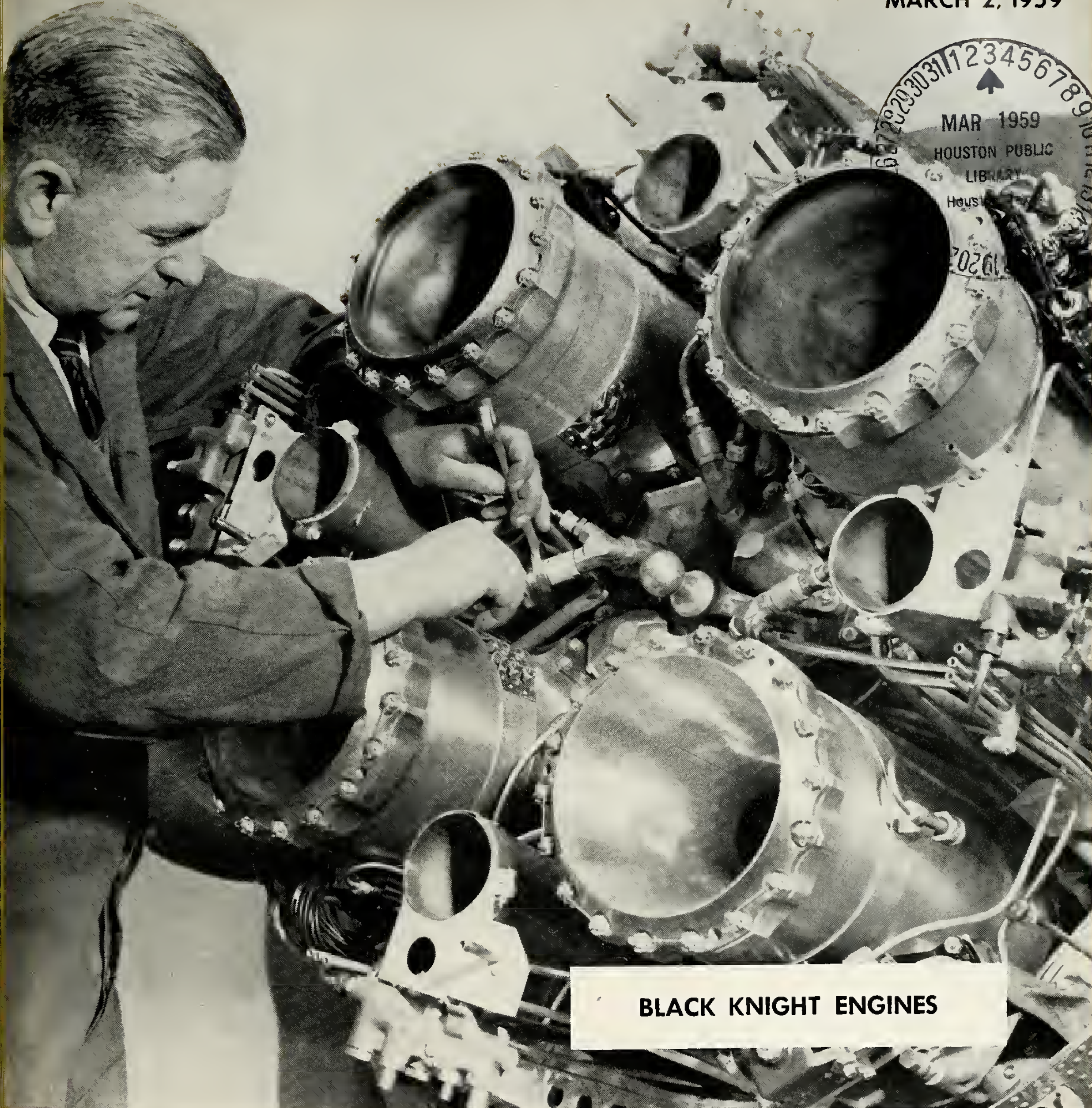
MARCH 2, 1959



BLACK KNIGHT ENGINES

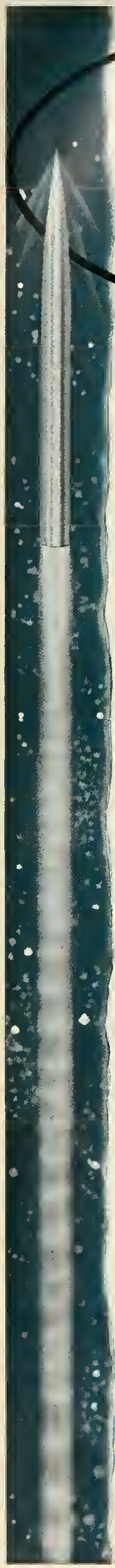
missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

SPECIAL FEATURE:

Producing Integrated Electronics for Small Missiles 21

AN AMERICAN AVIATION PUBLICATION



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missiles and rockets Vol. 5, No. 9, March 2, 19

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

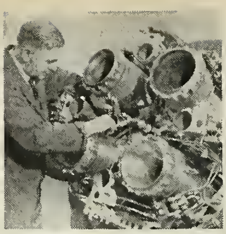
MARCH 2 HEADLINES

ASTRONAUTICS ENGINEERING

MISSILE ELECTRONICS

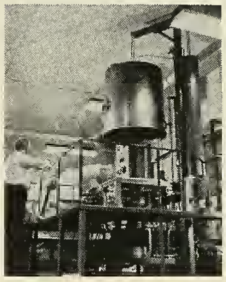
DEPARTMENTS

NEXT WEEK: Structural Ceramic Applications for Missiles
Missile Test Ranges of the World

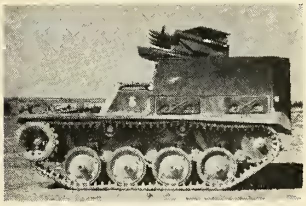


COVER: Armstrong-Siddeley gamma rocket engines are powerplant for *Black Knight* (p. 31).

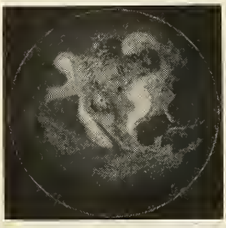
ALCOA 14,000 ton press provides aluminum extrusions—some 20 ft. long—for *Titan* tanks and outer skin.



SINGER's cast epoxy mirror is a new milestone in reflective optical components (p. 16).



NORD-AVIATION's *SS-10* and *SS-11* anti-tank missile may be supplied to U.S. forces in Europe (p. 32).



NEW WEATHER Bureau section will work with NASA in meteorological research with rockets and satelliites (p. 17).

The Neglected Atomic Propulsion Program

It is a sad and obvious fact that the nation's progress in producing an atomic-powered aircraft or a nuclear rocket engine is not as good as it either could or should be.

The present status of both the nuclear plane, which would be a missile launching platform, and the nuclear rocket engine are treated in the 25th semi-annual report of the Atomic Energy Commission for July-December, 1958.

Of the Nuclear Propulsion for Manned Aircraft, it says:

"Investigations were continued on two basic systems, the direct-cycle and the indirect-cycle.

"General Electric Co., Evendale, Ohio, is under contract to develop reactors for the direct cycle system.

"Pratt and Whitney will perform research and development leading to indirect-cycle reactors for aircraft propulsion."

The report continued that:

At the National Reactor Testing Station, Idaho, the core test facility is being used to experiment with a second reactor core in which materials with higher performance capabilities are used; and construction is essentially completed on R&D facilities at the Connecticut Aircraft Nuclear Engine Laboratory of P&W; and the design of a Shield Test Air Facility was started in June for construction at the National Reactor Testing Station, with completion due in June, 1960.

Further, the report said that the ANP research and development effort had successfully passed many important technical milestones, including the operation of turbojet engines in parallel from a common heat source; the completion of 47 flights in a one-megawatt reactor in a nuclear test airplane outfitted with a complete crew shield; and the accumulation of thousands of hours of irradiation testing of aircraft materials, components and subsystems.

The Nuclear Propulsion for Unmanned Vehicles in the report is divided into three parts.

In nuclear rocket propulsion (*Rover*) the program to demonstrate the feasibility of nuclear rockets continued at the Los Alamos Scientific Laboratory, the major effort being devoted to development and fabrication of an initial test device, *Kiwi-A*. This is a relatively lower power experimental reactor using solid fuel elements and a gaseous propellant.

The nuclear ramjet propulsion program (*Pluto*) to demonstrate the feasibility of a high temperature air-cooled reactor for ramjets was continued by the University of California Lawrence Radiation Laboratory at Livermore. North American Aviation Inc. is working on materials. Design and development continued on *Tory II*, a small-scale non-flyable reactor to be constructed at the Nevada Test Site.

In systems for nuclear auxiliary power (*Snap*), two basic approaches are being followed for space purposes. The first (*Snap 1*) is being developed by the Martin Company, Baltimore, to use the heat from a radioactive isotope to operate electrical power conversion equipment. The second (*Snap 2*) is an Atomics International contract to use a nuclear reactor as a heat source to operate a generator. Work on a test facility at Santa Susana, Calif., has begun.

The above is not so important for what it says as for what it does not. The AEC has never been notorious for releasing information. But on the other hand neither has it been reticent about accomplishment in its field—for which it is the sole releasing agency. To both subjects—nuclear aircraft and nuclear rocket—the reports devote a little more than two pages. And, judged by a factor of accomplishment, it doesn't seem to rate more.

Whether it is lack of money or lack of recognition, the fact remains that the overall aerial nuclear propulsion project—including reactor, engine, shield and vehicle—which began in 1946 has since died and had rebirth, been strangled, kicked, starved, beaten and neglected. More than a dozen committees have charted its program, usually in different directions. Project officers in the program have been transferred, promoted and died during its 13-year meandering course. One of these said recently—and wearily:

"It isn't so much a matter of money as of interference and vacillation. The project is extremely complex and difficult. Thus far no one group has ever lasted long enough or been let alone long enough to encompass all its details. One and perhaps the only solution is to give the project to one agency and only one—and then to protect it from interference on all sides."

Clarke Newlon

NOTABLE ACHIEVEMENTS AT JPL . . .

PIONEERING IN SPACE RESEARCH

Another important advance in man's knowledge of outer space was provided by Pioneer III. This, like many others of a continuing series of space probes, was designed and launched by Jet Propulsion Laboratory for the National Aeronautics and Space Administration. JPL is administered by the California Institute of Technology for NASA.

During its flight of 38 hours, Pioneer III was tracked by JPL tracking stations for 25 hours, the maximum time it was above the horizon for these stations.

The primary scientific experiment was the measurement of the radiation environment at distances far from the Earth and telemetering data of fundamental scientific value was recorded for 22 hours. Analysis of this data revealed, at 10,000 miles from the Earth, the existence of a belt of high radiation intensity greater than that observed by the Explorer satellites.

This discovery is of vital importance as it poses new problems affecting the dispatch of future vehicles into space. The study and solution of such problems compose a large part of the research and development programs now in extensive operation at the Laboratory.

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CALIFORNIA INSTITUTE OF TECHNOLOGY

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OPPORTUNITIES NOW OPEN IN THESE CLASSIFICATIONS ▶ APPLIED MATHEMATICIANS . ENGINEERING PHYSICISTS . COMPUTER ANALYSTS . IBM-704 PROGRAMMERS AERONAUTICAL ENGINEERS . RESEARCH ANALYSTS . DESIGN ENGINEERS . STRUCTURES AND DEVELOPMENT ENGINEERS the missile week

washington countdown

Capitol Hill heat . . .

over DOD's missile program grew white hot last week when DOD's planned programmed obligations for FY 1959-60 revealed that $400 million less has been obligated for missiles in FY 1960 than was obligated in FY 1959. DOD plans to obligate $6.817 billion in FY 1960 for missiles, compared to $7.212 billion in FY 1959. ICBM and IRBM planned obligations account for about 30%. In FY 1960, planned programmed obligations for long range ballistic missiles drop about $230 million (reason is that funding of *Thor* and *Jupiter* is almost completed) from the FY 1959 high of $2.966 billion.

NASA's space probe hardware . . .

will be *Vega* and *Centaur,* capable of orbiting 7,500 pounds 300 miles, or of accelerating 1,000 pounds to escape velocity. *Vega* will be an *Atlas* with GE's first stage *Vanguard* (X-405) on top. The advanced *Vega* will add JPL's 6K, a 6,000 pound storable solid engine, as its third stage. *Centaur* will be an *Atlas* with a high energy liquid oxygen and hydrogen engine (Pratt & Whitney) as its second stage.

Navy was highly pleased . . .

with the successful launch of *Vanguard II.* Frosting on the cake for Chief of Naval Operations Arleigh Burke was a bottle of excellent scotch whisky he won betting *Vanguard II* would go. The loser: President Eisenhower.

A three-months leave . . .

for reasons of health, which begins in March for Navy Under-secretary William B. Franke, has cast doubt on his ever assuming the Secretary's job when Thomas L. Gates leaves. Franke is scheduled to take the job in June.

First shipboard firing of *Talos* . . .

was successfully carried out last week by the guided missile cruiser Galveston, off Puerto Rico. Galveston is the first ship to be equipped with the Bendix-RCA surface-to-air missile.

First telescope in space . . .

is being readied, according to reports from scientists at the Smithsonian Astrophysical Observatory and Harvard College Observatory. The unmanned vehicle would carry 150 pounds of equipment to scan the sky in the ultraviolet part of the electromagnetic spectrum.

***Bomarc* and *Lacrosse* . . .**

will be Canada's major defenses against air attack. Prime Minister Diefenbaker told the House of Commons the decision to scrap the Avro Arrow CF-105 interceptor and switch to missiles was made because potential aggressors now are going from manned bombers to guided missiles. Diefenbaker said the agreement with U.S. is that Canada will pay for one-third of cost of Canadian *Bomarc* bases and the U.S. two-thirds, adding Canada expects "a reasonable and fair share" of contracts for production of technical equipment.

Filling jobs in the Pentagon . . .

is becoming an increasingly difficult task. However, two Department of Defense spots were taken last week by Dr. Hector B. Skifter and Dr. Howard A. Wilcox. Dr. Skifter is taking leave of absence as president of the Airborne Instruments Laboratory of Cutler-Hammer, Inc., to be Assistant Director of Defense Research and Engineering (Air Defense). Dr. Wilcox is leaving the post of Assistant Director of Research at the Navy's NOTS, China Lake, facility, to become Deputy Director of Defense Research and Engineering.

Initial *Mercury* tests . . .

will be conducted with *Little Joe,* a cluster of four *Sergeant* engines (guidance by Sperry Gyroscope, propulsion by Thiokol) to be designated as TX-3320 and TX-3322. ABMA has a NASA $2.2 million contract to produce the cluster. North American has a $400,000 contract for the casing, transport vehicles and launcher. Thiokol has a $110,000 contract to build small solid rockets (SM-19E1) to be attached to the side of *Little Joe* for initial acceleration.

***Titan* continues high . . .**

batting average. Wednesday's short-range (200-300 mile) test firing of first stage from Cape Canaveral was second successful in three attempts. Previous successful test firing was Feb. 6.

industry countdown

Another entry . . .

in the ALBM is Douglas, with Donald W. Douglas, Jr., being quoted on the West Coast as saying his company has submitted a proposal for an ALBM and a relatively "inexpensive" solid surface-to-surface missile. Latter would be successor to the *Honest John.*

Hispano-Suiza will build . . .

an initial 200 bi-liquid SEPR rockets, Type 841, used as booster engine on the Mirage III interceptor. With a minimum thrust of 1653 lbs., at 52,000 ft. (using two combustion chambers) it has a maximum thrust of 35,450 lbs. Propellants are nitric acid and TX-2.

Terrier or *Tartar* . . .

will be on 51 ships under present Navy shipbuilding programs, including three carriers, three cruisers, and 20 guided missile frigates.

400-mile range . . .

for testing *X-15* in California and Nevada, was developed and built by the Electronic Engineering Co. of California for NASA. Work began in 1956 under $2 million contract. Master control station in the radar instrumentation system is at Edwards AFB.

Big orders for Scout . . .

contractors is indicated by a recent AF-NASA agreement. NASA will supply *Scout* specs to AF, who will then have contractors modify the 35,000-pound, four-stage 70 ft. experimental research rocket to suit AF test requirements. AF version is System 609A (m/r, Feb. 23, p. 13). First stage will be an Aerojet Senior, a modification of early *Polaris* motor; second stage will be an improved *Sergeant* by Thiokol; third will be a new scale-up of *Vanguard* third stage by ABL; fourth stage, same as *Vanguard* third, will be by JPL. Minneapolis-Honeywell will have guidance and spin stabilization.

Project *Mercury's* bill . . .

will exceed $200 million. *Mercury* is budgeted for over $58 million in FY 1959, and for $70 million in FY 1960. NASA and McDonnell have signed a definitive contract estimated at $18 million for delivery of 12 capsules during next 14 months. NASA Administrator Glennan told Congress that more than $2 billion will be spent before the nation procures basic rocket engines needed for its space program, and the agency will need 2,500 more employees if the present NASA-ABMA agreement does not work out.

AF screened 350 sources . . .

for its 480L strategic communications support system which may have more fund implications than the DEW line. ITT-RCA were selected from four proposals submitted by teams representing 18 companies. AF required all bidders not to design and engineer the system so as to have advantage in subsequent procurement over other suppliers, and, when feasible, not to compete with other suppliers for future systems and sub-systems requirements.

"Weather eyes" for . . .

Vanguard II were development of Electro-Optical Division of Perkin-Elmer. Mercury battery packs were developed and manufactured by Mallory Battery Co. of Cleveland, a division of P. R. Mallory & Co. Inc. Dow Chemical Co. reports skin and internal structure of satellite are of magnesium.

First large-scale commercial . . .

plant for production of boric oxide will be American Potash & Chemical Corp's Trona, Calif. facility, now under construction.

Movable nozzle of new type . . .

will provide better steering and control of the Lockheed *Polaris*. Conceived by scientists at the Applied Physics Laboratory, Johns Hopkins University, it has been tested successfully at the Navy Propellant Plant at Indian Head, Md. The molybdenum nozzle was designed by the Systems Engineering Division of Cleveland Pneumatic Industries, Washington, D.C., and manufactured by Cleveland's Pneumatic Tube Division in Cleveland.

Vandenberg work schedule . . .

has been stepped up to seven days a week for an 84-hour work week where second *Atlas* complex is shaping up. Three pads of first complex are about completed with one missile on launcher. Second complex, originally scheduled for completion in mid May, now is slated for early April.

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READY NOW for the day man first explores the planets, Nortronics' concept of Astronertial Guidance is the most accurate known for long-duration flights. Astronertial Systems now in production deliver a wide margin of added accuracy–using Nortronics' exclusive 24-hour star tracker to correct continuously for the small, then ever-compounding errors inherent in "pure" inertial systems.

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MAGAZINE OF WORLD ASTRONAUTICS

NASA Plans Include East-West Minitrack Fence

Other goals are two additional parabolic dishes for continuous deep-space tracking, and developing safe tracking and communications for man in space.

by Paul Means

WASHINGTON—An east-west fence of four Minitrack stations stretching from Western Europe across the Atlantic and the North American Continent to Alaska is an immediate goal of the National Aeronautics and Space Administration.

Of great interest to the electronics industry, completion of the new fence—added to a north-south string of stations already in service—will enable NASA to track satellites of all inclinations, including polar orbits.

The existing Minitrack network can only track satellites with orbital inclinations less than 35 degrees from the equator, and do some non-continuous deep-space tracking. It uses a north-south chain of 11 Minitrack stations in the United States and abroad, ranging in latitude from Maryland to Santiago, Chile.

Two other NASA projects to be completed in the next two years are:

1. Construction of two 85-ft.-diameter parabolic dishes similar to the one at Goldstone, N.M., at Woomera, Australia, and at an undisclosed site in South Africa, for continuous tracking of vehicles traveling in deep space.

2. Development of a tracking and communications system that will insure the safety of Project *Mercury's* first man in space.

• **Funds Picture**—NASA's proposed operational tracking fund of $11.5 million is only a small portion of the overall budget request of $485,300,000 for the agency for Fiscal 1960. But it is more than double the tracking appropriation of $4.3 million approved in Fiscal 1959.

At the same time, however, the Fiscal 1960 request for tracking funds for the Advanced Projects Research Agency is $17 million, a sharp drop from the $23 million fund of Fiscal 1959. ARPA's total budget request is $455 million.

Though no figures for the construction of tracking installations are available, NASA has just asked Congress for an additional $12,050,000 to carry out the projects listed above.

According to NASA Administrator T. Keith Glennan, $3,300,000 of the additional money will be used to construct the east-west Minitrack fence and to improve existing stations; $3,500,000 will be used for initial expenditures on the construction of the large radar dishes in Australia and South Africa; and $5,250,000 will be used to build a Project *Mercury* tracking, communication and radar acquisition network in Southern Texas.

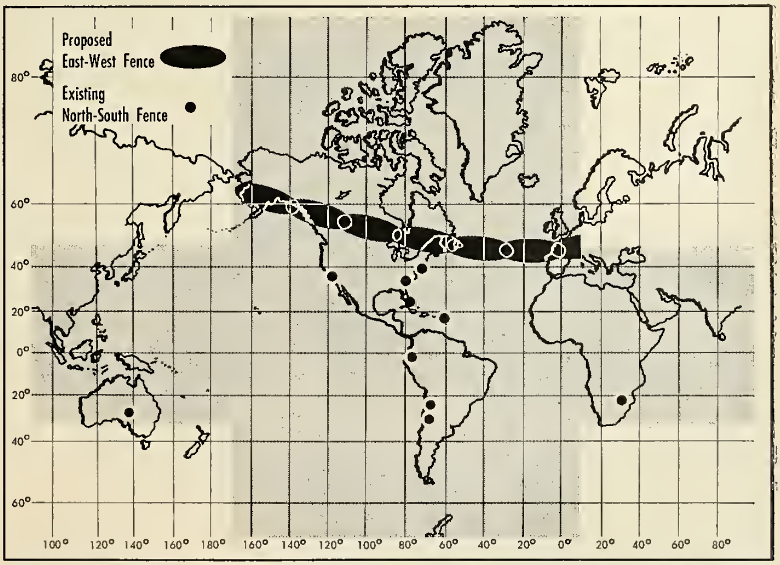
NASA officials say that the large radar dishes and the Project *Mercury* installations will need more money later.

• **Existing stations**—The cornerstone of NASA's current and future tracking operations are the Minitrack stations originally developed for the IGY.

Stations presently in operation are at Blossom Point, Md.; Ft. Stewart, Ga. (this will be moved shortly); Havana, Cuba; Quito, Ecuador; Lima, Peru; Antofagasta and Santiago, Chile; Antigua, British West Indies; Esslen Park, Union of South Africa; Woomera, Australia, and San Diego, Calif.

The four South American stations and the ones at Havana and Ft. Stewart were operated by the Army Signal Corps during the IGY. The Signal Corps staffs are being replaced by contract staffs under technical direction of NASA.

Antigua, a part of the Atlantic



NASA PROPOSES to build new Minitrack stations in Europe, Canada and Alaska. These, plus existing north-south chain, would make possible tracking of all satellites from 0 to 90° inclination. Minitrack costs would total $3.3 million.

Missile Range, is the initial station after orbit for Cape Canaveral launchings, and supplies information during the sub-launching phase along with another station at Grand Turk in the Bahamas.

The San Diego station was operated by the Naval Electronics Laboratory and is now operated under contract by NASA.

The Australian and South African stations are operated by the respective countries as their contribution to the IGY.

These stations comprise a completely functional network with communications headquarters under the direction of the Naval Research Laboratories in Washington, D.C.

• **How it works**—The primary components of these Minitrack stations are:

1. Nine to 15 antennae whose design and installation allow the system to detect signals generated from sources in a fan-like space directly over the station.
2. A highly-developed radio receiver sensitive to signals of 108 megacycles plus or minus five cycles.
3. A precision time section whose counter instrument can tell local time down to the 1/1000th of a second.
4. A phase comparison section which determines the angular position of the satellite. This is accomplished by measuring, electronically, the difference in time required for satellite transmissions to each of two ground antennae spaced 500 feet apart. This is known as the "interferometer" principle.
5. A bank of two recorders which present on a paper chart the signals received from the satellite plotted against an accurate and precise time base. The speed of the chart can be varied from zero to 100 millimeters per second.

Three fixes on a launched satellite by one or more Minitrack stations must occur before the elements of the orbit can be computed. Computation of the inclination and equatorial intersection will give the plane in which the satellite is orbiting. Other elements of the orbit computed by Minitracks are the perigee, period, argument of perigee, and epoch.

With the construction of the east-west Minitrack fence, NASA will be able to track any satellite regardless of orbit, and evaluate the necessary information quickly.

• **Photo fixes**—A second set of satellite and deep-space tracking equipment are the Baker-Nunn photographic satellite-tracking telescopes, developed for the IGY by the Smithsonian Institute and now operated by the Smithsonian under NASA direction.

These instruments fix the position of a space vehicle by taking a picture

THREE STATIONS using huge parabolic dishes will provide overlapping deep-space coverage for unbroken tracking.

of it against a star background, thereby determining the vehicle's position with respect to time at different parts of the earth.

The Baker-Nunn equipment is effective only when the space vehicle is in the light and the telescope is in the dark under clear weather conditions. Best periods for optical observation are an hour after sunset and about an hour before sunrise.

These camera-telescopes are currently in operation at Palm Beach, Fla.; Arequipa, Peru; Villa Delores, Argentina; Nani Tal, India; Cadiz, Spain; Olifanstfontein, So. Africa; Mitaka, Japan; Haleaka, Hawaii; and White Sands, N.M.

Additional Baker-Nunn installations will be constructed along the proposed east-west Minitrack fence.

• **Big dishes**—Also aiding NASA's tracking operations are the larger tracking facilities which can send and receive signals over a wider band, allow for reduced power supplies in space vehicles, and work at longer distances.

These include the Air Force's 60-ft.-diameter parabolic dishes, which are in operation in Hawaii and on the Atlantic Missile Rrange, and the numerous helicol antenna tracking units situated throughout the world.

NASA's large 85-ft.-diameter parabolic dish at Goldstone, N.M., built by the Army for its first satellite attempts, will be one-third of a proposed deep-space tracking network designed to continuously track space vehicles to the moon and beyond.

The three stations, at one-third intervals around the earth (New Mexico, Australia and South Africa), will overlap in their deep-space coverage areas so as to provide a continuous tracking pattern, and will be the key tracking apparatus as rockets travel farther from earth.

• *Mercury* **challenge**—A more immediate problem is to provide adequate tracking facilities for Project *Mercury*, insuring the necessary safety for the first man in space. Tracking and communication facilities will have to be more extensive and refined than those currently used for unmanned satellites.

It makes relatively little difference whether the present tracking facilities achieve their fixes on an unmanned satellite on the vehicle's first, second, or later orbits. But *Mercury's* manned capsule is scheduled to make two or three orbits only.

It will therefore be necessary to compute the elements of the capsule's orbit quickly in order to determine the exact time to trigger the retro-rockets for its descent.

To locate the capsule quickly after it has landed, it will be necessary to track it immediately on descent, which is more difficult since it no longer will be in free orbit and will be affected by drag. Without this tracking capability, it will be impossible to recover the man from the capsule in the alloted safety time.

Another problem Project *Mercury* poses is development of an extensive communications network, so that information can be quickly funneled from all over the world to a central computing center.

Initial construction on the Project *Mercury* network will take place in the near future at a location in Southern Texas—the $5,250,000 project announced by Administrator Glennan and referred to earlier.

NASA, DOD Have Widely Divergent Patent Rights

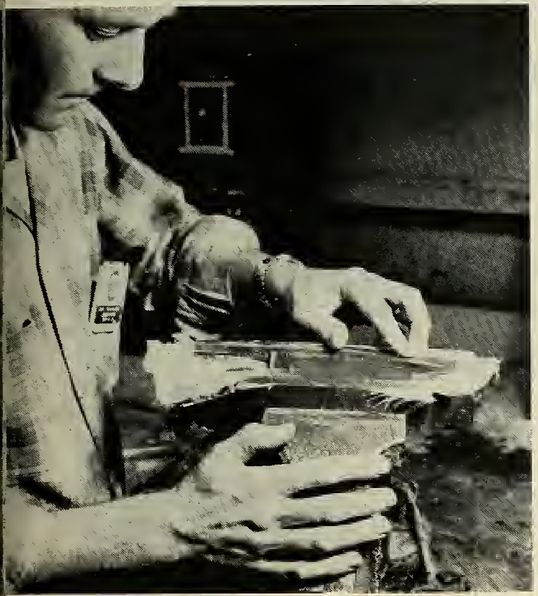
WASHINGTON—The National Aeronautics and Space Administration has the same basic procurement authority as the Pentagon and will follow the Armed Services Procurement Regulation in making contracts, according to John A. Johnson, general counsel of NASA and long-time Air Force general counsel.

But the same thing doesn't hold for one important field—patents.

NASA is required to acquire title to certain inventions made under its contracts unless the Administrator—on grounds of the public interest—signs a waiver. DOD generally acquires only a royalty-free license.

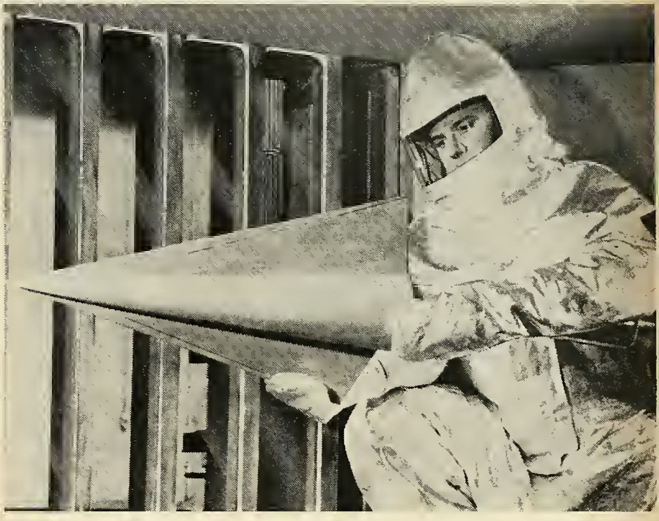
There is no present intention to seek an amendment to the National Aeronautics and Space Act to alter this divergence, although Johnson says it is "undesirable." But he is promising to make every effort to administer the patent section "fairly and objectively."

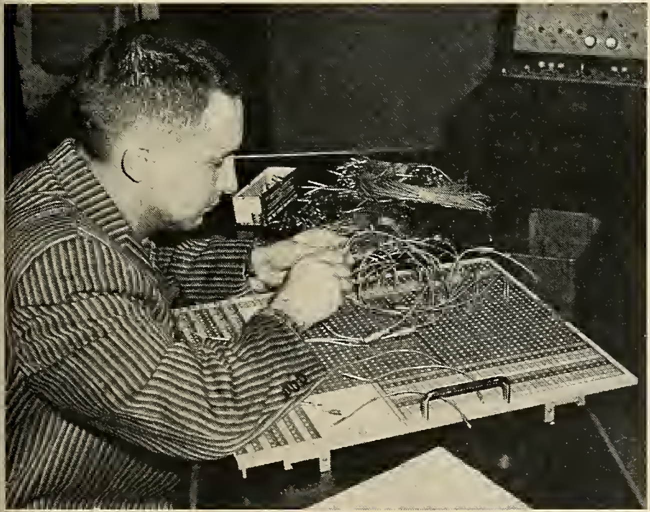
ASTRONAUTICS in the news . . .



ALLIED CHEMICAL's urethane foam is getting new use as material for wind tunnel test models, particularly at Chance Vought. Open mold is lined with glass cloth and epoxy resin laminated hefore foam is poured. The smooth skin offers less drag, and is cheaper than wooden surface models.

A SUPPLIER to many coal mining operations—Mine Safety Appliances Co. of Pittshurgh—is contrihuting to the space business. This aluminized asbestos suit is used at NASA's Langley Research Center for protection against wind tunnel heat.





MARTIN-DENVER has developed a Master Operations Control (MOC) which monitors countdown for the *Titan*, checking out suhsystems and testing instrumentation. Here, technician patches in a countdown on the master sequencer program hoard. Some 200 functions can he checked hy the system.

NEW VACUUM TEST chamber which simulates altitudes up to 140 miles has heen placed in operation in the environmental physics department of Aeronutronic Systems, Inc. The chamber has an 8-foot diameter. Lights are part of high-speed photography assemhly for use in upper atmosphere weather rocket experiments. The company, a suhsidiary of Ford Motor Co., has its research center at Newport Beach, Calif.

Singer's Cast Epoxy Resin Mirrors Require No Costly Hand Work

ALUMINUM reflective coating is bonded to plastic replicas in vacuum chambers.

APERTURE of f:0.6 is illustrated by sun rays made visible by smoke.

Polishing and finishing eliminated in plastic replica process. Mirrors withstand 20,000g in shock tests

NEW YORK—A new cast epoxy mirror now in production represents a victory over two of the major drawbacks which have plagued makers of reflective optical components—high cost and long production time—according to Frederick W. Howells, manager of The Singer Manufacturing Company's Military Products Division.

The company's Bridgeport Division has tooled up with high-vacuum chambers and other equipment specifically designed for mass production of the new product known as the Repli-Kote Mirror.

The new mirrors, according to SMPD spokesmen, are guaranteed to cost from one-half to one-fifth as much as ground glass mirrors, and they can be produced at a rate many times faster. With the present tooling, the Bridgeport plant can turn out from 50 to 200 units per day, depending on size. The largest mirror produced to date measures 10 inches in diameter.

The Repli-Kote Mirrors are cast in epoxy resin specially treated to provide durability, and vacuum coated with aluminum for reflectivity. The aluminum surface is overcoated with a protective film of silicon-monoxide. Average thickness of the aluminum coating ranges between five to eight millionths of an inch: and the bonding to the epoxy backing is very rugged.

• **No hand work**—In contrast to glass mirrors, the production of epoxy mirrors does not involve any hand finishing or polishing. The only handmade part in the process is a precision ground glass prototype—or master—from which the casting mold—or negative—is cast. The negative, like the finished product, is made of epoxy resin. The epoxy-backed mirrors can be cast to duplicate faithfully and to minute tolerances any shape that can be produced in glass by precision grinding—including parabolic, hyperbolic, elliptic, and other aspheric shapes normally not reproducible in glass on a mass production basis.

Despite the simplicity of production, the manufacturer says, the physical properties of the epoxy-backed mirrors are far superior to those of glass. Sample replica mirrors have withstood impacts up to 22,000 g in shock resistance tests. Yet precision has been attained in mass manufacture of 6-inch paraboloids with a 5¼-inch focal length concentrating 90% of incident collimated light within 0.1 millimeter diameter.

Resistance to thermal shock is another feature of the new mirrors. The rate of thermal diffusion through epoxy is much greater than it is through glass, and Repli-Kote Mirrors have been transferred directly from dry ice to boiling water without ill effects.

• **Easy mounting**—The new process also simplies the mounting problem since threaded inserts, mounting lugs, or other mounting fixtures can easily be cast into the mirror backing to meet specifications. Mechanical and electronic components can also be molded in the backing.

The plastic replica process was developed by SMPD's research and development arm—Haller, Raymond, and Brown, Inc., of State College, Pa. Immediate application is seen in infrared systems, such as the homing system in the Navy's *Sidewinder* AAM.

Haller, Raymond, and Brown recently also perfected an improved process for coating infrared reflectors to withstand stresses induced by rotation as fast as 5000 rpm. This process permits faster production than does hard anodizing and reduces cost about 80%, according to company spokesmen.

Weather Satellite Will Have Three Cameras

Later meteorological experiments will be responsibility of Weather Bureau Section

by Frank G. McGuire

WASHINGTON—The United States is planning to put a satellite containing three television cameras into orbit soon in the first of a series of such meteorological experiments. Under the cognizance of ARPA, this satellite apparently will be that agency's first project in the field of weather reconnaissance. The orbit sought will be a near-circular one at about 300 miles altitude, giving the satellite a 90-minute period.

Planning of experiments, data reduction and analysis, and application of information from later weather satellites will be the responsibility of the Meteorological Satellite Section (MSS) of the Weather Bureau. MSS will also conduct basic research in connection with the newly-acquired data. Funding will be done through NASA.

The initial satellite will be equipped with three vidicon TV units built by RCA. One will have a field of view about 1000 miles square and resolution of about 2½ miles. The other two cameras will have smaller fields of view, but better resolution.

A cutoff device will prevent the cameras from operating when a large percentage of useful view is out of the cameras' sight due to the satellite's attitude or insufficient illumination. There will be no control system aboard the satellite to affect its attitude once in orbit. It will operate at a low rate of spin—on the order of 10 rpm. Internal power will be furnished by solar battery.

• **Rapid scanning**—The vidicon unit with the wider field of view will be aimed perpendicular to the satellite's spin axis, and the other two will be aimed in the same direction along the spin axis. The cameras will scan for a fraction of a second, then store the data on tape in a two-second operation. The wide-angle-view vidicon unit will operate with an interval of approximately two minutes between exposures and an overlap of about 600 miles in successive exposures.

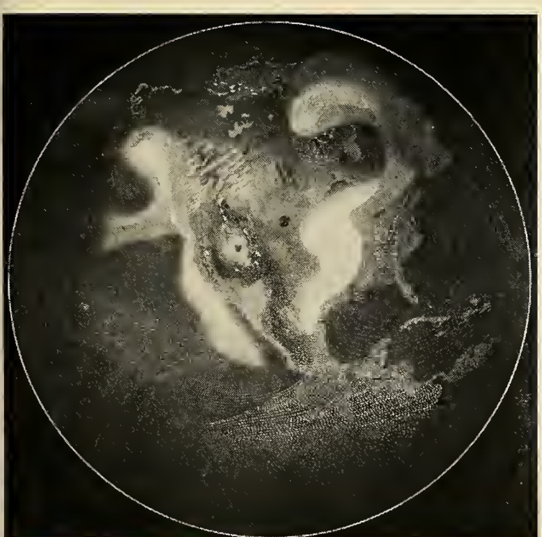
(The first weather satellite will not be established in a polar orbit, but it is anticipated that later satellites will be launched that way, so as to cover the entire earth. In this case, launching will most likely be carried out at Vandenberg AFB, Calif.)

A system of ground control will be utilized to command the satellite's photographic and readout operations. Readout will be triggered to ground stations once on each pass around earth and recorded on film and tape. The data will be forwarded to MSS at the Weather Bureau facility in Suitland, Md.

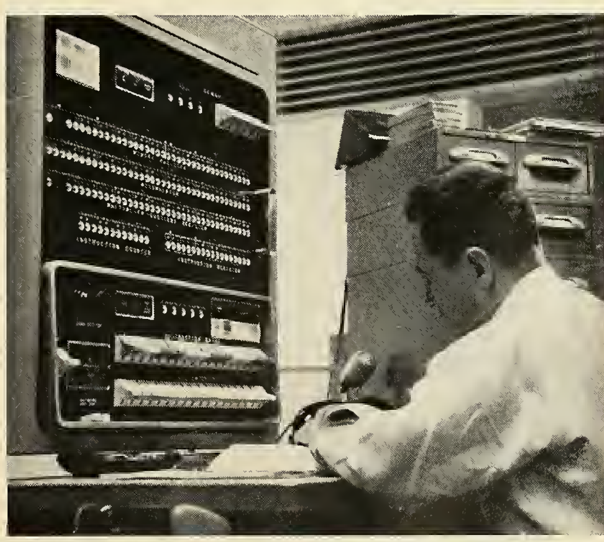
After data reduction is completed, the information gained will be used to supplement observations from ground stations, which the Weather Bureau has no plans of supplanting with satellite equipment.

• **Radiation data**—Five types of radiation sensors will also be included in the satellite's payload. Under construction by the Army Signal Corps Research and Development Laboratory, they will measure various components of radiation emitted and reflected by earth. By thus measuring the earth's albedo, MSS will be able to determine the net intake and outgo of radiation. Distribution of the net heating of the atmosphere, as governed by this radiation parameter, is believed to ultimately control circulation of the atmosphere. An accurate series of data on this phenomenon would be of great value to meteorologists.

All data from the weather satellite



IMAGINARY weather picture taken from a rocket 4000 miles above the earth.



DATA from satellites would be processed at Bureau's Suitland, Md. Meteorological Satellite Section (MSS) facility.

will be available to other nations of the world. For example, dissemination of information might be handled by the World Meteorological Organization, of which the USSR is a member.

• **MSS plans**—The Weather Bureau's Meteorological Satellite Section, with Dr. Sigmund Fritz as section chief, was organized in March, 1958. Later, it was expanded upon the invitation of NASA to act as its agent in the field of weather satellites.

The section has a staff of 14 at present. Tentative plans call for expanding this to 40 by June.

MSS is currently studying photographs from such projects as *HUGO* in order to gain as much experience as possible in interpreting extreme-altitude photographs. Techniques developed during these preliminary investigations will then be available for application to actual satellite data.

Future plans and objectives of MSS are numerous. One calls for a radar installation aboard a satellite to measure cloud structure and precipitation. Vidicon cameras can see only the tops of cloud formations.

MSS would also like to be able to measure surface barometric pressure from a satellite, which it cannot do now. In addition, it wants a stabilized satellite and/or a "stationary" satellite in a 22,000-mile orbit. A trio of satellites which were both stabilized and "stationary" could keep the entire globe under constant surveillance.

Future weather satellites may also measure the effects of ultraviolet and other rays on the lower atmosphere. Also, the radiation emitted by atmospheric gases should indicate the world-wide distribution of water vapor, ozone and carbon dioxide, and could conceivably show temperature distribution near the tropopause and lower stratosphere.

Armour Enters Empirical Rocket Applications

CHICAGO—Armour Research Foundation and its Chemistry and Chemical Engineering Department are establishing a static test site some 50 miles west of here which reflects the recent de-emphasis of combustion in general in favor of the more specific needs of rocket propulsion.

Armour, which has been deeply involved in theoretical combustion studies and laboratory preparation of liquid ozone, is moving more and more into empirical rocket applications. The new test site is equipped with a concrete test stand, instrumentation block house, utilities building and an adequate supply of water and 220-volt electric power.

The test stand was designed for either solid or liquid propellant motors and has a capacity of 10,000 pounds thrust. Currently, it is being used in a materials testing program with a 500-lb. acid-aniline rocket. A test of gaseous fluorine and ammonia combustion was performed on Dec. 27, 1957, in a miniature rocket motor.

The site is being considered for decontamination tests of fluorine rocket motors, possible exotic solid propellants, with provisions to be made if and when liquid ozone is considered safe enough for test in a rocket motor.

• **Large staff**—Armour Research Foundation is a 20-year-old organization with a staff of about 1200 (800 are engineers and scientists). Its personnel are employed in nine research departments. The propellant work is split into two areas—C. Charles Miesse supervises the Combustion Research Section; Gerald M. Platz is Supervisor of Propellant Chemistry Research.

The Combustion Research Laboratory is equipped with numerous test cells for detailed investigation of a wide range of combustion phenomena:

1. Small-scale (2.05-in. ID) jet engine for helicopter rotor tip propulsion.
2. 1.5 x 3.5-in. low-pressure combustion tunnel for high-altitude (4-in. Hg) studies at flow velocities of M = 0.3.
3. 2.0-in. ID low-pressure combustion tunnel for evaluation of combustion characteristics of exotic fuels (under construction).
4. Vertical combustor with settling chamber for investigation of combustion characteristics of low-volatility fuels.
5. Nash vacuum pump with 650 cfm capacity under all pressures from 2-in. Hg to atmospheric.

Propulsion projects have included:

1. Boron chemistry—A five-year program was conducted for the Callery Chemical Company under a contract from the Navy's Bureau of Aeronautics. In general, it dealt with the chemistry of compounds containing boron, hydrogen, and carbon. More specifically, it was concerned with process studies for high-energy fuel Plant No. 2 at Muskogee, Oklahoma.

2. Combustion in low volatile fuels—In an effort to improve combustor performance and increase heat release rates, the Navy has sponsored a basic research program on the combustion of heavy residual fuels. During the three years of this project, analytical and laboratory investigations have been pursued regarding the basic properties of injection, atomization, vaporization, ignition, mixing and combustion. Atomization of liquid fuels has been studied in great detail.

The second phase of this program, initiated recently, involves determination of the mechanism for combustion chamber deposits and corrosion, and establishment of design criteria for eliminating this universal problem.

3. Rocket exhaust gas impingement—For testing the sensitivity of heat-resistant material to high-temperature, high-velocity gases, a specimen was mounted in the exhaust jet of a 220-lb.-thrust liquid propellant rocket. A series of six tests at an average of 60 seconds duration was completed satisfactorily. Although ARF did not name the material, it can be assumed that it was Armour's ceramic-coated metal.

4. Nozzle material evaluation—Also under investigation is a comprehensive study of the mechanism of failure of rocket nozzle materials, as the result of exposure to high-energy solid propellants. Subject evaluation is conducted by the Ceramics and Minerals Division, under the Supervision of S. W. Bradstreet.

5. Ozone chemistry—Practically at a standstill.

Proposed areas of effort, m/r learned, include:

1. A rocket-turbine power system which might be competitive with the gas turbine if materials can be found to take the higher temperature.
2. Utilization of gases in extra-terrestrial atmospheres for combustion. Atmospheres of Venus or Mars could furnish carbon dioxide as a propellant. Most promising reactant with CO_2 would be either boron or beryllium. The reaction of beryllium with CO_2 appears to offer a considerable advantage in heat evolved per unit weight of fuel over any current system in which both fuel and oxidant are carried.
3. Decontamination of HF vapors and aerosols resulting from scrubber effluent or fluorine spills.

Named Managing Editor

WASHINGTON—Donald E. Perry, news editor of Missiles and Rockets Magazine, has been named Managing Editor. Perry, former Martin writer on the *Bullpup*, *Missile Master*, and *Lacrosse* programs, joined the staff one year ago as an assistant editor.

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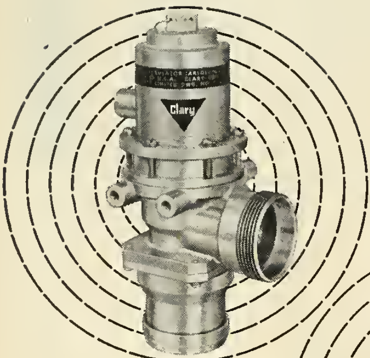
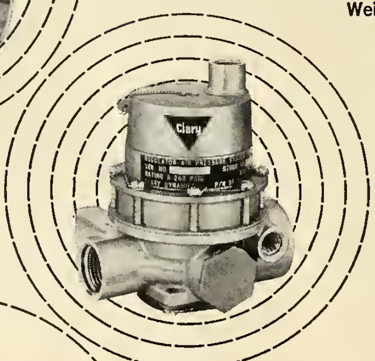


ABSOLUTE PRESSURE REGULATOR maintains an outlet pressure of 18½ to 20 PSIA with variations in flow rate from 3 to 350 SCFM under 30 to 100 PSIA inlet pressure and −65°F. to +350°F.

Weight: 2.1 pounds Length: 8.55 inches
Tube Size: Inlet: 1.50 inches
Outlet: 2.00 inches



DIFFERENTIAL PRESSURE REGULATOR maintains an outlet pressure of 6 PSIG ±.25 with flow variations from 3 to 160 SCFM under 10 to 250 PSIG inlet pressure and −65°F. to +350°F.

Weight: 1.5 pounds Length: 4.00 inches
Tube Size: Inlet: .75 inches
Outlet: special flange

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Integrated Electronics for Small Missiles

Prime consideration in design and manufacture is that the missile be considered as a round of ammunition

The facets of manufacturing integrated electronics for small missiles are many. This paper presents some of the important factors that must be considered and stresses that design, manufacturing and quality control are inseparable if efficient, reliable small missile electronics are to result. Electronics must be designed and manufactured as an integral part of the missile. The black-box, shock-mount, mounting bracket, appendage-like treatment of electronics has no place in a modern high-performance small missile.

Mechanical design suitable to meet the various environments is a major factor influencing the manufacturing process.

Some of the techniques employed in design and manufacture are mentioned. Any one of these is worthy of a separate treatise. It is not in any way intended to present a detailed discussion but merely to alert the reader to some of the many factors influencing the manufacture of integrated small missile electronics.

The material presented is based on experience obtained in design and manufacture of missiles at the Naval Industrial Reserve Ordnance Plant, at Pomona. Convair-Pomona operates the plant under Naval Ordnance Contracts.

Much of the material contained was originally prepared by K. C. York and Henry Chrystie, Design Specialists at Convair-Pomona. Acknowledgement is due the personnel of the Naval Inspector of Ordnance Office and the Convair Engineering Staff because the information contained herein is their work.

by Gordon E. Sylvester

Assistant Chief Engineer-Product Engineering

Convair/Pomona, Convair Division of General Dynamics Corporation

POMONA, CALIF.—In discussing manufacture of integrated small missile electronics, it is first necessary to understand the philosophy used in the design of the hardware. A small missile should be considered as ammunition, or an educated shell, rather than an airplane with the pilot removed.

This distinction is important because it has considerable effect on our approach to design and manufacturing. In this discussion it is important to understand that the problems of design, quality control and manufacturing are so inter-related that one cannot be discussed without including the other two.

Let us first discuss some important design considerations which, when combined, establish the requirements for the electronics we build for small missiles. These are listed in Fig. 1.

• **Small space and low weight**—Ever-increasing performance is demanded of our modern military vehicles. An important factor governing performance is size and weight.

Therefore, it has become necessary to devise means whereby electronics will occupy less of the total airframe, and also at the same time be able to perform additional and more sophisticated functions than were previously necessary.

Fig. 2 shows a trend in the unit volume occupied by electronics in several missiles. It is interesting to note trends taking place in smaller missile electronic packaging. It is obvious that a reduction in missile length will result in increased maneuverability.

• **Environments known**—Many of the environments encountered in small missiles are well known to the missile and electronics industry. Some of the typical environments which have considerable influence on the product we manufacture are listed in Fig. 3.

• **Testable and visually inspectable**—The total electronics must be built up from functionally testable subassemblies and assemblies in order that an orderly manufacturing and testing process can be evolved. Excessive testing is wasteful; however, too little testing can result in exorbitant rework costs especially when tear-down of complicated assemblies is involved.

Even with various sophisticated testing devices now available including automatic programing, automatic read-out, and automatic acceptance or rejection decision, there is still no substitute for good visual inspection during the manufacturing process. Therefore, visual inspection operations must be provided during manufacturing, and designs must be made in such a manner as to readily permit thorough visual examination.

• **Reliability defined**—Much has been written and said about reliability in the past few years. Most of this has

FIG. 1: DESIGN CONSIDERATIONS

Small Missile Integrated Electronics

1. Small Space and Low Weight
2. Environments
   - Shock
   - Virbration
   - Temperature
   - Moisture
3. Testable Assemblies and Subassemblies
4. Visually Inspectable
5. Reliable
6. Interchangeability and Spare Parts
7. Minimum Cost in Production
8. Ability to Incorporate Changes with Minimum Disruption of Manufacturing

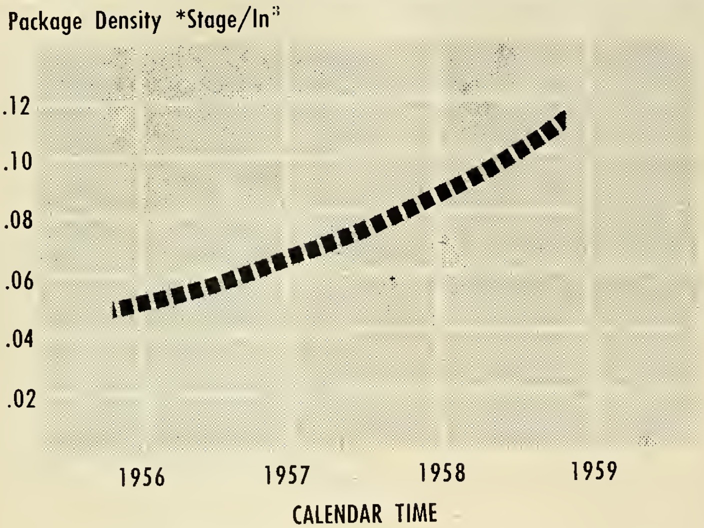
been directed towards electronics and has centered on design considerations; however, that is not the total story.

In the manufacturing phase, reliability means minute attention to details at each and every step. Each wire, when skinned, must be done in such a manner as not to nick a strand; each soldered joint must be made as nearly perfect as possible; and each process such as cleaning, plating, etc., must be accomplished under controlled conditions such that satisfactory performance of the end product is assured.

I might dwell for a moment on the subject of component parts. Each component part that goes into the missile must be assured of its functional reliability. After a part has been tested and demonstrated to satisfy the design requirements, no changes in process can be allowed until such changes have been demonstrated to yield a product adequate for the purpose intended.

It is important that all people engaged in missile electronics understand the extreme importance of controlling changes in manufacturing processes. Many a design has not proven satisfactory in production because some small change was allowed in the manufacturing or quality control process which nullified the functional reliability of the device being built.

FIG. 2: TREND IN SMALL MISSILE ELECTRONIC PACKAGE DENSITY



*A "stage" consists of a single electron tube, diode or transistor together with its associated resistors, capacitors, relays, transformers, etc.

FIG. 3: TYPICAL ENVIRONMENTAL REQUIREMENTS

OPERATIVE VIBRATION

A. Electrical Power On—No damage sustained
10g peak
20—1000 cps frequency sweep in each of 3 orthogonal planes

B. Operate within tolerance
5g peak
20—1000 cps frequency sweep in each of 3 orthogonal planes

STORAGE VIBRATION

2g at 23 cps applied in each of 3 orthogonal planes—total 75 hours

STEADY STATE ACCELERATION

40g

SHOCK

Electrical power ON — 0—50g in .003 second; 50g for minimum .010 second

TEMPERATURE

Operating within tolerance
—40°F to +125°F plus solar radiation and internally induced heat

Storage
No damage sustained
Must function within tolerance after exposure
—65°F to +160°F

MOISTURE

Operate within tolerance
Relative humidity up to 95% may include condensation

• **Interchangeability and spare parts**—We continuously strive for improvement in reliability which should result in fewer failures and less need for spare parts. However, the state of the art has not advanced to the point where spare parts are no longer necessary. In the integrated approach with small spaces available, we can allow only very little clearance between the spare parts—therefore, close control of the mechanical dimensions is necessary to achieve interchangeability.

In addition, and probably even more important in the manufacturing process, is the control of tolerances of the various electrical parameters. Tolerances used in the manufacturing process can be easily established by simply adding arithmetically tolerances of the various parts that make up an over-all system to obtain the system tolerance, and then adding the effects of various environments. However, this method of tolerance derivation can result in tight tolerances prohibiting economic manufacture.

Methods of tolerance derivation and justification are beyond the scope of this paper. However, it should be pointed out that a method of combining tolerances on a probability basis is being employed and should result in considerable reduction in production cost, and yet provide a high degree of assurance that a missile, when fired, will function satisfactorily to accomplish its mission.

Of course, certain rigid quality control procedures must necessarily accompany such a system in manufacturing.

• **Low cost of production**—Ammunition, as we consider small missiles, usually means large quantities in production. Therefore, the cost of producing each item becomes extremely important. Our design, manufacturing and quality control processes must be developed to allow for minimum costs for production and yet yield a weapon entirely suitable for accomplishing its mission. Particular attention must be given to integrating the design and mauufacturing in such a

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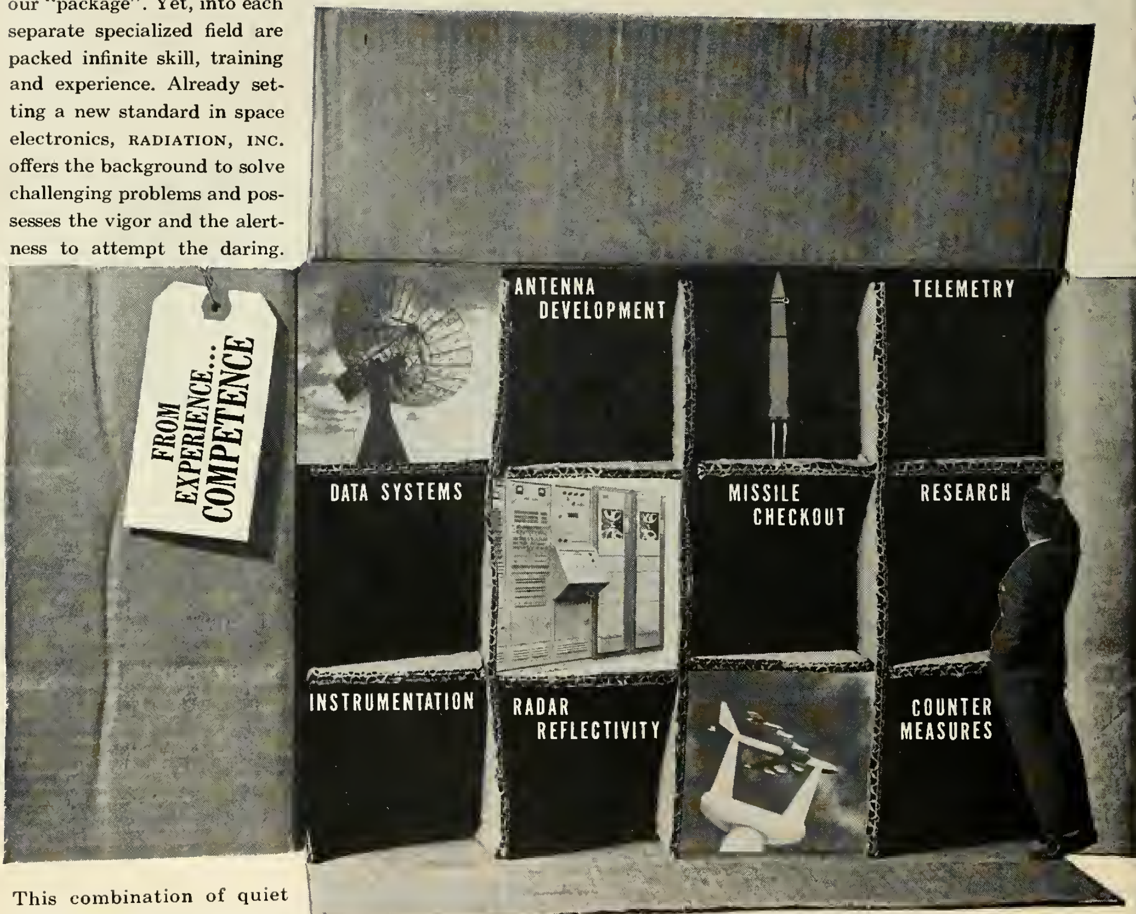

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manner as to permit this happy combination.

• **Ability to readily incorporate changes**—As the missile technology improves, we find that we can improve the performance of our vehicle. This usually leads to changes within the electronics. If, for instance, we make all of the electronics in one assembly without some breakdown, necessary changes become extremely difficult, if not impossible, to incorporate without a major change in the missile.

Therefore, design and manufacturing processes must be devised which will permit ready incorporation of improvements with minimum disruption of manufacturing.

Mechanical Design for Shock and Vibration

Shock and vibration requirements probably influence the manufacture of integrated electronics more than any other one factor, and therefore are worthy of a detailed discussion.

Design and manufacturing of missile electronic equipment would be simplified if shock and vibration isolation could be used. Isolation, though desirable, is not compatible with design requirements for many reasons.

First, as we have pointed out earlier, the space allotted to electronics must be kept to an absolute minimum. Isolation requires that a significant clearance be provided around equipment. It has been estimated that a clearance of .3 inch around each component would be required to provide protection for a system having a 50cps resonance under a 70g acceleration loading. Additional space is required for the isolation mounts.

The problems of dimensional control and mechanical interchangeability commensurate with economical production further complicate the situation by requiring even additional space.

The second objection to isolation is possible adverse effects upon the missile control system. The mass of the missile electronics may be as great as ⅕ the total missile mass. Supporting this mass on a low-frequency isolation system would induce a low-frequency missile vibration mode which could have a deleterious effect upon missile guidance.

These two reasons combined with other minor ones virtually preclude the use of shock and vibration isolation within the missile.

• **Early missile equipment**—Early missile equipment packages were designed using conventional aircraft and electronic practices. Chassis were fabricated from thin sheet metal. Vacuum tubes were supported from sockets and so forth.

This equipment had to be extensively tested to assure that it would function in the missile environment. This environment in some cases exceeded specifications for individual parts to such an extent that special testing of parts such as vacuum tubes resulted in yields as low as 20%, even though the tubes themselves met their individual specification requirements.

Then, after the units were assembled, they were vibration-tested extensively to determine their weaknesses. The weaknesses found were corrected by rework. Finally, after rework, equipment would sometimes function in the environment, but it had very poor reliability.

• **Effects of excessive acceleration**—Probably the main source of improper operation in the early equipment was excessive acceleration caused by resonant amplification of low-frequency vibration. Some packages amplified 5g input vibration to as high as 100g's at certain frequencies below 300cps. A component part failure would occur when the part was perfectly satisfactory for even 10 to 15g acceleration.

This failure would occur if a part and its mounting structure had close to the same resonant frequency. In this case, the part's resonant mode would be excited to a destructive amplitude.

• **Current missile equipment**—Missile equipment is now designed and manufactured to vibrate as an integral unit with no excessive resonant amplification throughout the vibration spectrum. Since shock and vibration isolation is not compatible with the missile, design and manufacturing processes were developed to eliminate excessive resonant amplification of vibration.

Elimination of vibration amplification produced excellent results. Missile equipment now has more damage resistance under shock and vibration than the original equipment would have on standard aircraft isolation mounts. Current equipment is designed and manufactured to have great internal rigidity. Packages are only microscopically deformed by the missile shock and vibration environment. This produces excellent damage resistance.

In addition to the considerations for mechanical design for shock and vibration, the small missile must be capable of fast warm-up, i.e., ready to fire very quickly after initial application of electrical power. This capability must not be impaired throughout the operating temperature regime. At the same time, this device may be held in readiness for instantaneous firing, and therefore, must be capable of operating continuously over long periods of time without suffering damage.

In addition to ambient temperature considerations, such other factors as skin temperature due to high speeds, internal heats generated by the auxiliary power supply or other devices, and particularly, heat generated by the rocket motor and its exhaust must be given detailed consideration as to their effects on the integrated electronics.

Producibility and/or Cost Reduction

Producibility is the ability to produce equipment in quantities and at a minimum cost. How can this be achieved? One way is to consider the principle source of production costs—namely manhours.

We can strive for cost reduction by reducing the manhours required to produce a finished article in all stages of assembly starting at the raw materials (which, incidentally, are a very small part of the final cost). We can further reduce the using costs by reducing the manhours required to ship, operate, maintain, and handle, etc., the equipment and by obtaining the maximum usable life from it.

The time to reduce manufacturing costs is in the early stages of design. If the basic costs are not held to a minimum at this time, then it will be too late and all that can be done will be to beat on the heads of the efficiency experts in the production department. Any failure on their part to produce efficiently must be charged back to the initial design.

• **Standard hardware designs**—A principal aim on hardware is to have an adequate selection of items of known performance available to assemble into a useful arrangement with prior knowledge that these parts will perform as expected.

This can be interpreted to mean that there should be certain standardized items such as chassis, terminal boards, blocks, panels, etc., which will have been previously designed and tested in various combinations under the required environmental conditions so that we will not be faced with hardware design and testing each time we need a new electronic device.

Furthermore, these items should be interchangeable according to a defined pattern so that expansion or change in the electronic system can be accommodated in the factory with minimum cost and effort.

• **General considerations**—The decision

Ryan has built every production rocket motor for America's first operational guided missile—the Army's Corporal—for over five years.

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Designed by the Cal-Tech Jet Propulsion Laboratories, the Corporal motor is built by Ryan for the Firestone Tire and Rubber Company, prime contractors for the Corporal missile.

The Army relies on the Corporal's rocket motors for unerring performance—shot after shot. America's aircraft, engine, and missile manufacturers can rely on Ryan, too—for building complete propulsion systems . . . for building single components for rocket motors, ramjets, or turbojet engines.

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Ryan Aeronautical Company, San Diego, Calif.

on the manufacturing method to be used to obtain a piece of hardware should not be made solely by the designer. Instead, he should know what manufacturing methods are available and design so that at least one of these methods may be used.

The design should, wherever possible, allow for a choice of manufacturing methods, bearing in mind that a decision may be made to obtain manufacture of the item in various facilities.

Wherever possible, future designs intended for quantity production should be capable of being made on automatic manufacturing (automation) machinery in existence or being developed. An automation machine should not be developed to fit a design; it must be the other way around.

• **Sizes and shapes**—Packaging schemes for integrating electronic apparatus into missiles which are cylindrical-shaped resolve into two basic classes:

Class I. Rectangular (orthogonal) blocks, bits, and pieces (which generally are easier to manufacture).

Class II. Odd shapes (such as sectors) (which generally are more efficient of space utilization.)

Therefore, the selection of the actual configuration of modules should be treated as an entirely separate problem from any decision on a general arrangement of the equipment. The lower manufacturing costs resulting from Class I must be weighed against improved space utilization, which may result from Class II, and the price in manhours or dollars which may be paid for an improvement in space utilization at the expense of producibility must be carefully considered.

Odd shapes such as sectors, pie shapes, wedges, discs, doughnuts, etc., can be designed so as to use almost all of the available space, but their use should be limited to special applications because of the following advantages of the rectangular configurations:

1. Rectangles may be used as part of other systems, larger or smaller in size, or entirely different in nature, shape, or application.
2. Rectangles are easier to make.
3. Because of their greater ease of manufacture, rectangular parts may be produced on a shorter time scale.
4. It is easier to handle and store rectangular pieces. Careful consideration and application of rectangular modules during design can often offset any space advantage attendant with odd-shaped assemblies.

• **Repairs vital**—Most designs must be capable of repair at any time in their life. The more convenient this is, the better. The possible field repair of an item should not be prevented by the design or manufacturing method used. The repair of an item should not be purposely prevented by design when, in an emergency, there may be no other way to obtain satisfactory operation.

• **Materials, processes and techniques**—In general, the following should be considered:

1. The first choice should be those for which the factory is already trained and equipped.

2. Second choice would be those the factory can accommodate with only a little effort and little or no new equipment.

3. We should consider very carefully just what we are doing to a factory by requiring that they learn and equip for an entirely new material, process or technique.

4. Old, well-known, and very common materials or processes may (because of the ease of obtaining and handling them and training employees to use them) be a better choice than the newest, untried and inexperienced idea which may result in only a slight gain. This depends, of course, on just what the design requires.

5. Inevitably it will be necessary to develop and utilize new materials and processes. Trouble has occurred when development of these was not started in time to meet production requirements. There must be complete understanding and cooperation between design, manufacturing and quality control groups in order that all requirements can efficiently be realized.

6. All new materials, processes, and techniques must be approved for production use by engineering and must be acceptable to the factory before being specified on drawings. There must be mutual agreement or blood, sweat, and tears. The designer cannot adopt the attitude of "I will design it and they can make it. That's what they are paid for." This will only result in chaos.

• **Manufacturing modification**—Almost all electronic component parts must be modified in some manner prior to actual assembly on a terminal board, chassis, etc. This modification must be kept to an absolute minimum to reduce costs.

For example, a resistor cylindrical in shape with axial leads at each end is practically never used as purchased. The leads must be cut, bent, formed, cleaned, or dipped before the part can be used. All of these operations add to the cost of this part because they all require manhours.

A standard method of modifying all similar parts in the same or in several ways will result in appreciably lower costs. For example, all cylindrical parts less than ¾-inch long could have the leads cut and bent so as to be inserted 3/16-inch deep into holes 1 inch apart.

This need not be done by hand since tools can be built or purchased to do it automatically. The parts can be procured from the vendor and mounted in various ways so as to be inserted in the tools for automatic

MARTIN's *Bullpup* tactical air-to-surface missile is one example of the "educated shell" which utilizes integrated electronics.

modification of the parts.

• **Tooling savings**—Uniform and standard hardware will reflect in the lower cost of uniform and standard tooling. For example, a standardized cross-hatch or grid pattern has been developed for locating terminal points on a standard etched circuit board. A tool may be made that will be capable of punching or drilling holes at all terminal points at once, but with a selective device built in so that it could be set to punch or drill only a specified group of holes.

This one tool can then be set to punch a very large variety of terminal boards. The net result will be a well-made punch or drill jig to do a family of jobs instead of a family of tools each able to do only one job.

A board of this type can be sent down an automatic assembly line where component parts insertion heads adjusted to the same cross-hatch pattern can be used to insert parts. The ultimate in design would be standard locations for component parts so that the heads will not need to be reset for a different or new assembly.

Some general considerations with regard to tooling (including factory test and inspection equipment):

1. Rectangular hardware allows the use of the standard adjustments on many machines and eliminates the need for many adapters, jigs, fixtures, etc.

2. The ideal situation would be no tools or test equipment. The best compromise is the minimum required to do manufacturing, servicing, testing, maintenance and inspection.

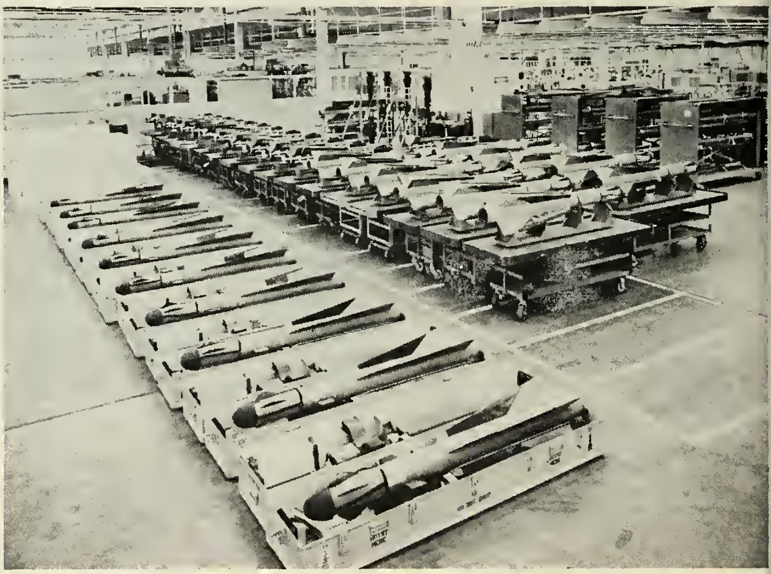
• **Production testing**—Production testing, a crutch to design and manufacturing, is vitally necessary in the manufacturing scheme. The importance of tolerance considerations has been previously pointed out. Production testing can most economically be accomplished when it conforms to an integrated plan devised by cooperative effort between the design, manufacturing and quality control groups.

Such a plan will provide the necessary assurance during the various manufacturing stages without over-testing or excessive use of testing time. It has been found that the test plan is a very necessary adjunct to the manufacturing process.

In small missile manufacturing it has been shown that a carefully thought out, well prepared test plan greatly simplifies the problem of introducing the missile into the manufacturing process, considerably assists in plant layout and determining functional flow of material in the factory, and gives the customer an assurance of what he is accepting when the completed missile is presented for final acceptance.

These production functional tests are now conducted on automatically programed and read-out test equipment. Universal automatic test equipment which permits the application of various AC and DC stimuli with acceptable responses all controlled by punched cards are now in use. A permanent printed record is made on an electric typewriter.

To demonstrate satisfactory equipment performance in a vibration environment, production testing under vibration is sometimes employed. A successful production vibration test has been developed which utilizes a fixed fundamental frequency below 50 cps at 5g combined with 40g vibratory transient tapping. This tapping is obtained by a cantilevered system excited by the fundamental frequency.



INTEGRATED ELECTRONICS is a must for such missiles as the *Falcon*, assembly line-produced at Hughes Aircraft, in Tuscon.

Other Design Considerations

• **Heat transfer**—As a general rule we do not usually have a problem of supplying or retaining heat, but heat removal is one of the biggest problems in electronic packaging.

The heat may be removed by radiation, conduction, or convection or by combinations of these. Any one of the three methods may be improved upon by appropriate design. For example, fins can be added to improve radiation (and convection) or better conductors of heat may be used—such as silver or copper.

In general, mechanical systems for the removal of heat (blowers, refrigerators, etc.) are not compatible with small missile application.

Recent experience indicates that for compact integrated electronic systems such as utilized in small missiles, heat is best removed by conduction provided that there is enough mass in the surrounding structure to serve as an adequate heat sink. Heat conduction paths must be provided carefully from the source of the heat to the area where the intensity of the heat is low enough that it is not harmful.

Since perhaps the largest heat source is vacuum tubes, they must have firm-fitting wrappers or shields of a form which makes many points of contact with the tube envelope and with the adjacent heat-conducting materials. In the case of sub-miniature tubes, they may be wrapped and inserted in holes in metal blocks which will act as the heat sink or will conduct to a heat sink.

It is indeed fortunate that the requirements for heat transfer coincide with those for shock and vibration requirements.

• **Component parts**—Watch out for the new and glamorous part that is such an advance in the state of the art and does everything better. The most reliable parts are those of conservative designs that have been made by the million for several years, under good conditions of quality control.

Watch out for the company with the big deal, the salesman who is doing you a favor by letting you have enough of his new and wonderful gadget to take care of your prototype. Have you ever heard these words: "We know we have a problem, but don't worry, we will straighten it out by the time you get into production?"

When a decision to use the unique item is made, any one of dozens of things may happen—and usually that which is least expected. For example, the following case histories:

1. The vendor's product really was very good. Unfortunately for us, many others found out about it at the same time we did, so the vendor was swamped with orders—some of them larger than ours. Accordingly we found ourselves way down on the list and we had to beg for our smaller needs.
2. The vendor's product was good, but it was made on a pilot line set-up, on a laboratory basis. We investigated the plant and found that he had under construction adequate facilities to take care of our anticipated needs, so we committed ourselves to his item. The trouble was that it took him quite a while to get his expected quality out of the new machinery and the new people.
3. The vendor was an old, established and well-known firm, with an excellent reputation. He had an item which he, we, and others evaluated and were all happy with, so how could we miss on this one? We ordered and received thousands of the item.
   Suddenly, to our horror, we found that all those items that we had so thoroughly inspected no longer gave the same results. Several months had gone by and many were now installed in the finished product, but there had been a long term drift in one of the characteristics due to an insignificant change in the vendor's process. There was only one thing for us to do—take them out—the hard way.
4. This one was another good product. We tested it, of course. It had some features no other had, and even though there was only one source of supply, we recognized the risk and investigated the vendor very thoroughly, satisfying ourselves that we were safe enough. He wasn't overloaded with other people's orders, he had good backing, his people were happy, etc.
   We covered all the angles. And what happened? It was no fault of his that his neighbor's plant burned down and took his with it. We had no choice but to get him going in a new plant as fast as possible, and we bit our nails down to the first knuckle while we were doing it.

• **Structure and parts supports**—As previously discussed, in the past sheet metal was extensively used in the manufacture of the missile electronic supports. Sheet metal parts are, in general, relatively cheap to manufacture once the forming dies are available. They also provide a lightweight structure.

Recently, however, there has been a trend away from the sheet metal parts toward castings. We have found that the use of thin-wall castings provides a fairly cheap structure. At the same time, it provides the high degree of rigidity necessary to meet the vibration and shock environments.

These structures are less susceptible to warpage, thus permitting close spacing of the mechanical parts and still allowing mechanical interchangeability. Sheet metal parts are susceptible to warpage during assembly and in order to insure mechanical interchangeability even with moderately close spacing, it has been necessary to utilize assembly jigs and fixtures and then provide expensive gauges to insure complete interchangeability.

• **Component part mountings and etched boards**—Electronic component parts are supported from the etched circuit board where that technique is employed, or supported on terminals where point-to-point wiring is employed. In general, epoxy filled glass boards are used. At least one of the missile projects utilizes point-to-point wiring exclusively.

We have found the use of etched circuit boards highly desirable, and by controlling the design and manufacturing processes, we have been quite successful in meeting the environmental requirements.

One interesting sidelight on the use of etched circuits is the problem of coordination required between design and tools. We have found it expedient to lay out all etched circuits on a standard grid pattern. This way, standard spacings on tools can be employed.

Etched circuits are not without their own problems, however, particularly where high-impedance circuits are involved. It is necessary to protect the circuits of the boards from the effects of humidity. They must be kept cleaned in such a manner that foreign materials cannot cause leakage between circuits, and thus, impair the operation of the device.

Again, in order to meet shock and vibration requirements, it is necessary that components such as resistors, capacitors, etc., must be mounted to the boards in such a manner that they form an integrated mass.

This is usually accomplished by potting and encapsulation techniques. However, potting and encapsulating materials have a tendency to change electrical characteristics when exposed to various environments. Ground or guard circuits are sometimes used on etched boards to nullify the effects of leakage.

Soviet Author Writes On Thermal Materials

The Soviet publication, Journal of the Air Fleet, has published an article by S. N. Kan which discusses the various methods of overcoming the problem of heat.

Despite recent enthusiasm for such materials as alloys based on aluminum or titanium and those who favor cooling or insulating during flight, the ideal material would be one with a zero coefficient of linear expansion, according to Kan. In principle, he states, it is possible to produce alloys with a low coefficient of linear expansion. For example, an admixture of 43% nickel to steel reduces the coefficient of linear expansion by a factor of two, and this value is retained up to a temperature of 430°C.

The author notes that chemistry is affording new solutions to the problem and cites the ability of some modern plastics to retain their strength at temperatures of −50° to +170°C and even higher. In addition, these are only half the weight of aluminum and one-eighth the weight of steel.

Some are even stronger than steel, Kan points out, and says it is possible to utilize these materials successfully in the manufacture of rocket and aircraft engines. There also are plastics which are one-tenth the weight of cork and have high heat-insulating and soundproofing properties.

The glass panels and canopies of manned vehicles can be replaced by polycarbonates, usable within wide temperature ranges. He notes a high degree of interest in plastics reinforced with glass fabric or fibers, which are

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While in New York for the I.R.E. Show, you cordially invited to visit the IBM booth and IBM Product Display Center at IBM He quarters, 590 Madison Avenue at East 57th Stre two-thirds as heavy as duraluminum, two-ninths as heavy as steel, but just as strong as nonferrous metals and alloys. By means of heat treatment, Kan continues, closely packed sheets of glass fabric, or glass mats, impregnated with resin can easily be fashioned into large scale sections for aircraft and missile construction.

The plastic Fluoroplast—4 is distinguished by its high-temperature stability. Parts made from this material may be used within a temperature range of approximately −200°C to +250°C. Fluoroplast—4 may also be included as an ingredient of heat-resistant varnishes which remain unchanged even at temperatures of 400°C.

OIT Releases Reports on Beryllium and Molybdenum

WASHINGTON—An Air Force report evaluating the five processes for fabricating beryllium is now available from the Office of Technical Services of the U.S. Department of Commerce.

Best results were achieved, according to the report, from the process of cold compacting followed by upsetting.

Also available from the Department is a report containing extracts of a 1956 Navy-sponsored symposium on the technology of molybdenum and its alloy. Included are excerpts of 14 papers on molybdenum as a structural material.

About the Cover

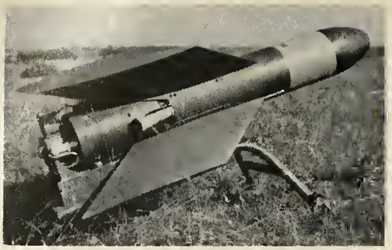
The powerplant for Britain's *Black Knight* re-entry test vehicle, shown on this week's m/r cover, consists of four Armstrong-Siddeley gamma rocket engines rotatable in paired trunnion mountings for control of pitch, yaw and roll.

Propellant for the vehicle is high-test hydrogen peroxide and kerosene, providing a thrust level of 16,400 lbs. at sea level and almost 19,000 lbs. in vacuum.

Design work on the 35-foot-long *Black Knight* began in 1955 and it made a successful first flight on Sept. 7, 1958, traveling 60 miles downrange at Woomera after achieving a 300-mile altitude.

The present contract on *Black Knight* calls for a batch of 24 single-stage vehicles. With the addition of a solid-propellant second stage now being developed by Saunders Roe, altitudes of 600 to 1500 miles are expected.

The British are using the re-entry data gained from experiments with *Black Knight* to further the development program on *Blue Streak.*



U.S. Buying *SS 10-11* for Forces in Europe

by Frank G. McGuire

WASHINGTON—The United States is currently conducting negotiations for the "imminent" purchase of several thousand French *SS 10* anti-tank missiles from Nord-Aviation, m/r has learned. The weapons will be used to equip American forces in Europe. The U.S. government is also purchasing an unspecified number of *SS 11* missiles.

As Pentagon officials phrased it: "We are definitely buying the *SS 10*, regardless of the fact that others are still under evaluation. It's not a question of 'If' . . . it's 'When'? Licensing of U.S. manufacturers is another question, as yet unsettled."

The other missiles still under consideration are the *Kobra,* a German design, and the Vickers *Vigilante*, a British design. Although these are said by their manufacturers to be lighter and simpler than the *SS 10* and *SS 11*, the U.S. is taking a close look at their kill-ability. Nord-Aviation officials, commenting on the *SS 10* kill-ability, said, "A hit is a kill," and evidently have proven their point to the Pentagon's satisfaction.

• **Established ability**—Training of operators on the *SS 10* and *SS 11* has been brought to a point where the average operator makes 80 to 90% hits of all missiles fired. The warhead of either one of these missiles will definitely knock out any tank in existence today, according to Nord-Aviation. Armor penetration of the *SS 10* is 16.54 inches.

The *SS 10* crew is nominally two men, but only if it is desirable for the firing operator to be in a remote position from the launcher (such as atop a hill). In a pinch, one man can operate the system.

Officials have stressed that the *SS 11* is not a replacement for the *SS 10*, but rather a complementary weapon. French officials were reluctant to discuss the *SS 12*, but it is assumed that it is of the same family as its numerical predecessors, only much improved.

The main difference between the *SS 10* and *SS 11* is weight, range and striking power. The *SS 10* is basically an infantry weapon designed for close combat. The *SS 11*, a heavier missile, may be used by infantry (since it uses the same ground equipment as *SS 10*), but is primarily for use aboard vehicles such as jeeps, helicopters and landing craft.

• **In operation**—Operational equipment for the *SS 10* is comprised of a transport box and launcher; control stick similar to that used in aircraft; a signal generator; a selection box, and sighting equipment.

In the field, the transport box becomes the launcher for the missile. The control stick, connected to the signal generator, causes square waveform signals to be produced at a frequency of 12.5 cycles per second. These signals cause the spoilers to vibrate at a fixed frequency, but through variations in the position of the control stick, they hold the spoilers in one position longer than another, thereby causing a change in the pitch or yaw attitude of the missile.

The selection box passes the waveform signals to the particular missile selected for firing by the operator. A firing sequence control system in this unit governs the sequence of launching of the various missiles in the multiple launcher.

The operational field equipment for the *SS 11* consists of a metal transport/launcher box and a standard fire-control post, comprised of the generator, control stick and one or two selection boxes. The ground equipment for the two missiles is mostly interchangeable.

Nord-Aviation also has under production the *Type 5103* air-to-air or air-to-ground missile, the *CT-10* and *CT-20* target missiles and the *SS 12*.

SS *10/11*—COMPARED PERFORMANCES

NORD AVIATION	Range[1]		Minimum radius of turn yds	Approx. speed mph	Maximum duration of flight sec.	Average percentage of impacts on targets	Penetration
	Min. practicable yds	Maximum yds					
SS 10 Type 5203	330	1750	710	180	20	80%	With shaped charge 16.54 in. of steel plate.
SS 11 Type 5210	550	3830	550	425	22	90%	With shaped charge 19.6 in. of steel plate 50.8 t/sq. in. tensile strength.

[1] The range depends on the position of the operator, on the configuration of the ground, on the training of the operator, etc. The figures indicated are minimas.

SS *10/11*—COMPARED STATISTICS

NORD AVIATION	Dimensions			Total weight (lbs)	Propulsion	Guidance	Warhead	
	overall length	body diameter	span				Description	Weight (lbs)
SS-10 Type 5203	33"86	6'50	29"53	33,07	Solid propellant rocket. Two stages. Booster stage imparts missile velocity of 260 ft/sec. Instant speed remains constant during its flight.	Wire control.	Hollow shaped charge or mixed charge with fragmentation charge for anti-personnel use.	9
S-11 Type 5210	3'10	6'46	20"47	63	Solid propellant rocket. Two stages. Booster stage imparts missile velocity of 330 ft/sec. in 1.4 second. Sustainer stage in-velocity to 624 ft/sec. in 22 seconds.	Wire control.	Hollow shaped charge for anti-tank warfare (125 AC) or fragmentation head anti-personnel (140 AP)	13

contract awards

The National Aeronautics and Space Administration has made public a breakdown of its Research and Development contract awards from Oct. 1, 1958, through this Jan. 31—the first four months of NASA's existence.

The report lists 49 separate contracts involving $105,395,000 out of the Fiscal 1959 budget. This is $5 million more than the entire amount earmarked for R&D last year by the National Advisory Committee on Aeronautics, forerunner of NASA.

The awards are listed below. The figure in most cases represents both the 1959 obligations and the total amount of the contract. Where the total amount exceeds the 1959 amount, the total is given in parentheses. In several of these cases, the total figure covers a period of several years and represents a working estimate of what the total will be. In three instances an asterisk appears in parentheses, meaning that the total amount of the contract is still under negotiation.

$8,160,000—Jet Propulsion Laboratory, California Institute of Technology, for research.
$110,000—Yale University, for molecular study.
$1,900,000—Naval Research Laboratory, for partial support of Space Sciences. Division sounding rockets program.
$7,120,000—Air Force Ballistic Missile Div., for earth satellites (including *Thor-Able* boosters).
$8,540,000—Army Ordnance Missile Command, for *Juno II* boosters.
$80,000—Bureau of Standards, Department of Commerce, for computing services.
$130,000—Alton Engineering Co., for alterations to buildings at Bellevue Annex.
$2,000,000—Naval Research Laboratory, for partial support of Space Sciences Div.'s earth satellite program.
$270,000—Bureau of Standards, for research on rubidium frequency standards.
$10,000 ($19,320)—Iowa State University, for reduction analysis.
$2,110,000 ($2,600,000)—Army Ordnance Missile Command, for lunar probe projects.
$2,000,000—Air Force Ballistic Missile Div., for lunar probe projects.
$200,000—Naval Ordnance Test Station, for lunar probe projects.
$40,000—Bureau of Standards, for computing services.
$8,990,000—Air Force Ballistic Missile Div., for space probes.
$340,000—Army Ballistic Missile Agency, for deep-space study.
$1,300,000—Jet Propulsion Laboratory, for deep-space study.
$10,000—Bureau of Standards, for computing services.
$150,000—Army Corps of Engineers, for construction of building addition at JPL.
$40,000 ($292,000)—Iowa State University, for space probe instrumentation.
$23,500,000—Naval Research Laboratory, for support of the Vanguard Division, Space Projects Center.
$2,150,000—Army Ordnance Missile Command, for 100-ft. inflatable sphere.
$430,000—Air Force's Wright Air Development Center for "state-of-art" work on rocket engines.
$2,000,000 ($3,400,000)—Jet Propulsion Laboratory, for development of 6000-lb.-thrust storable propellant system.
$10,000,000 ($102,000,000)—Rocketdyne Div., North American Aviation, Inc., for 1,000,000-lb.-thrust rocket engine.
$1,900,000—Atomic Energy Commission, for Rover Program (nuclear rocket engines).
$75,000—Government of Peru, for operation of earth satellite radio tracking and receiving stations for six months beginning Jan. 1, 1959.
$80,000—University of Chile, for operation of two earth satellite tracking and receiving stations beginning Jan. 1. 1959.
$600,000 (*)—Bendix Radio Corp., for operations of Minitrack stations in South America and Cuba for 18 months beginning Jan. 1, 1959.
$120,000—Smithsonian Astrophysics Laboratory, for photo reduction equipment.
$470,000 ($2,500,000)—Smithsonian Institution, for tracking and data reduction services.
$60,000—Endebrook-White Company, for modification of impact basin to provide working space for Space Projects Center personnel.
$140,000—Minneapolis-Honeywell Regulator Co., for automatic flight control systems for manned space flight.
$110,000—Douglas Aircraft Co., for propellent tank assemblies for high-energy fuel rockets.
$180,000—Solar Aircraft Co., for high-energy fuel rocket thrust chambers and necessary tooling.
$100,000—Navy Bureau of Ordnance, for *X-248* rockets.
$1,120,000—Navy Bureau of Ordnance, for *X-254* rockets.
$1,020,000—Navy Bureau of Aeronautics, for *Jupiter* seniors.
$90,000—Army Ballistic Missile Agency, for *XM-45* rockets.
$620,000—Army Ballistic Missile Agency, for *TX-33-20* rockets.
$1,400,000 (*)—Air Force Ballistic Missile Div., for *Atlas D* boosters.
$5,600,000—(*)—Air Force Ballistic Missile Div., for *Atlas D* boosters.
$120,000—Army Ballistic Missile Agency, for *XM-45* rockets.
$70,000—Aerolab Development Co., for booster hardware, sets for *TX-33*.
$110,000—Thiokol, Inc., for *XM-19E1* rockets.
$2,200,000—Army Ballistic Missile Agency, for *TX-33-20* and *TX-33-22* rockets.
$4,490,000 ($15,500,000)—Army Ordnance Missile Command for parts of *Redstone* boosters.
$400,000—Missile Div., North American Aviation, Inc., for transport vehicles and launcher (S-91-4).
$2,740,000 ($4,450,000)—Army Ordnance Missile Command, for *Jupiter* boosters.

Recent contract awards by the armed services include:

ARMY

$2,619,599—**RCA Defense Electronic Products,** for reduction, evaluation and interpretation of data obtained under measurement program.

$814,395—**Western Electric Co. Inc.,** for *Nike* spare parts and components. (12 contracts.)

$565,000—**Rocketdyne Div., North American Aviation,** for rocket engines and for design and development. (two contracts.)

$364,378—**Dunn Construction Co., Birmingham, Ala.,** for static test tower modification and support facility at Redstone Arsenal.

$1,178,246—**The Martin Co.,** for R&D on the *Pershing* system.

$650,000—**Sancor Div., Siegler Corp.,** El Segundo, Calif., for production of launching system components for *Nike-Hercules* (add-on contract from Consolidated Western Steel Co.).

$2,949,651—**Daniel Construction Co. of Alabama,** for construction of engineering building at Redstone Arsenal.

$112,360—**Douglas Aircraft Co., Inc., Charlotte, N.C., Ordnance Missile Plant,** for *Nike* spare parts and components.

$99,876—**Westinghouse Electric Corp.,** for detailed study of synthetic spectrum radar instrumentation.

$88,832—**Hoover Awning and Mfg. Co.,** Miami, for bag assemblies and radome covers for Redstone Arsenal.

$79,735—**Raytheon Manufacturing Co.,** for *Hawk* repair parts.

AIR FORCE

$2,600,000—**Marquardt Aircraft Co.,** for *Bomarc* ramjet engines.

$2,100,000—**Crosley Div., Avco Manufacturing Corp.,** for *Falcon* components.

$500,000—**The Talco Engineering Co., Mesa, Ariz., a subsidiary of the Gabriel Co., Cleveland,** for development and production of rocket catapults for aircraft emergency escape systems.

$14,460,000—**Massachusetts Institute of Technology,** for air defense R&D (additional payment for facilities at AF Cambridge Research Center).

$3,100,000—**Systems Div., Consolidated Electrodynamics Corp.,** for *Atlas* ground support equipment (subcontracts from Convair Astronautics).

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

$240,598—**Aerojet-General Corp.,** for research on ultra-energy fuels for rocket propulsion, upper-atmosphere power plants, mechanism of combustion of composite solid propellants, and continuation of research on kinetics of solid phase reactions (four contracts).

$142,500—**Polytechnic Institute of Brooklyn,** for continued research on analytical and experimental study of high-frequency oscillatory combustion and of scaling of rocket motors.

$135,000—**Convair Division, General Dynamics Corp.,** for investigation of use of sub-zero coolants in machining.

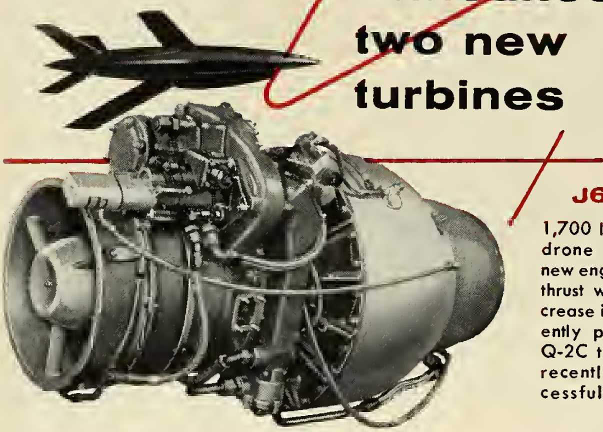
NAVY

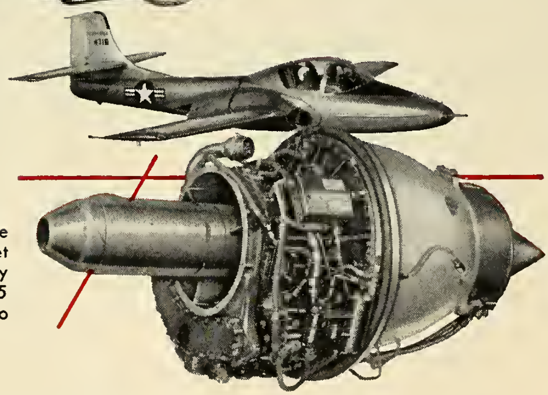
$1,909,654—**Aerojet General Corp.,** for rocket motors.

$396,459—**G-M Laboratories, Inc.,** Chicago, for servo motors (two contracts).

$259,046—**Bendix Aviation Corp., Montrose, Pa., Div.,** for synchros.

$60,595—**Arinc Research Corp.,** Washington, D.C. for production reliability improvement of program of guided missile electron tubes.





missile people

Vice President **William G. Reynolds** and General Counsel **Joseph H. McConnell** have been elected executive vice-presidents of Reynolds Metals Co. The new positions are said to reflect expansion of the company's operations and "the outlook for further expansion of the aluminum industry."

Directors of Thompson Ramo Wooldridge, Inc., have elected four operating executives of the corporation's Thompson Products divisions in Cleveland to vice presidencies. They are **Pierce T. Angell,** engineering manager of TRW's Tapco Group, **Robert E. Cummings,** manager of the Products Valve division, **William M. Jones,** manager of the Commercial Electronics Group, and **Carl L. Kahlert,** manager of the Replacement division.

R. R. Henely has been appointed Neosho Plant engineer for Rocketdyne division, North American Aviation, Inc. **Harold W. Bell,** director of North American's Missile Div.'s Aero-Space Laboratories, will serve as a member of the NASA Research Advisory Committee on Missile and Spacecraft Aerodynamics.

George F. Hannaum, director, Industry Planning Service, Aircraft Industries Association, has been named assistant general manager of the Association. The new assignment will be in addition to his current duties as director of IPS. AIA said the move is designed to maintain more frequent personal liaison among member companies and closer internal coordination of Association activities. AIA's Materials Procurement Committee has named **W. L. Hoffman,** materials manager of Chance Vought Aircraft, Inc., as chairman, and **E. D. Carter,** director of Materiel & Procurement for The Martin Co., as vice chairman, of the Committee for 1959. The two Committee officers succeed **F. L. Dobbins** of Boeing Airplane Co., and **James Mattern** of Sperry Gyroscope Co.

Carlos C. Wood has been named to the new post of director of advanced engineering planning, Douglas Aircraft Company. Formerly chief engineer, Long Beach division, Wood will be succeeded by **Charles S. Glasgow,** assistant chief engineer. Wood will be responsible for planning engineering programs and forecasting technical trends five to 15 years ahead.

George F. Cooper has been named administrative assistant of Hercules Powder Co.'s Baccus, Utah, plant. Since May, 1958, Cooper has been Personnel Department superintendent at Allegany Ballistics Laboratory, near Cumberland, Md.

letters

Jupiter Theodolites

To the Editor:

We were very pleased to see the prominent attention you gave to the azimuth alignment theodolites (m/r Feb. 2), and their important role in helping to assure the accuracy of long-range missiles.

There is one additional point that deserves mention. That is that the particular theodolites we produce for the *Jupiter* were developed jointly with the Army Ballistic Missile Agency at Redstone Arsenal. The group there, under Dr. Walter Haussermann, Fritz Mueller and Henry Rothe were responsible, and deserve credit for the overall alignment system development. Our responsibility was to develop and produce instruments to meet the highly precise requirements of that system.

Carlton W. Miller
Electro-Optical Division
The Perkin-Elmer Corp.
Norwalk, Conn.

Missile Magnesium

To the Editor:

With magnesium alloys being used in more than 20 different missiles, it was a decided surprise to read in Alfred J. Zaehringer's article in the Jan. 26 issue of m/r that "missile applications (for magnesium) exist but are small."

Because of security regulations, it is impossible to present a detailed listing of magnesium missile applications for publication. However, your second annual Engineering Progress Issue, dated July 28, 1958, listed magnesium as a "major material" in the *Falcon I* and *II, Bomarc, Mace, Snark, Nike-Ajax, Nike-Hercules* and *Sparrow III*. In addition to these, magnesium is used in varying amounts in the missile and the guidance equipment structure of the *Regulus II, Vanguard* launching vehicle, *Matador, Nike-Zeus, Talos, Terrier I* and *II, Falcon III, Tartar, Atlas, Polaris, Jupiter* and *Titan*. A substantial interest in magnesium alloys has been shown by designers of more advanced missiles and space vehicles.

The magnesium-rare earth and magnesium-thorium alloys were among the first commercially-available light-metal alloys to provide useful strengths in the elevated-temperature range. HK31A-H24 sheet and plate are being used at temperatures up to 550°F and HM21A-T8 sheet and plate are being used at temperatures exceeding 700° F. Similar magnesium elevated-temperature alloys are available in cast, forged and extruded forms as well. For equal weight, magnesium alloys remain the strongest commercially-available structural materials over a wide temperature range, where strength is based on buckling and rigidity.

The article also states that magnesium has suffered because of "relatively high cost and the contention that production is too small for widespread use in a strategic area." The total cost of using a material depends not only on the cost of the metal itself but also on the cost of fabricating the end article. In many cases simple magnesium monocoque structures have proven to be less expensive than more complex structures of heavier metals in doing the same job. As for production, it should be noted that (1) output of primary magnesium can be multiplied several times through the use of currently unused capacity, (2) the magnesium industry has built far into the future in its sheet, extrusion and casting capacity and is able to activate a very substantial additional capacity for military requirements when called upon, and (3) magnesium is one of the metals (the only other is molybdenum) in which the United States is self-sufficient.

Clayton L. Dickey
Public Relations Department
The Dow Chemical Company
Midland, Mich.

Present Threat

To the Editor:

Congratulations on the much hardened logic of your 16 February editorial in m/r. I appreciated the piece for two reasons. First, because of the realistic approach, and then, dear to my heart, since it implies the significance of the manned threat. Not only today, but for more than a few years to come.

Somewhere in the blaze and glory of our steel fingers of fate that are probing ever upward from Canaveral, many of us have lost touch with Bears and the Bisons—a too real monkey on the back. It's a sort of national rationalization. "Why worry about something that can already kill us—let's worry about something that is going to be able to kill us." The psychological sop is all too obvious—"going to be able" is so much less horrendous than "can."

Captain Ernest A. Beasley, Jr.
Ch., Press and Magazines
Office of Information Services
Ent Air Force Base
Colorado Springs, Colo.

missile business

by Reed Bundy

The National Aeronautics and Space Administration expects to invest more than half-a-billion dollars in Fiscal 1959-60 in contracts with industry in support of its ambitious space programs. This is small potatoes compared to military contracting, of course, but it's a huge jump over NASA's predecessor, the National Advisory Committee for Aeronautics. Last year NACA's R&D program totalled only about $100 million—and this was entirely in-house.

NASA's contract funds from all sources will be approximately $220 million in 1959 and $330 million in 1960. The great bulk of the 1959 money is already programed (see p. 33 of this week's m/r).

How the half-billion will be spent was outlined recently by Albert F. Siepert, NASA's Director of Business Administration, in a speech before the Nassau-Suffolk Industrial Procurement Conference on Long Island. Siepert said about 50% will be devoted to procurement of vehicles and instruments, or scientific investigations in space which cover sounding rockets, earth satellites, lunar probes and deep-space probes. Some 20% will go for propulsion technology, including development of solid fuel rockets, high-energy fuel rockets, the 1.5-million-lb.-thrust single chamber nuclear rocket engine development, and auxiliary power units to be used in payloads.

Another 20%, according to Siepert, will be slated for developing technology for manned space flight, including construction of the first manned capsule under Project *Mercury*. About 6% will be spent for specific investigations of satellite applications in meteorology and communications. And the balance will go into tracking and data acquisition and advanced space technology.

Industry need not fear, the NASA official said, that it will have to learn a "new system" in order to do business with the civilian space agency. Although NASA has independent status and will operate under its own procurement regulations, Siepert said, its contracting and procurement policies will "conform as nearly as practicable" with the Armed Services Procurement Act and its subsequent regulations.

"A major milestone" on the way to the Air Force's goal of fixed-price type contracts was reached with negotiation of a $25-million contract with Rocketdyne Division of North American Aviation. The contract, calling for IOC production of *Thor* engines, was hailed by Maj. Gen. Ben. I. Funk, commander of the Ballistic Missiles Center, as the "first time in the history of the (AF) ballistic missiles program" that a fixed-price-incentive type contract had been worked out.

The Pentagon has reported to Congress that it is working on standardization plans for guided missiles. There are now seven Federal Supply Catalog classes covering basic end items and equipment of missile systems.

The 80% reimbursement provision for cost-type contracts has been written into the Armed Services Procurement Regulations. It authorizes reimbursement of prime contractors for 100% of the payments made to subcontractors so long as such payments do not exceed 80% reimbursement basis for cost-type subcontracts.

Some ups and downs: Douglas Aircraft Company has reported that its missile business in 1958 increased 109% over 1957. Its annual report to stockholders cited a new record output of $415.6 million in missiles, components and ground-support equipment during the year. But net earnings fell off—in line with company predictions to stockholders—from $30,665,000 in 1957 to $16,847,000 in 1958. . . . Conversely, Bendix Aviation reported a rise in earnings in the first quarter of its fiscal year—and a drop in sales. The company said earnings for the quarter which ended Dec. 31 rose to $5,157,864 from $4,897,486 a year earlier. Sales and other income, however, fell from $167,064,856 a year earlier to $154,494,028 . . . . General Dynamics Corp. estimated net sales for 1958 will exceed $1,500,000,000, approximating the record sales of 1957. But earnings are expected to be under the 1957 record.

Advertiser's Index

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Paris: Jean-Marie Riche, 11 Rue Condorcet, Paris (9e), France. Phone: TRUdaine, 15-39, Cable address: NEWS AIR PARIS.

when and where

MARCH

IRE, AIEE and Association for Computing Machinery, 1959 Western Joint Computer Conference, Fairmont Hotel, San Francisco, March 3-5.

Institute of the Aeronautical Sciences, Flight Propulsion Meeting, (classified), Hotel Carter, Cleveland, March 5-6.

Second Western Space Conference and Exhibits, Great Western Exhibit Center, Los Angeles, March 5-7.

Gas Turbine Division of the American Society of Mechanical Engineers, Turbine in Action, Cincinnati, March 8-11.

Third Annual Shock Tube Symposium, Old Point Comfort, Ft. Monroe, Va. For details: Armed Forces Special Weapons Center, Kirtland AFB, Albuquerque, N.M. Attn.: SWRS R. R. Birnkoff. 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.

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.

Institute of Radio Engineers, Spring Technical Conference on Electronic Data Processing, Cincinnati Section, Engineering Society Bldg., Cincinnati, Apr. 21-22.

Institute of Environmental Engineers, 1959 Annual Meeting, La Salle Hotel, Chicago, Apr. 22-24.

American Rocket Society, Controllable Satellite Conference, Massachusetts Institute of Technology, Cambridge, Apr. 30-May 1.

MAY

Institute of Radio Engineers, 11th National Aeronautical Electronics Conference, Dayton, Ohio, May 4-6.

Instrument Society of America, 5th National Instrumentation Flight Test Symposium, Seattle, May 4-7.

CLASSIFIED

Precision Computing Resolvers

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Highest accuracy in rotating components is a CPPC fundamental. Our Precision Computing Resolvers are no exception. Without compensation, a recent production run of resolvers showed functional errors of .06% <u>or less.</u> Perpendicularity of axes was ±3′ in 360°. Due to extreme symmetry of rotor and stator, nulls are excellent in these resolvers. Low phase shifts are also a feature.

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PRICE AND DELIVERY

We ask you to review what you are paying for precision computing resolvers. In the past CPPC has been able to lower traditional prices of rotary components.

We are already tooled for many types of these resolvers and can make quick delivery in quantity or short run. Whenever you need <u>any</u> rotary component, think of CPPC.

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ENGINEERS—For a career in rotary components and computers, write David D. Brown, Personnel Director, Dept. K3

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