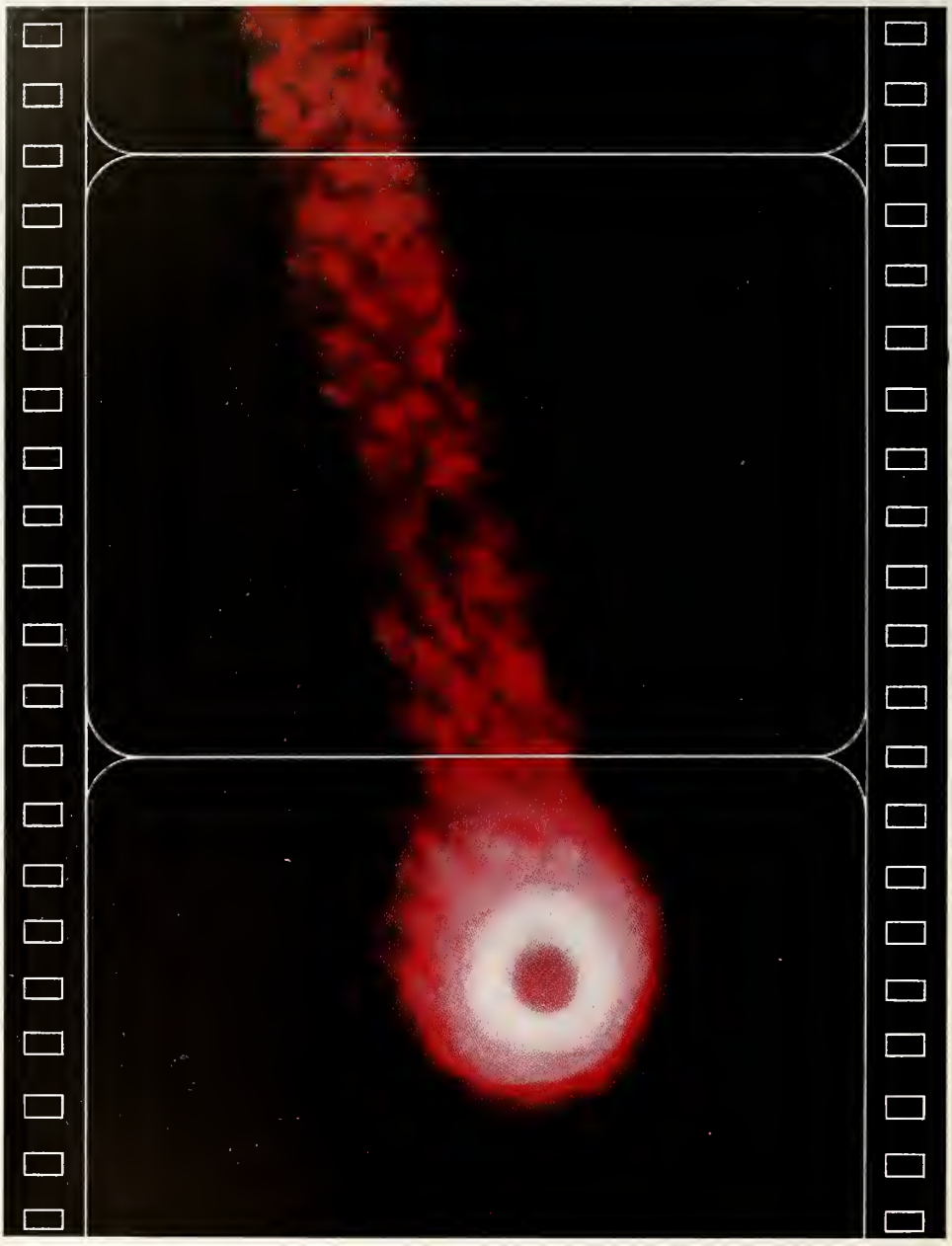
AUGUST 22, 1960

missiles and rockets

THE MISSILE/SPACE WEEKLY

Mirror Blank for Stratoscope II

AN AMERICAN AVIATION PUBLICATION



Re-entry portrait at 12,000 MPH. Critical performance data of re-entry vehicles at temperatures exceeding 12,000 degrees are obtained by a re-entry monitoring team from the Avco-Everett Research Laboratory. Portraits under these difficult conditions are obtained regularly as part of a general research program to study re-entry phenomena and related problems. Airborne equipment is used to acquire radiation data, trajectory information, and photographic documentation.

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THE MISSILE / SPACE WEEKLY

missiles and rockets

August 22, 1960 Volume 7, No. 8

THE COVER

Blank for largest fused silica mirror ever made, produced by Corning Glass. It will be precision-ground by Perkin-Elmer for use in Stratoscope II. See p. 25.

AUGUST 22 HEADLINES

SPECIAL REPORT: MISSILE/SPACE OPTICS

NUCLEONICS

DEPARTMENTS

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Leonard A. Eiserer
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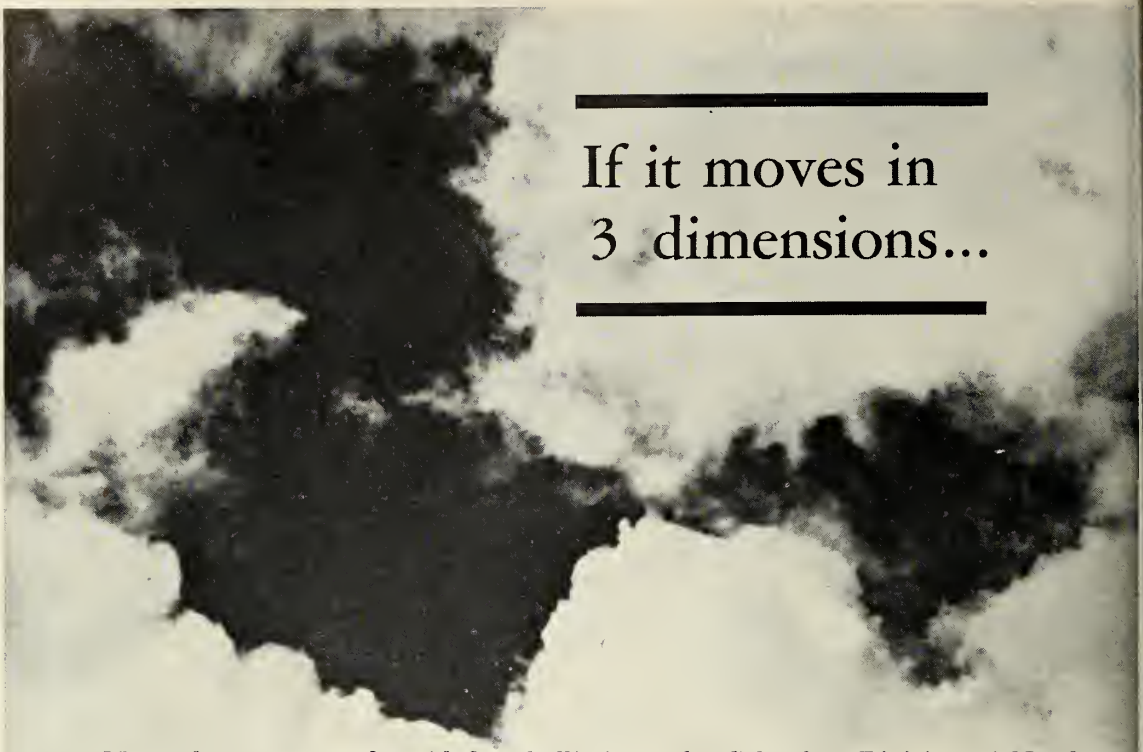

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NEW TARGET MISSILE—Two missiles in one, this high or low level supersonic target missile for U. S. Army is now in development at Columbus Division. Launched by solid booster, ramjet-powered, it performs from subsonic up through Mach 2, and from ground level to 60,000 feet. NAA Columbus also produces Navy's A3J Vigilante, world's most versatile Mach 2 manned weapon system, and the T2J Buckeye multipurpose jet trainer.

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Columbus, Ohio

The Countdown

WASHINGTON

First Step to Strategic Unification

Over and above his duties as SAC commander, Gen. Thomas S. Power is being made director of Strategic Target Planning for the Joint Chiefs of Staff—a new post. Defense Secretary Gates says the move does not involve any "rearrangement" of command and that *Polaris* will stay under the Navy. But it could still be a first step to a joint command over all strategic weapons.

Three More Atlas Pads Ready

The second half of the first (6 *Atlas*) squadron at Warren AFB is nearly operational. So much so, COUNTDOWN hears that with sufficient warning the ICBM's could be fired now.

SAC is the Winner

Shift in responsibility for building ICBM bases from the Ballistic Missile Division to Air Materiel Command is generally being interpreted as a victory for SAC. This has been further cemented by an AF plan to eliminate strategic missile wings as such an integrate them into strategic wings of SAC bombers and tankers. Any possibility that a separate missile force might be created around BMD now seems dead indeed.

Minuteman Rail Launching

A railroad spur will be built soon at Vandenberg AFB. It will be used for the first test shot of a *Minuteman* ICBM from a special rail launch car now under development by American Machine & Foundry and ACF Industries. Date of launch: probably early 1961.

Echo Moon Orbit

NASA is looking over a proposal to try a lunar probe with an *Echo*-type balloon. Sales point: the metallic covered balloon could be tracked visually all the way and, as an added attraction, it would make propaganda capital for the U.S.

What About Mercury?

Hilliard W. Page, general manager of General Electric's MSVD, claims the three *basic* steps in the mastery of safe return from space flight are: 1) recovery of ballistic missile re-entry vehicles (accomplished); 2) the Aug. 11 recovery of the *Discoverer XIII* capsule from orbit; 3) future recovery of a space vehicle from lunar or interplanetary flight.

INDUSTRY

From the Front Office

Navy has awarded Raytheon two additional contracts topping $2.5 million for *Polaris* advanced guidance systems. Most sub-systems will contain welded modular assemblies . . . GE-Pittsfield has just won a $1.3 million contract for prototype fabrication of more *Polaris* inertial systems . . . also from GE-Syracuse, comes word of an advanced long-range acquisition radar which reportedly "more than triples" defensive capabilities of *Nike-Hercules*. A prototype of this radar was used in the Aug. 12 kill of one *Hercules* by another at White Sands.

ARDC Electronic Report Due

Five volume report of ARDC's Winter Study Group will be available to industry in mid-September. Under the organization of the Mitre Corp., the group has completed an intensive review of all AF electronic systems. Its report contains recommendations for future requirements of the AF Command and Control Electronics complex.

New Sounding Rocket

Latest entry in the sounding rocket field is Rocketdyne's 105-in. bird which can be fired out of a 5-in. gun or from its shipping container. Ammonium nitrate motor can kick a 6-lb. payload to 230,000 ft.

ICBM Base Lag Investigation

Despite Air Force moves to counteract slippage at ICBM bases (p. 8), chances are good there will be a Congressional investigation of industry's performance as well as military management of the program. The big question seems to be when hearings can be held. The short session now in progress mitigates against immediate action. But one could still be held in the fall—before election time.

Renegotiation Battle

Fight for changes in the Renegotiation Act is now shifting to the Senate Finance Committee. A House study group is standing pat on a recommendation to extend the Act unchanged.

Off to Broadway

"White Alice"—communications network for the early warning lines up north—is moving to Broadway. A play of that name is now in production. Main action takes place, so says the script, in a concrete radar tower perched 1500 ft. above Warning Site "Jane" at Cape Anchor. Backdrop is the Arctic sky.

INTERNATIONAL

Resistance to Skybolt

There are indications a move is afoot in British industry to head off purchase of the Douglas *Skybolt* ALBM. One possible alternative apparently being offered is the *Blue Steel* powered by the new Bristol Siddeley *Stentor* ramjet. The new engine would greatly increase the *Blue Steel's* stand off capability.

Italy's Jupiters on the Line

Great secrecy surrounds the deployment of Chrysler *Jupiters* to Italy. But COUNTDOWN hears that some missiles are being put into place in fixed pads and they are expected to be operational fairly soon.

Eye on Space

Ignoring its own country's disinterest in space, Normalair Ltd. of Britian is now displaying a line of respiratory equipment for astronauts.

Ease German Rocket Plant

From under the Iron Curtain comes word that R&D of solid rocket fuels is in progress at the Gumnitz forced labor camp near Pasewalk, Pomerania. Most of the prisoners are chemists, physicists and electronic specialists convicted of political crimes.

SAC snaps the whip . . .

AF Cracks Down on ICBM Bas

by James Baar and William E. Howard

Tough new management policies—aimed largely at industry—are being jammed into action this week by the Air Force to end slippage in the mushrooming ICBM base-building program before the nation's deterrent power is compromised.

Behind the scenes could be heard the whiplash of the Strategic Air Command—the bases' impatient customer.

The new policies follow a major Air Force and Corps of Engineers shakeup which was precipitated by delays of up to six months in readying combat *Atlas* pads at Warren AFB, Cheyenne, Wyo., and at SAC's doorstep around Offutt AFB, Neb. Essentially, the AF action is intended to:

–Apply a hammer-lock hold on the awarding and policing of all base construction contracts.

–Replace R&D "improvementism" with get-it-done production line techniques.

–Expose any further "opportunism" on the part of industry and labor.

–Head off any further slippage.

However, one dubious area remains—bickering and irresponsibility among labor unions and workers at the various sites. Strikes and jurisdictional battles have cost the program more than 30,000 man-days that can be pinpointed by the AF, and thousands more indirectly.

Goading the "catch-up" effort along is the possibility of an investigation by the House Military Operations Subcommittee headed by Rep. Chet Holifield (D-Calif.) into alleged deception and profiteering in connection with the sub-contracts being let to unqualified companies and bid-brokering or "shopping" by construction primes.

Even more important, they are looking into the Air Force-Corps of Engineers management setup and procurement practices with industry.

The subcommittee may trigger a full-scale hearing into the program.

• **Catchup a question**—Under its new organizational setup, the AF has taken responsibility for virtually all base-building away from its Ballistic Missile Division and handed it to the Air Materiel Command. Maj. Gen. Thomas P. Gerrity, a 46-year-old top procurement and production man, has initiated "Operation Catchup"—as chief of AMC's Ballistic Missile Center and newly made czar of ICBM base construction.

GERRITY
Starts "Operation Catchup"

He has given orders to a site activation "task force" of 12 senior colonels, several of them from SAC, to make sure the "pads come in on schedule." The task force commanders are being put in charge of seven *Atlas* and five *Titan* bases under construction. (BMD retains responsibility for nearly finished pads at Offutt, Warren and Vandenberg AFB.)

Precisely how much catchup will be possible under the re-aligned management structure remains a grim question. Where delays have occurred in the construction of facilities and in the delivery of equipment, the making up of time is difficult. The Engineers also contend that there have been changes ordered in the configuration of the pads—*After* completion dates—making on-time delivery virtually impossible.

In addition, there is a serious question whether it will be possible to prevent further slippage through continuing labor difficulties.

Local labor unions have fought among themselves since the beginning of construction at Warren and Offutt over who should do what. Chief source of the work-stopping jurisdictional disputes is a varying question as to what constitutes construction and what constitutes maintenance at the sites.

The local workers have repeatedly walked off the job over such picayune matters as, for example, who should install ceiling light fixtures at Offutt's Site A, and whether Convair workers could uncrate Convair-made launch control consoles at the site.

The Air Force and Convair have been powerless to halt such walkouts. They say they are still powerless. However, some critics of the program say that better management could reduce these stoppages. An effort is under way to get the international unions to make their locals change their business-as-usual policy.

• **What's the hurry?**—The men responsible for bringing the pads in at Warren and Offutt say the craftsmen at the site generally are indifferent as to what is at stake.

"These unions don't even want to hear about the urgency of this program," snorted one disgusted supervisor. "Their only interest is how much they can get out of the sugar bowl in the time it is here."

But labor alone cannot be blamed for all the slippage.

Both the Air Force and the Corps of Engineers candidly admit their management has failed in part. The admission is implicit in the switchover from BMD to AMC and in the Army's decision to establish a centralized Ballistic Missile Consrtuction Office under Brig. Gen. Alvin C. Welling in the same building with Gerrity at Englewood, Calif. The AF also concedes that there have been too many engineering changes.

As one top AF official puts it: "The engineers have had it long enough. Now it's time for production men to build it."

Under the new system, site activation commanders have full authority not only to oversee construction and installation, but to police the contracts. Formerly they had only indirect authority over contract supervision. These commanders will report to the youthful-looking Gerrity who for years has been overseeing AF bomber production and procurement.

• **Offutt story**—Most of the flare-up over the building lag is presently concentrated on the nine coffin-type *Atlas* pads at Offutt. This three-by-three complex for the 566th Strategic Missile Squadron was started in April, 1959. It

Delays

was to have been operational by this October. But the pads now are not expected to be ready until March or April.

It is here, in the Nebraska cornfields, that the Army Engineers are being accused of permitting "bid brokering" by the facility construction prime contractor, Malan Construction Corp. of New York City. The Corps has disclosed that Malan subbed out more than 90% of its contracts to "46 to 50" other companies. Nor is this all.

Malan, in the original bidding for the $13-million Offutt contract, was rejected by the Army as unqualified for the job, despite its low bid. Malan appealed and, by making a management-financial arrangement with Grove, Shepherd, Wilson and Kruge, Inc., a long-established firm which had done jobs previously for the Corps, was given the contract.

Philip Grove, vice president of GSWK, told M/R his firm performed 45% of the work at the sites and subbed out 55% to 26 "specialty" companies. He said his firm was in a "joint venture" with Malan and reports of bid brokering were "grossly exaggerated." But the Corps said "technically" GSWK was a sub to Malan and that Malan had other subs, bringing the total close to 50.

One of these subs, Superior Electric of New Jersey, was finally fired for "inactivity." Another sub which had only $150,000 in assets won a $2-million contract from Malan.

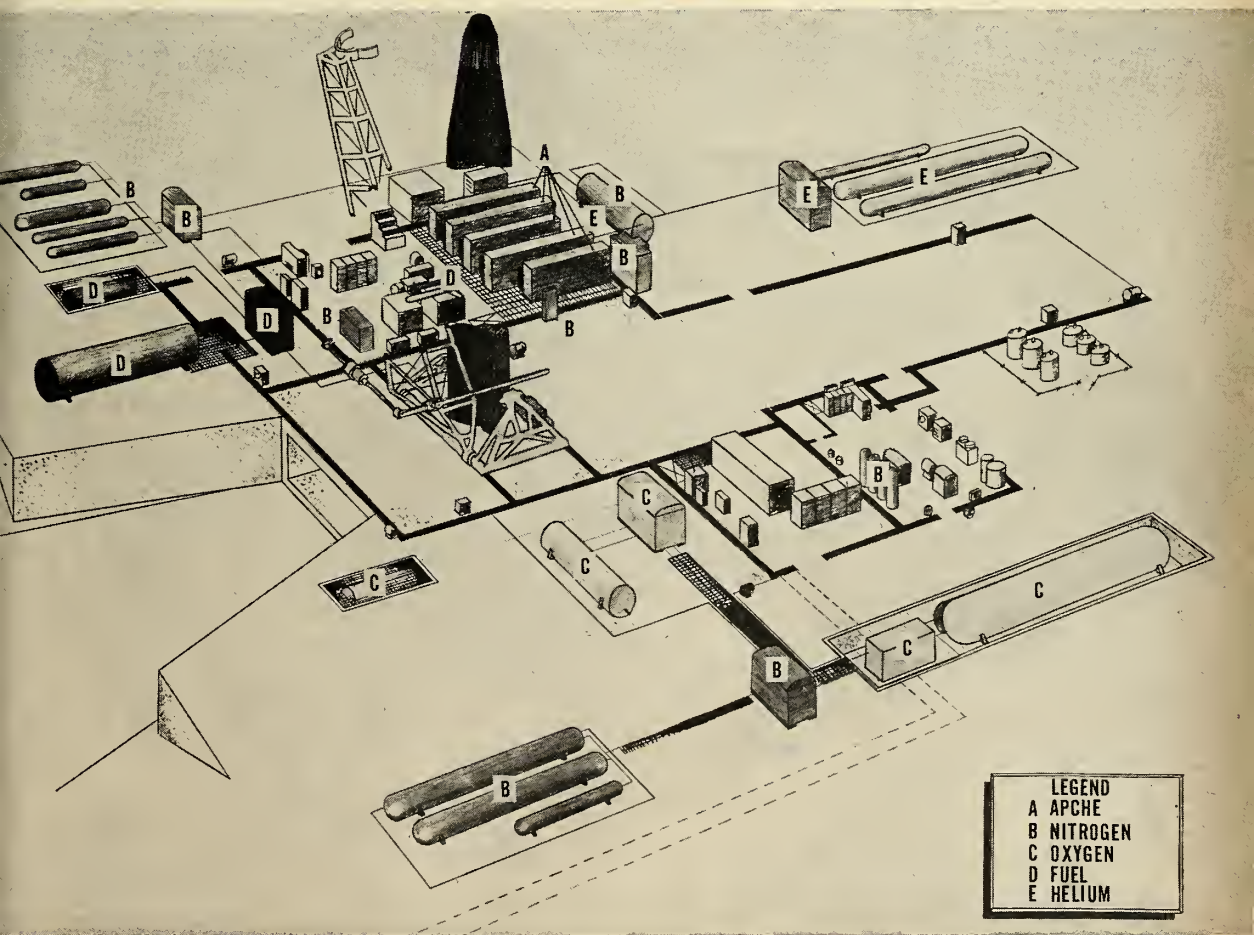
To prohibit a repetition of Malan's contracting arrangement, the Army—at AF insistence—has instituted a new requirement for the prime builder to accomplish at least 15% of the work himself; identify all of his subs in his original bid and make no changes without Army approval. The Army also is setting up a qualified bidders list to prevent "fly by nighters" from venturing into the program.

• **Pressure on Convair**—The AF said Convair also had contributed to slippage at Offutt. The prime for the program, Convair was reported to be six weeks late in delivery of ground support equipment. The company, the AF said, also brought mechanical contractors on board late and "underestimated the task," accounting for a two-month setback.

Convair has been required to expedite GSE deliveries and speed its advance planning.

Delays at Offutt are partly attributable to bad weather and some 37 engineering change orders. Authorities concede that these have hurt, but not to the extent of six months. What's the real reason?

One thing stands out clearly at Offutt's *Atlas* sites: hardly anyone seems to be in a real hurry. Somewhere between Washington and the warm green cornfields, the sense of urgency has run out.



COMPLEXITY OF OFFUTT propellant loading systems for Atlas has created a major problem: how to get skilled local labor to install it. Slippage has been caused by sub-standard values, failure to anchor pressure lines, grease applied to LOX joints.

The Missile/Space Week

Lemnitzer Picked to Replace Ailing Twining

Gen. Lyman Louis Lemnitzer, 61-year-old Army Chief of Staff, has been nominated by Pres. Eisenhower to succeed retiring Gen. Nathan E. Twining, 62, as Chairman of the Joint Chiefs of Staff. Gen. George H. Decker, now Army Vice Chief of Staff and Lt. Gen. Arthur G. Trudeau, Army R&D chief, have been mentioned for Lemnitzer's present position.

U.S. Scores Missile Successes

Still batting 1.000 in recent launchings, the United States added these missile successes to its list: An Air Force *Bomarc B* bagged a *Regulus* target drone traveling more than 1000 mph over the Gulf of Mexico Aug. 11. The next day, an Army *Nike-Hercules* blasted another *Hercules* 11 miles above the White Sands, N.M., missile range, both traveling at speeds in excess of Mach 7.

Also on Aug. 12: The Air Force sent an inertially-guided *Atlas* ICBM 5000 miles down the Atlantic Missile Range. Navy's *Polaris* zoomed 1100 miles from a land-pad launching to a target near Puerto Rico. Only flaw in the record: A 1.5-ton instrumented nose cone carried by the *Atlas* was not recovered from its watery target. But recovery was a secondary objective in the test to develop the new guidance system.

Martin Co. Saves $10 Million on Missile Master

The Martin Co. is returning $10 million on a $95-million contract it received in 1955 from the Army for the Missile Master system. Some 400,000 man-hours were trimmed from the originally estimated one million man-hours development time. Spare parts estimate of 15% was cut in half, because of "the excellent basic design of the system." Missile Masters are operating in six strategic areas, and four more will be added by the end of the year.

Rocketplane X-15 Sets Second World Record

After careful checking of *X-15* instrumentation readings and data from ground stations, the altitude record set by the North American rocketplane August 12 was revised to read 136,500 ft. instead of the 131,000 ft. first reported. Air Force Maj. Robert White flew the plane to the near-26 miles high mark.

Re-entry from 19½ Miles Up

While Maj. White made news by flying up, Capt. Joseph Kittinger hit the headlines when he came down. The 31-year-old Air Force Captain stepped out of his open gondola balloon at an altitude of 103,300 ft. and plummeted toward the New Mexico desert below. Free-falling the first 17 miles, Kittinger reached speeds of 450 mph, gradually slowing as the air became denser. At about 2½ miles above the earth his parachute opened and brought him to a safe landing. His 13 min., 8 sec. trip chalked up at least four records for the space survival program.

Attitude Arc Jet Engine Contract Awarded

A 1-kw electric arc jet rocket engine will be built by Plasmadyne Corp., Santa Ana, Calif., under a $200,000, 12-month NASA contract.

Flood Would Force Unfreezing

Legislation that would require the Administration to spend all funds appropriated by Congress for defense in FY 1961 has been proposed by Rep. Daniel Flood (D-Pa.), a member of the House Defense Appropriations Subcommittee.

Air Force to Reorganize Its Top Research Command

The USAF Research and Development Command will announce shortly the top command reorganization of its Research Division and the Office of Scientific Research.

The changes resulting from this mild shakeup are:

–Maj. Gen. William M. Canterbury will either be replaced or retired as commander of the Research Division for reasons of health.

–Brig. Gen. Ben Holzman, deputy and acting commander, will go to the Cambridge Research Laboratories as Commander.

–Dr. Knox Milsaps, former chief scientist at Holloman AFB, will replace Col. A. P. Gagge as director of AFOSR. Dr. Milsaps will also wear a second hat as chief scientist of AFRD, assuming both duties on Oct. 1. Col. Gagge has held the post since 1956.

Col. Gagge is expected to be reassigned to the Pentagon.

Maj. Gen. Daniel Hooks, presently commanding the Air Force Missile Development Center at Holloman AFB, probably will assume command of the Research Division.

Col. Nathan L. Krisberg, now commander of ARDC's European Office, is believed likely to become the Division's vice commander.

ARDC officials said there was no particular significance to the shuffle except the continuing effort to strengthen the basic research efforts of the Air Force. Gen. Canterbury, even then in bad health, was assigned when the division was formed a few months ago. It encompassed the OSR and was intended to beef up the basic research center to the same level as ARDC's other commands.

Gen. Holzman, basically a meterologist and one of the six weather experts to pick D-Day in the European Theater, World War II, commanded OSR for two years before moving up to the deputy slot of the division. There was some possibility, officials said, that he might remain in command after Gen. Canterbury's departure but it was unlikely. The Air Force wants the two-star spot filled with a major general and General Holzman has insufficient time in grade for a promotion at this time.

Dr. Milsaps holds a bachelor of science degree from Alabama Polytechnic with a Phd in physics and mathematics from Caltech. During his years at Holloman he developed the sled technique for testing gravity forces. He is a past president of the Holloman Section of the American Rocket Society.

Some companies protest . . .

Minuteman Enviroment Bidders Pressed

by Richard van Osten

Los Angeles—In an apparent attempt to push up the operational date of *Minuteman*, the Air Force is giving bidders only two weeks to submit proposals on the ICBM's environmental control system.

The proposals are due Aug. 26.

This early deadline, set at an Aug. 12 meeting here, is being protested by several of the 30-odd bidders. Companies with offices on the East Coast are complaining that 14 days is much too short a time to transmit data, study the system's configuration and determine where their capabilities and products can be used.

There are indications the AF would like to get at least some *Minutemen* in combat silos by late next year—followed by a fully operational 150-missile site on the previously announced date of July 31, 1962.

Proposals for subsystems and components of the overall environmental system are scheduled to be evaluated by Oct. 1. On or about the same date, a straight fixed-price engineering and development contract will be awarded to cover a four-month period in which a complete prototype system is to be developed and tested. Initial testing of the system and components is scheduled for completion no later than Jan. 31, 1961.

Next step will be the award, about March 1, of a new and separate contract for initial supply and installation of environmental systems at the first operational deployment area, Malmstrom AFB, Great Falls, Mont. The latter contract will call for 15 launch control facility (LCF) and 150 launch facility (LF) environmental systems.

Schedule for the full-scale contract calls for deliveries to begin in May, 1961, with delivery and installation of at least 30 launch facility and three launch control facility systems be completed by July 31, 1961. The remainder of the systems are to be delivered and installed by July, 1962.

• **Tight timing**—This planning will require close coordination with silo construction. A large portion of the environmental systems for both silo (LF) and LCF installations must be in place during actual concrete pouring. Invitations to bid on contracts for silo and other facility construction are expected to go out about Oct. 1—at the same time the contract for engineering and development of the system is awarded.

Time is of the essence, Lt. Col. Ira J. Blanco, Director of *Minuteman* facilities program for the USAF's Ballistic Missiles Center, told the Los Angeles briefing.

Pointing out that schedule dates requested are "not targets," he said the dates must be met.

"We are dead serious about schedule deliveries. If one section of the contracting falls behind the whole weapon system can go off schedule."

Most sensitive area of all in the timetable is the end point in the development program, the Air Force office added.

Hercules Wins 3rd Stage

Minuteman third-stage engines will be produced by Hercules Powder Co., ending a hotly contested race with Aerojet-General.

According to the Air Force, Hercules won the contract because of successful completion of its research and development work.

The R&D effort included a solid propellant with the highest I_{sp} of any measured to date, pivot nozzles for thrust vectoring, thrust termination which enables the range to be controlled and accurately programed, lightweight nozzles of non-eroding materials and a glass-reinforced plastic case from the Young Development Division of Hercules.

Negotiations between the firm and the Air Force's Ballistic Missile Center are due to start in the near future.

• **Complexities**—The rush into the *Minuteman's* environmental system was not based on quick judgment. Analysis, says Blanco, showed that the weapon system's requirement could be met in most areas with commercial equipment. Some prospective suppliers are a little less confident.

The *Minuteman* environment control system is complex—in order to maintain temperatures and humidity with tolerances of the present propellant. The missiles will probably be recycled on a schedule yet to be determined, but the USAF plans no scheduled maintenance at *Minuteman* sites for a three-year period. It would like to boost this to five years. This presents a reliability problem.

The environmental system's meantime between failures (MTBF) is not pegged at three years. For the overall system, MTBF is set at 14,000 hours—something less than two years. Components of the environmental system will have to better this timetable. This is what worries some possible suppliers.

The Air Force will not accept redundancy in the environmental system. This bothers engineers accustomed to three-way back systems.

• **No deviations**—The Air Force is adamant about space requirements, also. Components and systems must fit the prescribed envelope. There is little enough room for support equipment and the AF simply will not "buy" hardware that deviates from the plans they are trying to freeze now.

Another environmental system requirement is that the systems design and arrangement must provide the capability of restoring functional operations within three hours actual working time at the site in event of any operational failures in the system.

• **Separate systems**—The overall *Minuteman* environmental control system is divided into two complete, functioning systems. One will handle requirements at the LCF. The other will take care of the LF.

The LCF system provides normal functions of temperature, humidity and air purity within the underground control center. It consists of two brine chiller modular packages, two modular unit air conditioners, electric heating components, an activated carbon unit for odor control and an exhaust fan to remove fumes from the storage battery compartment.

The LF system is simpler—the silo being normally unmanned. It consists of a single brine chiller modular package in the support building and a single modular unit air conditioner in the silo's equipment room.

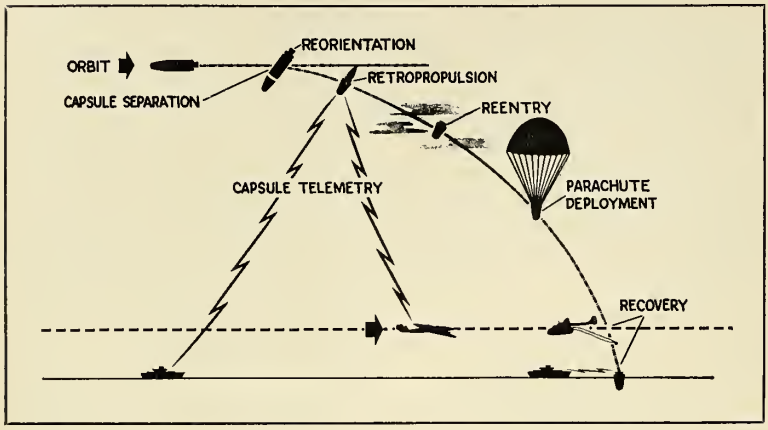
• **High pressure**—There is no doubt the AF, sensitive to criticism on ICBM site construction delays, will keep high pressure on all phases of *Minuteman*. Disliking the words "schedule dates," the AF prefers to call steps in its timetable "milestones." But as one firm's representative said at the bidder's conference:

"It's going to take a lot of 100-yard dashes to put this mile together."

Monkey retrieval planned . . .

Discoverer Success Speeds AF Plans

Recovery results will be given to Mercury program; development of Samos and Midas will also be expedited



FIRST ORBITAL recovery came with an assist from Navy frogmen.

SUCCESSFUL RECOVERY of *Discoverer XIII's* capsule from orbit has moved the Air Force into competition with the early phase of NASA's *Mercury* man-in-space project.

The Air Force is planning to recover a monkey from orbit before NASA fires a primate downrange on a ballistic trajectory.

An attempt to return a primate from orbit will be made with *Discoverer XV*—scheduled for launching in the middle of September. NASA's *Mercury* program lists a downrange shot with a monkey aboard a *Redstone* in October. (NASA won't try to boost a monkey into orbit until March or April of next year, barring further slippage in the program.)

However, the Air Force does not plan to go beyond a monkey, although more than one may be launched in life capsules.

After the historic recovery of the *Discoverer XIII* capsule Aug. 11, Lt. Gen. Bernard A. Schriever, said all of the AF results will be made available to the *Mercury* project. He added that he hopes the combined effort will lead the way to *Dyna-Soar*.

Development of the *Midas* infrared early warning satellite and the *Samos* reconnaissance satellite are also being speeded by the first *Discoverer* success. The Air Research and Development Command chief notes that stabilization and recovery techniques are similar and both use Lockheed *Agena* upper stages. *Atlas* boosters will replace the *Discoverer Thor* boosters to put up the heavier *Midas* and *Samos* payloads.

Schriever also revealed these plans:

–About 35 *Discoverers* in all (22 after the Aug. 11 shot) will be fired through 1961 at the rate of about two per month.

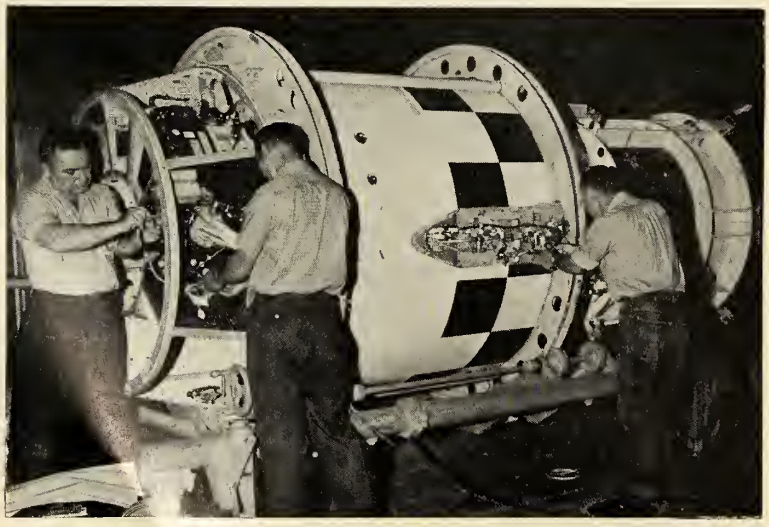
–First shot of a restartable Lockheed-Bell *Agena B* second stage will come in September.

–A series of *Discoverers* will carry infrared sensors to test equipment for *Midas*. However, there won't be any cameras, because the ones needed for *Samos* would be too bulky for the capsule.

• **It worked**—Successful recovery of the *Discoverer XIII* satellite capsule was not due to any major design changes in the system, but can be credited to the fact that "this time everything worked," according to a spokesman for Lockheed Missiles and Space Division.

Discoverer XIII contained a diagnostic instrument package designed to pinpoint problems which previously balked successful recovery of the 85-lb. capsules after ejection from orbit. Principal function of this package was to provide minute time breakdowns via telemetry of all phases of orbital operation during the re-entry sequence.

Together with its predecessor, *Discoverer XII*, which failed to orbit, the capsule was one of the most heavily instrumented in the entire program. It



CONFIDENT LOCKHEED engineer inserted a note in the Agena capsule predicting that this time—for the first time in the series—the capsule would be recovered.

was recovered very close to the planned splash area 300 miles northwest of Hawaii on Aug. 11.

Air Force C-119S of the 6593rd test squadron, patrolling the area in hope of making an air snatch with trapeze-type recovery gear, were thwarted by broken clouds in the recovery area which delayed sighting. The parachute-borne capsule was sighted by the crew of a C-119, however, and it was pulled from the water by a Navy frogman from a H04-S helicopter. The capsule arrived aboard ship, the Haiti victory, just 3 hrs. 54 mins. after its ejection from orbit over Alaska at 7:11 PM. When recovered, the capsule was still transmitting radio signals.

Lockheed said only minor changes had been made in the system and that additional instrumentation was almost entirely of a sampling type designed to monitor the re-entry and recovery phases with extreme detail. Air Force Ballistic Missile Division declined to discuss changes on the grounds that such information was classified.

• **High heat**—Telemetry data transmitted from the capsule indicated that drag and heating effects became severe at about 350,000 ft. temperatures on the surface of the protective shield rose to about 4000° F.

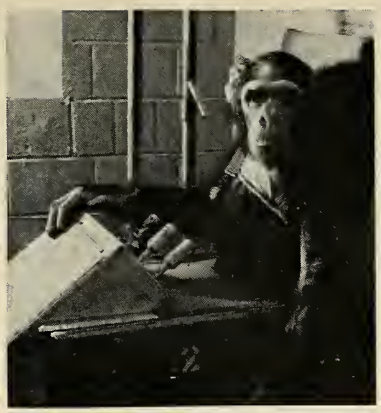
A thin gold plating on the inside surfaces of the heat shield helped to protect the payload from the relatively long exposure to aerodynamic heating. Unlike the nose cone of a ballistic missile, whose ablation period can be measured in seconds, the *Discoverer* capsule faced an exposure to intense heat for periods which could be measured in minutes, due to its more gradual re-entry path.

Bowl-shaped ablative heat shield of the capsule was 33 in. in diameter and 27 in. long. with its cone-shaped afterbody, the entire vehicle was about 40 in. in length.

During re-entry, a two-minute telemetry blackout was caused by the fact that high temperatures broke the air down into a plasma which blocked radio signals. At about 135,000 feet, the speed and surface temperature of the vehicle dropped to a point where radio signals could once again be transmitted.

During the blackout period, a tape recorder inside the capsule received and stored data on re-entry phenomena, transmitting this information after the blackout period ended. Maximum deceleration force on the capsule was between 10 and 15G's.

First stage of the *Discoverer* vehicle was a modified Douglas *Thor* propelled by a 165,000 lb. thrust Rocketdyne liquid propellant engine. Height of the first stage with its adapter



CHIMP named Pale Face, now training at Holloman AFB, may be first astrosimian.

was 66.7 ft. guidance and control was provided by a tape-fed programer for pitch and roll control and an autopilot for attitude stabilization.

Second stage was a Lockheed *Agena* vehicle, 19.2 ft. in height and 5 ft. in diameter, weighing approximately 8400 lbs. at launch. Orbital weight after fuel exhaustion was approximately 1600 lbs. after burnout of the booster, the first stage and second

MODIFIED THOR boosted Discoverer XIII into orbit. Program will total 35 shots.

stage separated.

Satellite guidance and control system included an inertial reference package, an infrared scanning device, a pneumatic jet control system and a hydraulic control system. The inertial reference package and the pneumatic jets, aided by the infra-red horizon scanner, combined to place the second stage in a horizontal attitude prior to ignition of the *Agena's* bell liquid fuel rocket engine.

Following the coast period, the engine, developing more than 15,000 lbs. thrust, propelled the second stage into orbit. Command for second stage ignition originated at Point Mugu, Calif.

After ignition, the pneumatic jet control system was succeeded by the hydraulic control system which gimballed the Bell engine to hold the satellite horizontal during orbital injection. The infrared horizon scanner continued to operate, relaying corrections to the second stage guidance system.

After cutoff of the *Agena* engine, the pneumatic jet control system resumed operation. Compressed gas under high pressure was metered to a series of external jets which swung the vehicle horizontally 180 degrees.

• **On 17th pass**—*Discoverer XIII* made 17 earth orbits during a period of 27 hours before ejecting the capsule. During the 17th pass, a timing device triggered gas jets which pitched the vehicle into a position 60 degrees down from horizontal. Separation of the re-entry vehicle was accomplished by a series of explosive bolts and springs. The retro-rocket was fired immediately after separation.

After retro-rocket burnout, the vehicle was travelling at only slightly less than orbital speed and following a path of less than five degrees from horizontal. After re-entering the earth's atmosphere, the trajectory became progressively more vertical as the vehicle slowed. Release of the parachute was accomplished by a switch operated by deceleration forces.

The entry and recovery vehicle was built by General Electric's Missile and Space Vehicle Department in Philadelphia.

Ejection capsule of *Discoverer XIII* weighed 300 lbs. at the time it left orbit. During descent, it shed its retro-rocket, parachute cover, and heat shield to reduce the weight to 85 lbs.

Launch of *Discoverer I* was on Feb. 28, 1959. The capsule from *Discoverer II* re-entered successfully on April 14, 1959 but due to the incorrect setting of a timer, was ejected prematurely. The capsule and its parachute were visually sighted in the Spitzbergen area at the computed time and position of re-entry and telemetry also gave positive indication of ejection.

The shadow test . . .

Echo Tests Practicality of Passiv

by Jay Holmes

ECONOMIC PRACTICALITY of a passive communications satellite system will be tested this week when NASA's *Echo I* balloon enters the earth's shadow for the first time.

Preliminary calculations give the 100-ft. aluminized plastic sphere, which was lofted into a nearly circular 1000-mile orbit on a second try Aug. 12, a life of about one year. However, there is no assurance that its useful life as a reflector will last beyond the first time it is hidden from the sun and plunges into supercold space. This will occur about Aug. 22.

To be acceptable, a satellite system must be at least potentially cheaper than conventional methods of building new transcontinental and intercontinental channels—such as submarine cables or microwave repeaters in hovering aircraft. Furthermore, the rebound type system is in competition with the active repeater communications satellite embodied in the Army's Project *Courier*.

Echo I's plunge into darkness will help answer the key question of how long such a satellite can live—and the frequency of launchings needed to provide enough such balloons to maintain relays between any two stations at any time.

• **Reversion to solid?**—Early experimentation had established that passive reflection of microwave signals from a satellite is a feasible way of adding to the earth's limited supply of radio channels. Successful reflections from the moon and the relatively small *Tiros I* weather satellite had proven the concept (M/R Aug. 15, p. 38).

However, *Echo I* is kept inflated in the near vacuum of space by only the incredibly low pressure of 4×10^{-5} psi (about three millionths of sea level atmosphere). Even this little amount, NASA calculates, is 25,000 times the external pressure of solar radiation and air drag at 1000 miles.

As soon as the balloon spends any length of time in darkness, the gaseous benzoic acid, anthraquinone and a trace of air inside it may contract and revert to a solid state—allowing the balloon to deflate.

When it returns to sunlight, there is a question whether it will re-inflate to the perfect spherical shape required for useful radio reflection.

Another problem is the effect of micrometeorites. There is no question that at least some punctures will be caused when the thin surface is struck by these particles of cosmic dust. Further, the launching took place at the height of the annual Perseid meteor shower, somewhat increasing the possibility that the *Echo* balloon might be struck by a larger meteor.

NASA scientists planned for some micrometeorite leakage in *Echo's* internal design. The sublimation of 10 lbs. of benzoic acid, which has a relatively high vapor pressure, provided initial inflation. In reserve was 20 lbs. of anthraquinone, with a much lower vapor pressure. The anthraquinone sublimated much more slowly, so that some remained as a solid reserve to replace the benzoic acid gas as it leaked out the micrometeorite holes.

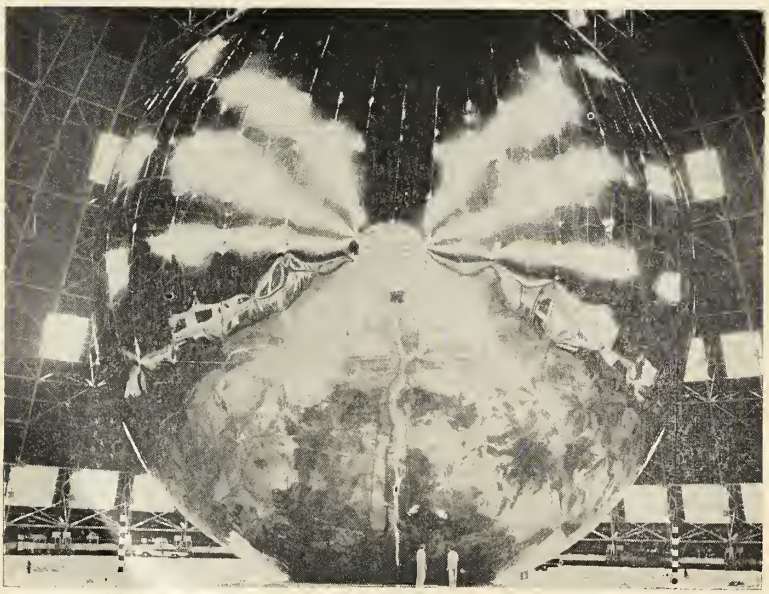
When most of the gas leaks out, the balloon will begin to distort and the quality of the reflected signals will degrade. Research is already under way at NASA's Langley Research Center to produce rigid satellites, which will not collapse after loss of internal pressures.

Since very little information on micrometeorite density is available, scientists are unable to predict how long the puncture and deflation process will take.

A third question with bearing on *Echo's* usefulness is the life of the solar cells powering the radio beacons. At 1000 miles, the balloon is passing through an intense portion of the lower Van Allen radiation belt. The Van Allen particles are bound to damage the solar cells. The only question is

Echo I Vital Statistics

Time of launch	5:39 a.m. (EDT) Aug. 12
Time of inflation	6:02
Vehicle	Thor-Delta
Perigee	943.0 stat. mi.
Apogee	1050.9 stat. mi.
Orbital inclination	47.243°
Velocity at perigee	15,980 mph
Velocity at apogee	15,636
Period	118.299 min.
Expected lifetime	1 year



ECHO SATELLITE is shown during ground inflation tests. Forty thousand lbs. of air is required to inflate the sphere on the ground, only a few lbs. in orbit.

ɔmmunication

when the damage will be incurred.

• **Communication experiments**—The first message relayed, a recorded statement by President Eisenhower, was transmitted from the Jet Propulsion Laboratory at Goldstone Lake, Calif., to the Bell Telephone Laboratory station at Holmdel, N.J., as the balloon was over the central United States near the close of its first orbit. The recording, played at an Aug. 12 press conference, was loud and clear with just a trace of whistling noise.

The first two-way exchange took place the following morning between engineers of Collins Radio at Cedar Rapids, Iowa, and the Alpha Corp. in Dallas, Tex. Later that day, JPL and Bell Labs accomplished a two-way exchange.

JPL and Bell Labs also accomplished simultaneous transmission and reception of recorded messages. Bell Labs played back Eisenhower's message while JPL sent a recording by Sen. Lyndon B. Johnson, chairman of the Senate Space Committee.

Many other organizations, both governments and private, conducted similar experiments. NASA provided orbital data to help scientists around the world in similar experiments. NASA's Abe Silverstein said he knew of no Soviet interest, however.

The American Telephone and Telegraph Co., parent company of Bell Labs, has an interest much greater than that of a government contractor in the success of satellite communications experiments. Only last month, company officials appeared before the Federal Communications Commission with a plea for the assignment of a broad section of the radio spectrum above 1000 megacycles for satellite and space communications.

AT&T wants to establish a network of 50 satellites to create additional telephone and television circuits throughout the world—both for commercial and military use.

John R. Pierce, director of research and communications principles at Bell Labs, credited with originating the idea of communications satellites in 1955, told the FCC active satellites like *Courier* appear superior to passive satellites for commercial communication. Major objections to *Echo*-type relay, he said, are the lifetime of the balloons and the requirement of very powerful ground transmitters, which would have to be separated by very large distances to avoid interference.

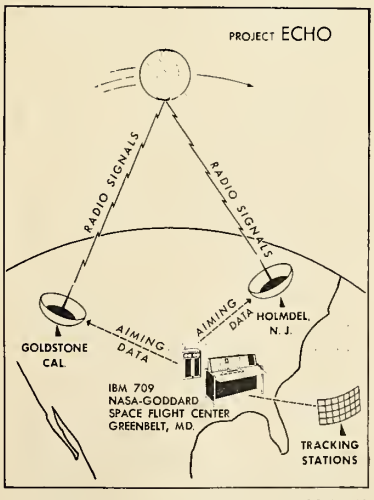
In the *Echo* experiments, JPL used an 85-ft. parabolic antenna to transmit 10 kilowatts at 2390 megacycles. Bell Labs used a 60 ft. transmitting antenna to transmit 10 kilowatts at 960 megacycles.

NASA's Newell D. Sanders, assistant director for applications and manned flight programs, has said studies indicate that at least 12 passive communications satellites spaced around the world are required to provide essentially continuous communication. Several satellites would have to be put in orbit by a single vehicle for the plan to be economically feasible, he said.

Pierce's figure on the number of satellites needed is higher. About 30 satellites in somewhat random 2500-mile polar orbits would provide a commercial grade of service between the eastern United States and Europe, he estimated. But he declared that individual satellites will have to have lifetimes in terms of years to be economically feasible.

NASA plans two more *Echo* experiments, in 1961 and 1962, and experiments with multiple satellites, under the code name Project *Rebound*, in the time period 1963-65.

• **Delta succeeds**—The Aug. 12 launching was the first success—on its second try—for the Douglas *Delta* second stage, a more sophisticated version of the workhorse *Able*. *Delta* has a second-stage guidance that makes possible an extremely precise orbital injection after a coast period up to 15 minutes, which brings the vehicle up to two-stage apogee.



ULTRA-FAST IBM computer at NASA's Goddard Center aims antennas at Echo.

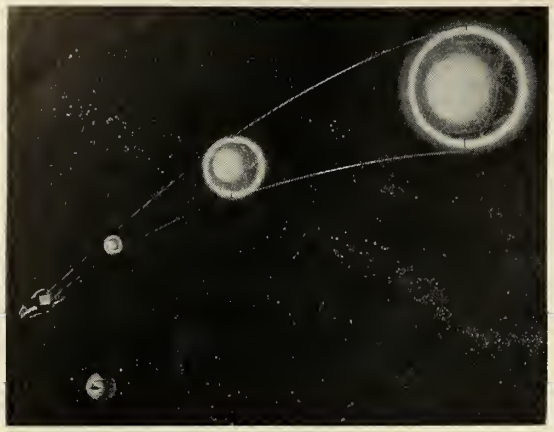
SEPARATION mechanism for Echo sphere shown in Douglas hangar at Cape. Spring throws in away from vehicle's 3rd stage.

Delta has an Aerojet-General storable liquid engine, Bell Telephone radio command guidance for 90 to 275 seconds and a specially developed Douglas flight controller during the coast period. The cause of the first *Echo* launch failure, in the May 13 launching, appeared on telemetry to have been the attitude jets designed to keep the vehicle on course during the long coast.

Just as in the *Thor-Able*, the booster was a modified *Thor* and the third stage was an Allegany Ballistics Lab-Hercules Powder Co. *Altair* 248 double-base solid rocket.

The balloon, made of Du Pont Mylar with a vacuum-deposited layer of Aluminum 2200 angstroms thick, was manufactured by the G. T. Schjeldahl Co. of Northfield, Minn. National Metallizing Division, Standard Packaging, Trenton, N.J., deposited the aluminum, which gave the sphere a reflectivity of 98%. The globe has 82 orange-slice shaped panels, each about 48 in. wide at the equator. The total plastic weight is 135 lbs. The aluminum weighs 4 lbs.

Other major contractors included: Kaiser-Fleetwings, Bristol, Pa., 26½-in. magnesium container that carried the package into orbit; Astro-Electronic Products Division, RCA, two 11-oz. tracking beacons transmitting 10 mw at 107.9 mc; General Mills, Minneapolis, initial development of inflatable sphere; Varian Associates, 10 kw power amplifier for the Goldstone transmitter; Remington Rand, computer in the Delta guidance, and tracking by Lincoln Laboratory, Atlantic Missile Range and Naval Research Laboratory.



JUPITER TRIP might be possible with ship powered by string of small nuclear reactors, suggested by Lockheed scientist.

PROTECTIVE COCOON of plastic could be spun by astronaut for emergency re-entry in system proposed in GE paper.

U.S. Delegates Paint Bright Picture

IAF meeting hears predictions of electric propulsion by 1963, two-stage trips to the moon

STOCKHOLM, SWEDEN—U.S. space exploration schedules will be revised upwards considerably if predictions made by U.S. delegates before the International Astronautical Federation come true.

One of these predictions, by Dr. Ernest Stuhlinger, chief of the Research Projects Laboratory of NASA's George C. Marshall Space Flight Center, is that electric propulsion systems may be flight-tested in 1962—and used for space missions the next year.

Stuhlinger and his Huntsville colleagues, led by the Marshall Center Director Wernher von Braun, were prominent among the U.S. speakers before the Federation.

Other papers by U.S. delegates discussed varied proposals from two-stage trips to the moon to a device that would allow an astronaut to spin a "space cocoon," allowing him to return safely to earth in emergencies.

Stuhlinger predicted that arc-heated and ion electric propulsion systems are being developed rapidly enough to be flight-tested in 1962.

He also said that space missions "may be flown from arc-heated systems from about 1963 on, and with ion systems from 1964 or 1965 on."

"Electric systems," according to Stuhlinger, "will be competitive with chemical systems on heavy freight missions in near space; on unmanned and manned missions to Venus and Mars; and very particularly on missions to more distant planets, and into deep space."

The present NASA space schedule for the 1960s is based on the use of chemical propulsion systems only. The advent of the type of efficient electric propulsion systems of the magnitude that Stuhlinger is talking about would drastically accelerate this schedule.

Reds Shun World Groups

STOCKHOLM, SWEDEN—*Russian delegates to the International Astronautical Federation meeting here have refused to go along with the proposal to establish an International Academy of Astronautics.*

They also refused to join a second international organization established here—an Institute of Space Law.

The Russian objection to the IAA is that there are already too many international bodies concerned with outer space. Their objection to the Space Law Institute is that this matter should be handled through the United Nations.

The new IAF is to have its headquarters in Paris, and will be headed by Dr. Theodor von Karman.

Also refusing membership in the new academy was Dr. Harrie S. W. Massey of Britain, who complained that research was suffering because scientists were trotting from one international conference to another.

• **Two to the moon**—Before man can go directly to the moon and return, a vehicle will have to be developed which has 12 million pounds of thrust at lift-off, but the U.S. hopes to perform manned lunar landings much earlier by refueling a *Saturn*-launched vehicle in flight.

Von Braun told the assembled space experts that the two-stage trip to the moon would be more reliable than the non-stop trip.

Other vehicles described by Von Braun were *Saturn*-launched space cargo stations and manned laboratories in earth orbits, and manned capsules that will be used to orbit the moon and to return man from the moon's surface.

The first phase of the two-stage trip to the moon, as Von Braun describes it, will be the launching by *Saturn* of a two-man capsule into earth orbit.

• **Tankers first**—Previously launched into the same orbit by *Saturn* boosters will be orbital tankers.

"Orbiting working crews, trained to perform certain functions under zero-gravity conditions," according to Von Braun, "connect the moonship and tanker and transfer the propellants from the latter to the former."

"The limited time period for the whole operation may demand a substantial number of *Saturn* pads on earth," Von Braun predicts, and if "limitations on time caused by the storage of hydrogen over extended

periods . . . prove decisive, lower energy storable propellants may have to be used . . . increasing the number of tanker flights by 50 percent."

Von Braun believes that the orbital tankers will prove to be more than a stop-gap measure. "A large vehicle could be assembled from a number of smaller ones," and by the time a large enough booster is developed for a direct trip to the moon, "the smaller, orbital-refueled vehicles would be of a more mature vintage and, therefore, more reliable."

Von Braun also envisages space stations where "high-acceleration space carrier vehicles could rendezvous and the transfer could be made to low-acceleration (ion or plasma) orbit-to-orbit spaceships."

Besides orbital tankers, Von Braun foresees orbital cargo carriers which would supply orbital space stations.

The orbital space station, Von Braun states, would have three individually sealed compartments: "(1) the crew capsule for powered flight, emergencies and re-entry; (2) the instrumentation and working area; and (3) the supply storage room.

Variations and modifications of the space station would be used for manned circumlunar space ships, and for the lunar manned-return capsule.

• **How big is big?**—If the U.S. desires to place 1 million pounds of cargo a year into orbit around the earth, the most desirable chemically propelled carrier would have a take-off weight of about 1 million pounds.

This is one of the conclusions reached by H. H. Koelle of NASA's Marshall Center in a paper based on his initial research into the problem: How large should rocket carriers be?

The parameters that must be used in determining the rocket carrier's size are according to Koelle, cost per pound of payload, mission reliability, annual transport volume, pad time, and the results in certain firing rates and the number of launch pads required.

And the ideal vehicle Koelle comes up with for low-orbit missions (for a 96-minute, 307-nautical-mile orbit) has characteristics identical with those of the rocket cargo carrier presently being developed by Koelle and his associates at Huntsville: *Saturn.*

In general, economic considerations tend to favor use of smaller vehicles, and operational consideration tend to favor use of larger vehicles. The resulting vehicle will be a compromise, Koelle believes.

His preliminary data indicates that operational requirements (payload size, real estate, etc.) rather than economy will be the determining factor; he doubts that the cost of putting cargo into low orbits will be much under $100 per lb. in the next decade.

How large the vehicle should be depends a great deal on how many years it will be used, and how many pounds per year the U.S. wants to put into earth orbits, Koelle believes.

"The size of the most desirable vehicle tends to increase with increased operational lifetime," Koelle states, and "tends to become more efficient . . . as reliability increases and production cost decreases.

Koelle warns that the numerical results given in his paper are correct only for orbital carrier vehicles using chemical propellents, and that a more refined study of this problem should be made.

• **To Jupiter**—Dr. R. H. Olds of Lockheed Missiles and Space Division described in his paper a nuclear-thermionic-ionic propulsion system which could operate under full thrust for the two years necessary to carry it to the planet Jupiter with enough residual power to operate its instruments for several years after.

The key to the whole system, Olds stated, is a series of small nuclear reactors about two feet in diameter producing 1200°C to banks of thermionic generators which convert the heat directly into electrical energy for the ion beam motors.

The fuel, according to Olds, would be 110 pounds of cesium vapor, which would be capable of delivering an equal amount of payload to Jupiter.

Before such a system becomes a reality, Olds stressed, more reliable generators, motors, pumps and similar items containing moving parts will have to be developed.

• **Cocoon safety**—How a man in space could "spin his own cocoon" for a fast return to earth in an emergency was described by Harold L. Bloom of General Electric's Missile and Space Vehicle Department.

Reading a paper which he co-authored with GE's John H. Quillinan, Bloom described a space suit over with an oxygen supply, recovery aids, and survival gear. Over the space suit is a plastic covering with attached tanks of foaming plastic and mixer, and a retro-rocket.

First, the escaping astronaut would fire his retro to head back toward earth. He would then inflate the plastic covering which would have proper shape for re-entry and impact. Next, the space between the man and the plastic covering would be filled with foam plastic. A hardened dense plastic foam would serve as the ablation heat shield, and a less dense, spongelike foam would act as a cushion.

NASA Adds Education Staff

The National Aeronautics and Space Administration is building a staff to conduct broad educational work about its activities on a long-term basis.

Heretofore, the NASA Office of Public Information has been so preoccupied with meeting the day-to-day demands of the current press—newspapers, magazines and radio-television—that it has not been able to give what officials felt was sufficient attention to long-term activities.

Last May 27, a new Office of Technical Information and Educational Programs was established, reporting directly to the office of the associate administrator. Shelby Thompson, deputy director of the Division of Information Services, Atomic Energy Commission, was named as director of the new NASA office.

Thompson's division took over the old NASA Technical Information Division, which had been in the Office of Business Administration. In addition, the new division assumed the function of preparing documentary films, exhibits, leaflets, reports and booklets of a general information nature, which had been part of the job of the Office of Public Information, headed by Walter T. Bonney. The OPI reports directly to the NASA administrator.

As a result, the OPI, with a staff the same size as before, is able to give more attention to current news. Bonney said that at last count telephone queries to the OPI were averaging about 400 a day.

Meanwhile, OPI has set up a nine-desk newsroom that brings all OPI information officers together in one room.

Herbert H. Rosen, former deputy director of OPI, has transferred to the new OTIEP. Joseph A. Stein, former chief of the OPI News Division, has been promoted to deputy director. Paul P. Haney replaces Stein.

Thompson said his division eventually will have a staff of 10 to 15 in addition to the 30 persons in the old Technical Information Division, headed by Bertram A. Mulcahy. Thompson said he has not yet chosen his chief deputy.

The former AEC official said he will welcome the cooperation of industry in his efforts to gain broad public support for America's space program. He said he hopes to be on all industry mailing lists, so that he will know of everything being done and will be able to suggest areas of possible activity when asked.

mergers and expansions

ARDC—renamed three of its Research Division's directorates. Geophysics Research Directorate and the Electronics Research Directorate located at Hanscom Field, Bedford, Mass. Both will be identified as the Air Force Cambridge Research Laboratories. AFRD's Detachment No. 3 at Thule, AFB, Greenland is redesignated Detachment No. 1 of AFCRL.

RADIO CORP. of AMERICA has broken ground near Palm Beach, Fla., for a new $4-million plant for its Series 301 electronic computer system. The 180,000-sq.-ft. facility will be in operation next January and employ several hundred persons.

IT&T has acquired the electromagnetic vibration equipment interest —including manufacturing rights, tooling, equipment, inventory and key personnel—from the L. C. Miller Co. of Los Angeles. IT&T will market an accelerometer calibration system and develop and expand other products into a complete line of vibration testing equipment.

TAYLOR FIBRE CO. is acquiring Dytronics Inc., Rochester, Mich. The manufacturer of die-stamped circuits for electrical and electronic applications will be operated as a subsidiary at its present location, retaining present officers and employees.

financial

Lear, Inc.—First-half earnings increased 10% over the corresponding period in 1959, reaching $1.2 million this year. Sales amounted to $45.6 million, compared with $38.6 million the initial half of 1959.

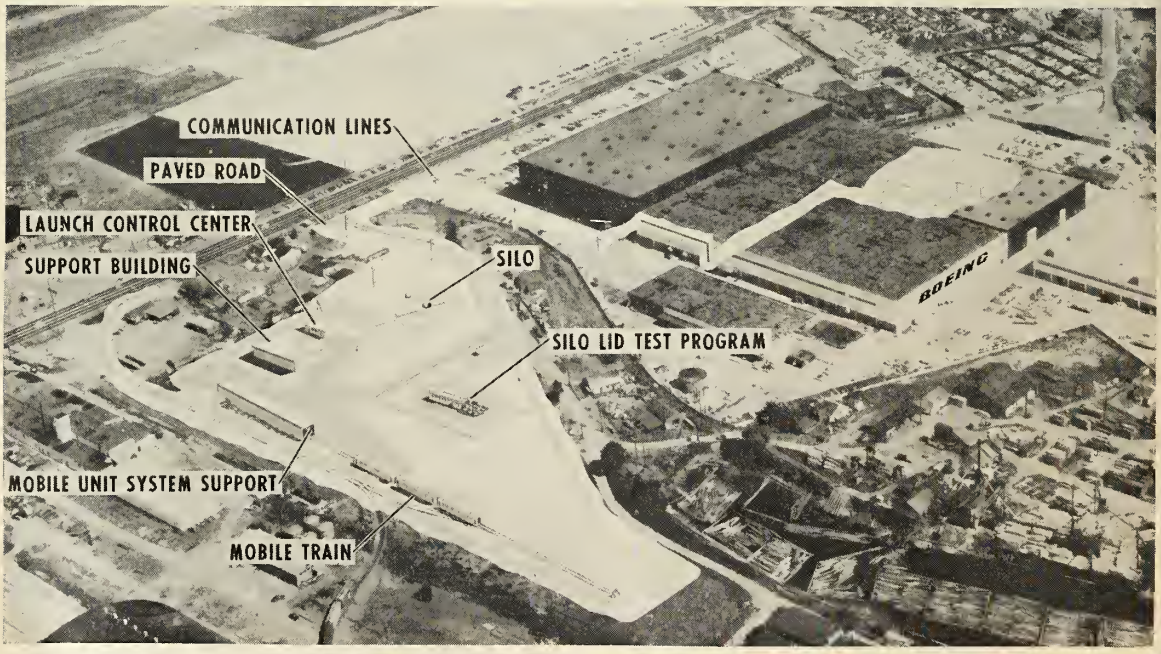
Texas Instruments—Both quarter and six-months totals reached new highs for TI, but the company forecasts a slight downward trend for the remainder of the year. For the three months ending June 30, net income rose to nearly $4 million on sales of $59.9 million, from $3.3 million income on gross of $51.5 million a year earlier. Third-quarter figures are expected to run somewhat lower than the first two quarters, with year totals expected to be between $16.5 million and $17,250,000, on sales of between $235 million and $240 million.

Ryan Aeronautical—During the nine months ending July 31, Ryan sustained a drop in profits to $1.6 million from the $1.8 million earned the same period last year. Sales during this time were $84 million compared to $53.7 million last year. Although not yet final, anticipated third-quarter figures are expected to reach $750,000 profits on sales of $33 million. Sales for the third quarter in 1959 were $16.4 million.

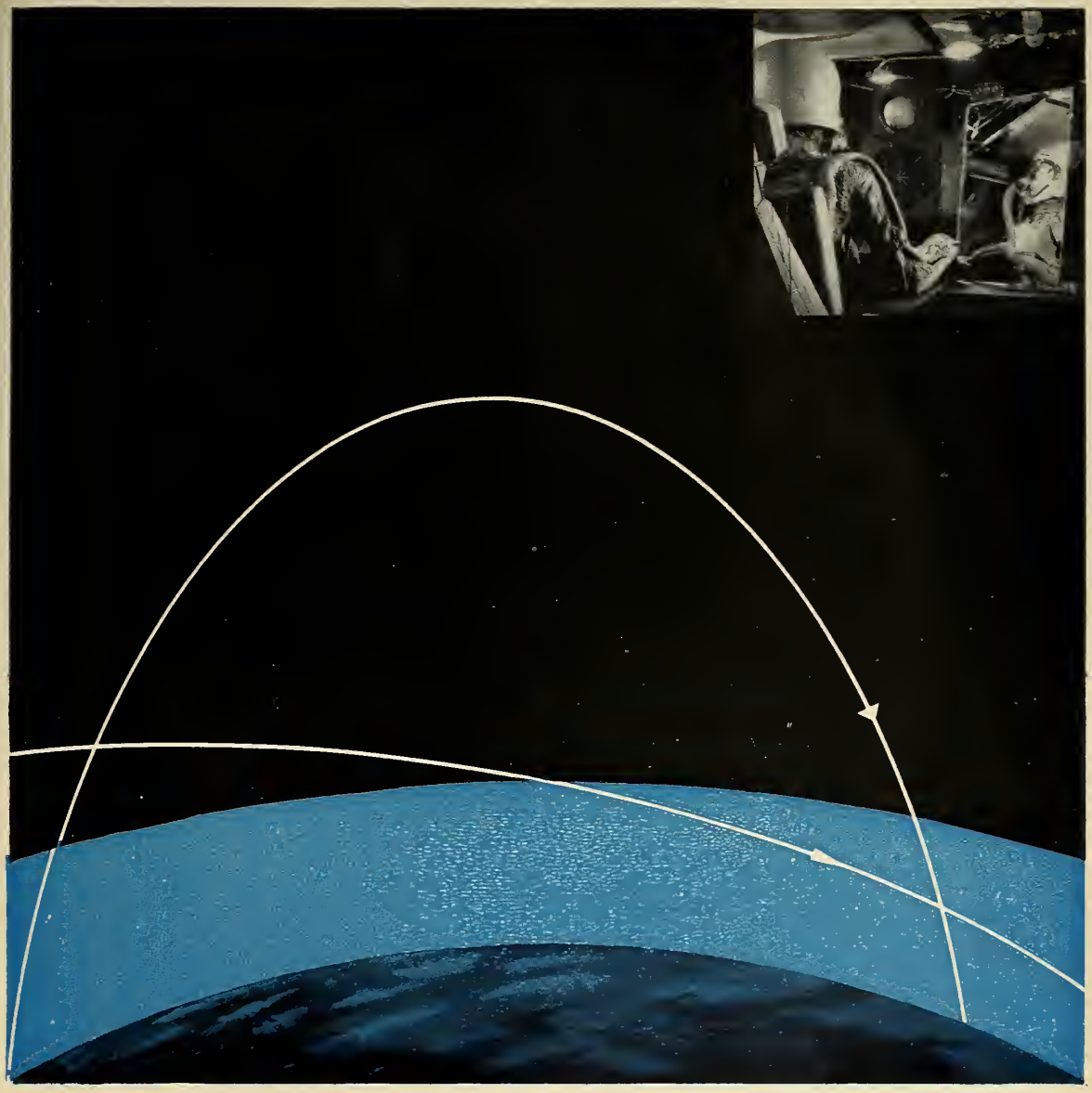
Vitro Corp.—Net income for the first six months of 1960 doubled the same period in 1959, while gross increased 10%. Income totaled $546,398 on sales of $30.5 million.

Lockheed Aircraft Co.—The company plunged $55.4 million into the red for the first six months of this year, while writing off $67.6 million in costs, partly on the Electra. Chairman Gross said the company has been operating profitably since June 26 and will earn between $9 and $10 million in the second half. This would put Lockheed's 1960 loss near $45 million. In 1959 the company earned $8.7 million on sales of $1.3 billion.

General Dynamics—Second quarter earnings dropped 26% from the like 1959 period despite a 12% increase in sales. Indicated earnings were $5.9 million on sales of $506.4 million. Second quarter in 1959 showed indicated earnings of $8 million on sales of $452.6 million. First six months income this year is $12 million on sales of $979.8 million. Same period in 1959 brought income of $15.1 million on sales of $804.3 million.



MINUTEMAN LAUNCH COMPLEX will be completed by the end of the year next to Boeing Airplane Co.'s Seattle Facility. Called the Seattle Test Program, the complex will enable the concurrent development of ground support equipment and elements of the systems. No launches will be made here, but the Air Force hopes that tests conducted on the site will make it possible to speed development timetables and save money in the construction of operational launch sites.



Ballistic and boost-glide flight paths

These flight paths, arcing through space and re-entering the atmosphere, are characteristic of the paths of a ballistic missile and a boost-glide vehicle. In both areas, Boeing holds major contract responsibilities. Boeing is weapon system integrator for the solid-fuel ICBM, Minuteman, and as part of a USAF-NASA research program, is developing Dyna-Soar to study the problems of manned space flight. The Dyna-Soar vehicle will be capable of re-entering the atmosphere and making a normal controlled landing.

Boeing scientists and engineers, in addition, are advancing the state of the art in many areas: advanced military and commercial aircraft, hypersonic flight, space crew environments, vertical and short take-off and landing aircraft, gas turbine engines, anti-submarine warfare systems, among others.

Professional-Level Openings

These and other future-oriented programs at Boeing offer outstanding career openings to professional specialists in the scientific and engineering disciplines, as well as in a broad spectrum of company activities in other-than-engineering areas. You'll find at Boeing a professional environment conducive to deeply rewarding achievement. Drop a note, now, to Mr. John C. Sanders, Professional Personnel Administrator, Dept. MII, Boeing Airplane Company, P. O. Box 3822, Seattle 24, Wash.

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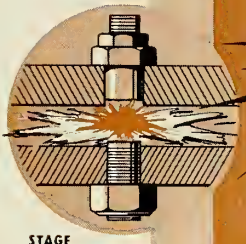
THRUST TERMINATION

XB

Complete Missile & Space Vehicle Ordnance Systems

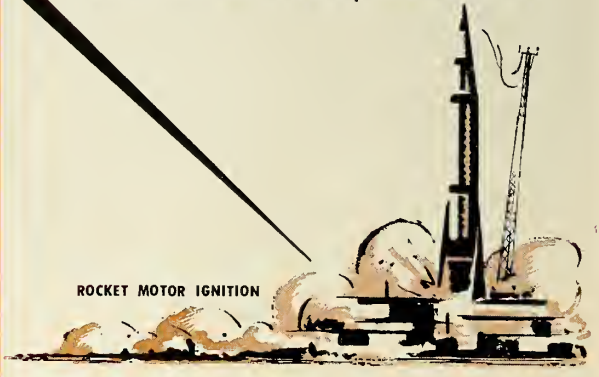
Exploding Bridgewire Ordnance

Complete XB Systems Capability For Missiles and Space Vehicles



STAGE SEPARATION BOLT

MISSILE DESTRUCT

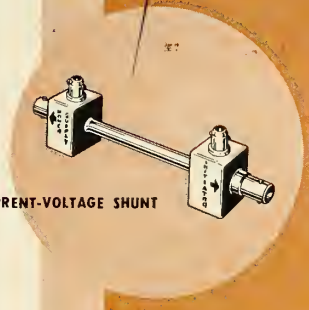


ROCKET MOTOR IGNITION

McCormick Selph Associates, after two years intensive study and development of high voltage power supplies, now offers a complete exploding bridgewire systems capability: available as complete missile and space vehicle XB ordnance systems (power supplies, transmission line and XB ordnance) or as separate components and devices. The Mc/S/A power supply uses no spark gap or thyratron high-voltage switches, charges condensers below minimum breakdown potential of air (< 327 volts), uses light and compact electrolytic condensers and has a controllable discharge rate.

Mc/S/A's approach provides wide versatility of application.

- POWER SUPPLIES
- EXPLOSIVE BOLTS
- XB CURRENT-VOLTAGE SHUNT
- INITIATORS
- IGNITERS
- PRESSURE CARTRIDGES



XB CURRENT-VOLTAGE SHUNT

To separate the characteristics of the XB initiator from the power supply, Mc/S/A has developed a current and voltage measuring shunt to be used in conjunction with dual-channel recording oscilloscopes. This dynamic test instrument provides voltage and amperes vs. time oscillograms at the XB initiator and permits accurate analysis of initiation characteristics separately from power supply and transmission line.

Contact Mc/S/A Applications Engineering Department with your specific XB systems or components requirements.

EXPLOSIVE ORDNANCE

McCormick Selph Associates

HOLLISTER AIRPORT/HOLLISTER, CALIFORNIA

Technical Countdown

ELECTRONICS

Courier Will Have High Capacity

The Army-ARPA *Courier*—first active satellite communications system—will be able to handle almost 3.5 million words per day, roughly equivalent to twice the daily output of a major news wire service. Almost 100% redundant electronic circuitry and equipment will give the satellite an estimated 90% probability of remaining active for one year.

Army Reduces R&D Lead Time

The Army Signal Corps has, in some cases, reduced normal R&D lead time by as much as 50% through a "limited procurement" technique. Authority is given to buy promising items after successful engineering tests, but prior to complete user tests and standardization.

Thermionic Converter Operates

Conversion of nuclear fission heat directly to electric power by means of a cesium-cell thermionic converter has been reported by General Atomics Division of General Dynamics. The converter produced 90 watts from a nuclear fuel element of uranium carbide and zirconium carbide, with an overall efficiency of 10% at 3500°F.

Communications-Electronics Dictionary Published

A 25,000-item dictionary covering military communications and electronics is being published by the Air Force. Compiled at Maxwell AFB, "AF Manual 100-39" will be distributed late this month.

GROUND SUPPORT EQUIPMENT

Minuteman Test Area Completed at Cape

A $7-million launch area for the Boeing *Minuteman* has been completed at Cape Canaveral. The installation includes two complete launch sites, each with blockhouse, flat pad, service towers, 90-ft. underground silo, and assembly, storage, inspection and industrial area facilities.

FM-AM For Telemetry?

A considerable improvement in telemetry would be realized by changing the standard frequency-division system from FM-FM to FM-AM, according to one top expert in the field. Writing in the June *Transactions* of the IRE PGSET, Dr. L. L. Rauch says that such a change would result in better r-f spectrum utilization and better use of near-optimum demodulation and data reduction methods.

Plastic Bags for Space Repair Stations

"Drydocks" for space vehicles have been proposed by a General Electric engineer. Speaking at the recent AAS meeting, he said the space repair station could be a plastic skin drawn over the vehicle to be worked on, then inflated to provide a comfortable working atmosphere for the astromechanics.

PROPULSION

Hi-Fi Retro-rockets for Discoverer

Success of *Discoverer XIII* depended heavily on critical retro-rocket burning time and thrust to achieve precise re-entry. Rockets used were Thiokol TE-236A, similar to those slated for *Mercury*. The 50-lb. engines burned for about ten seconds.

Agena-B to Get Operational Test

An *Agena-B* will be used next month to put a *Discoverer* satellite in orbit. This first operational use of the bigger, restartable *Agena* is considerably ahead of announced schedule.

Satellite Stabilization Works Well

Accuracy of the attitude stabilization system on last week's successful *Discoverer XIII* reportedly was within one degree. A combination gas-jet control system and IR horizon scanner operate to stabilize the vehicle in different sequenced attitudes for injection, orbiting and—finally—for separation and re-entry.

ADVANCED MATERIALS

Heat Treater Looks Ahead

Second-generation solid-engine cases will find heat-treating facilities ready and waiting at the J. W. Rex Co. The firm is constructing a furnace with a working area 40 ft. high and 12 ft. across designed to handle chambers for million-pound solid rockets.

Hydrogen from Diesel Fuel

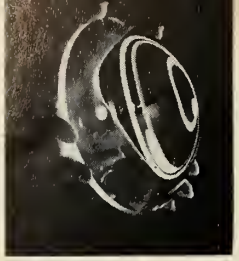
Army Engineers have developed a mobile unit capable of delivering 1000 ft.^{3} per hour of 98% pure hydrogen from ordinary diesel fuel oil. The unit was built by Girdler Construction Corp.

Silicon Prices Slashed

Prices of electronic-grade silicon were cut 6 to 28% by Merck & Co. The reduction was attributed to lower production costs resulting from new and expanded facilities.

Teflon Antenna on Discoverer

A mixture of Teflon and ceramic fibers was used in the *Discoverer XIII* second-stage beacon antenna. The uniformly ablating composite is a development of Rogers Corp.



SPECIAL ASPHERIC optical elements such as these will afford Mercury astronaut 190° field of view vision through his periscope while in orbit.

OPTICS

SPECIAL REPORT

Market Is Likely to Double

Although technology has suffered from relative shortage of R&D support, a bright future seems assured

by Charles D. LaFond

DESPITE AN ACUTE manpower deficiency, the optics market in the missile/space industry is expected to double in from three to five years. Its volume for Fiscal 1961 is estimated to be from $75-85 million.

Ninety percent of this market today is military, but with growing support from the National Aeronautics and Space Administration non-military sales for both R&D and products are expected to increase steadily for some time to come. This should broaden the diversity of technological advancement, but it is not expected to reduce the dependence of the optical industry on government sales.

For several decades half its revenue and most of its advanced research impetus have been derived from the military. Its future growth, however, appears tied directly to missile/space advancement.

• **Will optics need continue?**—This is a question frequently asked—usually by those in competitive fields. It is invariably followed with a whole string of reasons why optics is obsolescent.

This bias is well grounded in ignorance.

Land-Air is an engineering service company doing a great deal of contract work for the military at various missile ranges. Its personnel have lived with, operated, maintained and modified all types of electronic and electro-optical missile support systems. One of its senior engineers summed up the situation this way:

No one system, optical or electronic, can become the one and only system for missile/space use. The task is to fully develop each system to perform the functions for which it is best adapted, to use each system cognizant of its specialized role, and to use secondary benefits derived without compromising its primary purpose.

• **Is there an optics lag?**—This is a more difficult question. Technological advancement has been slower relatively than in other areas such as electronics. The reason is quite apparent—the military services have not allotted the funds for R&D so necessary for stretching state of the art.

Regardless of this lack of support, the industry has advanced. American optics has reached a point where it no longer is dependent on European supply of precision components.

The future looks even better. Dr. Konstantin Pestrecov, chief of Nortronics optical systems group, says: "The challenges for improvement in all areas of optics are likely to be solved in the U.S. because of growing importance of optics in missile/space systems. European nations are not devoting the same emphasis to these areas and therefore are not in a position to pursue development of capability to the same extent as the U.S."

• **Why is growth assured?**—The resurgent growth of optics in the Missile Age is a result of two things: the unique abilities of advanced optical components and systems; and the need to achieve high accuracy and resolution during the development of missiles, their flight operation phase, and their application.

This requirement for accuracy and resolution is a direct result of the enormous altitudes and ranges characteristic of missiles. Missile requirements have led to accuracy requirements in the seconds and fractions of seconds-of-arc range. In fact, seconds of arc are now becoming gross units. The micro-radian, approximately 0.2 second of arc, has now become a more convenient unit of angular measurement in missile optics.

• **Optical developments**—In the development of electro-optical systems for missiles, the crucial area is still the basic optical system. Development here has been directed to the design and fabrication of lenses capable of essentially perfect imagery when used in severe temperature and vibration environments. The design of "perfect," or diffraction-limited, lenses (those whose accuracy and resolution are limited only by physical laws) was almost impossible for the optical designer until the advent of high-speed computers.

The second development which the optical designer required was the freedom to use lens surfaces which were not spherical. In the past, he was forced to restrict his design to combinations of spherical surfaces which in many cases failed to give him complete corrections.

During the fabrication of the 20-in.-diameter f/1 satellite tracking optics, the optician developed techniques for fabricating surfaces which departed from spherical. Since then, aspheric lenses have played a major role in increasing optical system performance

A Special Report

This 16-page section, compiled under the direction of M/R Associate Editor Charles D. LaFond, surveys the market outlook and recent technological advances in a field seldom covered as a unit. Some highlights:

- Optics share of missile/space business likely to double in 3-5 years.
- U.S. optics industry is no longer dependent on European components.
- Astronomers remain vital to data collection, can now get 'clean' data.
- New firms may move into expanding area of missile tracking.
- Competition grows in production of tooling and alignment devices.
- Reconnaissance and research breed sophisticated new photo devices.
- Interest increases in light transmission through fiber optics.
- Optics finding application in guidance, navigation and communications.

while at the same item reducing "package" size and weight.

• **Optics in missile R&D**—The effect of missiles in accelerating progress in optics has been broad. The use of optics as a tool during the development of missiles, its use as a critical subsystem during the launch phase, and its prime role in missile and satellite payloads assure continued use.

One of the earliest development applications of optics was in Perkin-Elmer's Baker Super-Schmidt Meteor Camera. This f/0.67 system secured photographs of meteors entering the atmosphere, which permitted astronomers to determine their precise deceleration. This then allowed them to predict the upper atmosphere densities to be encountered later.

When missiles reach the flight test phase, tracking telescopes provide trajectory measurement and allow close monitoring of the engineering performance of the missile. Long-focal-length tracking telescopes have proved themselves invaluable during the critical first firings in the missile program.

• **Optical missile alignment**—Optics is now used as the link between the inertial guidance system and the earth coordinate system on which the target will be found.

In a normal launch from a fixed pad, the azimuth alignment of the stable platform is monitored by an autocollimator. The autocollimator, with a sensitivity of 0.1 second of arc and an accuracy of 1 sec. of arc, senses platform deviations in azimuth.

The correcting signal from the autocollimator restores the desired azimuth heading which will direct the missile to its target. In this fixed launch-pad application, the optical problem is one of maintaining the stable platform and the autocollimated axis constant with respect to either the celestial pole or an artificial reflector.

In addition to this prime reference system, a bi-axial autocollimating monitor must be used to continuously monitor the optical and radio sextants which are periodically used to calibrate the inertial navigation system. This heavy use of optical reference systems to tie the missile guidance system to the inertial and astronomical navigation systems has led to development of extremely precise, stable periscopes.

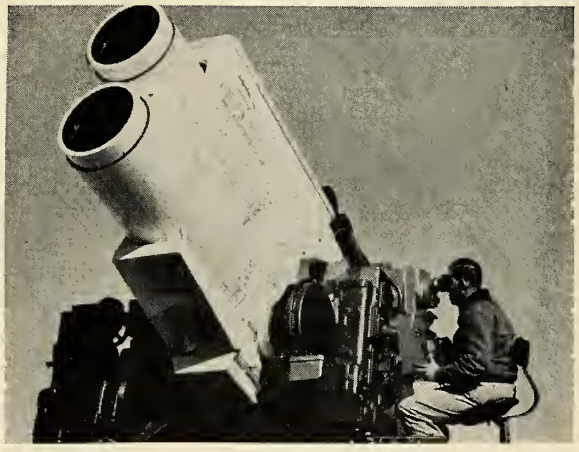
• **Geodetic applications** — During both the test and possible use of the guided missile, one of the present problems arises from the ambiguity in the relative surveyed locations of geographical points.

Conventional surveying techniques have established precise mapping of continental or regional land masses. Present techniques for linking these regional surveys or continental surveys to each other across large spans of water, however, are less precise than the inertial guidance systems.

Conventional astronomical techniques are incapable of achieving the desired accuracy because of gravitational anomalies.

The most precise means of linking the maps of separate land masses is based on use of ballistic cameras and flares or strobe lights on missiles or satellites. The pyrotechnic flare or strobe light at missile or satellite altitude is photographed by two fixed, open-shutter ballistic plate cameras located at known points on one land mass and by a third camera located over the unknown point requiring calibration.

Stellar background is used as the basis of measurement. The first two cameras, with their known base line, determine an angle with the flare. The location of the unknown station is determined, using the known base line and the fact that the lines of sight from all three stations intersect at the flare.



MARK I ROTI (Recording Optical Tracking Instrument) is an automatic tracking system developed by Perkin-Elmer and recently delivered to Air Force Missile Development Center, White Sands. It provides detailed missile performance data at distances up to several hundred miles.

• **Surveillance and reconnaissance**—The full potential of optics for resolution and accuracy and for maximum information content is available in missile and satellite payload applications.

One of the major reasons is that the optical system is essentially above the degrading influence of the turbulent atmosphere. Hence it is limited only by the laws of diffraction, which allow resolution increases in direct proportion to increases in the aperture.

The resolution and maximum information content advantages of optics are shown by the panoramic camera. The information contained in its roll of film would require hours of telemetry transmission. Major current problem in systems of this sort is in stabilizing the camera and image compensation to prevent the motion of the missile or satellite from degrading the photograph.

The materials and structural problems involved have been solved adequately for apertures up to 5 or 6 inches. It is believed that the problems of large aperture instruments—36 in. diameter and greater—will be solved more readily for astronomical applications than for surveillance and reconnaissance applications.

Current development of high sensitivity, 1/30th second-of-arc star trackers and stabilizing techniques for balloon-borne telescopes will greatly ease the guiding problem.

Unfortunately, surveillance and reconnaissance from satellite and missile altitudes are extremely complex. Their informational effectiveness will be limited by the difficulty of achieving image and motion compensation better than 1/30th or 1/50th of a second of arc, and by the limited band-width available for the transmittal of information.

• **Problems galore**—The greatest problem today, a Ball Bros. official told M/R, is the lack of trained optical engineers. Optics, he said, has been shamefully neglected by engineering schools. The few good physicists in the field are just not interested in everyday optical engineering.

Others complain there are too few optical and photographic scientists. Even skilled optical specialists are hard to find. But, worst of all, none of the many companies which have felt this shortage sees any signs of improvement.

Many manufacturers believe that optical progress is being delayed to a large extent by simple economics—the very high cost of tooling up for radical experimental optical systems.

Most in the industry have felt the duress of having to produce precision optics within 1-second-of-arc tolerance. They recognize the need for such accuracies, but somehow, they feel, the in-

dustry must improve production techniques and make the technology more of a science than an art.

Part of this problem may be the result of another common feeling now being voiced by younger engineers. They say there is an ever present strong resistance to any change in the industry, especially in production techniques.

Much of this resistance stems from the highly skilled craftsmen in the trade.

The broad use of photography in missile work has generated another problem. Many feel that now is the time for the government and industry to sit down and carefully review requirements.

Many times the limitations of photography are not recognized. For example, many missiles have been launched during heavy overcast. Under such conditions most of the footage will be useless.

• **New products needed**—Typical of any field experiencing accelerated growth, the optics industry has a multitude of new material, product, and process requirements. The rate of growth to a large extent depends on how fast these requirements can be met. Here are a few more urgent needs:

• **New materials** to solve environmental conditions not conducive to high-quality optics (vibration, sudden temperature change, rapid acceleration, etc.)—materials offering real stability during missile flight. Also, improvements in glass and crystalline substances of special characteristics—so that large-diameter optical blanks of high quality can be obtained readily.

• **Production capability** for cast optics. It should be possible to reproduce in quantity with image quality comparable to astronomical telescope elements. Another must is automated production of high-quality aspheric surfaces to any given prescriptions.

• **New lens elements** capable of ultra-high resolution—in the magnitude of 6 million image elements/sq. in. Lightweight optical elements must be produced also without loss of quality, precision, or reproducibility.

• **Shutters** of large diameter must have greatly increased reliability.

• **Equipment** refinements in many areas are needed: automatic tracking with automatic focus and real-time readout; vastly increased photographic frame rates and automatic exposure control; adequate attitude and stability control of directional optics; more sensitive, less noisy detectors for all spectral regions; low-power, high-temperature optical communications modulators; long-range inertial guidance by optical means.

1961 Military Market Estimates for Optical Industry

(Figures represent reasonable summary of estimates resulting from M/R poll of 115 manufacturers, directly or indirectly associated with military optics. Totals include electro-optics but exclude these instruments primarily designed for infrared. Also excluded from this roundup are ophthalmic, medical, metallographic, spectrographic, spectrometric, and photomicographic instruments and microscopes.)

	(millions of dollars)
Specialized instruments	150-175
Photographic lenses	45- 55
Projection equipment	45- 55
Binoculars & telescopes	7- 11
Optical process & quality-control instruments	3- 4
Total (Military)	250-300
Total (Missile/Space)	75- 85

• **Data assessment** from film is too slow. A rapid means in both processing and data reduction must be developed.

• **Who controls components market?**—The so-called U.S. "optical industry" is unlike almost any other segment of our whole industrial world. It is an industry of specialized producers. True, there are many large manufacturers who control large pieces, but none dominate in all areas.

A brief rundown of the kings in the optical components domain must include the following:

–Optical glass—About seven manufacturers produce the bulk of the high-grade optical glass, with four companies in the lead. The biggest are Eastman Kodak (Hawk Eye Works), Bausch & Lomb, Pittsburgh Plate, and Corning Glass Works. The others are American Bifocal Co., Hayward Scientific Glass Corp., and Southwest Optical Co.

–Lenses, prisms, mirrors—Chief figure without question is the American Optical Company—over 35% of its sales are in the precision lens field. Next are Eastman Kodak, Bausch & Lomb, Elgeet Optical Co., C. P. Goerz American Optical Co., and Wollensak Optical Co. Not quite so big but still important producers are Bell & Howell, Argus Cameras, Kalart Co., Meyer Opticraft Co., Atlantic Research Corp., Nortronics, Aerojet-General, Simpson Optical Co.

–*Filters*—High-quality precision optics are of little benefit to many instruments without equally perfect filters. In this area, the U.S. has obtained international control and five companies are leading the field: Kodak, Harrison & Harrison, Ednalite, Tiffen, and Enteco.

• **Who are systems leaders?**—Leading producers of instruments and systems change almost every few years. The reason is just a reflection of our leap-frogging technology. (More details are provided on manufacturers and equipment in succeeding sections.)

–Tracking—J. W. Fecker Div. of American Optical Co. looks like the current leader in missile optical tracking instrumentation. Besides its own systems it handles the Contraves Ag Zurich cinetheodolites and has installed, maintained, and modified the system at every major range in the U.S. Askania-Werke, Wild Heerbrugg (Swiss), and Perkin-Elmer rank next in that order. P-E handles the Bodenseewerk systems. Others include Electro-Optical Systems, Bausch & Lomb, Nortronics, Mitchell, Bowen and Cook Electric.

–Telescopes—Perkin-Elmer is currently developing some of the bigger telescopes (a 36-in. reflector for Stratoscope II and a 48-in. reflector for M.I.T.) but for the smaller and higher volume instruments Bausch & Lomb, Fecker, Kollmorgen and Air Cargo Equipment Div. of ElectroVision Corp. are ahead, B&L leading.

–Tooling & alignment instruments—Keuffel & Esser has about the widest line of industrial tooling and missile alignment devices in the Free World. It controls 40% of the market. K&E also handles Askania theodolites under the K&E brand name. Nearest and biggest competitors are Hilger-Watts, England, and Brunson Instrument Co. Next in line are Perkin-Elmer, Davidson Optronics, Bausch & Lomb, Kollmorgen, Air Cargo Equip., Nortronics, Texas Instruments, Kern Instruments, Farrant Optical, and Optron.

–Special photographic equip.—For precision still and motion photographic equipment (excluding tracking and surveillance), these are the leaders: Perkin-Elmer, Chicago Aerial, Cook Electric, Bausch & Lomb, Consolidated Electrodynamics Corp., Milliken, Mitchell, Bell & Howell, Eastman Kodak, Wollensak, Argus Cameras, Cameraflex, Federal Mfg. & Engineering Corp., Avco, Electro-Optical, and Fairchild Camera.

–Guidance & navigation—A relatively small field at the present time, optical guidance and navigation is in its infancy. These are the current leaders: Chicago Aerial, Ball Brothers, Kollsman, Cook Electric, Nortronics, Texas Instruments, Kollmorgen.

–Surveillance—This is an area of growing importance. More and more manufacturers are moving into the field with new advanced systems: CBS Laboratories, Chicago Aerial, Texas Instruments, Milliken, Cook Electric, Bausch & Lomb, Nortronics, Westinghouse, Aerojet-General, Hughes, Kodak.

OPTICS

Visual Sighting Still Vital

Astronomers now can hoist instruments high enough to get 'clean' data; some high spots in new instrumentation

DESPITE ADVANCES in telemetry and radiotelescopy, visual observation of space phenomena and space vehicles remains indispensable to the collection and interpretation of data.

And the astronomers can at last get through the atmospheric veil that has for centuries restricted their observations. With our progress in space technology, we can now lift instruments through the fog and obtain "clean" information. Eventually man, too, will follow.

Dr. John Strong of Johns Hopkins University and Cmdr. Malcolm Ross, U.S. Navy, have achieved much with their celestial observations from aboard an astronomical balloon.

Dr. Martin Schwarzschild's Stratoscope I, an unmanned balloon, successfully carried a 12-in. telescope up seven times. The clearest solar pictures ever made were photographed on these missions. His Stratoscope II, carrying a larger telescope, will go aloft sometime in 1961 to observe the atmospheres of Jupiter and Venus and to make other studies of Saturn, Pluto, and the Great Nebula in Orion, according to the Princeton University professor.

Prof. Leo Goldberg, of the University of Michigan, predicted recently that either a satellite or moon observatory probably can be established within 20 years. (He further believes that man would be a liability on such a platform, because he would make accurate aiming impossible.)

The first true astronomical research satellite is now being built by Ball Brothers Corp. NASA plans to launch the 300-lb. satellite on a *Thor-Delta* rocket next year.

• **High spots**—None of this would be possible, of course, without a vast number of improvements in instrumentation. A brief glimpse at recent developments for astronomy should include the following:

Perkin-Elmer, long a leader in optics and well known to astronomers for its Baker-Schmidt telescope, continues to supply better instruments. Its six Super Schmidt meteor cameras are being used in pairs to study height, speed, and direction of passing meteors.

The Stratoscope I telescope was built by P-E and the 36-in. Stratoscope II is now being built by the company. The fused-silica blank for the 36-in. mirror was cast by Corning Glass Works.

Definition with this system is expected to greatly exceed that offered by the 12-in. instrument.

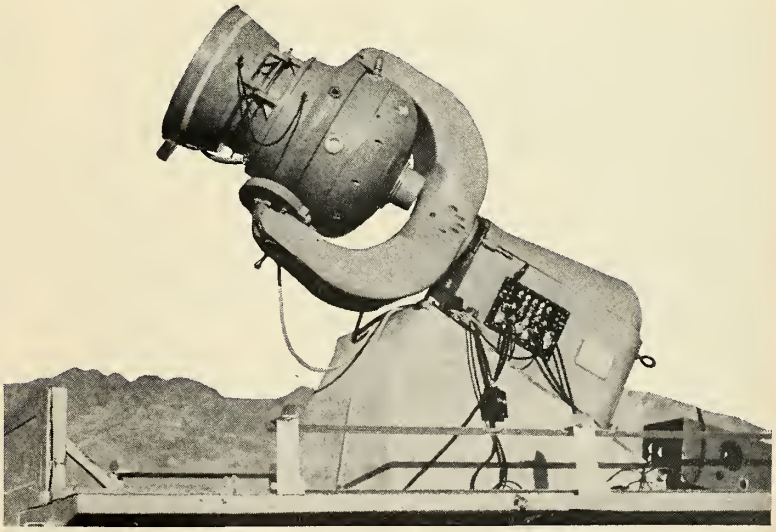
By employing closed-circuit television techniques with powerful telescopes, the Air Force says it can now capture photographs of stars heretofore unobtainable. Key to the system is an image reproducer developed by ITT laboratories of Ft. Wayne.

An electronic transducer receives light through the telescope and transforms it to electrical impulses. These are amplified and converted to a visual image on a storage cathode-ray tube. The object being scanned then may be observed visually or photographed.

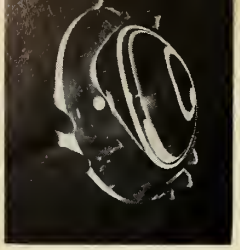
So sensitive is the equipment, says the Air Force, that photographic exposure time can be sufficiently brief to eliminate the quality degradation so often caused by atmospheric tremors. Exposure time can be reduced over 10,000 times with the system.

Another recently developed aid to stellar studies is a wavefront-inverting interferometer, conceived and built by the National Bureau of Standards in Washington. Simple and accurate, it can be used to measure the diameter, separation, and time of meridional transit of stars. (It may also be used to check aberrations in reflector- or refractor-type astronomical objectives.)

The system consists essentially of a special prism assembly, eyepiece, and a camera attached to a telescope. The desired wavefront inversion is introduced by the nature of the prism used, a modified Koesters prism made up of two identical prisms cemented together with a partially reflecting film on the inner face. Fringes can be viewed from either side.



BAKER SUPER SCHMIDT Meteor Cameras built by Perkin-Elmer. Early meteor photographs taken with this camera yielded data on upper-atmosphere densities which would be encountered by missiles and satellites. The camera, which has a 52° field of view, also took the first photo of Vanguard I.



OPTICS

Missile Tracking Field Due

Three makers now lead technology established during World War II; a survey of advances in telescopes and came

OPTICAL TRACKING has been, remains, and will continue indefinitely to be a primary method of obtaining and recording missile performance information.

Its value is long-established; while its progress has undoubtedly been accelerated since missile manufacturing became big business, it is well to remember that the cinetheodolite was a standard field item in the German Army during the Second World War.

Today, two general classes of instruments are used by all missile ranges: the cinetheodolite and ballistic camera, for precisely recording spatial position of a missile in flight; and the long-focal-length photo telescope, for recording events.

Three manufacturers—Fecker, Askania, and Perkin-Elmer—at present lead the field. But new products and growing in-house capabilities indicate that others may move into—and change—the picture within a few years.

• **Biggest supplier**—J. W. Fecker, Inc., a division of American Optical Co., has more major tracking systems in operational use today than any other single company. It has achieved this record with two principal instruments: the EOTS (Electro-Optical Tracking System) cinetheodolite and the IGOR (Intercept Ground Optical Recorder) long focal-length photo telescope.

Over 50 EOTS's are now in use and many more are on order for missiles ranges in and around the U.S. (They are also used by General Electric to check BMEWS antennas.)

Good from 1 km to infinity, the 35-mm instrument can track at accelerations up to 60°/sec.² and with velocities for both azimuth and elevation from 0.02° to 30°/sec. Frame rate is variable from 10 to 30/sec. Contraves Ag Zurich Switzerland, manufactures the EOTS; Fecker installs, modifies and maintains them.

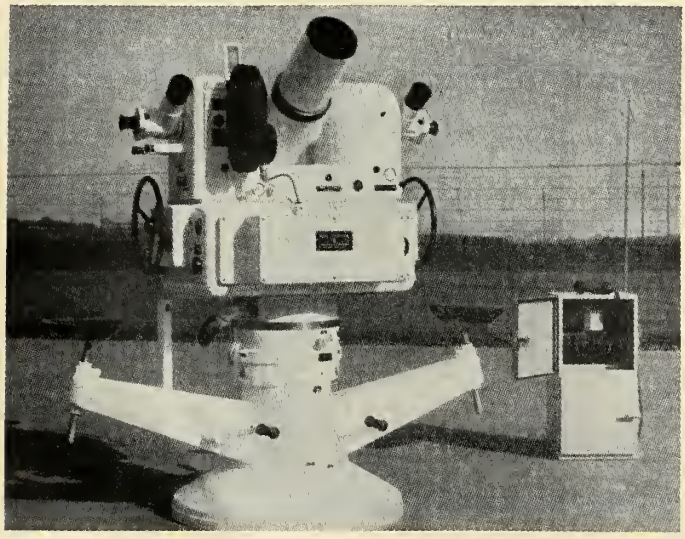
The IGOR photo-telescope is used to record events, rather than trajectory. It has an initial focal length of 90 in. and can be stepped up to 500 in. A very precise and high-quality instrument, it is also considerably less costly than competitor instruments, according to Fecker. Twelve have been placed in operation and more are on order.

• **Hundreds of miles**—Similar to the IGOR is Perkin-Elmer's Mark I ROTI (Recording Optical Tracking Instrument) recently placed in operation at the Atlantic Missile Range and White Sands Proving Ground. It can provide detailed photos at distances up to hundreds of miles of missile flight path, velocity, acceleration attitude, etc. (A modified version is being used for infrared missile plume studies at AMR.)

Perkin-Elmer has developed 12 satellite tracking cameras for Air Research and Development Command, USAF. Called SATRACK, the cameras are used to plot the orbital positions of U.S. and foreign satellites from strategic sites around the world.

Another P-E device is its panoramic tracking camera, first developed for the Air Force. Using a rotating prism to "wipe" an image on film, the airborne camera covers a 180° field perpendicular to the plane's heading with each exposure.

• **First with theodolites**—The first and still a major world producer of cinetheodolites is Askania-Werke of Germany. Its Kth58 (manual) and Kth



LEFT: *EOTS PHOTO-THEODOLITE, built by Contraves/Ag Zurich, Switzerland, is sold by J. W. Fecker, Inc., throughout U.S. It is widely regarded as among the best for missile/space tracking use. More than 50 are now in use.*

RIGHT: *NORTRONICS will develop this 60-millimeter ballistic camera—largest of its type. A recent Air Force contract calls for six of the cameras, which will make use of a new louvre-type shutter one foot in diameter.*

o Expand

58E (motor-driven) instruments are used at every major missile range. Each offers unlimited azimuthal range, 180° elevation, and 15° depression angles.

Interchangeable cameras can be used for either 5 or 10 frames/sec. operation. Lenses, too, are interchangeable for focal lengths of 30, 60, 100, or 300 cm.

The best known ballistic camera in the field is probably the BC-4, developed by Wild Heerbrugg, Ltd., of Heerbrugg, Switzerland. Used on most of the major missile ranges, it is believed by many to be the most accurate optical measuring device of its kind in use.

Nortronics Div. of Northrop Corp. is currently designing a new 60-mm ballistic camera for the Air Force. It will be used to determine exact missile trajectory by photographing its flight against a background of stars. Specifications call for a louvre-type 12-in.-dia. shutter to operate at a speed of 2 millisec. Six will be delivered.

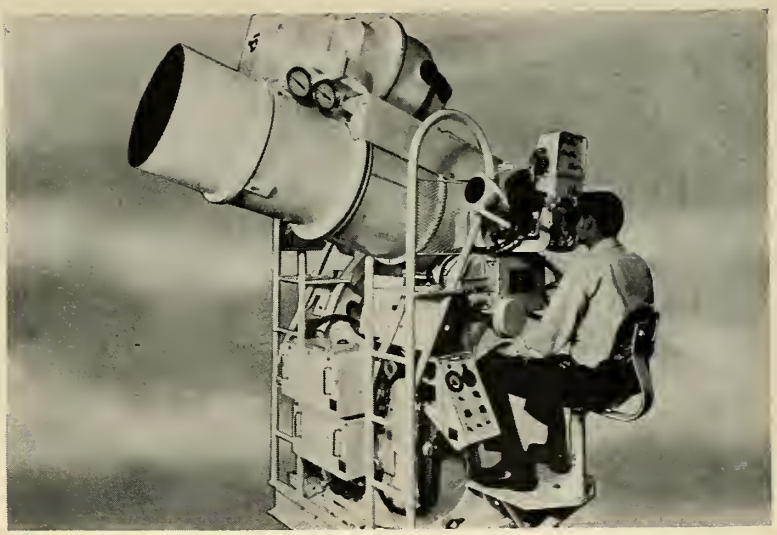
• **New system for Cape**—To provide highly accurate real-time missile trajectory information, Radiation, Inc., is reportedly developing a new system for the Air Force called SORTI. The Star Oriented Real-Time Tracking Instrument will in effect combine a ballistic camera system with electronic tracking and stellar orientation reference. The system will be built, it is believed, for the Missile Test Center at Cape Canaveral.

Designed especially for range tracking is the Model V. Multidata 70-mm Camera by Flight Research, Inc., of Richmond, Va. Frame rates from 10 to 60 ft./sec. and exposure times from 1/30 to 1/1440 sec. are standard. Start-up time for full speed operation is 3 sec.

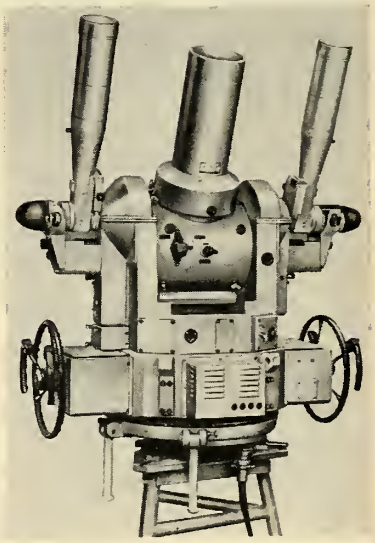
Cameraflex Corp., Garden City, N.Y., has designed and built the Model IBDM-20 for use as a radar antenna-mounted boresight camera. It will be used to collect data for calibration, tracking-error correction, etc.

Less magazine, the 35-mm camera assembly weighs 15 lbs.

Frame rate is 20/sec., but this can be raised to 48/sec. with a change of drive gears. The system has a reflex-type viewfinder with bore-sight reticle. A three-track optical data recorder handles square wave pulses up to 2 kc.



ABOVE: *IGOR MARK II 70-mm Tracking Telescope is used to document events during missile firings. Tracking rate is 10°/sec. Optical system is an 18-in. clear-aperture catadioptic telescope with variable focal lengths.*



RIGHT: *ASKANIA-WERKE'S widely used Kth 58E automatic tracking cine-theodolite. Germans used early type in 1941.*

BELOW: *CINETHEODOLITE, built by Bodenseewerk, German subsidiary of Perkin-Elmer, is one of series of intermediate-focal-length units designed primarily for tracking missiles at short and medium ranges. Electrically driven, it permits frame rate of five exposures per second.*

OPTICS

Optical Alignment Field Sees Steadily Growing Rivalry

AMERICAN BOSCH-ARMA CORP. mock-up of typical collimator pit as laid o for Atlas ICBM. In ceiling are two openings: one to align the porro prism on t inertial platform, and the Polaris (star) sighting hole. To the left and rear of t alignment group are the azimuth reference prisms for calibration of the electro-col mator. Reference-prism alignment can be cross-checked with an alignment on Polar

OPTICAL TOOLING and alignment devices have changed drastically since World War II.

When the war ended, they were mostly optical-mechanical systems. From 1945 to 1950, there was a sharp decline in interest in the field. The '50's, however, saw the beginning of a surge toward electro-optics and electro-opti-mechanical instruments and systems—an upsurge largely created by missile/space impetus.

The missile/space field is by far the biggest current user of precision angular and linear measuring instruments. Because this field demands rigid quality control, inspection, and unusually close tolerances, the establishment of separate metrological laboratories—such as GE-Pittsfield and Keuffel & Esser (K&E)—is increasing.

Competition in the auto-collimator field is steadily rising. Leaders now are Perkin-Elmer, K&E, Davidson, Farrand Optical and Texas Instruments.

Practically no U.S. firms make standard theodolites. Those sold under the name of K&E are made in West Germany by Askania-Werke. Bodenseewerk supplies P-E. Contraves, Kern Instruments and Wild Heerbrugg (all Swiss) also are important European producers for the rest of the world. It just is not economically feasible for U.S. manufacturers to compete in the standard lines. For special theodolites, however, the U.S. can compete with its manpower and production capabilities.

Here are a few of the best devices now in use—and some of the more notable recent advances:

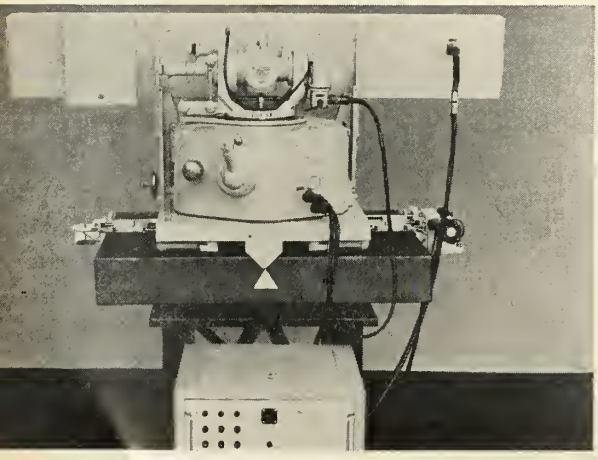
Perkin-Elmer's precision Azimuth Alignment Theodolite (actually, it combines an autocollimator with a theodolite) is used to align guidance platforms of many missiles, including *Jupiter, Mace, Thor* and *Atlas*. It can detect alignment deviations to less than 1 sec. of arc, the company says.

• **Self-correctors**—Among its hundreds of precision optical tooling and alignment devices, two of K&E's special systems are finding particularly widespread use. These are its electronic tilt-angle transducer and an electronic autocollimator. Each system uses the same type of power amplifiers and similar indicators (different scales); only sensing units are different.

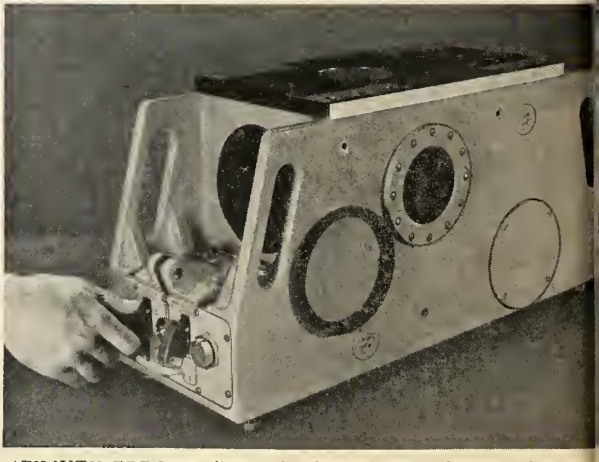
The tilt-angle transducer is a leveling unit, detecting automatically angular deviation with respect to gravity. By feeding the signal from the amplifier into a servo-mechanism, the system can be made to correct itself remotely.

The electronic auto-collimator differs from its optical cousins in its photo-electric sensing; it is much more sensitive. Used to measure angular deviations of a reflective surface with respect to the collimator axis, it too can be made self-correcting.

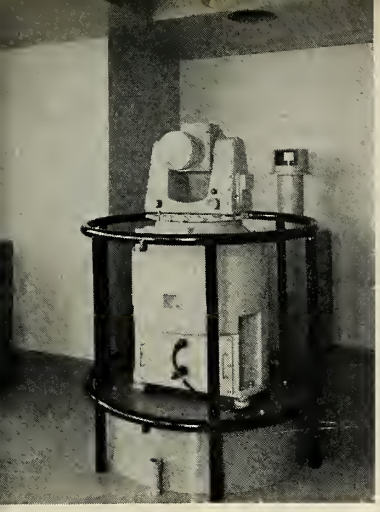
K&E also has produced recently a few prototype theodolites specifically



DAVIDSON THEODOLITE used to align the Thor missile prior to launching. Similar instruments are employed for different alignment phases of Atlas, Jupiter and Minuteman. Davidson has also built a highly accurate Platform Alignment Fixture.



AZIMUTH ERROR Indicator developed by Bausch & Lomb is used in Polaris submarines for missile guidance alignment before launching. It is tied in with General Electric's fire control system, together with three other B&L optical devices.



designed for missile alignment. These are direct-reading azimuth theodolites accurate to 0.5 sec. of arc. They are currently being used to align inertial guidance platforms.

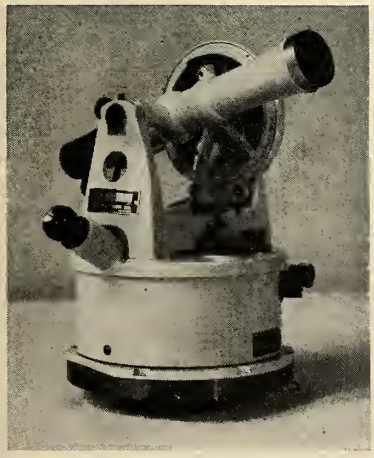
Another system was recently developed for initial missile alignment by Automation Laboratories, Inc., in New York. A prototype system, it is capable of measuring dynamically a 1-sec. deviation of line of sight to a source or target with a 3° or 4° field of view, according to the company.

• **Fixing acceleration** — Optron Corp. of Santa Barbara, Calif., has developed a line of calibration systems based on its Model 701 Displacement Follower. An electro-optical instrument, it measures vibration, motion and displacement for a myriad of applications. For example, it is used to study the three axes of motion of an accelerometer.

The instrument includes a CRT, amplifier, optical system with beam splitter and an end-on, 10-stage, multiplier phototube. When a spot of light is focused on the work, a photocell-servo system causes the spot to follow the object's motion.

The output presents an exact waveform of motion. Displacement can be read directly in inches; displayed on an oscilloscope, the waveform provides displacement and frequency readout. When both of these are known, acceleration may be calculated.

Linearity variation, absolute or terminal, over full scale from true linear line does not exceed ±0.2% full scale, according to Optron. Interchangeable lenses permit five displacement ranges with resolution of the lowest at 12 micro inches.



DIRECT READING azimuth theodolite developed by Keuffel & Esser Co. has accuracy to within less than 0.5 sec. of arc. It was designed for missile alignment.

• **Missile angles**—Among its many optical alignment devices, Davidson Optronics, Inc., built a missile elevation alignment set, D-980, recently for Minneapolis Honeywell. Used to determine the inclination angle of a missile with respect to horizontal, the system operates automatically up to launch time. It provides a warning signal when the missile position is ±0.5° of the desired angle, an uncaging signal when it is within 1 minute of the correct angle.

Davidson also built a Platform Alignment Fixture for Autonetics Div. of N.A.A. Having an accuracy to 1 sec. of arc, the rugged fixture will be used to secure alignment of inertial instruments to reference accelerometers on the stabilized platform of a missile autonavigator. Total fixture weight is 3.5 tons.

Through use of an automatic autocollimator with aperture sharing capabilities, the reading from an optical level is optically transferred by means of a front surface mirror and optical cube to the porro prism. The transferring procedure is achieved by translating the autocollimator along a precision slide until the optical axis reaches the porro prism.

• **Polaris applications** — PEAC, Photo-Electric Auto-Collimator, developed by Barnes Engineering Co. is used for prelaunch azimuth alignment of the inertial guidance system for *Polaris*. It is capable, says the company, of detecting deviation of an angular position to better than 1 sec. of arc.

A major portion of the *Polaris* optical alignment instrumentation is provided by Bausch & Lomb. Used with General Electric's fire control system are four B&L devices. The principal unit is its Azimuth Error Indicator (AEI), used to set the guidance package on the desired trajectory.

It performs a measurement function so that the inertial guidance receives constant precise settings from fire control prior to launch.

OPTICS

SOME OF TODAY'S most advanced photographic instruments are emerging from two generally disassociated fields: reconnaissance and research.

Photography is a component of many of the optical systems associated with the missile/space field. But in most systems, modified off-the-shelf camera equipment is merged with theodolites or telescopes and an electrical or electronic control system.

In both photo-reconnaissance and basic and applied research, new configurations are being born. For reconnaissance, camera manufacturers are building equipment to satisfy stringent and unusual requirements rather than modify existing instruments to fit special applications. For research, the scientists themselves often build radically advanced devices simply because neither the know-how or instrumentation exists from manufacturers.

These are some of the newest developments in both fields:

• **Photo-Reconnaissance** — For manned and unmanned aerial reconnaissance Chicago Aerial has developed a line of compact photographic equipment and electronic accessories. One, the Sonne Continuous Strip Camera (invented by CAI's president) produces a single exposure of up to 400 feet in length. Resolution and quality are high.

Its KA-30 day or night camera is automatic and has built-in image motion compensation to eliminate blur. Coupled with the CBS Laboratories' Photoscan system, images are obtained and stored by the camera. By processing the film automatically, the negatives can then be scanned electronically and converted to video signals for immediate transmission to ground. Either way, permanent record is obtained.

The 5-second airborne processing was developed by Ansco. It uses a self-arresting liquid monobath. Emulsions are pre-hardened.

Use of a similar technique has been proposed by RCA's Astro-Electronic Products Div. with a maneuverable satellite-chasing camera. This particu-

Advanced Photographic Units Spawned

Strict and unusual requirements in both reconnaissance and research have made it necessary to depart from standard equipment

lar application technique would be especially suitable for a high-resolution space camera, currently being developed by his division, said manager Spencer Spaulding, speaking before the American Rocket Society in Los Angeles recently.

The new camera records images in the form of electrical charges on sensitive tape. Capable of storing up to 300 pictures, the equipment would transmit the data to earth, using standard television techniques, on radio command after each orbit is completed.

The camera could be launched either separately or with a satellite and ejected later. In either event, the objective would be for the camera vehicle to remain roughly 100 feet from the satellite to observe satellite performance.

By preprograming and radio assist from ground tracking stations, the camera would photograph its subject from different locations. If pulsed light were used for control, illumination also would be provided for use in the earth's shadow, said Spaulding.

BULOVA ENGINEER checks the optical system of a special camera developed by the company. It is one of several classified photographic units developed for aerial reconnaissance purposes. (The photo was made through a large "master" diaphragm-shutter used in the testing device.)

• **Research Photo-Instrumentation** —Avco's Research and Advanced Development Div. recently installed the first commercially produced 50 nanosecond (50 x 10^{-9} sec.) hypervelocity shadowgraph system. It will be used by Eglin AFB's Air Proving Ground Center as a tool to study terminal ballistics conducted under simulated high altitude conditions.

A complex light source-lens-camera system, its 0.25-μsec. light source and 0.50-μsec. Kerr Cell shutter can obtain images of projectiles travelling over 1400 ft./sec.

Similar laboratory shadowgraphs were used by Avco in studies resulting in operational ICBM nose-cone designs.

Benson-Lehner Corp. of Santa Monica has produced an ultra high speed camera having a frame rate up to 1.6 million frames/sec. Film is held stationary in a disk-like drum while the image is reflected onto the film with a wedge-shaped, air-turbine driven mirror. A Kerr Cell shutter controls light passage. A flash lamp produces 400 million lumens for 3 milliseconds.

The systems should find research use in study of arc discharges, explosive reactions, shock cavitations, etc.

The Project *Mercury* space capsule will carry two D. B. Milliken Co. 16-mm observation cameras. Special purpose and very lightweight, one will photograph the astronaut while the other records instrument panel readings.

Operation of both cameras will be programed. Film speed during launch and re-entry will be 3 ft./sec., during orbit 1.2 in./sec.

A Kerr Cell camera has been developed by Electro-Optical having an exposure time of 5 millimicroseconds. By using the phenomena of electrically induced bi-refringement in liquid nitrobenzene, no mechanical shutter is required.

The company has used the device for the study of explosion phenomena and other hypervelocity research. The fast switching capability necessary for the cameras unusual exposure time also led to the development of exploding wire (see "Communications").

OPTICS

Fiber Optics Improves Sca

Huge potential for light transmission method; high resolution possible in electronic imaging with 'light pipes'

ENGINEERS WITH line-scanning problems are taking an active interest in a remarkable new method of transmitting light—fiber optics.

This infant technology represents the realization of a new application of an old principle: total internal reflection.

If a glass cylinder has an index of refraction greater than that of the surrounding medium, those light rays entering one end which are incident on the cylindrical surface at angles greater than the critical angle will undergo total internal reflection. The light will, in effect, be trapped within the cylinder.

A cone of rays, having a divergent angle determined by the critical angle, will be emitted at the other end of the cylinder. Qualitatively, this is the principle of fiber optics.

In addition, a moderate bending of the tube will result in only a slight loss of efficiency, since some of the rays close to the critical angle will escape. If the bending is gradual over the length, this effect is negligible.

Thus, if a bundle of these "light pipes" is constructed using very small-diameter fibers with the ends polished to high-grade optical plane surfaces, it is possible to transmit a complex image of light and dark areas through the bundle.

If, in the fabrication of the bundle, the order of the fibers has been maintained, a picture will be visible at the emitting end.

In practice, certain problems arise. The output resolution can be no finer than the fiber. Actual resolution turns out to be of the order of 1.5 times the fiber diameter.

• **Track jumpers**—Light rays which are not totally reflected back into a fiber may enter adjacent fibers. This results in a general reduction in contrast of the entire image.

American Optical Co., a major producer of fiber optic bundles, overcomes this difficulty in the fabrication process. The major cross-sectional area of a fiber consists of a high-refractive index glass. This is the primary medium of light transmission. This is surrounded by a thin layer of low index glass which serves as a boundary condition for total internal reflection.

DuMont Military Electronics Dept. of Fairchild Camera & Instrument Corp. goes one step further and coats the assembly with a thin metallic cover which reflects back or absorbs any rays not handled by the glass-to-glass junction.

Current individual clad fibers have an outside diameter of 0.002 in. and a maximum length of about one meter.

Bundle ends are matched in the distribution of fibers so that both ends of the fiber occupy the same geometric position. The intermediate part of the bundle can be permitted to hang loose, making it possible to lock the viewing end in position and move the input end around to "look" in various directions.

The limit of bending radius per fiber is 20 times its diameter. This amounts to a 0.04-in. radius of curvature. A smaller radius of curvature would cause serious image distortion.

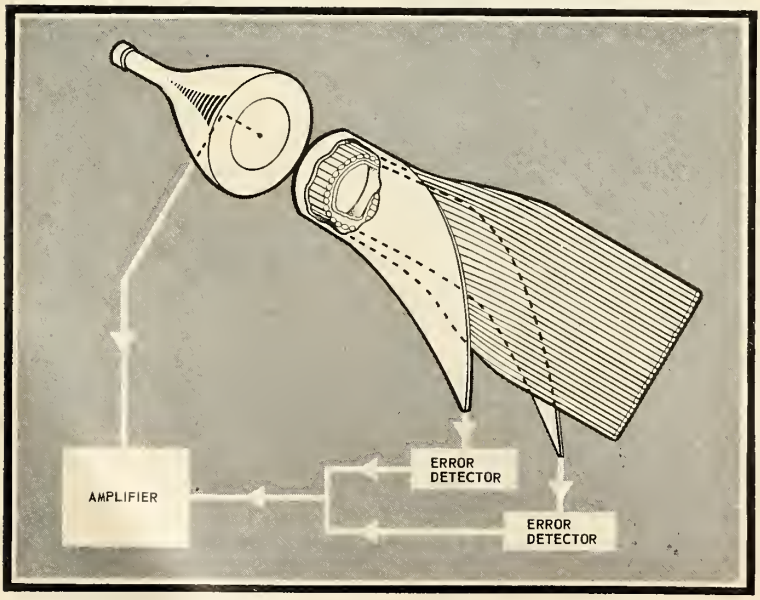
Broken fibers show up as dark spots at the emitting end of the bundle.

• **Oral inspection**—The applications of fiber optics are many and extremely varied. Although most aspects of the development are still in the research phase, the Research and Advanced Development Division of Avco Corp. has applied it to a TV optical probe.

The firm's medical research department developed the instrument which permits a dentist to view any part of a patient's mouth magnified on a TV screen. The probe is being developed for medical use to explore inside the human body.

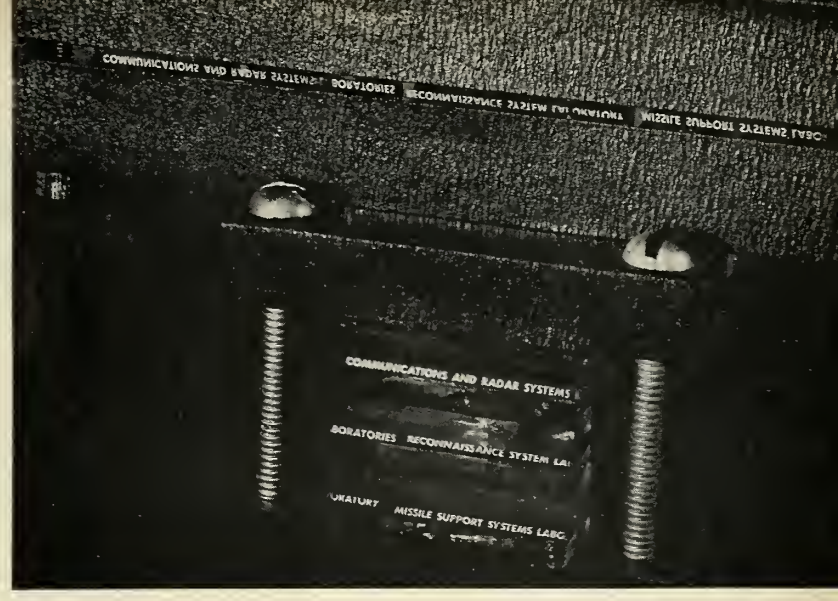
From this example it is obvious that fiber optics can handle problems which cannot be solved with a lens and mirror system. There are other areas where the use of fiber optics simplifies or improves such systems.

A short bundle can be used to transfer a curved-image surface to a flat one or to a different curve. An example of this is a fiber optics faceplate for cathode ray tubes. According to Du-



ERROR SENSING system unrolls cathode-ray tube spiral into straight line on film.

ɔystems



LONG LINE on input broken into three segments by fiber optic system. Bonded only at the ends, the input can "look" in any direction.

Mont, there are several reasons for maintaining the phosphor surface approximately spherical.

A fiber faceplate can meet this condition and, by grinding the external face flat, the image field is made plane. A second advantage is in the realization of high efficiency of light transfer and the absence of scattering and parallax problems.

• **Raster-spiral uses**—The major field of application is in line scan systems. DuMont says that fiber optics are uniquely qualified for this.

Although the general problem has many facets, the reduction of side-looking radar data can be examined as a typical application.

When a 0.02 microsecond pulse is transmitted, the return is a video signal containing 50 megacycle components. It is desired to print this information as a varying density line across a film in the order of 100 microseconds.

Because of the high scanning and data rates involved, mechanical systems with modulated light sources are impractical for this and cathode-ray tubes has proven a somewhat-less-than-ideal solution.

The cathode tube is used inefficiently because of the nature of the radar data. A standard commercial tube can readily reproduce 200,000 picture elements over its surface. But it is difficult to build a tube which will reproduce the required 5000 to 20,000 elements along a straight line.

The cathode tube spot must be very small and bright. This implies small beam currents at very high ultor potentials. A certain amount of "splash" occurs at the phosphor, enlarging the spot and producing possibly dangerous X-rays. Focus modulation is required as the beam moves across the tube and this is less than perfect. Internal reflection in the faceplate results in a halo and effectively increases the spot diameter.

In practice, it has proven impossible to prevent the tube from being the resolution-limiting element in the system.

Fiber optics permits the utilization of a greater area of the cathode-ray tube. This is accomplished through an optical segmenter—the unit breaks up a single line into segments in the form of a raster.

The fibers are laid in the form of a wide sheet. DuMont achieves this by winding a few layers of fiber on a long cylinder. The fibers are bonded in a narrow strip down an element of the cylinder and then cut along the center of the strip. The sheet is opened out, and—because it is bonded only at the ends—it can be separated into a number of short segments.

The video would be used to modulate a three-or-more-line raster scan on a flying-spot scanner tube using the return from a single radar pulse. The segmenter would then assemble it into a single line for printing on film.

It is a relatively simple matter to obtain a 500 to 1000 line resolution along a single line of the scanner tube. By employing a 10 element segmenter, 5000 to 10,000 line resolution across the film can be realized.

Another application of this segmenter is in the field of line-scan television aerial reconnaissance. A single line along the earth is imaged onto the single-line input of the segmenter. The segmenter transforms this to a raster which is, in turn, imaged onto a television pickup tube. The video output can be transmitted to a ground station, presented on a cathode-ray tube in raster form, reconverted to a single line through a second segmenter and printed out on film.

An increase in resolution by a factor of 10 is achieved without any extension in television tube pickup art.

There may be a slight loss in information as the line is broken up into segments due to the finite retrace time of cathode-ray tube scan. This can be totally eliminated by using a spiral scan.

A spiral sweep on a cathode-ray tube permits a single line to be several times the diameter of the tube. The fibers can unroll this spiral into a straight line.

The most difficult aspect of these applications is that of maintaining registry between the cathode-ray tube spiral or raster and the fiber optics spiral or raster.

• **Self alignment**—DuMont says that it is presumably possible to control the cathode-ray tube voltages with sufficient accuracy so that, once aligned, registry would remain perfect throughout the recording.

Realistically, some sort of feedback arrangement is desirable. One means of accomplishing this in a spiral system would be to flank, top and bottom, the readout sheet of fibers with two similar sheets. One end, including the flank sheets, is rolled into the required spiral. The signal sheet is flattened out at the other end for line recording on film. The flank sheets are rolled at their free ends and exposed to photoelectric cells.

If the cathode-ray tube spot starts to wander off its prescribed spiral path, one of the cells is excited and the spot is pulled back onto its correct course.

The potential of fiber optics is enormous. Chicago Aerial Industries Inc. is using fiber optic configurations in the development of ice detector systems for aircraft and in the construction of a flat cathode-ray tube.

DuMont points to fiber optics utilization in satellite reconnaissance in a manner similar to the radar application. Radio Corporation of America is also working with this versatile concept.

missiles and rockets

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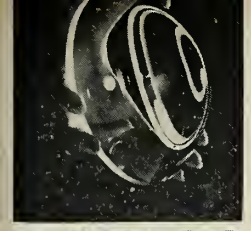


OPTICS

Optics Will Guide Spacecraft

Systems already in development will be exploited in guidance, navigation and communications

FOR YEARS optical systems have been used for collection and preservation of data. Now, with the imperative need arising from the surety of manned space flights, optics will not only be aimed at the stars—they will be used as an aid to steer craft toward them.

Not only are these new applications in navigation, but also in communications. With vast, almost unbelievable distances to be covered, new problems in communications are being unveiled. New answers must be found.

Finally, there is the possibility of devising visually guided missiles, only in its infancy. Who knows but what some future form of optical guidance may control spacecraft automatically from point to point?

• **Guidance**—Currently under development by Chicago Aerial is a passive optical guidance system for air-to-surface missiles. Called SOLO (Selective Optical Lock-On), it is responsive to visual and infrared emissions. Immune to jamming, SOLO is locked onto the target by visual reference when the pilot sights through his viewer. The system was developed for the Martin Co. which is currently testing it for possible use in an improved *Bullpup*.

Transistorized and gyro-stabilized, the guidance package weighs less than 10 lbs., says the company. Maximum guidance error at 2 miles range reportedly is from 13 to 26 feet max.

• **Navigation**—An Automatic Astro Compass, MD-1, has been developed by Kollsman Instrument Corp. for the Air Force for continuous and precise heading. The compass measures relative bearing of a star, angle between star and vehicle heading axis. By computing azimuth, heading of the vehicle relative to north can be determined.

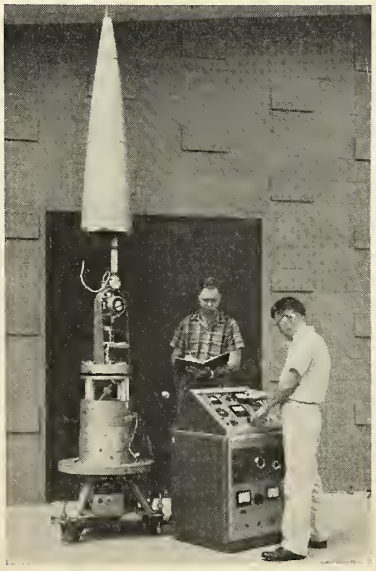
The tracker for the system is a small servo-controlled photo-electric telescope, carried on a small pitch and roll platform, horizontally stabilized by reference to a vertical gyro.

Designed initially for the B-52 long range strategic bomber, it will have almost direct application for manned spacecraft of the future. Kollsman has suggested however that instead of the present 3-star fix, a 4-body method be employed using two star trackers, one sun tracker, and one planet tracker.

For posible use in future celestial navigation is the Radiation Tracking Transducer developed by Electro-Optical. The RTT is a semiconductor sensor capable of detecting and resolving angular position of light at angles of motion less than 0.1 sec. of arc, says the company.

• **Communication**—Electro-Optical also is currently studying the feasibility of using solar radiation as a means of transmission for communications. Called SOCOM, the research is sponsored by AF Wright Air Development Div. in Dayton.

EOS engineers estimate that signal-to-noise ratio for such a system at a range of 10 million miles would be roughly 10 db. This is based on use of mirror antennas having areas of 1 sq. meter and 10 cps bandwidths. A factor of 10 increase in S/N might be possible by cooling the detector stage of the receiving systems, said EOS.



SUN-SEEKING pointing control for the Aerobee research rocket is manufactured by Ball Brothers Research Corp.

Cassegrainian optics would be used for energy collection. EOS believes that such an optical system could be satellite tested in two years.

The company for some time has been investigating the use of electrically exploded wires for communications by making use of the resulting high-intensity light. The study was a by-product of research sponsored by the Army Ordnance Corps in exploding wire for fuse initiators.

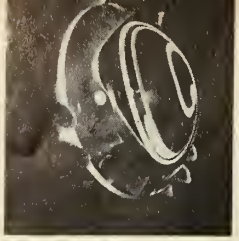
The technique involves switching tremendous amounts of current into thin wires in millimicrosecond time. Many times the material's vaporization energy is poured into the wire creating temperature over 100,000°C and pressures in the megabar range.

By using tungsten wire, researchers found that surface temperatures of 5000°C (plus the superheated interior) would give a light source excellent visibility and large output.

Optical-frequency communications took another big step toward reality with Hughes Aircraft's recent development of a laser—or optical maser (M/R, 7/18/60). The coherent-beam generator offers promise of extending the electromagnetic spectrum available for communications up to 500,000 gigacycles (kmc)—which includes infrared and approaches visible light.

Heart of the light-amplifying laser is a half-inch cube of synthetic ruby crystal. Irradiated by a powerful light source, the atoms are excited to a higher energy state and energy is reradiated in a narrow band of frequencies. The excited atoms are coupled to an atomic resonator and stimulated to emit the radiation in-phase. This is in contrast to ordinary light sources where the atoms radiate individually at random and produce "incoherent" light energy.

The laser radiates an almost perfectly parallel beam—less than one-hundredth degree of arc wide. It could have important application in space communications and radar as well as providing a new scientific tool for basic research.



OPTICS

Periscopes Now Well Wedded to Optical Display Systems

UNTIL RECENTLY, the only common denominator between periscopes and optical display systems was the characteristic of direct readout.

Now periscope systems employ multiple indices for various measurements and its viewers are assuming the characteristics of miniature display panels. New capability for inner space craft—submarines—and new requirements for outerspace craft are helping to spawn complex hybrids.

• **Display systems**—Using an advanced plastic lens developed by its Pacific Optical Div., Chicago Aerial is developing an integrated data display called V.I.P. (Visual Integrated Presentation). How close to hardware this advanced concept may be is an unknown, but its potential for space, aircraft, ground, and undersea use would be almost limitless.

A major display system is currently under development for the Army at Aeronutronic Div. of Ford Motor Co. A part of Tactical Operations Control project, the system will be an integrated tactical command intelligence center housing computers and a communications control.

Processed data will be fed into a CRT, photographed, film processed, and then projected for a blow-up display. Film processing is automatic under vacuum in 2 seconds. The process was developed by Aeronutronic's Carl Heinz-Lotze with the assistance of Ansco and Eastman-Kodak researchers.

The projection system uses a single back light source with 5 lenses to provide 4-color display. A 4-overlay screen also can be used.

Two display projectors are being developed by Nortronics for the Navy. One is a 70-mm rear-view projector for studying aerial and panoramic photos, and—in conjunction with a computer—it will be used to determine exact positions of details in the photos. The other will be a comparative view projector employing two screens for photo comparison and for projection of stereo photographs.

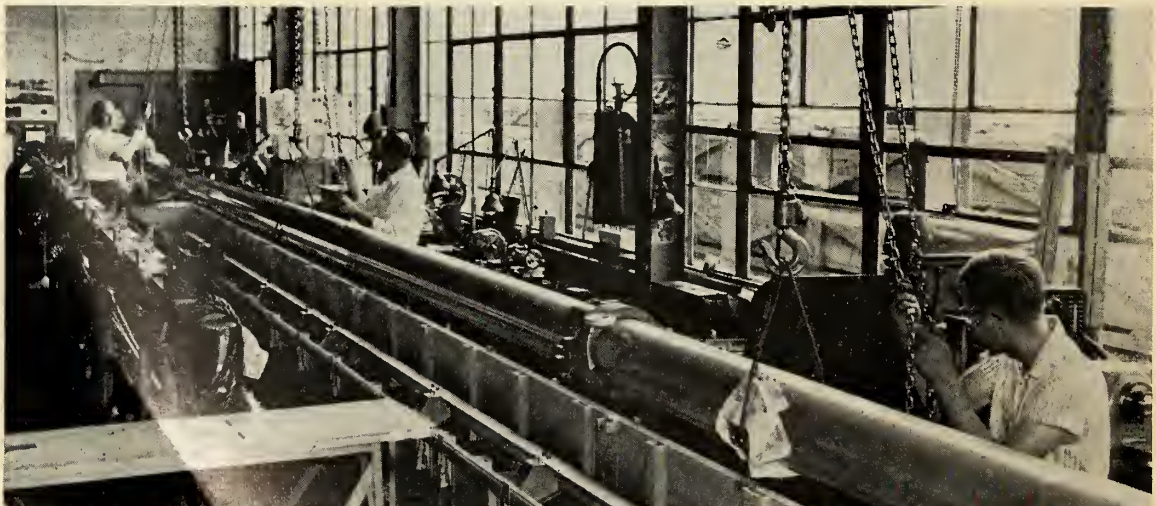
• **Periscopes**—The *Mercury* manned space capsule will use a unique periscope system designed and built by Perkin-Elmer. Used as a navigational aid as well as a viewer for the astronaut aboard, it will provide an 8-in. diameter display screen. It will cover a 190° field of view normally, but a power lens assembly can be swung into the system providing a magnified 20° view superimposed in the center of the former field.

An aspheric surface will be used for the 190° field. The periscope also will have an optical altimeter. Four indices on the screen will be used to measure apparent diameter of the earth circle displayed. For orientation, another index will permit measuring the angle of the sun with respect to the capsules longitudinal axis. Other indices will be used to derive capsule direction, location over the earth, and attitude.

The much publicized Type 11 Star Tracking Periscope used in the Navy's *Polaris* submarines is a product of Kollmorgen Corp., Northampton, Mass. It is an integral part of the Ship's Inertial Navigation System and is used to correct the Sperry or Autonetics inertial systems. It is the world's largest periscope.

The emergency periscope and alignment periscope for *Polaris* submarines are being provided by Bausch & Lomb.

Kollmorgen also manufactures the Bunkerscope, a line of missile bunker-type periscopes. Employing both high and low power ranges, the devices show images in true color.



TYPE 11 PERISCOPE, the world's largest, shown being loaded into its shipping case for delivery to the USS George Washington, nuclear-driven Polaris submarine. The periscope represents a significant achievement by its developer, Kollmorgen Optical Corp., in the application of modern precision optical techniques for advanced systems. It is a vital part of Navy's SINS.

OPTICS

Materials, Processes Keep Pace

Industry draws on vast experience to meet needs of missile/space effort; fantastic accuracy achieved by Corning Glass Works and other lens manufacturers

TWO WORLD WARS, the emergence of the motion picture industry and the insatiable demands of over 40 million camera amateurs laid the groundwork of this country's capability to meet the exacting requirements of missile optics.

The perfection of sandless optical glass and magnesium fluoride coatings are only a part of the story. New grinding and polishing materials and processes were rapidly reduced to mass production techniques without any loss of quality.

Lens curvature deviation can be checked down to one hundred thousandths of an inch. Quality control procedures are carried to impossible lengths.

To mention two highlights, Corning is extruding glass in prism shape and the Hawk-Eye Works of Eastman-Kodak is producing a lens with a speed of f/0.75—close to the theoretical maximum of f/0.5.

The optics industry has plunged into new areas to answer the ever increasing needs of the missile-space effort.

• **Space telescopes** — Lightweight mirrors of fused silica have been developed by Corning Glass Works for use in missile, satellite, and airborne telescope systems. The company is producing mirror blanks made by an unusual sandwich construction that reduces critical size and weight of mounting and auxiliary equipment.

The mirror blanks consist of two fused silica plates separated by walls or tubes of the same high purity glass. The ribs are permanently sealed to each plate under intense heat.

With this type of construction, Corning believes mirror weight can be reduced to half that of a solid disk with equal surface area.

The near zero thermal expansion of fused silica means the mirrors will retain their shape under sudden and extreme temperature changes. The ribs help maintain rigidity. These qualities should assure distortion-free images even in hostile environments.

FLATNESS of an optical element is shown being checked by a Newton ring test, a technique long used by specialists in optics.

SLATED FOR USE in the Stratoscope II balloon-borne telescope project, this 36-in. fused silica quartz mirror produced by Perkin-Elmer from a Corning blank weighs more than 400 lbs. It is polished to an accuracy of 1/1,000,000th in.

The surface of the blanks will accept any standard reflective coatings and can be precision ground and finished with standard optical equipment.

The fused silica reportedly is one of the purest man-made substances—impurities average less than one part per million.

The material can withstand long-term use at temperatures over 1700°F and intermittent use to 2250°F. The softening point is 2880°F. Coefficient of thermal expansion is 3 x 10^{-7} per degree F, giving the material excellent resistance to thermal shock.

Multiform fused silica is extremely viscous at high temperatures and tends to sublime before it can liquefy and flow. Tests of the material in a plasma jet show uniform removal of sample surfaces by ablation.

• **Orbiting sightseers**—Heat resistant glass viewports are being produced by Corning for McDonnell Aircraft's *Mercury* capsules.

Corning is making glass panes for a large rectangular window in each of the experimental capsules. The glass will have to maintain good visibility at searing temperatures generated when the capsule plunges back into earth's atmosphere.

The windows will include four panels of high temperature glass, two of them strengthened by a tempering process. The outside pane will be 21 inches high, the innermost, 13 inches.

Because the capsules will land in the ocean, the windows must remain completely watertight despite the intense heat of re-entry.

Photronics Corporation of Flushing, N.Y., recently received a contract from the Navy to design and fabricate a high acuity aerial reconnaissance lens which will provide particularly high resolution for low contrast targets.

The aspheric surfaces will require accuracy in excess of 2 micro-inches and the metal parts must be accurate to over 0.0001 in.

When its design has been accomplished, the company believes it will have developed a lens superior to any which now exists in its area of application. A precursor of the lens exhibits an average laboratory resolution in excess of 200 lines per mm.

• **Polymer invasion**—Low-cost optically ground and polished plastic lenses in a wide variety of sizes, shapes, and types have been developed by Fostoria Corporation. The primary advantage of the plastic lenses, according to the company, is low cost—about half that of equivalent glass lenses.

Other advantages are: Light weight; relative lack of distortion; high resistance to chipping and breakage; and ease of machining for quick, inexpensive mounting. In addition, plastic lenses are extremely clear transmitting up to 7% more light than glass lenses of the same thickness.

All types are now being manufactured including optically ground solid, molded, lenticular lenses; Fresnel, aspheric, and other specialized lenses also can be fabricated.

Kodak scientists recently announced a new method for detecting aerial film distortions as small as 0.0002 in. wide. Technique is based on moire-pattern effect, network of wavy lines of interference. Moire patterns have been used by Kodak researchers to locate minute film distortions by printing a half-tone tint on the aerial negative under study. A glass print is then made from the negative and registered with the master halftone screen. Location and size of distortions then become visible as irregularities in the resulting moire pattern.

Last fall the National Bureau of Standards announced development of a computer routine, called LENSTAR, to assist in the design of optical lenses. It provides a visual presentation of any one of several previously computed focal plane images. A rapid method has been devised for interpolating between them so that an operator may choose the most applicable image.

SNAP Units Well Along in Development

AEC spokesmen see 300-kw spacecraft APU available within five years, predict host of applications during '60's

by William Beller

A NUCLEAR auxiliary power unit generating 30 kilowatts of electrical power will be ready for spacecraft use within five years, according to a key Atomic Energy Commission official.

Within four years a 3-kilowatt unit will be available, says Lt. Col G. M. Anderson (USAF), AEC's Chief of Systems for Nuclear Auxiliary Power (SNAP).

Before the end of 1962, he predicts, a 300-watt unit with no moving parts will be awaiting flight test.

Spacecraft designers are being urged by AEC to learn about these units because within this decade they "will be the predominant and most reliable source of high power that will be available for application in space satellites."

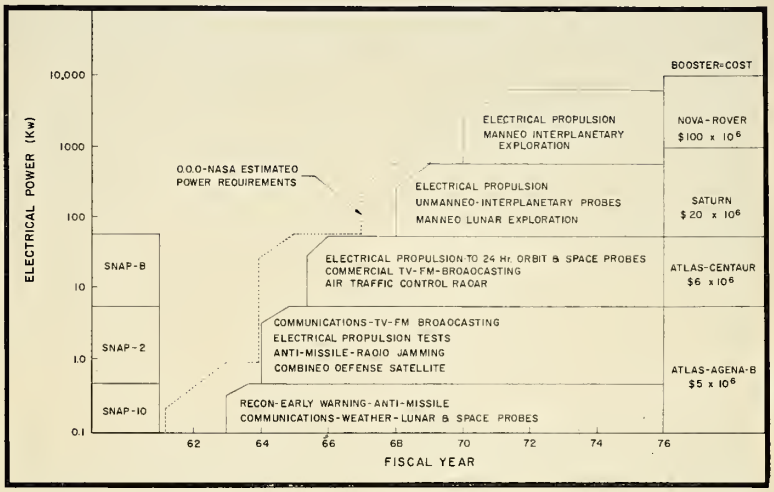
SNAP 2, 8 and 10 are the three nuclear reactor space electric power units that the AEC is currently developing for the National Aeronautics and Space Administration and the Air Force.

The SNAP 2 system is designed to generate 3 kilowatts of useful electrical power continuously for one year. A prototype of the reactor for the system, called the SNAP Experimental Reactor (SER), was built by Atomics International Div., North American Aviation, and put into full-power operation in November, 1959.

SER has already passed a 1000-hour continuous shakedown test at 50 kilowatts thermal power. Between November, 1959 and June, 1960, the system generated more than 147,000 kilowatt-hours of thermal energy.

• **No moving parts**—The SNAP 8 and 10 programs are peel-offs from the SNAP 2 program. The three systems use similar nuclear reactors, employ the same advanced materials and are operated in the 1200° to 1400°F temperature range. They differ in power output and design details.

The SNAP 8 system is a larger version of the SNAP 2. Each uses a turbogenerator to convert heat energy to electrical energy. However, the SNAP 8 unit will be generating 30 electrical kilowatts, which can be boosted to 60 kilowatts by adding a second turbogenerator to the system. Thus, SNAP 8 will be yielding 10 to 20 times as much power as SNAP 2.



TIMETABLE AND USE of three nuclear auxiliary power systems for spacecraft.

Recent advances in developing thermoelectric semiconductors have made the process of converting nuclear-generated heat into electrical energy economic in the relatively low-power region, below one kilowatt.

In the prototype SNAP 3 generator built by The Martin Company and revealed by President Eisenhower last year, the efficiency of this 5-watt radioisotope-powered device was reported to be 5 to 6%. Martin avers that "in the next year or so this efficiency can be doubled."

The merits of such a static source of power, which is now available for field use, led AEC to starting the SNAP 10 program. The unit under development, which uses a reactor as the heat source, is expected to yield 300 electrical watts for an unshielded system weight of 355 lbs., a little more than a pound a watt.

• **SNAP uses**—If SNAP 8's 60-kilowatt system were coupled to an electrical propulsion unit, the combination could send the *Atlas*-boosted *Centaur* spacecraft (9000 pounds) from a 200-mile orbit to a 22,000-mile (24-hour) orbit. This is the finding that NASA recently reported to the Joint Committee on Atomic Energy.

Because of the low thrust and acceleration the unit would be developing—4.5 x 10^{-5}g—the trip would take about two months. This contrasts badly with the speedy 5.4 hours a chemically propelled spacecraft would take.

Yet, if the time factor is not all-governing and if the spacecraft in each instance is unmanned, then for the same delivered payload the craft with the SNAP 8 would be far smaller and less expensive than the chemically powered craft.

The SNAP 8 would also be a continuing power source, available for such things as orbit corrections, communications work and scientific instruments.

Testifying before the Joint Committee, Atomics International's deputy chief of Compact Reactor Division, J. R. Wetch, anticipated the following developments on the basis of SNAP

developments during the 1960 decade:

–Earth satellites providing reliable, low-cost, all-weather, intercontinental telephone systems.

–All-weather, global FM and TV broadcasting coverage.

–Precise air-traffic control and navigational aid from near-earth satellites.

–Satellite global weather surveying and land surveying, leading to improved forecasting and more accurate maps.

• **Sun-seeking cells**—Electrical power in a spacecraft can come from any of three basic energy sources: chemical, solar or nuclear. Though the chemical systems are generally more familiar and therefore simpler than the other two, the life of a chemical system is severely limited. After about a week, the system is drained of energy.

Solar cells if shielded from radiation damage—as might occur in Van Allen belt—have a fairly long life expectancy, measured in years. The devices are highly useful for the small power requirements of a few watts to several hundred watts.

The cells fail when they lose the sun, perhaps when the spacecraft is entering the earth's shadow. This problem is somewhat overcome by the cells' feeding energy into storage batteries during the sunlit periods. Nevertheless, for high-power outputs the solar cell system becomes expensive, heavy, large and difficult to integrate into a spacecraft.

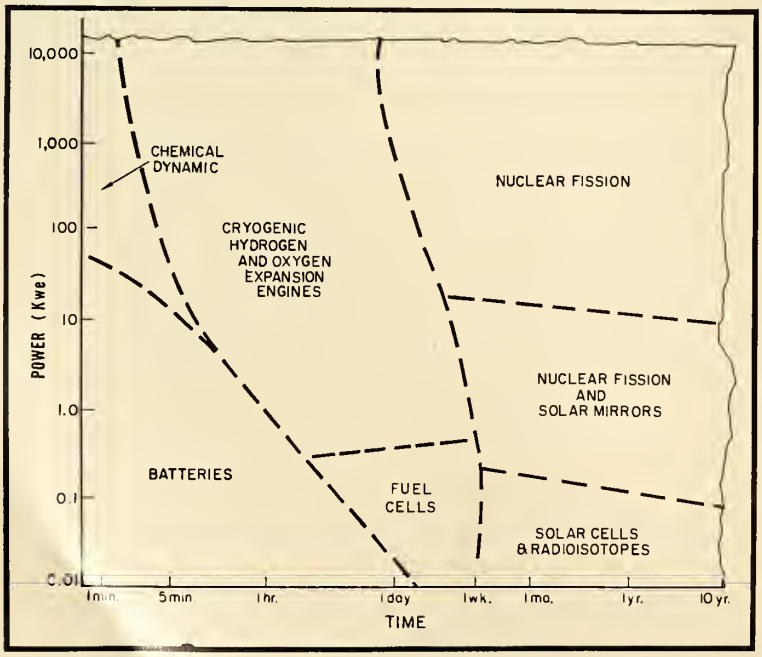
From a cost and weight viewpoint, the solar mirror ranks high as a source of electrical energy. A large parabolic reflector is folded into a spacecraft, and then unfolded at altitude. The reflector focuses the solar energy on a boiler, whose working liquid is a low boiling-point metal. The liquid, operating under a Rankine cycle, transfers its energy to a turbine coupled to an electric generator.

For deriving powers greater than 10 to 30 kilowatts, the solar mirror package becomes unwieldly for any spacecraft now contemplated. The system also suffers from having to be continuously oriented toward the sun. Some experts have even questioned the feasibility of the solar-mirror concept because of the perhaps deleterious effect of micrometeorites impinging on the reflecting optical surfaces.

• **A nuclear diode**—Three sources of nuclear energy can be considered: radioisotope, fission process and fusion process. There are no reports that fusion will be used for getting space electrical power.

For generating space power in the kilowatt and higher regimes, particularly for long time periods, nuclear fission reactors appear to be the best current way. Note that the energy content of fission nuclear-power systems is 1000 kw-hr/lb.

The nuclear power system for spacecraft embraces three major sub-systems: a nuclear heat source, a power conversion system, and a heat dump system. The heat source can be either a radioisotope or a reactor.



USEFUL REGIMES of energy sources which can generate electrical power in space.

The radioisotope energy system, dependent as it is upon the natural decay rate of its fuel, is limited in electrical energy output to about one kilowatt. On the other hand, the reactor system has no such limitation.

Three power conversion systems are being studied: turbo-electric, thermoelectric and thermionic.

The thermionic system offers the biggest potential for high power and light weight (5 lbs./kw). Its future is nearer than many experts have believed. Earlier this month, the General Atomic Div., General Dynamics, announced development of a cesium cell thermionic converter that produced 90 watts of electric power directly from the heat of nuclear fission.

The theory of operation is the same as that of the diode. The cathode is heated until electrons boil off and are picked up by the anode. In this way, an emf is generated between the two surfaces. A drawback is that the cathode must operate at very high temperatures, greater than 1500°F.

• **High temperature, low weight**—For any of the power conversion systems to work, there must be a temperature gradient—and thus a heat sink. This leads to a radiator system which in space can dispose of its energy only through thermal radiation.

Since a thermal radiator acts best when its temperature is high, then for a respectable Carnot cycle efficiency the heat source temperature must be even higher. Also, to get rid of the heat even at high temperatures, an appropriately large radiator system must be used.

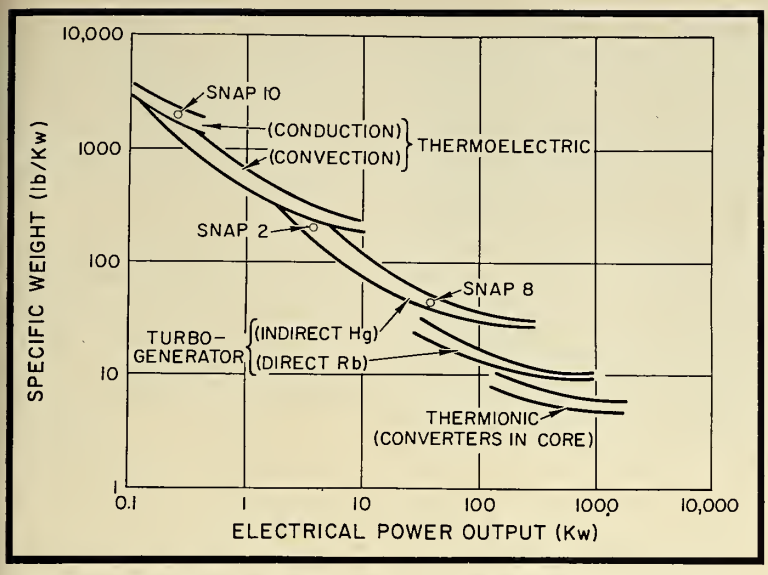
These factors and other design considerations combine to form the following observations, which were indicated at last week's International Astronautical Congress in Stockholm by Lt. Col. Anderson and Atomics International's Wetch and H. M. Dieckamp:

–To reach the lightest system weight for a space power nuclear unit, it should operate at the highest source temperature materials will allow.

–The most power per pound of system weight will come from space nuclear powerplants operating in the 300-3000-kilowatt electrical size range.

• **Elements of SNAP 2**—The SNAP 2 system has all the functional items of a conventional Rankine cycle. The energy from a heat source, a nuclear reactor, brings a working fluid (mercury) to superheat in a boiler. The gas gives up its energy by expanding in a turbine, which drives an alternator. The mercury is then cooled and condensed in a radiator and pumped back into the boiler for another cycle.

The nuclear reactor used here, which is being developed by Atomics International, produces heat energy by



SPECIFIC WEIGHTS of the systems used to turn nuclear energy into electrical.

the fissioning of U-235. A sodium-potassium eutectic liquid metal (NaK) picks up some of this energy by being pumped into the reactor's core, proceeding along the interstitial passages between the fuel elements, and then flowing out again.

At a flow rate of 61.3 lb./min, the liquid metal absorbs 50 kilowatts of thermal power. In the process, the fluid's temperature is raised from 1000° to 1200°F.

Heat exchange occurs in the boiler-superheater, where the NaK converts the mercury working fluid into a gas. The superheater is a concentric tube, counterflow, once-through boiler. NaK flows in the annulus and mercury through the central tube. The mercury is next expanded through a two-stage impulse turbine.

The turbine drives an alternator which is a permanent magnet machine with a sealed stator. The alternator delivers up to 3.5 kilowatts at 110 volts and 2000 cps.

After exiting from the turbine, the mercury vapor passes to a combination radiator-condenser which forms part of the outer skin of the spacecraft. The mercury condenses at 600°F and 6 psia within a number of small diameter parallel tubes.

These tubes are attached to an aluminum skin which dumps the heat of condensation into space. The area necessary to radiate 40 kilowatts is about 100 sq. ft. The condensate is returned to the boiler by a boiler feed pump.

• **One moving part**—All rotating components in the power conversion system are mounted on a common shaft which is called the Combined Rotating Unit (CRU). This is the only moving part in the SNAP 2 system. It is being developed by Thompson Ramo Wooldridge, Inc., under subcontract to

Atomics International.

Rotating at 40,000 rpm, the shaft rides on mercury dynamic bearings. Principal components on the shaft are:

(1) The permanent magnet induction NaK pump, whose operation is similar to that of a conventional electromagnetic pump except that the moving magnetic field is put in by a rotating magnet.

(2) The mercury turbine.

(3) The alternator, a permanent magnet machine with a sealed stator.

(4) The mercury pump, a conventional but miniature centrifugal device that supplies pressurized mercury to the boiler and to the shaft bearings.

The entire rotating unit is enclosed in a hermetically sealed housing, thereby preventing loss of the mercury working fluid during the system's life.

• **Elements of SNAP 8**—The SNAP 8 system will use a reactor quite similar to SNAP 2's but with thinner and many more fuel elements. This change is necessary in order to get more heat power, higher heat transfer to the intermediate fluid, and at the same time keep system weight and size low.

Other changes will be dictated by the power upgrading: The flow rates of both the intermediate and working fluids will be increased tenfold in order to bring more thermal energy to the turbine. A 1% increase in Carnot efficiency will be squeezed out of the system by upping the coolant's working temperature to 1350°F. This efficiency increase would be greater if the coolant's temperature entering the reactor did not also rise.

Aerojet-General is developing SNAP 8's power conversion system for NASA. It is still too early for the system's specifications to be firm. However, this much is known: Operating temperatures and pressures higher than SNAP 2's will be used. The system will retain the Combined Rotating Unit devised for the SNAP 2 unit.

One difference is that the NaK pump will be separately motor-driven. This change is needed to produce efficiently the higher pressures required by the tenfold increase in coolant circulation.

If the reactor drives two power conversion units, SNAP 8's electrical output doubles to 60 kilowatts.

• **Elements of SNAP 10**—The SNAP 10 concept uses as its heat source a reactor derived from SNAP 2. Conductively coupled to the reactor is a combined thermoelectric converter-radiator.

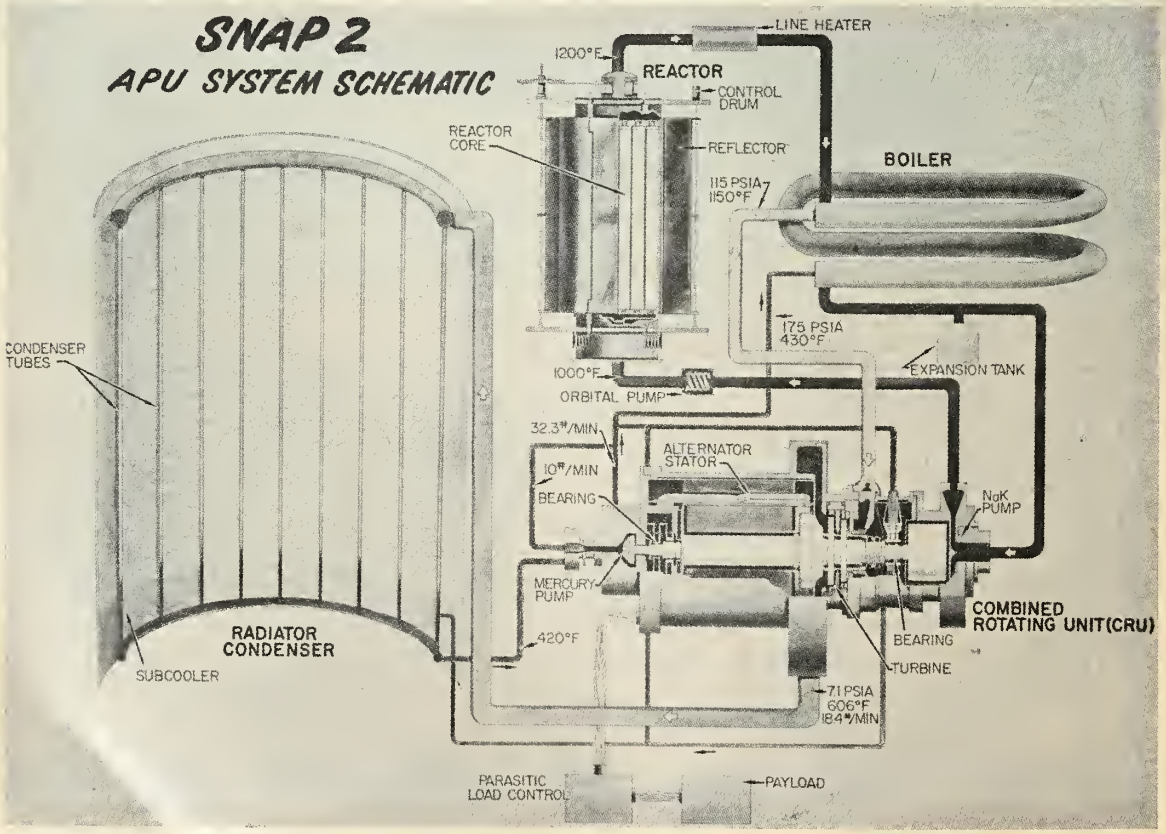
The thermoelectric converter comprises 30 10-watt modules. Each thermocouple hot junction is kept at temperature by contact with the external surface of the reactor's reflector. Each thermocouple cold junction is connected to a finned radiator.

Sufficient heat is rejected by the radiator to maintain the required temperature gradient between junctions.

The overall conversion efficiency of space systems using today's thermoelectric conversion materials is low, from two to four percent. Still, where only low power outputs are needed, the attractiveness of static operation brilliantly offsets such poor efficiencies.

For high-power outputs, the cost in efficiency would not be paid.

These nuclear auxiliary power units will soon be with us, if rate of progress is any measure. It was less than five years from the start of the SNAP pro-



SCHEMATIC POINTS UP fact that SNAP 2 nuclear auxiliary power unit (APU) operates as a Rankine cycle system.

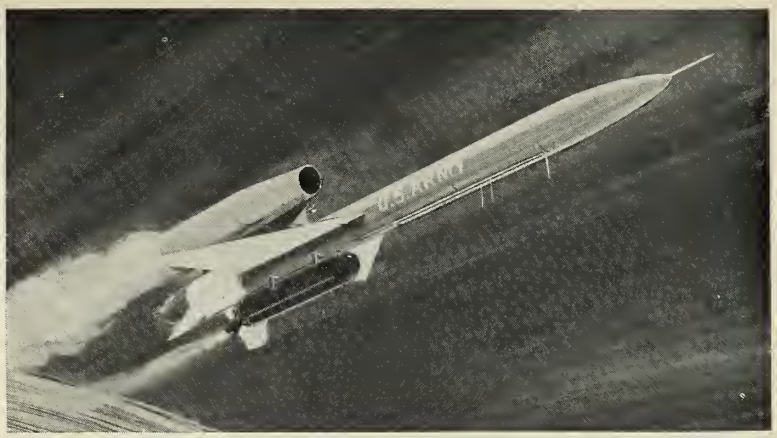
gram until the first compact reactor began operating. In another five years, by 1965, we are being promised SNAP 10, 2 and 8. It would be a pessimistic spacecraft engineer, indeed, who discounted the prospects of nuclear-derived electrical power for use in advanced satellites and probes.

SNAP 2 SYSTEM

Net elec. output pwr.	3 kwe
Reactor thermal pwr.	50 kwt
Elec. freq.	2000 cps
Voltage	110 volts
Radiator area	110 ft^2
Auxiliary Power Unit wt.	600 lbs.
Lifetime objective	1 year
Availability	1964
Cycle conditions	
Reactor outlet temp.	1200°F
Reactor inlet temp.	1000°F
Hg superheat temp.	1150°F
Hg boiling pres.	110 psia
Hg boiling temp.	924°F
Hg turbine exhaust temp.	600°F
Hg turbine exhaust pres.	6.8 psia
Radiation temp. (fin centerline)	580°F
NaK-78 flow rate	61.3 lbs./min
Hg flow rate	17.4 lbs./min
Reactor heat loss	5 kwt
Parasitic load	0.300 kwe
Control power req.	0.100 kwe
Rankine cycle eff.	0.22
Subcooling	200°F
Preheat pwr. (component ineff.)	2.00 kw
Boiler and pipe losses	2.00 kw
Overall system eff.	6%

SNAP 8 SYSTEM

Power	
Pwr. elec. net to payload	35 kw
Reactor thermal pwr.	300 kw
Radiator heat dissipation	255 kw
Heat losses	10 kw
Heat Transfer Areas	
Reactor core	25.8 $ft.^2$
Radiator surface	360 $ft.^2$
Lifetime objective	1 year
Availability	1965
Temperatures	
Maximum reactor fuel	1420°F
Average reactor fuel	1290°F
Average fuel surface	1270°F
Coolant inlet	1150°F
Coolant outlet	1350°F
Turbine-Alternator	
Turbine speed	20,000 rpm
Frequency	1000 cps, 3Φ
Voltage	43.6/75.6 volts
Reactor	
Critical mass	5.2 kg
Core dia. (core vessel ID)	9.2 in.
Core length (active)	11 in.
Radial reflector thick., Be	2.5 in.
Axial reflector thick.	1.5 in. BeO
No. control elements	4
No. safety elements	2
Peak flux	3×10^{12} nv
Temp. coeff.	-4×10^{-5}
Power coeff.	−0.2¢/kw
Reactivity/control drum	3%
Reactivity/safety element	4.2%
No. fuel rods	163
Fuel rod dia. (cladding OD)	⅝ in.



ARTIST'S DRAWING shows *Redhead-Roadrunner* **in action at high level.**

New Target Missile Shown

The shape of North American Aviation's new high- or low-level supersonic Army target missile—the *Redhead-Roadrunner*—was shown publicly for the first time late last month at the company's Columbus Division.

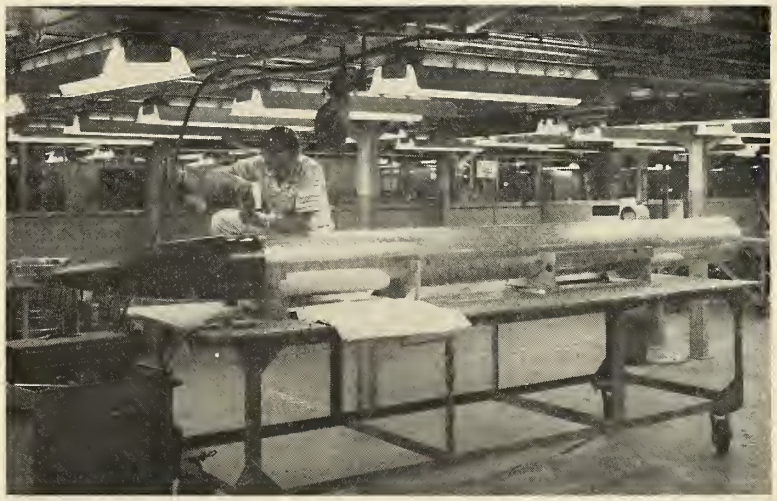
A full-scale mock-up of the missile's slender fuselage, minus the rear section and tail radome, had been assembled for antenna and radar selectivity testing. The rear sections were not needed for this program.

The $3,940,581 Army contract to North American, awarded on June 24, calls for fabrication and flight testing of the new missile system.

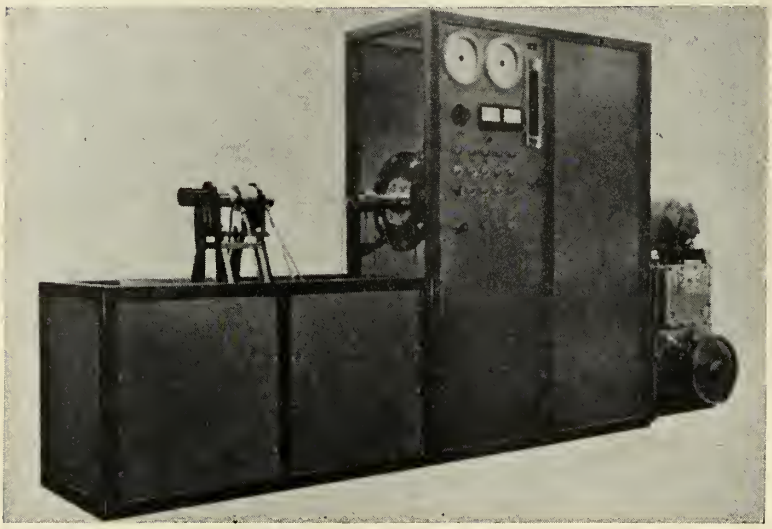
NAA has awarded Marquardt a subcontract for the drone's ramjet propulsion and associated fuel controls. It will be ground-launched by a disposable, solid-propellant booster rocket, presumably to be produced by NAA's solid propulsion operation at McGregor, Tex.

The 19-ft.-long, 1-ft.-diameter missile is designed to fly from subsonic speed through Mach 2, and to climb to more than 50,000 ft. on controlled target missions.

A stubby, six-ft. delta wing can be field-attached to the bird for added maneuverability on high-level supersonic flights; it is not needed for low-level missions. The missile, controlled by a pair of small, rear-mounted stabilizers, will be recoverable by parachute.



FULL-SCALE MOCKUP of new high- or low-level supersonic target missile being built for Army by North American Aviation's Columbus Division will be used for antenna pattern and radar reflectivity tests. Leadman George Miller is shown putting finishing touches on the missile.



MHD Continuous Flow Facility

A continuous flow of ionized gas with a velocity of 4500 meters/sec. at 10,000°K and an average conductivity of 1 mho/cm is provided in a magneto-hydrodynamic flow facility from MHD Research Inc.

In operation, a flow of gas is provided by a gas-stabilized electric arc capable of reaching a stagnation temperature of over 10,000°K. The hot gas proceeds through a mixing chamber into a supersonic nozzle and is expelled in an expanded condition as a low-pressure supersonic flow.

At the exit of this nozzle, the gas enters a constant-diameter channel contained within a watercooled transparent tube. While travelling within this tube the gas is available for experimental use. After leaving the tube it enters the heat exchanger where it is cooled and subsequently exhausted through the vacuum pump.

A control panel provides convenient grouping of all controls and indicators for the power, gas, coolant, vacuum, and accessory equipment. This panel is located adjacent to the operating area so that all controls and instrumentation are within continuous control and observation of the experimenter.

Circle No. 225 on Subscriber Service Card.

Electronic Accessories

An electronic chassis handle, a self-aligning shock locking block for electronic equipment cabinet chassis and two new full ball-bearing slides for electronic equipment packaging are available from Jonathan Manufacturing Co.

The two ball-bearing slides, type 150-QPD—quick disconnecting and pivoting; and type QD—quick disconnecting, both feature rapid disconnection of the chassis portion of the slide, positive lock in the extended position, extreme thinness and exceptional weight-handling ability. Both types of ball-bearing slide mechanisms are part of the "Thinline" (0.50 in. width max.) series.

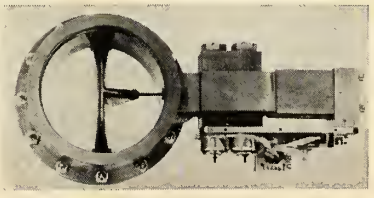
The "Shock-Block" is a pair of self-aligning keyed blocks, used to lock electronic equipment chassis securely in place to prevent magnification of shock and vibration by transmission from cabinet to chassis.

Circle No. 226 on Subscriber Service Card.

Shearable Disc Valves

A hermetically sealed shearable disc valve is available in a range of sizes from B. H. Hadley, Inc.

The Hadley shearable disc valve (patent pending) has a non-aging metallic disc that provides zero leakage indefinitely, in the pre-sheared condition. Actuation is rapid either by pneumatic, hydraulic or pressure cartridge (squib) action. In the open position, there is full flow with minimum pressure drop. The sheared disc is completely retained, and no fragments are released into the fluid stream. Upon reclosure of the valve, after shearing, leakage is exceptionally low.



Circle No. 227 on Subscriber Service Card.

Nylon to Metal Welding

A two-step process has been developed by Plastic Associates for chemically "welding" nylon to metal.

The chemical welding method makes use of an epoxy paste that chemically unites with the metal surface on which it is applied. A separate solvent solution applied to the nylon part softens the surface and allows the nylon molecules to blend with the epoxy bonding agent as the latter hardens. The entire operation is performed at room temperature, achieving an extremely tough, shock-resistant union between the nylon and the metal within a few hours.

Circle No. 228 on Subscriber Service Card.

Helium Regulator

A helium regulator developed by the Dyna-Matics Corp. makes it possible to control missile fuel tank pressures regardless of environmental conditions. The two-stage design of this new unit minimizes the effect of large flow ranges and variations in both temperature and inlet pressures.

Orthodox balancing devices, which usually require running seals, have been omitted in this new design, thus eliminating friction and leakage potentials. Static seals, poppet seals and synthetic material diaphragms are used, making the unit suitable for almost all gasses and fluids. Each of the seals is Teflon-seated to assure zero leakage at no-flow, lockup conditions.

Circle No. 229 on Subscriber Service Card.

High Load Cap Screw

Perfection of a cap screw utilizing the Aer-O-Torq recess for high torque strength has been announced by Aer-O-Line Manufacturing & Supply Co. Because the recess requires less metal for a given necessary driving torque, the new cap screws actually have less metal in the heads and the heads are up to 35% shorter.

In addition to their scientifically designed distribution of metal in the

heads of the new cap screws, the manufacturer states that the screws torque higher, distribute the load over wider bearing surfaces, provide more wrenching power and clamping force without indenting the fastened material.

Circle No. 230 on Subscriber Service Card.

Magnetostrictive Cleaner

An ultrasonic cleaning system developed by the Harris Transducer Corp., a subsidiary of General Instruments, is on the market. The system features a proprietary magnetostrictive transducer.

Because of its exclusive strip construction, the system withstands tank operating temperatures up to 300°F, gives continuous long life operation and is simple to maintain.

Circle No. 231 on Subscriber Service Card.

Fractional HP Gear Motor

A fractional horsepower gear motor which uses a unique rectangular field stack, coupled with toroidal field windings, to obtain unusually high efficiency in a small package size has been developed by The Bendix Corp's Bendix-Pacific Division.

Approximately 1 3/8 x 2¼ x 4 3/8 in. and weighing 1¼ lbs., the unit is capable of delivering output power approaching 1/10 hp continuous duty to ¼ hp intermittent duty. Special heat dissipating techniques have been used to result in a low temperature rise during operation.

Circle No. 232 on Subscriber Service Card.

Hi-Temp Vacuum Oven

A laboratory oven, developed by Labline, Inc. has a temperature range from room to 260°C (500°F) within an 11 in. diameter x 12 in. deep stainless steel vacuum chamber.

The radiant heating elements are completely enclosed with no exposed-wire heaters to take up space. Heats from room to 500°F in one hour with temperature uniformity maintained within ±1°F at all settings.

Circle No. 233 on Subscriber Service Card.

Decade Counter Module

A Miniature Decade Counter Module—the DC-111—featuring a minimum of component parts, is available from Burroughs Corp.'s Electronic Tube Division. The unit combines the BEAM-X switch, Type BX-1000, with transistors in a circuit capable of resolving pulses at 110 KC. Electrical outputs are provided to operate remote NIXIE indicator tubes and printers, and to perform other circuit functions.

Circle No. 234 on Subscriber Service Card.

Primary Pressure Standard

A Primary Pressure Standard that provides a digital display of a pressure input or provides a positive indication when a desired pressure level is reached has been announced by Wallace O. Leonard, Inc.

This standard, which utilizes the Klose Technique, takes full advantage of the basic accuracy of a simple air dead weight tester while providing direct readout of pressure over a prescribed range.

The Leonard Standard has a typical accuracy of 1/50% of reading over the range of .4 to 250 psi including all errors due to friction, hysteresis, temperature, repeatability, resolution, linearity and readibility.

Circle No. 235 on Subscriber Service Card.

new literature

VIBRATION STANDARDS—American Standard Methods for the Calibration of Shock and Vibration Pickups, S2.2-1959, has been approved and published by the American Standards Association. It describes most calibration methods in use today, and covers specifically the three basic types—constant acceleration, sinusoidal motion and transient motion.

Circle No. 200 on Subscriber Service Card.

CONTROL SUBSYSTEMS—A four-page, two-color brochure, has been issued by the Instrument Division, American Electronics, Inc. The brochure outlines the capabilities of the Instrument Division in the development and packaging of electronic, electromechanical and mechanical subsystems for control systems in missile, space and aircraft vehicles.

Circle No. 201 on Subscriber Service Card.

PROPULSION FACILITIES—A 20 page two-color brochure is available introducing the purpose, personnel and plant of Amcel Propulsion Inc., a subsidiary established in 1959 by Celanese Corporation of America to create a comprehensive missiles program. Amcel's goal in research and development, as well as actual production is directed toward the development of highest quality liquid and solid fuels and fuel components for propellants and explosives.

Circle No. 202 on Subscriber Service Card.

MAGNET ALLOY—A new illustrated brochure describing properties and applications of an improved copper-nickel-iron ductile permanent magnet alloy of the generic "Cunife" type has been published by Hoskins Mfg. Co. Properties listed include high coercive force and energy product values.

Circle No. 203 on Subscriber Service Card.

SERVOMOTOR DATA—A four-page folder showing advance performance data for model 8 SM 461 Size 8 Servomotor has just been released by the Helipot Division of Beckman Instruments, Inc. The illustrated data sheet lists features of the new motor, shows dimensional outline drawings and torque-speed curves for the unit. In addition, construction features are delineated, and all principle electrical and mechanical characteristics are called out.

Circle No. 204 on Subscriber Service Card.

GOLD CLAD MOLY STAMPINGS—Bulletin Z-104, a one page technical data sheet, describing gold clad molybdenum stampings for silicon semiconductor devices, is now available from Accurate Specialties Co., Inc. The Bulletin completely describes the clad metal stamping consisting of gold clad molybdenum and its use as a base tab material in silicon semiconductors.

Circle No. 205 on Subscriber Service Card.

NUCLEAR EMULSION RECOVERY VEHICLE—A four-page brochure, designated PIB-47, describing the vehicle that will be used to obtain a profile picture of the Van Allen Radiation Belt is available from General Electric's Missile and Space Vehicle Department. It also contains general information on this project of the National Aeronautics and Space Administration. Illustrations include schematics of the vehicle's planned flight trajectory and its emulsion package, and photographs of the vehicle.

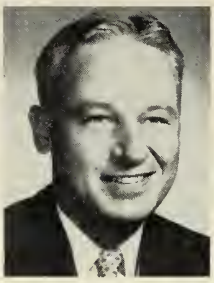
Circle No. 206 on Subscriber Service Card.

MISSILE PRODUCTS—A description of the many products Minnesota Mining and Manufacturing Co. produces for the missile and rocket industry is contained in a new booklet. The brochure is well illustrated, and describes in brief 79 products listed under such headings as adhesives and sealers, ceramics and refractories, coated abrasives, data duplicating and handling systems and elastomers-plastics-resins.

Circle No. 207 on Subscriber Service Card.

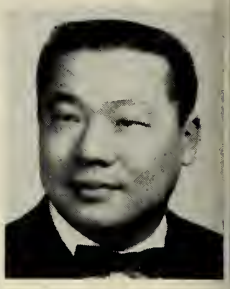
names in the news


STARY


BAUMANN


WALSH


BELL


CHAO

M. L. Stary: Named manager of Aerojet-General Corp.'s newly established Spacecraft Division at its Azusa, Calif. plant. The new division is an outgrowth of the Systems Division, established in 1958.

Robert J. Baumann: Appointed manager of the Systems Division, Beckman Instruments, Inc. Prior to his assignment as acting systems manager last December, he was a member of the corporate marketing staff.

J. Paul Walsh: Former director of the Space and Weapons Systems Division at C-E-I-R, Inc., promoted to director of the firm's Arlington Research Center. Prior to joining the firm he was deputy director of Project *Vanguard* and later joined IBM as systems manager of the Federal Systems Division.

William S. Bell: Joins the Washington, D.C. district sales offce of Radiation Inc. as assistant manager. Was formerly project engineer for the Vitro Corp. where he worked on the *Terrier, Talos* and *Polaris* missiles weapon systems.

Dr. W. Wai Chao: Former chief of research appointed director of Research and Development at Vickers Inc., division of Sperry Rand Corp. Prior to joining Vickers he directed engineering efforts on the second stage liquid rocket engine for the *Discoverer* program and altitude control rocket systems for Project *Mercury* and the *X-15* airplane.

Lt. Cmdr. Linwood L. Leftwich (USN-ret.): Former vice president of Feedback Controls, Inc. joins Cubic Corporation as senior staff engineer. He previously served as project officer, Guided Missile Test Instrumentation Systems, Bureau of Aeronautics where he was responsible for the development of the *AN/FPS-16* missile and satellite tracking radar.

George C. Connor: Elected senior vice president-marketing at Sylvania Electric Products Inc., succeeding **Barton K. Wickstrum** now executive vice president of General Time Corp.

Edwin Suuronen: Former engineer-business systems elected manager-Business Operations Evaluations and Developments in the Operations Research and Synthesis section of General Electric's Light Military Electronics Dept.

Carl J. Wenzinger: Joins the Goddard Space Flight Center, NASA, as assistant project manager of the Orbiting Astronomical Observatory. Was formerly with Cook Electric Co.'s Research Laboratories.

Dr. Joseph R. Feldmeir: Appointed associate director of Philco Corp.'s Research Division, with responsibility in long range planning of technical programs. Was associated with the Bettis Atomic Power Division of Westinghouse Electric Corp. where he directed research in the nuclear energy field.

Mervyn E. Shopenn and **Albert M. Waifer, Jr.:** Formerly with Tempo Instruments and International Standard Engineering, respectively, join Adler Electronics Military Products Division as communication systems project engineers.

Albert F. Lopez: Named head of the newly-created Intelligence Systems Dept. of HRB-Singer, Inc., Prior to joining the firm in 1952 he was an instructor in the electrical engineering department at the Pennsylvania State University.

John W. Corcoran: Appointed chief scientist in the Research and Development Division of Beckman & Whitley.

Thomas A. Pakenham: Former assistant vice-president for mechanical systems with General Bronze Corp., named vice president of manufacturing at Portland Industries Corp.

John Lyon Collyer: Chairman of the executive committee of B.F. Goodrich's board of directors appointed a director of Grumman Aircraft Engineering Corp., succeeding the late **Leon A. Swirbul.**

Dr. Jack S. Anderson: Former Royal Industries, Inc.'s vice president engineering for all subsidiaries joins Crane Co.'s newly-formed Systems and Controls Group as director of engineering. The group includes Hydro-Aire Co., Chapman Valve and Swartwout Companies.

Edward V. Z. Lane: Named director of market research and development for American Super-Temperature Wires, Inc., a subsidiary of Haveg Industries, Inc.

Alfred J. Koorey: Appointed senior engineer for Aerojet-General Corp.'s *Minuteman* activities at Cape Canaveral with responsibility for receiving and inspecting the propulsion systems and determining their flight readiness.

Jack R. Grieve: Former supervisor of non-destructive testing at Alco Products Inc., joins the Metallurgical Dept. of Superior Tube Co. where he will be in charge of non-destructive testing development for metal tubing.

A. A. Shamah: Joins the Sparton Electronics Division of Sparton Corp. as manager-marketing for its newly established eastern region. Formerly served as assistant sales manager with Servo Corporation.

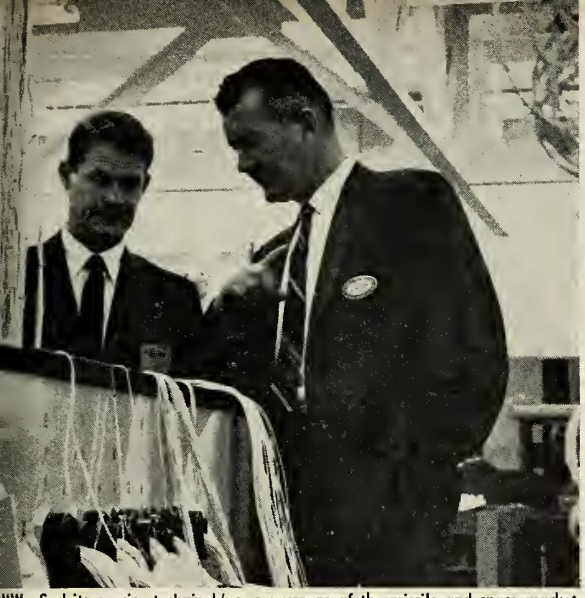
Thomas G. Lanphier, Jr.: Appointed to the newly created office of vice president-planning for Fairbanks Whitney Corp. Was formerly vice president and assistant to the president of General Dynamics Corp.'s Convair Division.

Dr. Sidney L. Simon: Former manager of Systems Engineering appointed chief engineer, Missile Electronics and Controls Divs., RCA Defense Electronic Products, succeeding **Dr. Robert C. Seamans, Jr.,** now with NASA.

Harlan Tripp: Formerly manager of the ceramic bonding department of Gulton Industries, Inc., named director of research and engineering for Vitramon, Inc.

Jack Warner: Formerly with Space Technology Laboratories, Inc., and Gilfillan Brothers, Inc., joins the technical staff of Space Electronics Corp.

Henry F. Colvin III: Former chief of Flight Data Research and Development for Kollsman Instrument Corp., joins The Liquidometer Corp. as its manager of Advanced Development, Military Products.



"We find its concise technical/news coverage of the missile and space market very valuable in keeping up with develapments in this rapidly growing field." R. P. Della-Vedowa, Manager, Quality Assurance and Test Services, Satellite Systems, Lockheed Missiles and Space Division.

"I consider M/R an excellent source of information an new advances and applications in the missile/space field. It keeps us abreast of the state of the art in missiles and rockets for a better understanding of advanced requirements in antennas." A. F. Gaetano, Head, Electromagnetic Systems.

WHY DO SO MANY KEY PEOPLE AT LOCKHEED AIRCRAFT READ MISSILES AND ROCKETS?

1,080 PAID SUBSCRIPTIONS! In 1959 Lockheed Aircraft Corp. ranked *third* among all military prime contractors. Its missile and space achievements include the Polaris ballistic missile and the Agena satellite, plus many others. Therefore, it is natural for 1,080 of M/R's paid subscribers to be concentrated in Lockheed. And since many of these MISSILES AND ROCKETS subscriptions have high pass-along readership, there are many times that number of M/R readers.

Some of the many reasons why M/R commands intense readership at Lockheed are given in the picture story. They were obtained as a result of a recent visit to the company by M/R Executive Editor Clarke Newlon (insert).

These comments and those of other key readers in other missile/space companies clearly show what M/R has known all along . . . that the missile/space industry is a separate, distinct market with requirements which change almost daily . . . a market that can best be interpreted by undiluted, *weekly* technical/news coverage. It is this kind of coverage which makes M/R the leader . . . explains its deep, penetrating readership and acceptance.

"The weekly issues of M/R give us fresh coverage . . . not month-old news. Editorially it is well written, sprightly and lively." J. L. Shaenhair, Assistant Manager, Polaris Missile Section.

"M/R gives us what we want to read in the missile field. There is no waste of time wading through material foreign to our interests." L. H. Amaya, Manager of Lockheed's Digital Computer Operations.

contracts

ARMY

$19,500,000—**Hughes Aircraft Co.**, Fullerton, for "missile monitor" air defense command posts.

$11,341,510—**Western Electric Co. Inc.**, New York City, for *Nike-Zeus* production equipment. (Two contracts.)

$4,681,765—**Hughes Aircraft Co., Ground Systems Group**, Fulierton, Calif., for radar netting for AN/MSQ-18.

$3,000,000—**Beech Aircraft Corp.**, Wichita, Kan., for production of additional Beechcraft Model 1025 missile targets.

$2,750,000—**North American Aviation, Inc.'s Autonetics Division**, Downey, Calif., for continuing product engineering on the FADAC computer.

$2,593,038—**Motorola, Inc.**, Scottsdale, Ariz., for radar data transmitting and receiving sets and anciliary items.

$2,082,440—**Western Electric Co.**, New York City, for *Nike* spare parts and components. (Eleven contracts.)

$1,645,731—**Trailmobile, Inc.**, Springfield, Mo., for *Lacrosse* missile containers.

$1,300,000—**Sperry Gyroscope Co.**, for developing a super power klystron tube to be used with *Nike-Zeus*.

$1,000,000—**Sylvania Electric Products, Inc.**, for two ground antenna systems for Project *Advent*, a communications satellite network.

$996,774—**Northrop Corp., Radioplane Div.**, for target missile flight services.

$800,000—**Beckman Instruments, Inc., Systems Division**, Anaheim, Calif., for two analog-to-digital data acquisition and computing systems for use in conjunction with the *Pershing*. Subcontract from **Aetron Division of Aerojet-General Corp.**

$689,762—**Southern, Waldrip & Harvick Co.**, Long Beach, Calif., for SAC missile facilities, Mather AFB.

$545,000—**Chrysler Corp.**, Detroit, for engineering services on the *Redstone* missile.

$527,849—**The Martin Co.**, Orlando, for replenishment spare parts for the *Lacrosse*. (Eight contracts.)

$480,000—**Dunn Engineering Associates, Inc.**, Cambridge, for the construction of radome boresight and dish antenna test equipment for the *Hawk* system.

$276,117—**Douglas Aircraft Co.**, Santa Monica, for *Nike* spare parts and components. (Two contracts.)

$168,972—**Duval Engineering & Construction Co.**, Jacksonville, Fla., for 40x50 ft. unloading wharf, a structural steel unloading bridge 40 ft. long by 5 ft. wide and related work for *Saturn*.

$65,000—**Aero Systems Engineering Division, Aero Services Inc.**, Philadelphia, for a space age imagery interpretation and evaluation.

$48,434—**Firestone Tire & Rubber Co.**, Los Angeles, for repair parts for the *Corporal* missile system.

$28,382—**Astro-Electronic Products**, Princeton, N.J., for Project *Tiros* and anciliary items.

AIR FORCE

The Gabriel Co.'s Bohanan Manufacturing Co., Compton, Calif., for engineering, development, qualification and production of the hydraulic vernier actuators for the *Atlas*. Subcontract from **General Dynamics Corp.'s Convair Astronautics Division.** Amount not disclosed.

Hexcel Products Inc., Berkeley, Calif., for investigation of sandwich structures made with foam-filled honeycomb core. Amount not disclosed.

$5,500,000—**Douglas Aircraft Co.**, Los Angeles, for additional production of MB-1 *Genie* rockets.

$5,279,088—**Radio Corp. of America**, Camden, N.J., for on-site operation and off-site maintenance and logistics supply support for the Alaskan long lines system.

$417,347—**Melpar, Inc.'s Simulation and Training Systems Laboratory of the Data Processing and Support Systems Dept.**, Falls Church, Va., for design and fabrication of three trainers for the *Bullpup*, GAM 83 A/B.

$300,000—**Babcock Relays, Inc.**, Costa Mesa, Calif., for miniature BR-7 relays suitable for check-out and launch systems for the *Atlas*. Subcontract from **Consolidated Electronics Industries Corp.'s Technical Electronics Co. division.**

$235,000—**The Garrett Corp.'s AiResearch Manufacturing Co.**, Los Angeles, for development of a test space capsule.

$208,000—**American Bosch Arma Corp.'s Arma Division**, Hempstead, N.Y., for research and development of ultraprecise accelerometers for inertial guidance of future vehicles on extended space flights.

$200,000—**Melpar Inc.'s Ground Data Handling Equipment Laboratory**, Falls Church, Va., for developing ground support equipment for the FINDER system.

$47,670—**Federal Electric Corp.**, Paramus, N.J., for architect and engineer services necessary to prepare final instruction plans and specifications for FY-61 military construction program for DEW line.

NAVY

Thompson Ramo Wooldridge Inc.'s Dage Television Division, Michigan City, Ind., for manufacturing a television camera and transmitter that will fit into the nose cone of the 4½-in.-diameter *ARCAS* rocket. Amount not disclosed.

$3,200,000—**Sylvania Electric Products, Inc.**, Waltham, Mass., for electronic data processing equipment to direct movement of the radio telescope at the Naval Research Station, Sugar Grove, W.Va.

$2,900,000—**Minneapolis-Honeywell Regulator Co.**, for production of *ASROC* missiles.

$2,500,000—**Raytheon Co.**, Waltham, Mass., for work on electronic systems for *Polaris* (two contracts).

$666,000—**Dorne & Margolin, Inc.**, Westbury, L.I., N.Y., for manufacture of electronic countermeasure direction finders.

$1,010,000—**Fairchild Engine & Airplane Corp., Astronics Division** Wyandanch, L.I., N.Y., for manufacture of electronic countermeasure trainers.

$600,910—**The Fischer & Porter Co.**, Warminster, Pa., for a data acquisition and computation facility at the Naval Air Turbine Test Station in W. Trenton, N.J.

$58,974—**Philco Corp.**, Philadelphia, for services and materials to redesign the antenna system and burst delay computer of target detecting devices.

$36,992—**McCormich Selph Associates, Inc.**, Hollister, Calif., for services and material and facilities to design study of "Hummingbird" rocket motor.

NASA

$900,000—**Chance Vought Range Systems Div.**, Dallas, for operation of the Project *Mercury* space capsule tracking station in the Hawaiian Islands.

$482,670—**Electronic Associates, Inc.**, Long Branch, N.J., for analog computing system.

$200,000—**Plasmadyne Corp.**, Santa Ana, Calif., for development of an electric arc jet rocket engine of a minimum thrust level of .01 lb.

MISCELLANEOUS

Pittsburgh-Des Moines Steel Co., Pittsburgh, for constructing the space simulator vacuum chamber for General Electric Co.'s Missile and Space Vehicle Div. at Valley Forge, Pa.

$3,200,000—**Waltham Laboratories, Sylvania Electric Products Inc.**, N.Y. City, for electronic data processing equipment.

$900,000—**Telecomputing Corp.**, Los Angeles, for tracking antennas.

reviews

DIGITAL COMPUTER AND CONTROL ENGINEERING, Robert Steven Ledley, McGraw-Hill Book Co., New York, 835 pp., $14.50.

Here is a computer book that can be easily understood and its material immediately applied by any engineer who has passed a course in integral calculus.

This observation is not meant to downgrade the book but rather is intended to point up the extreme readability of the text and its practicality. A voluminous amount of material is covered, and in great detail. Therefore, those readers who want only a general knowledge of digital computers and control engineering would do well to buy a thinner text.

The author uses typical engineering pedagogy by explaining first in terms of specifics and then in generalities. In fact, in one extensive example the author designs a computer from start to finish.

In keeping with the elementary character of the book—intended for senior undergraduate or first-year graduate students and non-specialists in computer engineering—it covers a broad spectrum of subjects.

Overall design of degital systems is covered in Parts 1 and 2; the logical design of digital circuitry, Parts 3 and 4; and the design of digital circuits, Part 5.

The book is recommended for readers who are concerned with design or operation or use of digital computers.

EFFECT OF HEAT TREATMENT ON THE METALLURGICAL AND MECHANICAL PROPERTIES OF 7AL-3MO TITANIUM ALLOY, P. L. Hendricks, WADC. Order PB 161363 from Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C. 109 pp., $2.50.

The metallurgical and mechanical properties of a titanium alloy were determined on a production size heat.

Determination of tensile properties, heat treatment, stress rupture, creep stability, compressive yield, modulus, and impact strength were investigated.

ADVANCES IN SPACE SCIENCE, Volume 2, edited by Frederick Ordway, III, Academic Press, New York, 450 pp., $13.

This second volume of technical monographs on space flight subjects serves as the first to give the reader palatable surveys of timely topics. Seven contributors, all experts in their respective fields, have succeeded in making their presentations readable by emphasizing physical concepts and clearing the reader's path of much mathematical underbrush.

The subjects covered and their authors are as follows: Experimental physics using space vehicles, Charles P. Sonnett; Tracking artificial satellites and space vehicles, Karl G. Henize; Materials in space, Frederick L. Bagby; Plasma propulsion devices, Morton Camac; Electrostatic propulsion systems for space vehicles, Ernst Stuhlinger and Robert N. Seitz; and Attitude control of satellites and space vehicles, Robert E. Roberson.

—when and where—

AUGUST

Cryogenic Engineering Conference, University of Colorado and NBS, Boulder, Colo., Aug. 23-25.

Western Electronics Show and Convention, Los Angeles Memorial Sports Arena, Los Angeles, Aug. 23-26.

AGARD, Combustion and Propulsion Panel, "Advanced Propulsion Techniques," Pasadena, Aug. 24-26.

International Union of Pure and Applied Physics, International Conference on High Energy Nuclear Physics, University of Rochester, Rochester, N.Y., Aug. 25-Sept. 3.

German Rocket Society, Annual Meeting, Hanover, Aug. 26-28.

University of Connecticut, Eleventh Annual Basic Statistical Quality Control Institute, Storrs, Aug. 28-Sept. 9.

Combustion Institute, Eighth International Symposium on Combustion, CalTech, Pasadena, Calif., Aug. 29-Sept. 2.

10th International Congress of Applied Mechanics, Congress Bldg., Stresa, Italy, Aug. 31-Sept. 7.

SEPTEMBER

Society of Instrument Technology and British Interplanetary Society, One-day Joint Symposium on Rocket and Satellite Instrumentation, Manson House, London, Sept. 1.

13th General Assembly of the International Scientific Radio Union, University College, London, Sept. 5-15.

International Summer Course on Solid State Physics, sponsored by: Italian Physical Society, in cooperation with NATO, CURATOM and National Committee on Nuclear Research, Italian Nuclear Energy Center, Varese, Italy, Sept. 5-24.

Society of British Aircraft Constructors Show and Flying Display, Farnborough, England, Sept. 6-11.

Electronics Industries Association, Second Conference on Value Engineering, Disneyland Hotel, Anaheim, Calif., Sept. 7-8.

Joint Automatic Control Conference, Massachusetts Institute of Technology, Cambridge, Sept. 7-9.

AGARD, Seminar jointly sponsored by AGARD and the Instituto Lombardo di Scienze e Lettere, "Propulsion for Astronautics," Varenna, Italy, Sept. 8-12.

American Chemical Society, 138 National Meeting, New York City, Sept. 11-16.

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editorial . . .

The Missile Is Here to Stay

A U.S. BUSINESS publication recently inquired in a headline "Is Ballistic Missile Era Waning?" It went on to say:

"Missiles now in the works will have enough range, accuracy and payload to hit within less than a mile of any place on earth with a force of millions of pounds of TNT. What more, it's asked, could any ballistic missile do?"

We could point out any number of things (like reconnaissance and return) that missiles can do; we would prefer to point out that such a statement could only be made by someone with a lack of appreciation of the way the world moves.

Looking back, we can see that it would have been pleasant in some ways if man had stopped with the long bow and the sailing ship. Other progress might have died there too, but at least we wouldn't have the threat of instantaneous destruction hanging over our heads at all times.

The fact is that man does not cease to progress, for better or for worse. We do not know what the third and fourth and fifth generation of ballistic missiles will be like—but we are quite sure they will come.

They will come because man will devise ways to counter his fellow man's first- and second-generation missiles, making the third, fourth and fifth generations necessary. They will come because man in his terrible ingenuity will find ways to make weapons more deadly and more accurate and more difficult to counter.

It has always been thus and it probably always will be—until man reaches the millenium of disarmament. And even then some world (or cosmic) organization will have to maintain sufficient arms to enforce the peace.

The statement also ignores the fact that we are entering—perhaps being dragged is a better phrase—into the Age of Space.

Again, we don't know what the sixth, seventh and eighth generations of ballistic missiles will be. We don't know whether they will be designed to be fired from roving spacecraft, the moon or Venus. We don't know whether they will be part of a defensive force, a retaliatory force or just plain predatory—or even if they will be designed to inflict hurt on other earthly beings—but they will be there.

Finally, the statement ignores the virtual certainty that peaceful and commercial uses will be found for the ballistic missile.

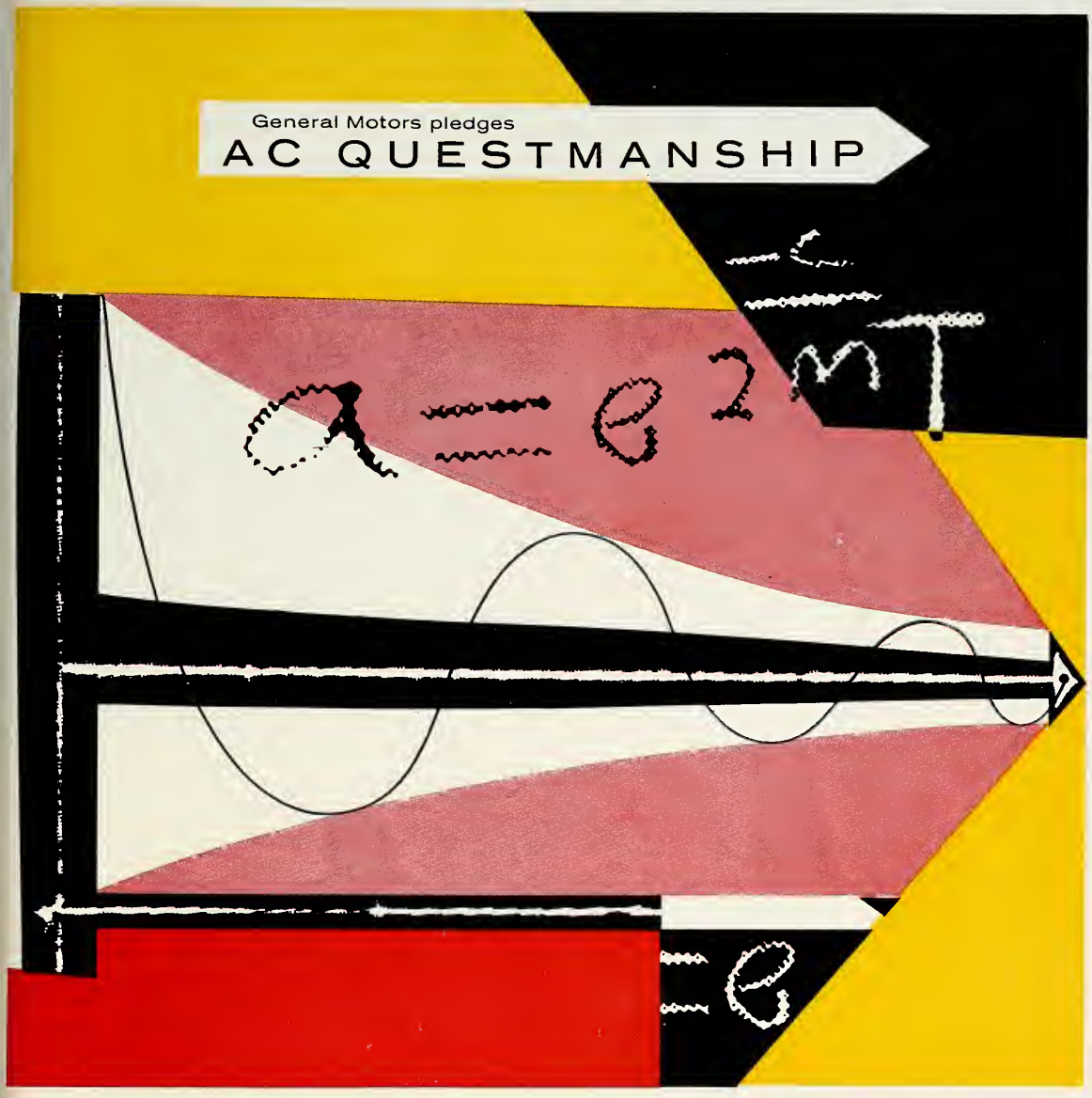
WHETHER you call it a spacecraft or a missile, whether it is manned or unmanned, the ballistic-trajectory vehicle will find everyday uses. It can carry mail. (Its air-breathing predecessors are already doing so.) It can carry cargo. It can carry passengers—although personally we prefer to wait awhile before being one.

Could anyone seriously think that the missiles which put *Echo* and *Discoverer XIII* into orbit are the last words in propulsion?

The applications the ballistic missile will find in defense, in exploration, in commerce—on this earth or in the heavens—appear to us to be practically limitless.

And saying that its era is waning seems somewhat equivalent to the well remembered words of those who said "Better get a horse"—or "the airplane will never sink a battleship."

Clarke Newlon



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Safety Valve FOR AN ASTRONAUT

If America's first man-carrying rocket runs into trouble, a unique Donner device will play a vital role in bringing the Astronaut safely back to earth.

Known as a "maximum altitude sensor," the all solid-state system is essentially a fixed purpose miniature analog computer housed in a magnesium case only five inches long. Installed in the capsule, it goes into action if it is necessary to abort the rocket flight before the Astronaut's escape tower is jettisoned.

What It Does

The Donner device, which was developed for McDonnell Aviation with the approval of NASA, provides programmed time delay that operates rescue devices at maximum altitude.

Under abort conditions, the maximum altitude sensor provides output information which will:

1. Energize devices for firing the explosive bolts holding the escape tower onto the top of the capsule. This allows the escape tower to separate.

2. Energize the system which causes the escape tower jettison rocket to fire. With the tower separated, barostats are armed to open parachutes and furnish the Astronaut's capsule a safe descent.

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