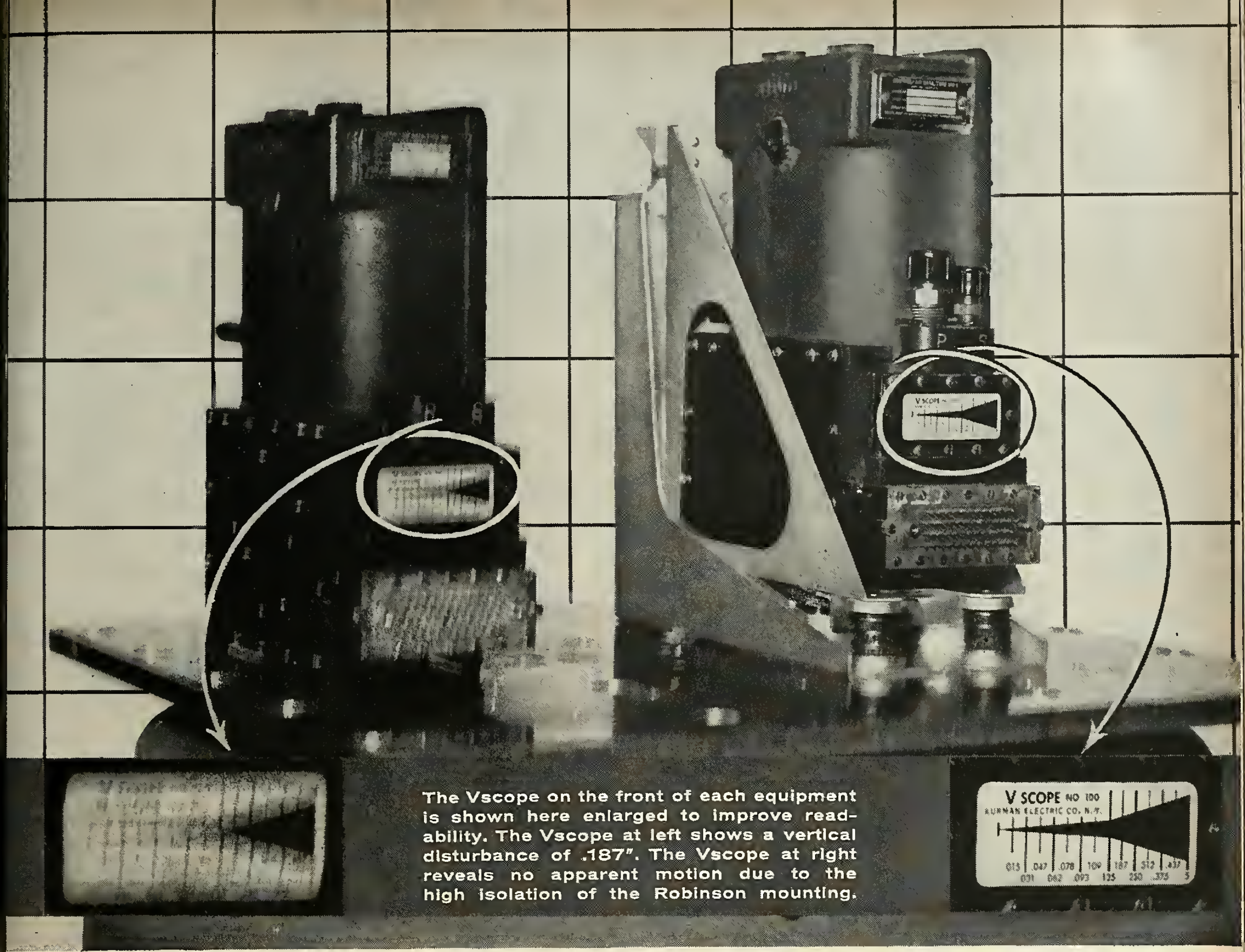
MARCH 9, 1959

ESCAPE VELOCITY TEST

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION



The Vscope on the front of each equipment is shown here enlarged to improve readability. The Vscope at left shows a vertical disturbance of .187". The Vscope at right reveals no apparent motion due to the high isolation of the Robinson mounting.

12.0 "G" reduced to 0.6 "G"

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Look at the above illustration, showing two Bendix air data sensors on an electromagnetic shake table. Notice the left hand unit which is mounted solidly to the oscillating head of the shaker. The image is blurred because a vibratory input of about .187" double amplitude at 35 c.p.s., equalling an acceleration force of 12 "g's", is being applied directly to it.

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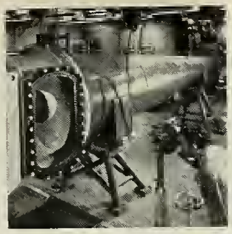
missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS



COVER: AF's Arnold Research Center shifts to space-missile projects (p. 31).

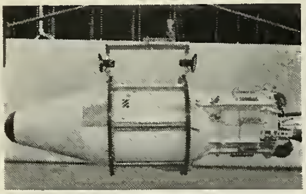
MARCH 9 HEADLINES

ASTRONAUTICS ENGINEERING

MISSILE SUPPORT EQUIPMENT

MISSILE ELECTRONICS

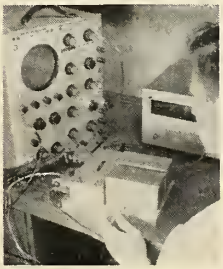
DEPARTMENTS



PAYLOAD section of *Discoverer I* including Bell's Hustler engine has 19 ft. length (p. 20).

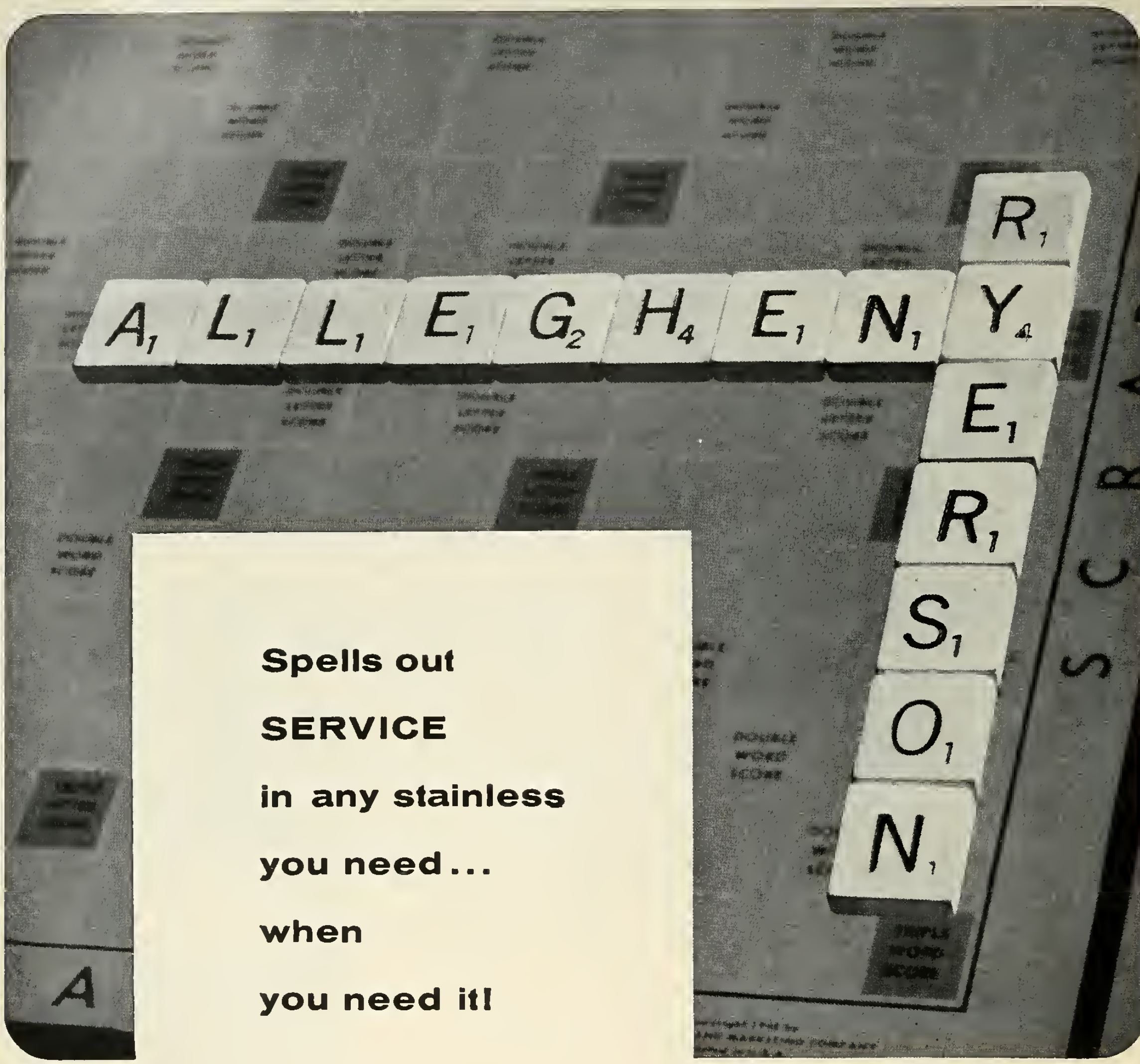
ARMY's *Pioneer IV* just prior to launch at Cape Canaveral for orbit about the sun (p. 20).

MONOPROPELLANT research is getting stressed at Wyandotte's Michigan facility (p. 23).



ASCOP follows new modular concept for design of telemetering equipment (p. 43).

Experience—*the* <u>*extra*</u> *alloy in* Allegheny Stainless



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HETS Program: Space Cooperation

One of the brightest spots to show up in the nation's space exploration picture appears in the form of the present cooperation between the National Aeronautics and Space Administration and the Department of Defense in the development and production of two parallel programs—NASA's *Scout* project and the S-609A enterprise of the Air Force. Combined, the two will be known as HETS—Hyper Environmental Test System.

We recently mentioned in this space that the head of ARPA had announced to his somewhat amazed staff and the military services that in the future NASA would undertake the development of all powerplants for space exploration, civilian and military. We thought, and still think, that inherently this could be dangerous in that the very real needs of the military might be delayed or lost in the zeal for peaceful space activities; that, however, the old NACA and the military had a fine record of working together and that this could and must be continued between NASA and the services.

Now in the HETS program—just announced or just about to be—comes a degree of cooperative understanding that is heartening indeed. The facts are these:

NASA needed a cheap, four-stage vehicle *(Scout)* which would loft payloads on the order of 50 pounds, either for space exploration or to be placed in orbit. NASA wanted it for general purpose tests in high-altitude environmental soundings.

The Air Force wanted approximately the same vehicle (S-609A) for re-entry testing, to perfect a profile for the space missile platform *Dyna-Soar* and for checking various components for temperature, radiation resistance, stability and posture.

Under the present arrangement NASA will contract for the hardware. Some bids have already been requested. The vehicle will be four-stage with its components either developments of presently existing hardware or some second generations of that presently existing. For example, the first stage could very well be closely akin to the solid-fuel *Sergeant*. For NASA use the vehicles can be simple and unsophisticated.

The Air Force will need a somewhat higher degree of accomplishment in its vehicle—certainly more guidance including perhaps gimballed motors. But, since the AF and NASA worked together on the specification, this extra equipment can be built during the 18 months or so required to produce the basic booster and can be added with a minimum of delay. NASA will be doing its testing at Wallops Island and the Air Force at Cape Canaveral or Vandenberg.

This is a fine example of what can be done in the country's space program, and not entirely typical. In the U.S. space setup as it now stands, three services and several governmental agencies or offices have split the responsibility and the authority for producing a military and peaceful program which will ensure our at least equality in the vast and new field of space exploration. The result is at least confusing. It could be disastrous.

There are two many bosses, too many agencies and too many fingers in the pie; too many jealousies, too much in-fighting, too much politics. If the U.S. space program suceeds—it may be in spite of itself. At least the HETS program is a hopeful sign in that direction.

Here, two agencies of the several involved had a need for approximately the same hardware to carry out parallel test programs. The officials in charge got together, agreed on a cooperative plan, worked out the details and went to work. Bless them.

This joint enterprise will save the country money, scarce talent and probably time. It may even establish a precedent which other agencies could follow. It could allow a unified program with a common goal—something we have not had before.

Clarke Newlon

washington countdown

NATO nation interest . . .

in *Lacrosse* is picking up. Could it be because it will become operational with U.S. troops at Huntsville and Fort Sill on June 1, or is it because in a nine-mile firing last week at White Sands miss distance was nine feet—one foot a mile?

Speaking of operational . . .

U.S. missiles, Navy's *Bullpup* joins the Pacific fleet next month, with a target data for *Mace* of about June.

***Mrs. V* is follow-up . . .**

and a new name from MIS (maneuverability in space) of the *Discoverer* project. Main purpose is bio-med studies.

Even competitors say . . .

GE has the "track" for Army's Missile *Able*. Still running strong in the competition which is up now for JCS review and a decision after July 1 (budgetary consideration) are Martin, Cornell Aeronautical Labs, Armour Research Foundation, Douglas, and Minneapolis-Honeywell. *Mauler* (Sperry Rand, GE Convair and Martin) will await a decision after July 1, too. But *Dyna-Soar* and *Bold Orion* (WS-199B) will be decided about May 1.

Selection of Philip B. Taylor . . .

as assistant secretary of Air Force for Materiel came after several weeks of screening half a dozen or more prospects. A PhD in mechanical engineering, Taylor has been with Sanderson & Porter, New York management engineers, since 1947, served previously in the Pentagon as consultant for Defense R&D.

May we suggest . . .

the code name of *DOT* for a submariner's small missile to knock down *DAT* (the drone assisted torpedo) which was heavily emphasized at Navy's Seapower Symposium in Washington last week. It would be a good companion for *DASH* (helicopter-launched A/S homing missiles, with Republic a good contender). Symposium, incidentally, echoed with rumors that Navy plans to fire *Lulu* from an 8" gun. Publicly, Navy said it wants industry in the next 10 years to produce a triple-purpose missile: anti-aircraft, SAM, and anti-submarine.

Congress may override . . .

previous Pentagon and Administration moves affecting the *Nike-Zeus* production go-ahead. An indication may be in Defense Secretary McElroy's statement to Congress that the Pentagon now is considering the possibility of beginning some sort of "pre-planning production program." It's estimated that *Zeus* will cost $7.5 billion to produce. Army says now's the time to go ahead with preparation of plants and tooling for production. However, McElroy says his best scientists have told him that *Zeus* is not at this stage.

Venus firing dates . . .

given out by Rep. Overton Brooks in a television interview last week match dates given by m/r months ago. On June 3, Brooks said, an *"Able IV Thor"* would carry a 78-pound payload to the vicinity of the planet, and on the following day an *"Able IV Atlas,"* would try to orbit a 325-pound payload around Venus.

Expanded research . . .

into high-power microwave radar is planned by Cornell Aeronautical Laboratory with receipt of a $1.3 million Army Ordnance contract. The laboratory has a two-fold objective: experimental investigation into the means and techniques for radiating very high peak microwave radar power; and investigation of propagation phenomena, possibly for ICBM detection. Cornell originally had a $200,000 research contract in this field for Project *Plato*, and successfully transmitted 21 million watts of peak power without electrical breakdown. New research will be aimed at 50 million watts.

And incidentally, *Plato* . . .

was dropped, Maj. Gen. J. B. Medaris told Congress, after $18.5 million was spent on the project. He indicated action was taken on a higher level because of budgetary considerations.

Contractors will get chance . . .

to speak out on NASA's temporary rules governing waiver of Government patent rights under the agency at a public hearing in Washington, May 18. Those wishing to appear must advise NASA by May 1; however, written briefs can be filed within next 60 days. As a matter of policy, waivers will be granted where the stimulus of ownership of patent rights will encourage the contractor to more speedily develop an invention to the point of practical application.

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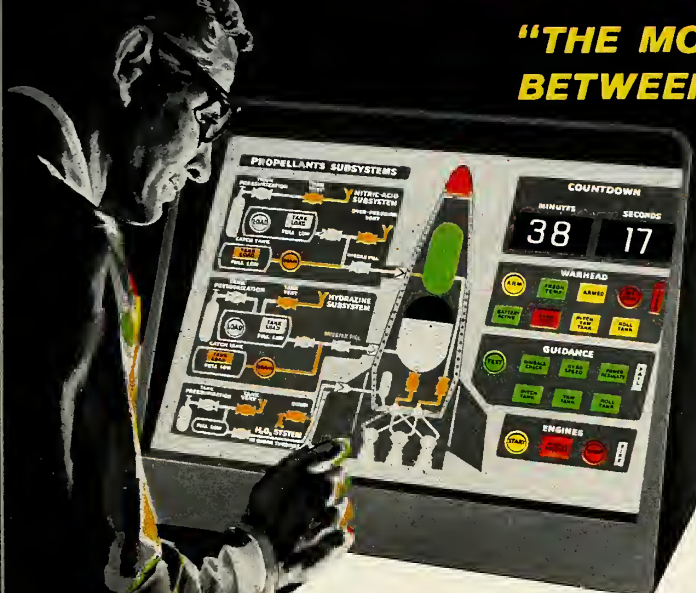

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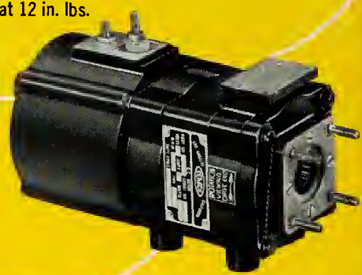
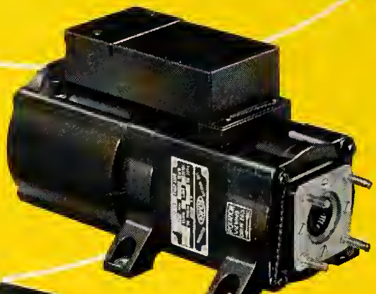
Type D-1082	**4 HP**	**2 HP**
Weight:	16 lbs. 3 oz.	16 lbs. 3 oz.
Motor Torque:	25 in. lbs.	12 in. lbs.
R.P.M.:	10,000	10,700 (approx.)
Terminal Voltage:	27 volts DC	27 volts DC
Operation:	In a period of 34 minutes: any 4 min. @ 25 in. lbs., balance at 12 in. lbs.	



Type D-1082-1	**4 HP**	**2 HP**
Weight:	13.87 lbs.	13.87 lbs.
Motor Torque:	25 in. lbs.	25 in. lbs.
R.P.M.:	10,000	11,500
Terminal Voltage:	27 volts DC	27 volts DC
Operation:	2 minutes max. @ 25 in. lbs. plus 10 min. max. @ 12 in. lbs.	



Type D-1029-1	
Weight:	20 lbs.
Horsepower:	6 HP
R.P.M.:	7500
Terminal Voltage:	26.6 volts DC
Duty Cycle:	4.5 HP for 7.5 minutes 6.0 HP for 20 seconds 2.0 HP for 30 minutes

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Weight:	15 lbs.
Horsepower:	2 HP
R.P.M.:	10,000
Volts:	115 volts AC

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industry countdown

Navy's *Eagle* missile program . . .

is getting a thorough going-over. Main purpose is try to hold down costs on the air-to-air missile. Final list of sub-contractors has not been approved by the Navy and will be forthcoming before the green light is given the prime contractors, Bendix-Grumman.

Canadian firms have been asked . . .

to bid on more than 100 items of the *Bomarc* weapon system. First of these contracts is $1.7 million to Canadair for *Bomarc* wings and ailerons. Announcement came from L. A. Wood, Boeing vice president and general manager of its Pilotless Aircraft Division. Wood said that many Canadian firms should be able to bid competitively with domestic industry on the high-precision work required in the *Bomarc* missile program.

Missile and aircraft R&D . . .

employ more scientists and engineers percentage-wise than any other manufacturing industry, a recent National Science Foundation survey revealed. The aircraft/missile and parts industry employs about 67% of its 84,900 scientists and engineers in R&D projects. Sixty-two percent of the industry's 51,500 technicians are engaged in R&D compared to the average of 27% employed in R&D by all other major industries.

Jupiter's ground equipment . . .

will be produced by Chrysler Corp. under an Army contract amounting to $20,944,039.

200 flights of RJ43 ramjet . . .

have been completed in operations on the Boeing *Bomarc*, Lockheed Kingfisher, and Lockheed X-7, a flight program released by Marquardt Aircraft Co. recently revealed.

Two full-scale propulsion reactors . . .

and seven military reactor prototypes went critical during the last six months of 1958, according to the semi-annual report of the Atomic Energy Commission. The AEC also reported progress in developing reactors for use in unmanned vehicles. These include those for *Rover* (non-nuclear parts have been transferred from Air Force to the National Aeronautics and Space Administration), *Pluto*, and Project *Snap* to provide nuclear auxiliary power for space satellites.

Solid fuel elements . . .

and a gaseous propellant are used in developing *Kiwi-A*—the initial test vehicle for Project *Rover*—and to demonstrate feasibility of nuclear rocket propulsion. Work is being done at the Los Alamos Scientific Laboratory. *Kiwi-A*, which uses a relatively low-power experimental reactor, was assembled without nuclear components by ACF Industries, Inc., at the AEC's South Albuquerque Works Plant and reassembled at Nevada Test Site with nuclear components.

AEC reported . . .

encouraging results in materials research by the Atomics International Division of North American Aviation in connection with Project *Pluto*. Initial data on high-temperature materials have been extended to include the effect of fuel additives. AEC points out that a nuclear ramjet, such as being developed under *Pluto*, could propel missiles with unlimited ranges within the earth's atmosphere. Atomics International also is the contractor on *Snap-II* which uses a nuclear reactor as a heat source to operate a generator for nuclear auxiliary power source in space. *Snap-I*, under development by The Martin Company, will use heat from a radioactive isotope to operate electrical power conversion equipment.

New hose can handle 600 degree . . .

temperatures for short periods. Developed by the Thermoid Division of the H. K. Porter Company, Inc., the hose is made of Dupont "Viton," and lasts almost indefinitely at 350 degree temperatures. The hose also has high abrasion resistance and resists extremes of chemical attack.

500,000 unit production increase . . .

has been reported by Tri-Point Plastics Inc., for the month of January. The company specializes in "Teflon" plastic components for the electronics and missile fields.

Kollsman Motor Corp. . . .

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Type	Input		Rated Output			Max. Altitude at Rated Output	Approx. Wt. Lbs.	Designed to Gov't. Part No.
	Volts	Amps.	Volts	Phase	VA Rating			
32B92	27.5	126	115	1 3	1500 1800	20,000	37	—
32B81	27.5	100	115/200	3	1500	Unlimited	65	—
32B77	27.5	180	115/200	3	3000	Unlimited	75	—
32B79	27.5	400	115/200	3	7000	Unlimited	115	—
32B76	27.5	20	115	3	500	70,000	25	—
32B122	27.5	150	115/200	3	2500	50,000	65	—
32B41	27.5	150	115/200	1 3	2500 3000	50,000	68	—
32B52	27.5	35	115/200	1 3	500 500	40,000	25	—
32B106	27.5	95	115	3	1400	35,000	44	—
32B27	27.5	285	115/200	1 3	3500 4000	50,000	76	—

GENERAL PURPOSE INVERTERS—400 CYCLE OUTPUT

Type	Input		Rated Output			Max. Altitude at Rated Output	Approx. Wt. Lbs.	Designed to Gov't. Part No.
	Volts	Amps.	Volts	Phase	VA Rating			
12128	27.5	1	26	1	6	35,000	2.2	AN3496
12126	27.5	2	26	3	10	35,000	2.3	E1615
MG-54	27.5	22	115/200	1 3	250 250	50,000	17	E5109
12142	27.5	22	115	1 3	250 250	35,000	13	E1617
12143	27.5	22	115	3	250	35,000	13	—
32E01	27.5	35	115	3	500	50,000	26	AN3533-1
32E00	27.5	51	115	1 3	500 750	50,000	34	AN3534-1
MG-65	27.5	52	115/200	1 3	750 750	50,000	35	E52805-2
MG-61	27.5	126	115	1	1750	50,000	54	53C6767
1518	27.5	126	115	1 3	1500 1800	20,000	37	—
32E06	27.5	160	115/200	1 3	2000 2250	50,000	56	E1725
32E03-3	27.5	150	115	1	2500	50,000	58	53B6227
32E03-9	27.5	160	115/200	1 3	2500 3000	50,000	58	E54807
32E09	27.5	160	115	1 3	2500 3000	50,000	60	—

Red Bank Division — Bendix AVIATION CORPORATION

missiles and rockets
MAGAZINE OF WORLD ASTRONAUTICS

World Rapidly Adding More Missile Ranges

United States is negotiating in hopes of cooperation in man-in-space plans. Existing ranges vary from relatively small facilities to those extending thousands of miles. Small nations are participating at a fast-growing rate.

by William O. Miller

WASHINGTON—The United States is negotiating with a number of other governments for joint participation in space research. These discussions, m/r has been told, are being pursued with the hope that the world's rocket and missile ranges—with or without Soviet participation—will be used cooperatively for man-in-space.

Dr. T. Keith Glennan, top man in the nation's space administration, already has expressed U.S. willingness to participate in a joint satellite venture with Great Britain and the USSR. Meanwhile, the State Department is negotiating with Britain and Australia for permission to put tracking stations in the Admiralty Islands to the north of New Guinea and on Christmas Island in the Indian Ocean. The Christmas Island facilities would also serve as an extension of Australia's Woomera range.

The negotiations are important in the development of an adequate detection and identification system for defense of the free world. Of high priority also is mutual use of the world's rocket ranges—first for worldwide space communications and tracking, and later as launch sites for manned space vehicles.

As a service to m/r readers, the following comprehensive listing of the more important known missile and space test ranges has been compiled. There is considerable doubt about some of the reported ranges in the Soviet Union, Red China and Russian satellite nations.

• **Wide variety**—Although many of the world's ranges are relatively small in size, some of them spread over tens of thousands of square miles of the surface of the earth. Others probe long slender fingers thousands of miles out to sea.

Two interesting facts concerning them are that unclassified trade literature and other journalistic publications indicate they are so numerous, and that the investment in instrumentation and other features represents literally billions of dollars.

Vital to evolving national defense programs and to the exploration of the vertical frontier, these ranges have come into existence in recent years as dramatic landmarks of the mushrooming expansion of the human horizon.

• **Small nations, too**—A rapid survey of English-language books and periodicals establishes that even many of the smaller nations of the world are developing missile test ranges. In addition to the United States and the Soviet Union which, of course, have many such facilities, the random survey has produced information on missile and rocket ranges and research-vehicle launch sites in many parts of the world.

Included are those in Algeria, Argentina, Australia, Brazil, Canada, mainland China, France, Germany (both East and West), the Hebrides, the Indian Ocean, Japan, Korea, Libya, Poland, various Pacific islands, Sardinia, Scotland, Tibet and Wales, plus oceanic shipboard launchings in the waters of the Arctic, Antarctic, Atlantic, and the North, Central and South Pacific.

• **Australia**—One of the largest research and development test ranges in the world is the famous Woomera Range in Australia. Its origin dates from a survey in 1946 by a joint United Kingdom-Australian mission, and it was actually established as the Long Range Weapons Organization in 1947. The ultimate decision for this location was based on good visibility throughout the year, and opportunities for observing and recovering the missiles.

The range extends from Woomera in south-central Australia to the northwest coast, a distance of between 1100 and 1200 miles.

Recently, in anticipation of heavy IRBM testing, the width of the range has been increased to include many additional thousands of square miles. The joint United Kingdom-Australian program has been extended another five years. Plans are to more than double the length of the range by extending it on across water to Christmas Island in the Indian Ocean, for a total distance of 2700 miles.

Woomera is a proper name for this gigantic range. It is the aboriginal name for the launching device used by Bushmen to speed a spear toward its target.

Woomera's geographic conditions and testing advantages are strikingly similar to those of the White Sands Missile Range, and there have been many exchange visits of groups from these two major ranges. Although Woomera is inconveniently located some 12,000 miles from its primary source of missiles and rockets, the testing of drones, ramjets and ballistic missiles, among other projects, continues. So does the launching of rockets for upper atmospheric research.

The Christmas Island terminal of the Woomera range has had other research and development uses. In 1957 the two hundred civilians living on the island were evacuated to permit British hydrogen bomb testing.

• **Canada**—The best known research work using rockets in Canada has been the active IGY program at Fort Churchill. This is a joint scientific program of the Canadian and United State governments. Army troops of both nations, as well as industrial representatives and scientists from both sides of the international border, have participated in this program. There have been as many as twenty consecutive successful firings of *Aerobee*, *Aerobee-Hi* and *Nike-Cajun* rockets, and possibly longer records have been established including the use of other types of research vehicles.

With the IGY facilities constructed

largely by the United States Army, this installation is located in Manitoba, near Fort Churchill, midpoint on the western side of Hudson Bay. The site was partially developed by the Canadian Army, whose missile launch crews had tested *Nike* missiles there under 35°F-below-zero weather conditions as early as the winter of 1954-1955.

Elsewhere in Canada there are test facilities for guided weapons. The Canadian Defense Research Board and the Royal Canadian Air Force, for instance, test air defense missiles at the Cold Lake range in Alberta.

• **French ranges**—Most missile testing by the French takes place at Colomb Bechar, deep in the Algerian Sahara. This major North African range has been in existence about ten or eleven years. Its primary work has centered about the testing of surface-to-surface and surface-to-air missiles, although some development testing of high-altitude research rockets has taken place.

Colomb Bechar, beyond the Atlas mountains, is located not far across the southern border of French Morocco into Algeria. Like many other major research and development test ranges of the world, its facilities have been made available for an international workload. Because of the unstable domestic and international political situations in North Africa, however, other European spokesmen have expressed the desire that NATO IRBM ballistic missile testing be accomplished elsewhere.

Some testing is done within France itself. One range which has been used for testing ramjets and shorter-range missiles, exists near Cannes on the Mediterranean. Undoubtedly there are other such facilities elsewhere within the country.

• **German ranges**—Within both East and West Germany there appears to be activity in missile research and development. Much of the World War II weapon system testing was done at Peenemunde, on the Baltic, and at the Blizna firing range, in Poland. There are many indications that Soviet scientists and technicians have long since reactivated the test and other facilities at Peenemunde.

West Germany's principal launch site is located near Cuxhaven on the North Sea. IGY rocket launchings were planned to take place from here. There has also been activity near Luneburger Heide, northeast of Hanover, and near Bremen, where the active German Rocket Society carries out an interesting research and development test program.

• **Great Britain**—Without question, the British have the most ambitious missile and space technology program in the world, other than those of the United States and the Soviet Union. They are moving forward on every front, including research in the human factors of space flight. In the early autumn of 1959 they will host in London the Tenth Congress of the International Astronautical Federation, the first of the Big Three nations in space technology to have this honor.

British research and development testing of rockets and missiles is carried on in several places. In addition to making extensive use of the huge Woomera establishment in Australia and possibly other NATO ranges, they have test ranges located in Wales, Scotland and the Hebrides. They have even tested radio-controlled target drones in North Africa.

Even before the Woomera range became available, the test range at Aberporth, on the coast of Wales, was the scene of considerable activity. This range has since continued in heavy use for testing air defense missiles and ground-to-air weapon systems. One of the greatest disadvantages of the Aberporth range, according to the British, has been the fact that the overwater flights have all but eliminated the possibility of recovering test missiles after impacting or recovering the bits of the target itself to determine the lethality of the warhead burst.

Meanwhile, other testing is conducted on a small missile range on the Solway coast of Scotland. Much of the workload here appears to be missile weapons for use by ground forces. There are also indications that this facility will be used for launching high-altitude research rockets and limited ICBM component testing.

Recently Great Britain annexed Rockall Island near the Hebrides in the area of a new test range now under development. The main installations are going into the South Uist area, with primary instrumentation established on the island of Hirta. Other instrumentation is being installed in the lonely St. Kilda island group of the Outer Hebrides, on the flank of the firing range. This range, when fully operational, will materially assist the expanding British research and development program.

• **Japan**—The Japanese appear to have at least three test ranges where experimental flights take place. One is the Michikawa rocket center in Akita Prefecture, northwestern Honshu. From there Japanese scientists and engineers from Tokyo University's Institute of Industrial Science have tested research rockets for IGY use, firing toward the Japan Sea. Recent successes here have climaxed a three-year program of rocket development.

Military missile testing is conducted elsewhere. One range is the Ojoji Proving Ground in northeastern Japan. The testing of military missile systems began here with the firing of the first post-war Japanese military missile on July 24, 1956. The Somagarah range in central Japan became operational about 1957 for missile work, and other weapon systems have been tested there.

• **Other Nations** — Interest in rocketry and space technology, official or otherwise, has given rise to considerable activity in many other nations of the world.

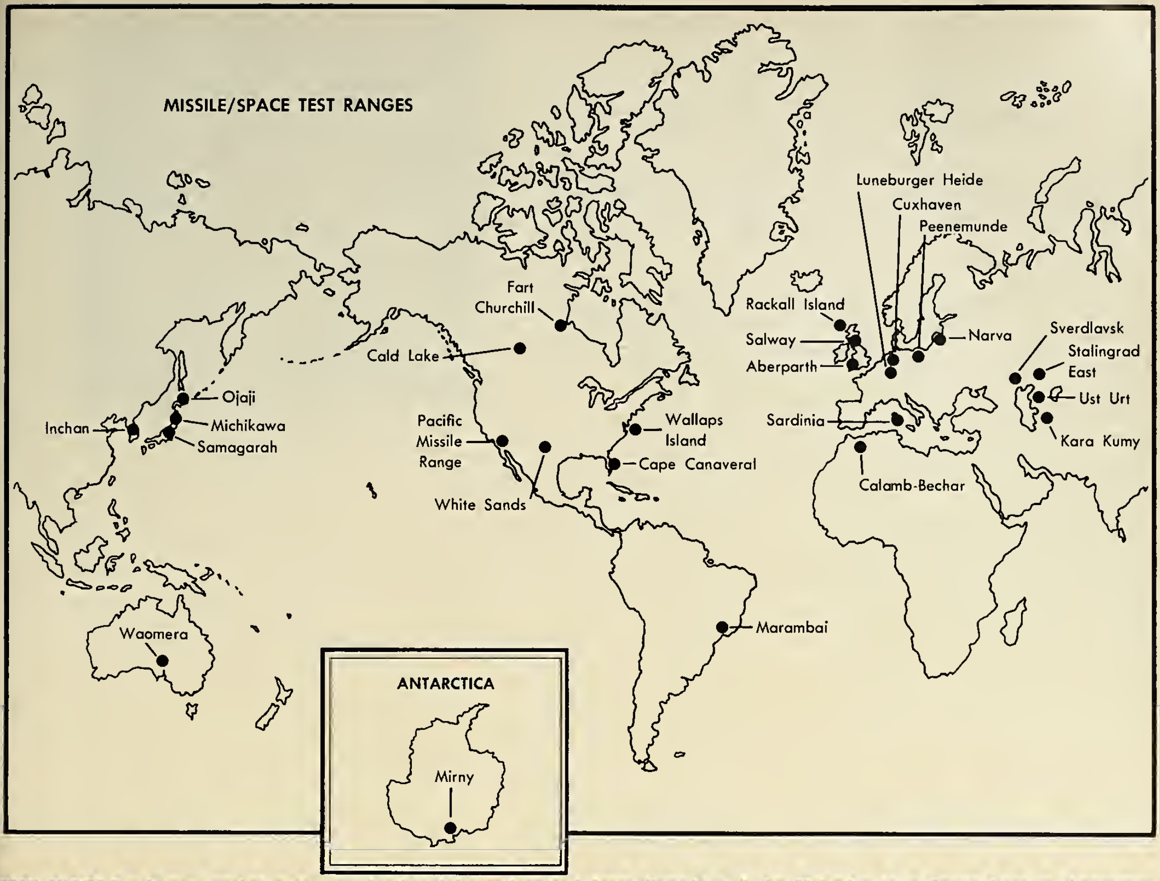
In South Korea, for example, the government has only recently expressed interest in the development of missiles. The National Defense Scientific Research Institute of that country has successfully launched its first experimental guided rocket in a test firing near Inchon, some twenty miles west of Seoul. Non-official interest in rocketry on the part of South Koreans has led to efforts to secure recognition from the Ministry of Education for a Korean Astronautical Society.

Italy has been much more active in missile research and development, and the Italian government has established a full-fledged missile test range on the Mediterranean island of Sardinia. The main instrumentation complex and administrative headquarters are located at Cagliari, where a large aircraft control and warning station is in operation.

A variety of projects have already been tested on this range, principally air defense and ground-to-air missiles. Because of the political situation in Algeria, the Italian government has proposed the use of the Sardinian range instead of Colomb Bechar for NATO intermediate-range ballistic missile testing. This may occur, although the Ralph M. Parsons Company, of Los Angeles, has undertaken a survey of possible sites for missile test ranges in several NATO countries under a contract from NATO's Advisory Group for Aeronautical Research and Development.

In Brazil, too, the government has established a modest program of research and development related to rocketry and space biology. Best known is the Brazilian Army's project involving lofting an animal payload into the region above seventy miles. The launch site for this activity is at Marambai, across the bay from Rio de Janeiro.

The Argentines have had an active Asociacion Argentina Interplanetaria for many years, one which has even given courses on rocketry and satellites within the Science Faculty of the University of Buenos Aires. Recently the Instituto de Investigaciones Cientificas y Tecnicas de las Fuerzas Armadas



THE WORLD's known rocket ranges circle the globe and extend from Canada and the Hebrides to a Soviet base in Antarctica.

conducted an exhibition of various missiles both for aviation and ground use, although nothing has been learned concerning the missile range upon which these have been tested.

• **Russia**—Public information concerning activities in countries within the Soviet sphere of influence is more difficult to obtain. Nevertheless, there are indications that considerable activity is going on in several of those countries, much of it supported directly by the Soviet Union. The reactivation of Peenemunde, mentioned above, is one example.

In Poland the large Polskie Towarzystwo Astronautyczne and the Rocket Section of Krakow's Metallurgical Academy are developmentally testing multistage meteorological rockets. The Chinese Communist government, too, appears actively interested in rocketry and space technology, although their ambitious comments on these subjects have produced no hardware which has come to the attention of this survey.

It is within the Soviet Union, itself, that one of the world's two major programs of weapon system development and astronautical scientific research is being pushed with tremendous priority. There are persistent rumors that the Russians have set up a launching site on a Tibetan plateau to take advantage of the high altitude. While this would be an excellent location for any missile and space work the Soviets might be carrying out jointly with the Communist Chinese, the logistical problems would appear to be almost overwhelming for a program of any size.

While details are unavailable, the Russians are known to have missile and space vehicle launching sites in the Ust Urt and Kara Kumy desert regions to the east of the Caspian Sea. Additional test centers are located near East Stalingrad and in the north near Narva, just to the west of Leningrad.

Launching bases are numerous around industrial centers, particularly in western Russia. While many of these are sure to be air defense type launching sites, they also are presumed to include a number of IRBM bases. Additional missile launching sites are reported in the north of Siberia and others as far east as Sakhalein and the Kamchatka peninsula.

The Russians also have indicated they plan to launch rockets at the other end of the earth—Antarctica. Alexander Nesmyanov, President of the USSR Academy of Sciences, has said Russia eventually will launch satellites from Mirny, its large and permanent base on the southern polar continent. Russia also has announced that it expects to launch some 30 rockets from Mirny as part of its contribution to the International Geophysical Year.

• **U.S. effort**—Inasmuch as coverage of the U.S. missile and space effort is large part of the mission of m/r, only mention of major bases will be made.

The two main sites are, of course, the Atlantic and the Pacific Missile Ranges. Additional testing is carried out at the White Sands range in New Mexico and more tests are being scheduled for the Wallops Island test range on the Atlantic coast of Virginia, a facility now operated by the National Aeronautics and Space Administration.

Anderson Promoted From ARDC To Head AMC

Popular commander becomes a contender for chief of staff after hectic but rewarding efforts to speed missiles.

by James J. Haggerty, Jr.
Contributing Editor to m/r

WASHINGTON—This month the Air Force's Air Materiel Command, which spends more than $8,000,000,000 annually with U.S. industry, gets a new boss.

General Edwin W. Rawlings, who earned the respect of the aircraft and missile manufacturing industry for his efficient administration of AMC over the past several years, is stepping down from the important post to retire. His replacement is Lt. Gen. S. E. ("Sam") Anderson, who has served as commander of Air Research and Development Command for the last 19 months.

With his advancement to the higher-ranking command comes four-star rank for Sam Anderson, subject to Congressional sanction. His is a new name which must be added to the roster of "possibles" in the popular guessing game, "Pick the Next Chief of Staff." In view of announced and anticipated retirements among the USAF hierarchy, Anderson will be one of a half-dozen top contenders.

Despite his high ranking, Sam Anderson is a comparative unknown. He is not even as well known as some of his subordinates in ARDC, such as Maj. Gen. Bernard A. Schriever, his deputy commander for ballistic missiles, whose job has exposed him more frequently to the public view. Anderson's relative lack of publicity stems largely from personal reluctance to face the glare of the national spotlight. "I'm not a very interesting guy," he says.

His own view to the contrary, Sam Anderson is a very interesting guy, particularly to the thousands of contractors who do business with his new command.

• **Left artillery**—At 53, Anderson already has close to 33 years commissioned service, plus an additional four in the U.S. Military Academy. He became a second lieutenant in the Coast Artillery upon graduation from West Point, but he never got around to serving in that branch. Instead, he went to Brooks Field, Tex., to take up flying training.

After the usual succession of instructorships and operational jobs, Anderson, then a colonel, landed on the War Department General Staff in the early days of World War II. In early 1943, he shipped to the Pacific and saw brief combat action there—just long enough to win a Silver Star. Later the same year, he turned up in the European Theater of Operations and flew a number of missions as a wing commander, adding the Distinguished Flying Cross to his growing list of decorations.

In October, 1943, he became commanding general of the IX Bomber Command of the IX Air Force, and stayed in that post until the end of the war in Europe.

• **After the war**—His post-war service was equally distinguished. He was named a member of the Joint Strategic Survey Commission in 1946 and two years later became Director of Plans and Operations under the Deputy Chief of Staff/Operations in the Pentagon. In 1950, he was placed in command of the Eighth Air Force (SAC) at Carswell AFB, Texas.

In May, 1953, he returned to the Pacific area for another tour of combat duty as commanding general of the Fifth Air Force in Korea. Again it was a brief tour, since the Korean "police action" was stalemated less than two months after he assumed command, but he had the satisfaction of seeing his forces rack up a record of 74 kills in the month of June, highest monthly total of the war, including the Korean action's record day in which 15 MiG's were destroyed.

Returning to the United States the following year, Anderson took over the important post of director of the Weapons Systems Evaluation Group of the Department of Defense. In this job he displayed a talent for tact and diplomacy and his tour as director was marked by an uncommon harmony among the members of the group, who represented different services and held varying opinions as to the proper conduct of a potential war.

"He handled the job so well," says one of his top assistants, "that even the Navy was sorry to see him leave."

• **Pre- and post-*Sputnik***—He left WSEG to take over Air Research and Development Command on Aug. 1, 1957, just 64 days before the Soviets launched their first *Sputnik*. His 19 months as commander on ARDC were hectic ones. In the brief pre-*Sputnik* period, he had to battle an Administration-imposed economy wave with its attendant ceiling on expenditures. In the months that followed the *Sputnik* furore, he had to accelerate everything, but with still far-from-unlimited funds.

His record for that trying period is an excellent one. Despite the overpublicized failures of some missile projects, a number of important weapons were brought into operational use or to near-service status. The Convair *Atlas*, for instance, is now several months ahead of its pre-*Sputnik* schedule.

Anderson's ARDC administration also brought into being or revived and accelerated such important projects as the solid fuel *Minuteman* ICBM, the hypersonic B-70 missile platform, the F-108 interceptor, the *Dyna-Soar* orbital bomber and one of Anderson's pet projects, the air-launched ballistic missile.

• **ALBM pushed**—It was ARDC which got the ball rolling on this latter, very important area of research, in January, 1958.

ARDC moved fast on this project and in less than a year two contractors —The Martin Company and Lockheed Aircraft Corporation—were air-launching test vehicles. Under ARDC supervision, some 23 companies were studying designs and launching techniques.

Most of the companies are now preparing detailed proposals which are to be submitted to ARDC this spring. On the basis of these proposals, the Air Force will decide how or whether to proceed with the ALBM idea. It is a safe bet that at least one contract will be awarded.

• **Computer brain**—Sam Anderson has shown rare ability to keep track of the vast ARDC organization in what his aides call his "computer brain." He retains nearly all he reads or hears and frequently astounds his co-workers by citing minute details of one of the multitudinous projects under his supervision. His natty appearance reflects the tidy mind, down to the precise white-blond mustache.

The measure of any top executive is how his underlings feel about him and in that respect Sam Anderson rates tops. To a man, his ARDC staff regrets his departure while rejoicing in his promotion. Although a firm commander, he is always pleasant, they say, and shows a great deal of consideration for the lowliest people under his command.

His interest in people was pointed up during his Korean tour, when he encountered a young Korean pianist named Tong "Tony" Han. Anderson, a music lover, was impressed by the youngster's talent, and along with two other USAF officers, he sponsored Tony's entry into the United States and a course at the famed Juilliard School of Music. The young Korean has since performed with several of America's top symphonies.

Brisk and businesslike in speech and manner, Anderson is impatient with wandering presentations. Staff members have learned to "give him the facts" in brief, concise fashion.

• **For relaxation**—Anderson is not all business, however. He is an avid fisherman and hunter, and he likes an occasional card game. On plane trips, instead of poring over papers or calling a staff meeting, he prefers to organize a bridge game in the belief that relaxation better prepares him for upcoming business.

Anderson also tries his hand at golf, but not too successfully of late, possibly because of his hectic duties.

• **Old ties**—Sam Anderson goes to Air Materiel Command as no stranger, because of the close ties between his old and his new commands. Weapon systems project offices are jointly staffed by ARDC and AMC personnel. Schriever's ballistic missile division works hand in hand with an AMC counterpart office, as does the air defense systems integration division at Bedford, Mass. ARDC and AMC have a number of other overlapping interests, and Anderson himself got together at least once a month with Rawlings for a formal joint staff meeting.

• **Some opinions**—Anderson has some opinions of interest to industry. For one thing, he shares the belief that manned aircraft will figure in defense for quite a while.

"There will be a reduction in inventory of manned aircraft," he says, "but they still have potential—and I'm speaking of atmospheric aircraft." As to whether manned aircraft development can be carried beyond the B-70, Anderson is inclined to think it can.

"When I came here less than two years ago, the general opinion was that you could not build an intercontinental bomber to fly supersonic all the way. In that short time it has been demonstrated that you can. The big problem is heat transfer, but with the progress being made in that direction, we can't rule out anything. We need both aircraft and missiles in complement, because it is easier for the enemy to defend against either one than it is to defend against both."

On where the U.S. stands vis-a-vis the Soviet Union in research and development, Anderson thinks the Soviets are "about as advanced as we are, in some areas ahead, in some behind."

"But," he adds, "you have to qualify your judgment on what they want to do."

He concedes the Soviets the edge in missile propulsion, but adds "we have the power for as far as we want to go." There is evidence that the U.S. is more advanced in materials research, he states.

ARDC's Far-flung Set-up and How It Works

The sprawling command which Anderson will turn over to his still-unnamed successor now numbers 45,600 personnel, about half military and half civilian. About one-quarter of these people are in the technical, engineering or scientific brackets.

ARDC's job is largely research management. Within the last year, it has awarded 3600 contracts to 1100 industrial organizations and an additional 1600 contracts to 249 universities and private research groups. Its contractual obligations run to about $700 million a year, and its overall obligations—including operations, facilities and equipment—amount to $2.8 billion.

It is a multi-faceted command whose range of responsibilities runs from modification of weapons and equipment which have been in service for years to handling the USAF participation in military and civilian space research projects. It administers basic and applied research and operational development in the broad fields of propulsion, materials, electronics, geophysics, biosciences and aeromechanics.

The command structure consists of headquarters at Andrews AFB, Md., near Washington, seven major centers covering various fields of interest, and two sub-centers.

The major centers include:

• **Wright Air Development Center,** at Wright-Patterson AFB, Dayton, Ohio, which conducts basic and applied research in several areas with an extensive "in-house" research program, augmented by contractual work.

• **Air Force Cambridge Research Center,** Bedford, Mass., which handles basic and applied research in electronics, geophysics and human engineering, both in-house and contractually.

• **Air Force Missile Development Center,** Holloman AFB, N.M., which is interested in scientific fields relating to short-range missiles, guidance subsystems and biodynamics testing.

• **Arnold Engineering Development Center,** Tullahoma, Tenn. (see p. 31, this issue of m/r), which covers aerodynamics and simulated altitude propulsion testing.

• **Air Proving Ground Center,** Eglin AFB, Fla. which researches in fields related to system engineering and operational evaluation testing, and non-nuclear weapons.

• **Air Force Special Weapons Center,** Kirtland AFB, N.M., which works closely with the Atomic Energy Commission on nuclear weapons applications, effects and testing.

• **Rome Air Development Center,** Griffiss AFB, N.Y., which handles research in intelligence devices, ground-based electronic devices for surveillance and flight control, and electromagnetic radiation warfare.

In addition to the centers, there is the Air Force Office of Scientific Research in Washington, D.C. AFOSR conducts the exploratory research program of ARDC through contracts with the scientific community. It manages about three-fifths of ARDC's contractual basic research.

ARDC has a similar unit in Brussels, the EOARDC, or European Office, ARDC, which draws upon the available scientific talent in free Europe and provides a means of communication between U.S. and pro-Western scientists in Europe.

Pioneer Deviates in Trajectory

But first stage *Jupiter* fired perfectly with less than one second lift-off delay by ABMA team

by Paul Means

WASHINGTON—Early Tuesday morning, March 3, a group of sleepy NASA and Army space experts announced that the United States had finally done what the Soviet Union had done two months before—only not as well.

Pioneer IV, moving into its orbit as a captive asteroid of the sun, had deviated below its expected trajectory, thereby moving past the moon at too great a distance to carry out a major part of its planned experiments.

After two nights of delays, the countdown of the U.S.'s fifth lunar attempt proceeded smoothly. The launch team had to use all of its built-in delays in order to fire the vehicle at exactly 12:10 a.m. According to AMOC Commander Gen. John B. Medaris, the team missed by less than one second.

The Army's big *Jupiter* booster fired perfectly. The deviation in trajectory was thought to have occurred in the performance of one of the later stages.

Thrust and velocity, shortcomings of previous lunar probes, was more than adequate. The four-stage *Pioneer IV* achieved an initial velocity of 24,890 statute miles per hour,—95 mph less than planned, but 210 mph more than was needed to escape the earth's gravitational pull.

Tracking stations around the world reported picking up the 960.05 megacycle signals of *Pioneer IV's* 90 hour duration battery-powered radio transmitter minutes after launch. The strength of the signal itself was important to NASA scientists, since *Pioneer III's* signal had been weaker than expected, which could have been the result of some as-yet-unexplained condition in space.

Two Geiger-Mueller tubes in the 13.50 pound 20 by 9 inch payload measured radiation as the vehicle went through the Van Allen belts. One tube was shielded with lead to give specific information about high energy radiation.

The tubes are expected to return information about clouds of radiation between the belts and the moon, and about the radiation streams of the sun.

Because *Pioneer IV* missed the moon by 35,000 miles rather than the planned 15,000 to 20,000 miles, a camera triggering device to be used on future probes was not set off by a photo-electric sensor, which would have been activated by the moon's light.

Little to no information was received about the moon's gravitational field, or about its magnetic field and the radiation within it because of the wide miss.

In comparison, the Soviet Union's *Lunik* moved to within 5,000 miles of the moon, which means that if the vehicle's instruments were working properly, Soviet scientists know a great deal about the moon and its properties that U.S. scientists have yet to learn.

On its way toward a solar orbit, *Pioneer IV* was hardly affected by the moon's gravitational field. It's perihelion will be slightly inside the earth's own orbit, and its apohelion will be slightly outside. *Pioneer IV* will complete each orbit around the sun in about the same amount of time as the earth's year.

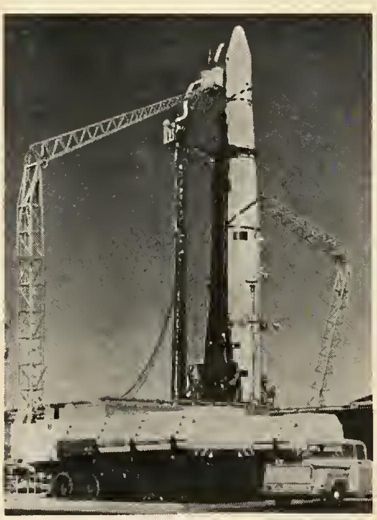
One question left unanswered by *Pioneer IV's* successful launch was the reason for the delay of three months since the failure of *Pioneer III.* ABMA officials claim that the vehicle could have been launched two months ago, and that they were prevented from doing so by administrative delay.

Discoverer I Orbit Dubious

Intermittent signals may be caused by satellite's tumbling or solar heat reviving cold batteries

WASHINGTON—As m/r went to press, DOD would not say definitely that *Discoverer I* launched Feb. 28 from Vandenberg AFB was in orbit. Intermittent radio signals had given credence to the belief that it was in a polar orbit and was operating on its 15 channels.

One theory was that the batteries were dead because of the extreme cold and perhaps would come to life when heated sufficiently by the sun. The telemetry package has two battery power systems—one of short duration to furnish power for the initial tracking and telemetry operations, and a secondary system for general telemetry designed to last several weeks.



A second theory regarding the intermittent transmissions was that the vehicle was tumbling end over end as it circled the earth at 18,000 mph, thereby causing the erratic signals. This could mean that one of the most important pieces of the new equipment was not working—an infrared horizon scanner which sends signals to the guidance system to provide attitude stabilization.

The first stage modified *Thor* had a burning time of 157 seconds.

The second stage Lockheed vehicle was powered by a Bell Hustler engine using white fuming nitric acid and JP-4, with a "slug" of UDMH for hypergolic ignition. Its height is 18.8 feet with a diameter of five feet. It weighed 7,000 pounds, and after exhausting the fuel, had an orbital weight of about 1,300 pounds including the 40-pound payload.

The major purpose of the first launch was to test ground and launch equipment and telemeter certain measurements including atmospheric densities.

The attitude stabilizer which may not have worked incorporates a three-axis control system after the orbital boost and during the short coast period between the burnout of the first stage and the firing of the second stage.

The planned orbit was on a magnetic heading of 183°. It was apparent from fragmentary data available that the perigee could be as close to earth as 146 miles and the apogee as far as 550 miles.

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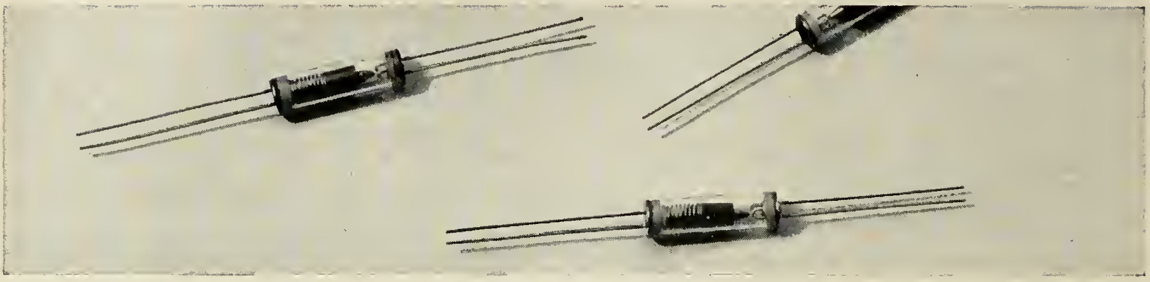

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PHIL FERRIS watches the burning of a new liquid monopropellant inside a high-pressure bomb with Lucite viewing windows.

Wyandotte Pressing Research Work on Monopropellants

Company has new plant producing EtO and may be turning out other organic oxides, but much work is classified.

WYANDOTTE, MICH.—The field of monopropellant molecules is coming in for increased emphasis at Wyandotte Chemicals Corp., a leader in this research field since 1949. High on the priority list is new applications for aminoethycellulose perchlorates (AECP) as composites and in double base solids as a high energy additive.

Beyond ethylene oxide, the company is reluctant to talk about its propellants. However, William Cuddy, who heads up Wyandotte's liquid propellant research, recently presented a classified paper at a monopropellant symposium in Detroit, sponsored by ARS.

Wyandotte is a producer of ethylene oxide and recently put on stream a $37 million Et0 plant at Geismar, La. Other organic oxides—notably propylene oxide—are also growing production items that may figure into the monopropellant picture for Wyandotte. Just how much Et0 is being used in missiles is unknown.

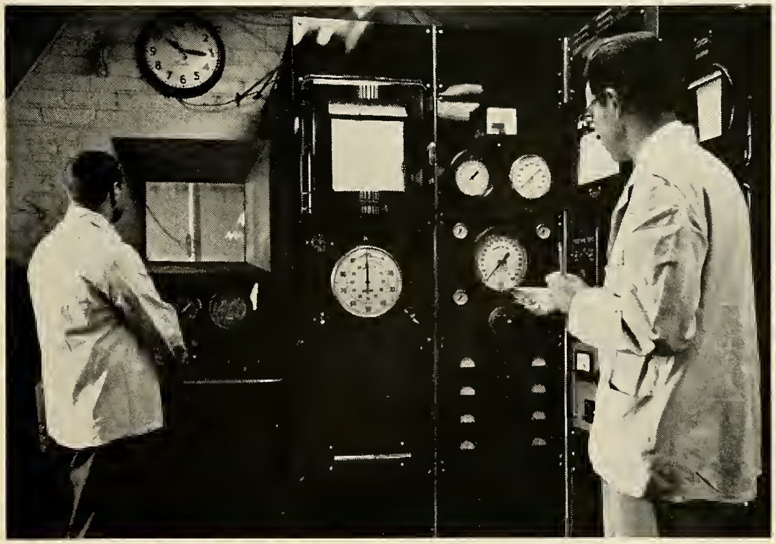
Auxiliary power units in some big ballistic missiles use the low-impulse, low-reaction temperature oxide. Wyandotte's 60 million lb./yr. production of this material is small compared to other producers who are grinding out tonnage lots. Total U.S. production capacity of Et0 this year should be near 1.5 billion pounds.

Et0 use, in missiles at least, is small, and more money is to be made in selling systems than in a material that sells for under 20¢ per pound. Conservative estimates of the oxide use in missiles are on the order of 200 tons/year.

Grasp of this concept is pointed out by Sundstrand's progress in pushing Et0 for ballistic missiles APU's. Dr. Arthur Ash, a key in Sundstrand's Et0 APU efforts originally came from Wyandotte Chemicals after having worked at Wyandotte's High Pressure Lab.

So, Wyandotte is coming around to turning out complete systems rather than just trying to sell monopropellant chemicals. At best, Wyandotte's work on new monopropellants can be described as early. Under a Bureau of Aeronautics contract, lab work is going on to develop a monopropellant with an I_{sp} of over 250 seconds. Production, costs, stability, and sensitivity are some of the "engineering details" that remain to be ironed out. One of the most important is the matter of sensitivity, Wyandotte admits, and tendencies to detonate will have to be licked.

To permit concurrent hardware and propellants evaluation, four new test cells, two chemical labs, general services, and office space are being expanded. Therefore, the primary purpose of Wyandotte for now will be to develop both solid and liquid high energy rocket propellants for the services as well as related hardware. Several of the experimental propellants have already demonstrated higher performance than any currently used in U.S. missile programs.



LARGE CONTROL panels automatically start the firing of rocket motors. The panel also records the test results. Pat Howard and Bill Simpson watch the test. The company has built two modern chemical laboratories to expand high pressure work.

letters

Teflon Troubles

To the Editor:

Re your special report on wire and cables. I have watched for some rebuttal to your excellent article on teflon-insulated wire that would substantiate the problems that we have encountered in using such wire on missile components and for missile wiring.

Evidence from missile component malfunctions and laboratory tests indicates that the teflon insulation on wire becomes a conductor of electricity when the teflon begins to vaporize. Mono tetra fluoro ethylene is liberated when the teflon vaporizes, and evidently the mono fluoro conducts the electricity. At 730°F teflon starts to vaporize, therefore, the temperature environment into which the teflon-insulated wire is placed must be scrutinized for possible high-temperature spots that could cause the wiring to short out during operations. Booster boat tail or booster engine compartments have exhibited high temperature in the order of 800 to 1000°F.

Considerable effort has been expended to reduce the temperature environment within engine compartments to below 500°F. Until the engine compartment temperatures can be positively controlled, the use of teflon-insulated wire in engine compartments would require shielding and cooling to assure that the wire is kept below the vaporization temperature of teflon.

A teflon-coated wire malfunction in a solenoid valve was brought to the attention of the writer. The teflon-coated wire wound solenoid had become over-heated due to a fluid stoppage in the valve. The solenoid coil shorted from the inner wiring through the coil to the outer wire of the coil. The fluorine gas flow could be traced from the inner wire through the coil by the crystalization of the vaporized teflon on the wire of the coil.

Typical test data show the flow of 10 amperes from a 5-volt supply between conductors of teflon-insulated cable 20 seconds after flame was applied to the table. The current flow ceased with a continual application of heat after the teflon is vaporized. Tests indicate that teflon begins to vaporize at about 730°F. Wire with teflon insulation if subjected to spot temperatures in excess of 730°F would have its insulation resistance reduced and would fault between conductors.

J. G. Lindberg
Senior Research Engineer
North American Aviation Inc.
Downey, Calif.

F-108, NUCLEAR TURBOJET, AND RAMJET PROJECTS OFFER CHALLENGING OPPORTUNITIES TO PROFESSIONAL ENGINEERS AND SCIENTISTS

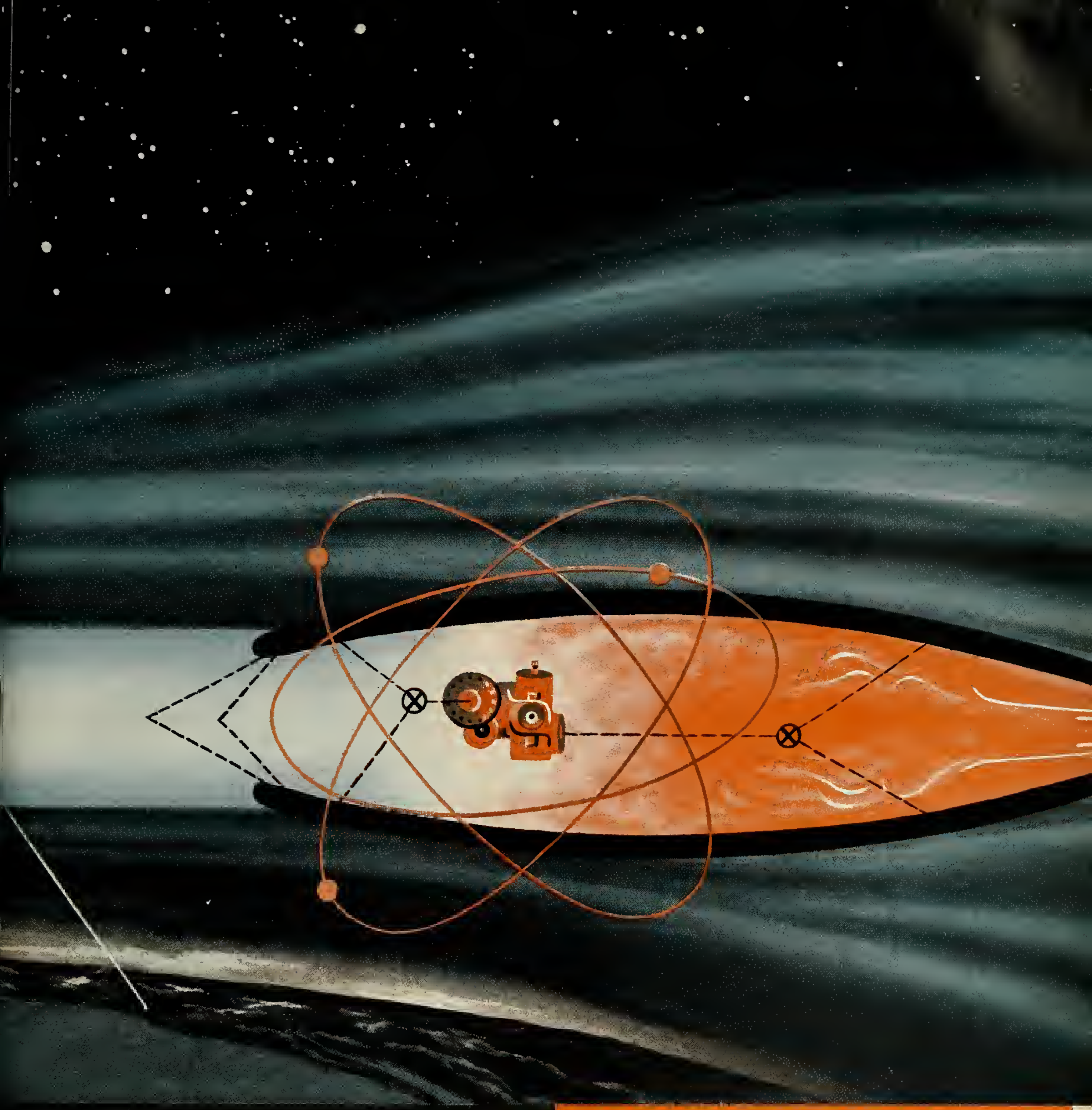
Advanced projects for air and space operations now underway in the Controls and Accessories Division at Marquardt Aircraft offer engineers and scientists challenging opportunities in a variety of technical areas. Here, where we are dealing with development problems on high-performance systems with stringent design and reliability requirements, professional engineers will find real challenge and opportunity for accomplishment.

Project personnel are currently working in such areas as the engine control system for the G-E nuclear turbojet; inlet control systems for the McDonnell F-4H, North American F-108 and the North American Hound Dog missile; the fuel control system for the supersonic Bomarc's ramjet engine; auxiliary power systems, pumps, and actuators; and are developing a unique and advanced space power unit.

C & A Division activities range in scope from preliminary design through final production.

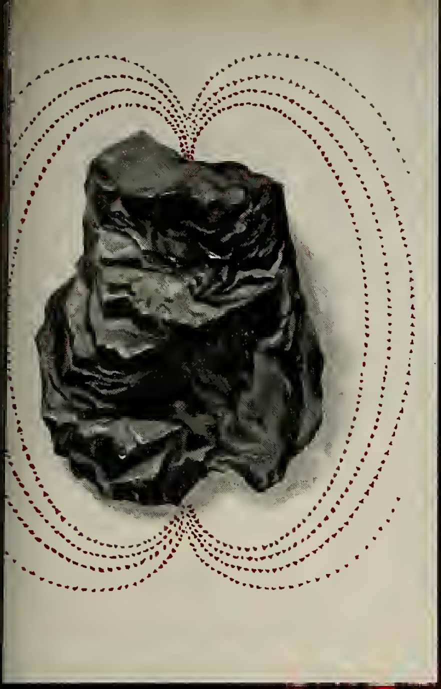
Professional engineers and scientists capable of making contributions in these and related areas are invited to investigate the employment opportunities at Marquardt. You will find a combination of significant, active projects and a lively interest in new ideas, creating an environment for professional growth. May I suggest you write Mr. Floyd Hargiss, Professional Personnel Department, 16552 Saticoy Street, Van Nuys, California?

Roy E. Marquardt, *President*



MAGNETOHYDRODYNAMICS

EXPANDING THE FRONTIERS OF SPAC



Cover Story:

Weapons Testing Booms at AF's Arnold Center

Facility supports nearly all top-priority systems of services as well as lunar probes. Wind tunnel used in achieving escape velocity for first time anywhere.

TULLAHOMA, TENN.—The Arnold Engineering Development Center has more than 20 test units booked solid for as much as 14 months to come in its efforts to keep the Air Force abreast of the space age.

A rising percentage of the continuing program of design modifications and changes is devoted to guided missiles and space vehicles rather than ramjets and manned aircraft.

Maj. Gen. Troup Miller, Jr., commanding officer, says the 10-year-old Air Research and Development Command facility really has come into its own during the last 18 months—with the dawn of the space age.

• **Tunnel breakthrough**—One of the most significant tests here was recorded in February, when a velocity of approximately nine miles a second was generated in the arc-driven hypervelocity tunnel Hotshot 2 of the Gas Dynamics Facility. This was the first time escape velocity had been reached, or exceeded, in a wind tunnel.

This facility, along with two others, is supporting almost all of the top-priority Army, Navy and Air Force missile weapon system projects, including *Atlas, Polaris, Minuteman, Dyna-Soar, Bomarc, Thor, Jupiter* and *Sergeant*. Tests are scheduled for *Titan*. And the *X-15* and B-70 bomber programs have been tested here.

One company official recently said missile tests run at Arnold achieved results which could not otherwise have been accomplished without setting up additional facilities at an estimated cost of $25 million. The Center, incidently, was designed by Sverdrup & Parcel, Inc., consulting engineers.

• **Transonic circuit**—The Transonic circuit is a continuous-flow closed circuit tunnel capable of operating pressure levels from a near vacuum to stagnation pressure of 2.5 atmospheres. It can test large-scale aerodynamic models and full-scale air-breathing and rocket propulsion systems. Recent modifications will permit solid and liquid rocket propellant tests. Both the Transonic model tunnel and the supersonic model tunnel are being used in rocket testing.

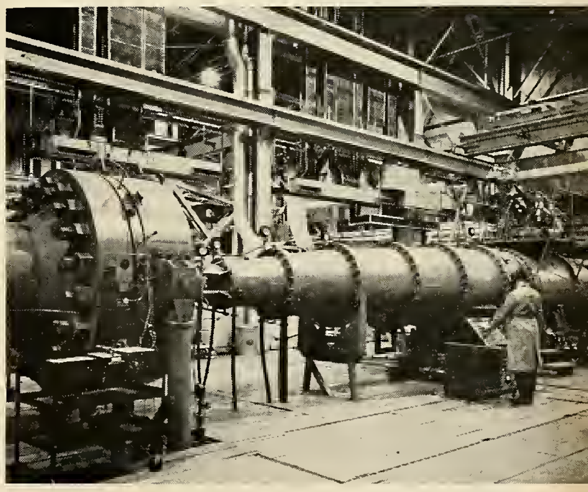
The Hotshot 2 arc-driven tunnel is so involved in boost-glide and re-entry projects that tunnel research (for which it was originally designed) can be accomplished only on a second-priority basis. Air in this 50-inch diameter tunnel, initially confined to an arc chamber by a diaphragm near the throat of an attached convergent-divergent nozzle, is heated and compressed by an electric arc discharge and expanded by the conical nozzle to the test section and vacuum tank. A useful run of about 20 milliseconds duration is obtained.

• **Test cells**—Velocities from 100 to 2500 mph, altitudes to more than 100,000 feet, and airflow temperatures from –120° to plus 650°F can be simulated in the facility's test cells. A full-scale solid propellant rocket has been test fired at a simulated altitude of 90,000 feet. Results of high-altitude solid burning studies in the Engine Test Facility have prompted design changes in several missiles and space vehicles.

Extensive testing in support of the lunar probes includes work with spin rockets, third-stage rockets, verniers and retrorockets.

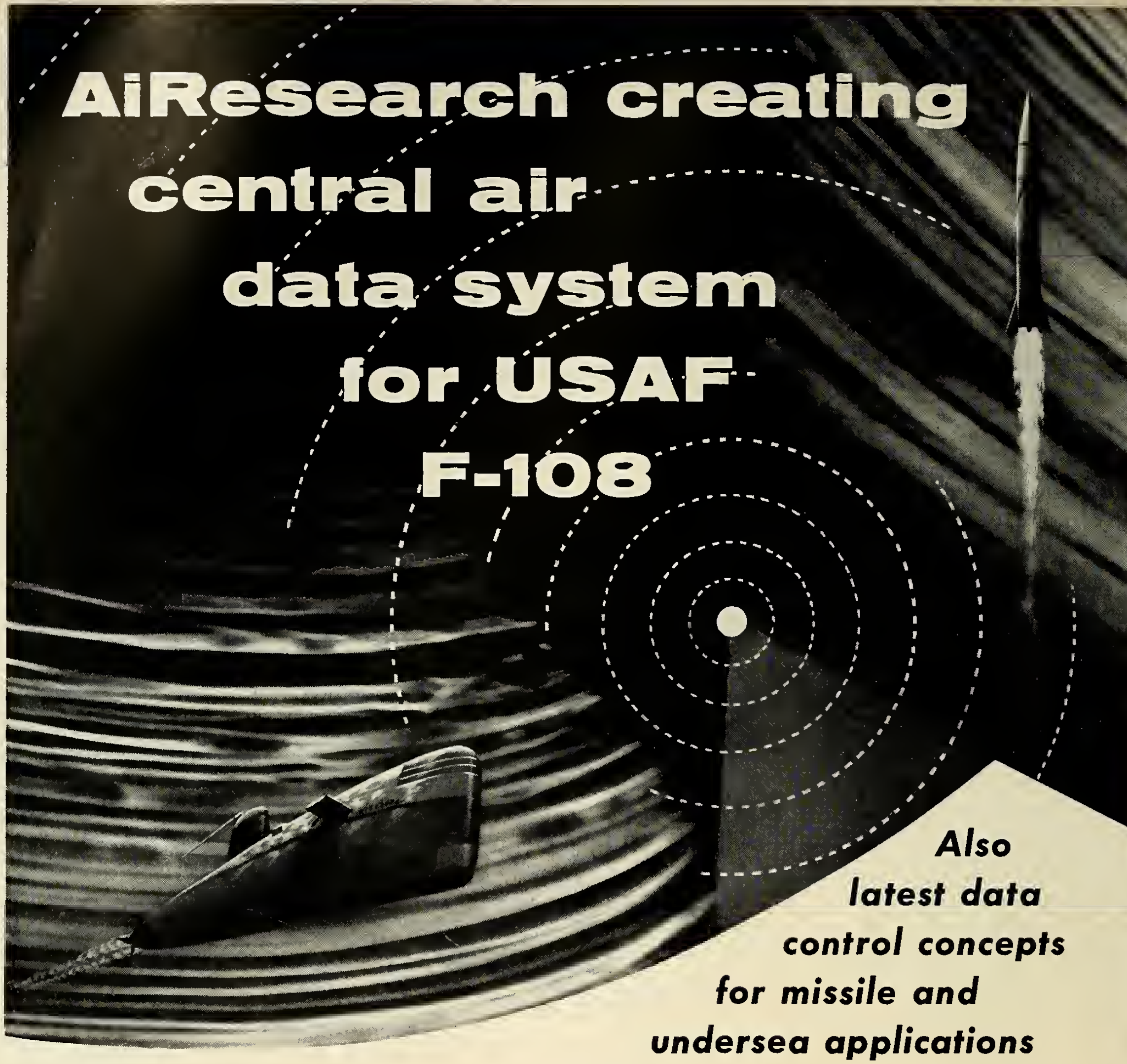
The 16-foot test section of the Propulsion Wind Tunnel's Transonic circuit has made possible full-scale aerodynamic testing, showing the value of work with production models of missiles. Current testing of rockets broadens use of this wind tunnel—one of the most versatile in the free world.

VARIABLE STATOR vanes in transonic circuit of the propulsion wind tunnel help control the airflow from three-stage compressor at Arnold.



TUNNEL B2 of Gas Dynamics Facility, with 50-inch diameter, is only large continuous-flow wind tunnel in nation to operate at Mach 8.

AiResearch creating central air data system for USAF F-108



Also latest data control concepts for missile and undersea applications

The AiResearch Centralized Air Data Computing System will sense, measure and automatically correct for air parameters affecting flight of the North American-Air Force F-108 Interceptor and will supply simplified air data to the pilot. Eliminating duplication of components, the system will cut down space and weight requirements over decentralized systems by many times.

The centralized combination of transducers, computers and indicators represents an integrated system concept combining electrical, electronic, pneumatic, hydraulic, electro-mechanical and mechanical servo capabilities. Technical experience in each of these fields enables AiResearch to achieve optimized systems covering a wide range of functions while meeting the most rigid specifications. Systems management is an integral part of each Central Air Data program enabling AiResearch to assume the overall responsibility for systems or subsystems.

The first fully optimized central air data system is already operational aboard the Navy's supersonic F4H-1, the first aircraft to fly with such a system. Similar equipment is on the Navy's first weapon system, the A3J "Vigilante." This broad AiResearch systems capability is now being applied in the fields of military aircraft, commercial jet transports, missiles and submarines.

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New Robot Is Big Step in Numerical Control

Automatically Programmed Tool developed at MIT translates jargon and guides cutting.

by James J. Haggerty, Jr.
Contributing Editor to m/r

CAMBRIDGE, MASS.—The latest wrinkle in automatic machine tooling is a master robot which can understand human language and translate it into cutting directions for a numerically-controlled machine.

This new system, regarded as a very important step in adjusting manufacturing techniques to the complex requirements of the space age, offers a method of reducing further the time between initial design of an aircraft or missile part and its actual production. It could cut costs by reducing man-hours and machining time, and it permits automatic and highly accurate machining of more complicated parts.

Demonstrated to a press and industry group at Massachusetts Institute of Technology last week, the system is known as APT, for Automatically Programmed Tool. It represents a major advancement in numerical control—the method of guiding a machine tool without a human operator by the "player piano" technique, in this case a punched tape which directs the cutting movements of the machine in turning out a part.

Numerical control has made gradual inroads in aircraft and missile manufacturing processes over the last few years and today there are 80 such automatic machines operating in the industry.

• **Shorthand jargon**—The breakthrough provided by APT lies in the method of producing the tape. Where formerly the tape data for a given part was laboriously calculated mathematically by humans, the APT computer gets its instructions in a simple, easy-to-prepare jargon. For example:

"ON KUL, ON SPN, GO RGT, TL LFT, CIRCLE/CTR AT, +2, +3, RADIUS, +5."

This language, fed to the electronic brain on punched cards, translates into:

"Turn on the coolant, turn on the spindle, go right with the tool on the left side along the circle whose center is located at x equals 2, y equals 3, with a radius of 5."

An extra in the APT computer system is its capability of preserving the design integrity of the part by checking up on the accuracy of the information fed it. Ben S. Lee, assistant public relations director of Aircraft Industries Association, provided an unscheduled demonstration of APT's double-check talent during a press inspection of the system.

Asked to design his own part specifications and feed it to the machine, Lee drew up some hastily-compiled data for a modern curvy ash-tray.

The APT computer digested his information in seconds and came back with a terse teletype reply:

"GEOMETRICALLY IMPOSSIBL."

Red-faced Lee took some consolation from the brainy computer's report. "At least I can spell 'impossible'," he said.

• **Language course**—This would mean nothing to an ordinary electronic computer. However, the APT system's designers worked up a simple "training course" to teach the language to general purpose computers already in wide industry use. The text book in this training course is a deck of 12,000 to 18,000 punch cards, worked up by MIT and its collaborators over a two-year research period which involved computer thinking equivalent to 25 man-years.

Insertion of these cards into a general purpose computer converts it to an APT computer which can understand the language and guide a number of machine tools through the proper motions to produce a part automatically and with greater accuracy than heretofore.

Development of the language is credited to Dr. Douglas T. Ross, an MIT mathematician. His computer jargon consists of 107 words of six letters or fewer, adequate to handle a wide variety of machining jobs, including manufacture of highly complex parts.

• **How it's applied**—The part-manufacturing sequence with APT is this:

A designer conceives the part, detailed drawings of it are made, and these drawings are converted into APT language, a job considerably more simple than manual programing and one which can be handled by any technician after a short training period. The language statements are then punched on "part program cards"—another simple job—fed into the computer and the rest of the operation is automatic.

The APT system has two added advantages: first, the computer language was designed so that a standard procedure can be followed throughout the aircraft and missile industry; second, the system was purposely designed to allow future growth to accommodate still more complex parts.

APT was developed under a cooperative program spearheaded by MIT's Servomechanisms Laboratory. The project was funded primarily by the Air Force's Air Materiel Command, with help from 19 member companies of Aircraft Industries Association, who are using their own money for service testing and continuing development of the system.

• **Hailed by military**—Lt. Gen. Clarence S. ("Bill") Irvine, Air Force Deputy Chief of Staff/Materiel, hailed APT as a significant advance. He pointed out that, in the technological war with the USSR, the military must not only pioneer advanced types of equipment, but it must make an equal effort to advance design and production techniques.

Developments in the manufacturing processes such as APT make contributions in two very important areas: cost-cutting in a period when weapons systems complexity dictates higher and higher prices, and reduction of lead time.

An example of the advantages of APT in these areas was cited: the programming task for a typical wing rib

(Continued on page 47)

Missile Needs Pose Challenges for Ceramics

Industry expects demand within decade for materials that will take temperatures up to 4000°F in missiles.

by **R. T. Inglis and D. L. Krout, Jr.**

Senior Design Engineer and Design Specialist, respectively, at Convair/Pomona, Division of General Dynamics Corporation.

POMONA, CALIF.—The high speeds of today's missiles and the resulting high temperature environment are merely scratching the surface of the so-called "Thermal Barrier."

Ira H. Abbott, Assistant Director of Research for Aerodynamics and Flight Mechanics for the National Aeronautics and Space Administration, has informed the Aircraft Industries Association that top operating temperatures within the next five years are likely to be 2000°F for prolonged exposure, and 3000°F for a few minutes.

Within ten years, Abbott wrote AIA, operating temperature of 2500°F should be expected for an hour, and 4000°F for a few minutes.

• **Anticipated needs**—The NASA official said that within five years low-density thermal insulation for structural and electrical materials probably will have to stand up to temperatures as high as 2500°F—and that this range is likely to go up to 3000°F within ten years. Ceramic insulation, he said, will be needed to meet temperatures from 1500° to 4000°F.

"It is believed," Abbott added, "that there will be a need for protective coatings for metallic and non-metallic materials that will be capable of withstanding temperatures to 3000°F, and that flame plating and ceramics . . . to withstand oxidation and erosion at temperature as high as 5000°F will be needed."

High-temperature structures are the problem of the missile and aircraft industry, and a challenge to the ceramics industry. This article will examine this area in more detail.

Manufacturing Requirements

Because aircraft and missile manufacturers hesitate to rely on a single supplier, the production process should not be so proprietary as to preclude multiple sources.

Naturally, the process must be completely reliable, insuring an end product of uniform quality. There should be quality control methods for the non-destructive detection of hidden flaws. And production facilities and labor market must be adequate to meet delivery dates.

The manufacturing tolerances generally used on missile structure are as follows:

Diametrical	=	Down to ± .010 in./ft. of diameter
Length	=	Generally ± .030″ per assembly
Thickness	=	10% on thin gauges and progressively less on thicker gauges

Fig. 1 illustrates the tolerance range used on stainless steel sheet. These tolerances are necessary to insure not only fit and contour, but also the weight control and strength so essential to missile manufacturing. Center of gravity shift and weight variation seriously affect performance.

Radomes, a more exacting field, can require contour tolerances of ± .002 inch and thickness control of 0.8%.

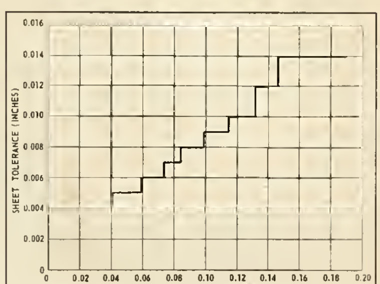


FIG. 1 indicates the tolerance range used on stainless steel sheet.

• **Handling problems**—Undoubtedly, ceramic structures will bring handling problems somewhat different from those previously experienced by the missile industry and armed services. These will include handling not only within the factory but also in transit, in storage and in the field with the military services. The experience and recommendations of the ceramic industry will be invaluable here.

Industry cooperation will be required to acquaint missile designers with engineering techniques, terminology, and special manufacturing problems unique to ceramics.

Strength Properties

Figs. 2, 3 and 4 compare the strength to weight, stiffness to weight and thermal shock resistance of three metals and two ceramics.

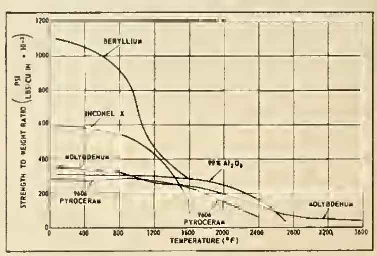


FIG. 2—The strength to weight ratio, comparing metals to ceramics.

These are molybdenum, Inconel X, beryllium, alumina and Pyroceram (9606).

Fig. 2 demonstrates that while beryllium and Inconel X are excellent below 1200°F on an ultimate tensile strength to weight basis, they fall off rapidly above this and only molybdenum compares favorably with the two ceramics thereafter. It should be noted that compression allowable stresses of ceramics are many times greater than their tension allowables.

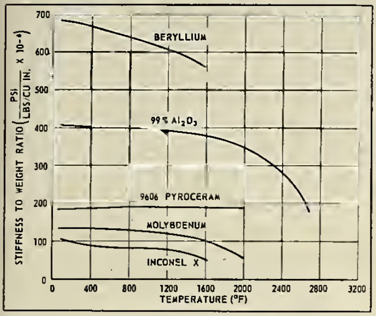


FIG. 3—The stiffness to weight ratio of metals vs. ceramics.

Fig. 3 shows that the trend of the two ceramics will be superior to the metals in the higher temperature range for a stiffness, Young's modulus, to weight ratio comparison. Beryllium will fall off rapidly after 1600°F. It should be noted that structural stiffness is important in missiles to insure advantageous control response rate.

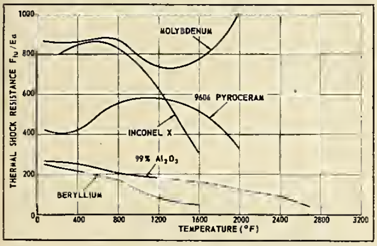


FIG. 4—Comparison of thermal shock resistance factor with steady-state temperature differentials.

Fig. 4 compares these materials for an elastic range thermal shock resistance under conditions of steady-state temperature differentials. Steady-state temperature differentials are defined as conditions where temperature variation is linear through the specimen. In all fairness, it should be pointed out that all of the metals will be far superior in the plastic range due to their greatly reduced tangent moduli and ductility.

Designing for Ceramics

Ceramics used extensively as materials in airframe primary structures must be subjected to stresses close to their ultimate strength.

To accomplish this, the aircraft designer must take into account all stresses and stress concentrations regardless of how small an area they may act upon. The smallest local failure will result in a complete and massive failure, because of ceramic's complete lack of ductility. This type of analysis is much more time-consuming and therefore more costly than that required for metal structures.

• **Some allowables**—Before one can efficiently design a ceramic structure, he must have design allowables. The following are major factors affecting the allowable of a given ceramic body:

1. Surface conditions: Tests show a spread of 4 to 1 between the best results and those from specimens with severe stress concentrations resulting from surface finish. The R.M.S. finish in ceramics is not the criterion for stress concentration. The bottom radius of minute surface finishing scratches determine the stress concentration effect.

2. Size effect: Generally the larger the body the lower the allowable.

3. Method of manufacture: Is it slip-cast, pressed, etc?

Thermal Stresses

Temperature gradients through the wall of a structure will, in general, induce tensile stresses on the cooler side and compressive stresses on the hotter side. This is a particularly acute problem in high-speed aircraft and missiles where thermal fluxes are of such great magnitude.

Fig. 5 illustrates the effect of steady-state thermal gradients on the thermal stress across the walls of two unrestrained ceramic cylinders made of Corning Glass Pyroceram (9606) and high purity alumina (Al_2O_3).

The outer diameter was assumed at 2000°F with a straight line decreasing temperature towards the inner diameter. A notch sensitivity factor of 2.0 was arbitrarily assumed for both materials, that is, 50% of test allowables.

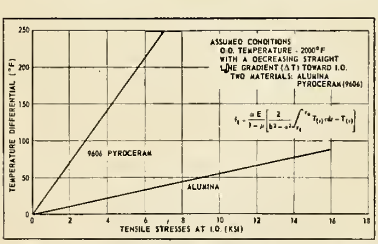


FIG. 5—Effect of temperature gradient on cylinder wall thermal stresses.

Although Pyroceram would fail at 7000 psi, as compared to alumina at 16,000 psi, the Pyroceram could withstand a considerably higher temperature gradient before failure than the alumina. This is due to the fact that the thermal expansion, Poisson's ratio and Young's modulus of Pyroceram are considerably lower than that of alumina.

It should be pointed out that these thermal stresses do not include combination with any stresses due to external loads (aerodynamic and inertia loads). Thus, thermal gradients, and the attendant thermal stresses induced, materially reduce the external load carrying capacity of the structure.

Reinforced and Pre-stressed Ceramics

At first blush, it would appear that reinforced and pre-stressed ceramics will solve the problem of the relatively low tensile allowables of ceramics as compared to metals. This is probably stimulated by reference to reinforced and pre-stressed concrete. The following discussion will demonstrate some of the problems involved in accomplishing a pre-stress on high-strength and high-temperature ceramics subjected to tensile stresses.

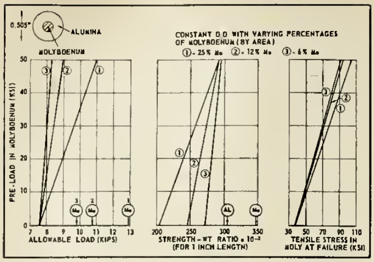
The relative stress distribution in a composite structure is proportional to Young's Modulus of Elasticity of the materials. Using alumina as the ceramic, it becomes apparent that the metallic reinforcing should have a large E (Young's Modulus of Elasticity).

This will tend towards having the low-tensile-strength alumina and the high-strength reinforcing fail simultaneously under external loading. Also, the metallic reinforcing material should maintain strength through the temperature range of the ceramic. These two pre-requisites make molybdenum a logical choice.

The firing temperature of alumina is above 3100°F. If the metallic reinforcing were pre-loaded in the ceramic at the firing temperature, the pre-load would be destroyed due to both the ceramic firing shrinkage and the thermal contraction during the cooling of the alumina as compared to the molybdenum. Thus, the pre-loading must be accomplished while the alumina is relatively cool.

• **Pre-loading effects**—The reinforcing will have to be pre-loaded on the finished ceramic body either in pre-drilled holes or in an external configuration. Fig. 6 demonstrates the effect of pre-load in the molybdenum and the ratio of alumina to molybdenum, by area, on the tensile load capacity of a given composite specimen at room temperature.

Fig. 6a demonstrates that the greater the percentage of molybdenum, the greater the load-carrying ability with pre-load. However, it should be noted that there is no difference in load-carrying capacity when there is no pre-load. This is due to the fact that there is practically an equal E (Young's modulus) and thus an even stress dis-



FIGS. 6a, b & c—Effects on alumina tensile specimen due to variations in molybdenum reinforcing and pre-stressing at room temperature.

tribution between the alumina and molybdenum.

Notice the encircled symbols along the abscissa, which demonstrate the load-carrying capacity of a pure molybdenum tensile specimen of a weight equivalent to the corresponding numbered composite specimen. In each case, the pure molybdenum specimen was capable of carrying a greater load than its equal weight composite counterpart.

Fig. 6b replots Fig. 6a on a strength to weight basis. With a zero pre-load the specimen with the least molybdenum reinforcing is superior. All three specimens seem equal with 50,000 psi pre-load. The encircled A_L and M_o on the abscissa indicate the relative strength to weight ratio figures for pure alumina and molybdenum. Again these are superior to the composite specimens.

• **Composite drawbacks**—Fig. 6c shows the stresses in the molybdenum at failure of the alumina in the composite specimen as affected by variations in pre-load. It should be noted that these become quite large and any further increase in the pre-load would yield the reinforcing, and, thus, gain little in load-carrying ability.

Granted that this composite specimen is of two specific materials, it does point out, however, that reinforcing and pre-loading will actually lose ground when compared to the basic materials alone on a strength-weight basis.

It is of interest to note that the tensile allowable used on the alumina was 38,000 psi which is extremely optimistic. A design allowable would have to be substantially lower to account for the notch sensitivity of the material. This would only tend to emphasize the facts already presented.

If a lower modulus, but high-strength ceramic were used, the net result would be to put a greater portion of the load in the molybdenum. The latter would fail rather than the ceramic if the ceramic modulus was low enough. Still, it does not appear that this would increase the allowable load appreciably over that of the pure ceramic; certainly not enough to justify the added complexity and expense of using reinforcing and preloading. This, of course, applies only to tensile stress regions.

• **Composite reaction**—The preceding discussion dealt with the room-temperature effects of reinforcing and pre-stressing. Possibly of greater interest is the reaction of a pre-stressed composite tensile specimen to temperature.

A composite tensile specimen of alumina with molybdenum is ideal due to the closely matched coefficients of thermal expansion of the two materials. By using specimen #2 of Fig. 6 with an initial 10,000 psi pre-load in the molybdenum, Fig. 7 demonstrates the effect of increased temperature and gradient on the molybdenum pre-load.

Fig. 7a shows a hypothetical, but reasonable, temperature differential between the alumina and molybdenum. Fig. 7b demonstrates the effect of temperature increase and temperature differential on the pre-load stress in the molybdenum. Young's modulus of elasticity at the various temperatures was used. Therefore, only the elastic range of the molybdenum is shown. Note the extremely high pre-load stress when the alumina temperature is 1200°F and the molybdenum is lower by 230°F.

Of course, the higher the pre-load, the lower the external load will be before failing the reinforcing. The pre-load curve will tend to flatten out in the plastic range of the molybdenum. Thus, with permanent set in the molybdenum, a recycling of temperature, or any cooling of the specimen, will radically reduce the pre-load effect.

In fact, if the recycling carried the specimen back to room temperature the "reinforcing" could then be reversed into a compression stress. Thus, the reinforcing would then be a detriment to the specimen. Creep in the reinforcing will also reduce the pre-load effect.

Structural Attachments

If ceramics are to be used as a primary structural material for missile airframes, satisfactory ceramic-to-ceramic and ceramic-to-metal attachments must be developed. Some required features are:

1. Strength: The attachment must withstand the structural loads over wide temperature ranges and high heating rates. Under these conditions, the thermal stresses resulting from differential expansion and gradient will add to the structural loads.

2. Stiffness: High fineness ratio missiles (high length to dia. ratio) require high over-all stiffness. This in part determines the natural frequency of the structure—the stiffer the structure, the higher the frequency. A high frequency structure has two major advantages: fewer problems from flutter and faster response, which enables the missile to maneuver faster.

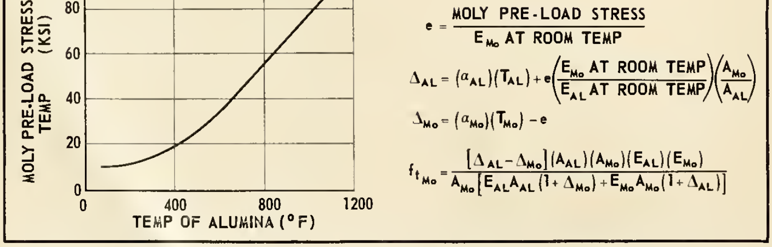
3. Weight: Weight must be held to a minimum for obvious reasons.

4. Size: A thin cross section is most desirable. All attachments for cylindrical body sections restrict access to the internal volume of the airframe.

5. Assembly: Extensive time, extreme care, special techniques and tools required for field assembly should be held to a minimum.

6. Cost: Fabrication cost must be held to a reasonable figure.

7. Materials: Strategic materials

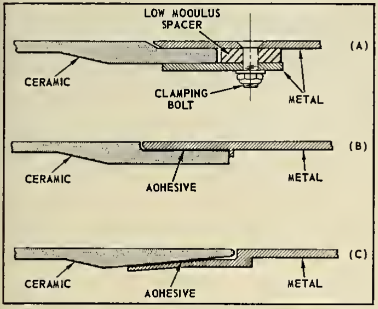


FIGS. 7a & b—The temperature effect on pre-load for alumina specimen. (12% molybdenum reinforcing at 10,000 psi pre-load.) (Ref. Fig. 6, specimen 2).

should be incorporated in the attachment only as a last resort.

Approaches to the Attachment Problem

• **Clamped attachments**—This method (shown in Fig. 9a) is almost universal with the glass and ceramic industries. It consists of clamping the ceramic on all edges with massive metal frames, putting the ceramic in compression. All ceramic-to-metal load transfer is by friction. The frame is stiff enough so that little load is transferred into the ceramic.



FIGS. 9a, b & c—Proposed clamped and cemented attachments for ceramics in missiles.

If this ceramic-metal combination is to be exposed to wide temperature variations, a metal must be selected that has a thermal coefficient of expansion which closely matches that of the ceramic over the operating temperature range.

This attachment has some disadvantages. The weight involved is more than can be tolerated in an efficient airframe design. Metal must be placed on the outside of the structure, thereby limiting the attachment to a temperature that the metal will withstand. As the metal is on the outside, it will be exposed to the heat source more than the ceramic.

Consequently it will heat faster, resulting in a greater thermal expansion, even if the coefficients are identical. This differential expansion will reduce the clamping force and in turn reduce the attachment's load-carrying capacity.

• **Cemented attachments**—(Figs. 9b and 9c) This type of attachment can be lighter in weight than the clamped attachment, for the cement will force the metal and ceramic to work as a unit, up to the limit of the cement. In this type of attachment, the load is transferred from ceramic to metal through the cement, primarily by shear.

For temperatures below approximately 500°F, organic cements can be used. These have the ability to yield, reducing the load induced from differential expansion.

For higher temperatures, an inorganic cement must be used. Generally these will withstand much higher temperatures but they lack ductility. Therefore, we now must match the expansion coefficients and heating rates of the ceramic, metal and cement.

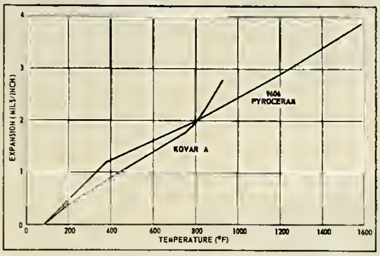


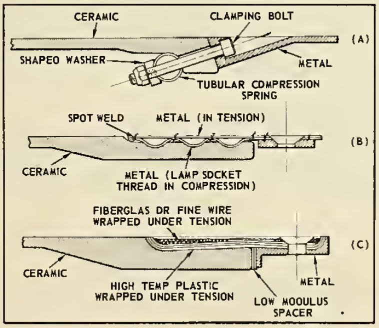
FIG. 8—Linear expansion vs. temperature for Kovar A and 9606 Pyroceram.

Fig. 8 is a plot of two materials whose expansions match quite well between room temperature and 900°F. These are Kovar A and 9606 Pyroceram. An example problem in differential expansion will best serve to show the importance of an accurate match.

Assume concentric thin wall cylinders of equal spring constants having Kovar A on the outside with an average temperature of 900°F and Pyroceram on the inside at an average temperature of 700°F. A differential expansion of approximately .001 in/in. of diameter will be the result.

The attachment, however, forces the two rings to expand equally, introducing a tensile stress of approximately 8000 psi in the ceramic. This stress must be added to the stresses resulting from the thermal gradient in the ceramic and the external loads.

• **Elastically clamped**—(Fig. 10) In this type of attachment the non-ceramic portion can be metal or plastic, inside or outside of the ceramic structure.



FIGS. 10a, b & c—Suggested elastic attachment using metal or plastic.

Elastic deformation in the metal or plastic is intended to compensate for the differential thermal expansion between the two materials. The necessity of matching thermal expansions is therefore not as important in these approaches. These schemes appear to offer the best chance of working at temperatures above 1000°F.

In the scheme illustrated by Fig. 10a, a tension bolt has its head in the metal portion, and shank passing through an oversize hole or slot in the ceramic body, compression tube and washer, into a nut. When the bolt is tightened the tube tends to flatten, thereby clamping the ceramic and metal structures together.

When the composite structure is heated, this tube spring will deform more or tend to return to its original shape, depending upon the differential expansion. Thus a pre-load is retained over a wide range of temperature and gradient. The clamping force is limited by the elastic load range of the tube.

In Fig. 10b the threaded metal portion is installed on the ceramic. The outside metal sheet then is wrapped over the threads with a high hoop tenload, and welded to the thread prior to relaxing the hoop tension. This tension in the outside sheet will flatten the top of the threads, forcing the root into the groove in the ceramic.

Differential expansion between ceramic and metal will produce greater or reduced bending in the metal thread. This insures thread contact and acts as a pre-load.

Fig. 10c shows fiberglas and plastic tape wrapped and cured on the ceramic under tension. This is followed by wrapping individual filaments of fiberglas or fine wire under tension. A cover of fiberglas is placed on the outside for insulation. Elastic strain in the fiberglas and wire will insure a clamping force over a wide temperature range.

Protective Coatings

There is also a large field for ceramics as coatings to protect and insulate high-temperature metallic alloys. Such metals as molybdenum exhibit excellent mechanical properties at high temperatures but are also subject to severe oxidation at these temperatures in a normal atmosphere. Thus, ceramic protective coatings are desirable to provide longer metal life.

These coatings should inhibit oxidation, intergranular corrosion, and de-carburization; have low porosity; have good impact strength to resist spalling and chipping; provide good insulation, and possess good adhesion to the parent metal, plus an ability to withstand elongation of parent metal without fracture.

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Procurement Overhaul Sought

Saltonstall bill, aimed at cutting lead time and Pentagon red tape, has strong support in industry and among some high DOD officials.

by Erica M. Karr

WASHINGTON—If the Saltonstall procurement bill is enacted essentially as is, the defense industry may expect faster Pentagon decisions, and more responsibility without supervision.

Sen. Leverett Saltonstall (R-Mass.), ranking Republican of the Armed Services Committee, pointed out when he introduced the measure recently that "obsolete procurement practices" are red-taping both industry and Defense officials at a time when "the capability for lightning-fast response is essential for our nation's security." His bill is aimed at reducing both lead time in new military weapon development, and unnecessary Pentagon administrative practices.

• **Broad backing**—Saltonstall claims his proposal is supported by almost every major industrial association, members of the Harvard Business School defense procurement group, and ranking military procurement officials—"although the Defense Department has not committed itself formally."

However, some Pentagon officials would like a little more "flexibility" than the weapon systems concept currently provides and may get stubborn about the limitations which Saltonstall's bill would impose in this area.

The Aircraft Industries Association indicated it would support "the basic objectives" of the measure, which will undergo a detailed analysis by an AIA legislative committee.

In brief, the bill is designed to boost small business participation in subcontracting; put negotiation, competitive negotiation and formal advertising "on an equal par"; encourage use of incentive and fixed-price contracts; extend the weapon system concept, and permit simpler specifications, preferably of the performance type.

The Massachusetts Senator said the original spur for the bill was the testimony of a Harvard Business School professor during the post-*Sputnik* investigation of our space program. Dr. J. Sterling Livingston pointed out at the time that Soviet lead time on weapons development was about half ours—an average of five years compared to the "10 to 11 years to develop and produce an air-weapons system," in the United States.

The bill is a refinement of a similar measure introduced by Saltonstall late in the last session. "A great deal more effort has been devoted to the bill during the recess of Congress," Saltonstall said, and it now represents "the best judgment of many of the most experienced men in the procurement field."

• **Congressional sanction**—Under the Armed Services Procurement Act of 1947 the purchase rule is for advertised bidding with 17 exceptions under which the Defense Department can negotiate its contracts. These include contracts which involve classified data, perishable items, research work or standardization, and those which call for speedy action, one particular brand, small quantities or professional services. Still another exception is contracts involving only one source. In actual practice during the past few years, over 85% of the military's funds were spent under this form of "exception" contracting. Involved is a complex determination process to justify a "no advertised bid" decision.

Although the exceptions require no competition, the Pentagon has been using "competitive negotiation" with two or more firms whenever feasible. The Saltonstall bill encourages use of the competitive approach by calling for either advertised bids or competitive negotiation whenever this is "consistent with the needs of the military departments."

Unqualified negotiation would continue under the exception provision "when no competition is possible or when overriding considerations . . . preclude competition."

The proposal to elevate negotiated procurement to the same legal level as advertised bidding is expected to meet strong opposition from some legislators who feel there has been too much negotiation and not enough advertised bidding. The House Armed Services Committee's Investigations Subcommittee, headed by Rep. F. Edward Hebert (D-La.), plans a fine-tooth-comb-ing of this subject.

• **Weapon systems legalized**—Although the Air Force and—to a lesser extent—the Navy have been using the weapon system concept, this has been an administrative determination. The Saltonstall bill would give it legal sanction and extend its use under the term "operational system" to cover facilities and equipment which are not weapons.

It would require the head of each military department to name a manager for each operational system. He would have authority and responsibility from start to finish—through the planning, budgeting, research, design, development and delivery of the system and its logistic support.

Saltonstall feels there is now too much scattering of authority. There is no one office to which a contractor can go for a quick decision, and much time is wasted going through channels. The operational system manager's office would have authority to come up with answers as they are needed. The bill would also leave more of the decision-making to industry itself.

Although the weapon systems have cut lead time considerably, there are certain obvious risks in centralizing such authority in one company: Prime contractors obviously do not like to farm work out if they can figure out a way to keep it in their own shop. This tends to narrow the industrial base for military procurement and could slow down a project if the contractor has to make plant changes to produce a new item.

Saltonstall's bill calls for the prime contractor to subcontract "the maximum practicable amount" competitively and to see that small business gets a fair shake.

Although the bill would not require that this be written into prime contracts, the intent of the bill is clear. And Defense procurement officials know from experience that powerful microscopes are used by the tireless investigators on Capitol Hill.

• **Specious specs**—Specification-happy procurement officials have cost the nation inestimably in time and money, both for the Pentagon and industry. Detailed requirements for one electronic tube, for example, cover 190 pages. One West Coast manufacturer, who complained that the product would not work if he followed the specifications laid down under his contract, was told by the Pentagon to go ahead anyway. After the contract was completed, it was suggested, he could apply for another cost-plus contract to make an item that would work.

The new bill calls for the "simplest" specifications possible, expressed "in terms of performance rather than in terms of design and manufacturing details" whenever practicable.

• **Renegotiation eased**—The legislation would seek to amend the Renegotiation Act to exempt fixed-price advertised-bid and incentive contracts from renegotiation. "To subject any such contract to renegotiation, as is done by present law, subjects the contractor to speculative, potentially inequitable, costly and time-consuming second-guessing," Saltonstall said. "Any necessary price redetermination should be negotiated between the contractor and the procuring agency after all costs under a contract have been ascertained. The services have the necessary authority to do this."

Under the current law, Saltonstall said, a manufacturer who has paid for renegotiation procedure and possible appeal to the tax court, may find he is in worse financial shape than if he had not affected any saving on the contract in the first place.

Although Saltonstall feels strongly about this part of his bill, renegotiation changes would involve the Senate Finance Committee and this provision of the bill may require a separate measure.

Cost contracts and cost-plus-fixed-fee contracts would be specifically authorized for research and development work under the Saltonstall legislation. At present, their use is barred if another type of contract is likely to be less costly.

• **Good prospects**—Although the bill will have its foes, chances for passage appear favorable. The first hurdle will be the Senate Armed Services Committee, which is waiting for the Pentagon's views before scheduling hearings.

Because of its technical nature, the Saltonstall measure has been termed "a long, hard, dirty but important job." Said one Capitol Hill observer: "It will all depend on whether the committee is willing to put up with the torture."

IT&T to Study Terminal Guidance for Air Force

FORT WAYNE, IND.—A contract to study space vehicle terminal guidance methods has been awarded to International Telephone and Telegraph Corp. by the Air Force's Air Research and Development Command.

The IT&T Astrionics Laboratory here will perform the study. This group, responsible for space technology research and development, is a branch of the Missile and Space Systems Laboratory, with headquarters at Nutley, N.J.

The program will cover the complex problems of guiding a space vehicle from the mid-course phase of its flight to the terminal point, including initial condition accuracies, adverse physical phenomena, required vehicle performance, environment, sensor characteristics and reliability.

Instrumenting the guidance system will involve sensing the ship's velocity vector relative to the space objects, altitude of ship above the surface, attitude of ship with respect to velocity vector, and latitude and longitude.

KEARFOTT TACHOMETERS

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Kearfott offers one of the broadest lines of precision tachometers in the industry. Light, compact and resistant to temperature, vibration and shock, they are available for a wide variety of applications.

Size 11 (R860)

Integrating Tachometers, special types of rate generators, are almost invariably provided integrally coupled to a motor. They feature tachometer generators of high output-to-null ratio and are temperature stabilized or compensated for highest accuracy integration, rate computation, etc. In addition to reducing the in-phase null level toward zero, errors due to temperature effects are minimized over a wide ambient range. Linearity, in some cases as low as .01%, is usually better than ±.1%, while phase shift is 0±1°. For extreme accuracy, models with low temperature coefficient drag cups are also available.

Rate Generators feature high output-to-null ratios and are designed for application as rate servos and to provide damping in very high gain systems. These Kearfott units offer high linearity, high output and low inertia and are often integrally coupled to a low inertia motor; in this design the in-phase null is virtually reduced to zero. Quadrature null is as low as .25% of the 1000 rpm outputs while harmonics seldom exceed .1% of the output at 1000 rpm.

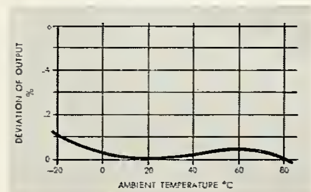
Damping Tachometers have relatively low output-to-null ratios and are designed primarily for damping purposes. They feature extremely low inertia and power consumption, linearity which is normally within ±.5%, and phase shift within 10° of reference. Kearfott damping tachometers are usually integrally coupled to a low inertia motor.

INTEGRATOR TACHOMETERS

(Typical Characteristics)

	Size 11 (R860)	Size 15 (T816)	Size 18 (V892)
Excitation Voltage (400 cps)	115	115	115
Volts at 0 rpm (RMS)	.020	.020	.010
Volts at 1000 rpm (RMS)	2.75	2.7	2.00
Phase shift at 3600 rpm	0°	0°	0°
Linearity at 0-3600 rpm	.07	.05	.07
Operating Temperature Range	−54° + 125°	−54° + 125°	−54° + 125°

TEMPERATURE

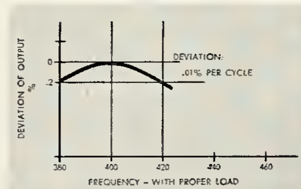


RATE TACHOMETERS | DAMPING TACHOMETERS

(Typical Characteristics)

	Size 15 (R800)	Size 18 (V806)	Size 8 (M824)	Size 10 (P822)	Size 11 (R809)
Excitation Voltage (400 cps)	115	115	26	115	115
Volts at 0 rpm (RMS)	.013	.026	.015	.019	.019
Volts at 1000 rpm (RMS)	3.1	3.0	.234	.450	.5
Phase shift at 3600 rpm	5°	4.5°	10°	5°	5°
Linearity at 0-3600 rpm	.25	.25	.3	.3	.3
Operating Temperature Range	−54° + 100°	−54° + 125°	−54° + 125°	−54° + 125°	−54° + 125°

FREQUENCY

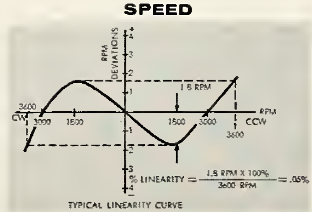


INTEGRAL SERVO MOTOR DATA

(Typical Characteristics)

	Size 8	Size 10	Size 11	Size 15	Size 18
No Load Speed (RPM)	5400	6600	5500	8000	8000
Stall Torque (oz. in.)	.3	.35	.55	.45	1.30
Excitation Voltage (400 cps)	18-40	26-40/20	115-40/20	115-40/20	115-115/57.5
Rotor Moment of Inertia (Gm.CM²)	1.3	.76	7.7	7.0	35
Operating Temperature Range	−54° + 100°	−54° + 125°	−54° + 125°	−54° + 125°	−54° + 125°
Unit Weight (incl. tachometer)—oz.	3.1	4.6	9.0	14.0	30

SPEED



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missile people

The Radio Corporation of America has appointed **Maj. Gen. Francis L. Ankenbrandt,** USAF (Ret.) as deputy director of the USAF Communications Planning Project. The Air Force had disclosed earlier that the International Telephone and Telegraph Co., and RCA will develop and supervise the long-term program to determine present and future requirements of its network of wires and radio. Gen. Ankenbrandt, who is Manager, RCA Defense Projects, will serve under **Ellery W. Stone,** previously selected by I.T.&.T. to head the project.

FXR, Inc., has appointed **F. J. Gaffney** as executive vice president and general manager. He was formerly vice president for engineering of the Teleregister Corp.

AVCO has announced the appointments of **Louis R. Simov** as vice president-manufacturing, and **Dr. Leonard C. Maier, Jr.** as vice president-marketing (Defense Products) for the Crosley Division of the Corporation. Simov was formerly director of manufacturing for the Crosley Division, and Maier was formerly manager of the industrial and military tube operation of the Cathode Ray Department of the General Electric Co.

The Consolidated Diesel Electric Corporation has appointed **Albert Berger** as contracts administrator. A lawyer, Berger was formerly contract administrator for the Greenwich, Conn., laboratories of American Machine and Foundry.

Arthur J. R. Schneider has been promoted to chief engineer of the Technical Products Division of the Waste King Corp. He was formerly chief research engineer of the Division.

The Allen B. Du Mont Laboratories, Inc., has promoted **Charles A. Benenson** as assistant manager of its Systems Laboratory and **Michael V. Sullivan** as assistant manager of its Reconnaissance Laboratory. Both are new positions. The two men previously held the title of research engineer.

M. Clayton Burgy, assistant manager of Hercules Powder Company's explosives plant at Ishpeming, Mich., has been named technical specialist at the company's new rocket propellant plant at Bacchus, Utah. Succeeding Burgy will be **Clement J. Koeferl,** presently supervisor of Hercules' Carthage, Mo., plant.

North American Aviation's Los Angeles Division has announced the promotions of **Charles E. Ryker** to controller, **James E. Driskell** to director of personnel, and **Robert S. Johnson** to assistant to the general manager.

New Block Group Stresses Modular Concept

K-Block modules produced by ASCOP can be used in various telemetering systems as well as in data multicoding.

by Donald E. Perry

PRINCETON, N.J.—The Modular Concept in airborne data acquisition systems is getting another boost from Applied Science Corporation of Princeton (ASCOP), which is producing a new group of K-Block modules.

They have been engineered principally for multiplexing and coding (multicoding) data in pulse width PDM form, but can also be used in telemetering systems employing PCM, PAM and FM/FM techniques. K-Blocks are specifically designed to operate in the extreme environmental conditions of missiles and space vehicles.

This latest ASCOP production item brings added emphasis to the Modular Concept trend in military electronics where weight and size reduction, performance dependability, reduced maintenance and costs, and optimum flexibility for usage, are criteria.

Basically, the concept is the capability of assembling highly flexible electronic systems by using a variety of interchangeable "building blocks." But first, a standard must be established by which the physical proportions of all elements of airborne data acquisition systems are regulated.

Let's start with a rectangular solid as the basic modular shape. Any of its six surfaces could be used for attachment to adjacent modules. If the remaining dimension of each attaching module is made a multiple of one dimension (length, width, or thickness) of the basic module, then stacking is always possible between any side of an attaching module and a group made up of one or more basic modules.

Optimum flexibility of stacking is achieved when all the dimensions of the basic modules bear a multiple relationship to each other.

If this system is followed, the volume occupied by each module will be multiples of the volume of the basic module. By choosing a basic module of small volume, provision is made for almost unlimited volume flexibility, resulting in good component packaging density (components per cubic inch) for any size or type of circuit.

Criteria in module design for optimum flexibility calls for modular stacking from any of six surfaces; built-in standardized type input and output connectors which can serve as test point terminals; capability of independently performing with design environment; and for sales appearance, a distinctive appearance characterized by low silhouette functional outline.

This flexibility of assembling many functional systems in various physical arrangements—each fulfilling a specific requirement—allows the user to procure additional modules for maintenance replacement, or to add others for changes in flight test programs having different data acquisition requirements

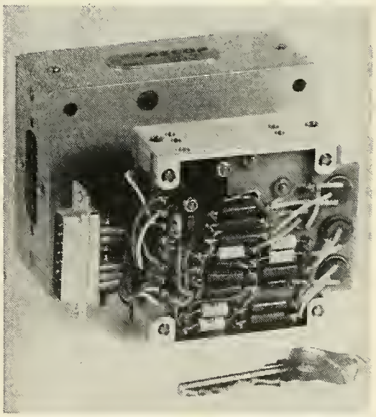
This has been the pattern for ASCOP in its K-Series line which can be systems-engineered into complete data acquisition units. Prestige item of the line is a multicoder with an electronic commutator as the principal module. It accepts 0-5V and –2½V imputs to plus 2½V imputs from a wide range of data pickups, multiplexing and coding them in pulse width form.

Low-level amplifiers raise millivolt inputs to the 0-5V level. Pulse width keyers code the output of the commutators.

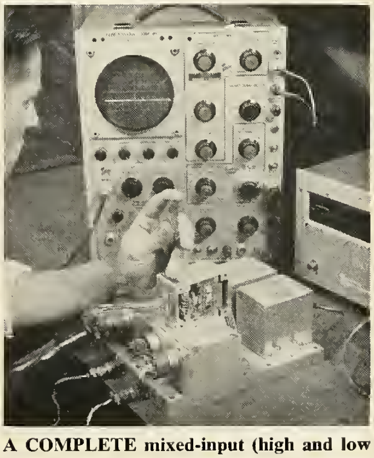
Some typical environmental specifications for the K-Series (which incidentally are backed up by a company-developed epoxy conformal coating for components protection against humidity, vibration and shock) are:

Temperature, –55C to 100C continuous; vibration, 30g at 5-2000 cps; shock, 200g for 11 milliseconds; constant acceleration, 200g for one minute along each direction of each major axis; altitude, 500,000 feet or better, and humidity, 95% R.H.

ASCOP K-SERIES Mixed Input Multicoder, assembled to fit missile test requirements. Dual commutator is on the left.

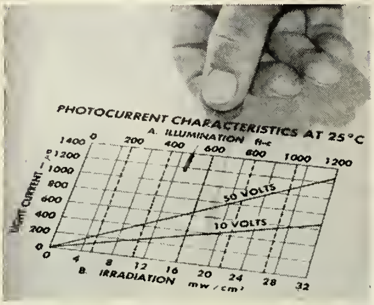


INTERIOR OF a K-Series transistorized Pulse Width keyer module, shown with outside casing, for coding the output.



A COMPLETE mixed-input (high and low level) multicoder shown on test bench. The engineer adjusts a modular keyer.

Photo-duo-diode Shuts Off current in Darkness



DALLAS—A subminiature light-sensing photo-duo-diode which allows current flow when either junction is exposed to light, and shuts the current off in darkness, has been produced by Texas Instruments, Inc.

The company claims that the sensitivity of the new TI device is on the order of four times that of any other commercially available photosensitive unit.

The combination of sensitivity and subminiature makes the device suitable for applications such as the reading of data from punched tape and card systems. The single-ended glass case measures 0.500-inch by 0.085-inch in diameter. A minute glass lens is located at the end opposite the leads.

Designated the 1N2175, the new TI photo-duo-diode passes up to 1200 microamps when exposed to 1200 foot-candles of light. In darkness, the device will pass less than 0.5 microamps. Dissipation is rated at 250 milliwatts at 25°C and any biasing voltage up to 50 volts will operate the device.

As the 1N2175 is an N-P-N double-diode unit, it will operate on either alternating or direct current. It is derated to 125°C with a minimum operating temperature of –55°C.

ECS Opens Automatic Data Processing Center

LOS ANGELES—The Electronic Control Systems facility of General Dynamics Corporation's Stromberg-Carlson Division has opened its first automatic data processing center here.

The center will prepare magnetic tapes to the specifications of aircraft manufacturing companies on the West Coast who have installed ECS Digimatic Contouring Systems.

The finished tape will be a record of all the data and instructions necessary for cutting out a specified part on a given machine tool. All that the machine tool operator need do is to set up the raw material, place the magnetic tape on the numerical control console, and press a button.

Electronic Control Systems is manufacturing three additional tape preparation units which the Air Materiel Command will use to establish three additional Digimatic Tape Centers in the U.S. for support of Air Force contouring control systems.

Radio Sextant Can Track Sun, Moon Continuously

CEDAR RAPIDS, IOWA—The Collins Radio Co. has constructed a radio sextant which, for the first time in history, can track the moon continuously.

At the company's Feather Ridge Observatory near Cedar Rapids, the sextant has been tracking the moon since late summer 1958.

The sextant has been delivered and installed aboard the Navy's experimental navigation ship, the USS Compass Island, where it will be used for navigational research.

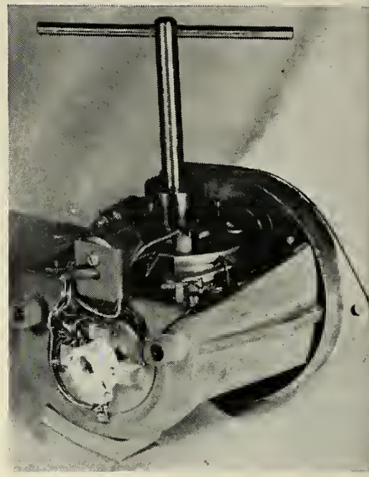
According to company spokesmen, the sextant is capable of tracking both the moon and sun under all weather conditions from moonrise to moonset and from sunrise to sunset.

The sextant, designated AN/SRN-4, was developed under a research and development contract with the Navy's Bureau of Ships with funding and technical supervision by the Special Projects Office, Bureau of Ordnance.

COLLINS AN/SRN-4 radio sextant.

The sextant utilizes a 5-foot parabolic type antenna, and a radio receiver built for the measurement of thermal radiation in the short microwave region. The receiver operates at a wave length of 1.8 centimeters and allows determination of antenna position.

Roll Reference Gyro Started by Spiral Spring



LOS ANGELES—A new roll reference gyro for missiles and drones developed by the Whittaker Gyro Division of the Telecomputing Corp., is energized by a spiral "clock" spring.

The spring-energized gyro reduces width and, once wound and armed at the factory, can be stored for indefinite periods without loss of accuracy.

The frame-mounted spring brings the rotor to operational velocity in less than 10 milliseconds after launching. The spring then disengages and permits the gyro to function as an inertial reference.

Weighing 35 pounds, the spring gyro is hermetically sealed, but is available in a tape dust-seal for proving tests. The control period for gyro operation is only 30 seconds, but others have been designed for up to 10 minutes of flight with minimum drift.

Low Noise Temperatures in Parametric Amplifier

CULVER CITY, CALIF.—Noise temperatures as low as 50° above absolute zero for a diode cooled by liquid nitrogen, and only 100° above absolute zero operating at room temperature have been obtained by Hughes Aircraft Co. in a high gain 3000-megacycle parametric amplifier using sample diodes of a newly developed type.

Hughes has begun producing these diodes at a rate of several hundred per week.

The diode is the heart of the parametric amplifier but also has other important microwave applications such as switching and harmonic generation. It

is available in two hermetically-sealed versions—one for the region below 1000 megacycles and a second for the microwave region. It reportedly costs about as much as good microwave mixer crystals.

• **Compared to masers**—The low noise performance of amplifiers using the new diode is expected to be in a range competitive in many applications with the solid state maser, which holds the record for absolute minimum noise performance. However, the parametric amplifier does not require low temperatures for operation. It does have two channels of amplification, usually called the signal and idler channels, which are used simultaneously to obtain the low noise temperatures quoted above.

As a further comparison, the best reported low-noise microwave tubes have noise temperatures of about 300°K at 3000 megacycles, but have the advantage of single-channel amplification and electrical tunability.

The amplifier was designed and operated by Dr. R. C. Knechti and R. Weglein of Hughes Research Laboratories for the noise measurements and is related to the type of amplifier developed by Dr. Uenohara at the Bell Telephone Laboratories. With the noise temperatures of 50°K and 100°K obtained at liquid nitrogen and room temperatures respectively, the 3000-megacycle amplifier gives 30 db of amplification with two megacycles bandwidth or 10 db of amplification with 25 megacycles bandwidth.

Such amplifiers would, of course, be useful in many applications of microwave and UHF receivers where greater sensitivity or lower receiver noise is required.

The production models of the Hughes diode, designated HPA-2800 and HPA-2810 have a nominal cutoff frequency of 70,000 megacycles at maximum back bias with a nominal zero-bias capacitance of 2.5 mmf. Its noise performance is attributed to its low equivalent series resistance at microwave frequencies.

Radiation-Levinthal Merger Being Discussed

MELBOURNE, Fla.—Discussions are in progress to merge Radiation Inc. with the Levinthal Electronic Products Inc. Radiation is located near here, Levinthal at Palo Alto, Calif.

Levinthal will be a wholly-owned subsidiary and continue to operate under its present management. Each company will have a representative on the other's board of directors. George Shaw, vice-president of Radiation and Albert J. Morris, vice-president of Levinthal, will maintain technical cross liaison.

Radiation officials said that the merger was intended to broaden the base of their operation, largely telemetry and digital computing instruments now. Levinthal has been creating electro surgical, medical and nucleonic instruments.

(Continued from page 33)

shape took just five hours by the APT method. Under manual programming, it required 200 man-hours. In general, say its developers, APT will permit man-hour reductions in the range of 80 to 95 per cent.

APT in its present form is not yet a panacea for the problems of intricate production in the space age, an industry representative stated. It must be further refined and it must be mass exploited.

• **Service tests**—First step toward putting it in wide industry use is a two-year program by the three participating groups to service test the equipment on actual production items. MIT is now preparing documentation to be distributed to the aircraft and missile and other industries.

It consists of six volumes with more than 600 pages of text, diagrams and charts. This, plus the language dictionary and the master cards, will permit any contractor who has possession of or access to a suitable computer (preferably but not necessarily the IBM 704 in wide industry use) to make parts through APT. The 19 member companies of AIA will introduce the system, and other companies will be invited to participate.

It is anticipated that actual production use of the equipment will develop a number of refinements in APT. They will be reported to the APT Project Coordinating Group of AIA's Numerical Control Panel, which will in turn make the results available to the Servomechanisms Laboratory and AMC's Manufacturing Methods Division.

• **Program's history**—APT is the latest step in a long research program on numerical control production methods. First numerically-controlled operations were started in 1952 and the scale on which they are employed in actual production has been climbing steadily since. Some plants developed interim automatic programming methods pending development of APT.

The cooperative APT program got under way early in 1957. First industry testing started last April, when MIT provided a field trial version

APT is itself an interim system. Although the electronic link between design and production has shaved programming man-hours to a significant degree, it has not completely eliminated manual programming. In future research on the system, MIT and its collaborators will look for new ways of shortening further the time and effort between design of a part and the cutting of metal.

contract awards

ARMY

$8,362,732—**Chrysler Corp.**, for the *Jupiter* program.

$6,700,000—**Lear, Inc.**, Grand Rapids, Mich., Div., for R&D on *Nike-Zeus* system (sub-contract from Bell Telephone).

$2,949,652—**Daniel Construction Co. of Alabama**, Birmingham, for construction of missions engineering building at Redstone Arsenal.

$1,721,189—**Robinson & Wilson**, San Bernardino, Calif., for guided missile vehicle assembly building for Project *Sentry* at Vandenberg AFB.

$1,341,357—**Cornell Aeronautical Laboratory, Inc.**, Buffalo, N.Y., for high-power microwave radar research program.

$1,140,000—**Rocketdyne Div., North American Aviation, Inc.**, for design and development (two contracts).

$925,484—**Radioplane Co.**, Van Nuys, Calif., for supplies and services.

$732,257—**American Machine and Foundry Co.**, for *Pogo-Hi* targets.

$631,981—**Whitaker Gyro Div., Telecomputing Corp.**, Van Nuys, Calif., for overhauling gyros.

$495,356—**B. B. Saxon**, Fort Walton Beach, Fla., for modifications and additions to buildings at Eglin AFB launching facility.

$448,000—**R. D. Lowman General Contractor, Inc.**, El Paso, Tex., for *Nike-Zeus* LAR receiver annex and R&D site work.

$378,900—**Harvey Aluminum, Inc.**, Torrance, Calif., for fuses.

$234,214—**Western Electric Co., Inc.**, for electron tubes.

$218,526—**Western Electric Co., Inc.**, for *Nike* spare parts and components (four contracts).

$212,524—**Radioplane Div., Northrop Aircraft, Inc.**, for amendment of basic contract to provide additional services, engineering changes and certain product improvements.

$155,653—**Douglas Aircraft Co., Inc.**, for launching area items and repair parts.

AIR FORCE

$6,000,000—**Marquardt Aircraft Co.**, for RJ43-MA-11 ramjet engines for *Bomarc* program.

$3,000,000—**Lear, Inc.**, Grand Rapids, Mich., Div., for coordinate converter systems for *Bomarc* (follow-on order from Boeing).

$2,283,120—**Convair (San Diego) Div.**, General Dynamics Corp., for design, construction and installation of an automatic data handling system for the Wright Air Development Center.

$950,610—**Westinghouse Electric Corp.**, for electron tubes.

$731,996—**Philco Corp.**, for technical services (two contracts).

$486,300—**General Motors Corp.**, for technical services.

$316,000—**RCA Service Co. Div.**, for technical services.

$100,000—**Harvard College**, for study of fundamental physics of ferromagnetic and ferroelectric materials.

$95,000—**Stanford University**, for investigation of microwave properties of plasmas.

$88,400—**National Scientific Laboratories, Inc.**, Washington, D.C., for technical services.

$65,600—**North American Aviation, Inc.**, for technical services.

$80,000—**University of Illinois**, for continued research on "Diffusion in Semi-conductors and Related Problems."

$31,515—**University of California**, for "Study of High-Precision Geocentric and Interplanetary Orbits."

$55,000—**University of Maryland**, for research on "Rapid Cosmic Ray Variations and Solar Effects."

NAVY

$94,540—**Pennsylvania State University**, for research on aluminum hydride and related hydride.

$93,732—**Aerojet-General Corp.**, for modification of *Aerobee 100, 150 and 300* sounding rockets.

$86,446—**Princeton University**, for research in heat transfer from ionized gas to a gaseous coolant.

$88,150—**The Franklin Institute of the State of Pennsylvania**, for development, design and fabrication of 52 vertical scale indicators.

$71,494—**Vertol Aircraft Corp.**, Morton, Pa., for research on rotating wing aerodynamics.

west coast industry

by Fred S. Hunter

Weapon system tests of Convair's new F-106A got off to a fancy start at the White Sands missile range when two GAR-3 *Falcons,* the first guided air rockets to be launched from the advanced interceptor using the new Hughes MA-1 fire control system, scored direct hits on a parachute target. The MA-1 fire control system is capable of flying the F-106 throughout the entire interceptor mission from detection to destruction of the target, leaving the pilot free to make tactical decisions, and the GAR-3 flies faster, climbs higher and knocks down targets at longer range than previous Hughes *Falcons.*

GAR-3 improvements include a nose cone that is longer and more pointed than the stubby, rounded radomes of the GAR-1D and GAR-2 rockets which comprise the armament of the currently operational Convair F-102 interceptors. It is of a plastic material which Hughes says represents a significant development of nose cone material capable of withstanding a great variety of environments created by speed and temperatures and enables the *Falcon* to adjust to these environments in fractions of seconds.

Industrial Association of the San Fernando Valley, encouraged apparently by the location of the new Thompson Ramo Wooldridge research center on rezoned agricultural land in the area followed by RCA's acquisition of a 50-acre site for a missile and radar center, has filed two tract maps with the city on 500 acres which might serve a similar purpose, and is considering 14 possible areas in all. The association estimates research and development centers might add $100 million to the valley's annual payroll.

Dr. H. V. Neher, Caltech physics professor and a member of the U.S. IGY panel on cosmic radiation, explains why balloons are preferred over rockets for studies of cosmic distribution. They give several hours of measurements instead of a few minutes, and the ionization chambers they carry aloft give better statistics than rocket-borne Geiger counters. Dr. Neher notes that there is increasing evidence that cosmic rays do not come from the sun, but possibly from the stars or distant galaxies. And more study is needed to determine whether the so-called Van Allen belts of radiation around the earth are caused by cosmic rays or particles from the sun.

John Marschalk's resignation as executive director of the Strategic Industries Association came as a surprise to many of us. He's been the personification of the association since its organization in 1954. But he will be available as a consultant and objectives of the group are unchanged, says Harvey Riggs, president of International Electronic Research Corp., who recently took over the SIA presidency, succeeding Ted Coleman, president of Coleman Engineering Co.

Riggs hopes to see SIA's membership, now about 90, expand to 300 or 400 firms in the immediate future. Most of the 90 paying dues now are located in the Los Angeles area. Riggs wants to spread out nationally. He has his eye, particularly, on San Francisco Bay and the area around Washington. Meanwhile, SIA is looking around for a successor to Marschalk. It needs a man who knows his way around the Department of Defense.

WS-131B is weapon system designation for North American Aviation's *GAM-77* (also known as the *Hound Dog)* for the Boeing B-52G. If you are curious as to what may have been the *WS-133A,* you can relax. There never was a *WS-131A* beyond a few pieces of metal.

Paints for aircraft and missiles now make up a $1-million-a-year business for W. P. Fuller & Co. Sample missile product—a special heat-resistant paint for the *Explorer I.*

Did you know that T. Keith Glennan, administrator of the National Aeronautics and Space Administration, was a sound expert in the Hollywood movie studios before World War II? . . . And that since Vandenberg AFB became operational, the daily newspaper at Santa Maria proclaims in its masthead that it is the "Missile Capital of the Free World"?

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Engineers and Scientists at Republic Aviation—with a turn for dry professional humor—say that they're asked to solve every problem of upper atmosphere and space flight with the factor

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Advertiser's Index

CLASSIFIED

when and where

MARCH

Third Annual Shock Tube Symposium, Old Point Comfort, Ft. Monroe, Va. March 10-11.

Support Equipment Institute, Organizational Meeting, Statler Hotel, Washington, D. C., March 12.

American Society for Metals, 11th Western Exposition and Congress, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, March 16-20.

The American Rocket Society, 1959 Sectional Meeting, Daytona Plaza Hotel, Daytona Beach, Fla., March 23-25.

Institute of Radio Engineers, National Convention, Coliseum and Waldorf-Astoria Hotel, New York, March 23-26.

Society of the Plastics Industry, 16th Annual Conference, Pacific Coast Section, Hotel del Coronado, San Diego, March 25-27.

American Society of Mechanical Engineers, Instruments and Regulators Division Conference, Cleveland, March 29-Apr. 2.

Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, New York, March 31-Apr. 3.

APRIL

Conference on Electrically Exploded Wires, sponsored by the Thermal Radiation Laboratory of the Geophysics Research Directorate of the Air Force Cambridge Research Center, Somerset Hotel, Boston, Apr. 2-3.

American Society for Quality Control, Portland Chapter, Oregon Museum of Science and Industry, Portland, Apr. 3-4.

1959 Nuclear Congress, Municipal Auditorium, Cleveland. For information: Engineers Joint Council, 29 West 39th St., New York. Apr. 5-10.

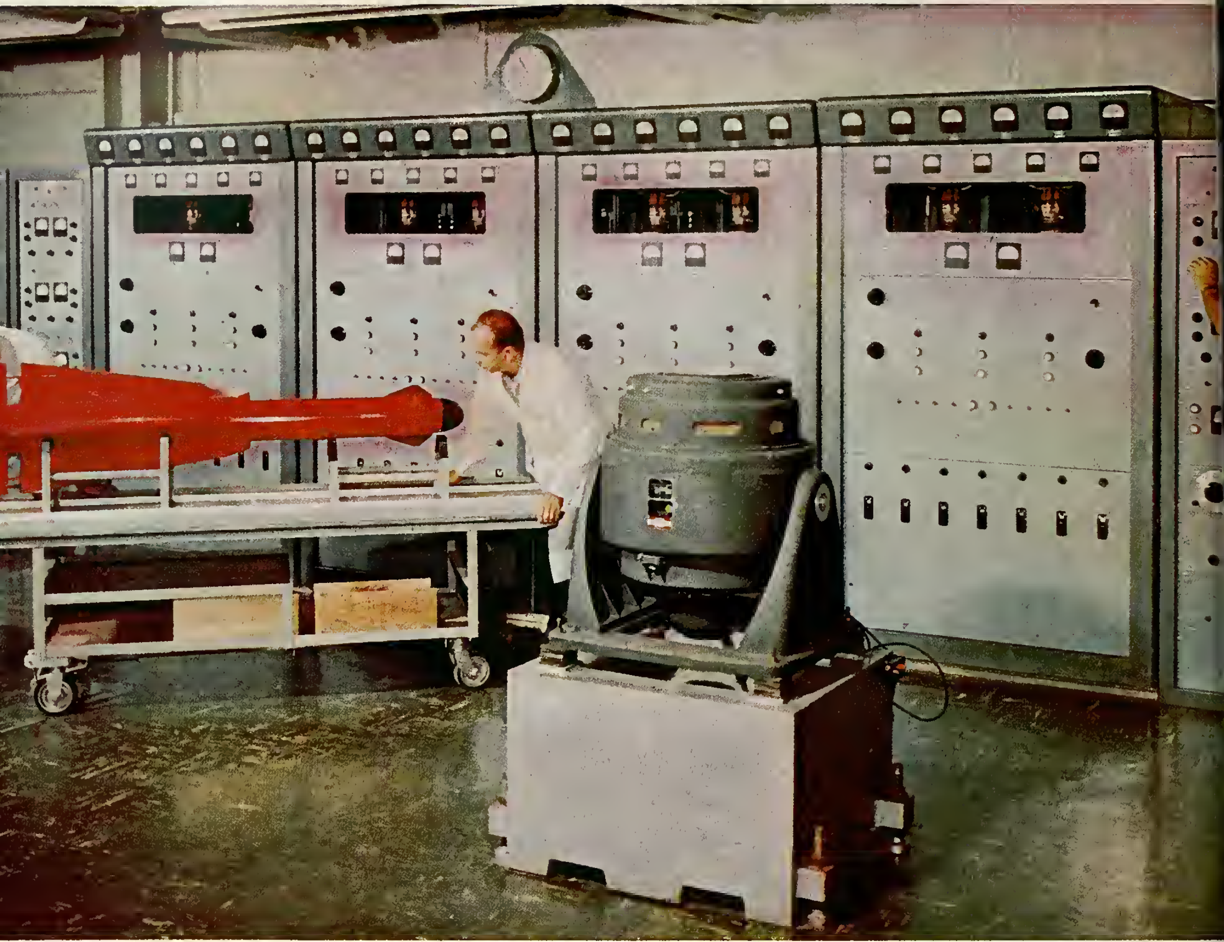
American Welding Society, 1959 Welding Show and 40th Annual Convention, International Amphitheatre and Hotel Sherman, Chicago, Apr. 7-10.

Air Force Association, World Congress of Flight, Las Vegas, Nev., Apr. 12-19.

Aeronautical Training Society, 17th Annual Meeting, Las Vegas, Apr. 16-17.

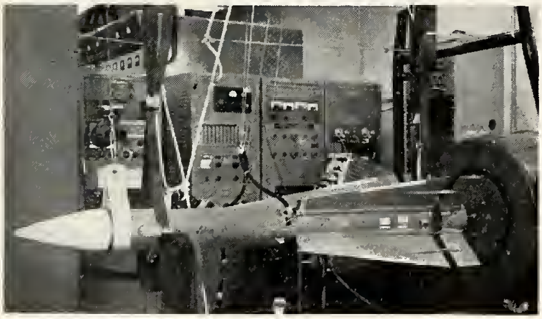
American Society of Tool Engineers, Annual Meeting, Schroeder Hotel, Milwaukee, Apr. 18-22.

American Rocket Society, Man-in-Space Conference, Hotel Chamberlain, Hampton, Va., Apr. 20-22.



sure death...

THE HUGHES FALCON PROVES ITS RELIABILITY THROUGH LING VIBRATION TESTING SYSTEMS!



Vibrotion testing o GAR-3 on o Ling System

Overcoming destructive vibration forces is an important part of reliability determination at Hughes Aircraft Company.

Both individual components and complete packages such as this production model Falcon (GAR-1D), are qualified through a continuing program of environmental vibration testing, using the many Ling Vibration Systems installed at Hughes.

Latest in the series of Hughes air-to-air missiles, the GAR-3, has been put through a random wave vibration test program using another Ling Vibration System.

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