in Natick, Mass., to assume the position of vice president-administration. **Fred Thompson** was also promoted to Eastern Division Sales Manager.

William K. Squires has been named operations research manager for Lockheed's Electronics and Avionics Division. He was formerly associated with the Rand Corp., where he directed studies in nuclear weapons effects, communications and radar. Prior to that he was president of Telemeter Magnetics, Inc.

Edward L. Swainson has been appointed technical assistant to the president of the Military Products Division of American-Standard. He will be responsible for technical liaison between departments of the division and will have a major responsibility for its long-range technical planning.

Avco Corp., Nashville Division has announced the appointments of **Bernard Clark** as general manager-operations and **Eugene B. Husselman** as manager of the materials department.

by M/R Staff
from Translations

Crimean Telescope Among World's Largest

One of the largest telescopes in the world, and the Soviet's biggest, will be guided almost completely by the body upon which it is focused.

Designed to stand in the Crimean Astrophysical Observatory of the Academy of Sciences, USSR, it will be used to track artificial earth satellites and cosmic rockets and study nonstationary stars, the stucture of the moon, planets and distant galaxies.

The 2600mm-diametered mirror's sighting, focusing and correction for refraction systems will be automatized, employing the light flowing from the body it will track. In this type of guidance system, as described in *Trud* (Nov. 4, 1959) the light rays strike a special receiver and are transformed into alternating electrical signals. These signals, amplified a million times, set the control system into motion and introduce corrections in the position of the telescope tube.

In addition, a group of Soviet scientists has worked out an automatic device to rotate the dome and shutter simultaneously with the telescope to create an almost entirely automatic system. It is now developing a program of control whereby the astronomer can issue the necessary commands beforehand and the instrument itself will aim at the desired object, follow and photograph it, then turn to other objects.

Photographs taken with this system are expected to be of quality superior to those from manually operated instruments, since controls will eliminate defects and elongation caused by the earth's rotation and duration of exposure.

New Forming Process?

A new metal forming process producing shapes directly from the molten state reputedly is being developed by a Russian metallurgist.

A. V. Stepanov in *Vestnik mashinostroyeniya* (No. 11, 1959) describes his process as utilizing capillary forces, where liquid metal rises within an opening in the die, floating freely on the top of the metal bath. A "graft," or piece, of the same metal with the same shape as the opening in the die, is introduced into the die opening until it reaches the liquid metal and welds to it. It is then withdrawn at a rate corresponding to the rate of solidification, which can be controlled by a proper cooling system.

Stepanov claims to have obtained wires, strips .5-2.00 mm thick and up to 120mm wide, round tubing 5, 60 and 100mm in diameter, elliptical spirally wound tubing, and tubular panels up to 120mm wide, some with no additional surface machining.

Borane for Cooling

The Soviets claim the discovery of a new "exotic" fuel "borane," a mixture of hydrocarbon and a boron compound. Considered three times as powerful as alcohol fuels, it is used for cooling purposes instead of liquid oxygen.

Success in the USSR's space program is attributed also to simplification. According to West German magazine *Quick* (No. 44, 1959), the Soviets still use the principle of the *V-2*—a regular rudder made from graphite moving in the jet stream of the rocket. Auxiliary rockets are used only for braking and acceleration purposes. Black and white paint is used to protect the instruments carried by the rockets.

Vegetation on Mars?

The "Grand Old Man" of Russian astronomy, Prof. G. A. Tikhov, maintains that he has offered indisputable proof of the existence of cholorophyll —and hence vegetation—on Mars.

Interviewed by a correspondent for the West German magazine *Quick*, (No. 44, 1959) he disclosed extensive studies on the subject. His feeling is that manned space flights are necessary to find new inhabitable areas to alleviate earth's crowded conditions.

When would man land on the moon? "In two to three years," says Prof. Tikhov.

Stationary Orbits

The Russians have their own program to put radio and television relay systems into space.

A paper by Soviet scientist Prof. S. Katayev, reported in *Isvestiya*, (Nov. 6, 1959) tells of a Soviet plan to put satellites into stationary 22,000-mile-high orbits. Katayev states that a radio relay system in the satellite would open all of the USSR to TV.

Other satellites not carrying relay systems will be used to reflect radio waves transmitted from ground TV stations back to earth. The waves would be received by large antennas, amplified, converted and transmitted to ordinary TV receivers.

Soviet scientists are also discussing, according to Katayev, the possibility of predicting the future development of the earth by similar rockets carrying photographic equipment. By photographing Mars, which is estimated to be millions of years older than earth, and on which at one time conditions may have been similar to this planet's, the Soviet astronomers expect to see what physical changes may be in store for it. The Soviets also expect to photograph celestial bodies with their space telescopes in the near future.

Dr. Albert Parry, professor of Russian at Colgate University, has long contributed a monthly column on Soviet Affairs to M/R. Because of the increasing interest in things Russian, we now plan to supplement this coverage with more frequent material emanating from the USSR, translated by official sources in this country, and compiled by the M/R editors.

ASW Problem Answered

To the Editor:

In your editorial of August 10 you voiced the fear that the Navy Department was not properly organized to handle the anti-submarine warfare problem. I wrote to Senator Eugene J. McCarthy (D-Minn.) and included a copy of your editorial.

He obtained a gracious and informative response from Rear Adm. H. A. Yeager. A copy of this letter was sent to me by Senator McCarthy and certainly clarifies in my mind any questions which might have been raised regarding Navy organization to cope with the ASW problem.

Charles Eumurian
1016 W. County Road B2
St. Paul 13, Minn.

(We have obtained permission from both Senator McCarthy and Admiral Yeager to print the Admiral's response to Mr. Eumurian's request. It follows:)

"My dear Senator McCarthy:

"The criticism contained in the article of the organization of the Navy Department for dealing with antisubmarine warfare measures is not without foundation, but as with many such articles, it is out of date. Significant improvements have been made and industry is now eminently satisfied with the situation. Salient among the improvements which have been made was the establishment in January 1958 of the Antisubmarine Readiness Executive, a special assistant to the Chief of Naval Operations charged with the supervision of all matters pertaining to ASW readiness.

"Additional improvements include the establishment in July 1959 of the Deputy Chief of Naval Operations for Development, whose supporting staff includes a section designed exclusively for handling ASW projects. Reorganizations have taken place within the technical bureaus and in the Office of Naval Research to streamline procedures for handling ASW matters.

"Instructions have been issued to facilitate access by properly cleared members of industry to classified information necessary for progress in the development of improved ASW methods. Additional instructions to facilitate the submission and processing of proposals relating to antisubmarine warfare are being developed, and are expected to be issued shortly.

"Reorganization and streamlined procedures will not solve the Navy's antisubmarine warfare problem. What is needed is an extensive program of basic research in oceanography and other related fields, and the provision of financial support as required to translate sound ideas into useable ASW systems.

"Progress is being made in these research efforts, under Navy contracts, and in projects being pursued by industrial concerns, several of which are expected to result in government contracts. Thus far, however, no feasible, inexpensive, overall solution to the threat posed by the existence of the 450-unit Soviet submarine fleet has been evolved.

In the absence of such a solution, the Navy is improving its current ASW capabilities by intensive training and by the introduction of promising new methods as rapidly as their value can be proven by rigorous test and evaluation procedures. We believe that only through such deliberate and carefully conducted procedures can the expenditure of public funds on the increasingly expensive equipments required in antisubmarine warfare be justified.

/s/ H. A. YEAGER
Rear Admiral, U.S. Navy"

Avco's Acquisition

To the Editor:

The August 31st issue of MISSILES AND ROCKETS carries a story on page 41 entitled "The Growth of Avco" in which it states that Bendix was acquired by Avco. It is obvious to us that it was **Bendix Home Appliance,** but to the average reader this could mean **Bendix Aviation Corp.**

Even at this late date I would appreciate it if you could correct any impression that Avco had acquired the Bendix Aviation Corp. Obviously this is not true and the "Bendix" to which the story referred was the Bendix Home Appliance Corp. which, I believe, Avco later sold to **Philco.** There is no connection between this organization and our own but the similarity in names has always caused some confusion.

W. A. Mara, Director
Advertising & Public Relations
Bendix Aviation Corporation

The Spaceless Military

To the Editor:

There have been a number of public statements recently by President Eisenhower, Defense Secretary McElroy, Dr. Herbert York and other high government officials justifying the reduction in funds for the *Saturn* 1.5-million-pound booster rocket program and its transfer to NASA on the basis that it is of use only in our civilian space research program. It is explained that our military programs do not require rocket engines of this large size and that the lower-thrust ICBM engine programs are being funded with "all the money they can absorb efficiently."

At the same time, it is well known throughout the missile/space industry, and published in the technical journals, that any program for a manned space vehicle with capabilities beyond the low orbits to be achieved in the *Mercury* program will require much larger booster engines.

This amounts to a clear and public admission that the U.S. Air Force has not recognized the military value of manned space vehicles to the point of establishing a military requirement document which would lead to funding of a large booster engine.

It seems incredible that our military people continue to make mistakes of this magnitude in the planning of new weapons systems . . .

W. J. Billerbeck
Engineer
Silver Spring, Md.

The decision that the U.S. military had no mission in space was made by the Administration. The Services, most particularly the Air Force, nonconcur rather vehemently.—Ed.

ASTROLOG Welcomed

To the Editor:

I have noted with interest and appreciation the very handy summary of missiles and rockets which appeared in your Sept. 7 and Nov. 9 issues.

Without a reference guide such as your ASTROLOG it is an impossible job to keep track of the many types of rockets and missiles which the armed services are now using or testing. Those of us in the information business welcome your very helpful compilation with enthusiasm.

Frank L. Fullaway
Captain, U.S. Navy
Director, Administrative Division
Office of Information
Department of the Navy

contracts

NASA

$400,000—**Telemeter Magnetics, Inc.,** Los Angeles, for development and manufacture of airborne digital programmers and ground-based check-out systems for Project *Vega.* Subcontract from **Jet Propulsion Laboratory.**

$38,037—**Coopman Electric Co.,** San Francisco, for thermocouple and miscellaneous wiring for 3.5-ft. hypersonic wind tunnel.

MISCELLANEOUS

$270,000—**Sylvania Research Laboratories, Division of Sylvania Electric Products, Inc.,** for research and development work on high-temperature materials for use in solid-fuel rocket engines.

NAVY

$5,250,000—**Westinghouse Electric Corp.,** for continued work on *Polaris* missile launching systems.

$300,000—**Packard Bell Electronics Corp.,** for the production of radar test sets.

$73,338—**The Dynamics Research Corporation,** Stoneham, Mass., for continued investigations of the *Polaris* submarine inertial navigation system.

$65,447—**American Machine & Foundry Co.,** Chicago, for studying experimental model of an interval environmental simulator for space crew. Project C-41111.

$28,020—**Ampex Corp.,** Los Angeles, for magnetic tape recorder system and components.

$25,345—**Ampex Corp.,** Los Angeles, for magnetic tape recorder and reducing components.

AIR FORCE

Convair (Astronautics) Division of General Dynamics Corp., has received a contract for the design of a major space vehicle launch complex at the Atlantic Missile Range, Cape Canaveral, Fla. Amount not disclosed.

$9,384,733—**Stromberg-Carlson,** div. of **General Dynamics Corp.,** for changes in design of a complex reconnaissance system. Total cost of project to date, $26,907,062.

$202,980—**Potter Instrument Co.,** Plainview, N.Y., for punched tape reading equipment to be used in the *Minuteman* ICBM program. Subcontract from **Autonetics Division, North American Aviation Co.**

$118,000—**General Electric Co., Heavy Military Electronics Dept.,** for study involving launch control system communication techniques for the *Minuteman* ICBM. Subcontract from **Boeing Airplane Co.**

$85,711—**The Martin Co.,** Orlando, for *Bullpup* trainers, ground pilot *GAM-83.*

$79,500—**Boeing Airplane Co., Pilotless Aircraft Div.,** Seattle, for reproducible copy and negatives applicable to *IM99A* missiles. (Two contracts).

$74,975—**Cornell Aeronautical Laboratory, Inc.,** Buffalo, N.Y., for research directed toward the investigation of auroral and lunar reflected signals.

$34,160—**Stanford Research Institute,** Menlo Park, Calif., for research on application of electron beam machining techniques to semiconductors.

ARMY

$4,721,786—**Del E. Webb Construction Co.,** Los Angeles, for rocket engine test stand 1B at Edwards AFB.

$700,000—**Northeastern Engineering, Inc.,** Manchester, N.H., for 600 frequency meters.

$426,400—**C. H. Leavell & Co.,** El Paso, Tex., for *Nike-Zeus* facilities, battery control building, White Sands Missile Range, N.M.

$255,357—**Western Electric Co., Inc.,** N.Y.C., for reconditioning secondary items for *Nike* guidance system.

$226,905—**Microwave Electronic Tube Co., Inc.,** Salem, Mass., for electron tubes.

$179,382—**Proctor Engineering Co.,** Tulsa, Okla., for construction of nose cone facility at Forbes AFB, Topeka, Kan.

$129,847—**North American Aviation, Inc.,** Downey, Calif., for study of space vehicle vulnerability.

$100,000—**Melpar, Inc.,** Falls Church, Va., for flight test data processor.

$80,900—**The Martin Co.,** Orlando, for *Lacrosse* missile and related equipment.

$80,333—**Western Electric Co., Inc.,** N.Y.C., for *Nike* spare parts and components (Two contracts).

$49,000—**Ohio State University Research Foundation,** Columbus, for additional research work on satellite ionization phenomena and observation.

$33,250—**Research Triangle Institute,** Durham, N.C., for basic research, design and analysis of experiments to determine effects of factors on response variables.

$30,380—**H. B. Zachry Co.,** San Antonio, Tex., for *Nike-Zeus* facilities, landing strip and AIL facilities, White Sands Missile Range.

$30,000—**California Institute of Technology,** Pasadena, for hypersonic research.

$29,680—**Firestone Tire and Rubber Co.,** Los Angeles, for modification of guided missile.

$28,182—**Douglas Aircraft Co., Inc.,** Santa Monica, for launching area items.

—reviews—

QUANTITATIVE MOLECULAR SPECTROSCOPY AND GAS EMISSIVITIES, S. S. Penner, California Institute of Technology. Addison-Wesley Publishing Company. 571 pp. $15.

Written as a text book, the volume covers selected topics in quantitative applied spectroscopy.

The theoretical and experimental studies which are considered in detail are representative of the types of research problems encountered in connection with the development of modern propulsion devices.

The book is aimed towards students in applied science as an introduction to the literature on a class of radiation problems which largely fall into the temperature range intermediate between that of interest to the molecular spectroscopist and the astrophysicist.

CHEMISTRY OF NUCLEAR POWER, J. K. Dawson, and G. Long, A.R.I.C. Philosophical Library Inc., 208 pp. $10.00.

The authors, both of whom are engaged on research work at the Chemistry Division, Harwell, England, present a highly authoritative and informative account of the part of the chemist in the development of nuclear power.

From the raw materials through the various separating processes and reactors to the disposal methods in current use the subject matter is presented as a broad picture of established practice and present lines of thought. The chemical problems of the future are treated in closing in a manner digestible to those with scientific training but lacking specialized knowledge in nuclear technology.

RANDOM VIBRATION, Edited by Stephen H. Crandall, Massachusetts Institute of Technology. John Wiley and Sons Inc. and Massachusetts Institute of Technology, 411 pp. $8.50.

The material in this book is specifically addressed to engineers who are already familiar with the classical problem of mechanical vibration. The new concepts required to extend ordinary vibration theory into the field of random vibration are described and a broad picture is given of the current state of the art of designing and testing equipment which must withstand random vibration.

The recent development of high power rocket engines has introduced a new aspect to the problem of mechanical vibration. These propulsion units generate noise and vibrational energy in a stochastic manner over a wide band of frequencies. The resulting random vibration often constitutes a severe environment with respect to fatigue of airframe panels and with respect to reliability of airborne electronic equipment.

The book is divided into two parts. The first six chapters treat basic concepts and background material. The final sections deal directly with the problems of design and testing.

ADVERTISER'S INDEX

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CLASSIFIED

WASH. REPRESENTATION Govt. sales liaison, Public Relations, cover all fields, J. V. Hurson Assoc., 412 Albee Bldg., D.C., RE 7-4122.

Public Awakens to Space Loss

For the past year or more we have believed, and frequently reiterated on this page, that as the prospects of a hot war become less threatening, the aspects of the cold war become more deadly. That the cold war is really the more terrifying because it is being waged for the minds of men. That the physical capture and control of a man leaves room for rebellion and escape, whereas the capture and control of his mind leaves a man nothing.

This battle for men's minds is being carried on in a number of ways, but its best exemplification is in the race for space. As was pointed out in an article in this magazine last week, a race does not necessarily need two participants; all it requires is one runner, a prize and an interested audience.

At the moment probably much of the world, which is the highly interested audience, would say there is only one contestant—Russia. Others might hold differently and give the United States second place—since there isn't a possible third participant and there isn't likely to be one soon.

As the winner of the race so far, Russia is picking up all the prizes—the accolades of the world, the solidified appreciation of its own people and probably potential billions of dollars on the world market—through its demonstration of scientific and technical superiority.

Noting some of these things in a recent paper laid before the American Rocket Society meeting in Washington, Dr. William H. Pickering, Director of NASA's Jet Propulsion Laboratory, declared that we must either pursue our space developments actively and successfully or declare ourselves completely out of the space race. He laid down three ground rules for successful competition:

1. The U.S. public must understand the importance of our space program.

2. We must establish national objectives clearly to set up a mainstream of dramatic achievement as well as a broad base of exploration and exploitation.

3. We must establish the management and the funds to properly support, on a long-term basis, our real national objectives.

Note that Dr. Pickering has made public understanding first on his list. From all indications the understanding must be imparted on a very high level.

There has been no indication from the Administration and very little from our space agencies that they feel any sense of urgency or apprehension—or even embarrassment over our loss of world prestige. We have business as usual, bigger automobiles and a balanced budget.

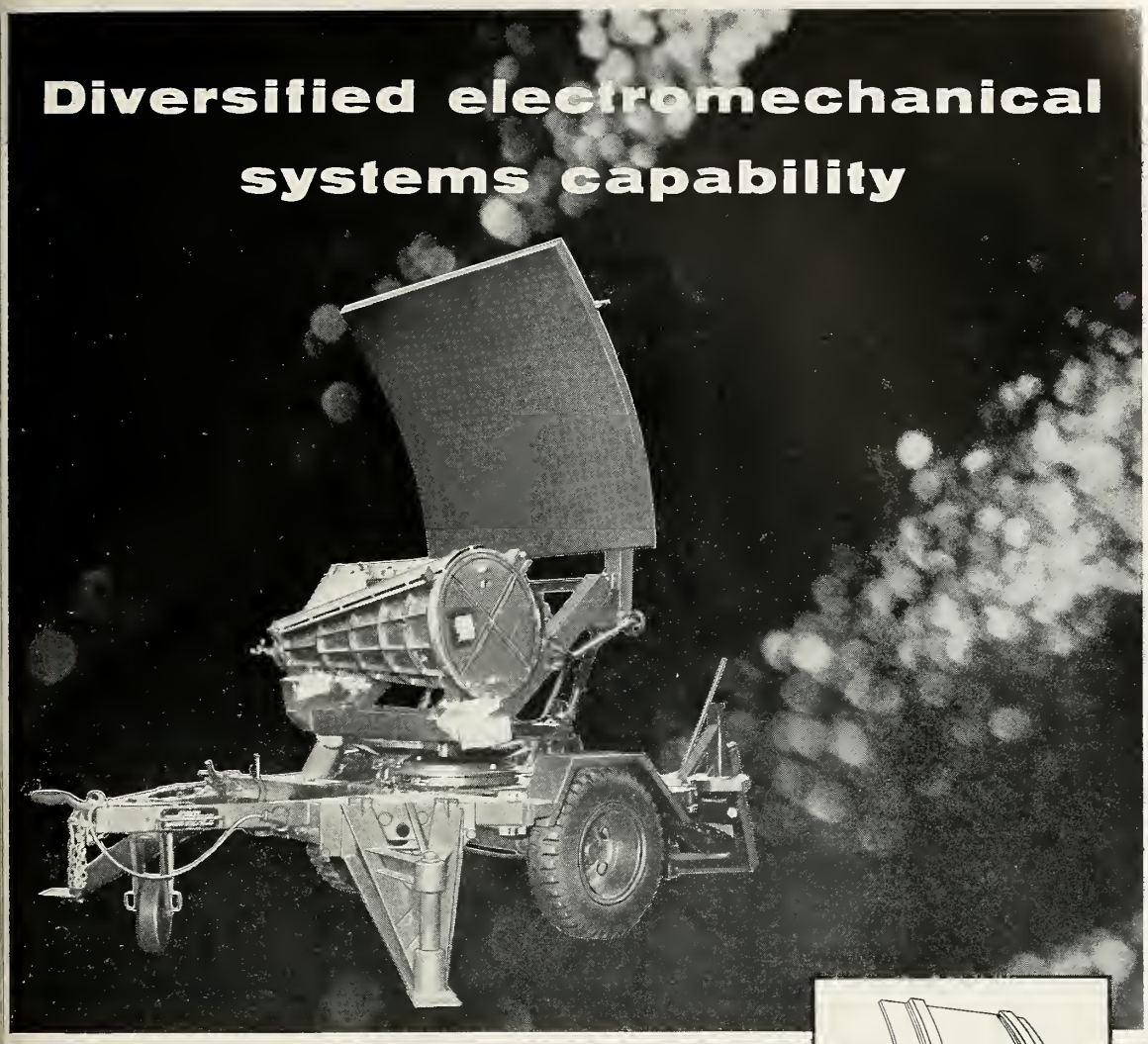
Does the American public enjoy having the Russians rub our noses in our failures? Does it enjoy having foremost Soviet Scientist Sedov look at the *Titan* and ask slyly: "What scale is it?"

There are indications the public does not, and does not share the Administration's lack of concern. A recent newspaper poll in Los Angeles on the subject brought an unprecedented and overwhelming reply with three out of four persons saying they are "ashamed" of our place in the space race. Six out of 10 wanted the U.S. to catch up even at the cost of reducing the U.S. standard of living. More than half said they would be willing to pay $50 a year more in income taxes if the money were allocated to the space program.

We cannot escape the feeling that this public awakening will be reflected in a campaign issue in 1960, that it may even become the hottest issue of all. That a great many voters will seek an answer for our failures and demand a placing of the blame.

CLARKE NEWLON

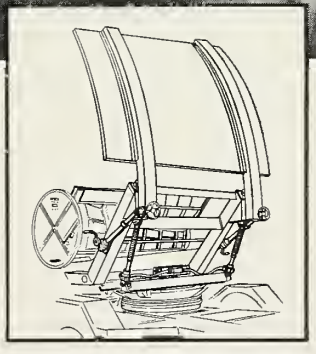
Diversified electromechanical systems capability



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

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

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



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

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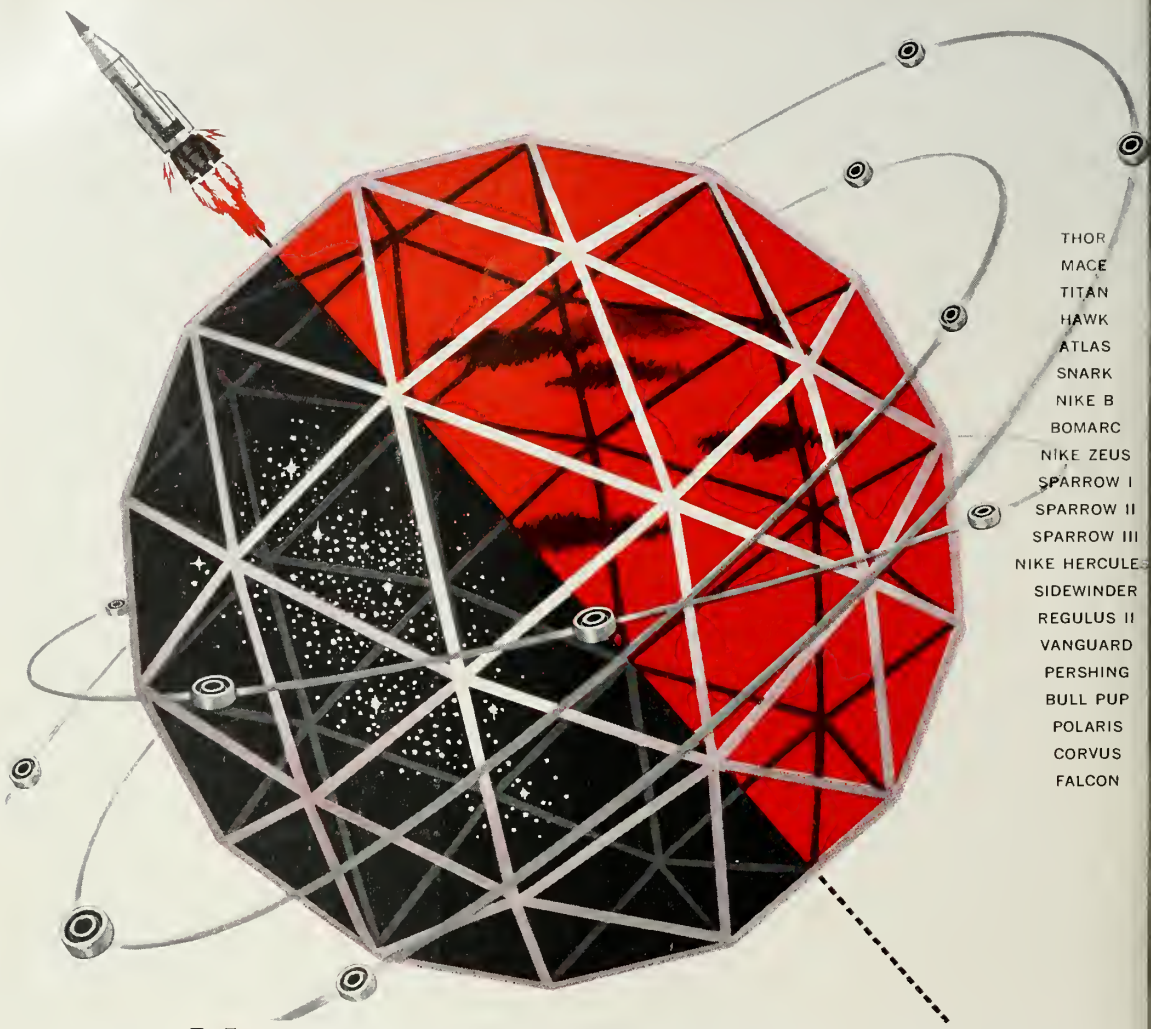

New ND Processes Improve Instrument Sensitivity!

In delicately-precise instrumentation, parts must react to relatively small rotive forces. Here . . . bearing torque is the highly critical factor. Separator selection, bearing finish and clinically clean assembly areas are extremely important.

It's here that New Departure is setting new industry standards! Special dies and in-process gauging of separators assure ball retention with improved torque and vibration characteristics. In addition, new N.D. honing processes and Talyrond gauging deliver uniform accuracy to millionths of an inch. Moreover, having originated the first bearing industry "white room", followed by continuous experience, New Departure's present day, modern assembly areas approach fantastic levels of cleanliness.

An everyday example of N.D.'s contribution to improved instrument sensitivity can be found in the Smithsonian Institution-selected Micro Clocks. These vitally important instruments are accurately tracking both U.S. and foreign satellite movements in time determinations of 1 milli-second . . . and better!

For new *performance* and *reliability* in your precision instruments, ask your N.D. Miniature/Instrument Bearing *Specialist* to sit in on early design level discussions. For further information call or write Department L.S., New Departure Division, General Motors Corp., Bristol, Conn.

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