FEBRUARY 29, 1960

WO-DIMENSIONAL ELECTRONICS

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

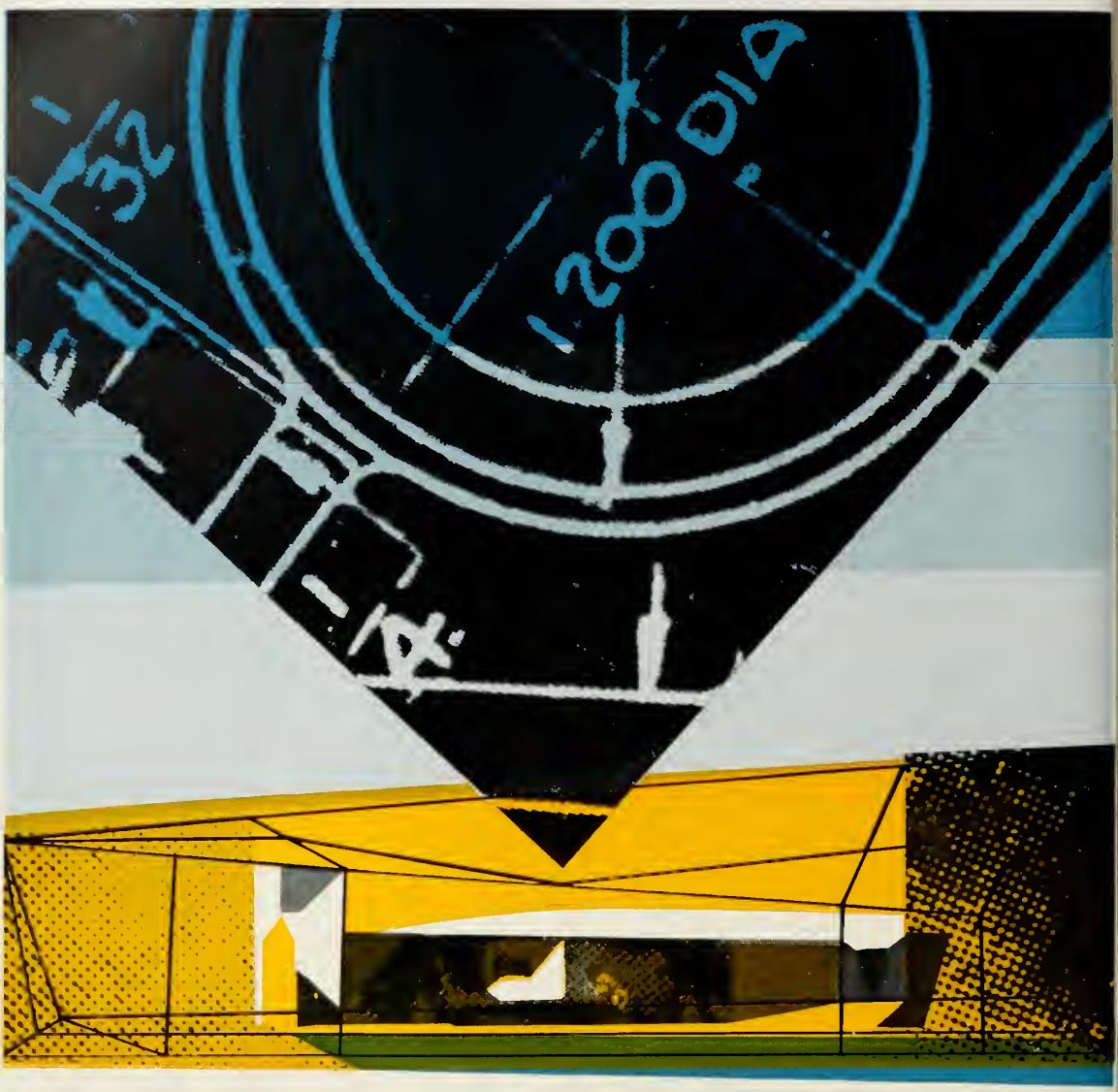
INUAL ASTRIONICS ISSUE

survey of the expanding technology
d a report on the growing market

AN AMERICAN AVIATION PUBLICATION

General Motors pledges

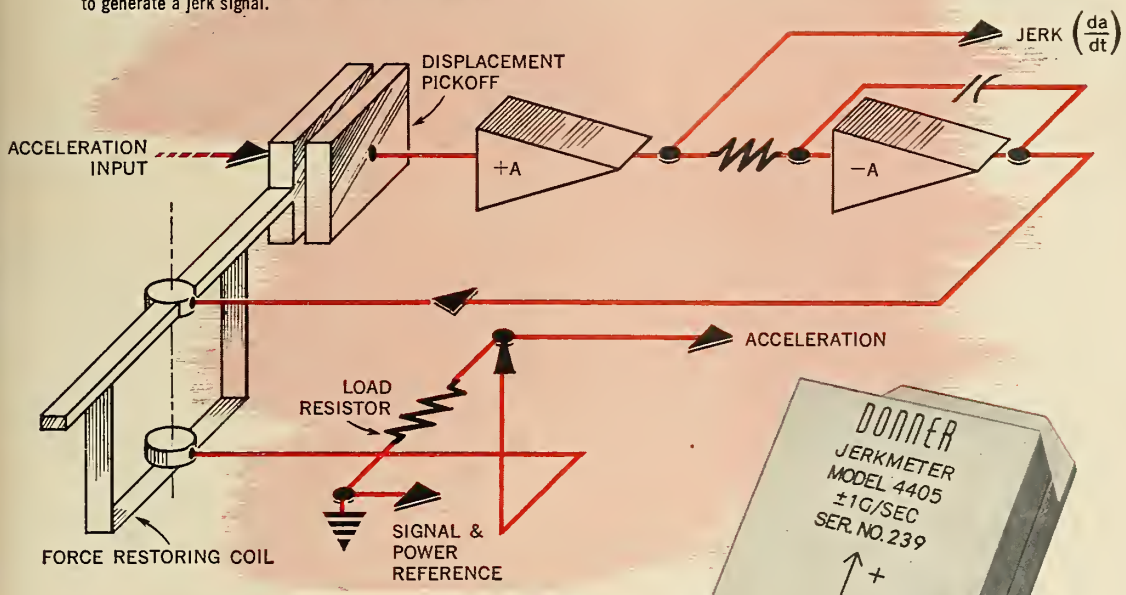
AC QUESTMANSHIP



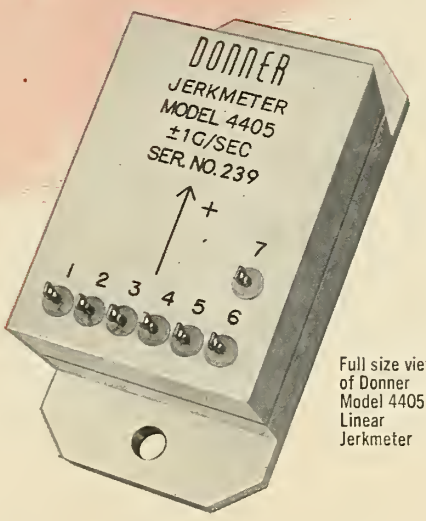
AC Seeks and Solves the Significant—Since GM has pledged its resources to this nation's defense, AC plans to forge to the forefront in the international race for technological superiority. The resolution of scientific problems even more complex than AChiever inertial guidance—that's what AC now has on its agenda / This is AC QUESTMANSHIP. It's an exciting creative quest for new ideas, methods, components and systems . . . to promote AC's many projects in guidance, navigation, control and detection / Questmanship is readily apparent in AC Manufacturing, headed by Mr. Roy McCullough, AC Works Manager. His group "offers an outstanding challenge to engineers capable of understanding the most advanced scientific concepts . . . and developing the techniques and tools to implement those concepts on a production basis" / There may be a position for you on our specially selected staff . . . if you have a B.S., M.S. or Ph.D. in the electronics, scientific, electrical or mechanical fields, plus related experience. If you are a "seeker and solver," you should write AC's Director of Scientific and Professional Employment, Mr. Robert Allen, Oak Creek Plant, Box 746, South Milwaukee, Wisconsin.

GUIDANCE / NAVIGATION / CONTROL / DETECTION / AC SPARK PLUG *The Electronics Division of General Motors*

● Functional diagram of Donner Linear Jerkmeter. This unique instrument operates as a subminiature servo-system of the force-balance type which is responsive to jerk along the sensitivity axis of the linear unit and about the sensitive axis of the angular unit. Basically, the system consists of a transistorized accelerometer with an integrator inserted into the servo-loop to generate a jerk signal.



HOW TO MEASURE $\frac{da}{dt}$



Full size view of Donner Model 4405 Linear Jerkmeter

New Donner precision Jerkmeters measure linear and angular jerk to ±0.5% or better.

If your measurement and control problem requires accurate measurement of jerk or the rate of change of acceleration, Donner Scientific's new line of precision angular and linear jerkmeters can help.

These new instruments are the only truly accurate device of this type ever made. They are designed to meet the most demanding applications. Both angular and linear jerkmeters provide an output voltage proportional to jerk which in turn can be used to instigate compensatory control forces or other actions. *An acceleration analog output voltage is also available.*

Typically, a jerkmeter installed in a jet aircraft will provide an instantaneous output proportional to the rate of change of g's. This signal can be used to predict impending disaster conditions.

Other applications include use wherever constant acceleration is required. Here, the Donner jerkmeter provides a "velocity-damping" term. The jerkmeter also provides a third order term for stabilizing displacement devices. It can also be used as an inertial indicator of first motion.

KEY SPECIFICATIONS for Model 4405 Linear Jerkmeter

RANGES
Acceleration: ±1 g full range to ±30 g full range
Jerk: ±0.5 g/sec full range to ±20 g/sec full range

OUTPUT FULL SCALE
Accelerometer: ±7.5 v dc
Jerk: ±7.5 v dc

RESOLUTION
0.1% full scale or better

LINEARITY
0.1% full scale or better

HYSTERESIS
Less than 0.1%

POWER
+15 v dc at 10 ma and −15v dc at 10 ma

SIZE
3" long, 1½" wide, 1⅝" high

WEIGHT
7.5 ounces

WANT MORE INFORMATION? *The new Donner Jerkmeter is another product from a firm specializing in the manufacture of accurate fixed and general purpose analog systems designed to analyze, measure, and control inputs interlocking time, acceleration, jerk, velocity, and other dynamic inputs. Complete technical information can be obtained by calling your nearby Donner engineering sales representative or writing Dept. 123*

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CONCORD, CALIFORNIA

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Missiles and Rockets Volume 6 Number 9

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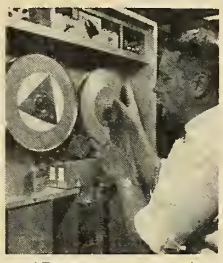
COVER: Engineer at Motorola's Solid State Electronics Dept. in Phoenix, Ariz., observes thin-film evaporation process. This still-developing art may produce complete electronic circuits thinner than this paper.



HIGH-SPEED magnetic tape relay by Datamatic Div. of Minneapolis-Honeywell is reported to be most efficient tape handling system yet. Major electronics trends are reported in review starting on p. 38.

TYPICAL of three-dimensional radar systems is Hughes FRESCANAR (Army's AN/MPS-23) which simultaneously detects, computes and transmits to missile batteries data on approaching targets. See story starting on p. 65.

SEVERE testing is applied to inertial guidance systems, like this model for the *X-15*, to establish accuracy and reliability. See a report on developments in guidance, p. 70.

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

31,500 copies this issue

FEBRUARY 29 HEADLINES

PROPULSION ENGINEERING

ADVANCED MATERIALS

INTERNATIONAL

PRODUCTS AND PROCESSES

THE MISSILE WEEK

U.S. Reg. Pdg.

DEPARTMENTS

TO REACH THE MOON... MEN AT WORK

These men are ARMA researchers. They are putting to use a three-dimensional Trajectory Analyzer, designed and produced by them to provide simple, visual understanding of the complexities involved in guiding missiles to interplanetary bodies.

Today they use it in their studies of trajectory kinematics and missile guidance in lunar orbits. Sometime soon they will employ it to study travel to other bodies.

The Trajectory Analyzer—with which the trajectory of any computer-simulated or real missile can quickly be plotted *in grease pencil*—demonstrates the ingenuity and analytical ability of ARMA's imaginative research staff, creators of the Atlas ICBM inertial guidance system. Their experience and performance are unequalled in the broad field of space navigation.

ARMA, because of its *people*, will find many of the answers in astronautics. ARMA, Garden City, N.Y., a division of American Bosch Arma Corporation . . . the future is our business.

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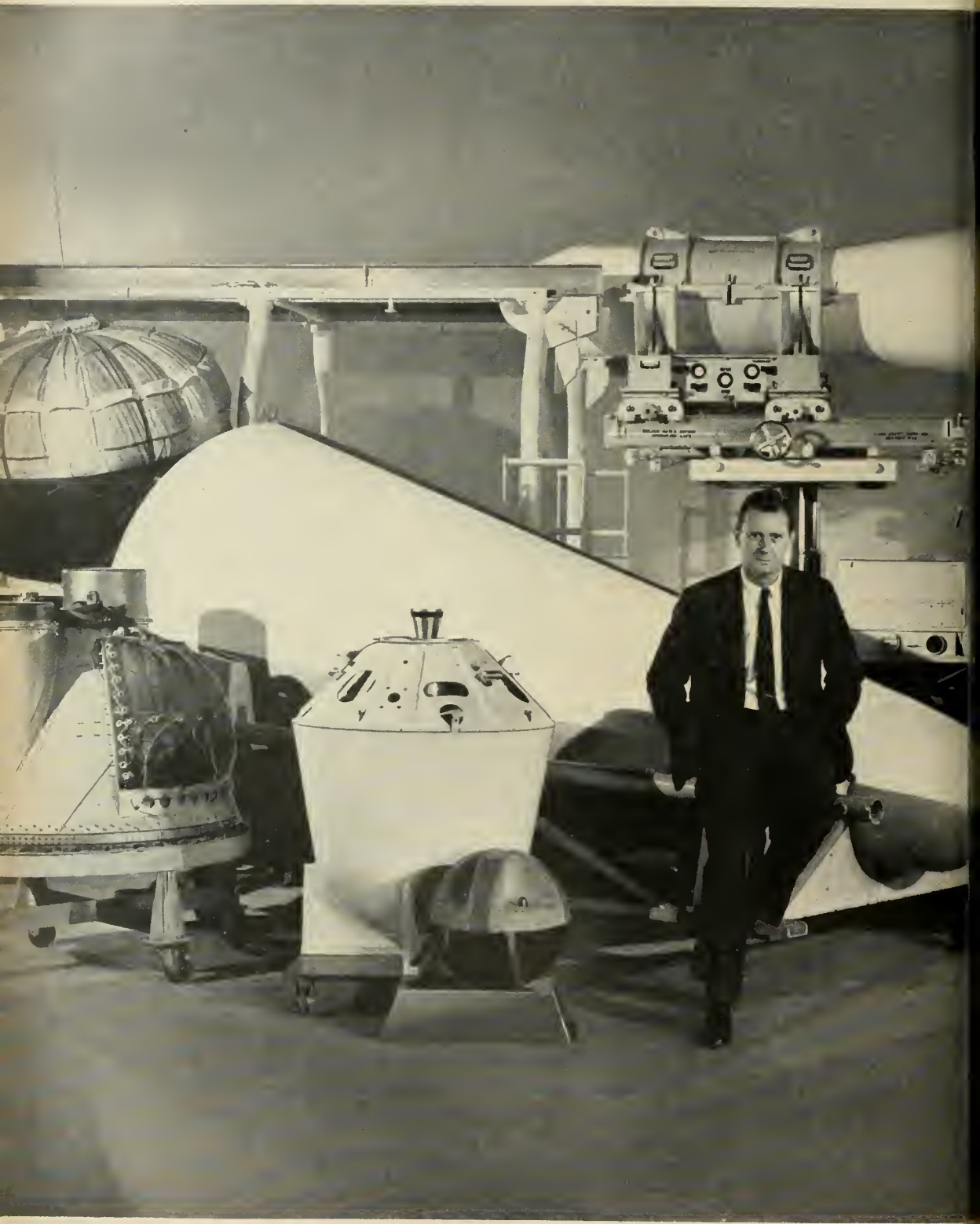
4000 subcontractors are represented
re-entry vehicle "family portrait"



n this unique
lramatizing . . .

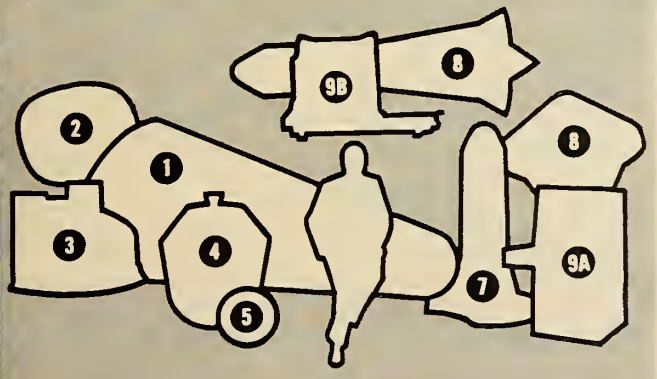
4 years of USAF, G.E., SUBCONTRACTOR re-entry vehicle progress

The key to this progress has been teamwork . . . teamwork between General Electric's Missile and Space Vehicle Department, the Ballistic Missile Division and the Ballistic Missile Center of the United States Air Force and the over 4000 small and large subcontractors alike who have helped MSVD make so many vital contributions to U.S. re-entry vehicle progress.

IN 1959 ALONE, the following figures indicate the emphasis MSVD placed upon this important factor of subcontractor teamwork on Air Force projects.

- Over 35,000 different purchase orders were placed by MSVD on subcontractors in 1959.
- More than 25,000 of these MSVD purchases were made from "small" subcontractor businesses.
- More than $26,000,000 worth of goods and services were purchased by these 35,000 orders. This amount represented a major portion of the contract dollars received by MSVD.
- And more than $13,000,000 of this $26,000,000 went to "small" business firms.

If you'd like more information about G.E.'s Missile and Space Vehicle Department . . . its subcontracting activities, its re-entry vehicle programs or about any of its space technology activities . . . write to Section 160-70, G.E. Missile and Space Vehicle Department, 3198 Chestnut Street, Philadelphia 4, Pa.



Mr. Hilliard W. Paige, General Manager, Missile and Space Vehicle Department with Air Force re-entry vehicles developed by MSVD.

1. RVX-2 Re-entry/Recovery Vehicle, the largest ablation-type re-entry vehicle to travel full ICBM-range and be recovered.
2. Flotation balloon used in recovering USAF-MSVD research re-entry vehicles.
3. Recovery equipment package for RVX-2.
4. Satellite Aeromedical Re-entry/Recovery Vehicle for USAF Discoverer Program.
5. Mark-2 recoverable Data Capsule which flew in Thor re-entry vehicle and returned first films from outer space.
6. Mark-3, an advanced operational-type re-entry vehicle for Atlas.
7. RVX-1, first ablation-type re-entry vehicle to be recovered after full ICBM-range flight.
8. Mark-2, first U.S. operational heat-sink re-entry vehicle now in use on USAF Thor and Atlas missiles.
9. Typical ground support equipment developed by MSVD for USAF use. (A) Mark-2 prelaunch check-out console. (B) Mark-3 missile mating equipment.

MISSILE AND SPACE VEHICLE DEPARTMENT

GENERAL ELECTRIC

A Department of the Defense Electronics Division

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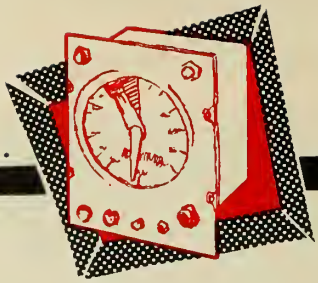
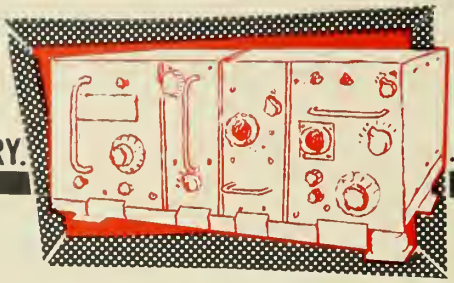
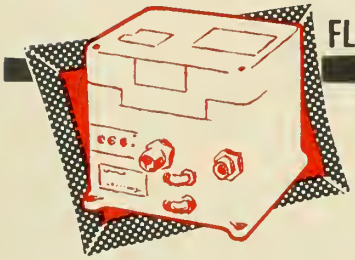
ALTIMETER SYSTEMS . . .



. BEACONRY.



. RADAR - ECM . . .



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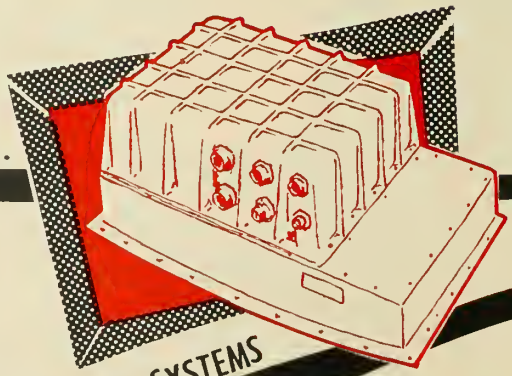
FIELD ENGINEERING . . .



HARNESS SYSTEMS

ENGINEERS AND SCIENTISTS ARE INVITED TO PHONE OR SEND RESUMES TO MR. FRANK BUNN, TECHNICAL EMPLOYMENT OFFICER, EMERSON RESEARCH LABORATORIES AT SILVER SPRING, MD., JUNIPER 8-7273; OR TO MR. FREDERICK YOUNG, TECHNICAL EMPLOYMENT MANAGER, GOVERNMENT ELECTRONICS DIVISION AT JERSEY CITY, N.J., SWARTHMORE 5-3500, EXTENSION 405. FOR FIELD ENGINEERING POSITIONS, CONTACT MR. RICHARD LAYBOURNE, WASHINGTON, D.C., TUCKERMAN 2-6800.

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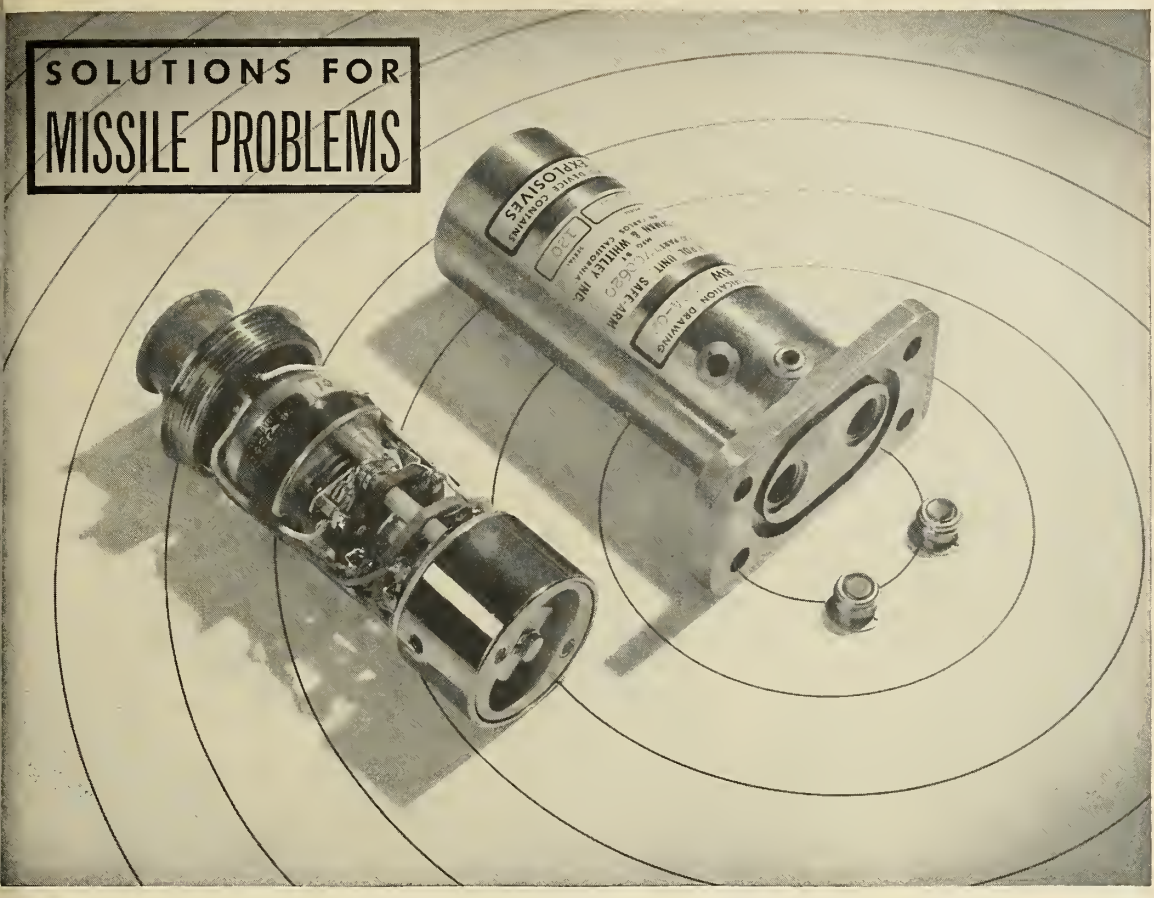

safe/arm initiators

Ten years of pioneering in the missile component field has made possible this new line of Beckman & Whitley solenoid-operated safe/arm explosive initiators. Unit on the left has cover removed to show internal arrangement.

Weighing only 1.85 lb loaded, this model is 5 in. by 3 in. by 1¾ in. It was designed to military requirements. It can be armed or disarmed by remote electrical signal and includes both visual and electrical telemetering facilities for indication of armed or disarmed condition. On reception of a command firing signal, the unit will initiate associated primacord, low-energy detonating cord, (LEDC) or bulk charges.

This may be just what you need. On the other hand, Beckman & Whitley can provide the engineering capability, the production facilities, and perhaps most important, the speed necessary to give you anything you do need in the line of propellant-actuated devices.

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333 COMMERCE AVE., S.W. GRAND RAPIDS, MICHIGAN

01

Washington Countdown

IN THE PENTAGON

Nike-Hercules improvements . . .
are being sought by the Army to enable the Western Electric missile to be used more effectively against Soviet air-to-surface missiles. The Army claims the *Nike-Hercules* is already capable of downing any Soviet versions of the North American *Hound Dog*.

• • •

Some $44 million . . .
is sought for the *Nike-Hercules* improvement program. The Army also wants an extra $180 million added to its FY 1961 budget for purchase of more *Pershings, Honest Johns, Little Johns, Hawks, Davy Crocketts* and *Redeyes*.

• • •

Another 200 miles . . .
or so can be added to the current 900-mile *Polaris* range simply by removing test equipment from the bird. The equipment is for monitoring the test shots.

• • •

New interservice sniping . . .
is being heard along Pentagon corridors in connection with the *Polaris* program. The latest item: *Polaris* subs may be tailed by groups of Soviet subs from the vast undersea Russian fleet. (A neat trick since *Polaris* subs are much faster than any Soviet diesel-powered sub.)

• • •

Project *Defender* studies . . .
aimed at finding an advanced missile defense system are expected to remain in the study stage during FY 1961. The big ARPA project includes such studies as SPAD—a proposed anti-missile satellite system.

• • •

Transfer of *Transit* . . .
from ARPA to the Navy is still tentatively scheduled for July, but the final word is still to be given. Meantime the second *Transit* navigation R&D satellite is scheduled to be boosted by a *Thor* from Cape Canaveral in March.

• • •

The third BMEWS station . . .
which will be built at Flyingdales Moor in Yorkshire, is not expected to be completed before 1963. The first at Thule, Greenland, is scheduled to go into operation later this year.

ON CAPITOL HILL

The ABMA transfer . . .
from the Army to NASA apparently won't be as cut and dried as some government officials thought. NASA Chief T. Keith Glennan has been forced to openly fight for transfer with the flat claim that his agency is in charge of the nation's entire space program and will need big boosters like *Saturn* long before the Armed Services do.

• • •

The big defense debate . . .
keeps sliding out of focus. The point is not what forces the United States has today, but what the Soviet missile arsenal will be in three years—and what the United States will have to face it.

AT NASA

Political difficulties . . .
are reported to be affecting plans to construct Project *Mercury* tracking stations in Sonora, Mexico, and the Canary Islands. However, NASA denies the report. The two stations are part of an 18-station network that must be ready in 1961.

• • •

The *Saturn* team . . .
is understood to be disappointed that NASA has not allowed for many high-paying super grade positions. Lucrative industry offers are reported to be taking on a greater attraction; some defections are expected.

INTERNATIONAL

The French Navy's *Masurca* . . .
a new solid surface-to-air missile, will soon be installed on several French warships. This *Masurca* is similar in appearance to the Convair *Terrier*.

• • •

***Luniks I* and *II* . . .**
may not have been launched from the Sputnik pads at Kapustin Yar or Aral'sk as previously believed. Some of the latest computations based on radar readings in Finland and Turkey pinpoint the *Lunik* launching pads at Irkutsk on Lake Baikal.

• • •

The first *Blue Streak* . . .
test launching at the Woomera Range in Australia is reported to be imminent. The British IRBM will be hard-based and have a range of some 2000 miles.

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

N/D Designs Assembly Savings Into Critical Miniature/Instrument Ball Bearings!

Helping customers *simplify* instrument assembly is a specialty of the N/D engineering group. How? Thraugh *creative* Miniature/Instrument ball bearing applicotion and design. Often, a new ball bearing design will produce assembly savings in excess of its additianal casts. Integral ball bearings, too, very often cut dawn difficult and costly hand assembly af shaft and parts.

A timely example of N/D custamer assembly savings can be seen in Nike Ajax and Hercules missile graund support. Here, *special* N/D Instrument ball bearings are now used in precisian potentiometers. New Departure engineers recommended eliminating twa *single* raw instrument bearings, mounted in duplex and requiring precision spacer and separate guide roller. They replaced this assembly with a *special* N D *double* raw high precisian instrument ball bearing with integral outer race guide roller . . . and shaft mounted with a nut. This ane recammendation produced cast savings af over 400%! In turn, the customer was able to reduce the potentiameter selling price ta the gavernment. What's more, the New Departure Instrument Ball Bearings improved potentiometer reliability!

Yau can look to minimum assembly costs and unsurpassed *reliability*. Include an N/D Miniature Instrument Bearing Specialist in yaur early design level discussions. Far immediate information or assistance, call or write Department L.S., New Departure Divisian, General Motars Corporation, Bristol, Connecticut.

NEW DEPARTURE

MINIATURE & INSTRUMENT BALL BEARINGS

proved reliability you can build around

Industry Countdown

MANUFACTURING

France is believed . . .
to have licked the weight problem so that it can fit its new nuclear weapon in an IRBM warhead. The big question: will the U.S. or Britain help France develop an IRBM? France hopes to have IRBM's on operational status by 1967, and would prefer solid-fueled motors. The chances are considered good that the French may now try to speed up the IRBM program by using a de Havilland *Blue Streak* as the first stage and developing their own second stage.

• • •

An $11-million facility . . .
will be built at Hill AFB, Utah, for assembly and repair of Boeing *Minuteman* ICBM's. The new plant—to be designated Air Force Plant 77—is scheduled for completion in 15 months. An A&E to design the plant will be picked within a week.

• • •

Secret Project *Tattletale* . . .
is now under way at Eglin AFB, Fla., using six *Aerobee 300's*. Hughes Aircraft is the contractor for ARDC . . . First *Astrobee 500* will be fired next month from Eglin by ARDC Cambridge Research Center scientists using a rail launcher. Four vehicles are in the program.

• • •

Harvard Business School . . .
has a $265,000 Ford Foundation grant to study the relationships between the government and its weapon system contractors. The study will develop recommendations for changes in either government or business policy and practice and could have a far-reaching affect upon the defense industry.

• • •

Switch from rails to wheels . . .
has been effected in a 350,000-lb., 151-ft. portable missile service structure developed by the Army Corps of Engineers. The tower—believed to be the heaviest thing mounted on pneumatic tires in the country—is electrically driven.

PROPULSION

Over next five years . . .
Douglas Aircraft estimates the government's missile and rocket motor case procurement requirements will run close to $1 billion.

• • •

Requirement forcing contractor . . .
to share facilities cost may snarl the negotiations between the Air Force and Aerojet for a big solid booster. Aerojet is reported to be unhappy over this provision.

ASTRIONICS

Winner of the critical . . .
monitor and control display system for the NASA *Mercury* man-in-space project is the Stromberg-Carlson Division of General Dynamics. Visual display of such data as the astronaut's heart rate, blood pressure, body temperature and the capsule's oxygen pressurization, acceleration rate and route while in orbit will be housed in a 60 x 40-ft. control center at Cape Canaveral.

• • •

Lockheed is looking . . .
for a site in New Jersey to headquarter its New Lockheed Electronics Co.

• • •

***Titan* will be first . . .**
liquid-fueled missile to use complete PCM telemetry system. AC Spark Plug, prime guidance contractor, spent several months evaluating PCM before awarding $2.5-million contract to Radiation Inc. The highly sophisticated airborne package, said to be 10 times more accurate than other systems, will be used with both new and existing ground-based equipment.

WE HEAR THAT

If *Nike-Zeus* Gets . . .
production green light, Douglas Aircraft will do much of the manufacturing at its Charlotte, N.C., Plant . . . Oscar F. Carlson, retired AF brigadier, has left Douglas to become assistant to the general manager of Martin-Denver to aid in management and administration of the *Titan* program . . . The Garrett Corp. has formed a subsidiary in Tokyo—Garrett (Japan) Ltd. . . . Overheard at the magneto-hydrodynamics (MHD) symposium in Philadelphia: "The meeting generated much heat, little light, and less power."

Friendly Fluorine Fight

To the Editor:

I would like to make a few comments on the discussion in Jay Holmes' (Propulsion Engineering) column (M/R, Jan. 4), regarding a paper given by Dr. Walter T. Olson of NASA to the American Institute of Chemical Engineers.

His suggestion for the use of fluorine as a hypergolic igniter for the liquid hydrogen-liquid oxygen system will certainly work, as we have been doing this for the past several years in our liquid cyanogen-liquid oxygen system—as explained in my article appearing in your magazine recently (M/R, Dec. 14). However, his suggestion that the fluorine be contained in a separate tank and be gradually cut off as the hydrogen-oxygen combustion is going full blast is needless, since the fluorine can be so placed as to be pushed ahead by the incoming liquid oxygen and, therefore, very little is needed. For example, we use one to two ounces of the liquid for starting our 400-pound-thrust size cyanogen rocket motor.

One cannot escape the feeling that Dr. Olson looks on fluorine with rather a jaundiced eye. He rates the hydrogen-oxygen system as the most promising, and completely ignores the hydrogen-fluorine system. Further, he states that if difficulties are involved in the handling of liquid hydrogen, he foresees the hydrazine-fluorine combination as only a few points behind hydrogen-oxygen in specific impulse. This confuses the picture, so then one must conclude that what he really fears is high chamber temperatures, and this point I had hoped was made clear in my aforementioned article.

Summarizing my friend Ted's timid approach, I would conclude by saying that he is gallantly marching forward exactly in reverse.

William L. Doyle
Director
High Temperature Test Area
Research Institute
Temple University
Elverson, Pa.

Attack on Information Lag

To the Editor:

This in reference to your editorial ("Needed: A Central Materials File") of Nov. 23, 1959.

You have accurately pointed out the prime obstacles to the free and rapid flow of technical information from generation to use. That is, increasing specialization of subject matter, growing complexity of detail, proliferation of fields, proprietary constraints, and publication delays.

However, we believe we have taken a number of steps toward correcting this general defect, at least insofar as defense needs are concerned.

In view of the interest in this subject indicated by your thoughtful editorial, perhaps you would like to comment on our arrangements for meeting this problem.

J. R. Townsend
Special Assistant
Office of the Director of Defense
Research & Engineering
Washington 25, D.C.

Mr. Townsend refers to an experiment tried at Battelle Memorial Institute where a Titanium Metallurgical Laboratory was established for the purpose of:

(a) collecting all useful data, published and unpublished, concerning titanium and possible competitors; (b) visiting persons and companies engaged in work with titanium to exchange data on titanium; (c) doing any laboratory research of small or reconnaissance nature on new ideas or to find quick answers in support of the information function; (d) answering responsible questions on technical matters related to titanium; (e) supplying information on various engineering phases of titanium; (f) issuing occasional papers as a means of directing engineering attention to important but incompletely solved

hases of titanium development.

Mr. Townsend adds that the Department of Defense—due to the success f the Battelle titanium work—is preparng to conduct a similar experiment in lastics and reinforced plastics. It sounds ke an excellent idea; presumably Mr. ownsend could give more detailed inormation on request.—Ed.

'leasure Was Ours

o the Editor:

On behalf of the commander and peronnel of Francis E. Warren Air Force ase, I wish to thank you and your staff or the outstanding article ("The New ront—ICBM's Rise on Prairie") in your an. 11 issue.

A special vote of thanks to Jim Baar nd Bill Howard, whose excellent story ividly portrayed the build-up of our base. : was as much a pleasure meeting these entlemen as it was reading their story. oth the picture coverage and text were xcellent.

John A. Nydegger
Major, USAF
Staff Information Officer

Cameron Forgings

To the Editor:

We note with considerable interest and ome concern your article in the Feb. 1 ssue. Interest because at Cameron we are ell aware that "Demand for Missile Forgings Grows," as we find that our volume of production forgings going to the missile builders is continually increasing. Concern because Cameron Iron Works was not listed among the "other industry leaders" supplying missile forgings.

An overwhelming percentage of *Nike-Ajax* and *Nike-Hercules* missiles fly today with Cameron one-piece forged booster nozzles. Cameron nozzles are in *Honest John, Little John, Terrier, Hawk,* and many other birds. These forgings have been in production for a number of years. Adapters, closures, heads and spin blanks for these items and numerous other missile forgings are in daily production in our plant.

In the exotic and refractory material field a very significant number of long-range missiles contain Cameron forged unalloyed, arc-cast molybdenum nozzles and Cameron forged 90% tantalum, 10% tungsten throat inserts. Development work is being carried forward investigating other refractory materials.

In addition to the aforementioned missile forgings, nearly all of the gas turbine engines furnishing propulsion for planes and missiles contain Cameron forged shafts, wheels, cases, etc., all produced from high-density and super alloys.

R. D. Springer
Assistant Sales Manager
Special Products Division
Cameron Iron Works, Inc.
P. O. Box 1212
Houston 1, Tex.

M/R's face is red. Cameron's name was dropped inadvertently in writing the final draft of the article. Our apologies to an important supplier of missile/space forgings.—Ed.

Geography Lesson

To the Editor:

We now have Mt. Tranquillon reduced to its proper elevation when—pow! Lockheed's Eagle Mountain test site is placed 80 miles at sea! See page 35, next-to-last paragraph of Lockheed article (M/R, Feb. 8), ". . . heavily-wooded 4000-acre site 90 miles southwest of San Francisco." Obviously gentlemen, you do not have a map of California. Enclosed find a very handy one for your ready reference.

Seriously, I think you have a very fine publication, but just couldn't resist the friendly gibe.

Ken Allen
2426 Benjamin Drive
Mountain View, Calif.

Materials Interest

To the Editor:

We were very much impressed with your Nov. 23 issue (Special Materials Issue). We would like to get several copies of that issue if they are still available.

T. C. DuMond,
American Society for Metals,
Metals Park, Novelty, O.

Copies on the way—Ed.

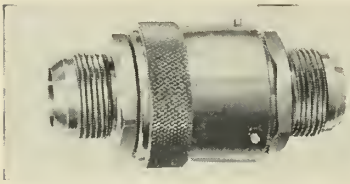
CONNECT AND DISCONNECT ELECTRONIC COOLANT SYSTEM LINES

with AEROQUIP SELF-SEALING COUPLINGS

Now, you con connect and disconnect coolant lines on electronic equipment in seconds, using Aeroquip Self-Sealing Couplings. Aeroquip offers a range of quick-disconnect couplings to meet requirements of all airborne and ground support electronic systems. Types include miniaturized couplings for compact airborne systems (the miniaturized coupling pictured above weighs only .037 lbs.) as well as standard sizes through 1½". Operating features of Aeroquip Couplings include high flow rates and a variety of connection and disconnection methods, with little or no fluid loss.

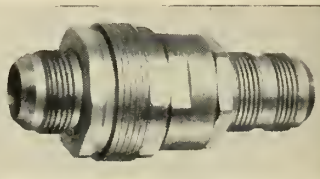
Aeroquip's engineering staff, the largest and most complete in its field, has developed literally hundreds of specialized quick-disconnect couplings. If you have a fluid line connection or disconnection problem, Aeroquip's unmatched experience and resources are at your service.

Fill in and mail the coupon below for information and engineering assistance.



3750 Series Quick Disconnect Coupling for ¼" to 1½" lines features visual lock indicator pins for foolproof connection. Full flow design with low pressure drop.

1010 Series Miniaturized Coupling for airborne electronic systems. Lightweight (.037 lbs.) and compact envelope design permits use in confined space. For ¼" O.D. tube size lines.



3900 Series PUSH-PULL Couplings offer very low pressure drop, and ease of connection and disconnection with no fluid loss in a wide range of sizes. Designed for low lubricity fluids such as FC-75.

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Lanphier Bows Out at Convair

Criticism of President's defense policies results in forced resignation, but he will continue campaign

By William J. Coughlin

Los Angeles—Convair Vice President Thomas G. Lanphier, Jr., was forced to resign from the company last week for his public attacks on president Eisenhower's defense policies.

Lanphier announced his resignation in mid-week after being warned by top officials of General Dynamics Corp., Convair's parent company, to cease his criticism of Administration policies.

General Dynamics President Frank Pace called Lanphier on the carpet within two days after a San Diego press dinner at which the outspoken division vice president attacked President Eisenhower's handling of defense programs.

Lanphier said last week he will continue his campaign against the Administration on a personal basis and on behalf of presidential candidate Senator Stuart Symington (D-Mo.)

• **Blames system**—"I am not leaving voluntarily," Lanphier said. "I am forced to leave by the system—a system which when I speak on matters of national defense finds me factored as a 'Missile Salesman.' Because I am employed in a defense industry and even though I am insistent they are my personal views, I find my observations inferred to carry the endorsement of the organization which employs me."

The Feb. 3 statement to which General Dynamics officials took exception was made at a Convair dinner preceding the first press tour of the *Atlas* production line. Lanphier told visiting newsmen that the President was taking "very dangerous chances" with the nation's survival and added: "I don't think he has that right." He insisted Strategic Air Command should be placed on airborne alert to narrow the defense gap arising from Soviet missile superiority. It was one of the bluntest public attacks ever made on Administration defense policies.

Those present at the dinner included Maj. Gen. O. J. Ritland, Commander of the Air Force's Ballistic Missile Division, and J. V. Naish, President of Convair. Both had been advised in advance of the tenor of the remarks Lanphier intended to make.

Lanphier said he was speaking as an individual, not as a Convair vice president. After his remarks received widespread and not entirely accurate press coverage, Lanphier was called to New York to explain his statements to General Dynamics officials, including Pace.

Rather than be silenced he elected to resign.

• **Reiterations**—"As I understand Democracy, an American who sincerely believes that the nation is in danger must in good conscience say so," Lanphier declared in his resignation statement last Tuesday night. "In this vein, I feel strongly about what I believe to be the Administration's underestimation of the Soviet military for the next three years and I feel equally strong about its concurrent overestimation of the strength and survivability of our own defenses during that same period."

Immediately after announcing his resignation, Lanphier took his case to a nationwide television audience on NBC's Dave Garroway Show on Wednesday morning. There, he hammered again at the President's defense position.

"The father-image is no defense against Khrushchev," he asserted. He repeated his contention that the President is underestimating the military power of the enemy and overestimating that of the United States.

• **Broadens target**—In a private discussion just before his resignation last week, Lanphier extended his attack on the Administration to include Defense Secretary Thomas Gates. He said the defense secretary has not briefed himself adequately for his appearances before Congress.

"Gates goes over there without doing his homework in the most sensitive areas of all," he charged.

Lanphier also declared flatly: "The President is wrong when he says he knows more about modern weapons than anyone else. The evidence is that he does not know. Since his time, modern weaponry has advanced far beyond his comprehension of what it is."

• **Convair regrets**—Convair issued a statement on Tuesday saying that Lanphier's resignation for personal reasons would be effective March 15. President Naish said:

"It is with deep regret, both personal and corporate, that I accept Mr. Lanphier's resignation. During his long association with Convair, he was intimately associated with and made outstanding contributions to successful development of the *Atlas,* F-102, F-106 and B-58 Hustler programs.

"Mr. Lanphier had a distinguished career as an Air Force fighter pilot in World War II. Subsequently, he served as a special assistant for research and development to the Secretary of the Air Force. In recent years he has occupied the presidency of both the Air Force Association and the National Aeronautic Association. This unusual combination of experiences in all phases of air power uniquely qualified him for the responsible assignments he so effectively fulfilled on the Convair team."

From Army Air Corps Ace to Atlas Role

Heavily decorated as an Army Air Corps fighter pilot in World War II Thomas G. Lanphier, Jr., flew more than 100 combat missions in the Pacific and European theaters, shot down seven Japanese planes including one carrying Admiral Yamamoto. During 1949-51, he was successively special assistant to the Secretary of the Air Force for Research and Development; a member of the AF Scientific Advisory Board; and special assistant to Chairman Symington of the National Security Resources Board, representing Symington on the National Security Council's senior staff. He went to Convair in May, '51, as assistant to the President. In November '51, he became Vice President. He has served as president of both the Air Force Association and the National Aeronautic Association.

L.A. Space Show Loses DOD Support

Pentagon raps promoters as implying official backing; A.I.A., Chamber maintained 'hands-off' attitude

The Defense Department has rapped the planned Los Angeles International Air and Space Exposition for "implying" that it bas official military backing.

The Department denied that it is supporting the exposition and at least temporarily cancelled plans to set up military exhibits near tbe site of tbe show as part of Los Angeles 50th anniversary celebration of the first international air meet in the United States.

The Pentagon acted after it received a series of complaints that the commercial enterprise's agents allegedly were soliciting booth sales on the basis of DOD support.

Earlier, the Aerospace Industries Association issued a denial that it was supporting the exposition. Claims of its support had also allegedly been circulated.

• **'Sniping' charged**—Promoters of the exposition—scheduled to be held at the Los Angeles Sports Arena April 14-24—blamed a "disgruntled exemployee" for the complaints that led to the Defense Department's action.

Charles H. McLaughlin, Sr., president and general manager of the exposition, said the Los Angeles Chamber of Commerce also has been "sniping" at his project. Tbe Chamber bas refused to support the exposition.

A Pentagon spokesman said McLaughlin originally was told that the Armed Forces would not take part in the exposition because it was a profit-making enterprise. Later, the Pentagon agreed to set up displays nearby if tbey were made open to the public free of admission charge.

• **'Best wishes'**—Now-resigned Deputy Assistant Defense Secretary Chauncey Robbins wrote to McLaughlin Jan. 22:

"This is in further reference to the International Air and Space Exposition to be held in Hollywood, California, on April 14-24, 1960.

"On the basis of the completed questionnaire and additional information you forwarded, a display of Armed Forces exhibits from commands in the vicinity has been autborized at no cost to the government for transportation, maintenance of personnel and operating expenses, provided the exhibits are open to the general public free of charge and are publicized accordingly . . .

"You may be sure that you have our best wishes for a successful Exposition."

The exposition's backers reproduced the letter and distributed it with promotional material soliciting booths.

• **Lifting recommended**—Col. Dean Hess, head of the Armed Forces Information Office in Los Angeles, said complaints received by the Pentagon bad led to temporary suspension of military participation, but that after an investigation into tbe financial situation of the exposition backers he has recommended to Washington that the suspension be lifted.

He said records of the organizers which were made available to him showed no evidence of lack of financial responsibility, althougb only a few firms from the aircraft and missile field appeared to have signed up for space.

Col. Hess said McLaughlin had agreed to post a casb bond to cover expenses of military participation.

Col. Hess said he understood that as of last week 19 of the 400 exhibit spaces had been sold.

• **Proceeding without Chamber**—McLaughlin said plans for tbe exhibition were going ahead despite a decision by the prime California aircraft and missile manufacturers not to take part in the show.

"It looks good—we're getting lots of good support," the former hotel and motel man said.

Harold Wright, general manager of the Los Angeles Cbamber of Commerce, said the Cbamber was not endorsing the exhibition. He said McLaughlin had tried to interest tbe Chamber in the show and bad sought membership.

"We asked for data on wbo was behind it and evidence to back up his statement tbat a group of responsible citizens was supporting it," Wright added. He said tbat the evidence was not submitted.

Mergers and Expansions

Joining otber missile/space firms venturing into the European market, H. K. Porter & Cie S.A. makes its second overseas acquisition with the purchase of 51% of the stock of King Aircraft Corp., Ltd., of Glasgow. The Scottish firm specializes in aircraft engine and airframe accessories, including special lines of fasteners, clamps and couplings and flexible metallic hose. It will soon begin production of Porter products.

• **Other important mergers**—Howe Sound Co., of which Sperry Products is a division, announces acquisition of all outstanding stock of Triplett & Barton, Inc. T&B's Burbank, Calif., and Wichita, Kan., laboratories for nondestructive testing will be maintained by Sperry, but its manufacturing operations will be moved to the Sperry plant in Danbury.

Textron Electronics takes a giant step in the field by acquiring GC Electronics of Rockford, Ill., and Schafer Custom Engineering of Burbank, in exchange for 750,000 shares of Textron common stock. GC Electronics' and Schafer's combined sales for 1959 totaled $7,817,000.

Continental Can Co. has sold all its honeycomb facilities to Honeycomb Products, Inc., a new company producing fiberglass and paper products for the aircraft and building industries. All manufacturing rights for the U.S. and Canada to ACF Industries-developed electronic module and capacitor components have been purcbased by tbe Illinois Tool Works, Cbicago, for use in radio and television circuitry and defense projects.

In another electronics move, Telex Inc. of St. Paul now owns a 25% interest in Electro-Logic Corp., of California. Ballastran Corp. of Ft. Wayne was purchased by Telex earlier this month.

Applied Dynamics, Inc. is now a subsidiary of Bowmar Instrument Corp., and will operate as an independent company witb the same staff. Bentley-Harris Manufacturing Co. of Conshohocken, Pa., has been acquired by Raychem Corp. of Redwood City, Calif.

Sunbeam Corp., well-known in the appliance field, now enters the missile scene through acquiring John Oster Manufacturing Co. The new subsidiary's Avionic Division, producing precision electronic instruments, employs about 1150, 200 of whom are engaged in R&D and engineering.

• **Washington**—Senate Republican leader Everett Dirksen (Ill.), calling upon Democratic defense critics to use "restraint," accused Sen. Stuart Symington (D-Mo.) of not giving all the facts when he rapped the Administration in a Senate speech. Symington replied by calling upon the Administration to clear up the confusion over relative U.S. and Soviet missile strengths by announcing the current ratios. He said this was done last year by Defense Secretary McElroy who estimated that Russia then had a 3-to-1 missile lead.

• **Washington**—Gen. Nathan Twining, Chairman of the Joint Chiefs of Staff, has told Senate investigators he had never seen the estimates of Soviet missile strength given to Congress Jan. 29 by Central Intelligence Agency Director Allan W. Dulles. Twining said he was not aware of the figures when he assured Congress on Feb. 9 that the missile gap had been narrowed. The figures reputedly show the Soviets have more than a 3-to-1 lead in ready-to-launch long-range missiles.

• **Cape Canaveral**—An Air Force *Titan* ICBM passed its second-stage ignition test for the second time Feb. 24. The missile carried a prototype ablative re-entry vehicle containing a data capsule and nose cone which were recovered near Ascension Island, the intended impact area.

• **Washington**—The Eisenhower Administration was charged with delaying more than five months in assigning a DX high priority to NASA's *Mercury* man-in-space program. Rep. B. F. Sisk (D-Calif.) said NASA asked for the priority on Nov. 14, 1958. The request was rejected by the National Space Council Dec. 3, 1958. The priority was again sought six days later on Dec. 9 by the Civilian-Military Liaison Committee and referred to the NSC, which finally granted approval April 27, 1959. According to Sisk, DOD put the priority into effect on May 5, 1959. Sisk made the statement as the House approved President Eisenhower's request for an extra $23 million for NASA, most of it for *Mercury*.

• **Washington**—DOD said the mystery satellite picked up in a polar orbit probably is the ejected recovery capsule of the *Discoverer V* space vehicle launched at Vandenberg AFB last Aug. 13.

• **Seattle**—Lockheed Aircraft is acquiring Colby Steel and Mfg. Inc., Seattle, and Colby Crane and Mfg. Ltd., Vancouver. Both will be operated as wholly-owned subsidiaries.

• **Detroit**—Bendix Aviation Corp. stockholders voted to change the company's name to The Bendix Corp. The change will go into effect about June 1.

• **Farmingdale, N.Y.**—Republic Aviation will announce this week successful operation of its magnetic "pinched plasma" engine continuously for more than 118 hours. One of the first applications of this type of low-thrust engine will be in satellite attitude control. The test, run earlier this month, was terminated to take the engine down for inspection. The engine uses nitrogen for fuel, converting it into a plasma which is pinched by a cylindrical magnetic field and then ejected from the compression chamber at very high velocity. This cycle is repeated continuously at the rate of 30 times per minute. Power required is 3000 volts at 675 watts. The engine was developed by Republic's Plasma Propulsion Laboratory under contracts with the Office of Naval Research and the Air Force's Office of Scientific Research. Republic considers the test successful enough so that it plans to begin designing flyable versions of the engine.

Missile/Space Industry Conference Award Winners

PRINCIPALS AT Dr. Robert H. Goddard Memorial Dinner in Washington recently included, from the left: W. L. Wearly of Joy Manufacturing Co.; AF Capt. Joe E. Jordan who received Joy Aerospace Flight Award; Lt. Gen. Bernard A. Schriever; Mrs. Esther C. Goddard, Karel Jan (Charley) Bossart of Convair, recipient of the Dr. Robert H. Goddard Memorial Trophy presented by Missiles and Rockets Magazine; M/R Executive Editor F. Clarke Newlon; Richard B. Canright of Douglas, winner of Astronautics Engineer Achievement Award; Norman L. Baker, a news letter publisher who presented the award to Mr. Canright; and Delacey Ferris of Reaction Motors who received the Borg-Warner Missile Industry Award from R. F. Schultz.

Norair Proposes Two-Man Orbiting Space Laboratory

A one-week tour of duty for a two-man team operating an orbiting space laboratory is a concept developed by the Northrop Corp.'s Norair Astro Systems and Research Laboratories. The system would be used mainly for measurement and study of the earth's atmospheric phenomena.

The two-man vehicle would orbit at about 500 miles. Its required life support system could supply all needs for a one-week period under normal conditions—two weeks, if an emergency arose. Crews would be ferried to the vehicle by a shuttle system based on a modified *Mercury* capsule and a Norair maneuverability adapter. The actual laboratory platform would be ever-orbiting.

• **Three components**—Three major components would make up the complete system—a mission package and rendezvous/coupling adapter, a life support enclosure, and the shuttle vehicle. The first two units would be placed into orbit as a package and maintained by the shuttle vehicle until the life support enclosure was attached. The final vehicle would make one rotation, in an orbital plane, for each revolution, thus remaining directed towards the earth's center. The occupants could then operate in an essentially free-fall environment. Final-stage boosters would be collected into the vehicle's immediate area and held for further use.

The mission package would contain self-supporting mission equipment. Environment would be such that a man in a full pressure suit (for emergency only) could maintain the mission equipment as required. Special instrumentation for the mission would be modularized and contain its own go-no go test system.

The rendezvous/coupling adapter, second portion of the mission package, would be equipped to handle the shuttle vehicle and couple it to the life support system. Dual air lock provisions would also be available for any manned operations outside the structure. The mission package and rendezvous/coupling adapter would make up a single unit with two sections.

The life support enclosure would contain environmental equipment, communications and monitoring equipment, and off-duty living facilities. The multiple-wall shell would have one end fitted for the mission package and rendezvous/coupling adapter. The other end would have an emergency air lock for access to a standby shuttle; this end would also be a "tie up" point for the new life support enclosure when a replacement crew arrives via the shuttle.

The modified *Mercury* shuttle vehicle could be used either as a cargo or passenger transport. It would carry two men, food, water, oxygen, spare parts and test equipment. Parachutes would be used to recover the shuttle in earth landings. The shuttle would be maneuvered by special motors mounted in the adapter, and directed to orbiting rendezvous by both ground tracking and on-board guidance equipment. Close maneuvering at rendezvous would be aided by optical sights.

TWO-MAN laboratory would require life support system for a one-week period. Crews would be ferried by a modified *Mercury* capsule.

Arcas Launchers Put on Army's Range Ship

Launching facilities for *ARCAS* rockets have been installed aboard the Army Ordnance range ship *USAS American Mariner*. The rockets will be fired to calibrate the ship's precision radars and collect upper-atmospheric meteorological data.

Other additions and modifications have been made to extend the ship's capabilities for tracking, measuring and analyzing the in-flight performance of ballistic missiles. Assigned to the Atlantic Missile Range, the RCA-managed ship is a floating electronics laboratory. Her primary function is the collection of precise data for both offensive and defensive purposes under ARPA's Down-range Anti-missile Measurement Program (DAMP).

The DAMP Contract—administered through the Philadelphia Army Ordnance District—is part of an overall range measurement program. This, in turn, is a phase of ARPA's ballistic missile defense program—Project Defender.

In addition to the tracking radars, electronic equipment aboard the ship includes navigation, recording, communication, optical, and precision computing equipment. Some 60 scientists, engineers, and technicians man these facilities.

Data collected on the ship's missions are flown to the RCA data reduction center at Croydon, Pa., for analysis and distribution to 76 government agencies and scientific institutions.

The DAMP ship has been cited as an outstanding example of interservice-industry cooperation. The mission is sponsored by ARPA and administered by the Army. The *ARCAS* rockets are furnished by the Navy. The ship's operating area, the AMR, is managed by the Air Force.

Heteropowered Spacecraft Proposed

SAN DIEGO, CALIF.—Krafft A. Ehricke of the Convair (Astronautics) Division of General Dynamics Corp. has proposed a heteropowered spacecraft of 2.4-million-lb. takeoff thrust which could soft-land 60,000 lb. on the moon or place a 230,000-lb. payload in a 300-nautical-mile earth orbit.

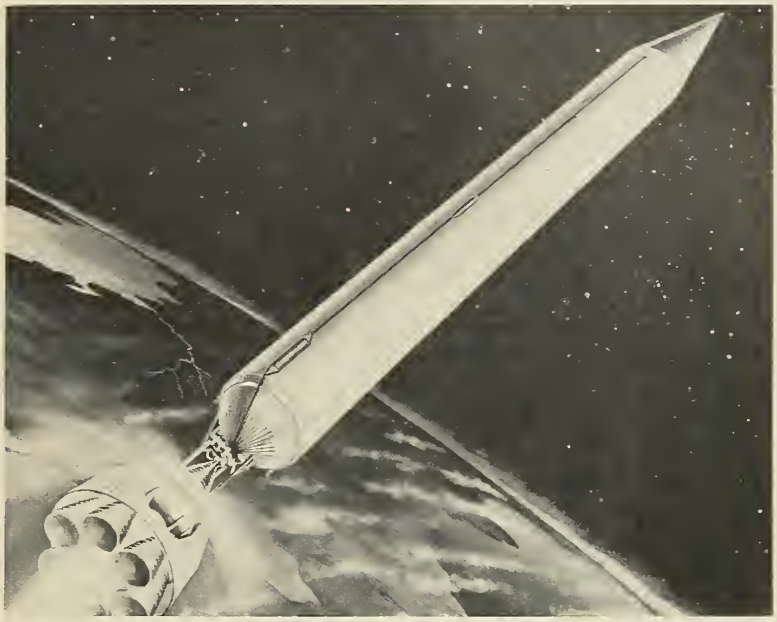
The 1¾-stage vehicle, *Helios II*, would weigh about 1.8-million lb., stand 220 ft. tall and be 32 ft. in diameter. It would be powered by large oxygen-hydrogen engines.

These chemical engines in the Ehricke design proposal are arranged around a 750,000-lb.-thrust nuclear engine. They operate against a thrust structure containing the oxygen tank which, due to its higher density, is much smaller than the main tank containing liquid hydrogen for the chemical as well as the nuclear engines.

To avoid radiation problems arising from running the large nuclear reactor up to full power on the ground, the vehicle takes off on chemical thrust.

The chemical booster serves to lift the nuclear vehicle up to a stratospheric launching level, and is staged above 100,000 ft. altitude as soon as radiation sensitivity of the particular payload permits.

The illustration shows separation of thrust structure, oxygen tank and chemical engines at staging, after the nuclear engine has been phased in.



ARTIST'S CONCEPT of combination chemical and nuclear engine-powered spacecraft which would soft-land 60,000 lbs. on moon.

• **Three jobs**—Three primary types of mission are seen for the spacecraft: orbital assembly of large nuclear interplanetary vehicles, maintenance of lunar establishments, and service as an astronautic coast guard vessel for rescue and other emergency missions.

In addition to soft-landing large payloads on the moon, it also is capable of placing about 78,000 lb. into a satellite orbit around Mars.

Ehricke says a vehicle of this type is feasible in the early 1970's—if the development of nuclear heat exchanger engines is pushed vigorously in the next 10 years.

Hawk Motor Fires After An Eight-hour Dunking

A solid-propelled Army *Hawk* motor was fired successfully in a recent test after being immersed in water for eight hours.

The test was conducted at the Army Rocket and Guided Missile Agency, Redstone Arsenal, Ala. The motor, manufactured by Aerojet-General, was immersed in four feet of water at 70°F for eight hours and then withdrawn and inspected for leakage. The propellant was still dry.

Then the weather seal was broken and the motor was placed back in the water. It was drained without drying and stored at 0°F for 48 hours. A thin coating of ice formed on the propellant bore and the igniter basket. Nevertheless, the motor was fired successfully.

The tests were part of the Raytheon *Hawk* qualification program now in progress at ARGMA.

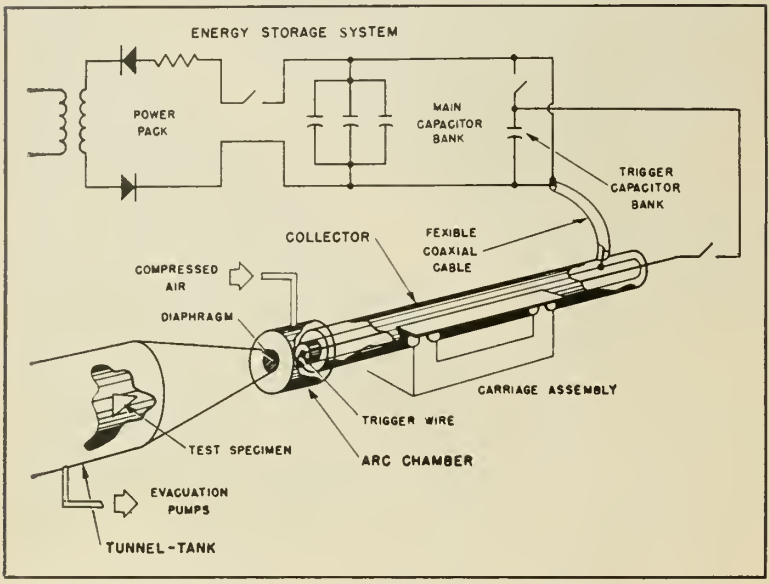
'Unconventional' Power Sources to Be Discussed

A special forum at the National Power Conference to be held in Chicago, March 29-31 will feature discussion of unconventional methods of power generation. Both direct and indirect energy conversion methods will be described.

Subject and speakers include "Magnetohydrodynamic Power," Dr. Arthur Kantrowitz, Avco Corp.; "Isotopic Heat and Power," W. W. T. Crane, Martin Co.; "AF Nuclear Rocket Program," Lt. Col. H. R. Schmidt, USAF; and "Fuel Cells," E. Gorin, Pittsburg Coal Co., Div. of Consolidation Coal Corp.

The three-day meeting will be primarily concerned with more prosaic methods of generating power. Some 90 papers will discuss all aspects of the power industry. The conference is sponsored by Illinois Institute of Technology. Further information is available from the Director, American Power Conference, IIT, Technology Center, Chicago 16, Illinois.

Hypervelocity Wind Tunnel Planned at McDonnell



TUNNEL WOULD test missiles components at altitudes to 100,000 ft.

A new "hotshot" hypervelocity impulse wind tunnel—providing test velocities of 9 to 24 times the speed of sound—will be installed by McDonnell Aircraft Co., St. Louis. It will be used to investigate thermal and aerodynamic properties of missiles and aircraft at hypersonic speeds and altitudes above 100,000 feet.

The system is composed of four basic sections: expansion cone/test section, vacuum reservoir, arc chamber, and energy storage system.

Prior to test, the arc chamber is filled with highly compressed air and the tunnel-tank evacuated to a pressure of one micron of mercury. Electric power from the energy storage system is delivered to the arc chamber, increasing the pressure and temperature of the air in the chamber up to 100,000 psi and approximately 14,000°F. The thin diaphragm separating the arc chamber from the tunnel-tank is vaporized by the high temperature. The high-pressure air expands through a tungsten throat to hypersonic velocities in the test section.

The energy storage system—ordered from Westinghouse Electric Corp.—can deliver electrical power at the average rate of 2 1/3 million kilowatts—more than six times the rating of the largest turbine-generator.

The McDonnell wind tunnel will be able to run an 0.08-second test every 15 minutes. When completed, it will have a 50-in. and a 30-in. diameter test section. Provisions have been incorporated for future expansion to a stored energy level of ten megajoules.

High Potential Seen for Nitronium Perchlorate

Callery Chemical Co. reports that nitronium perchlorate (NO_2ClO_4) shows potential of replacing ammonium perchlorate in some solid-propellant applications.

A high-density, energetic solid oxidizer, it may also offer attractive advantages in hybrid rocket systems, Callery said recently. It is now being made available in research quantities for experimentation by propellant manufacturers, with the expectation that large-scale production will follow.

In a technical bulletin, Callery said nitronium perchlorate has a heat of formation of 8±0.4 Kcal/mole. A white crystalline powder of particles one to five microns in diameter, it has a density of 2.25 g/cc and bulk density of 0.4 g/cc.

Shock sensitivity is low, according to Callery. The pure material did not detonate at 250 KG-cm impact. Impure material may be shock-sensitive. It does not melt; instead, it decomposes rapidly without explosion in the temperature range 250°-285° F.

It is extremely hygroscopic, reacting irreversibly with water to form a mixture of nitric and perchloric acids. It reacts with most organic materials and reducing agents.

High-strength Cobalt Steel Made by Universal-Cyclops

A new high-strength steel developed specifically for missile motor cases has been produced by Universal-Cyclops Steel Corp., Bridgeville, Pa.

Designated Unimach UCX2, the steel differs from the AISI 4100 series metals in that 1% cobalt has been added as an alloying element. When properly tempered to the 225,000-235,000 psi levels, the alloy shows essentially no susceptibility to notch sensitivity.

C. C. English, Manager of High-Temperature Sales, said that the alloy has excellent forming characteristics and good weldability; he predicted that production costs would be reduced accordingly.

High-Temperature Plastics Study Begins at Taylor

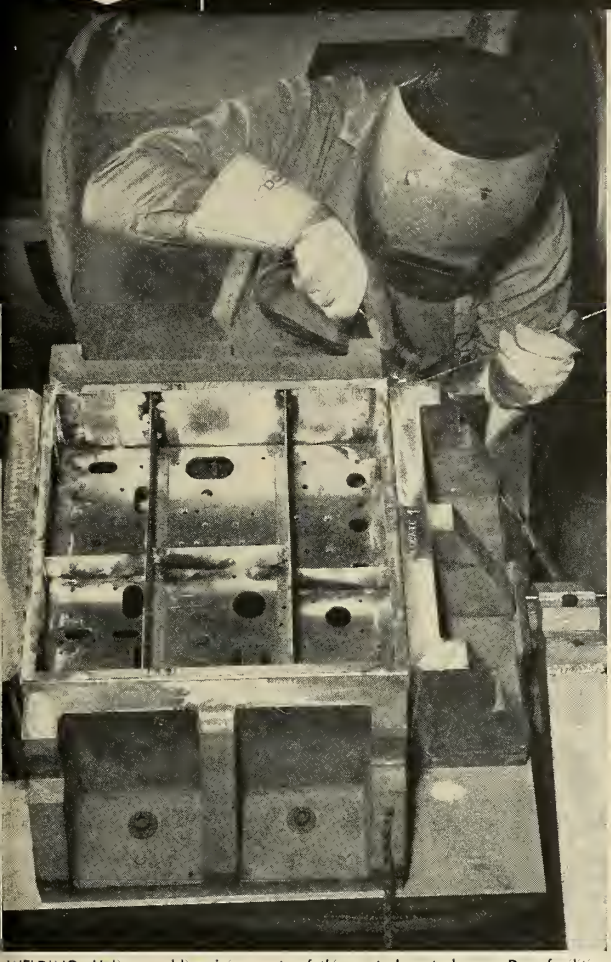
Superior plastic laminates for nose cones and throat nozzles are expected to result from a new research effort by Taylor Fibre Co., Norristown, Pa.

Dr. Carlisle M. Thacker, Technical Division Director, said the high-temperature erosion and high thermal insulation qualities of a wide variety of plastic materials will be studied.

Web and resin combinations will include paper, asbestos, nylon, Dacron, Orlon, Refrasil, graphite cloth and Teflon in laminates with many resins.

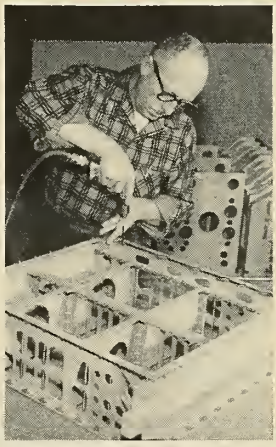
The qualities which influence missile applications are low heat conductivity; steady, slow evolution of low molecular weight gases on decomposition; high heat absorption from physical transitions and retained high structural

DOW *Now in magnesium and aluminum*



WELDING. Heliarc welding joins parts of this control central case. Dow facilities and personnel for welding are government certified.

DRAWING. This gyro cover is drawn in a single operation. It replaces a part which consisted of welded components.



ASSEMBLY of this 4-deck housing with rivets, bolts and welds precedes FINISHING with Dow Number 17 anodic treatment.

DOW FABRICATION PLANT SAVES WEIGHT, TIME, COSTS ON ICBM COMPUTER HOUSINGS

Working closely with the customer, Dow engineers suggested design modifications for a three-deck computer housing that yielded improvements in both production and application.

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strength after surface charring.

Thacker said several of the currently successful laminates were the result of an accident—they were initially designed for electrical applications. A research program based on missile needs should provide superior materials.

International Minerals Cuts Magnesium Dioxide Prices

A reduction in the price of low-boron magnesium dioxide, in all shipping categories, has been announced by International Minerals & Chemical Corp., at its Carlsbad, N.M., plant.

The new prices are $155 per ton in bulk and $160 per ton in bagged carloads, 30 tons minimum. This is down from $235 bulk and $240 bagged per ton.

The low-boron magnesium dioxide is used in nuclear reactors and research and is being evaluated for use in capacitors and missile nose cone coatings by the Air Force.

Polymers Obtained from Cotton Fiber Furfural

Moscow—A group of specialists at the Institute of Chemistry, Uzbek Academy of Sciences, under the direction of Candidate of Chemical Sciences A. Sultanov, has reportedly developed a method for obtaining new polymers —polyfurans and polysylvans—by means of the polymerization of furan and sylvan, extractable from the furfural of cotton fiber.

The Soviets claim the new polymers to be good film producers, and say they can be used by the cable industry in making glues for thermostable and bacteriostable coatings, and as solvents of polymeric materials.

The Fergana Hydrolysis Plant is said to be producing polysylvans. (*Vestnik Akademii nauk SSSR*, No. 11, 1959, p. 73)

Douglas Develops Plastic-Fiber Glass Zeus Nozzles

Fiber glass and plastic nozzles have been developed for the *Nike-Zeus* antimissile missile, Douglas Aircraft Corp. reports.

Douglas said the booster nozzle is the largest plastic rocket-motor nozzle built in this country. Nozzles on both booster and sustainer engines are made of the high-temperature-resistant fiber glass and plastic composition.

N. H. Sharpell, works manager of Douglas' Santa Monica division, announced that missile nozzle research and production activities are being shifted to an area of 50,000 sq. ft., tripling the space allotted to the expanding program. He said additional fabricating equipment is being installed. The new area also includes a section for research and development production of experimental nozzles.

Bags Used for Mace Landings

RUBBER-COATED fabric air bags fastened to the *Mace* missile are used as landing gear for recovery of the vehicle. Manufactured by Goodyear Tire, the recovery bags fit around the *Mace's* belly when popped into shape by compressed air during landing.

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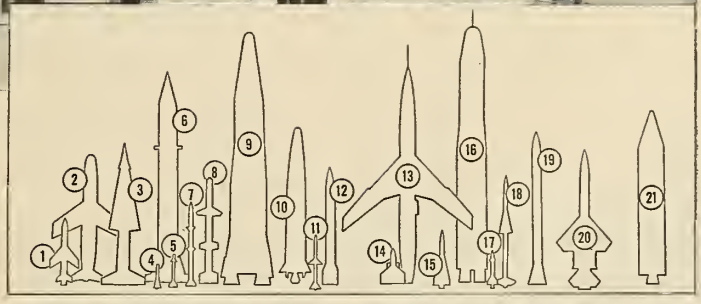

1. **Lacrosse.** Army. Ground-to-ground. Prime contractor: Martin.
2. **Mace.** Air Force. Ground-to-ground. Prime contractor: Martin.
3. **Nike Hercules.** Army. Ground-to-air. Prime contractor: Western Electric.
4. **Falcon.** Air Force. Air-to-air. Prime contractor: Hughes.
5. **Sidewinder (GAR-8).** Navy/Air Force. Air-to-air. Prime contractors: Philco; General Electric.
6. **Redstone.** Army. Ground-to-ground. Prime contractor: Chrysler Corp.
7. **Terrier.** Navy. Surface-to-air. Prime contractor: Convair.
8. **Talos.** Navy. Surface-to-air. Prime contractor: Bendix Aviation.
9. **Atlas.** Air Force. Ground-to-ground. Prime contractor: Convair.
10. **Thor.** Air Force. Ground-to-ground. Prime contractor: Douglas.
11. **Sparrow III.** Navy. Air-to-air. Prime contractor: Raytheon.
12. **Sergeant.** Army. Ground-to-ground. Prime contractor: Sperry Rand.
13. **Snark.** Air Force. Ground-to-ground. Prime contractor: Northrop.
14. **Quail.** Air Force. Air-to-ground. Prime contractor: McDonnell.
15. **Hawk.** Army. Ground-to-air. Prime contractor: Raytheon.
16. **Titan.** Air Force. Ground-to-ground. Prime contractor: Martin.
17. **Bullpup.** Navy. Air-to-ground. Prime contractor: Martin.
18. **Nike Ajax.** Army. Ground-to-air. Prime contractor: Western Electric.
19. **Corporal.** Army. Ground-to-ground. Prime contractors: Firestone; Gilfillan.
20. **Bomarc.** Air Force. Ground-to-air. Prime contractor: Boeing.
21. **Jupiter.** Army. Ground-to-ground. Prime contractor. Chrysler Corp.

British Renew Row over Launch Systems

Navy wants Polaris submarines; RAF favors aircraft launchers—debate affects U.S. sales hopes

by an M/R Correspondent

LONDON—Great Britain's 1960-61 defence budget has touched off another row among top-level authorities on whether nuclear deterrent missiles should be land-, sea-, or air-based.

The outcome could vitally effect U.S. industry's plans for selling *Polaris* FBM submarine missiles and the *Skybolt* air-launched ballistic missile.

On one side, the Royal Navy is in favour of creating a force of three or four nuclear-powered submarines, each equipped with 16 *Polaris* missiles and each with two crews. However, the value of *Polaris*-firing subs has been seriously questioned in Britain because of cost and probability of detection by an enemy. Britain plans construction of two nuclear submarines. One would employ U.S. know-how, but the second would be an all-British design. Both, however, are intended for antisubmarine work and not for firing ballistic missiles.

On the other side, the Royal Air Force argues that ballistic missiles should be fired from VTO aircraft or another type of plane capable of getting into the air rapidly. The argument advanced in favour of this system is that the aircraft could also be used for other purposes, whereas submarines have little use except in total war.

Britain's most advanced long-range missile is the de Havilland *Blue Streak*, designed to be launched from concrete pits, which the Navy and the RAF claim are too vulnerable. Experience with *Thor* missiles now in Britain has shown that it is impossible to keep the locations of the launching sites secret. Accuracy apparently achieved in the recent tests of Soviet missiles in the Pacific show that it would be quite easy to knock out all the possible launching sites in Britain.

• **Point of no return**—The inter-service dispute has been in existence for many months but the development of *Blue Streak* has proceeded so far that it would now be just as expensive to cancel the project as to complete it. Moreover, cancellation would be a heavy blow to the morale of scientists and engineers throughout the British missile industry.

The Government White Paper, "Report on Defence 1960," states that "the development of the British ballistic missile *Blue Streak* is continuing. However, it may be decided not to rely exclusively on fixed-site missiles as the successor to the medium bomber armed with the stand-off powered bomb. Therefore the possibilities of mobile launchers, whether aircraft or submarines, for long-range delivery of nuclear warheads are being investigated."

If it is decided to go over to mobile launchers, *Blue Streak* will still have a future as a satellite booster. Although no official statement on this has been made, it is understood that preliminary work on this has gone beyond the stage of just examining possibilities, and more detailed design studies are in progress.

The easy solution to the launching dispute would be to go ahead with all three possibilities, but this would involve increased expenditure. The estimated cost of defence for 1960-61 ($600 million) is apparently $322 million up on that for 1959-60, but this is partly a bookkeeping transaction—the real increase is about $250 million.

Russian Space Suit Is Described in German Paper

A new Soviet space suit, recently described in a German newspaper, is tailored to the wearer and made of insulating foam material. Its oxygen apparatus is located under a bulge of the same material and is an integral part of the suit.

There are 12 pockets containing the technical equipment: a built-in automatic telephone for short-distance communication; a radiation-measuring device, the buzzer of which is connected to the wearer's ear; a searchlight with a permanent-type battery; emergency food and drugs; a pocket-size transmitter; a new lightweight pistol with two magazines, one with regular ammunition, the other with flare cartridges; and other tools and instruments.

The article also notes that in case of emergency, a valve blocks the oxygen supply for 20 seconds. (*Der Mittag*, Dusseldorf, Jan. 8, p. 3.

Astronomer Sets Age of Wrinkles on the Moon

In a recent Soviet bulletin, K. A. Lyubarskiy discussed his method of estimating the age of the wrinkles on the moon, presupposing both meteoritic and volcanic lunar landforms.

The larger lunar seas and craters with an average diameter of 20-30 km are, according to Lyubarskiy, largely of volcanic origin, while the smaller disfigurations, or pockmarks, with diameters of about 6 or 7 km, are, for the most part, of meteoritic origin.

Knowing the velocity and mass distribution of the smaller craters, it is possible, the author argues, to compute the number of meteoritic bodies falling on a given area (ikm ^{2}) of the moon in a given time period (1 year) and thus estimate the age of the area or formation involved.

The author used Mare Tranquilitatis and Mare Humorum for his experiment; he estimates that the former is between 2 and 46 million years old and the latter between 4 and 94 million years. In terms of geological events on earth, this would correspond to the period of Alpine mountain building, or the Upper Cretaceous and beginning of the Tertiary. (*Byulleten' Vsesoyuznogo astronomo-geodezicheskogo obshchestva*, No. 25 (32) 1959, p. 3-8.)

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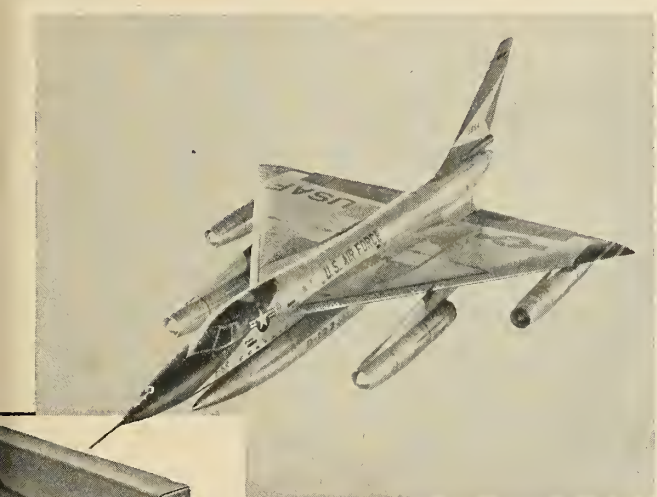
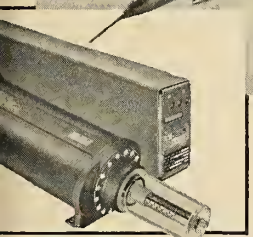
The Univac Automatic Antenna Coupler (Series 3200) has been installed in the Boeing 707 aircraft for all major airlines, the USAF KC-135 and the President's airplane, the VC-137. Both of the units shown on this page were developed by the staff which produced the first high altitude antenna coupler.





Originally developed for the Hughes AN/URC air-to-ground communication system, the Univac Automatic Antenna Coupler (Series 3300), has been adopted by Hughes Aircraft Co. for Convair's B-58 "Hustler".

Aboard the Convair B-58 Hustler and the Boeing 707, "black boxes" automatically attune HI radio communications to the speed, range and altitude of modern supersonic flight. The Univac Automatic Antenna Couplers are examples of specialized electronic equipment from the Remington Rand Univac Military Division. This equipment, though outside the realm of the large-scale data processing and control systems for which the Division is best known, demonstrates important capabilities.

The Antenna Coupler program is significant to those responsible for defense requirements for two reasons: First because it is an example of airborne equipment which meets severe operational and reliability specifications, and secondly because it demonstrates experience in the development of communications and control devices.

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Astronauts Will Require Less Sleep

Air Force documents needs during extended immersion in water for weightlessness

by Don Zylstra

Weightlessness poses real hazards or the first astronaut in terms of nuscular and skeletal deterioration. 3ut even more remarkable will be his educed sleep requirements, docunented for the first time this month ›y researchers in space medicine.

Less than seven hours of fitful sleep n a week was all a 28-year-old Air Force physician was able to manage during his long session in a Space Age bathtub at the Air Force Aerospace Medical Center at Brooks Air Force Base, Tex.

Nobody deprived Capt. Duane E. Graveline of his sleep. He was encouraged to doze off whenever he could. But seven hours out of 168 was all he seemed to need. His surprising wakefulness was recorded during his prolonged immersion in water in a test to simulate weightlessness.

Space physicians have already ordered a new version of the familiar steamer chair—a couch with built-in springs, making it tend to fold upward, pushing against the body of the astronaut. His muscles and skeleton, pressing against the spring pressure, would supply continuous "exercise" and the muscle tone that is lost during periods of complete inactivity and weightlessness. Doctors hope the device will reduce muscular weakness and changes in bone structure.

Clad in a water-tight, skindiver's rubber suit, Dr. Graveline spent seven days supported by the 400 gallons of warm water in his tub. During this time his bodily movements were restricted, corresponding with conditions the first astronauts will experience in their cramped space capsules.

• **No real sleep**—Space scientists expected many changes in his heartbeat and circulation. But his reduced sleep requirements came as something of a surprise. Even during the few hours he did doze, his "sleep" was far from sound.

Electroencephalograms of his brain were like those of normal adults just dropping off to sleep or beginning to awaken. Only twice during his buoyant seven days did the doctor record anything that resembled sound sleep and then only for three to five minutes at a time.

"Results of Dr. Graveline's seven-day immersion may have far-reaching influence on medical theories about the causes of sleep in humans," Dr. Hubertus Strughold, research advisor at the Aerospace Medical Center, said. "Greatly reduced muscular activity, accompanied by a corresponding diminished sleep requirement, is prompting a new look at all our concepts of sleep. This test also confirms our belief that much more research is needed before we can describe even 'normal' human behavior accurately."

• **Theories affected**—Both Drs. Strughold and Graveline noted that the weightlessness experiment would cast "interesting new light" on widely held medical theories about the nature of sleep. Much of the early test data would seem to support the "metabolic" theory—that sleep is induced by the by-products of normal metabolism in the human system. A reduced metabolic rate with drastically restricted exercise may have lessened Dr. Graveline's sleep needs.

The "kinesthetic-feedback" theory, also widely held, may also derive some support from the experiment. Dr. Graveline said. According to the kinesthetic theory, a decrease in the sensory input to the sleep-regulating area of the brain lessens the "feedback" along motor nerve paths, promoting sleep. The sleep center of the brain also apparently acts to "coordinate" sleep, promoting rest for all areas of the human system at the same time. Doctors studying results of the bathtub experiment agreed that it is "too early to draw many conclusions" from this first attempt.

Long periods of uninterrupted wakefulness on the part of astronauts may come as an unexpected bonus in planning space flight routines. But medical researchers agreed that "many of the elements" of true space flight were missing in their tank test.

Dr. Graveline, despite his lack of exercise, wasn't subjected to many of the sensory deprivations endured in other human experiments in space capsules. As a result, he was free from the hallucinations experienced by some astronauts in other tests.

• **Sit-ups in orbit?**—"Unless space pilots can exercise regularly, or are provided with conditions resembling gravity, they may be unable to handle essential tasks on re-entering the atmosphere in their space vehicles," Dr. Graveline said.

"My seven days in the tank indi-

SEVEN HOURS sleep out of 168 was all that was needed by Air Force Capt. Duane E. Graveline during tests at Brooks Air Force Base.

muscular deterioration . . .

cated I might have found the judgments and manual tasks demanded by re-entry virtually impossible."

Aerospace doctors noted significant deterioration in Dr. Graveline's muscles and bones. During an hour outside the tank daily to change his long underwear and his rubber suit, his skin turned blue, his pulse rate skyrocketed and his blood pressure was described as "critically low."

"During the last few days of the experiment it was actually a relief to get back into the water," Dr. Graveline said. "I became weaker each day.

"It was even difficult to muster enough energy to talk unless I was in the tank. I was unusually sensitive to changes in temperature. The water was kept at a steady 91.4°F. Even a degree higher or lower felt too hot or too cold."

• **General tearing-down**—"Daily examinations showed my muscles were getting softer and smaller. Calcium and phosphorus leaving the bones appeared in increasing quantities in the urine, subjecting the kidneys to abnormal elimination conditions."

Because his anti-gravity muscles and his bones no longer had work to perform, they were literally tearing themselves down. Although no significant weight loss accompanied these changes, he noted marked differences in his joints.

"During the test and for several days after leaving the tank, I noted an unaccustomed, loose-jointed feeling," Dr. Graveline said. "It was as if the ligaments had relaxed for want of something to do."

Certain sensations of the weightlessness of space flight are duplicated when a human body floats in water. While other organs and body functions continue to react to earth's gravity, bones and muscles respond to inactivity much as they would in weightless flight. Normal reactions of anti-gravity muscles, almost as subconscious as breathing, are no longer needed.

During his seven-day immersion, Dr. Graveline was supported only at the back of his head, and secured by his ankles. Only his head was above the water surface. Body movement was reduced to motion of his forearms through the limited arc needed to operate levers under his hands on the floor of the water-filled tank.

The levers enabled him to register his responses to work problems flashed before his eyes on an electronic panel.

• **Food for floating**—Brooks medical center researchers put Dr. Graveline on a special liquid diet for four weeks preceding the immersion test.

Frequent checks on Graveline's metabolic rate during the pre-tank period assured an adequate balance of food intake to his energy requirements.

Both volume and thickness increases and a higher red corpuscle count were noted in Dr. Graveline's blood during the experiment. But medical researchers were reluctant to attribute them directly to simulated weightlessness. They emphasized that better controls would produce more accurate data in this area.

Early inferences from the test indicate that astronauts will experience few bodily changes from a four or five-hour journey in space. But after 24 or 48 hours there will be "significant" reactions. Planning is already in progress to counteract them.

• **Waltz me around again**—After Dr. Graveline's waterborne experiment, he was flown north for a punishing session on the centrifuge at Wright-Patterson Air Force Base, Ohio. Before his week of enforced inactivity, the young medic had "blacked out" when extra forces pressing on his body reached 4.9 g.

Dr. Graveline climbed shakily from his tank, dressed in a flight suit, and was helped into the cockpit of an F-100 jet whose pilot whisked him from Brooks AFB to Wright-Patterson.

"My blood pressure had fallen to a critically low figure and was hardly measurable with conventional instruments. My pulse didn't drop below 150 for the entire flight," Dr. Graveline said. "Normally it's in the eighties.

"The centrifuge session was much harder to endure this time. I was giddy, my pulse went even higher and I was violently nauseated. But evidently my body was still able to provide sufficient blood circulation to nourish my brain and eyes. The g-forces climbed right up to 5 again before I blacked out."

Anyone for Tennis?

THIS 20-LB., 30'-diameter "balloonite" will be shot into a 1000-mile orbit sometime during the spring. Manufactured by G. T. Schjeldahl Co., it will carried in two small hemispheres, pictured near the young lady's feet, on a *Transit* vehicle.

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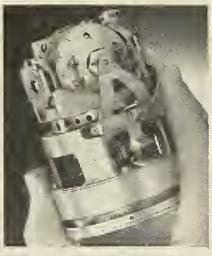

New small free gyro, "inner ear" of the simplified inertial platform.

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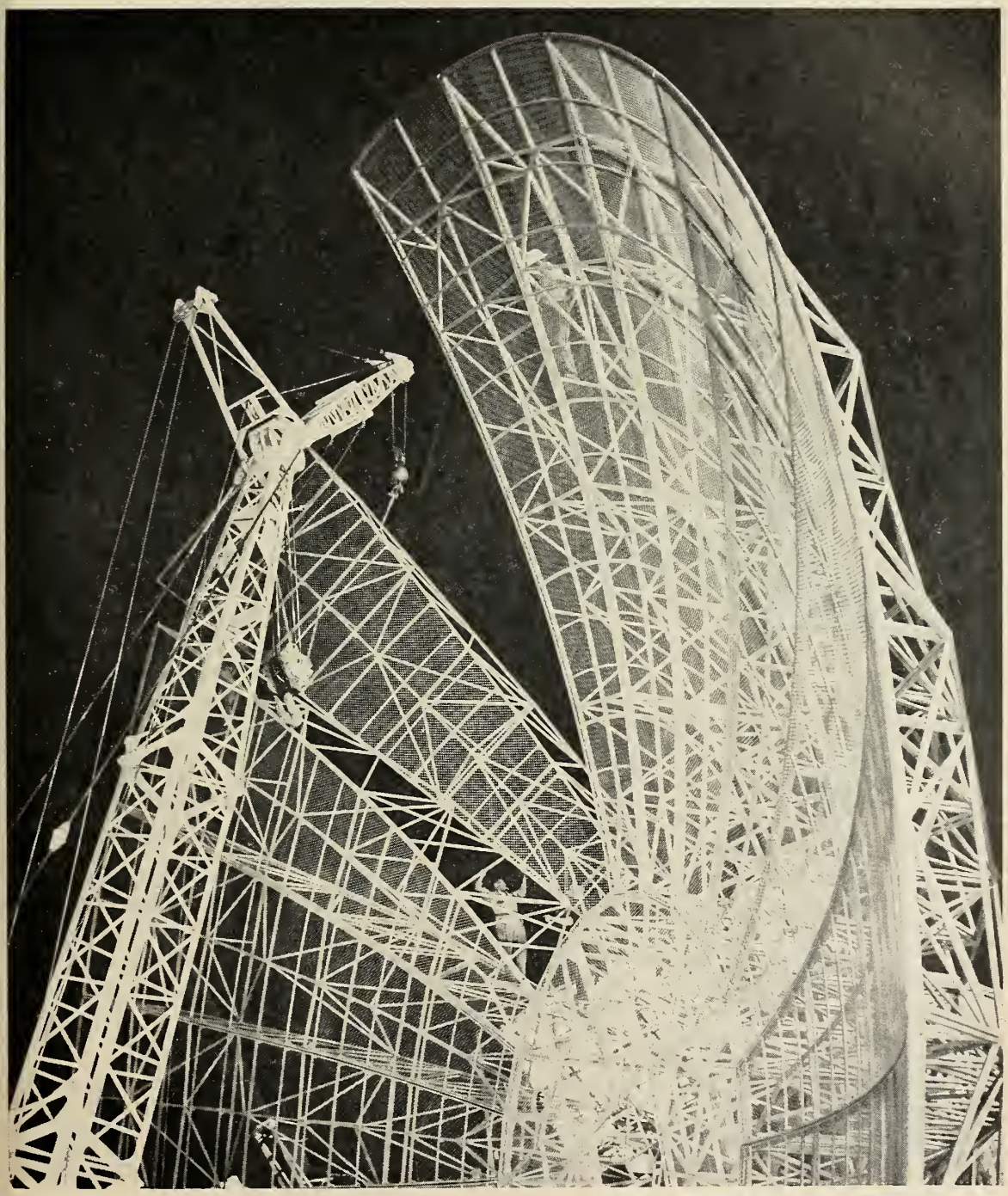

Goodyear's BMEWS Radar Tracking Antenna (see p. 56)

Boom Year Seen for Electronics

Market analysis shows rising sales and strenuous competition—increasing R&D costs are squeezing the smaller companies

by M/R Staff

Pushed hard by missiles, control, communications and warning systems, the military electronics market today is on the way to another record year. Expected 1960 sales: $5.2 billion.

Market analysts brimming with freshly digested figures from the FY 1961 defense budget are predicting an exuberantly rising sales curve through 1968. There isn't a dip or a plateau in sight.

Hand in hand with the spectacular increase in sales, they believe, will come an almost complete displacement of tubes by transistors. Where transistorized equipment will account for $1.560 billion, or 30% of the $5.2-billion military market this year, the Electronic Industries Association is forecasting the percentage will rise to 85% in 1968—$8.67 billion out of the $10.2 billion total.

This bodes well, of course, for manufacturers of transistors and related semiconductor devices. Or at least for some of them, as industry experts see it.

The dramatic increase in demand is almost certain to accelerate the current move toward large-scale, automated production lines. And this could bring about a drastic reduction in the number of transistor manufacturers. There are 42 today. But a "shakeout" could cut their ranks to four or five large producers in the next few years, it is believed.

Backing up this opinion is an Electronics Production Resources Agency report which shows a military requirement through 1961 for 38 million transistors. Fully 29.5 million of this number will be made from 30 basic transistor types now manufactured by seven of the major firms.

Ever-increasing R&D costs, accompanied by a chronic shortage of top-grade scientists, also are expected to put the squeeze on smaller companies lacking the financial resources to remain competitive.

There appears to be, however, practically no limit to opportunities for the designers and packagers of specialized equipment.

• **Major market factors**—The Air Force will be using huge amounts of equipment well into the decade, to back up its presently planned 27 squadrons of *Atlas* and *Titan* ICBM's and the follow-on installations for *Minuteman*. Electronic gear required by missiles of all types now averages from 40% to 45% of their total cost.

Prospects for the AF's air-launched ballistic missile—*Sky Bolt*—are still bright. This weapon could create a major demand for lightweight and miniaturized checkout, guidance and fire control gear that can be packed aboard an aircraft.

Another new market area about to open wide is the Air Force's *Midas*

How Electronics Figure in Defense Budget

	New Obligational Authority			Direct Obligations			Expenditures		
	FY 1959	FY 1960	FY 1961	FY 1959	FY 1960	FY 1961	FY 1959	FY 1960	FY 1961
Total Procurement	14,293	13,090	13,085	14,800	13,605	14,364	14,410	13,943	13,602
Army	1,249	1,379	1,337	1,097	1,388	1,524	1,388	1,251	1,198
Navy	4,557	3,851	4,673	4,757	4,240	4,697	4,464	4,322	4,355
Air Force	8,487	7,860	7,075	8,945	7,977	8,143	8,554	8,369	8,049
OSD	—	—	—	1	—	—	3	1	*
Aircraft	6,134	6,143	4,753	7,004	5,940	6,013	7,658	6,670	6,027
Army	64	119	119	54	117	136	113	108	132
Navy	1,649	1,739	1,640	1,820	1,646	1,875	2,152	1,683	1,663
Air Force	4,421	4,285	2,994	5,130	4,176	4,002	5,393	4,879	4,232
Missiles	4,107	3,244	3,825	3,702	3,540	3,805	3,339	3,500	3,479
Army	642	399	351	555	400	401	725	472	413
Navy	543	379	450	540	469	464	319	389	397
Air Force	2,923	2,466	3,024	2,607	2,671	2,941	2,295	2,639	2,669
Ships	1,947	1,139	2,035	1,846	1,500	1,740	1,493	1,651	1,644
Army	4	4	3	4	4	4	2	3	4
Navy	1,943	1,135	2,032	1,841	1,496	1,736	1,488	1,647	1,640
OSD	—	—	—	1	—	—	3	1	*
Ordnance, vehicles, etc.	491	836	870	484	818	1,023	476	600	691
Army	226	545	586	200	539	668	188	355	380
Navy	136	146	133	164	155	200	176	177	185
Air Force	129	145	151	120	125	155	113	68	125
Electronics & Communications	1,074	1,276	1,088	888	1,330	1,244	942	898	1,067
Army	121	151	148	111	169	169	185	156	140
Navy	100	315	179	184	318	183	153	196	160
Air Force	854	811	761	594	843	893	604	546	766
Other	540	451	513	877	476	539	502	623	739
Army	193	160	129	173	158	147	175	178	175
Navy	186	136	239	209	156	239	177	229	308
Air Force	161	154	145	495	162	153	150	236	256

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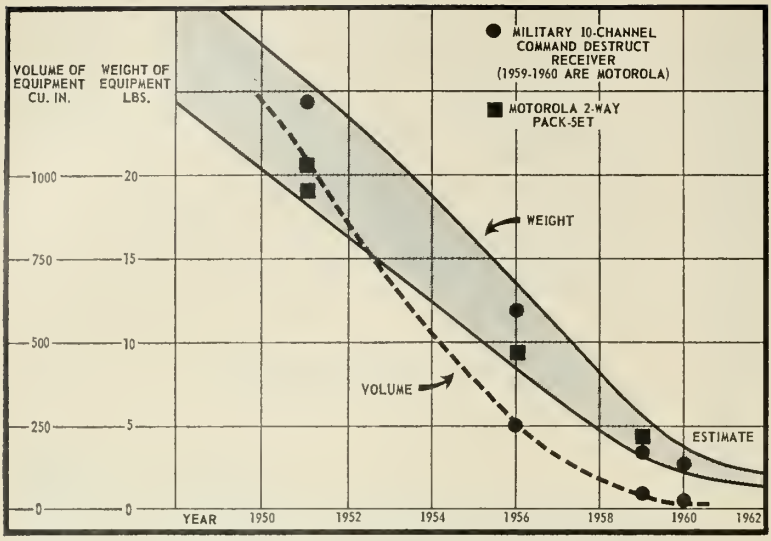


REDUCTION OF equipment size is not just a trend, it's big business. Fund outlays soon will make microminiaturization $1 billion industry.

early warning satellite program and *Samos*—the reconnaissance satellite. Each of these programs would use about a dozen satellites in space and perhaps 10 to 20 new tracking and reporting stations.

The AF has told M/R that these two systems would require completely independent facilities. As one official put it:

"There would be no point in having a *Midas* satellite if there was any chance that at the moment it detected an enemy ICBM headed for Chicago, its communications channel was preempted by the report from a recon satellite about a string of barges moving down the Volga."

A total of $95 million in AF R&D funds is earmarked for *Midas* and *Discoverer*, the early recon satellite. Another $221 million will be used for research, development, test and evaluation of *Samos* and *Sky Bolt*. The exact breakdown between the latter two strategic weapons has not been revealed.

Modernization of Strategic Air Command communications and continued funding of BMEWS and air defense alert systems is reflected in projected FY 1961 expenditures of $1.067 billion for electronics and communications. This is $169 million more than in the current fiscal year.

The Army is still stumping hard for its *Nike-Zeus* antimissile missile, which would require a vast amount of highly selective acquisition and tracking radar. While the chances appear rather remote that *Nike-Zeus* ever will go into full production, the Army nevertheless is spending more than $324 million in FY 1961. The total invested in the program so far is running to $760 million. But, significantly, the Army feels that regardless of whether test objectives are met, the investment will pay off in the electronics area.

Look for a step-up in the Navy's *Polaris* fleet ballistic missile submarine program. Twelve subs are programmed now. But once the first sub—the George Washington—is proved out this year, the chances are good for an acceleration in the 1962 budget, or possibly in a supplemental budget to FY 1961.

Anti-submarine warfare is a $1.370-billion item in the '61 budget—up $95 million over the current program. However, it is $220 million less than FY '59. Most of the shrinkage over the two years is in the procurement of major electronic hardware and in RDT&E.

Other current industry trends:

MICROMINIATURIZATION

Manufacturing techniques for the reduction of equipment size are being emitted at high frequency from every electronics conference. This is not just a fad—it's big business.

It went into high gear when the Army Signal Corps added a $5-million catalyst—the RCA contract to standardize microminiaturized components and assembly techniques. The missile industry needed this; so did the whole electronics industry.

Add to this the company-sponsored efforts in this field and the overall picture is one of nearly a billion-dollar technical revolution taking place over a three to four-year period.

More than 100 companies are working directly with RCA on its contract, and the rest of the industry is following the program with interest. All, however, are not convinced that this is indeed the correct approach—even though many of the techniques can be used on future systems whatever approach is used.

The current target is to achieve component densities of the order of 600,000 parts/cubic foot.

PHYSICAL ELECTRONICS

Those who feel the concept of microminiaturization is not the answer are attempting to make an evolutionary leap with physical electronics R&D.

Two major approaches have found vigorous sponsors in industry: molecular electronics and thin-film subsystems.

The Air Force came up with a $2-million development contract for Westinghouse after it had seen how much progress the company had made in its molecular-electronics effort. By using molecular-structure and atomic-field characteristics in various solid-state materials, complete subsystems had been created by Westinghouse researchers.

So far, over 20 of these functional subsystems have been made. According to the company, reproducibility is good, electrical efficiencies high (up to 70%), and unit reliabilities closely approach 100%. Essentially low-power devices, thermoelectrics used for power in the near future should increase reliability and vastly decrease overall size. Over 1000:1 size and weight reductions are believed practical, even over microminiaturized systems. The target now is development of a working system in from 3-5 years.

A major exponent of the thin-film approach is Motorola. Although not opposed to the molecular-electronics approach, it does believe it can do more, faster, with evaporative thin-film systems. Actually, the Semiconductor Div. in Phoenix also is starting a company-sponsored program to develop advanced functional subsystems.

Its program, called "microelectronics" will establish both physical and chemical techniques to form thin films of conductors, semiconductors, and insulators. By using "two dimensional" passive circuit elements and attaching unencapsulated active elements, it can realize component densities of 2 x 10^6 parts/cu. ft., Motorola says. It, too, will employ thermoelectrics for power.

The basic difference between this and the Westinghouse approach is that standard circuits will still be employed to obtain a desired function. Components will be distributed over the surface of a substrate and also will be stacked.

Only time will provide the answer as to which approach might be better. Probably the two will complement one another to provide the broadest possible range of future system configurations.

SEMICONDUCTORS

With new products coming off the manufacturing lines daily, plant expansions weekly, and new manufacturers springing up periodically, the semiconductor industry is certainly a prosperous one. Youthful, it is growing rapidly—in eight years its annual gross has climbed from five figures to a half-billion dollars. In another five years this figure will be doubled, according to industry estimates.

Three almost completely different product lines have evolved—for the military, industrial or commercial, and entertainment markets. Reliability requirements and a willingness to pay for high performance have produced a very high-quality military line. Low-quality producers either fall by the wayside or serve only the entertainment field. Competition for all of these markets is vigorous, which tends to assure good buyer prices in each market.

To compete, manufacturers first invested heavily to make better and different products. Now they are trying to automate to make them faster and cheaper. At the same time, most of the large manufacturers are involved in highly advanced research in "physical electronics," either solid-state functional systems or more nearly "conventional" thin-film subsystems.

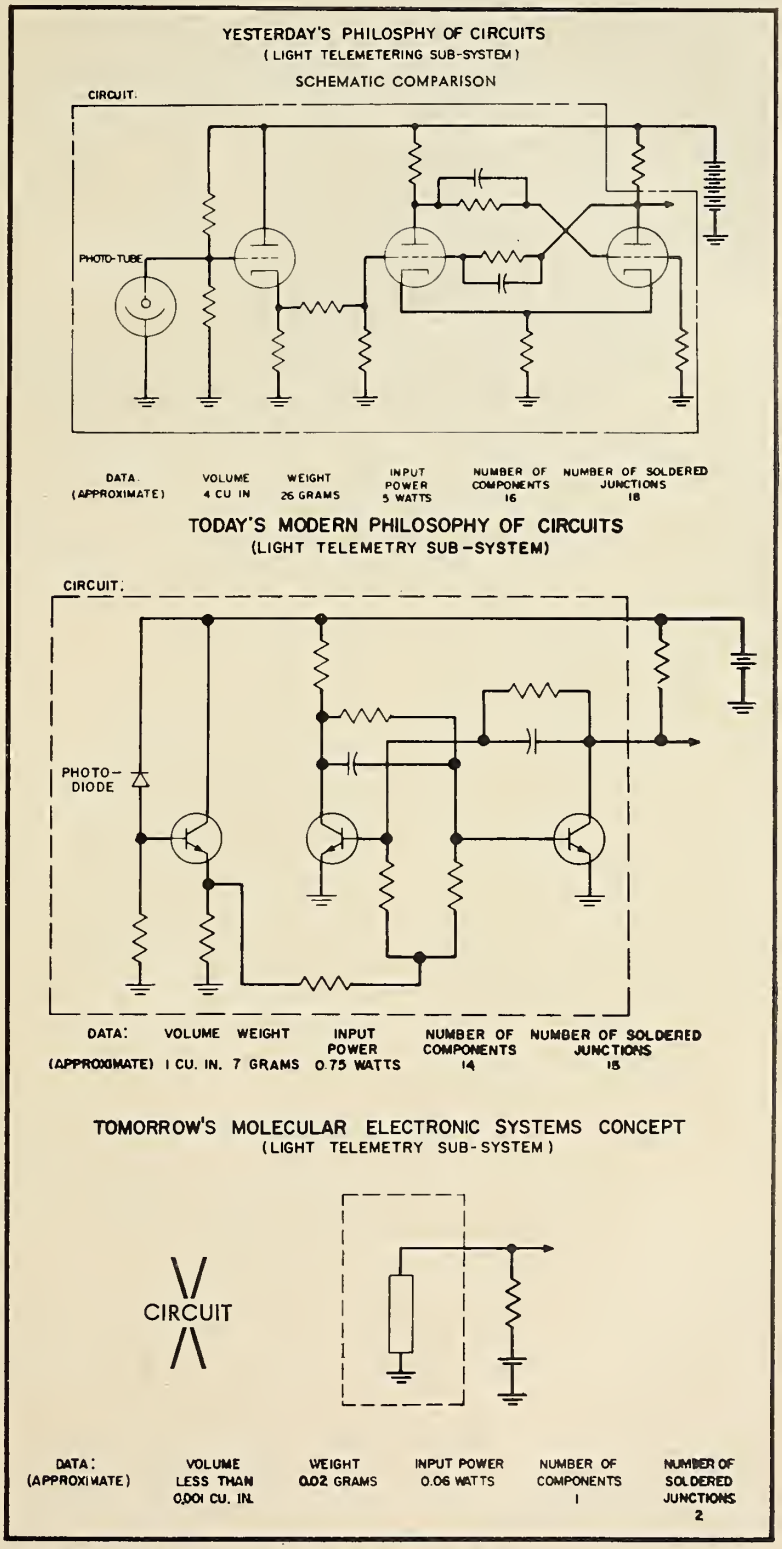
Who are the leaders of this industry? There is a lot of money to be made, so—as might be expected—they are the giants in the electronics field: GE, Hoffman Elec., Hughes, Motorola, Philco, RCA, Raytheon, Sylvania, Texas Instruments, Westinghouse. Other companies, specializing in lower-quality products, may have lines just as diversified and may even sell almost as many units. But the giants have the quality markets.

INFRARED

A fast-growing industry, infrared research and hardware market will have a total market approaching $400 million during FY 1960. Of this, nearly $125 million is for defense.

Significantly, a very large part of the IR defense dollar is for research. This is one field that has been only partly tapped. Given a few important breakthroughs, this industry could easily treble in size within a few short years.

Look at the range of applications: arming and fuzing missiles; missile homing; horizon and disc scanners (for use with vertical gyros and satellite attitude control systems); star-tracking



BLOCK DIAGRAM prepared by Westinghouse for M/R.

navigational systems; target detection, acquisition, and tracking; mapping; communications; vertical-over-height computers. These are just a few military applications; the commercial and scientific applications are twice as numerous.

One area receiving more attention now is IR communications. There are relatively few types of active infrared systems in use today, but for communications several advantages are readily apparent: narrow bandwidths and non-existence of sidelobes and scatter (atmospheric) effects offer high communications security; non-interference, inherent with this mode of transmission, will guarantee spectrum availability; low cost and equipment simplicity will provide up to a 10-mile communication range (in fair weather). Frequencies used lie in the near-infrared region of from 86 to 375 megamegacycles/sec.

There are some limitations in the state of the art of IR communications, primarily the effect of rain or fog on system degradation. Former limitations such as poor detector sensitivity, high noise level, poor optical transmission materials, etc., are rapidly being minimized or eliminated through materials, research and new design techniques.

A comparison of radar versus infrared detection, considering only today's state of the art, indicates that each has certain desirable characteristics, but only within certain parameters.

Infrared has superior angular resolution compared with that of radar. Radar has a limited maximum unobstructed range but its range measurement capability is good. IR is just the opposite: unlimited range with poor measurement capability.

IR does have two limitations that probably will prevent it from ever supplanting radar. It cannot operate against the sun, and it is subject to more degradation in inclement weather. Performance is very poor in fog, impossible in dense clouds.

However, maximum radar range is a function of target reflectivity, beacon power and detector sensitivity. Nothing can be done about the former and no appreciable improvements have been made in the latter for some time. Power can be increased, but this is costly and relatively unrewarding.

Infrared detection—already good—has been improving steadily and rapidly. Detector sensitivities are being increased.

Also, the speeds and sizes of missiles and aircraft are increasing rapidly. As they do, IR detectivity improves significantly.

A great deal of time and money is being applied to problems of infrared cell cooling. Five major areas are targets of this effort: reliability, weight and volume, gas contamination, power requirements, and hardware costs. Included in these investigations will be an attempt to reduce cooling time and to solve the accessibility problems with missiles.

Liquid nitrogen systems currently are most utilized in this field, but Peltier-thermoelectric cooling seems to offer the greatest opportunity for real gains in making reliable, small-sized, low-power systems.

Electronics in ASW

(NOA, in millions)

Navy Appropriation	Fiscal Year 1959	Fiscal Year 1960	Fiscal Year 1961
RDT&E	[1]$ 202.7	[2]$ 225.3	$ 180.5
Shipbuilding & conversion	1,012.6	485.7	762.3
Aircraft & related procurement	266.3	476.8	345.2
Procurement of ordnance & ammunition	54.1	50.2	55.2
Major electronics procurement	60.1	37.9	27.6
Total, all appropriations	**1,595.8**	**1,275.9**	**1,370.8**

[1]Includes $20,500,000 DOD emergency funds.

[2]Includes $45,000,000 Congress add-on.

DATA RECORDING

Expecting to do over $200 million in equipment sales alone during FY 1960, the 13-year-old magnetic tape recording industry has matured rapidly. Extremely versatile, it has found application in data processing systems, industrial machine control, telemetry, automatic checkout, video, training, entertainment, and a host of other areas.

Just a few years ago, magnetic tape was used to record frequencies up to several thousand cps. Although tape limits had not been reached, equipment limitations were the problem. Today, frequencies above 500 kc are becoming more common; video recording exceeds 6 mc and may soon accommodate 12 mc. Theoretically, some researchers believe it may be possible to reach a limit of 100 mc; but more must be known about magnetic materials before this can be proved.

Development in missile-borne systems has been toward compact miniaturized units, designed for specific applications. The knowledge gained, however, is being reflected in smaller systems for all applications. Lockheed Electronics and Avionics, Ampex, Datalab, Leach Corp., and others have produced extremely successful units, some weighing well below 20 pounds total (excluding power supply only). All of these systems are rugged and reliable with fairly high information capacity.

THERMOPLASTICS

An eventual threat to the magnetic tape industry is General Electrics' new thermoplastic recording (TPR) process. True, it may complement the now-standard and versatile magnetic tape, but it surely will make heavy inroads on the market.

Its application will be both military and commercial. Even in its developmental form, it can concentrate in a given space 100 times as much information as magnetic tape. Its output can be digital or it can produce color or black and white pictures.

PHOTOSCAN

Another new competitor, somewhat more limited in scope, is CBS Laboratories' Photoscan system, using highly advanced scanning and radio-photographic techniques. Directly applicable for missile and aircraft surveillance missions, it provides a means for almost instantaneous pictorial data acquisition and storage.

It can be used with various types of sensors, and it provides very high vertical and horizontal resolution. According to CBS, no loss is incurred in data transmission and the ground station equipment employs image-enhancement techniques to provide an even better photographic image.

GRAPHIC RECORDERS

Many types of graphic charts have been used in recording data for missile system checkout and telemetry. Early oscillographs and pen recorders were slow in response and subject to inertia errors. Photo-recording graphs had to be chemically developed in a longtime process that provided data only after considerable delay. Laborious and inaccurate manual reduction further complicated the process.

As new recording techniques gained in popularity, the older methods have had to be improved steadily. These improvements have come, and many of the older types have held their own very well.

Heat-sensitive recording papers and instantaneously developed photographic oscillograph charts have brought significant progress in galvanometer techniques. In addition, response and speed of these systems also have been improved to the point where they are sufficient for almost any application. Some models offer combinations of different methods in one machine—heat, electric, ink, curvilinear and rectilinear recording.

Other features aimed at providing better, faster and more convenient recording include record numbering, electronic flash timing, variable speeds, plug-in modules, and instantaneous readout. Present trends indicate emphasis on transistorization and higher-frequency response.

Probably the most advanced step made in graphic recording is the multi-stylus technique—using electrosensitive chart and electronically fired multiple fixed styli. Such systems, capable of plotting millions of data points each second, can provide both discrete-level analog plots and alpha-numeric annotation. They are particularly useful in recording sequential on-off data. The growing popularity of this technique is attested to by the increasing number of different models becoming available. At present, however, costs are high and systems complex, making them useful only in certain advanced applications.

ENERGY CONVERSION

The field of energy conversion for producing electric power is still confusing—both as to the amount of money it represents in continuous military and industrial investment and regarding the number of companies involved in serious research, development and production.

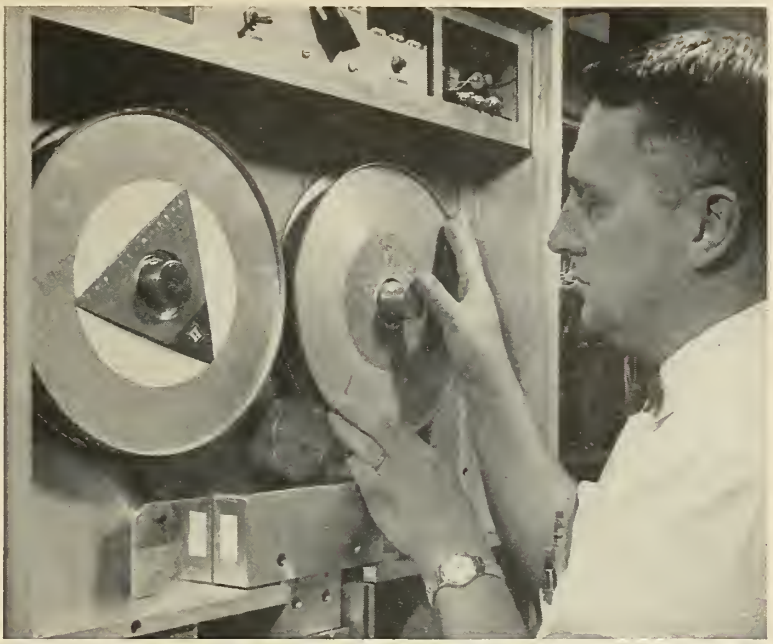
Total DOD funding is nearly $50 million a year. But how much industry is plowing into this potentially lucrative field is an unknown—except that it is a very sizeable sum.

The missile/space age has provided the necessary impetus because of the unusual auxiliary power requirements of its vehicles. And the commercial applications of advances in the field generally create more profits than do military or scientific use. The push is aimed at direct energy conversion.

Most recent estimates indicate that more than over 1000 companies contribute either directly or partially to energy conversion advancements. Areas of greatest interest today appear to be photoelectric and photochemical (both solar-type systems), thermoelectric, electrochemical, and thermionic emission.

NASA's money is going into solar-cell and regenerative fuel-cell development. The Air Force has spread its money over a broad area: solar cells, nuclear and nucleonics, fuel cells, fluids research. The Navy has been concentrating on fuel cells and thermolectricity. Army is aiming its dollars at fuel cells and solar cells. The AEC has worked almost solely with its SNAP development program. These use nuclear energy for indirect power conversion.

Fuel cells are enjoying by far the most widespread interest. Needless to say, battery manufacturers are using a great deal of their own money to stay in the field. Today they are doing well; how long they retain a large piece of the pie certainly depends on advances in these other areas, but so far battery makers have shown a lot of staying power.



HIGH-SPEED magnetic tape drive newly developed by Datamatic Division of Minneapolis-Honeywell can read or record 96,000 decimal digits per second. It is reported to be the most efficient tape handling system yet devised. Use of an all-vacuum rather than a mechanical drive is expected to virtually eliminate damage to magnetic tapes.

FUZING & ARMING

Shrouded by necessary but often inconvenient secrecy is the field of fuzing and arming, both for conventional and nuclear warheads.

The work is highly advanced technologically, but many observers feel that continued state-of-the-art advancements are being cramped by the security veil and lack of a centralized information "clearing house."

It's a one-customer market, and there are only five companies having a major interest: GE, Bulova, Minneapolis-Honeywell, Maxson, and Avco-Crosley. About 10 others are important but limited suppliers, and fewer than 40 major component suppliers complement the industry.

This also is one field in which the government has no shortage of experts. Its agencies all have very complete R&D in-house capabilities—not only in fuzing and arming per se, but in associated electronics and accessories.

Principal government agencies are the Army's Diamond Ordnance Fuze Lab and Picatinny Arsenal; the Navy's Ordnance Labs at Corona, Calif., and White Oak, Md., and the Ordnance Test Station, Inyokern, Calif.; the Air Force's Air Research and Development Command and Special Weapons Command; and the Atomic Energy Commission.

Ten-Fold Increase in Facilities Forecast

Military demands expected to parallel commercial requirements. More roles for satellites seen

by **Theodore J. Meek***

Although today's long-distance communications facilities are highly congested, a ten-fold increase is forecast in the next ten years. While the increasing use of transoceanic cable offers needed temporary relief, it is to the use of satellite systems that we now must look for a potentially more permanent solution.

Not only is the need for commercial facilities mounting rapidly, but military demands are expected to parallel this growth with even greater emphasis on reliability and mobility. Satellite systems appear to be ideal.

These demands are based on presently known requirements. However, if there are additional requirements for global real-time television transmission, world-wide control and programming of aircraft, and vast data handling systems for global surveillance systems, missile test ranges and tracking stations, then the urgency is more imperative to develop and use satellite systems.

The rapid growth of the world's population and its expanding area of interest make it mandatory that all means of communication be exploited.

In the Congressional presentation of the 1960 NASA budget, Dr. T. Keith Glennan outlined U.S. objectives in the exploration of outer space and the benefits in the economic realm that could accrue from such exploration. Communication satellites were particularly emphasized in making possible transocean and intercontinental video and telecommunication services.

Satellites for communications purposes may serve simply as passive reflectors of electromagnetic waves or, with appropriate instrumentation, they may be active repeaters. In the active case a transmitted signal is received from the ground, amplified, and retransmitted at a different frequency. While each method has its own advantages and disadvantages, there are a number of problems that affect each method to a greater or lesser extent.

Major problems such as frequency considerations, effects of environment, and certain electrical phenomenon will be discussed later. But first, let's review some of the near-future satellite projects.

• **Project** *Echo*—The National Aeronautics and Space Administration will provide the first opportunity for investigating the application of passive satellite relays to global communications.

In the spring of this year, it plans to launch a 100-foot diameter inflatable reflecting sphere into orbit and to establish communication circuits using it as a passive repeater. This will be the first of three intended launchings, although NASA does not have scheduled plans at this time for the other two satellites.

The communication circuits are to be a combined effort of NASA, Jet Propulsion Laboratory (JPL), Bell Telephone Laboratories (BTL), and the Naval Research Laboratory (NRL). The JPL site at Goldstone, Calif., will transmit via the satellite on 2390 mc and receive on 960 mc. The BTL site at Holmdel, N.J., will transmit on 960 mc and receive on 2390 mc. The NRL site at Stump Neck, Md., will receive only 26 2390 mc.

The first sphere will be launched by a Delta rocket from Cape Canaveral into an orbit inclined at 50° to the equator. To aid in tracking the satellite, a beacon transmitting on 108.00 mc will be carried by the third stage rocket, which should trail closely behind the payload for the first two or three passes around the earth.

The NASA Minitrack network will establish a preliminary ephemeris. If visibility permits this will be augmented by the Smithsonian Astrophysical Observatory Optical Tracking Network.

The NASA Goddard Space Flight Computing Center in Washington, D.C., will compute the satellite ephemeris for the third pass and transmit the data in digital form to the Goldstone site. This information will control the direction of the receiving antenna, and the transmitting antenna will be slaved to the receiving antenna. The receiving system at Goldstone, being designed to receive both frequencies simultaneously, will use the 2390-mc signal to make a self-tracking system of the Goldstone transmitter and receiver.

Tracking information also will be supplied to the Holmdel antennas in digital form from the Computing Center, or, if visibility permits, by an M-33 optical tracker. The NRL receiving antenna will be positioned by the same digital data.

While it is not known what tests NASA and BTL plan to conduct once the communication circuits have been established, it would be possible for them to investigate the effects of Faraday rotation of polarization caused by the magneto-ionic properties of the ionosphere, fading caused by scintillations in the reflection from the satellite, and the effects of different polarizations.

• **Military projects**—U.S. Military plans for communications relaying earth satellites are far more advanced and sophisticated than Project *Echo*. Brought together under a single development project called *Notus* are plans to launch several delayed-time repeater satellites in low-altitude orbits, two real-time repeater satellites in po

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Meek is assistant director of telecommunications systems at Page Communications Engineers, Inc., a division of Northrop Corp. As manager of range operations, Pacific Missile Range Study Group, he has been responsible for a large part of instrumentation in addition to communications. Previously a consultant on telecom. problems, he distinguished himself in South America, Europe, and Canada. He also has been an advisor to SHAPE and several NATO commands.

A graduate of the University of Toronto, he has done post-graduate work at McGill and Chicago Universities. He is a senior member of the IRE.

lar orbits, and several real-time repeater satellites in "stationary" orbits.

The various launchings are to be accomplished under discrete tasks. Task *Courier*, which is actually a continuation of Project Score (the Christmas-1958 satellite), will launch several satellites into circular orbits at relatively low altitudes of about 650 miles. This is expected to take place over a three-year development period beginning in mid-1960.

Each of the satellites will contain a receiver, transmitter, magnetic tape recorder and playback unit, and a triggering device. As the satellite passes over a transmitting ground station, it will receive the transmission and record it. Then, as it passes over other ground stations, those wishing to receive will trigger the repeater with a coded command signal causing it to transmit the stored information.

The real-time, or instantaneous, repeater satellite will be launched into orbit under Task *Steer*. Its purpose is to provide two-way communications in the polar regions.

Task *Tackle* will follow *Steer* with a more advanced type of communications repeater. This satellite is to be launched into a 6-hour polar orbit by a modified *Atlas*, and is intended to provide two-way ground-to-air and ship-to-shore communications.

Task *Decree* is the code name for the real-time repeater to be placed in a 24-hour equatorial orbit, also by a modified *Atlas*. This orbit, at an altitude of 23,300 miles, will result in the satellite remaining fixed in relation to a point on the surface of the earth; its angular velocity will be of the same direction and magnitude as that of the point on earth.

The first repeater to be sent up is intended to relay a large number of voice channels. A subsequent, larger *Decree* satellite, to be boosted into position by a *Saturn* clustered rocket, is expected to provide even greater traffic-handling capacity. A development period of from five to 10 years has been estimated for this task.

• **System impact**—With the approach of the era of space satellites a whole new series of problems will come into existence. Probably, some as yet cannot be foreseen; others having to do with economic, sociological, and international aspects may be expected to have a vast impact on our way of life.

From the point of view of economics, it is necessary to consider the costs involved. Funds totaling $230 million have been made available to the rocket-booster program. The major part is expected to be spent on the *Saturn* booster and its most important payload may be the 24-hour communication satellite.

Development Programs for Communication Satellites

	PROJECT		ORBIT	AGENCY
Passive	ECHO		1000-MILE INCLINED	NASA
Active	NOTUS:	COURIER	500-MILE INCLINED	ARMY
		STEER	6-HR POLAR	AIR FORCE
		TACKLE	6-HR POLAR	ARMY
		DECREE	24-HR "STATIONARY"	ARMY

Until a working system is established, accuracy of cost estimates is subject to a wide margin of error. If costs for developing the means of placing the satellite in orbit are neglected, very rough figures can be estimated. For example, three equally spaced active satellites in a 24-hour orbit, arranged to provide video bandwidths for near-global coverage, might cost $100-300 million.

The sums contemplated here are not the whole picture. Ground switching equipment of a complexity and scale hitherto not contemplated will be necessary. Computers will be needed for the effective utilization of the many channels and information thereon can be expected to show how the channels can be used most efficiently.

International agreement will be necessary as far as frequency allocation is concerned. However, the possibility of international cooperation should not be overlooked in the economic realm. Since satellite communication is by its very nature international and tremendously costly on an overall basis if not on a per channel basis, there exists the possibility of international funding.

The sociological impact of the establishment of a global communication system can have far reaching effect. The increased world-wide communications may provide a lessening of world tensions. Television coverage will have a profound influence on the peoples of different nations. With intelligent use, the interchange of social customs could result in far better understanding between nations.

• **Active repeater satellite**—If a satellite is placed in an equatorial orbit at about 22,300 miles above the earth, it will rotate about the earth at the same angular velocity as the earth rotates on its axis. It then appears stationary with respect to a point on the earth's surface.

Such a satellite suffers from high-path-loss of the order of 400 db, depending on antenna considerations and frequency. However, if an active repeater is placed in the vehicle, the burden on ground equipment is greatly reduced and brings it within present-day capabilities.

Among the problems to be solved before an active satellite can be placed in a stationary orbit are methods of establishing and maintaining it in orbit, electronic and mechanical design of the payload, power supply, and methods of ensuring reliability.

Large boosters such as *Saturn* will be required to place the satellite in orbit.

Some authorities have suggested a minimum life span of the satellite in orbit as two years. As more sophisticated controls become available, it would seem reasonable to expect a longer life.

Electronic hardware must be developed specifically for this application. In spite of the fact that no extraordinary powers are contemplated, a 10-watt transmitter in the vehicle should be able to provide television channel bandwidth.

One of the main problems of an active satellite will be the provision of a power supply for the RF repeater. Both power sources and energy sources have been suggested. The power sources that convert sunlight by solar batteries into watts have a fairly low efficiency. A more radical technique using a strontium brick in a heat engine shows promise of yielding far higher efficiencies, although a considerable shielding problem would exist.

Energy sources are represented at present by high-performance batteries, but fuel cells show promise of high efficiency if the weight-size problems can be solved.

Many subsidiary problems will arise and their solution can be looked for in future development. Thus, a satellite at an altitude of 22,300 miles will have a group delay of about 250 milliseconds. Means to minimize problems associated with this condition must be looked for. Optimum methods of modulation and detection will have to be examined with particular attention to low-noise wide-band techniques for uses which will be dictated by the severe requirements of spatial communications. Deleterious effects due to Doppler shift may be expected to be a function of the particular modulation method used.

• **Passive repeater satellite**—In the passive case, very high-power transmitters and low-noise receivers are necessary. At present it appears that low

altitude orbits are most attractive because of noise considerations and suggestions have been made for the establishment of a multiplicity of satellites to provide world-wide coverage.

In an operating system, communications via satellites may not be practical for elevation angles down to zero relative to the horizon, because of the effects of the atmosphere on radio-wave transmission. Atmospheric scintillations may make accurate tracking of the signals difficult at low angles.

In addition, the temperature seen by the antenna rises sharply due to increased oxygen and water vapor absorption, and ground losses, when small elevation angles are approached. This factor is significant when exceptionally low-noise receivers are contemplated for the system. An angle of 7.25° has been suggested as the minimum elevation angle.

Some investigators have suggested that about 80 satellites would be required in an equatorial orbit at a height of 2500 miles for a reliability of visibility of 99.9% over a trans-Pacific path. This was under the assumption that the satellites would be randomly spaced.

Random spacing alone poses a problem and means of placing them in orbit to avoid excessive "bunching" needs investigation. With a guidance device, more desirable spacing could be programed requiring many fewer satellites.

In considering antennas for use in passive satellite communications, antenna beamwidth must be greater than probable satellite tracking error. Also, it must be wide enough that signals will not be greatly affected by refraction in the troposphere and ionosphere resulting in refractive scintillations and causing severe fading of the signal. The antenna mount must be able to move the antenna at the angular velocities and accelerations necessary to track the satellite.

Present techniques used in locating satellites and predicting their future position are refined to the point where azimuth and elevation angle can probably be predicted to ±0.1°, 24 hours in advance.

An examination of path loss indicates that very large antennas or improved receivers are necessary if transmitter power is to be held to a reasonable amount. Although antennas up to 600 feet appear feasible, it would seem unreasonable to use them for ground communications via earth satellites, rather than reserve them for communications.

The development of new low-noise receiver techniques in the uhf region has improved receiver noise levels to the point where noise from external sources must be considered. Receiver noise figures of 1 db are now possible at 4000 mc by using masers.

The near future certainly will see the development of parametric amplifiers to give similar noise figures in this frequency range. This corresponds to a receiver noise temperature of 76°K, which is well below the noise temperature of the ground and some extra-terrestrial sources at 4000 mc.

Receiving system losses must be minimized and the deleterious effects of antenna side lobes illuminating the ground or other nearby objects must also be recognized.

Further consideration must be given not only to man-made noise but to noise from extraterrestrial sources.

• **Frequency considerations**—Frequencies most suitable for space communications appear to be from about 100 to 10,000 mc, the lower limit being determined by galactic noise and ionospheric reflection and the upper limit by absorption due to water vapors. There appears to be a definite RF window from about 30 to 50 kmc, and above 60 kmc.

The oxygen-molecule absorption band appears to rule out transmission in the region between 50 and 60 kmc.

An extensive development effort will be required before effective use can be made of twice higher frequencies and in the meantime it will be necessary to make use of the lower band. While this is an attractive spectrum, it is being used currently by terrestrial services.

The problem of frequency interference arises even before space systems are in general use. Space communications, however, almost always involve line-of-sight transmission, and antenna directivity is one method of interference control.

The jurisdictional problem seems most difficult of solution. It will be necessary for all nations to agree on frequency assignments and on the manner in which the satellites will be used.

Finally, there are a number of important physical effects that must be explored. One of these is the effect of Faraday rotation of the polarization of the propagating wave as it travels through the atmosphere. The resulting decoupling loss at the lower frequencies will be serious. The frequency dependence of this effect should be explored carefully.

The use of circular polarization appears to be the best choice for passive satellite communications due to the effects of Faraday rotation. Among other problems, if linear polarization were used, the fading experienced at the receiver due to this effect would be severe and would require excessive margins of transmitter power.

• **Environmental effects**—A fundamental requirement of the satellite system is that it operate unattended with a very high degree of reliability. Possible sources of damage are bombardment by meteorites and high-energy particles, deleterious effects of residual atmosphere, and temperature.

No conclusive information is available on meteorite density and data on particle magnitude is conflicting. Studies have indicated that the possibility of skin puncture is very much greater than the probability of damage to components inside the vehicle.

In the case of the active satellite it has been suggested that a relatively lightweight shielding might give protection to critical elements and that the antenna might be protected with a dielectric sheet.

Besides meteorites, satellites will be subject to constant bombardment by high-energy particles from various sources such as cosmic and ultraviolet radiation, nuclear power supplies, and the Van Allen belts.

It has been postulated that damage due to primary cosmic radiation will be negligible but that secondary effects may produce damage after collision of primary high-energy particles with nuclei in the satellites' skin.

While the Van Allen belt of charged particles may not damage components, noise may be increased and the entire effect, particularly at the higher altitudes, is still unknown.

The effect of any residual gas molecules striking the surface of the satellite might be to cause sputtering by the removal of atoms from the metal surface. The normal oxide film will inhibit such effects, which are not expected to be a problem at altitudes above one hundred miles.

At stable orbit altitudes the major influences controlling temperature are the characteristics of the outer surface of the satellite, placement of heat-generating components, altitude and orbit. It is expected that temperature inside a satellite can be controlled within 40°C.

In the ionosphere it has been observed with ballistic missiles that power in excess of 3 watts to the antenna will cause ionization arc-over across the "leaky waveguide" opening used. While not strictly an environmental effect this phenomena may require delayed operation of high-powered transmitters while passing through the ionization region before a stable orbit is established.

Smaller, lighter, wider range

PNEUMATIC MISSILE REGULATORS

Shown are three pneumatic regulators from among the hundreds of sophisticated missile components developed and manufactured by Wallace O. Leonard, Inc. during the past ten years. Accommodating air, nitrogen or helium, these regulators are smaller and lighter than units of comparable capabilities, have a wide range of inlets and flows, have no buzz, and are practically insensitive to vibration and shock. Note specific performance data and parameters. These Leonard regulators are now in use on many major missile systems and in ground support.

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193000

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APPLICATION	MISSILE FUEL AND OXIDIZER TANK PRESSURIZATION. Maintains Constant Pressure During Firing Cycle.	PNEUMATIC STEERING NOZZLE SUPPLY Provides Accurately Controlled Gas Pressure to Nozzle for Missile Positioning and Stability Operations.	INSTRUMENT AIR BEARING SUPPLY Provides Precisely Regulated Gas Pressure for Guidance Components. Maintains Regulation Level and Control Over Wide Range of Inlet Conditions and Environments.
General Information	Available with Solenoid Shut-Off and Position Indicators	Integral Relief Valve Solenoid Actuation Optional	Available with Solenoid Shut-Off, Relief Features, etc.
System Medium	Air, Nitrogen or Helium	Air, Nitrogen or Helium	Air, Nitrogen or Helium
Pressure Data			
Regulating Range (Typical)	13-25 PSIG ±.5 PSIG	300-400 ±5 PSIG	30 to 55 ±.2 PSIG
Inlet Pressure	3000 to 600 PSIG	3000 to 600 PSIG	3000 to 200 PSIG
Proof	4500 PSIG	4500 PSIG	4500 PSIG
Burst	7500 PSIG	7500 PSIG	7500 PSIG
Flow	5-40 lbs./min.	6-24 lbs./min.	8 to 20 SCFM
Leakage			
Relief Port		10 cu. in./min.	2 cu. in./min.
Internal	10 cu. in./min. (when shut off)	10 cu. in./min.	1 cu. in./min.
External	Zero	Zero	1 cc/hr.
Temperature Range	—65° to +165° F	—65° to +165° F	—65° to +165° F
Vibration	MIL-E-5272, Proc. 1	MIL-E-5272, Proc. 1	MIL-E-5272, Proc. 1
Acceleration	20 G's (1 plane)	20 G's (1 plane)	20 G's (1 plane)
Weight	3.5 lbs.	3.7 lbs.	1.45 lbs.

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Market near $450 million in FY '60 . . .

Automatic Test Equipment Burgeons

Sophistication and poor relation of checkout with weapon are major problems hiking costs

by Charles D. LaFond

A hard look at today's automatic test equipment reveals an endless variety of systems. The field becomes kaleidoscopic as the view is narrowed —there is agreement on overall summetry, but the system appoaches are different. The field is still so new that none of the users are convinced yet as to which approach is really best.

Five years ago, a few farsighted manufacturers faced up to an inevitable problem in logistics. They determined that with the ever-increasing complexity in all types of electronic and weapon systems, the need for specialized test equipment would overprice already costly sophisticated systems. Testing time, manpower, and reliability requirements demanded a more practical approach to factory and field checkout procedures.

Their concept—a universal automatic test system—was not new; only the incentive of a potentially broad market was required to advance it from dream to reality. Progress since has been rapid.

• **Today's market**—Consider only the missile/space market and you find a highly lucrative sales area. Total FY 1960 expenditure approaches $7 billion. Missile support equipment will require roughly $3 billion—and half of this is for electronics systems. Depending on how you define it, automatic test equipment expenditures should reach nearly $450 million, or 30%, during FY 1960. And this is only a beginning.

True, more selectivity in missiles may be the policy as time goes on; but, while there will be fewer missile types, more of each type will be produced as it achieves operational status. With greater dispersion of the missile arsenal, more checkout units will be needed in the field to assure readiness.

By-products of those proven military devices will surely appear throughout many other industries. The potential there may be tremendous, but a "guesstimate" is hardly worthwhile until more is known about today's equipment applications and limitations.

• **Costs**—A survey performed by The Rand Corporation showed that the five-year maintenance cost for one weapon system was more than 10 times original system cost. The total included costs of support equipment, technician training, and spare parts provisioning.

The Rand study also indicated that lower downtime for complex systems adds excessively to overall costs because of the spare systems needed to assure constant combat readiness.

The use of automatic checkout equipment may solve many of these problems. Stromberg-Carlson recently stated that application of its SCATE in testing one complex system reduced a 12-hour manual test program to five minutes. Similarly, Convair-Pomona found that the use of its BOFTE system for *Terrier* checkout reduced total time by 75%. Cost per test dropped 97.5%. Costs of the automatic system approximated total cost of all individual, special, test units previously used.

• **Characteristics similar**—Successful checkout equipments in use today have many attributes in common. They reflect the practical advantages of automation and current fabrication techniques:

1) Initial self-checking, continuous self-verification, and fail-safe features assure high reliability and confidence.

2) Employment of stimulus-response patterns for testing provides consistant and complete performance of test sequences for fault location from subsystem to part.

3) Standardized test procedures and permanent output record provide coherent history for subsequent analysis and evaluation.

4) High-speed testing permits precise dynamic performance measurements where it previously could not be evaluated adequately (servo systems).

5) High-speed testing saves useful operational life of systems under test by reducing test time.

6) Standardized modular construction assures ease of modification or system expansion.

7) Automatic checkout cuts total manpower requirements, reduces required skill levels of operating personnel, and minimizes human error.

• **Problems**—Many observers feel that developments may have exceeded today's requirements. Increased sophistication in checkout systems has brought an even greater cost increase.

With the exception of Lockheed's ACRE (for *Polaris* checkout, surveillance, and countdown)—which is probably tops in current sophistication and cost, the automatic checkout systems finding broadest use are those employing proven parts and circuits, resulting in low development costs.

Yet the Air Force reportedly has written its automatic checkout equipment specification, MIL-T-26664, around North American's GS-1A system. This is a fully transistorized, complex system capable of testing a vast number of functional systems at high speed. It is an evolutionary basic system resulting from development and use of two earlier systems dating back to 1955.

Still high on the list of problems is the urgent need for early marriage of checkout system with weapon system. Without this, costs are unnecessarily raised and test efficiency is lowered. An awareness of the problem, at least, exists now; the new generation weapon systems will reflect this philosophy in their initial design. The situation can be corrected only in part with new members of old missile families.

Other developments needed to solve existing problems are:

• Cheaper and more adaptable test units.

• Better but not necessarily more complex fault-isolation techniques.

• Programable stimulus generators flexible enough for broad application—preferably a "family" of standardized adapter modules.

• **Human engineering**—One area in automatic test equipment development receiving increased emphasis is "human engineering." This may merely reflect a general trend in industry to place more weight on this aspect of design.

Chief purpose, of course, is to insure final designs offering the equipment configuration most efficient for both operation and maintenance.

A major proponent of this approach has been Stromberg-Carlson, particularly in its development of the SCATE system. The company also en-

listed the aid of consultants from Dunlap & Associates and Courtney & Company, specialists in human engineering.

Engineering-psychological parameters considered were such design factors as character legibility, brightness, position determination, accessibility, and operator comfort. Indicator knob and button characteristics were determined by a combination of factors: use frequency and sequence, visual intensity of light sources, and all necessary anthropometric, motor, and visual data. The final effort was to develop the most efficient operating and maintenance procedures for the man-machine system.

• **System descriptions**—With the many systems currently in use, there are naturally many differences—some unique. The accompanying chart is a breakdown of the manufacturers of major checkout equipments and the missiles with which their systems have been or will be associated.

Some of the individual characteristics of many of these systems are described briefly below (the "standard" characteristics listed above apply to each unless otherwise noted):

• ACRE, Automatic Checkout and Readiness Equipment, is a joint Lockheed, Packard-Bell effort. As indicated earlier, this is a most ambitious development—highly sophisticated and functionally ambidextrous.

Actually, there are two systems: ACRE-SSBN, for tactical use aboard *Polaris*-armed submarines; and ACRE-Octopus, for factory and depot use.

Initial programing is with magnetic or perforated tape input to a magnetic-drum memory. A magnetic-core buffer permits temporary storage of test data.

The system will not only perform the more "conventional" missile tests; it performs continuous readiness checks and final countdowns.

For maximum reliability, dual redundancy is incorporated in the system design.

• In reviewing Radio Corp. of America's checkout developments, a swarm of acronyms soon results. Nevertheless, here is a rapid summary:

Out of a 1955 Army Ordnance contract to RCA for a comprehensive R&D program to standardize guided missile test equipments came certain design criteria. From these, RCA developed DEE, Digital Evaluation Equipment. Together with MEE, Mechanical Evaluation Equipment, the program evolved into MPTE, Multi-Purpose Test Equipment. The program now is called GEE, for General Evaluation Equipment.

DEE is a basic electronic checkout system for third and fourth echelon maintenance. It is transistorized and has a high density magnetic tape storage input.

A unique feature is a provision for waveform analysis: pulse widths 0.2 to 10 μsec.$\pm$10%; pulse amplitude 0.5 to 200 volts $\pm$10% (slope and tilt linearity accuracy of $\pm$2.5%); rise time 4 μsec to 0.2μsec. $\pm$5%.

• SCATE, Stromberg Carlson Automatic Test Equipment, has enjoyed broad usage. Transistorized, it uses perforated-tape programing.

The system is largely self-adjusting and self-calibrating. It features simple and relatively low-speed operation with high measurement accuracy: dc voltage to 0.01%, frequencies to one part in 10^5 or better.

• DATICO, Digital Automatic Tape Intelligence Checkout, was conceived by Nortronics Div. of Northrop Corp., in 1956, born in 1958. Since that time it has had broad usage.

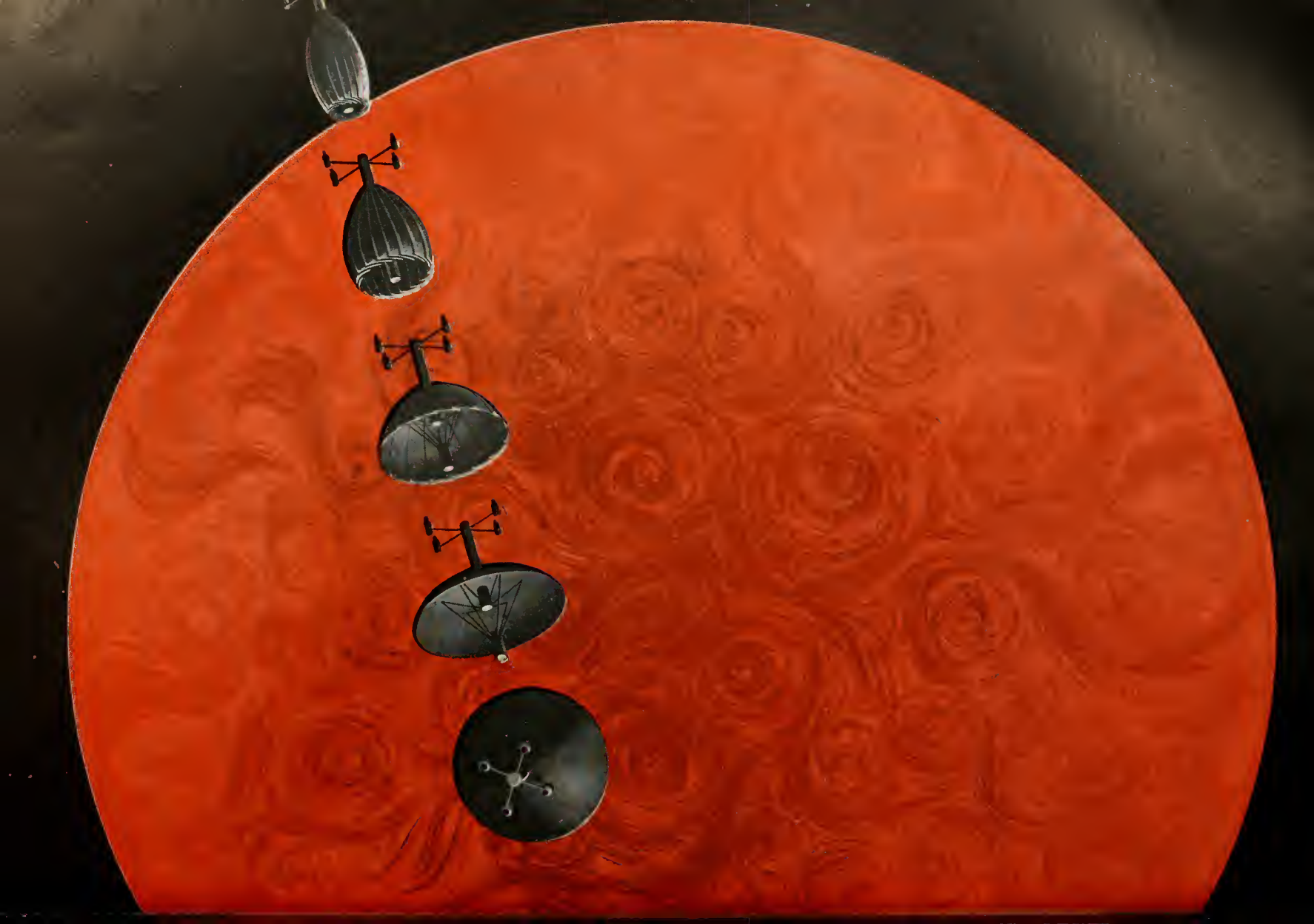
Generally unsophisticated, it is a low-speed system, simple and reliable. Programing and control are by perforated tape and patchboard.

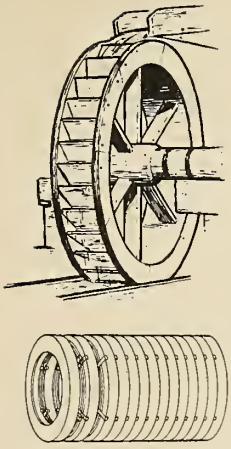
NORSCAN, Nortronics System Computing Analyzer, skips several evoultionary steps in comparison with DATICO. This is an all-transistorized prototype employing solid-state switching. Very high-speed, it features perforated tape initial programing, magnetic drum storage, and a core buffer.

A stored "confidence index" will provide a scale against which readings

Missile Systems and Test Equipment

	ATLAS	BOMARC	CORPORAL	CORVUS	FALCON (Series)	HAWK	HOUND DOG	JUPITER	LACROSSE	MACE	MATADOR	MINUTEMAN	NIKE AJAX	NIKE HERCULES	NIKE ZEUS	POLARIS	QUAIL	REDSTONE	SERGEANT	SIDEWINDER	SNARK	SPARROW III	TALOS	TARTAR	TERRIER	THOR	TITAN
AUTONETICS, N.A.A.							■					■															
BEHDIX RADIO DIV.										■																	
BENDIX-YORK DIV.																							■				
CHRYSLER CORP.								■										■									
CONSOLIDATED SYSTEMS CORP. – C.E.C.	■																										
CONVAIR POMONA																				■				■			
DuMONT								■														■					
EPSCO	■														■										■		
GOODYEAR										■																	
HUGHES AIRCRAFT CO.					■																						
HYCON																								■			
ITT – FED. DIV.		■																									
LOCKHEED & PACKARD BELL																■											
MARTIN – BALTIMORE										■	■																■
McDONNELL																	■										
MINN.-HONEYWELL	■																										
MOTOROLA		■																									
NORTRONICS			■			■			■				■	■		■			■		■						
PHILCO CORP.																				■							
RCA	■																										
RADIATION, INC.	■	■																									
SPERRY RAND																			■								
STROMBERG CARLSON	■	■													■												
TEMPCO				■																							





Solar energy conversion: Through recent advances in materials and electronics, we are on the threshold of a new era of energy utilization. By concentrating solar radiation into the cavity of a thermionic converter, electrical power is generated directly from sunlight without moving parts or circulating fluids. This freedom from earthbound energy sources promises far-reaching applications in space exploration. Artist's concept shows the unfolding of a solar collector mirror with its central power package which would be attached to various types of space vehicles. Lockheed design of thermionic converter operating model is shown at left. The water wheel depicts one of man's earliest known forms of energy conversion.

THERMIONICS

EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY

The development of new techniques in energy conversion is typical of the broad diversification of work at Lockheed Missiles and Space Division. The Division possesses complete capability in more than 40 areas of science and technology — from concept to operation. Its programs provide a fascinating challenge to creative engineers and scientists. They include: celestial mechanics; computer research and development; electromagnetic wave propagation and radiation; electronics; the flight sciences; human engineering; magnetohydrodynamics; man in space; materials and processes; applied mathematics; operations research and analysis; ionic, nuclear and plasma propulsion and exotic fuels; sonics; space communications; space medicine; space navigation; and space physics.

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Lockheed

MISSILES AND SPACE DIVISION

Systems Manager for the Navy POLARIS FBM; the Air Force AGENA Satellite in the DISCOVERER Program; the MIDAS and SAMOS Satellites; Air Force X-7; and Army KINGFISHER

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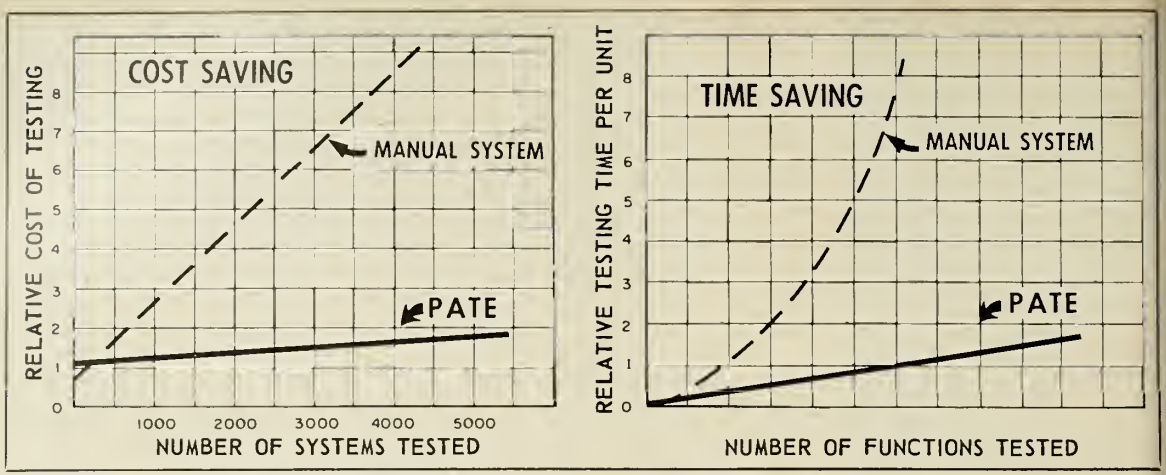


COMPARISON OF COST and time savings of Motorola's PATE to a missile system. Motorola developed an earlier checkout system for the Navy's *Terrier* antiaircraft missile.

may be compared to provide an indication of how good a "GO" readout really is.

• The Curtiss-Wright DEMON, like NORSCAN, is a highly advanced solid-state system. Programing is similar, with magnetic tape used for storage. A buffer memory provides timescale changing from the 12,500-character/sec main storage rate to a random rate.

• PATE, Programed Automatic Test Equipment, developed by the Military Electronics Div. of Motorola, Inc., Phoenix, is the result of a program dating back to 1955. An early checkout system was developed for Convair's *Terrier* missile. More advances came with development of TGSE system for the B-58 Hustler 1FF packages. This was tape controlled with sophisticated pulse-tape measurement units.

Finally, the more flexible PATE evolved for use with the *Bomarc* data link. Primarily solid-state, it has minimal switching characteristics and uses a mechanical tape reader, but can be provided with an optical reader for increased speed. Programing is digital with perforated tape. No storage unit is provided.

A particular feature of the system, according to Motorola, is that it can measure, in terms of synchro voltage, instantaneous shaft position and instantaneous angular velocity to an accuracy of ±0.05°. System measurements are accurate to 0.001% full scale.

• The GS-1A and the more complex C2-49A automatic checkout systems, developed by Autonetics Div. of North American Aviation, are fully transistorized.

Completely self-contained, these high-speed systems make use of a complete initial self-test routine and four separate self-verification checkout procedures during operation.

Both use digital techniques and perforated-tape programing. They have evolved out of an earlier GS-1 and the Mark II Automatic Tester, first developed for *Navaho* back in 1955.

• BOFTE, Bureau of Ordnance Fleet Test Equipment, developed by Convair-Pomona, is a relatively low-cost high-speed system. The Convair approach is somewhat different from most other checkout systems.

It employs Remington Rand punch-card programing. Missile systems under test are energized only during the performance of the tests. Output is stored in a magnetic-core memory unit. Readout and evaluation are performed after missile-systems shutdown.

• RACE, Rapid Automatic Checkout Equipment, was originally developed by Sperry Microwave Electronics Div.—Sperry Rand Corp. for the B-58 Hustler's bombing/navigational system. It can provide an analog voltage or digital output. A high-speed system, it is programed with perforated tape.

In use with the *Sergeant* surface-to-surface missile, a special time generator provides base and control for all timing operations. Time base is with a 1-kc transistorized oscillator, accurate to 0.001%. The generator itself is accurate to 1-msec. and has 5-msec. repeatability.

• TATTE, *Talos* Automatic Tactical Test Equipment, is a Bendix-York Div. system.

Using perforated-tape programing, it was designed for both depot and shipboard use. An initial self-check can be programed into the system, but thereafter verification is manually actuated at the operator's discretion.

A *Talos* simulator also has been developed by Bendix for use in checking out TATTE and for training purposes. It simulates several models of the *Talos* missile.

• The AN/DSM-32 is a low-cost system A. B. DuMont Laboratories, Inc., designed for guidance and distributor parts of *Jupiter* missile checkout.

To reduce circuit complexity and overall size, yet retain flexibility, DuMont used patchboard programing. Because it employs analog-computer patching techniques, total test functions are somewhat limited.

There are also some advantages. For example, the scanning sequence can be optimized without time-sequenced programing inputs since all plugboard contacts are available simultaneously. Stepping switches can therefore be used on a single-incremented basis —one step per test. Test sequence is fixed, and stepper hunting is eliminated.

• The AN/DSM-54 and -55 Missile Test Sets are two similar systems developed by Hycon Mfg. Co. for the Navy's *Terrier/Tartar* group. These too are lowcost equipments designed for broad flexibility and maximum use of Federal standard parts.

Programing is by perforated tape. It also uses replaceable overlays to modify panel nomenclature for different missiles or types of tests.

• Guardian, also transistorized, is a high-speed system using digital techniques. Developed by Monitor Systems, Inc., a subsidiary of Epsco, the system has one particularly unique characteristic. It employs an "urgency selector" which offers the operator two or more alternate test routines depending on the degree of urgency of the previous test result.

• The UG-897 Systems Analyzer was designed by Minneapolis-Honeywell for the McDonnell F-101B flight checkout. Relatively low-speed, its developers believe it offers unusually high reliability and simplicity.

Bright Future But New Demands

by Hal Gettings

The future of telemetering is very bright, according to the authors of the newest book on the subject.* They say that "as long as there are experiments conducted remotely, involving any form of measurement, telemetering will always be in demand. With the whole vast realm of space to be explored . . . there seems little chance that telemetering . . . will be adequate for very long at a time. The conditions and environments of the future telemetering's operations should . . . provide challenging problems for many new generations of telemetering engineers."

In spite of the rosy picture painted, there is doubt in some quarters that telemetry is progressing at the rate necessary to keep up with its vital function. As pointed out in a previous article, (M/R, Oct. 5, 1959), lack of unity and coordination among those concerned with the field has been a major roadblock. Efforts to solve this problem—although still continuing—have not met with much success.

The first phase of such a program—establishment of a telemetering information and analysis center at George Washington University—so far has found no agency willing to underwrite expenses. A survey of members of the National Security Industries Association showed a considerable number of organizations with definite interest in the project—some with sufficient interest to offer to contribute financial support.

Apparently what is needed at this point is a body of some sort to pick up the project and see it through to operating status. Just who or what this body would be composed of seems a moot question.

Besides serving as a clearing house for information, the proposed center would maintain a continuing analysis of telemetering on a national scale to ascertain gaps in the state of the art, recommend new programs, and evaluate existing or proposed programs to avoid duplication of effort and unprofitable investigation.

• **Digital systems**—Typical of the uphill fight for progress in telemetry is the slow evolution of digital systems. Although many authorities agree that such systems—using pulse code modulation—have the most promising potential, evolution has been slow.

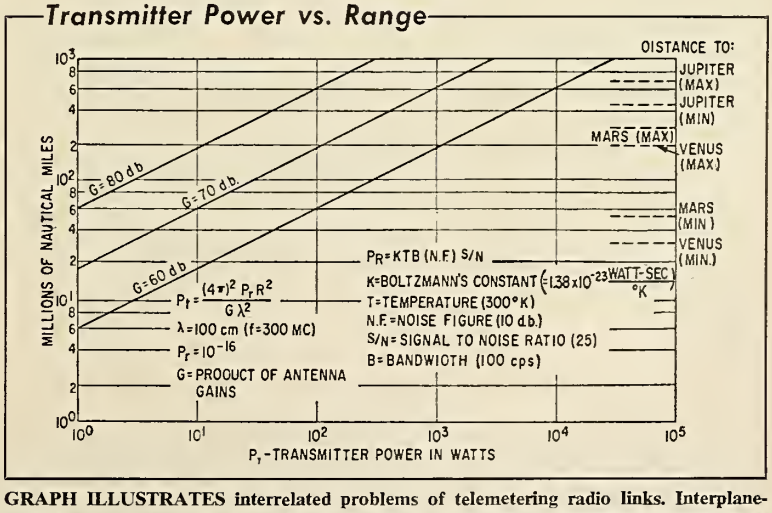
Techniques were fully developed years ago, and major subsystems have already been proved in use. It will probably be a year or more, however, before the first complete PCM system, built for the *Minuteman,* will fly in a missile. Airborne hardware development has been one problem, but the lack of coordination among manufacturers, missile makers, and range operators has been responsible for much of the lagging evolution.

• **Re-entry telemetry**—Possibly one of the most significant advances made during the past year was the development of techniques to overcome the problems of direct re-entry telemetry. Several companies have done extensive research on this vital phase. No one claims to have found the complete solution but progress undoubtedly has been made. Transmissions have been successfully received during the re-entry phase at frequencies in the 30-50 kmc range. Other experiments in the 3-30 mc band show promise but, due to component failure, have not been fully evaluated. Research in higher-frequencies techniques leads experimenters to believe that two-way communication between earth and re-entering vehicles is a reasonable hope.

• **Transmission fadeouts**—Another problem getting increased attention has been the telemetry blackouts experienced during ascent of some ICBM's. This transmission loss generally occurs during the final boost phase and appears to be closely associated with velocity. Researchers believe that the phenomenon may be caused by partial ionization due to heat generation—similar to the re-entry problem—and attenuation caused by the rocket flame.

As rockets reach higher altitudes, the propulsion flame changes from the familiar slender pillar to an almost hemispherical shape. And, as it goes higher, the "look-angle" of the receiving antennas increases to a near vertical—in effect, they look right up the missile's tail pipe. In addition, antenna arc-over sometimes occurs at certain altitudes.

The flame fan-out is believed to change the electrical structure of the antenna and materially affect its radiation pattern. One solution being investigated is a change in transmission frequencies. Another theory is that low-



GRAPH ILLUSTRATES interrelated problems of telemetering radio links. Interplanetary distances require high antenna gains for practical-level transmitter powers. Low power levels necessary for long-time transmitting capability make better antennas and more sensitive receivers mandatory. (Graph courtesy GE Defense Electronics Div.)

* *P. A. Borden, W. J. Mayo-Wells,* Telemetering Systems, *New York, Reinhold Publishing Co., 1959.*

	Transmitters	Receivers	Commutators Multiplexers	Converters	Subcarrier Oscillators	Discriminators	Amplifiers	Transducers	Antennas	Systems
ARF Products	X	X								
ASCOP	X	X	X	X	X		X			X
Adoge, Inc.			X	X						
Adler Electronics	X	X					X			
Advance Electronics	X	X					X			
Aero Guidance	X	X								
Aerolab			X		X					
Aeronutronic	X	X								
AlReseorch								X		
Airflyte			X	X						
Amelco	X	X								
American Electronics	X	X								
Americon Missile Prod.	X								X	
Anderson Labs.	X						X			
Antenna System, Inc.									X	
Arnoux			X	X			X	X		
Avco	X	X							X	
BJ Electronics								X		
B-L-H									X	
Beckman			X	X						
Bell Aircraft							X	X		
Belock Instr.			X	X				X		
Bendix Aviation	X		X	X		X		X	X	X
Blair Knox									X	
Bourns								X		
Brush Instr.						X	X	X		
Burroughs			X	X						
CEC				X				X		
CG Electronics		X	X	X						
Canoga	X	X								
Centronix	X	X				X				
Cleveland Met. Spec.			X		X					
Collins	X					X				
Colvin Labs.								X		
Cooper Dev.					X		X			
Crescent Eng.								X		
Curtiss-Wright				X	X					
Data-Control	X	X			X	X				X
Daystrom			X	X				X		
Dynatronics									X	X
Dorsett										X
EMR					X					
Electro Instr.			X	X			X			
Electronic Comm.		X		X	X		X			
Electro-Tech.			X							
Epsco			X	X						X
FXR						X				
Foirchild				X			X		X	
GE									X	X
Gobriel									X	
General Bronze									X	
General Devices	X	X	X	X	X		X			
General Electronic	X	X								
Giannini				X				X		
Goodyear									X	
Gulton	X	X		X			X	X		
Hallamore	X	X							X	

	Transmitters	Receivers	Commutators Multiplexers	Converters	Subcarrier Oscillators	Discriminators	Amplifiers	Transducers	Antennas	Systems
Hallicrafters	X	X		X						
Hoover				X	X		X			
ITT Labs.	X	X								
Kaiser	X						X			
Kauke				X			X			
Kearfott			X	X			X	X		
LEL	X	X			X		X			
Land-Air		X		X				X		
Leor					X			X		
Leonord								X		
Litton	X	X					X	X		
Lockheed	X	X							X	X
Martin										X
W. L. Maxson					X				X	
Melpar										X
Midwestern Instr.				X	X		X			
Minneapolis-Honeywell	X	X			X	X	X	X		
Moore Assoc.	X	X		X						
Motorola	X	X			X					
Mycalex		X	X							
Narmco									X	
Nems-Clarke		X								
Pacific Mercury				X	X					
Packard-Bell		X	X	X						
Ralph M. Parsons	X		X	X						
Philco	X	X		X					X	X
RCA	X	X								
Radiation Inc.	X	X	X	X	X			X	X	X
Raytheon		X		X			X			
Rheem				X			X			
Rotary Devices			X	X						
STL										X
Seeburg		X	X				X			
Servo Corp.		X								
Servomechanisms			X				X	X		
Singer Mfg.								X		
Space Electronics										X
Standord Controls								X		
Statham							X	X		
TACO									X	
TRW	X	X		X			X		X	
Tober Instr.								X		
Telechrome	X	X		X	X		X			
Telecomputing				X			X			
Telectro				X		X	X			
Tele-Dynomics										X
Telerad	X	X					X			
Texas Instr.	X		X	X	X		X			X
U.S. Science	X	X						X		
United Electrodynamics	X			X	X		X			X
Vector Mfg.	X		X		X	X	X			X
Vinson Mfg.								X		
Vitro			X	X						
Waugh Eng.	X	X								
Westinghouse	X	X								
Wlancko			X					X		

Manufacturers of Telemetry Equipment

The information presented in this chart was gathered from a number of sources: catalog and directory listings, advertisements, company literature and previous editorial coverage. In many cases, because telemetry and missiles are still young industries, areas of interest are sometimes poorly defined in relation to each other. Consequently, it is possible that some companies that should be included have been omitted. The purpose of the chart, however, is to indicate the varied types and numbers of organizations involved in radio telemetry as a vital part of our missile and space program.

ering the power output—as opposed to brute-force methods which call for increased power to overcome the loss —may be of benefit.

The look-angle problem may be solved by developing better receiving antennas and more sensitive receivers and by locating antennas to provide better tracking angles and backup.

In any case, the period of approaching burn-out is a critical one in the missile trajectory. Accurate telemetry data is extremely important at this stage; much investigation seems warranted to insure its reception.

• **Reliability vital**—Most experts agree that in telemetry, reliability is of transcendent importance. Other missile components or systems may fail but the telemetering equipment must work at all times and under all conditions. Paradoxically, however, most equipment is an economic compromise. Limited funds are available to develop better systems, and no missiles are flown to test telemetry. Instrumentation is usually left until the final stages of a missile design, with the result that proven systems—although often obsolete and inadequate—are stuffed into the bird in whatever space is left.

Reliability is receiving increased attention in this field, however, and many feel that the trend toward transistorization will be especially beneficial. One example is a transistorized phase-lock discriminator with a reliability factor four to five times better than its conventional predecessor.

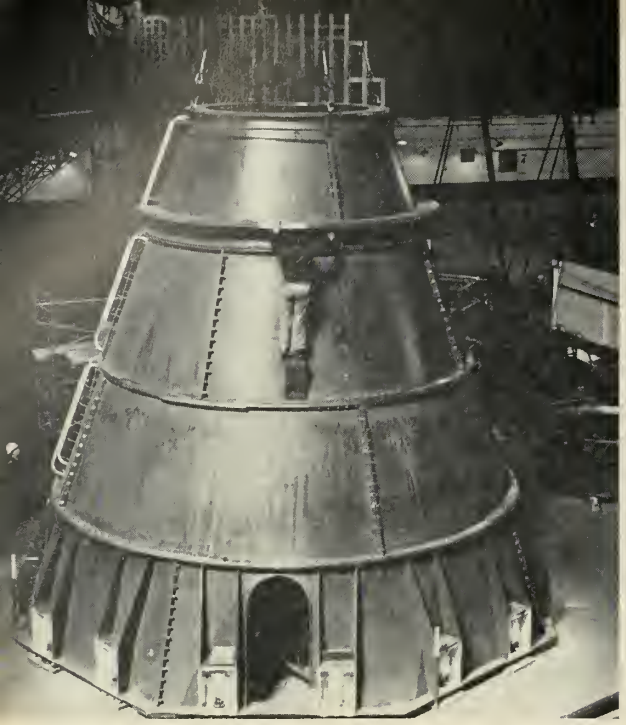
The trend toward transistors is becoming more pronounced in both airborne and ground systems. In addition to increased reliability, reduced volume and weight are important.

• **Molecular electronics promising**—The just-arriving field of molecular electronics may also contribute significantly to reliability and space-saving in telemetering equipment. Tiny units already demonstrated can sense radiation and emit an r-f signal proportional to the impact. Such units could monitor light and heat intensity and other radiations from almost any portion of the electromagnetic spectrum.

Some feel, however, that costs will probably preclude use in telemetry equipment for a long time. Mass production will have to be developed before molecular electronics will be economically practical for such purposes.

Considerable optimism has been expressed that tunnel diodes can be used in various telemetering applications. Here again, costs are a factor; they must be reduced drastically.

The trend toward automated checkout, with its increased accuracy and reduced checkout time, will be a boon to telemetry, as will increased use of parametric amplifiers.

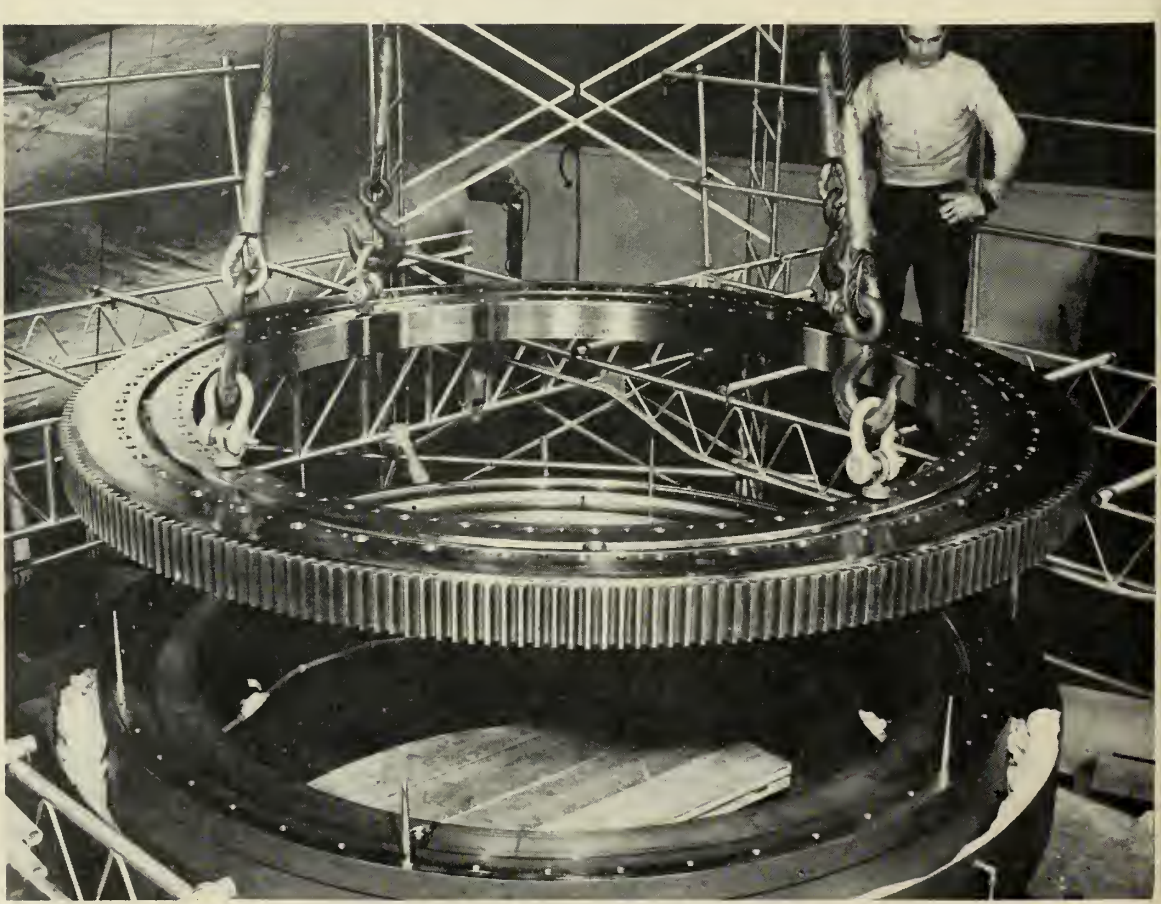


Building Antenna

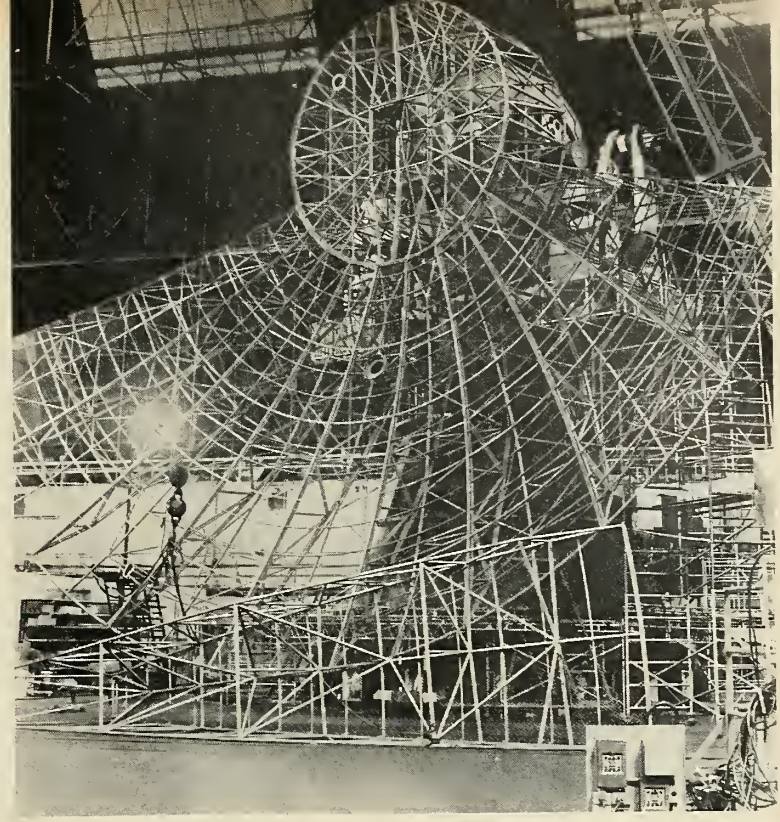
Huge first structure completed by Goodyear is being tested by RCA

←

FIRST STEP is erecting the pedestal. Only partially completed here, the 50-foot high supporting structure for the BMEWS radar tracking antenna already begins to overshadow the men working on it. Goodyear used steel up to 1″ thick in forming the pedestal. Entire equipment, including antenna, weighs 375,000 lbs., is one of world's largest.



or BMEWS



CONCAVE TRACKING antenna has 24-pie-shaped sections. The 400-pound aluminum sections are bolted into place one-by-one. Sections are interchangeable, augmenting system maintenance.

ANOTHER BIG task is installation of rotating gear. Here riggers lower steel ball bearing into supporting ring on which entire weight of antenna rests. Bearing is 10½ feet in diameter and weighs more than 9000 pounds. Ring weighs 10,600 pounds and 75 three-inch steel balls are nested in it.

GOODYEAR MAINTAINED close tolerance—three sixteenths of an inch—in building sections of the antenna. Two workmen are almost lost in the spider-web maze created by the aluminum mesh.

Industry Stresses Practical Engineering

Payoff shows in first-generation missiles with their high degree of accuracy and reliability

by J. Stubbs Walker*

LONDON—The outlook of the British government's research departments and industry's engineers has been "simplify, ruggedise, then simplify again." This kind of thinking has paid off in a high degree of accuracy and reliability that is not only claimed but has been test-proved in the "first-generation" missiles now coming off production lines.

With its extensive background of radar development dating back to the early 1930's, Britain's electronics industry has been well-founded to meet the challenging problems of missile guidance. There are still plenty to be ironed out, for at least two new problems crop up to every one that is solved.

But the electronic hardware now in operation on guided missiles like *Seaslug, Bloodhound, Thunderbird* and *Firestreak* is a good measure of the straightforward practical engineering approach that has underlined the governmental and industrial attitude to British weapons systems.

Security restrictions in Britain permit little to be said about the "second-generation" weapons now being prepared for production, but the broad picture is one of reasonable satisfaction, with one or two impressive breakthroughs and no mean measure of success in catching up in those fields (transistors, for instance) where America had an undoubted lead.

• **Klystron success**—An outstanding recent success is the development of the high-powered klystron, which opens up new possibilities in the illumination of missile targets with a continuous-wave beam instead of a pulsed beam. Previously, the c.w. power developed by the klystron was limited to some 200 watts, but it is said that the new tubes can handle "many times" this amount of energy. Unfortunately, information concerning precise power-handling capabilities has not been released.

Continuous-wave illumination of targets is not in itself new; it is used, for instance, in the semi-active guidance of the U.S.'s Raytheon *Hawk*. Until the development of the new tube, however, it was not possible even to approach the ranges at which targets can be indicated by pulse techniques.

The advantages of c.w. illumination are several. It is much less susceptible to countermeasure interference and the beam can be contained in a somewhat narrower frequency than the pulsed beam giving an improved signal-to-noise ratio.

Though no official indication has yet been given, my opinion is that this type of illumination may well be brought into operation with some of Britain's later weapons.

• **Tubes vs. transistors**—Most British missiles now on the production line are using airborne electronics which are almost 100% tube-operated. This is because British tube manufacturers had developed a range of ultra-rugged thermionics whose performance and reliability had been proved, whereas the failure rate of transistors under the stern environmental conditions of rockets was still to be evaluated.

Transistors, however, are now being introduced pretty generally in all but the r-f circuits of the missiles being prepared for the production line. In intermediate-frequency and control circuitry they have been tested sufficiently to show an extremely low failure rate even under conditions considerably more cruel than those normally met in actual flight condtions.

Achieving component reliability has, of course, been a considerable headache which was hardly eased by the fact that in the early days of missile development, somewhat extravagant requests were made by government departments for components made to specifications far and above those really required.

These high-flown requests, however, put the component manufacturers on their toes, with the result that both in stability and reliability, the Radio and Electronic Component Manufacturers' Federation claims, the U.K. "bits and pieces" for missile electronics are ahead of anything else in the world. It is at least significant that British specifications for the highest grade electronic components have now been accepted as international standards.

• **Thin-film**—At the London exhibition of the Physical Society in January there were some interesting examples of microminiaturisation produced by the Royal Radar Research Establishment (RRE), at Malvern, Worcs. These may well come to affect missile-borne electronics.

Though the examples were by no means approaching the ultimate in miniaturisation, they were worth noting—for with a component density of 2,000,000 parts per cubic foot RRE claims a fault rate of 0.01% per 1000 hours.

The components are in the form of thin films deposited by vacuum evaporation. Resistances consist of nickel-chromium films about 75 angstoms thick which are processed to give values up to 100,000 ohms in an area 5 mm square. Capacitors made in the form of a sandwich of thin metal films, with magnesium fluoride as dielectric, are built up to a capacity of 2000 pF at 25 volts d.c. in an area of 5 mm square.

"The immediate objective," says RRE, "is to scale down transistor circuits by at least 10:1 in both size and weight."

Transistors and diodes are fabricated on the microminiaturised circuits in flat form. One of the problems here is that of perfecting a satisfactory cir-

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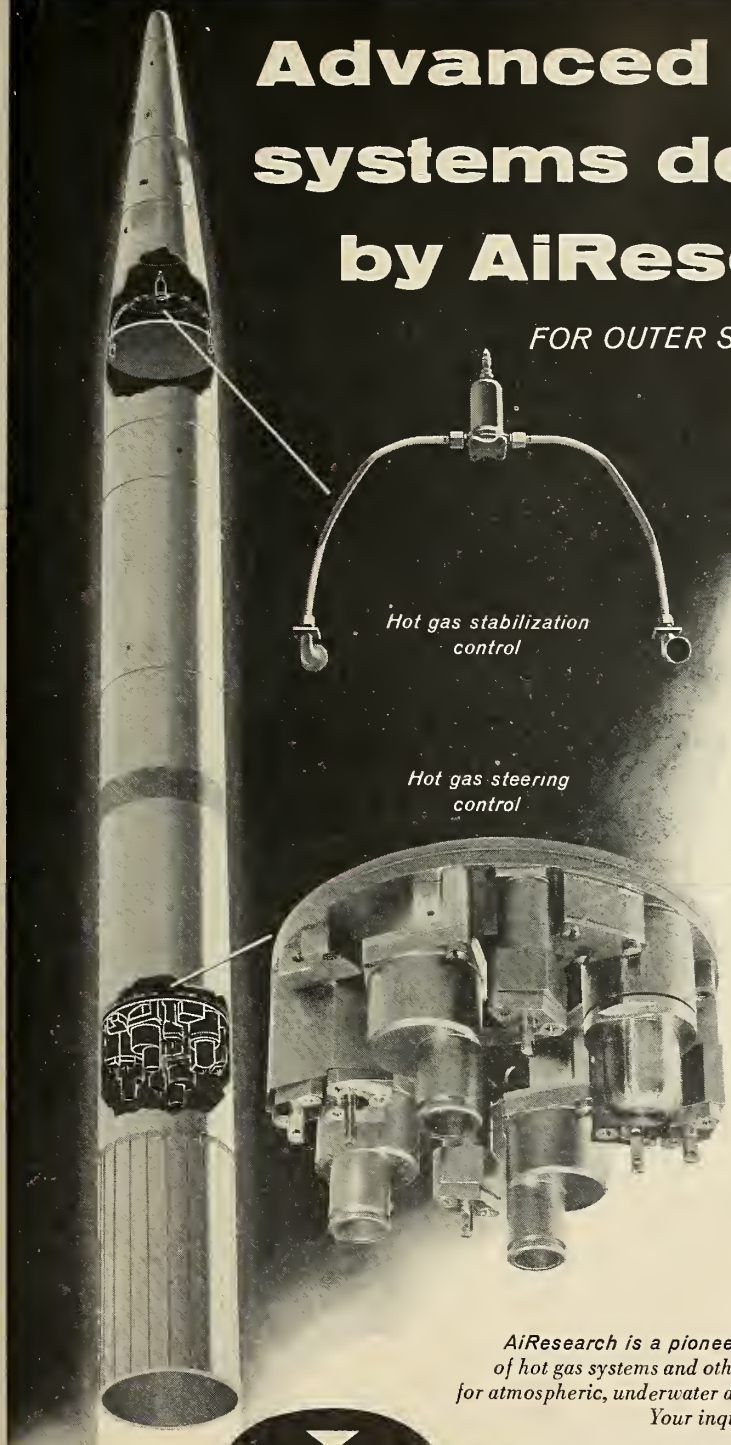
**J. Stubbs Walker is a writer and broadcaster, specializing in electronics and closely associated with the industry in Britain. After war service as an RAF squadron leader, he was for eight years science editor of the Daily Mail, London. Previously he was aviation correspondent of the Daily Herald and of the Sunday Times. Mr. Walker was specially commissioned by the Electronic Engineering Association in England to write this article for M/R.*

Advanced hot gas systems delivered by AiResearch

FOR OUTER SPACE, ATMOSPHERIC AND UNDERWATER STEERING



AiResearch is now in production on two greatly simplified hot gas steering control systems: a reaction control system for outer space flight stabilization and a hot gas actuator control system for terrestrial steering (in the atmosphere and under water).

Both systems eliminate any need for pumps, heat exchangers, accumulators and other apparatus required in earlier control systems. And both systems utilize hot gas, operating off either the main engine or a separate fuel source.

The gas in the outer space reaction control system is fed into a set of nozzles which imparts spin to the missile to stabilize its flight through space.

In the terrestrial hot gas actuator control system the gas is fed into an on-off controlled linear actuator which moves the fins controlling the missile's attitude in the atmosphere or under water. This system also utilizes a concept developed from the AiResearch hydraulic "printed circuit." This approach eliminates complicated plumbing, thereby decreasing the weight and increasing the reliability of the system.

AiResearch is a pioneer, leading developer and manufacturer of hot gas systems and other nonpropulsive power systems for atmospheric, underwater and outer space missions. Your inquiries are invited.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

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

cuit substrate. Present samples are on glass, but ceramic bases would be an improvement if and when materials with sufficiently smooth surfaces can be developed.

The same research unit—Royal Radar Research Establishment—has done much of the U.K. development work on infrared detectors for guided missiles—used, for instance, in the de Havilland air-to-air weapons. This has proved a fruitful line of research, and RRE has been backed up industrially by the Mullard organisation in a joint governmental-industrial approach to the problem.

Unfortunately, the indicative facts and figures on the efficiency of these devices (like so many of the other more interesting things about rocket electronics) are not available. High resolution with very small aerials is the obvious advantage.

• **Test equipment**—It is easy to focus too much attention on the actual guidance electronics of weapons, both airborne and groundbased, at the expense of the test equipment required in all phases of its design, manufacture and field operation. Reliability of the guidance is, of course, vital, but it is basically dependent on the reliability of its test equipment.

Both in Britain and the United States, there have been embarrassing situations when rockets have been pronounced unserviceable although, in fact, the fault has been with the test equipment. In the early days, in this country at least, this could sometimes be blamed on the overelaboration of test gear, particularly field equipment.

Now there has been an almost dramatic switch to simplified apparatus that can give a plain "Go—No-go" reading with 100% accuracy. (In actual operation, many of the missiles which have been test-flown at Woomera are transported for many miles over rough country *after* testing, then slung into their ramp and fired with no further attention. The failure rate has been negligible.)

In the kind of test equipment now used, transistorisation has become widely used: after all, it works under rather healthier environmental conditions than the missile-borne electronics.

Discussing testing procedures with some of the men who have been carrying out the Woomera firings, it is interesting to find that many of them believe that missiles are often *over* tested. Said one: "You go on checking your electronics until you wear 'em out. Give one quick overall test and get it in the air. Your failure rates are lower then."

Another example of test equipment requirements fulfilled by the industry is the complex electronics needed for designing, producing and testing plastic radomes. This delicate matter of overcoming problems of aberration of the radar signals to the scanner requires a whole series of operations.

First of all, computers are used to relate the dielectric properties of the material, its thickness and curvature, and the relation of these factors to the radar frequencies employed. The first thing to discover is *what* you want. Then you must find whether you have got what you want.

Finally, a "rectification set" must be used to smooth out the too-thick and too-thin sectors of the radome before a final acceptance test. English Electric reports that because of the original equipment it has produced for this work it has never yet, in a very large number of firings, had a nose-cone failure.

• **Price of success**—It is a pity, incidentally, that the Ministries concerned will not allow firms to announce the details of their test firings. I have recently been shown the classified figures on English Electric *Thunderbird* firings and they make good reading. The *Seaslug*, the Royal Navy surface-to-air missile, has proved so expensive on trials through the monotonous regularity with which its G.E.C. beam-riding equipment secures direct hits and destroys expensive target aircraft that the Admiralty has issued an instruction that in future trials it must be "aimed off."

Bell Develops Highly Reliable Inertial System

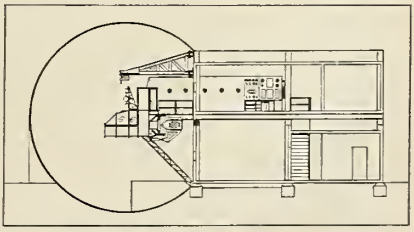
A highly classified inertial guidance system is being described by its developers, Bell Aircraft Corp., Buffalo, N.Y., as the most successful and reliable ". . . of any new inertial instrumentation concepts so far tested."

Extensive flight testing, said Bell, has indicated it to be an unprecedented high-performance system. It was designed for long-range guided missiles, satellites, and space vehicles.

The gyroscope is not considered a delicate instrument, and its maintenance and logistics requirements are low enough to make practical its application under field conditions, said the company.

A PLACE TO IRON OUT THE STRESSES OF SPACE

Seventeen different stresses will flay the minds and bodies of the first spacemen. Under the combined attack of acceleration, anxiety, heat and other stresses, how will man perform? The answer won't be known until the problem can be simulated, in all of its parameters. Vought Astronautics – a division of Chance Vought – is preparing the way with design studies of simulators like that illustrated above. Inside the laboratory's mock space vehicle, a man – without leaving the ground – would know the heat, movement, noise – and many psychological effects – of an extra-terrestrial voyage. He would glimpse a dynamic solar system and would experience, altogether, an invaluable preview of combined stresses of space flight. Vought Astronautics can produce and operate such a lab now for the development of spacecraft and the training of pilots.



From active flight instruments, motion, and a planetarium projection — a realistic preview of space flight.

AERONAUTICS ASTRONAUTICS ELECTRONICS GENESYS CORP. RANGE SYSTEMS RESEARCH

CHANCE VOUGHT DALLAS, TEXAS

Fast-Growing Semiconductor Materials

Hoffman's furnace speeds ingot production; a report on this and some gains in extraction techniques

by John F. Judge

Monocrystalline silicon ingots weighing up to 530 grams can be grown in less than 2½ hours in a new semiautomatic crystal growing furnace developed by Hoffman Electronics, of Los Angeles.

With simple modification, the furnace can be adapted to grow germanium crystals. Company spokesmen point out that the furnace's automatic features permit one person to operate four units simultaneously.

The automation sharply reduces the human error factor, since each operating cycle including pre-gas, meltdown, pulling and drawing, is push-button controlled. The speed of the seed rotation, withdrawal, time cooling rates are also rigidly controlled.

A radiamatic pyrometer keeps the furnace temperature to a preset value. An elaborate system of monitors constantly checks inert gas pressure, cooling system and the power requirements, flashing a warning when failure occurs.

Each of the mechanical parameters can be operated independently of the others. The operator can select crucible position, rotation, seed rotation, and pull rate as needed.

ZONE MELTING applied to a rod of powdered boron. A method for coating boron powder with boric acid made it possible for Bell Laboratories to process strong, pressed forms of boron.

The furnace incorporates the widely used Czochralski method—seed drawn ingots—and utilizes a specially developed resistance heating system.

The product of this instrument is the basic building block of the rapidly growing semiconductor industry—an estimated $510 million market in 1960. There are over 100 major U.S. firms producing transistors, diodes, rectifiers and infrared detector cells from silicon and germanium ingots.

• **Getting materials**—The separating of the two major raw materials, germanium and silicon, from their natural states is just the first step in a highly developed art that results in the starting products for the semiconductor industry.

Initially, germanium is recovered from the zinc, lead, and copper industries. Sylvania Electric Products takes recovered germanium tetrachloride, hydrolyzes it to the oxide and then hydrogen-reduces it to elemental germanium in the firm's Chemical and Metallurgical Division.

Other major producers such as American Zinc, Lead and Smelting Co., and American Metal Climax Inc., are engaged in the extraction of this element by various processes.

The common source of elemental silicon is the reduction of the tetrachloride by hydrogen.

The most important part of semiconductor starting materials production is the refining and purifying stages. To be effective, the germanium and silicon must be of such high purity that ordinary methods of analysis cannot be employed in checking and grading. Instead, the purity of these substances is measured electrically and expressed in terms of resistance per cm.

• **Zone melting**—In 1952, William G. Pfann of Bell Telephone Labs Inc. discovered the process of purification by zone melting. Today this method, with various extensions, is the standard means of refining germanium and silicon the world over.

Zone melting is based on an old principle used in fractional crystalliza-

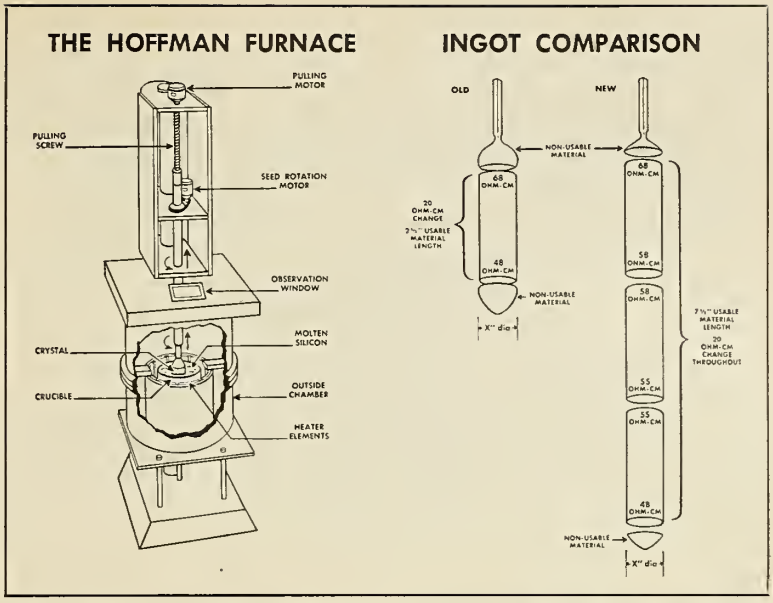
tion—the composition of a freezing crystal differs from its liquid. Pfann combined this with the passing of a short molten zone through a solid and came up with the process that, among other things, can distribute a desired impurity uniformly through a single crystal and make precisely controlled discontinuities in impurity concentrations. These discontinuities are the familiar p-n and n-p-n junctions in semiconductors.

The nature of the process is readily understood if one follows the molten zone through a solid containing impurities. If the impurities raise the melting point of the solid in the molten zone, they will travel in a direction opposite to the passage of the zone. If they lower the melting point, the reverse is true.

• **Variations**—There have been many variations on the basic theme by Bell Labs. There is temperature-gradient zone melting, wherein the zones are very small and are made to move not by a traveling heat source but by a temperature gradient impressed across the entire range of the melt.

The floating zone technique, first applied to silicon, involves the moving of a molten zone vertically along a bar grasped at either end. The zone is held in place by its own surface tension. This limits the size of the ingot to be purified but eliminates contact with a "boat" or crucible which usually introduces impurities, especially in refining silicon.

An improvement in this latter method was announced last year by Bell Labs. It consists of using specially shaped cross-sections—such as flat plates and tubes. This allows the melting of a thin cross-section without exceeding the surface tension effect, while increasing the total cross-sectional area treated by enlarging the width of the zone.



These techniques are catching on in areas far removed from semiconductors. They have been applied in metal purifying, organic and inorganic separations and even with water. The Russians recently announced the use of zone melting to purify water, alcohol and HCl through liquid air and other cooling methods.

• **Cutting boron content**—Boron is the only element that cannot be removed by zone refining—and it is one of the important contaminants in electronic silicon. Sylvania has been able to reduce the boron content from four to one part per billion and sometimes as low as three parts per ten billion and lower. The firm had been reducing silicon tetrachloride in process involving gaseous zinc. Substitution of hydrogen for zinc resulted in this decrease in boron content because of the relative ease of purifying hydrogen.

The stringent requirements of the electronic apparatus being produced now and in the near future have kept the supplier's laboratories hopping. The recent Westinghouse development in molecular electronics (M/R, Feb. 8, p. 22) is illustrative of the coming improvements in this field.

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ingenious approach . . .

Summers Produces an Expendable Gyro

by William J. Coughlin

SANTA MONICA—A new lightweight gas gyroscope appears to meet a long-sought need for small expendable units in military missiles.

Developed by Summers Gyroscope Co., this simplified gyro system has proved to be extremely reliable during eight months of test operation. Three-inch diameter units will provide up to 30 minutes running time, according to the Summers Company.

The gyro employs one of the world's oldest principles to provide a stored-energy system. But, where other gyros have used a stored propellant of some sort, ingenious use has been made of pressure differential to provide energy.

The gas gyroscope consists basically of a hollow rotor which has a number of equally separated open jets. The rotor is installed within a chamber which can be pressurized and is equipped for fast pressure release.

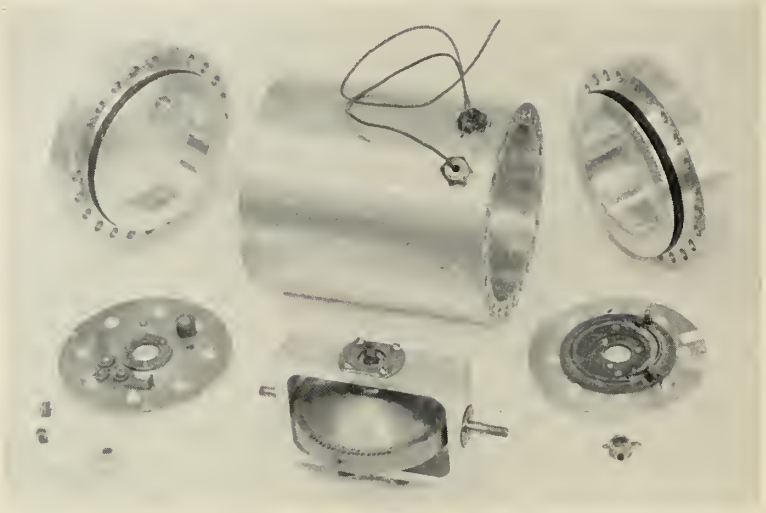
When pressure is released, the compressed gas escapes through the rotor jets and its stored energy is converted to angular momentum.

The gas gyro has several important characteristics:

• It is not burdened by electrical or mechanical power couplings through the gimballing system to the rotor.

• It is capable of an indefinite number of charging and discharging cycles

high shock resistance . . .



PROTOTYPE RATE GYRO developed by Summers Gyroscope operates at 2000 psi. Rugged, but inexpensive, a 3-in. dia. unit will run for nearly 30 minutes on discharge cycle. Disassembled view indicates simple construction.

without conventional wear.

• Even if a shroud or other jet-stream deflecting device is not employed, it will not exhibit conventional "case-erection" tendencies of other types of fast-accelerating gyroscopes.

Birchard H. Ford, associate research director in the new products division, says weight of the new gyro generally is less than that of other gyros performing the same functions and it is cheaper and more reliable. Also, there are fewer parts than in a conventional gyro.

Thirty minutes would appear to be the practical limit at the moment for a 3" gyro," Ford says. Research on coasting times indicates this could be extended somewhat, but would require more expensive bearings.

As planned, production cost is expected to be about one-third that of a spring-driven gyro designed to meet the same general requirements. (Summers builds conventional gyros for several U.S. missiles, including *Lacrosse* and *Bullpup*.)

• **Applications**—According to Ford, the gyro can be used in any application where a spring-loaded or energy-stored gyro can be used. The principle can be employed in vertical, free or rate gyros. A prototype rate gyro has been under test at Summers since last May.

In one application of the gyro, an electrical squib provides a shock wave which simultaneously uncages the gyro and breaks the diaphragm to allow escape of the gas from the outer chamber. Discharge also could be accomplished mechanically.

During pressurization of the case, the gas enters the rotor through the jet ports. Thus, no slip rings, pneumatic piping or other weight-increasing devices are needed.

In the fully-charged condition, pressure within the rotor is the same as in the case. If maximum accelerating speeds are not necessary, pressure can be released slowly from the case through a retarding orifice so that the rotor itself does not have to be designed to withstand the full pressure differential, achieving a weight-saving.

For example, if the case were to be pressurized to 2000 psi and the pressure released so that the rotor and the case were discharging at about the same rate, the rotor would not have to be subjected to more than a fraction of the initial 2000 psi.

Efficiency of converting the energy within the rotor to angular momentum would be the same in either case, Ford notes. Only essential difference lies in time required to achieve final momentum.

In an application where the gyro can be uncaged after reaching speed, a shroud can be employed to provide 35% more energy. When firing is desirable uncaged, however, elimination of the shroud means very little case erection tendency because there is little impinging on the gimbals.

Efficient rotors can be designed which will reach approximately 88% of maximum operating speed within one second, Summers reports. Rotor reaches full speed within two time-constants, which can be computed from size of the jets. Prototype testing indicates that optimum jet size gives a minimum time-constant of the order of one second.

A spherical rotor is employed to keep all weight not contributing to momentum to a minimum. Only light gimbals are required since no power couplings are needed through the gimbals.

• **Design parameters**—Energy obtained is a function of the diameter of the rotor to the fourth power. Thus, on extremely small applications, the point is reached where more energy might be obtained with a spring-driven gyro.

Ford suggests this is true in areas where gyros smaller than ¾" diameter are desired. Even here, he notes, the gas gyro might prove better due to better shock qualities and other advantages.

Gyros with diameters of 3 in. or greater are quite easily designed for this application, according to Ford.

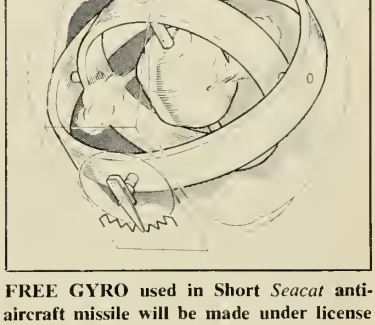
Gas employed could range from compressed air to the more exotic gases, it is reported. Ford says all known requirements can be met with the use of nitrogen at 2000 psi.

More extreme requirements could be met by a change to some of the denser inert gases when pressure increase must be avoided, or by use of filament-wrapped cases when 5000 psi or higher is required

Summers reports the gyro can stand more shock than conventional gyros because the rotor and gimbaling system are lighter. Rotor can be brazed or welded thin-shell steel construction. Fine machining is required for the precision jets. An aluminum cylinder with end plates provides the outer casing. Volume exterior to the rotor can be held at a ratio of 1=1 or less.

Summers estimates that gyros of 3" diameter or larger can be produced in quantity for around $100 each.

Shorts' Gyro

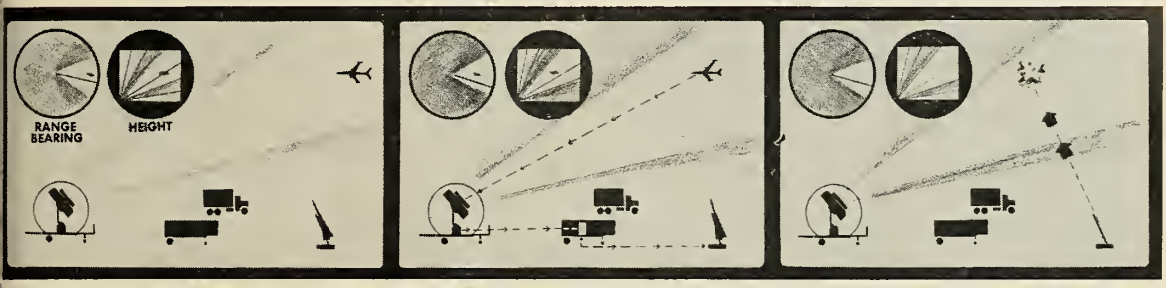


FREE GYRO used in Short *Seacat* anti-aircraft missile will be made under license in U.S. by Giannini Controls Corp.

slightly misnamed . . .

3-D Radar Grows in Importance

Survey of varying approaches indicates there probably is no single 'best' design



ARMY'S AN/MPS-23 radar (Hughes FRESCANAR) is representative of 3-D radar systems. It simultaneously detects range, bearing, and altitude of supersonic targets, computes information, and transmits to guided missile batteries which launch weapons.

by Hal Gettings

Three-dimensional radar is becoming increasingly important in detection of high-speed aircraft and missiles. Systems delivered and those still in the design stage are aimed at providing instantaneous data to interceptor control operators and automatic defense systems.

Primary feature of the 3-D equipment is simultaneous measurement of all three parameters of target position —range, altitude, and azimuth—with one system, for faster evaluation of enemy aircraft and missiles.

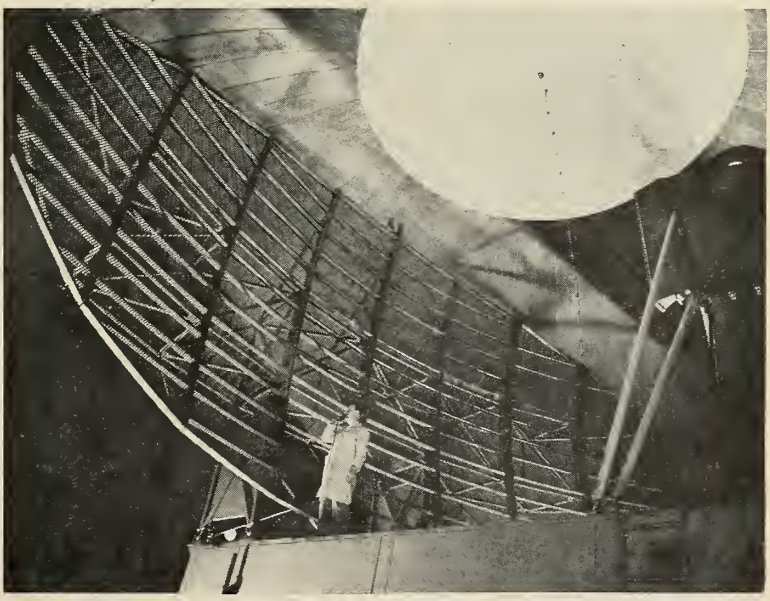
Previous methods required two separate radars: one for range and azimuth, and another for height-finding. Problems of synchronization, time delays, equipment multiplicity—with attendant maintenance and spares headaches—and other complications often make this method undesirable.

Actually, the designation "3-D" is not entirely correct. Although data is furnished on three dimensions, presentation of the data requires two different scopes. One is a conventional PPI—plan position indicator—which shows the horizontal relations of the target: azimuth and range. The other is the height-finding, or elevation, indication which shows the vertical sweep of the radar beam.

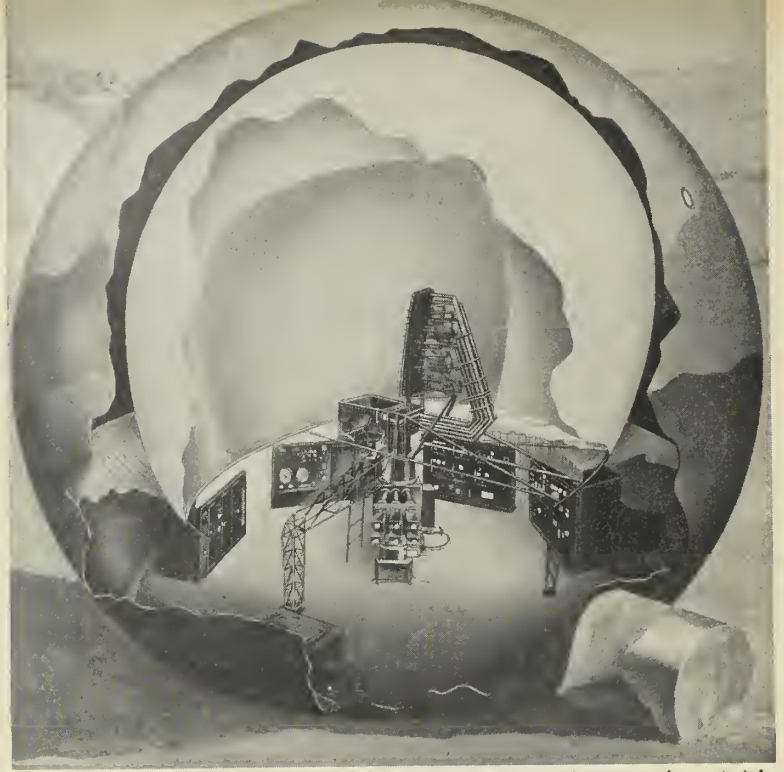
General Electric is reportedly working on a true three-dimensional presentation of target data, but details have not yet been released. It is assumed that methods similar to those used in the development of the 3-D oscilloscope would be used in the radar display.

• **Different techniques used**—As yet, no one has come up with one best way to design a 3-D radar. There seem to be as many ways to do the job as there are designers—and each feels that his way is the best. However, other factors —size, power, mobility, application— enter into the question, there probably is no one simple solution.

One of the first techniques used in an operational system was the "V-beam." Two fan-shaped beams from the same antenna—related to each other



SUPER-SENSITIVE ANTENNA of GE's AN/FPS-7—new long range, multi-beam air defense radar—measures 40 by 18 feet and just fits inside a 50-ft. radome. The white circle at top reduces the concentration of heat from the banks of de-icing lights, and permits uniform melting of snow and ice on the outside of the radome.



CUTAWAY DRAWING of TPS-27 shows painted-on antenna (gray area in center) in inflated Paraballoon. Entire system is enclosed in pressure-inflated radome approximately 50 feet in diameter.

FRESCANAR scope on left displays target range and bearing, that on right, altitude. Data is instantaneously transmitted to missile antiaircraft batteries which automatically track targets. Hughes' "3-D" system requires only one antenna and one master console as compared with conventional types which require two or more.

in somewhat the same way as the arms of a "V"—provide indications of the three target parameters. As the antenna rotates, an automatic computer determines the height and range of the target by measuring return echoes picked up by the vertical and slant beam reflectors in relationship to the angle between the two and the time between echoes.

At least two systems use the "stacked-beam" technique. This method uses one transmitter and one frequency and a number of receivers, according to the number of individual beams. In essence, the antenna pattern describes a vertical fan-shaped beam covering most of the vertical quadrant between 0 and 90 degrees. This beam is composed of a number of separate beams which partially overlap. Relative strengths of reflected signals received by the various beams determines the elevation angle (and altitude) of the target.

Advantages of this technique are extremely fast determination of target position and long range. It requires more power than some other methods.

• **Hughes system**—Hughes Aircraft claims to have produced the first practical 3-D radar. Its development—called FRESCANAR and designated AN/MPS-23—is part of the Army's Missile Monitor defense system. Units were delivered over one year ago. First versions of the radar were developed for the Navy for use aboard ship.

As used in the Missile Monitor, the MPS-23 feeds radar-detected target information to a radar processing center, which converts visual target data to digital information and sends it to various units of the defense system.

In the frequency-scanning technique, the antenna and feed remain fixed with respect to the vertical. Scanning for elevation angle data is accomplished through electronic switching of the beam angle by changing the frequency. The beam, therefore, sweeps up and down at an extremely fast rate—much faster than mechanical scanning. Scanning is programed by digital means to occupy precisely these successive positions in space calculated to yield maximum accuracy and coverage.

• **Sperry system**—One of the early systems to provide three-dimensional data at extreme ranges, Sperry's MPS-21 was delivered to the Marine Corps last November. This is a highly portable tactical early warning system designed to detect high-speed aircraft and missiles. It is transportable by helicopter and can be set up within two hours.

The MPS-21 uses a V-beam antenna pattern configuration. Search and height-find radar paraboloidal-shaped reflectors are superimposed on a single antenna. The face of each reflector pro-

Materials Memo

News of materiel for the aerospace industry— from the 27,000 products of the 3M Company

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The paper either as a 100% synthetic mica composition or containing additional reinforcing fibers may be produced in calipers from 2 to 10 mils. Only papers 5 mils thick are now available for sampling. Density of the paper can vary from 0.6 to 1.7.

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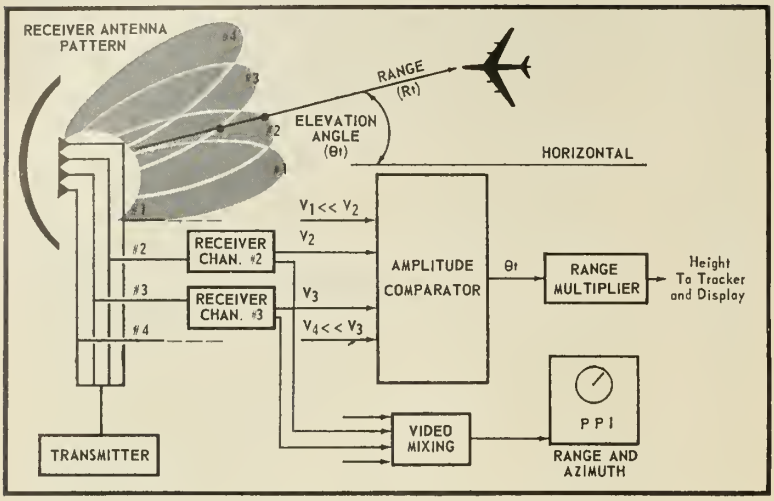


duces a composite, simultaneously transmitted radar beam which consists of a vertical beam for search and a slant beam for height-finding. Each surface of the antenna is fed by a separate horn, and two additional horns are used to receive the reflected signals. Targets passing through the two beams yield range, azimuth, and altitude data to the combat interceptor control. Horizontal scan speed is six rpm.

Designed for mobility, the system is packaged in cases that can be man-carried or assembled on pallets for transport by air or land vehicles. The assembled system is covered by a light-weight inflatable radome which makes it possible to use the system in any climate.

• **SAGE uses FPS-7**—Radar data for the SAGE continental air defense system will be provided by the General Electric FPS-7 radar. Recently delivered to the Air Force Air Defense Command, this unit is the first in a series of high-power multibeam systems for detection of aircraft at high altitudes and extreme ranges.

According to GE, the FPS-7 provides much faster target data on approaching aircraft than is possible with the conventional system. This data is relayed to the computers instantaneously, eliminating the present interdependence of one radar on another and speeding up the calculation of intercept data. This factor is increasingly important in this age of high-performance, long-range supersonic aircraft when human errors or excessive time in computation of radar data and the transmission of weapon control commands could be disastrous.

The FPS-7 features a unique "varifocal" antenna design. It operates on a multi-beam—or "stacked-beam"—principle whereby several narrow beams are fed to the antenna, as compared with the standard single broad-beam method.

Radio-frequency power for the FPS-7 system is generated by a five-foot high Klystron tube jointly developed by the Rome Air Development Center and General Electric. This multi-megawatt tube produces hundreds of times more power than the radar that was used to beam pulses to the moon and back in 1946. Its frequency limits can be held much closer than the frequency limits of conventional radio and TV transmitters.

A super-sensitive antenna, which weighs approximately seven tons and rotates 360°, focuses the high-power pulses of r-f energy emitted by the FPS-7. Its reflector measures 40 by 18 feet.

In addition, the FPS-7 includes 52 cabinets of electronic equipment. Printed circuitry and plug-in type units have been used wherever possible to simplify maintenance and increase system reliability.

The overall system is housed in an Arctic Tower with a 50-foot air-inflated radome to protect the antenna from wind, snow and ice. The radome is designed to withstand winds in excess of 100 mph. It is fabricated from neoprene-coated Nylon fabric in the shape of a ¾ sphere 55 ft. in diameter.

• **Westinghouse model**—The Westinghouse entry in the 3-D sweepstakes is the TPS-27, now in production. Built by the Electronics Division under a contract with Rome Air Development Center, this is a medium-range tactical system. Its primary feature is easy mobility—it can be set up and operating within four hours. The prototype system has been delivered to the Air Force for a comprehensive test program. The first of eight production models is scheduled for delivery in October, 1961.

The TPS-27 uses a "stacked-beam" technique to provide simultaneous height-range-azimuth information for input into automatic defense systems.

A unique feature of the Westinghouse radar is the 30-foot Paraballoon antenna used. Contributing to system mobility, the Paraballoon is lighter and more accurate than a conventional metal counterpart. Inflated and kept erect by low-pressure air, the antenna is precise to one-eighth wavelength. Dimensional stability is no problem. The reflecting surface is a silver-impregnated coating painted on the interior of one side of the oblate Paraballoon. The other side is transparent to r-f energy and serves as a supporting structure.

• **BMEWS radar 3-D**—The BMEWS detection radar—with its 3000-mile range—can also be classified as a 3-D system, in a different sense. Its "radar observer," called DRDTO (Detection Radar Take-off subsystem), estimates azimuth as well as range and velocity.

Emphasis Shifts to R&D of Components

by W. G. Wing*

Progress of inertial guidance directly depends on progress in development of gyroscopes and accelerometers. Consequently, intensive emphasis is being applied to research and development of these vital components. Accuracy and reliability are the two primary goals.

All inertial guidance systems require high-quality gyroscopes and accelerometers. In general, short-time operations emphasize the need for excellent accelerometers; long-time operations emphasize the need for excellent gyroscopes. To illustrate, in the case of a 5000-mile ballistic missile, an error in velocity measurement of one foot per second will cause an impact error of one nautical mile; because the missile velocity is some 18,000 feet per second, the required accuracy is 0.005%. Achieving this accuracy of velocity measurement is fundamentally dependent on accelerometer performance.

In the long operating time applications (such as cruise missiles), the rotation of the indicated vertical is measured with respect to the system gyroscopes. For this reason, any angular drift of the gyroscopes becomes directly a corresponding error in knowledge of position. If the gyroscopes drift at a rate of 0.016 degrees per hour, the position error will increase at a rate of one nautical mile per hour; this should be contrasted with the 5 to 10 degrees per hour drift which is normal for conventional aircraft instrument gyroscopes.

• **Gyroscopes**—Although gyroscope performance requirements differ markedly for different applications, all but the crudest require instruments of high quality. The excellent drift requirements of long mission time applications have previously been indicated; ballistic missiles permit relatively high drift rates but the required performance must be attained in a very troublesome acceleration and vibration environment. A ballistic missile, therefore, requires extreme mass balance accuracy and excellent isoelasticity (uniformity of rigidity in various directions).

INTEGRATING accelerometers ("space speedometers") measure velocity in three-dimensional space for inertial guidance stable platforms. Newest type developed by Sperry employs a spinning liquid instead of bearings to avoid friction errors and provide extreme accuracies.

A multitude of error sources must be considered in the design of inertial guidance gyroscopes. These include suspension friction, dimensional stability, effects of temperature, (variations of value and of gradients), magnetic field susceptibility, and isoelasticity.

The most obvious variable among gyroscope designs is the form of the suspension. The most common method of suspension for inertial guidance use is liquid flotation (with some supplemental means to establish axes of rotation). Flotation can reduce friction levels to complete negligibility and at the same time impart excellent resistance to shock and vibration. The density of the moving element is limited to that of the liquid used—and this limits the angular momentum and structural rigidity. Also, liquid-floated gyros must be constructed with extreme care to avoid contamination of the liquid or the presence of gas bubbles.

Hydrostatic bearings using gas under pressure have been employed for some time. With very careful design and fabrications, very low uncertainty torque levels are possible. The major drawback of this method of suspension is the need for a continuous supply of almost absolutely clean gas. In addition, very high tolerances are required in parts manufacture and very clean assemblies are necessary. On the plus side, the suspension method permits use of a high-density moving element and, hence, high rigidity and angular momentum.

The old standby of the control gyro field, the ball bearing gyroscope, is almost unknown in inertial system design. One recent design, the Sperry Rotorace gyro, shows promise for inertial applications in which high reliability and short warm-up periods are more important than extremely high orders of accuracy.

Both single and two-degree-of-freedom gyros are used (a single-degree-of-freedom gyro gives information about only one rotational axis while a two-degree-of-freedom gyro gives information about two axes at right angles). The single-degree-of-freedom design is the more commonly used; it has an advantage in that it requires extreme mass balance, isoelasticity and thermal symmetry in only two dimensions instead of three. On the minus side, it allows significant disturbances in the orientation of the spin axis under angular vibration. This leads to drift error. In addition, three single-degree-of-freedom gyros are needed for a complete directional reference system whereas only two two-degree-of-freedom gyros are needed.

Current gyro designs differ in a number of details; among these are:

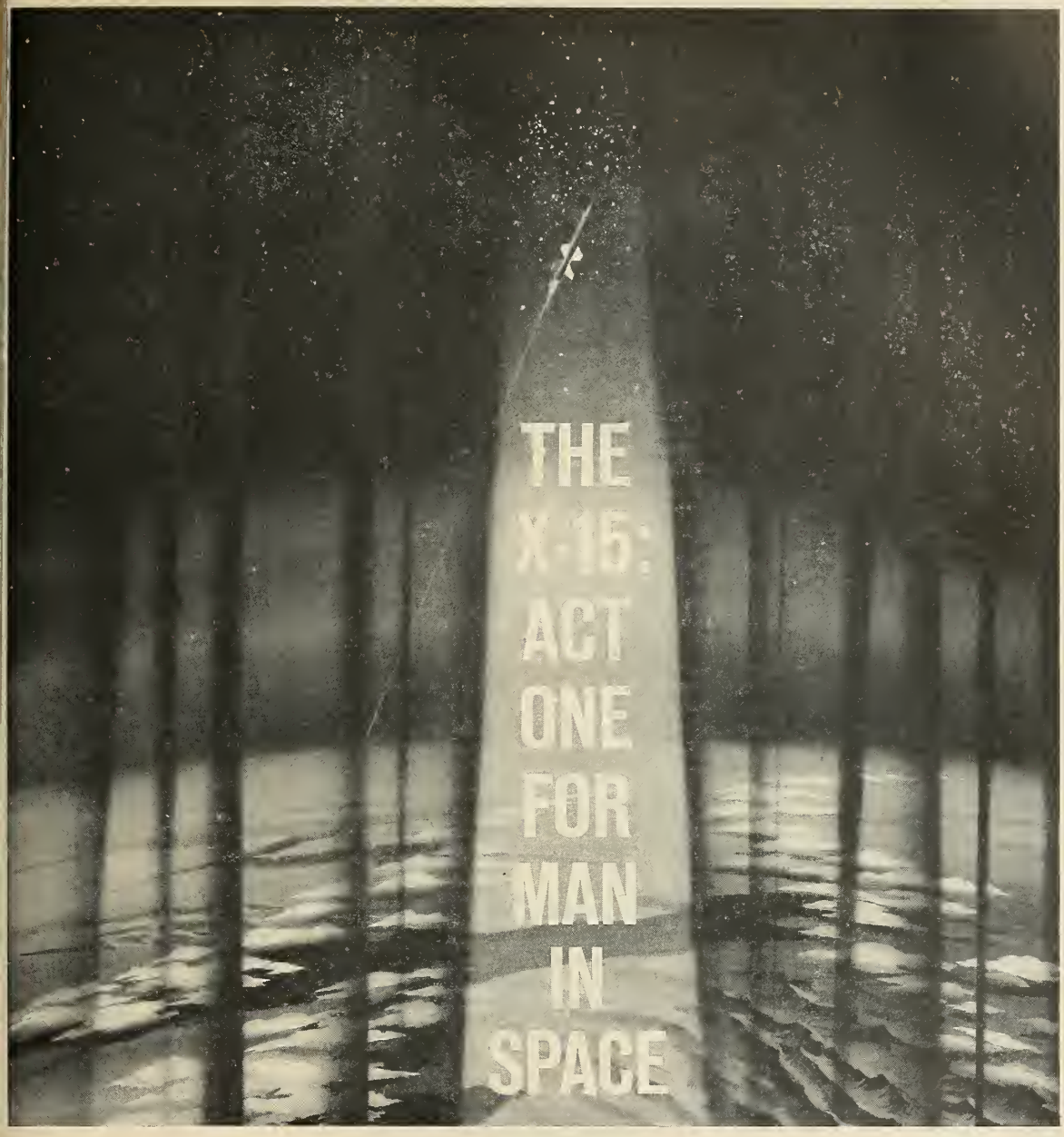
• Degree of damping (in single-degree-of-freedom types).

• Nature of spin axis bearings.

• Suspension used to supplement flotation (e.g. jewel pivot, magnetic, flexural, hydrostatic).

ABOUT THE AUTHOR

**W. G. Wing, a leading authority on inertial guidance, has specialized in the design and development of inertial systems and components at Sperry Gyroscope Company for the past 10 years. As manager of inertial systems products in the Air Armament Division for aerospace applications, he is in charge of advanced design as well as the product engineering and technical sales aspects of this work.*



As North American's X-15 – world's most advanced manned research craft—parts the curtain of earth's atmosphere, the arts of guidance and direction must play a critical role. Sperry's Air Armament Division, assigned the Flight Data System responsibility for the X-15, is meeting the challenge with inertial guidance gear of advanced design, precision and dependability.

But the problems of inertial guidance are not new to Sperry. During the past ten years, over 25-million Sperry man-hours have been employed to develop and produce successful inertial guidance. As a result, the nation has in the Convair B-58 Hustler the most thoroughly studied, analyzed, tested, evaluated and understood inertial guidance system in being – plus the advanced guidance equipment for the X-15 and for other future applications.

And in addition to work on government sponsored space guidance systems and techniques, Sperry scientists and engineers are exploring new and exotic techniques for gyros, advanced miniaturized digital computers, acceleration sensors, zero gravity environment systems—in many cases involving radical departures from current technology—with the aim of developing concepts, systems and hardware that are *ahead* of the challenges of man in space.

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Inertial instruments by Autonetics

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• Nature of angle pick-off.

• Nature and accuracy of torque generator (both ac and dc types are used with accuracies varying between .01% and 1%).

Successful inertial gyros have been built around all of these variations, but none of them enjoys a clear lead. Most applications, though, use the highly damped single-degree-of-freedom type. This has already been found suitable for all but the most severe guidance uses proposed.

• **Accelerometers**—With few exceptions, inertial guidance accelerometers are basically pendulums kept centered by some type of torque feedback. Suspension methods include all of those previously noted for gyros, with flotation and flexural types the most common. Devices using flexural suspension tend to be more simple and compact but are subject to null errors due to imperfect coincidence between the zero torque angle of the suspension and the zero single angle of the pick-off.

Several available accelerometer designs use moving coil, permanent magnet field devices for creating the force or torque feedback. The best examples of this form give accuracies in the order of 0.01%.

In other pendulous accelerometers, the torque produced by acceleration of the pendulum bob is balanced by the torque required to change the angular momentum of a wheel. Because the rate of change of angular momentum of a body is exactly proportional to the applied torque, this principle can lead to extremely accurate accelerometers. Designs of this general class take two basic forms: the pendulous gyro accelerometer and the kinetic doubly-integrating accelerometer.

In the pendulous gyro device the pendulum torque is balanced by gyro precession torque. The output is a shaft angle proportional to the first-time integral of the acceleration. In the kinetic doubly-integrating accelerometer, the pendulum torque is balanced by the acceleration torque of a flywheel. Its output is a shaft angle proportional to the second-time integral of acceleration.

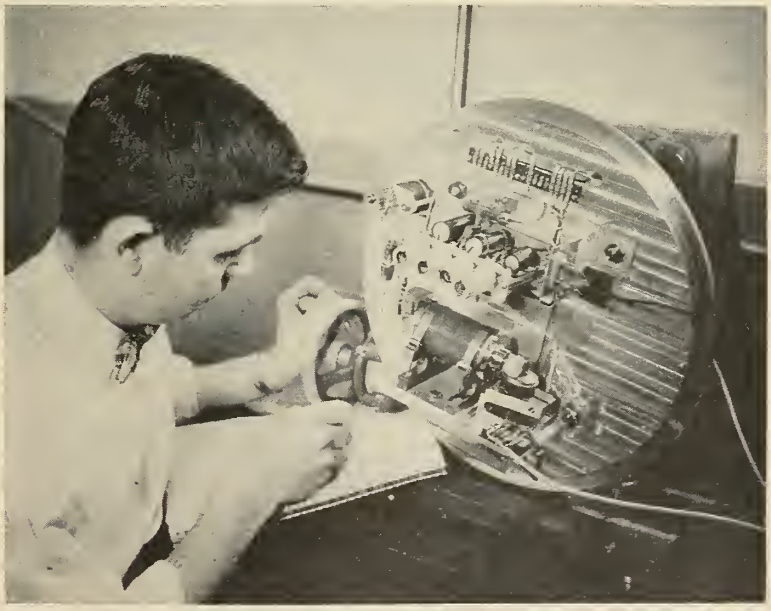
When vehicle velocities are very high, the gyro type is the better of the two; for low velocities, the kinetic, doubly-integrating type is quite satisfactory. Because of the inherent accuracy of the torque balance principle, both instruments can be highly accurate (substantially better than 0.01%). The chief error source is due to uncertainties in the degree of pendulousness.

Vibration causes errors in all pendulous accelerometers. Such errors can be controlled either by providing very great dynamic restraint on the pendulum or by making the pendulum arm long. Ideally, the pendulum should be of infinite length. For obvious reasons, only the use of great dynamic restraint is practical; in some designs this takes the form of viscous damping; in others, very high servo loop gains are employed; in some designs the natural frequency of the servo loop has been pushed up to the region of 1000 cps for this reason.

One accelerometer design which does not fall into any of the classes so far indicated uses a low-density test mass suspended in a body of viscous liquid. By spinning the liquid body, the test mass is forced to remain on the axis of spin. Under acceleration along the axis of spin, the test mass moves through the liquid at a rate proportional to the acceleration. The total displacement of the test mass is a measure of the first time integral of the acceleration.

The most commonly used accelerometers in inertial guidance systems are

INERTIAL guidance systems—such as this model for the *X-15* rocket plane shown on the "stable table"—receive exhaustive tests to determine accuracy and reliability.



SPECIAL ultraprecise indexing platforms have been created to measure accuracy of new integrating accelerometers at any point throughout full 360 degrees. Master table automatically compares response in any position with correct answers, exact within plus or minus 1.5 seconds of arc.

pendulums using either moving coil dc torque motors or the pendulous gyro principles. It is still not certain, however, that any of the types is clearly superior; other types are also under development which may prove to be superior to any thus far used.

• **Servo requirements**—Stable platform servos in inertial guidance systems must be of very high performance if high guidance accuracy is to be achieved. Fortunately, available techniques can provide the required accuracy.

The need for great accuracy results from two factors. For one thing, the gyros must be kept nulled to within a very few seconds of arc if good drift performance is to be obtained. For another, the accelerometers must be angularly stabilized with great accuracy if the direction of the measured acceleration is to be accurately known.

To achieve the required servo performance, direct drive (ungeared) servos have been commonly used. Use of direct drive motors eliminates the loop stability problems caused by backlash, reduces friction torques on the platform axes and eliminates the disturbing effect of the reflected inertia of servo motors and gear trains.

Direct drive motors are inherently low-efficiency devices, although the dc types are much more efficient than their ac counterparts (for this reason dc direct drive motors are the more common). Furthermore, direct-drive dc motors tend to be low-voltage, high-current devices. In early systems these characteristics resulted in serious control amplifier problems; power transistors have now largely overcome this problem.

• **Computers**—The first inertial guidance systems used analog computers exclusively, but digital computers are now becoming more common and can be expected within a few years to almost completely displace the analog computer. Despite the evident coming dominance of the digital computer in the inertial guidance field, it is probable that for the simpler, less demanding applications, the analog computer will remain useful.

• **Mixed systems**—Although inertial guidance can be performed without auxiliary equipment, it is frequently advantageous to provide information derived from other sources. For instance, for relatively long airborne missions, gyroscopes are not available which, within acceptable size and weight limitations, will provide the desired accuracy. Stellar inertial systems utilize information derived from star tracking to correct for gyro drift and hence give accuracy independent of mission time. In some instances, the star tracker is used only to provide heading information; in this case, only one body need be tracked—and this can be the sun during daylight hours and a star at night.

Doppler inputs can be used to provide for damping of oscillations (84-minute period) which are inherent in inertial systems or can be used as the primary source of velocity information. In the latter instance, the inertial system provides heavy filtering for doppler system noise and provides the higher frequency information or vehicle motion.

• **Other factors** — An important aspect of inertial guidance is its invulnerability to jamming and its independence of ground-based aids which might limit its range; these are, of course, particularly significant for military uses. Military applications have fostered the intensive development of inertial guidance despite very real prob-

lems of cost, weight and reliability.

The high cost of inertial guidance equipment results from the extreme tolerances required in parts, the great care required to assemble the parts and the extensive testing required to perform calibrations and assure quality. High cost thus relates largely to the amount of highly skilled labor which must go into each system. It is improbable that costs will come down a great deal unless component designs are developed which inherently give high accuracy with much less detailed work.

Reliability is also very much related to the extreme exactness required throughout an inertial guidance system to provide useful accuracy. In other words, a system can be operating in every detail but a small deterioration in performance may reduce the accuracy to an unacceptable level. Here, again, the most hopeful means of improving the situation is development of designs in which suitable performance is more inherent.

A great improvement has been made in weight during the past decade. Systems built in the early '50s tended to tip the scales in the one ton (or more) region. Present systems weigh a few hundreds of pounds and future systems (of good accuracy) can be expected to weigh in at well under 100 pounds.

• **The future**—It is almost universally accepted by designers of inertial equipment that new basic components are needed for inertial systems use; intensive efforts are being made to develop such components. As has been indicated previously, new components inherently capable of better performance should greatly reduce cost, improve reliability, reduce weight and, of course, improve accuracy.

Work is going on, for instance, in the electrostatic suspension of gyroscope rotors, cryogenic gyros and nuclear spin gyros. It is not yet certain that any of these is truly practical, but all are hopeful. There are other approaches which do not seem nearly as exotic but which may, ultimately, prove practical. It may be expected, for instance, that gas lubricated spin bearings will soon be in practical use.

• **Space applications**—The expected peculiarities of space travel obviously will present particular problems. During an early boost phase, the basic guidance would not be markedly different from that for a ballistic missile, but after initial boost the problem becomes quite different. For one thing, mission times become exceedingly long —achieving low gyro drift angles would be extremely difficult. Under weightless conditions, many sources of gyro drift would vanish.

Space Instrumentation Growing Up

Space instrumentation, the baby business of the electronics industry, is going to be given a very expensive diet to grow by in 1960.

Estimates are that the National Aeronautics and Space Administration will spend over $150 million during 1960 for satellite instrumentation, ground telemetry and tracking units, computers, and for the station-linking communications systems.

Specifically budgeted for space instrumentation and related fields in NASA's supplemental FY '60 budget and the FY '61 budget is $116 million. This does not include the $141 million in both budgets for Project *Mercury*, and NASA witnesses told Congress recently that communications is the largest single line item in that budget.

Construction and equipment items in the two budgets include: $9,500,000 for the construction of the NASA space communication center at the Goddard Space Flight Center; $4 million for vertical probe (sounding rockets) telemetry and tracking facilities at Wallops Island; $22 million in both budgets specifically for the *Mercury* tracking network; $8 million for the deep space network; and $4,750,000 for the Minitrack satellite tracking network.

Research and development items in the two budgets include: $20,700,000 for meteorology satellite applications, $5,600,000 for communications satellite applications; and $32,550,000 for tracking and data acquisition. The latter category is broken down into two items: $25,530,000 for operative communications and utilization, and $7,220,000 for advanced technological development.

An important part of NASA's space instrumentation program never leaves the ground. It involves the great amount of tracking and data acquisition equipment that must be built before man can go into space, and instrumented payloads can be tracked in deep space. This program is funded for $64,300,000 in the FY '61 budget.

• **Program by areas**—Maj. Victor W. Hammond, Assistant Director of NASA tracking and information, detailed this program for the House Space Committee recently. He divided the NASA tracking and data acquisition into four areas. One area is that equipment which supports the sounding rocket, or vertical probe program; the second area supports the earth satellite vehicle program; the third supports manned space flight; and the fourth supports flights into deep space. Separate equipment is needed for all four areas, and the equipment needed for one of the areas is inadequate to service the needs of one of the other.

The three areas in which NASA will concentrate in 1960 are satellite, manned space, and deep space.

• **Satellite tracking**—By next October, according to Maj. Hammond, NASA will have 14 stations able to track and receive telemetering signals not only on the currently used frequency (108 MC), but on the new frequency recently assigned at the International Telegraphic Union's conference at Geneva (136 MC).

A great deal of money, according to Maj. Hammond, will go to changing existing Minitrack stations so that they can use the new 136 MC frequency. This will involve new antennas as well as new electronics.

Presently, the NASA Minitrack fence is capable of tracking satellites in low inclination equatorial orbits. But NASA in 1960 will add to its north-south Minitrack fence and east-west fence capable of tracking satellites in polar orbits. These new stations will be constructed in Alaska, Minnesota, Newfoundland and England. The two fences, in combination, will be able to track any satellite in any orbit.

Another item in the budget which will make the satellite tracking fence more effective are the funds for automatic translation equipment to transmit the information from the Minitrack fence into Central Control at the Goddard Space Flight Center. Presently, data must be translated into a suitable form so that it can be teletyped.

Another new fence must be constructed for the Project *Mercury* man-in-space program. This fence, which is being constructed by a team headed by Western Electric, must have the necessary electronic equipment to handle data in as near real time as possible, be able to pin-point the position of the vehicle at all times, complete orbital elements and transmit them to the next tracking station immediately, be able to transmit information from all of the stations to Goddard almost instantaneously, must be able to receive and transmit data on the astronauts' life-support equipment in real time so that trained observers can analyze it, and must be able to continuously revise and relay to recovery forces the capsule's impact locations.

To overcome these problems, NASA must have the latest in electronic equipment for the 18 stations in the world-wide *Mercury* network, and many millions of dollars will be spent in purchasing this equipment.

Adequate facilities for deep space tracking require that two more radio antennas similar to the 85 ft. parabolic radio telescope at Goldstone, Calif., be built at one-third intervals around the world. NASA presently expects to build the other two stations at Woomera, Australia, and at Esslen Park, South Africa. Contracts on these two stations have not been let.

The basic trucking capabilities of these large diameter stations extends from 300 miles to the edge of the solar system. Such powerful systems are needed because the deep space satellite vehicle will be transmitting on very low power. An example of the effectiveness of the Goldstone unit is that *Pioneer IV* was tracked to a distance in excess of 400,000 miles. The three stations must be spaced at equal distances around the globe so that the deep space vehicle can be tracked at all times.

Missile Attitude Recorded By Photoelectric Device

LONDON—The Armament Research and Development Establishment of Great Britain has developed a photoelectric instrument which automatically measures and records the angular position in space of a guided missile.

It consists essentially of a telescope in which the image is swept at constant speed across an infrared detector by means of a rotating mirror. The sensitive area of the detector is in the form of a long narrow slit, so that at any given instant it detects only the energy falling within this narrow width, and as the image is swept across the slit the radiant energy from the missile is detected as a signal spike at some definite point along the sweep.

This gives the position of the missile in any one co-ordinate with respect to any convenient reference point; a second system, with its sweep at right angles to the first, gives the other co-ordinate. Recording is by a cathode ray oscilloscope with a constant-speed sweep initiated from the rotating mirror.

System accuracy is high because the slit width can be reduced to a value comparable with the resolution of the telescope.

French member of SETEL . . .

CFTH Leads French Guidance Effort

Compagnie Francaise Thomson-Houston is a top producer of missile electronics

by Mario Sollima*

BAGNEUX, FRANCE—Significant advances have been made in Europe over the past year by uniting industry in various NATO countries for the common defense effort.

Under an agreement with the United States, Raytheon has licensed five NATO countries to build *Hawk* ground-to-air missiles. These will be used to supply missile batteries which will be established as part of NATO's defenses. A prominent electronic manufacturer has been selected in Germany, Italy, Belgium, Holland, and France by the governments of each country to produce the *Hawks*.

To coordinate the industrial aspects of the program, the five manufacturers have formed a single company, called SETEL, "La Societé Européene de Téléguidage."

• **CFTH**—Typical of these national industrial leaders is the Compagnie Française Thomson-Houston (CFTH), a leading French radio manufacturer.

For a number of years, it has devoted a large part of its electronics activity to the missile field. This includes equipment carried by the missile as well as ground guidance equipment.

The domain of this electronics effort is very broad and covers equipments of varying size, weight, complexity, and nature. Some have been put into quantity production after a long and successful development period. Others, still being designed, will be developed in preparation for future needs.

Even though all this equipment is brought under the single heading of missile electronics, it has but one thing in common and that is the goal: to guide a missile toward a target. Actually the equipment belongs in several distinct technical areas, which are often the extension of former equipment and studies. Thus ground or airborne guidance radar is the result of former development on surveillance or tracking radar. Similarly, the missile's electronic equipment evolves from radar circuitry as well as from miniaturization techniques used in communications.

• **New difficulties**—While ground or airborne equipment did not create any new problems, the equipment carried by the missile does bring new difficulties concerning manufacturing methods.

Besides the great accelerations occuring during launching, missiles are subjected to vibrations whose amplitudes and spectra are truly exceptional. At the beginning, when studies were made in this new field, the effect of vibrations had been underestimated and every manufacturer met with resultant mishaps. Since then, our laboratories have had to be given new test facilities to reproduce these vibrations, to learn their effects, and to avoid their disadvantages.

On the other hand, missiles have to be stored for long periods, during which time maintenance is difficult or impossible. After storage and during a few minutes of flight, the equipment must operate perfectly and with the greatest accuracy, lest the missile be lost and the shot be a total failure.

• **Operational testing**—Experience proves unfortunately that it is impossible in a laboratory to reproduce the actual missile flight conditions. It is necessary to complete missile development and check-out during launchings, which brings into play long preparation periods, great measurement difficulties and high costs. In case of failure, the analysis of causes is often quite delicate. In many instances, it is due to defective components, the quality of which is an essential factor in missile applications.

In short, missile electronics requires both a perfect knowledge of different branches of electronics and long experience in the field of missiles. The former was a part of our inventory; the latter is being acquired steadily.

• **Transition**—After having been very active in the field of large radio broadcasting transmitters, CFTH started to develop radar in 1945. It supplied and installed GCA landing radar for the main European airports. Then, after having produced numerous radar types including navigation radar for the French Navy, in 1952 it was awarded the biggest off-shore electronics contract given in Europe by the U.S. Government. This covered quantity production of an automatic tracking radar, type COTAL, that controls the firing of 90mm antiaircraft guns.

After that, numerous types of radar were developed and manufactured, including early warning radar and high-accuracy tracking radar for missile guidance, as well as measuring and computing equipment such as responders, computers, plotting boards.

Simultaneously, a great amount of study and development work was centered on missile seekers. After a number of missile firings which gave excellent results, the first seeker type is now in quantity production. Subsequent types, further improved, are under development.

CFTH also manufactures semiconductors (diodes, transistors, rectifiers, etc.), radar tubes (magnetrons, klystrons, TR's and ATR's, thyratrons, etc.) and, in particular, very-high-power klystrons for advanced early warning radar.

As an active partner in SETEL, CFTH is called upon to put all its electronics experience to work in a common enterprise, rich in promise for the defense of the free world.

Mario Sollima is an engineering graduate of École Superieure d'Electricité, Paris. He started with Compagnie Française Thomson-Houston in 1927 and has devoted the main part of his activity to electronics. He is Chief Engineer of the company and Technical Manager of its Electronics Division.

Belts Defined

Van Allen Areas Are Now Well Explored

by Jay Holmes

Less than two years after James A. Van Allen announced the discovery of a belt of radiation surrounding the earth, its composition and source have been reasonably well established.

Reports on rocket and satellite experiments in the last year have established that the two major belts of trapped particles consist primarily of "soft"—low energy-electrons. The outer

belt is made up almost wholly of electrons. Most of the inner belt is soft electrons; however, a small but important fraction consists of high-energy protons, a major hazard to manned space flight. Except in very long-term exposure, the soft electrons constitute a negligible hazard.

Dr. Homer E. Newell, Jr., of the National Aeronautics and Space Administration has said that a person flying through the belts would be exposed to between 2 and 50 roentgens of radiation—a total well below the lethal dosage for human beings. This could be reduced, of course, by shielding. For comparison, the National Committee on Radiation Protection has set the maximum allowance for industrial workers at 5 roentgens a year. A dose of 400 to 600 roentgens is usually lethal for about half of the persons exposed to it.

The inner zone appears to begin at 600 miles altitude and extends to something over 4000 miles, with a maximum intensity about 2500 miles over the magnetic equator. The zone extends about 30° north and south of the magnetic equator, leaving wide areas open about the magnetic poles.

The inner belt is much the more stable of the two. Most scientists now believe the high-energy protons contained in it are caused by cosmic rays—extremely high-energy nuclei that originate outside the solar system. These high-energy nuclei collide with nuclei in the outer atmosphere. Among the products are high-energy neutrons, which decay in turn into protons and electrons. The protons are trapped by the earth's magnetic field in the inner belt.

• **Solar origins**—The soft electrons in the inner belt are believed to originate in the sun. The same is true of the soft electrons in the outer belt. A major item of evidence in favor of their solar origin is that they vary in intensity with solar activity.

During the great magnetic storm of Sept. 4-5, 1958, the particles in the outer belt and the artificial Project *Argus* shell decreased sharply, *Explorer IV* measurements showed. But in the same period there was no change in the number of particles it counted in the inner belt.

The outer belt of electrons now is believed to be the immediate cause of the earth's aurora. In the regions of the magnetic poles, this belt dips down to minimum altitudes of less than 200 miles. At the equator, the outer zone begins at about 8000 miles, reaches a peak around 10,000 miles and subsides gradually for another 15,000 miles.

Primary cosmic-ray particles are a negligible hazard because they are ex-

remely rare. Their products are dangerous only because the earth's magnetic field concentrates them in a narrow zone.

Solar activity creates a variable hazard. During a solar flare, a space craft will be subjected to a fairly high intensity of energetic protons. During periods of solar quiet, the danger is negligible. Since it is impossible to predict solar flares, some scientists believe it may be necessary to suspend all manned space flight for a year or two at periods of maximum activity in the 11-year solar cycle.

• **Major findings**—Here is a thumbnail listing of some of the major radiation-belt experiments reported in the last year:

• Stanley C. Freden and R. Stephen White of the Lawrence Radiation Laboratory, Livermore, Calif., found protons with energies greater than 75 million electron volts in the inner zone at 750 miles altitude. The experiment, using a *Thor-Able* rocket at Cape Canaveral in April, 1959, was reported to the sponsor, the Atomic Energy Commission.

• Peter Mayer, University of Chicago, found that intensity of cosmic radiation doubled 40 minutes after a solar flare occurred on Sept. 3, 1959. Also, Mayer uncovered a small but well-resolved radiation belt between the two major zones. His results, from *Explorer VI,* were reported at the Cleveland meeting of the American Physical Society in November.

• V. I. Krassovsky and associates in the Soviet Union found very soft electrons at altitudes from 300 to 1175 miles with a maximum at 800 miles over the geomagnetic equator. Their data, from *Sputnik III,* launched May 15, 1958, was reported to the 10th International Astronautical Congress at London in September.

• C. E. McIlwain and Pamela Rothwell of the State University of Iowa found a marked decrease in the intensity of trapped particles in the outer zone during the Sept. 4-5, 1958, magnetic storm, while the number of particles counted in the inner belt showed no change. Their results, obtained from *Explorer IV,* were reported at the Cleveland meeting of the American Physical Society.

• John B. Cladis of the Lockheed Missiles and Space Division established that the outer belt consists primarily of low-energy electrons—with less than 0.1% protons. A four-stage *Javelin* rocket was used in the experiments at Wallops Island, Va., last summer, performed in cooperation with the Air Force Special Weapons Center. Cladis reported the results last month at the New York meeting of the American Physical Society.

Tube Facilitates Direct Printing

A cathode ray type tube has been developed for direct electronic printing at high speed on non-sensitized dielectric material by the Electron Tube Division of Litton Industries.

The component is already being incorporated in facsimile, oscillography, address-labeling and television-type image reproduction equipment. Other applications soon will include high-speed computer readout, controlled information storage and erase for military tactical display maps and stock control uses, projection transparency generation, multiple copy reproduction, and simultaneous recording at any number of dispersed stations.

Tubes employing these techniques, but using much closer spacing of the writing elements to accurately print minute detail, can be furnished for specific application. Element densities up to one million per square inch are feasible.

Operating circuitry and components of the new Litton Printapix tubes are similar to those normally used for display, readout or oscillographic applications. Ordinary television components and techniques are often quite satisfactory. For operating convenience, the tube is frequently run with the printing head at ground potential.

Used with the new Printapix direct writing tube, ordinary paper provides a low-cost base material for image rendition. Printing quality can be improved by making the opposite side of the paper slightly conductive. Transparent media such as glass and thin

transparent plastic or commercial sheet polyesters may be used with Printapix. Dielectric Material transport requirements depend on the proposed application.

Image development with the Litton Printapix direct writing tube is simple, inexpensive, instantaneous and dry. One system uses a developing powder with two components, a toner and a carrier. Agitation of the combination produces a tribo-electric charging. The toner is a finely pigmented plastic material which becomes positively charged and is thus attracted to the negative charge image on the dielectric material. A typical carrier material is powdered iron.

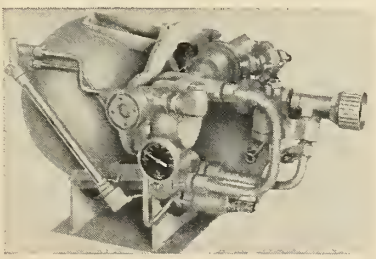
The developing powder is released as a cloud or fog very near the charged dielectric surface. Pigmented plastic is attracted to and retained on the charged areas by the coulomb force. The resultant image can either be erased for reuse of the base material and powder, or permanently fixed by a rapid heat cycle, pressure or other means. Since the pigment determines the resultant image color, multicolor reproductions may be obtained by proper development.

Circle No. 225 on Subscriber Service Card.

Packaged Cooling System

A cooling system for electronic gear recently announced by Vickers Inc., Division of Sperry Rand Corporation, utilizes fluorinated hydro-carbon fluids which act as thoroughly stable dielectric and heat transfer agents. The new package system dissipates an input of 47 KW with a unit weight of only 2 pounds per dissipated KW. System dry weight is 74 pounds.

This "Active" system—as compared



to "Passive," ablative-type cooling techniques—employs a centrifugal pump that circulates fluid through a liquid-to-air heat-exchanger core, then through the electronic gear. The fluid moves at rates as high as 52 gpm to maintain turbulent flow for maximum heat-transfer effectiveness. Output pressure of approximately 100 psi overcomes inherent resistances to flow found in coolant passages of electronic

gear, and holds the fluid in a liquid state for maximum dielectric strength.

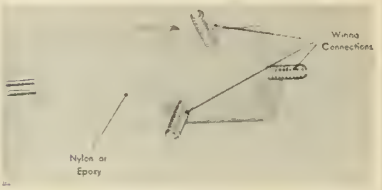
Individual component design considerations—increased output of the centrifugal pump, special pump bearings, fluid storage and fluid level indicator—compensate for hydrocarbon fluid characteristics such as high density, low lubricity and high coefficient of expansion.

An integral supercharge pressure control provides an operating range of from −65°F to +210°F. It prevents high pump pressure output at low temperatures and pump cavitation due to fluid vaporization at high temperatures.

Circle No. 226 on Subscriber Service Card.

High Temp Mercury Relays

A miniaturized family of 30 amp @ 115 volt AC mercury relays for ultra "high" and normal temperature requirements has been introduced by the Sorrels-Johnson Corp. These hermetically-sealed relays have a new feature—3-way wiring connections, to enable



multiple mounting positions heretofore unavailable in mercury relays of this type.

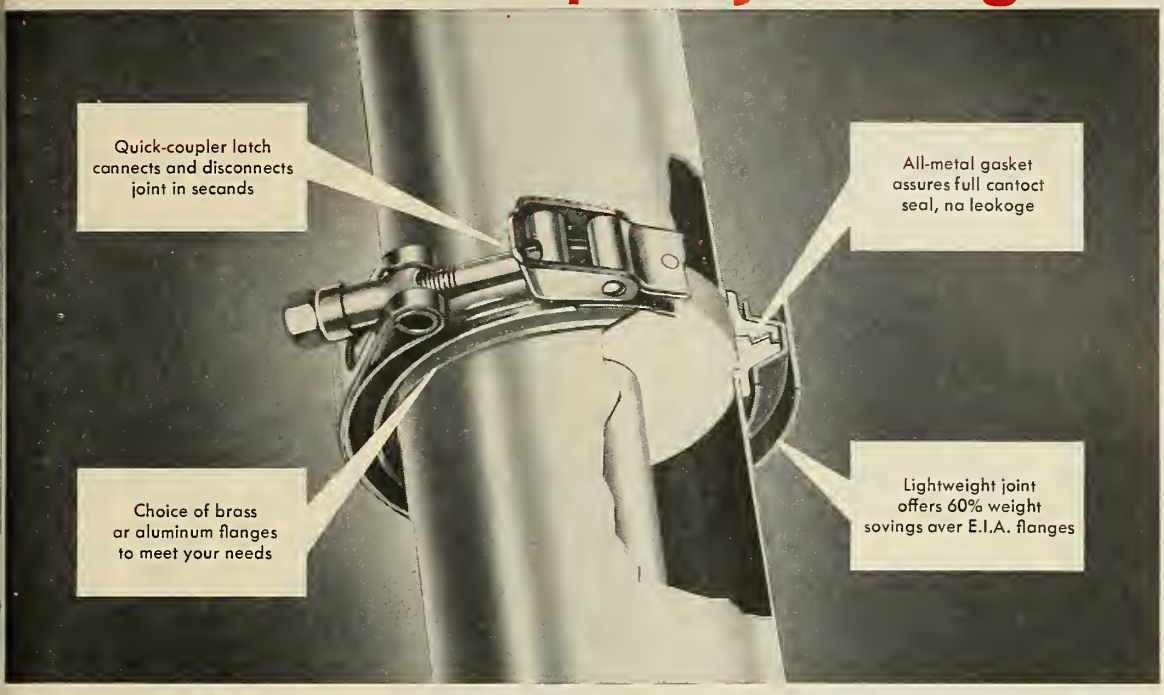
The relays give various time delays for AC relays without using thermal delay mechanisms. They enable remote control wiring with low voltage to the switch for homes; yet they handle strong current loads, despite their miniaturized size. Sealed construction, silent operation, and rugged materials make them ideal for a multitude of applications including street lights, instruments, grinders, and similar machine shop equipment.

Circle No. 227 on Subscriber Service Card.

Low-level Commutator

An ultrareliable low-level commutator has been produced by San Diego Scientific Corp. for switching millivolt signals at high speed. The model illustrated handles 96 channels of strain gauges and thermo-couples at 10,000 samples per second without preamplifiers. This magnetic multiplexer (Magne-Plexer) uses miniature magnetic amplifiers with a radio frequency

Zero Radio Frequency Leakage!



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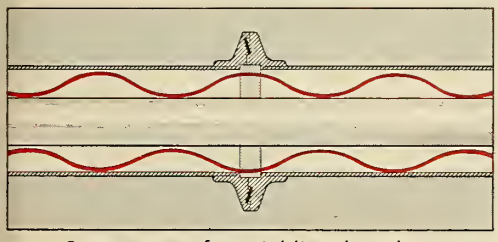

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Marman's CONOSEAL Jaint is designed ta eliminate radia frequency leakage in caaxial lines. It features an all-metal gasket seal that seals lines subject ta increased pawer. The CONOSEAL alsa pravides a 60% weight savings aver standard E.I.A. flanges and can be installed quickly, with minimum care and skill.

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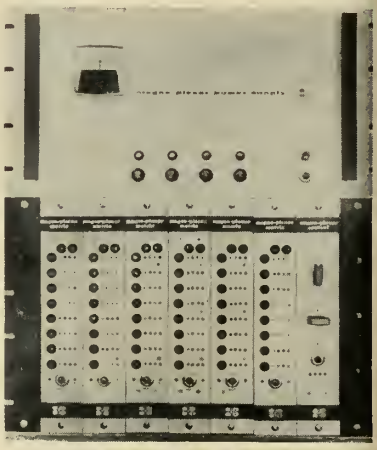
carrier, in combination with a nominal amount of transistor circuitry. Because of the floating inputs, it has practically infinite common mode rejection. Output is 5 volts of either sign. Typical accuracy is 0.2%.

The signal circuits are never interrupted for switching, which is accomplished by switching carrier power via

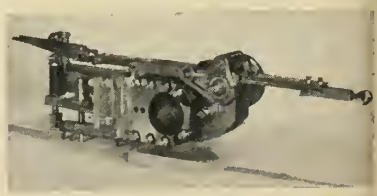


a solid-state matrix, thus eliminating contact potential errors in the signal input circuits. Programing can be varied by selecting desired circuits within the carrier switching matrix without disturbing, patching or reconnecting the signal inputs. Actual program selection is accomplished by replacing plug-in cards.

Circle No. 228 on Subscriber Service Card.

Pneumatic Servo Actuator

Development of a pneumatic servo actuator which has undergone severe endurance testing for 42 consecutive



hours at temperatures ranging up to 1600°F has been announced by the Controls and Accessories Division of The Marquardt Corporation.

The new air motor actuator is designed to function in extreme temperature and radiation environments. Fast response combined with advanced pneumatic servo valve and stabilization techniques make it possible to integrate the unit into aircraft, missile and nuclear control systems. Typical appli-

cations include rocket-engine thrust-vector controls, aerodynamic surface controls and reactor servicing machinery and control rod drives.

Prime mover of the actuator is an opposed pair of nutating disc motors with a rack and pinion drive. The absence of complex valving assures high reliability. Designed with a minimum amount of rubbing surfaces and constructed of high-temperature base alloys, the Marquardt actuator needs no lubrication.

Circle No. 229 on Subscriber Service Card.

Ten Per Cent Solar Cells

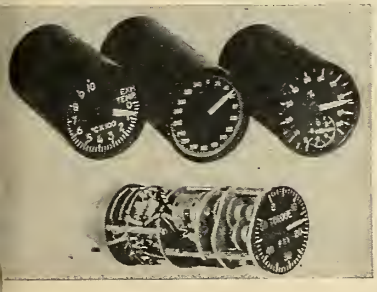
Hoffman Electronics Corp. has announced that it can offer gurauranteed 10% minimum conversion-efficiency solar cells for the first time in production quantities.

Also available for the first time are shingled solar-cell assemblies with 10% minimum conversion efficiencies. The high-efficiency cells, which are type 120C, measure 1 by 2 centimeters (0.4 by 0.8 in.), have a spectral response ranging from 4000 to 11,500 angstroms and an operating temperature range of –65°C to 175°C.

Circle No. 230 on Subscriber Service Card.

Modular-Built Indicators

A modular construction approach toward subminiature servo indicators developed by Servo Development Corp.



utilizes standard stock parts and is suited for prototype and limited production applications where delivery and engineering costs are important.

The basic module is the gear box in which up to seven .0937-in. diameter shafts are mounted in ABEC-7 ball bearings. Gear ratio of up to 65,000/1 are obtainable using precision 2 stock gears. The component module utilizes standard plates for mounting size 8 or size 10 rotating component. The dial section, another module, also utilizes standard parts. Dial configurations, which are to customer's specifications, are photographically processed to an accuracy of 6 minutes of arc.

Circle No. 231 on Subscriber Service Card.

New Literature

PHOTOMICROGRAPHY. A new book on "Photomicrography of Metals," a reference guide for metallurgists, has been published by Eastman Kodak Company. The 46-page data book may also serve as a short course in photomicrography for those metallurgists interested in reviewing the latest techniques in this field. In addition, Kodak points out, the booklet should be a valuable addition to metal industry technical libraries and a supplemental text for college-level metallurgy students. It is available for 50¢ plus 10¢ handling.

Circle No. 200 on Subscriber Service Card.

CORRECTION. The new literature item in M/R's edition of Jan. 11, page 42, describing a booklet on true position dimensioning available from the Scintilla Division of the Bendix Aviation Corp., neglected to point out that cost of the booklet is $3.00 ($2.50 in lots of 10 or more).

GENERATING COMPONENTS. Engineering specifications and application descriptions of electrical components for missile ground power equipment is contained in General Electric Company's new bulletin GEA-6973. The 12-page bulletin covers electrical generating components at either 60 or 400 cycles for applications such as military aircraft ground power, commercial aircraft ground power, computer power supply, missile ground power and special military projects. Application data, outstanding features and technical descriptions, as well as engineering performance statistics, cover such electrical equipment as high speed aircraft-type alternators, regulators and exciters; semi-industrial alternators, regulators and exciters; ac-to-ac and ac-to-dc motor-generator sets and static speed and voltage-regulated motor-alternator sets.

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GAMMA SPECTROMETER SYSTEM. Data folder GSS-1 giving details on a new gamma spectrometer system designed to eliminate the "dark current" defect common to conventional systems is available from Nuclear Measurements Corp. Known as Model GSS-I, the system is said to offer better resolution over a wider range, and to provide greater precision in gamma spectroscopy than possible with any other equipment now available.

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Another Way
RCA Serves Science
Through
Electronics

Systems Development for Space Technology

TELEVISION CAMERAS

Design a miniaturized camera system for taking "snapshots" from a satellite. Drastically reduce bandwidth to conserve power, yet maintain high resolution picture quality. The entire unit must operate unattended in a space environment.

Astro-Electronic Products Division took these demands in stride and developed several electronic camera systems scheduled for use in space science experiments. One of them is pictured above.

A special, ruggedized ½-inch Vidicon gives this compact camera a TV resolution capability of 500 lines. Because still pictures are to be transmitted, video bandwidth is cut to 62.5 kc by using a very slow (2 sec.) scanning rate. A specially designed, ruggedized shutter, designed for minimum of 100,000 operations, immobilizes the image and eliminates smear. The camera, less lens, is only 5 inches in length and weighs approximately 2 lbs. The transistorized camera electronics, including the power converter, is housed in a container measuring 6 x 6¼ x 3 inches.

Such a camera can be used to look at the earth's cloud cover from space, map the moon, study the solar system, or monitor the space vehicle itself. 1-inch Vidicon versions of these cameras are capable of 800 to 1,000 lines resolution. This is typical of the way AEP approaches problems, going beyond the bare requirements to develop space systems which can adapt to meet the needs of tomorrow.

RADIO CORPORATION OF AMERICA
Astro-Electronic Products Division ***Princeton, N.J.***

AM and FM Command Receivers—Another AEP Capability

contracts

NASA

Traceriab, Waltham, Mass., for research and development on a radiological analyzer for nonradioactive gases. Amount not disclosed.

$33,500,000—McDonnell Aircraft Corp., St. Louis, for *Mercury* space capsules.

$62,717—Mobile Aerial Towers, Inc., Port Wayne, Ind. for services and materials for pilot's capsule tower for delivery to Cape Canaveral.

NAVY

United States Chemical Milling Corp., Los Angeles, for supplying fiberglass linings for the *Sidewinder*. Amount not disclosed.

$25,200,000—Convair Div., General Dynamics, for advanced *Terrier* missiles.

MISCELLANEOUS

$9,500,000—Electronic Communications, Inc., St. Petersburg, Fla., for ALRI electronic equipment. Subcontract from Burroughs Corp.

$371,000—American Electronics, Inc., American Concertone Div., Culver City, Calif., for special-purpose tape recorders. Subcontracts from Sperry Gyroscope, Western Electric and Temco Aircraft.

$180,000—Trans Electronics, Inc., Canoga Park, for ground support equipment used with the *GAR 11* missile project. Subcontract from Hughes Aircraft Co.

$60,000—Electronic Engineering Co., Santa Ana, Calif., for design and construction of data translation equipment. Subcontract from Sandia Corp., Albuquerque, N.M.

ARMY

Southwestern Industrial Electronics Co., Division of Dresser Industries, Inc., Houston, for building 240 signal conditioning modules for use on the *Pershing*. Subcontract from Martin Co.

$10,888,000—Paul Hardemann, Inc., Stanton, Calif., for building and installing propellant loading sytsems for seven *Atlas* missile sites.

$4,499,634—Raytheon Co., Waltham, Mass., for *Hawk* missile test equipment.

$2,667,475—Douglas Aircraft Co., for *Nike-Hercules* launching area items.

$1,312,341—Chrysler Corp., Detroit, for additional *Jupiter* missile components.

$1,111,860—Federal Pacific Electric Co., Newark, N.J., for furnishing 5 kv metal-clad switchgear assemblies for six *Titan* missile launching items.

$1,075,000—Hughes Aircraft Co., Fullerton, Calif., for repair parts for the missile monitor system.

$975,000—Sperry Rand Corp., Salt Lake City, for research and development of *Sergeant* missile system.

$481,500—Aerojet-General Corp., Azusa, Calif., for classified work.

$399,324—Hayes Aircraft Co., Birmingham, Ala., for ground support equipment for the *Saturn*.

AIR FORCE

United Aircraft Corp.'s Norden Division, Stamford, Conn., for analog-to-digital converts to be used with the *Hound Dog* missile. Subcontract from North American Aviation Inc.'s Autonetics Div. Amount not disclosed.

$7,980,000—Burroughs Corp., Detroit, for training programs for installation personnel, installation of hardware and on-site logistic support and maintenance supply depot support in connection with the SAGE program.

$9,000,000—Callery Chemical Co., Muskogee, Okla., for production of pentaborane.

$116,000—Space Electronic Corp., Glendale, Calif., for studies and experiments in subsurface propagation of electromagnetic waves.

$100,000—Burton Manufacturing Co.'s Instrument Div., Santa Monica, Calif., for accelerometers. Two contracts.

$96,000—Space Electronics Corp., Glendale, Calif., for study of a terminal guidance system for the *Titan*. Subcontract from Avco Corp.'s Research & Advanced Development Division.

$64,848—General Electric Co., Scranton, Pa., for electron tubes.

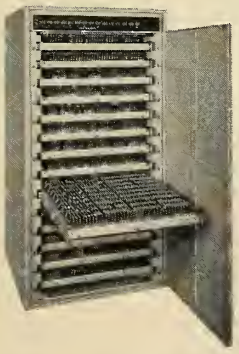
$51,600—Geophysical Institute, University of Alaska, for investigation of solar-induced phenomena at magnetically conjugate points on the earth.

$51,321—G. T. Schjeldahl Co., Northfield, Minn., for modification of design of the Robin meteorological rocket balloon and fabrication of balloons.

$42,678—General Precision Lab., Inc., Pleasantville, N.Y., for wind computers to be integrated into a complete airborne system.

Comparison between advanced Navy computer (foreground) and Univac Scientific (background) portrays dramatic reduction in size of large-capacity data processing equipment achieved by Remington Rand Univac.

The case of the shrinking computer



Central computer of the advanced Navy system shown at top of page illustrates compact size and ease of maintenance provided by building block construction. Containing 4,100 packages, the cabinet occupies only 37 cubic feet of space. Roll-out drawers permit easy and rapid access to component packages.

Remington Rand Univac compresses large-capacity performance into small package

In an advanced computer developed for the U.S. Navy, Remington Rand Univac dramatically reduced the size of large-scale data processing equipment. With a 32,786-word memory, the capacity of this miniaturized computer almost equals that of earlier vacuum tube systems of 10 times its size.

This compact, completely transistorized system has a cycle time of eight micro-seconds, and is linked with seven input-output registers, each of which may operate simultaneously and independently of computer programs.

Remington Rand Univac has openings on projects associated with advanced equipment such as the computer described above. These positions offer you the opportunity to advance your career development while at the same time participating in rapid advances in the state of the art.

If you are thinking of changing positions, or would consider a change, be sure to investigate the openings described below.

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DEVELOPMENT ENGINEERS—To develop advanced techniques in high speed memory circuits, switching circuits, and other data processing requirements. Engineers are also required for work on communications systems, antenna couplers, and servo mechanisms.

SYSTEMS ENGINEERS—Engineering, Mathematics, or Physics degree with experience in weapons and missile guidance systems involving digital control, digital conversion, radar and communications information processing, and display and output equipment.

PHYSICISTS—B.S., M.S., and Ph.D. levels for research and development of systems and circuitry of digital computers for evaluation of component reliability, and for physical research including evaporative thin film research and ferro-magnetic domain behavior as applied to computer elements.

PRODUCTION ENGINEERS—To plan automated processes, methods, and tooling for the world's most reliable computers. These openings on large production programs require imagination and creativity. Engineering degree preferred, with experience on electronic equipment.

RELIABILITY ENGINEERS—To perform reliability analysis and predictions, develop failure reporting procedures, analyze failures, and recommend corrective action.

Inquiries will be given prompt and confidential consideration. Send a resume of education and experience to:

R. K. PATTERSON
Dept. B-2

Remington Rand Univac

Division of Sperry Rand Corporation
2750 West Seventh Street, St. Paul 16, Minnesota.

There are also immediate openings in all areas of digital computer development. Inquiries should be addressed to:

F. E. NAGLE—Department B-2,
REMINGTON RAND UNIVAC
Division of Sperry Rand Corporation
1900 West Allegheny,
Philadelphia 29, Pennsylvania.

R. F. MARTIN—Department B-2,
REMINGTON RAND UNIVAC
Division of Sperry Rand Corporation
Wilson Avenue,
South Norwalk, Connecticut.

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SCHULTZE

Dr. Helmuth W. Schultze: Appointed director of commercial sales and development for The Alloyd Corp. Was formerly manager of new chemical and catalyst development for Climax Molybdenum Co., a division of American Metal Climax, and duties for Union Carbide Metals Co. performed similar

Jack Larsen: Elected manager of General Devices, Inc.'s Special Projects Department. Previously served as consultant to the Atomic Energy Commission in the development of reactor controls for the Nautilus and Sea Wolf and headed the Navy Dept.'s missile guidance section on the *Polaris*.

Jack H. Frailey: Former manager of missile systems. Missile Electronics and Control Div. of RCA, appointed to the newly-created post of executive assistant to the general manager at Itek Corp.'s Information Technology Center. Was previously project director of Lockheed Aircraft Corp.'s X-7A Ramjet test vehicle and *Polaris* missile program.

LANIER

Harold F. Lanier: Manager of Goodyear Aircraft Corp.'s Guidance Engineering Dept., named special assistant to **James Bridges**, director of electronics in the Office of the Director of Defense Research and Engineering, Department of Defense. Lanier headed the group which developed ATRAN, a self-contained electronic guidance system used in the Air Force's *TM-76A Mace* missile.

Donald T. Atkinson: Former operations research manager replaces **G. P. Bieging** as manager of marketing for General Electric Co.'s Missile and Space Vehicle Dept. Prior to joining the company in 1959 was vice president of operations for Edgcomb Steel of New England, Inc.

Dr. Robert W. Bass: Appointed chief scientist at Aeronca Manufacturing Corp.'s Aerospace Division, reporting to **Dr. P. A. Castruccio,** technical director. He will direct research in celestial mechanics and space-vehicle orbit-trajectory theory. Previously held research positions at Johns Hopkins and Princeton universities.

Karl R. Wendt: Formerly chief engineer of communications and radar section at Martin-Denver, chosen manager of Colorado Research Corp.'s research department.

Edwin S. Coyle: Promoted to manufacturing manager of the Electronic Controls Section of The Budd Co. Was formerly a project engineer in general research and development.

George F. East: Senior project engineer promoted to chief engineer in the Dynamics Division of Clary Corp.

T. F. Dixon: Director of research and engineering for Rocketdyne, division of

North American Aviation, Inc., chosen chairman of an ad hoc group charged with recommending a program of research and development of advanced rocket propulsion systems to the Department of Defense.

MOORE

David William Moore: Formerly manager of Lear Inc.'s Applied Research Laboratory, elected manager of the Solid State Physics Laboratory. Previous posts: Director of research facilities, Servomechanisms, Inc. and division manager and project engineer, Fairchild Camera and Instrument Corp.

Arthur Mac Arthur: Formerly with Lyndon Aircraft Inc., named manager-engineering, Military and Industrial Products Div. of Breeze Corporations, Inc. Has previously served in various management and engineering capacities with Convair, Avion, Inc., and Piasecki Helicopter.

Henry C. Guhl: Elected vice president-engineering by the board of directors of the National Vulcanized Fibre Co.

HIERHOLZER, JR.

Frank J. Hierholzer, Jr.: Named assistant department head of the Microtronics Dept. of Sperry Semiconductor division of Sperry Rand Corp. Was formerly senior engineer in the solid state electronics engineering section of the Materials Engineering Dept. of Westinghouse Electric Corp. Has several patents in the fields of arc discharge devices and semiconductor applications.

Edward Watt: Former design engineer with the Hamilton Watch Co., Electronics Div., joins Nacimco Products, manufacturer of electronic and electro-mechanical instruments and systems, as senior electronics engineer.

Edward L. Rucks: Former manager of Aerojet-General Corp.'s Plastics Division, named director of the firm's newly formed Structural Materials Division, the result of combining the Structural Plastics Div. and the Materials Dept. **Lawrence L. Gilbert,** former chief of the Materials Dept., will assist Rucks.

Neil J. Waterman: Appointed assistant head of the *Atlas* project office of flight test operations, Space Technology Laboratories, Inc. He joined STL project office in August, 1959, as an administrative engineer.

reviews

Here are abstracts of some papers given at the ARS Solid Propellant Rocket Research Conference. For further information, contact American Rocket Society, 500 5th Ave., New York 36, N.Y.

The Performance of Plug-Type Rocket Exhaust Nozzles. K. Berman and F. W. Crimp. General Electric Co. ARS paper 1047-60.

The paper reviews some of the essentials of plug nozzle design and operation and presents data on the application of plug nozzles to rocket propulsion systems.

Conclusions reached are: the performances of plug-type rocket exhaust nozzles exceeds that of a conventional converging-diverging nozzle in the over-expanded condition; the use of plug-type configuration on large liquid-propellant engines appears to offer distinct advantages in size, weight, cost, and performance; plug nozzle technology has advanced to the point that the plug is becoming competitive with clustered conventional nozzles for some solid-rocket applications; the plug-type nozzle configuration is adaptable for use as a variable throat area device.

A Method of Strength Analysis of Solid Propellant Rocket Grains. N. N. Au, Hughes Aircraft Company, Culver City, California. ARS paper 1062-60.

Steady-state stress and strain distributions in long cylindrical case-bonded propellant grains are developed on the basis that the propellant is an elastic, homogeneous, and isotropic material in generalized plane strain. Thermal effects are studied for case-bonded grains exposed to a temperature environment that is different from the cure temperature for a sufficiently long time, such that thermal equilibrium is achieved.

Stress and Strain Analysis of Cylindrical Case-Bonded Grains. J. Vandenkerckhove, Free University of Brussels and G. Lampens, Joint Powder Factories of Belgium. ARS paper 1064-60.

The paper analyzes the stresses and strains which appear in a case-bonded solid-propellant grain during the combustion, under the influence of the gas pressure.

Several conclusions important to the grain designer include: for thin, high performance walls, the chamber elasticity must be taken into account; the mechanical resistance of the grain is much more critical for large web fractions than for small ones; the temperature and rate of strain dependence of the modulus of elasticity and of the Poisson's ratio must be known accurately.

An Experimental Investigation of Unstable Combustion in Solid Propellant Rocket Motors. Capt. W. Grant Brownlee, Royal Canadian Artillery, and Frank E. Marble, Jet Propulsion Laboratory.

Experiments with case-bonded, cylindrically perforated motors using a polysulfide, ammonium-perchlorate propellants were reproducible as a result of careful manufacturing control and extended propellant curing time. In these motors, the oscillations were in the fundamental pseudo-standing tangential mode and were accompanied by increases in the average burning rate. At sufficiently high pressure levels all firings were stable. Reduction of the operating level led to mild instability. A sufficient further reduction produced a

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The importance of infrared development at Hughes is shown in substantial development contracts and in the fact that Hughes is investing its own funds in further exploration.

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Infrared Search-Systems Range Performance: R. H. Genoud / Missiles Seekers and Homers: W. A. Craven, et al.
Servomechanisms Design Considerations for Infrared Tracking Systems: J. E. Jacobs / Simulation of Infrared Systems: H. P. Meissinger

sudden change to maximum instability. Continued reduction in pressure level from this point resulted in a gradual decrease in the degree of instability.

Reliability Aspects of Solid Propellant Rocket Engines. B. R. Adelman and A. C. Keathley, United Research Corp., Menlo Park, Calif. ARS paper 1043-60.

The performance of the large solid-propellant engines presently under development will compare favorably to that of liquid-propellant systems such as LOX-kerosene and the common storable propellants.

Further, the potential exists for increases in the specific impulse of solid propellants using formulations now under study on laboratory scale which will permit overall performance characteristics such that solid-propellant engines will be competitive with practically any liquid units.

Resonant Burning of Solid Propellants: Review of Causes, Cures and Effects. R. H. Wall, Thiokol Chemical Corp., Redstone Division, Huntsville, Ala.

Unstable operation of solid-propellant rocket engines refers to unpredictable chamber pressure irregularities that cannot be explained by the common equilibrium pressure equation. In the more severe instances of unstable operation the engine chamber can be ruptured; lesser degrees of the problem might seriously affect performance.

This article presents a review and a discussion of the many factors associated with the occurence and suppression of the phenomenon.

An Experimental Comparison of Contoured and Conical Nozzles, Robert E. Overall, Thiokol Chemical Corp., Huntsville, Ala.

A comparison is made between the performance of conical and contoured nozzles in static tests. Data were gathered for approximately 250 solid-propellant motors loaded with propellant containing a very high percentage of metal additives. The contour designs tested were arbitrary bell-shaped nozzles, "Foelsch" contours, and contours based on a two-dimensional method of characteristics.

Propellant Ignition by High Convective Heat Fluxes, A. D. Baer, N. W. Ryan and D. L. Salt, University of Utah, Salt Lake City.

The ignition of composite rocket propellants by convective heat fluxes in the range of 40 to 400 BTU per sq. ft.-sec. is reported. The technique employs a shock tube as a hot gas generator, the shocked gas being used as the heat source. Ignition times in the range 5 to 45 milli-seconds were obtained, and a pronounced effect of oxygen in the heating gas was observed.

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This advanced automatic navigator was designed and developed by Ryan Electronics under Army contract and tested by the Army Electronics Proving Ground at Ft. Huachuca. Ryan's AN/APN-129(V) navigator is in production for use with the Army AO-1F Mohawk and RL-23D surveillance aircraft, and the Model 120B is guiding H-19 and H-34 Helicopters.

Ryan navigators are light, compact, and trouble-free. With no minimum altitude limitation, they are ideally fitted for the Army's low-level "nap of the earth" operations and vertical envelopment combat missions. Independent of ground facilities, they are practically immune to countermeasures.

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MARCH

Navy League Seapower Symposium, Sheraton Park Hotel, Washington, D.C., March 1-3.

Royal Astronomical Society and Royal Meteorological Society, "The British Rocket Programme," Royal Society of Arts, London, March 4.

British Interplanetary Society, "The Exploration of the Moon," Caxton Hall, London, March 5.

American Society of Mechanical Engineers, Gas Turbine Power and Hydraulic Conference, Rice Hotel, Houston, March 6-9.

Society of Instrument Technology, "Data Reduction for Guided Weapon Trials at Aberporth," Manson House, London, March 7.

Heat Transfer Symposium, Mechanical Engineering Dept., University of Florida, Gainesville, March 7-8.

Society for Aircraft Material and Process Engineers, Midwest Chapter Symposium, "Processing Materials for Re-Entry Structures," Miami Hotel, Dayton, Ohio, March 9-10.

Mechanical Properties of Engineering Ceramics, North Carolina State College School of Engineering and Office of Ordnance Research, U. S. Army, N.C. State College Campus, Raleigh, March 9-11.

National Flight Propulsion Meeting, Institute of the Aeronautical Sciences, (classified), Cleveland, March 10-11.

Electronic Industries Association, Defense Planning Seminar, Statler Hilton Hotel, Washington, D.C., March 15.

Institute of Radio Engineers 1960 International Convention, Waldorf-Astoria Hotel and New York Coliseum, New York City, March 21-24.

Symposium on Optical Spectrometric Measurement of High Temperatures, sponsored by University of Chicago's Applied Science Foundation; Jarrell-Ash Co.; National Science Foundation, University of Chicago, March 23-25.

22nd Annual American Power Conference, sponsored by Illinois Institute of Technology, American Society of Mechanical Engineers and others, Sherman Hotel, Chicago, March 29-31.

APRIL

University of Connecticut, Sixth Annual Advanced Statistical Quality Control Institute, Storrs, April 3-15.

Solar Energy Symposium, American Society of Mechanical Engineers, and Mechanical Engineering Dept., University of Florida, Gainesville, April 4-5.

1960 Nuclear Congress: "What Will the Future Development of Nuclear Energy Demand From Engineers?" sponsored by 28 engineering, scientific, management and technical organizations. Includes 6th Nuclear Engineering and Science Conference; 8th NICB Atomic Energy in Industry Conference; 6th International Atomic Exposition, New York City Coliseum, April 4-7.

American Chemical Society, 137th National Meeting, Cleveland, April 5-14.

American Rocket Society, Structural Design of Space Vehicles Conference, Biltmore Hotel, Santa Barbara, Calif., April 6-8.

1960 National Meeting "Hyper-Environments—Space Frontier," Institute of Environmental Sciences, Biltmore Hotel, Los Angeles, April 6-8.

Royal Aeronautical Society, Coventry Branch, "The Optimum Size of Rocket Engines," Coventry, England, April 7.

ASME-SAM Management Engineering Conference, Statler Hilton Hotel, New York City, April 7-8.

Advertiser's Index

EMPLOYMENT

Russian Threat Lies in 'Space Gap'

Writing on this page over the past year and a half, we have had frequent occasion to criticize the nation's space program and the people responsible for it. We shall continue to do so until the program gets the national effort and funding it deserves. Most particularly shall we continue to voice strongly our feelings about a national leadership which not only refuses to enter the space race—but declines to admit there is one.

On the other hand, there have been few allusions here to the so-called "missile gap" and "deterrent gap"—for several reasons.

First, the importance of the "missile gap" is exaggerated. No country could perform the industrial, logistic and military miracle of wiping out or even critically wounding the deterrent force of the Western World in one secret, instantly coordinated blow.

Second, the "deterrent gap" is probably nonexistent. The combination of SAC bombers, RAF bombers, nuclear-armed NATO fighter-bombers, IRBM's on station in Europe and ICBM's going on station in the U.S. is the most destructive offensive force ever known—if even half of its power were to be unleashed. True, it must be maintained, but a "gap" would come only if we criminally permitted it—and this we will not do.

Third, the Russians are quite prepared to forego conquest by military invasion if they can find a better way to do it. At the moment they have two excellent routes for this which must make the aspect of an atomic holocaust seem to them both foolish and unnecessary.

The world-wide prestige they have won with their successes in the space race can give them vast economic and political gains without fighting for them. And if they gain control of space—if they are able to deny the rest of the world equal rights in space—then they automatically gain control of the earth anyway.

To return to the so-called "missile gap" and U.S. deterrent strength, we quote the words of Lt. Gen. Bernard Schriever, commander of the Air Force Research and Development Command and the one man most responsible for achieving America's long-range ballistic missile capability. Speaking at the recent Goddard Memorial dinner, he said:

"In less than 5½ years, a multibillion-dollar nationwide missile and space-vehicle industry has been created. Today over 100,000 people are working full-time to bring into the operational inventory our *Atlas, Titan, Thor* and *Minuteman* missiles. Tens of thousands of people also are working on the U.S. Navy's *Polaris* missile, together with its nuclear-powered submarine base, and on the *Jupiter* missile developed under the stewardship of the Army. Countless thousands of other American citizens are supporting this nucleus of full-time workers. Moreover, the missile industry rests on a solid foundation. More than a billion dollars worth of vast and complex test facilities, production plants and fully instrumented missile and space vehicle test ranges, extending thousands of miles across the Atlantic and Pacific oceans have been brought into being.

". . . Schedules laid down for the *Atlas* program in 1954 and for the *Thor* and *Jupiter* programs in 1955 have been exceeded. The Navy's *Polaris* missile program, which was the outgrowth of a joint Army-Navy effort on the *Jupiter* in 1955, is making excellent progress. The Air Force *Atlas* and *Thor* missiles and the Army-developed *Jupiter* missiles are in production. The *Polaris* is expected to become a part of the deterrent power of the U.S. later this year. The Air Force *Minuteman* missile is scheduled to be in the force in significant numbers around mid-1963." . . .

Either a missile or a deterrent gap could be dangerous, but we believe these possibilities are being effectively dealt with. It is the more subtle danger of the "space gap" which we sincerely believe is the greatest threat.

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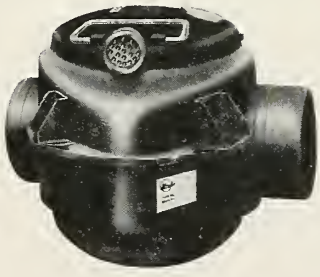

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