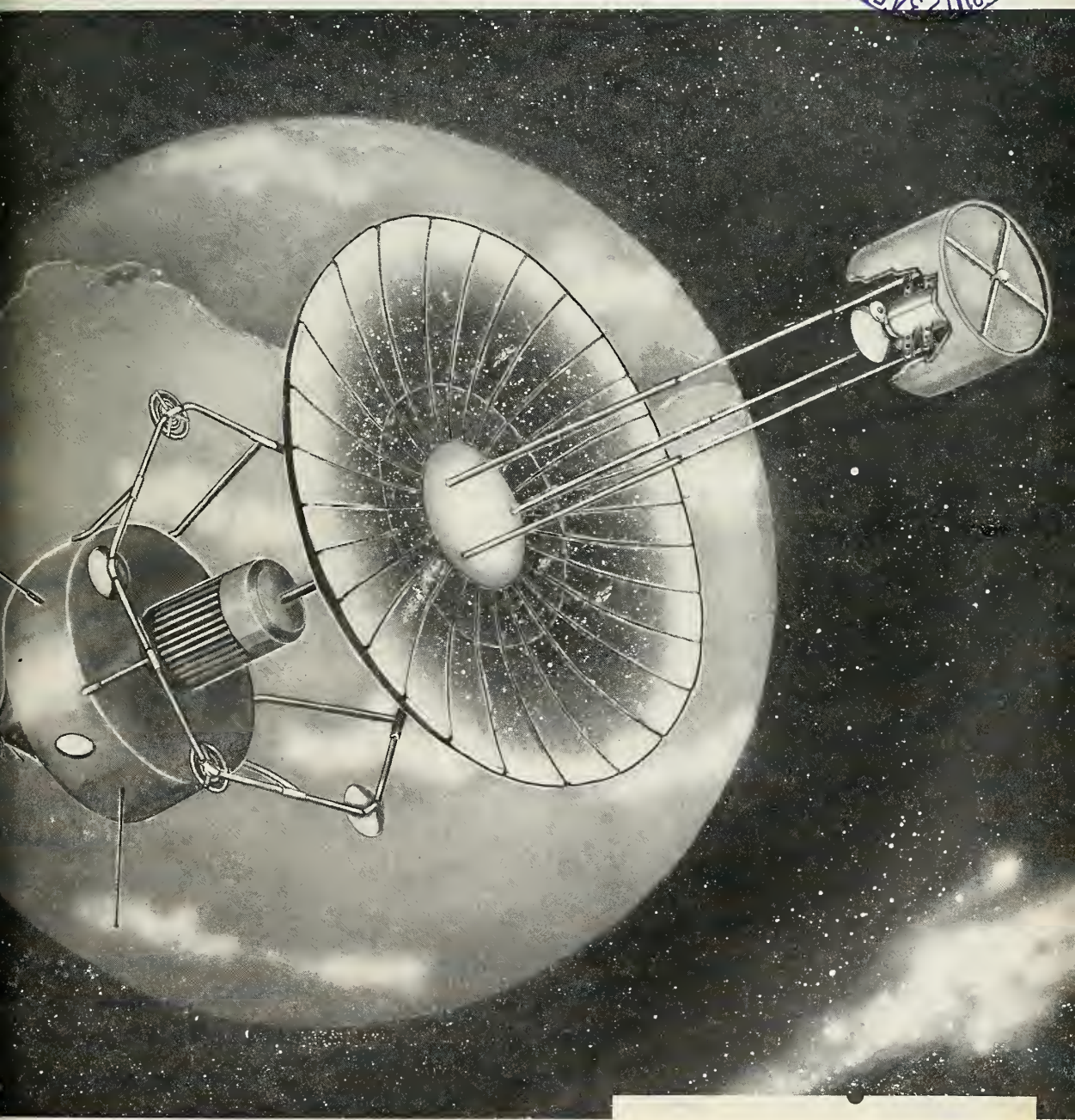
AUGUST 15, 1960

missiles and rockets

THE MISSILE/SPACE WEEKLY



15-kw Solar Mechanical Engine

Is Mercury Headed Toward Disaster? . .
Special Report: Solar Mechanical Power
NERV to Probe Lower Van Allen Belt . . 30

AN AMERICAN AVIATION PUBLICATION

BIG GYRO PERFORMANCE IN...

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*PATENTS APPLIED FOR

NEW—from Daystrom—are these three lines of performance-proved free and vertical gyros that permit you to write tighter gyro specs without sacrificing size and weight... with complete assurance of performance reliability.

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FM10 Miniature, non-floated, two-axis free gyro with synchro pickoffs and torquers on both gimbal axes.

VA10 Miniature, non-floated, air erected vertical gyro with potentiometer pickoffs on both axes. Verticality—operating or non operating—without separate caging mechanism insures (1) greater inherent reliability (2) simplicity of operation (3) lower cost (4) smaller size and (5) less weight.

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The BELL Model III B Accelerometer* is an electrically constrained, linear, inverted pendulum type with a D-C forcer and spring suspension. This precision instrument has been thoroughly tested and evaluated by government laboratories.

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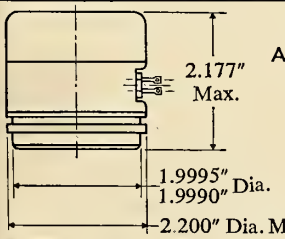

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SAC FLEXES A NEW MUSCLE

Beneath the wings of its B-52 intercontinental bombers SAC now packs a formidable new weapon—the GAM-77 HOUND DOG air-to-surface missile. The first operational unit to carry the supersonic HOUND DOG is the 4135th Strategic Wing, based at Eglin Air Force Base, Florida.

This B-52/GAM-77 union greatly extends the useful life and striking power of SAC's long range bombers and adds to the command's operational flexibility.

The HOUND DOG's versatile capabilities have been demonstrated in a number of free flights over the Atlantic Missile Range and the Eglin Gulf Test Range. In addition, it has withstood many extreme environmental tests including a 10,800 mile flight over the North Pole ending with a successful firing over AMR.

In just 30 months, the HOUND DOG air-to-surface missile progressed from the drawing board to its first flights with SAC crews. Combined with the B-52 bomber, the HOUND DOG gives SAC a powerful new deterrent for preserving world peace.

THE MISSILE DIVISION OF **NORTH AMERICAN AVIATION, INC.**

Downey, California

THE MISSILE / SPACE WEEKLY

missiles and rockets

August 15, 1960 Volume 7, No. 7

Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington 5, D.C.

Wayne W. Parrish
President

Leonard A. Eiserer
Exec. Vice President and General Manager

Fred S. Hunter
Vice Pres. and Editorial Director

Printed at the Telegraph Press, Harrisburg, Pa. Second Class postage paid at Washington, D.C. and at additional mailing offices.

Subscription rates: U.S., Canada and Postal Union Nations—1 year, $5.00; 2 years, $8.00; 3 years, $10.00. Foreign—1 year, $10.00; 2 years, $18.00; 3 years, $26.00. Single Copy rate—$.50. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., M/R, 1001 Vermont Ave., N.W., Washington 5, D.C. Please allow 4 weeks for change to become effective and enclose recent address label if possible.

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Biggest solar mechanical engine being developed is 15-kw system extending from satellite at top right in Sundstrand artist's drawing. See report on p. 24.

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Engineering notes from the **SM/I REPORTER**

BY STANLEY M. INGERSOLL, *Capabilities Engineer*

Report No. 9
TMC 601 LOX Tanking Computer System

Typical of our extensive participation in missile fuel management is our TMC 601 the main building block in the process of obtaining a completely automatic propellant loading system for missiles. It accurately measures, controls and indicates the level of liquid oxygen in missile tanks. The computer monitors the weight of the propellant aboard a missile, compares it with the desired weight, allows for tank diameter and propellant density correction and controls the flow of propellant to the missile. A two mode control system facilitates the rapid and accurate loading of the missile. The first mode permits extremely high pumping rates until 98% capacity is reached. The second mode then controls a precise proportioning valve which fills the tank to within 0.1% accuracy and provides for continuous topping. Entirely encased in a protective cover to withstand the extreme conditions generated by a firing, the TMC 601 measures the static head of the liquid in a tank by means of a highly refined pressure transducer.

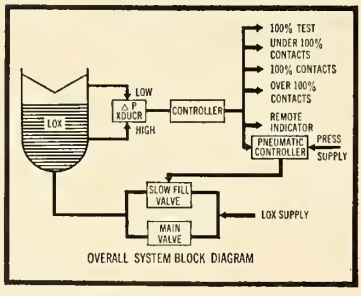
The TMC 601 does not require calibration after installation and can be easily and rapidly modified for new missile or tank configurations.

Typical Performance Specifications

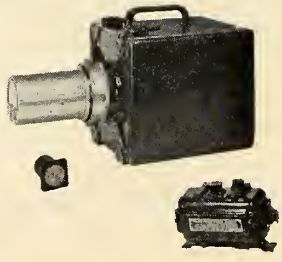
Input Power ..... 115 volts, 400 cycles, 15 watts
28 volts D.C., 2 Amps
115 volts, 60 cycles, 100 watts (heater)
25 PSIG—clean, dry air-pneumatic supply to TR 2013

Pressure ..... 1) Differential Pressure (liquid head) 10 PSIG (Range from 0.5 PSIG to 22 PSIG available)
2) Line Pressure 50 PSIG
3) Proof Pressure 90 PSIG

Accuracy ..... ±0.25% under severe environmental conditions
±0.1% under normal field temperature conditions of 50°F to 125°F



OVERALL SYSTEM BLOCK DIAGRAM



For more information and complete operating specifications, write or wire SM/I today. Address your inquiry to Stanley M. Ingersoll, Capabilities Engineer.

SM/I **SERVOMECHANISMS/INC.**
Los Angeles Division
12500 Aviation Boulevard
Hawthorne, California

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—when and where—

ASME-AIChE Heat Transfer Conferenc and Exhibit, Statler-Hilton Hotel, Bu falo, N.Y., Aug. 15-17.

XIth International Astronautical Congres IAF, Stockholm, Aug. 15-20.

Cryogenic Engineering Conference, Un versity of Colorado and National Bu reau of Standards, Boulder, Au 23-25.

Western Electronics Show and Conventio Los Angeles Memorial Sports Aren Aug. 23-26.

International Union of Pure and Applie Physics, International Conference o High Energy Nuclear Physics, Un versity of Rochester, Rochester, N.Y Aug. 25-Sept. 3.

The German Rocket Society, Annu Meeting, Hanover, Aug. 26-28.

University of Connecticut, Eleventh An nual Basic Statistical Quality Contro Institute, Storrs, Aug. 28-Sept. 9.

The Combustion Institute, 8th Interna tional Symposium on Combustio California Institute of Technology Pasadena, Aug. 29-Sept. 2.

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

SEPTEMBER

Society of Instrument Technology an British Interplanetary Society, One day joint symposium on Rocket an Satellite Instrumentation, Manso House, London, Sept. 1.

13th General Assembly of the Interna tional Scientific Radio Union, Univer sity College, London, Sept. 5-15.

Society of British Aircraft Constructor Show and Flying Display, Farnbor ough, England, Sept. 6-11.

Electronics Industries Association, Secon Conference on Value Engineering, Dis neyland Hotel, Anaheim, Calif., Sept 7-8.

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

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

Second International Congress in the Aeronautical Sciences, Zurich, Switz erland, Sept. 12-16.

IIIrd International Congress on Surface Activity, Cologne, Germany, Sept. 12 17.

Electronics Industries Association, Fall Conference, Sheraton-French Lick Hotel, French Lick, Ind., Sept. 13-16.

Engineering Management Conference, sponsored by American Institute of Electrical Engineers and American Society of Mechanical Engineers, Mor rison Hotel, Chicago, Sept. 14-16.

Armed Forces Chemical Association, 15th Annual Meeting, Sheraton Park Hotel, Washington, D.C., Sept. 15-16.

Institute of Radio Engineers, National Symposium Space Electronics & Telemetry, Shoreham Hotel, Washing ton, D.C., Sept. 19-22.

ASME-AIEE Power Conference, Belle vue-Stratford Hotel, Philadelphia, Sept. 21-23.

Anti-Euphoria

To the Editor:

Many thanks for writing your July 25 editorial ("Khrushchev—How Long, Oh Lord?"). What you say has been said before, but it needs to be said over and over again until we move off this euphoric dead center and begin to address ourselves to our national responsibilities.

You are to be congratulated for this editorial, particularly because of its timing. This is the "special week" (week of July 25) in which anyone who feels that we have made mistakes over the past eight years is being regarded as an enemy of the people and almost a traitor. It took real editorial guts to come out as strongly and clearly as you did at this time.

T. F. Walkowicz
New York City

Truth about Polaris (cont.)

To the Editor:

Recently, I sent you a letter (M/R, Aug. 1, p. 49) giving some information in rebuttal to a syndicated newspaper column of July 21. As you may recall, the columnist in question had some rather derogatory remarks about the *Polaris* missile program, and I attempted to point out some areas in which he was wrong.

After rereading my letter, and in the light of some additional information received from the West Coast, I would like to clarify a point or two.

I believe that I may have done Rear Adm. W. F. Raborn, *Polaris* Program Director, somewhat of a disservice in implying that the program had been advanced three years because of technical breakthroughs accomplished by Aerojet-General. Actually, the rapid progress of the *Polaris* program is due directly to Admiral Raborn's relentless drive and insistence on going to the interim 1200-nautical mile configuration. The Admiral's leadership and his energy have been the driving force in bringing the *Polaris* program to its present, early-successful status. The three technical breakthroughs by Aerojet, i.e., the propellant, the thrust termination and the thrust vector control successes, undoubtedly helped the Admiral in making the decision to advance the program.

In my letter, I referred to the A1a model. I have been informed that this model, although discussed, has never been designed or contracted. I was misled by the columnist's reference to the A1a model. In my letter I said the A1a would be capable of a 1500-nautical mile range. However, it is the A2 model that is designed for this extended range. The A2 model has been test-fired and will soon be committed to flight test at Cape Canaveral. The A2a model is in a feasibility study but has not reached the flight test stage.

As the purpose of my (original) letter was to give you facts in opposition to the fictions in the newspaper column, I thought this letter was in order. Although the first letter is essentially correct, I felt that you should have the most accurate information possible.

Walter G. Winslow
Public Affairs
Aerojet-General Corp.
Washington, D.C.

Pickup

To The Editor:

Everybody here was pleased with the Kiwi story in the July 18 issue. It picked up our spirits to see Los Alamos given the kind of credit we feel our scientists deserve.

Edward A. Connolly
Public Relations Office
Los Alamos Scientific Laboratory
Los Alamos, N.M.

CAPABILITIES FOR DEFENSE

Electrifying

If satellites and space vehicles stop "working", they are simply high cost space debris. Reliable power supplies are mandatory.

To meet this requirement, extensive Westinghouse research and development efforts are being applied to perfect reliable, compact, lightweight systems that will convert solar and nuclear energy into unfailing, long-life sources of electric power.

Westinghouse is investigating many new electrical power systems, but primary efforts are directed in six important areas. These are: 1. Thermoelectric; 2. Thermionic; 3. High-efficiency solar cells; 4. Photoemission; 5. Magnetohydrodynamic; 6. Rotating magnetic generation. This work is being performed by the Aircraft Equipment Department, Lima, Ohio, supported by the Central Research Laboratories and the Astronuclear Laboratories, Pittsburgh.

Space power requirements—in not too many years—will be measured not in watts or kilowatts, but in megawatts. This need presents formidable technical problems.

We are making progress toward their solution.

Westinghouse

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Moon, age 14 days
Spiral nebula in Ursa Major
Spiral nebula in Virgo
Space
Spiral nebula in Andromeda
Spiral nebulae in Canes Venatici
Filamentary nebula in Cygnus
Globular star cluster in Canes Venatici
Saturn and ring system
Head of Halley's Comet
Nebula in Sagittarius

...AND BRISTOL SIDDELEY SUPPLY THE POWER

Bristol Siddeley Engines Limited produce the Thor ramjet. Two Thors power the missile in the Bristol/Ferranti Bloodhound guided weapon system. This system forms the most effective defence against air attack at very low, up to very high altitudes. And the great flexibility and development potential of the ramjet ensure that Bloodhound will be able to intercept any attacking aircraft for many years to come.

The ramjet is the simplest air-breathing engine that has ever been devised and the Thor is virtually a stainless steel tube which can be lifted by two men. A thrust of over 20,000 lb at Mach 3 can be expected from a typical ramjet of the Thor's size.

At speeds of Mach 2.5 and upwards, the ramjet has a lower specific fuel consumption and a lighter weight than any other prime mover, and the higher the speed the greater its efficiency. In fact, it is the most efficient powerplant for long-range flight at high supersonic speeds within the earth's atmosphere.

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The Bristol Siddeley Marine Proteus powers the "Brave" class 96-ft. Royal Navy patrol boats.

The Bristol Siddeley Olympus high-thrust turbojet powers the Avro Vulcan V-bomber.

The Bristol Siddeley Maybach diesel engines power Britain's fastest express train—the British Railways "Bristolian".

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The Countdown

WASHINGTON

Another Discoverer Up

The Air Force on August 10 successfully launched the 1700-lb. *Discoverer XIII* satellite into polar orbit from Vandenberg AFB.

Mercury Mystery

NASA experts are still perplexed over the July 29 blow-up of an *Atlas-Mercury* 65 seconds after launch. Telemetry shows that 1½ sec. before it exploded, the *Atlas* booster made an unexplained spurt in velocity.

Thor Production Continued

The Air Force will buy 21 more Douglas *Thor* rockets for satellite and space probe use—11 for the AF's *Discoverer* program and 10 for NASA. All will have the new 165,000-lb.-thrust Rocketdyne engine and will be modified to accommodate the Lockheed-Bell *Agena B* second stage. Of the 21 ordered, 14 will be new rockets and seven previously ordered as tactical missiles will be modified for the space task.

Panama Protector

Decision by the Army to send two *Hawk* battalions to Panama is considered by some people in the Pentagon to be a defensive move against Red-tinged Cuba. COUNTDOWN hears that some U.S. strategists fear Castro might try to strike at the Panama Canal—possibly with unmarked Soviet-made jets.

The Future Lies Ahead

Some documents now being circulated through the NATO headquarters in the Pentagon bear a new classification stamp: COSMIC TOP SECRET.

Slippage, Slippage, Slippage

AEC has postponed until late September the test of its *Kiwi A3* reactor for the *Rover* nuclear rocket, previously scheduled for mid-August. Information gained in the *Kiwi A-Prime* test last month necessitated minor design changes. Also hampered by delay was NASA's Project *Echo* balloon-in-space launching—from Aug. 9 to Aug. 10—and then to Aug. 12.

INDUSTRY

Doubts on Dyna-Soar

The Air Force is putting all its *Dyna-Soar* re-entry eggs in the heat-ablation basket, reports Dr. Walter Dornberger of Bell, who favors two other parallel approaches —refractories and internal cooling.

GSE Sales Pitch

One factor which may push an uprated (1000-mile) *Pershing* into the role of leading contender as a NATO MRBM: an offer to let Europeans manufacture most of the GSE. NATO at present is said to believe it should have an operational MRBM by 1963.

Optical Guidance Perfected

Chicago Aerial has developed SOLO, the first known optical guidance system—with which a missile can follow a target image. Martin will test the system for an advanced version of *Bullpup,* which now uses visual reference and command guidance.

Taped Vibration Trick

Rocketdyne is using tape recordings of the actual vibrations of the *Saturn* H-1 engine to test components. They are played into a shake-table which simulates the engine at full thrust, thus providing a simple method to test for component reliability.

Mahogany Row

Rested up from his defense "crusade," former Convair exec Thomas Lanphier is joining Fairbanks-Whitney Corp. on Sept. 1. He will be VP-planning. About 5% of the business of Fairbanks Morse (one of F-W's divisions) is in the defense field.

Antiradar Still Hot

Navy interest in radar-seeking missiles is far from dead—despite cancellation of the Temco *Corvus.* The Navy is still working on *Cobra,* an antiradar, air-launched missile. It has an antiradar missile study going called ARM. (So does the Air Force.) And there are some *Corvus* test birds available for possible R&D work.

RP-76 Motor in Production

Qualification tests are completed on a new solid motor, developed by Standard Oil of Indiana, for the Army's RP-76 drone, produced by Radioplane. Amoco Chemicals Corp., Seymour, Ind., Standard's production subsidiary, has begun motor production.

INTERNATIONAL

British Polaris Sub?

Britain is toying with the idea of building a nuclear-powered submarine capable of carrying eight *Polaris* missiles. If approved, the money would come from other sectors of the defense budget (such as the recent one-third cutback in the Handley Page Victor Mark II bomber).

New British Ramjet

Bristol Siddeley Engines Ltd. has developed a new ramjet for missiles. The BSRJ. 824 engine is 99.6 in. long and 18 in. in diameter and burns kerosene.

French Mount Satellite Program

The new French budget earmarks about $20 million for some special space projects. They include instrumented satellites, which may be launched within the next 12-18 months.

Argentina Space Colloquium

A big effort is under way to attract top rocket men and organizations to a space colloquium at Buenos Aires in November. Hosts for the event are the National Commission for Space Research and the Argentina Interplanetary Association.

Mercury capsule would burn like meteor on re-entry if not correctly positioned. Pilot gets one try.

'latter Vanguard' . . .

Is Mercur

by James Baar

NASA's MERCURY manned-satellite program appears to be plummeting the United States toward a new humiliating disaster in the East-West space race.

This is the stark conclusion that looms in the minds of a growing number of eminent rocket scientists and engineers as the *Mercury* program continues to slip backward.

These experts, many of whom are already calling *Mercury* "a latter-day *Vanguard*," contend:

–The program today is more than one year behind its original schedule and is expected to slip to two. Therefore, it no longer offers any realistic hope of beating Russia in launching the first man into orbit around the earth —much less serve as an early stepping stone for reaching the moon.

–Despite precautions and improvements, *Mercury* continues to be a technically marginal program that could easily end in flaming tragedy. *Mercury*, at best, is a technical stop-gap justifiable only as an expedient. It is no substitute for what is needed sooner or later—a manueverable spacecraft similar to the Air Force's much hampered *Dyna-Soar*.

–*Mercury* originally had the supposed advantage of being cheap, an attribute that made it particularly attractive to the Administration. However, *Mercury* has proven to be a trip down a dead-end road that U.S. taxpayers are finding themselves paving in gold. Appropriations have reached a quarter-billion to date. They may double.

Dissatisfaction with *Mercury* has grown each time the program has slipped. The latest snag occurred on July 29, when an *Atlas* booster carrying the first production model of the *Mercury* capsule blew up 65 seconds after it was launched.

The program fell behind two more months through lack of a back up.

• **Rumbles on Hill**—Alarm has spread to Capitol Hill. Rep. Overton Brooks' House Space Committee is considering plans for a full-scale investigation of the *Mercury* program. Hearings probably would begin in January.

Meantime, scientists and congressmen are casting worried looks at Russia. The next item on the Soviet space schedule is expected to be a soft landing on the moon or the orbiting of a manned satellite. Oct. 4, the third anniversary of the launching of *Sputnik I*, is considered to be a likely date.

NASA's latest secret schedule calls for launching the first manned *Mercury* capsule into orbit about mid-1961. But even this is considered by many to be optimistic.

Late 1961 or early 1962 is thought to be more realistic. And, if the program continues to slip as all experience indicates it will, these dates also are too early.

It is because of these dates that many experts have come to feel that *Mercury* already has failed in achieving the principal mission for which it was created—beating Russia into space with a manned satellite.

• **Restive astronauts**—Even the seven *Mercury* astronauts are understood to be bridling under the expected odium of coming in second in the two-nation space race. Some of the astronauts are reported to have privately urged NASA to scrap much of the *Mercury* test program and take the much greater risk of attempting an early launching.

Such a plan would run directly counter to NASA's present policy of taking every possible precaution to insure the safety of any man launched into orbit in a *Mercury* capsule.

No one would agree with this policy more than technical critics of the program.

These experts, none of whom can be quoted by name because of their connection with the government in one way or another, express gravest doubts as to chances of the *Mercury* system operating as planned.

As one engineer put it:

"The capsule's retro-rockets must fire at the right time and the right angle for the capsule to re-enter at the right angle. Otherwise the ablative material on the capsule's blunt end will fail to protect the astronaut and both he and the capsule will be cooked. This timing and angle business isn't an easy thing, either. Look at *Discoverer*. The Air Force has been trying to get capsule's back from *Discoverer* for more than a year. No luck. And another thing: The astronaut gets only one chance. If those retrorockets don't eject him from orbit the right way the

Program Headed for Disaster?

'Yes,' say many space experts, continuing slippage in the only U.S. man-in-space program makes it almost certain that Russia will be first to put a man into orbit

first time, he has had it."

Nor is that all.

"We think of *Mercury* as the adventurous approach," one expert said. "If he lands in the water, he then hopes to be picked up by ship. But this isn't like a nose cone. Who knows where the capsule might land. I'd say the chances of drowning are more than fair."

• **Side show?**—Finally, and most important, is the charge that *Mercury* in the end is only a detour and not the main highway into space.

NASA has consistently defended *Mercury* as a program designed to answer the vital question: Can a man perform a useful function in the weightless environment of space.

The only way to answer the question beyond any doubt is to put a man in space. *Mercury* is designed to do just that. But it will do little more—as NASA itself concedes.

The next big step in manned exploration of space beyond the earth is the orbiting of the moon with a manned spacecraft. George M. Low, NASA's chief of manned space flight, said only recently in a paper written for the Senate Space Committee that the craft needed for such a trip would be a vehicle with aerodynamic surfaces like *Dyna-Soar*.

For this reason, many critics contend that *Mercury* is a waste of time and resources. They argue that the *Dyyna-Soar* program will prove anything that *Mercury* can prove and result in a useful spacecraft as well.

A number of NASA's experts privately agree. But they also are aware of the behind-the-scenes story of why NASA began the development of *Mercury* and they have loyally supported the program.

The story of *Mercury* begins with ARPA.

In the first months after Russia launched *Sputnik I*, ARPA initiated a number of studies to determine the best way to put a man in space. One main approach called for putting a capsule into orbit; the other, for a winged spacecraft.

In April, 1958, Dr. Wernher von Braun, then director of Development Operations of the old Army Ballistic Missile Agency, disclosed to Congress a proposal to send a man briefly 150 miles into space with a *Redstone*. The plan was part of a broad Army program that had been submitted for approval.

"We propose to separate the nose section with the man from the rest of the missile prior to re-entry into the atmosphere," Von Braun said. "The man himself will be in a pressurized capsule which is inserted into the nose section. The latter is equipped with controllable airbrakes which retard the fall as it gets back into the atmosphere. I must add, however, that this program has not received official approval yet.

DYNA-SOAR, depicted in this artist's sketch, is a maneuverable spacecraft designed to re-enter under pilot's control.

How Mercury Launch Times Have Slipped*

EVENT	ORIGINAL PLAN	REVISION NO. 1	REVISION NO. 2	PRESENT PLAN
First Redstone downrange with primate	November, 1959	March, 1960	July, 1960	October, 1960
First Redstone downrange with man	March, 1960	May, 1960	August, 1960	December, 1960
First Atlas downrange with operational capsule (instruments only)	January, 1960	March, 1960	May, 1960	September, 1960
First Atlas Boosting primate into orbit	May, 1960	August, 1960	September, 1960	March-April, 1961
First Atlas boosting man into orbit	June, 1960	December, 1960	March, 1961	August, 1961

**All dates are approximate. The schedule for the Mercury program has been kept "fluid" and secret since its inception.*

I do not know why. ARPA knows about it, but has not yet decided on it. There is a question of money involved, I believe."

• **Year from when?**—Asked how long it would take to complete such a program, Von Braun said one year.

"One year from now?" a Congressman asked.

"One year from the word 'go'," Von Braun said.

Dr. Hugh Dryden, deputy NASA Administrator and then director of the old National Advisory Committee for Aeronautics, said subsequently that the Von Braun proposal was like "shooting a young lady from a cannon." He questioned whether the expense would be worthwhile.

But in October, 1958, one year after *Sputnik I*, NASA opened for business and took over from ARPA and AF a study called Project *Mercury*.

Mercury carried Von Braun's plan only one step further. Instead of launching a man along a ballistic trajectory so that he would experience weightlessness for about five minutes the man would be launched into orbit.

At the same time, the Air Force was permitted to proceed with its studies for *Dyna-Soar*. But funding was at a low level and the program's priority was comparatively low.

Just who said what to whom at the meetings that resulted in NASA choosing the *Mercury* approach over *Dyna-Soar* has been obscured over the last few years. However, all the evidence points unquestionably to two reasons why the choice was made: *Mercury* appeared to be quicker and cheaper.

• **Cost comparison**—Experts familiar with the *Dyna-Soar* program have said an all-out *Dyna-Soar* R&D effort could have produced an early maneuverable spacecraft by about 1963 or possibly late 1962. The cost might have approached a billion dollars.

On the other hand, *Mercury* originally was expected to cost only about $200 million and take well under two years to put a man in orbit.

Appropriations for *Mercury* through FY 1961 have already reached $241 million. NASA officials have estimated that another $100 million will be needed. However, congressional sources expect this to be at least doubled.

These figures do not include such costs as the multi-million-dollar expense of Naval warships and planes needed for recovery and AF tracking facilities.

Mercury has slipped almost since its inception and the space programs that NASA keeps telling Congress are to follow have slipped accordingly.

NASA requested a top priority for *Mercury* in Nov., 1958. The program did not get it until May, 1959. This is generally the way matters have gone.

At present, NASA is still holding out a slim hope that a *Redstone* carrying a manned capsule can be launched downrange by the end of this year—more than a year and a half later than Von Braun said he could do the same thing.

However, the chances of NASA even meeting this new deadline are considered very slight. The result will be that the launching of a manned capsule into orbit will slip again.

But all of the nation's hopes have been put on *Mercury*. And there is no back-up if the program fails.

The Missile/Space Week

No Back-down on Polaris

The United States, in a note to the Kremlin, said it would not be deflected by Soviet threats from giving *Polaris* missiles to NATO. The note refuted Soviet charges that NATO *Polaris* negotiations threatened peace and constituted arming of West Germany.

DOD Unfreezes WW II Science Research Files

The Pentagon is ending the deepfreeze of most of the World War II scientific research documents. Among them are files of new missiles, radar, aerial combat and amphibious warfare techniques. The bulk of the 30,000 documents affected will go to the Library of Congress. Business and Defense Services Administration is preparing indexes to the information.

X-15 Hits Speed of 2190 mph

The X-15 rocket plane sped to a new world's record for manned flight in its latest test run, hitting top speed of 2190 mph. Powered by twin XLR-11 engines developing 12,000 lbs. thrust each, the dart-shaped plane reached maximum speed at 66,000 ft. The entire flight lasted only 10 minutes; top speed was reached after four minutes, fifteen seconds.

Atlas Flies 7000 Miles

An *Atlas* ICBM made its second longest trip to date—7000 miles down the Atlantic—while carrying 1000 lbs. of instrumentation in its 12-ft. Mark III nose cone. Although an *Atlas* flew 9000 miles May 20, the Aug. 9 test was designed to demonstrate versatility. The missile reached an altitude of about 1000 miles and covered the distance in 40 minutes. No attempt was made to recover the nose cone.

How to Recruit a Monkey?

Those pioneers of space—the flying chimpanzees—are not hapless draftees as one might suppose. As a matter of fact, they're volunteers. Brig. Gen. Don D. Flickinger, AF Chief of Bioastronautical Research, told the House Space Committee so. How do they indicate their astronautical urges? Friend chimp is trained to sit on a small stool for several days, then he's offered a banana or an apple. If the simian prefers the banana, he's a volunteer—and they almost always do!

3-Stage Minuteman Shot This Year

Third-stage contract will probably be awarded before firing; Boeing to build complete launch complex at Seattle

by Frank G. McGuire

SEATTLE—The Air Force plans to fire a three-stage *Minuteman* down the Atlantic Missile Range before the end of this year, in a drive to push the solid-fueled ICBM toward operational status by mid-1962.

Boeing Aircraft Co. revealed that the shot will be a full-range effort, with all three stages, rather than a limited-range attempt, and might possibly come before final award of a production contract for the third stage. It is likely, however, that the third stage award will be made to either Aerojet-General or Hercules Powder Co. before the AMR launch.

Boeing says that both versions of the third stage—being developed under separate contracts with Aerojet and Hercules—are fully compatible with the rest of the system.

The version being developed by Hercules is understood to be a greater departure from current practice than the Aerojet version.

Boeing also announced plans to construct a complete *Minuteman* launch complex at its Seattle facilities to test the entire weapon system. No launches will be made from the complex, designated the Seattle Test Program (STP).

T. A. Wilson, Boeing *Minuteman* Program Manager, said the complex will check out all elements of the system, including ground support equipment, to guarantee compatibility and integration of subsystems. He pointed out that the STP will compress the development time period of the *Minuteman* and will save considerable money in design and construction of operational launch sites.

The facility will also serve as a "test bed" for developing procedures and manuals required for training of SAC crews. The STP will include an underground silo, launch control center, tracks for the missile car, and a support building.

Construction is expected to begin this month, with completion of the facility scheduled for the end of the year. Tests will begin next year, after installation of equipment.

Wilson said the early *Minuteman* concept of having capability of launching individual stages of the missile to perform shorter range missions is still being worked on. This concept would allow the third stage to be used alone as a tactical weapon, two stages as an IRBM, or the complete weapon as an ICBM.

• **Upping payload**—"We are looking forward to continued improvement of the missile's performance," he said, "and hope to substantially increase the payload capability, although we don't expect it will ever match the payload of *Atlas* or *Titan*."

A three-part program will begin at Vandenberg AFB to transform the *Minuteman* into an operational strategic weapon. Preliminary work is underway at Boeing's Aerospace Division, and at the Air Force's Ballistic Missile Division in Los Angeles.

Several hundred Boeing employees will be assigned to VAFB next year, after construction of facilities there. Boeing presently has about 8000 employees on the program. When Air Force Plant #77 near Hill AFB, Utah, begins full-scale operation. Plant #77 is to be the *Minuteman* Assembly Plant.

The three part program at Vandenberg will include:

1. Conducting systems engineering to demonstrate installation, operation and maintenance procedures. 2. Training Air Force supervisors and instructors who, will train SAC crews. 3. Assisting SAC crews in launches from both silo and mobile facilities.

First of these SAC crews will be based at Malmstrom AFB, near Great Falls, Montana, in mid-1962.

Boeing revealed that the first two of its tethered silo shots for *Minuteman* at Edwards AFB were enough to supply the basic data for the launch method. Additional shots were carried to make refinements in the system, and the final two were from concrete silos, rather than the flexible research and development type.

Of the sixteen original shots planned, the final eight were cancelled, said Boeing, due to the success of the program. Wilson estimated that this cancellation saved the Air Force well over ten million dollars.

Boeing said production rates on the *Minuteman* are not high, but the overall program acceleration has been very rapid. The production techniques used in the program were proved out at Edwards AFB, and the company plans to use single-line production methods, with the personnel moving along the line of missiles.

The company has made a complete survey of all the planned sites, checking housing accommodations, and other necessities. Its site activation personnel will be used whenever practical and economical, the company said, with associate contractors being called upon for support when needed.

• **Stiff tests**—Components for *Minuteman* are tested at the development laboratories here, where stresses such as load, heat, internal pressures and external air pressures are simulated. The components are shock-tested to at least one hundred times the force of gravity.

The transerector for the missile has a gross weight of over 100,000 lbs., and a length of about 64 ft. The maximum gross weight allowed on California highways is 108,000 lbs., the lowest in the nation, and thus was used as a ceiling on the specifications for maximum gross weight.

Boeing is also conducting tests on the silo lid, which must pop off the silo despite possible interference of rocks, sand, or other obstructions. Compressed air is presently being used, but the operational site may use compressed air or mechanical means. The pop-off time allowed is very short, due to the necessary rapid reaction time.

Full cooperation with AF . . .

How Welling Will Push Base-building

by William J. Coughlin

LOS ANGELES—A hard-driving Army general who says he "operates with the advantage of a narrow military mind" has plunged into America's dragging ICBM base construction program.

Brig. Gen. Alvin C. Welling, commander of the newly created Army Engineers Ballistic Missile Construction Office, summoned his staff together seven minutes after arriving on the job here and ordered them to give full cooperation to the Air Force.

Welling, who has been given carte blanche to draft any Corps of Engineers personnel from anywhere in the world for the job, says he is not interested in the reasons for past delays or charges of interservice friction between the Army and the Air Force.

"I'm not interested in background; I'm interested in the future," he declared in an interview with MISSILES AND ROCKETS.

Warren AFB Operational

Three Atlas launch positions at Warren AFB, Cheyenne, Wyo., became operational last week, the Air Force reported. The three joined the operational and training base at Vandenberg AFB, Calif., as the only U.S. positions capable of firing an ICBM in anger.

Welling will work directly with Maj. Gen. Thomas F. Gerrity, who recently took over command of BMC in an Air Force Shakeup of the site activation program.

• **More 'angry men'**—Welling's first action in the new post was to name four Army colonels as directors of construction for each of the missile systems. They correspond roughly to the "12 Angry Men" named by the Air Force. The Corps of Engineers officers are:

Atlas D and *E*—Col. Charles Noble, former district engineer, Louisville District; *Atlas F*—Col. Edward D. Comm, former member of Joint Staff, Joint Chiefs of Staff; *Titan I*—Col. Carlin H. Whitsell, former district engineer, Eastern Ocean District; *Titan II*—Col. Carroll H. Dunn, former head of construction of BMEWS at Thule; *Minuteman*—Col. Noble will take charge after completion of duties on *Atlas D* and *E* programs.

The four colonels will be contracting officers. Present contracts will be brought under control of the new office except in those cases where construction already is so far along as to make such a move impractical, Welling told M/R.

Welling indicated hope that certain limitations on contract awards, such as the requirement that construction contracts must go to the lowest "responsible" bidder, might be changed to enable more effective placing of contracts.

• **New program**—The 50-year-old troubleshooter outlined a 10-point step-by-step program which he is immediately putting into effect:

1. Assure that going projects move forward with utmost urgency and precision, including a vigorous expediting of government-furnished equipment.

2. Arrange details of directing *Atlas D* and *E* operational bases through Corps of Engineers divisions and districts, using direct channels to the area engineers.

3. Prepare to contract for *Titan II* facilities, establishing adequate organization in BMCO and at the area level and arranging for appropriate support from the districts.

4. Do the same for *Minuteman*.

5. Modify if necessary and practical existing arrangements for supplying of government-furnished equipment to all programs.

6. Take over contracts for one *Titan I* operational base, assuming direct command of the area engineer and arranging for support from the district engineer.

7. Do the same for one *Atlas F* base.

8. Take over remaining contracts for *Titan I* operational bases.

9. Take over remaining contracts for *Atlas F* operational bases.

10. Solidify relationships with Patrick, Edwards and Vandenberg AFB's.

President Releases $476 Million

President Eisenhower retreated in the battle over defense spending last week in an apparent effort to reach a more defensible position.

Under fire in this election year from the Democratic Party and important factions of his own Republican Party, the retiring President approved the spending of $476 million out of more than $1 billion the Democratic Congress had added to his Fiscal Year 1961 budget. And he denied a Democratic charge that he had impounded the remaining $621 million.

At his press conference Aug. 10, Eisenhower attributed his change of heart to the tougher line that Soviet leaders have been taking since he sent his budget to Congress in January. As for the extra funds, he noted that Congress had cut some funds he requested and added in other areas. This makes a complicated problem that can't be solved in a matter of weeks, he maintained.

Thus the prospect is that more money may be released as the political campaign progresses. However, neither Sen. John F. Kennedy, the Democratic presidential candidate, nor Sen. Lyndon B. Johnson, majority leader and vice-presidential candidate who accused Eisenhower of impounding the money, is likely to move for any further appropriations while a substantial amount already appropriated remains unspent.

The Defense Department's revised spending plan calls for total expenditures of about $41.46 billion, an increase of $535 million over the January forecast. Of the increased money, only $150 to $160 million will be spent for hardware this year. More than $210 million of the extra money is earmarked for civilian pay increases.

These items were included in Eisenhower's approval of spending of add-on appropriations:

• **B-70**—About $100 million of the $195 million added by Congress will be used, bringing total spending to about $195 million.

• **Samos**—About $50 million of the $83.8 million added by Congress will be spent, bringing total funding to $427 million. A major portion of the additional funds will be used to provide an alternative approach to certain unspecified critical phases.

• **Polaris**—$312 million of the $382 million added by Congress will be spent, $55 million for procurement of aircraft and missiles, and $257 million for shipbuilding and conversion. Shipbuilding will be increased from three fully funded and nine partially funded submarines to five fully funded and five partially funded. Defense Secretary Gates said a start will be made on development of a longer-range *Polaris*.

How Mauler Will Look in Action

The Army recently released this artist's conception of the *Mauler* air defense missile being developed by Convair Div. of General Dynamics.

The automatic-firing system will be able to track targets and launch missiles from virtually any parked or moving position on its M-113 troop carrier-launcher, being developed by Food Machinery & Chemical.

Raytheon has the contract for the *Mauler's* antenna, which, together with its fire-control equipment, will be stabilized gyroscopically.

The Army announced two other successes in air defense missilery. A Raytheon *Hawk* destroyed a *Little John* over White Sands on July 27. A Boeing *Bomarc-A* caught a *QB-47* over Eglin Gulf Test Range Aug. 5.

Army May Join Weapons A, B

The Army's proposed *Missile A* and *Missile B* may be merged into a single new free-rocket system—*Missile A/B*—because of budgetary considerations. Continental Army Command is now writing military characteristics of the system.

This became known last week at the annual meeting in Washington of the Association of the U.S. Army. The Army is considering several approaches; although the service is divided within itself on which is best, there is almost universal agreement that it will be a free-flight system if the necessary accuracy can be obtained.

CONARC, the user command, wants a single missile that can do both jobs in the 3000-to-75,000-meter range. It's taking a hard look at *Slim John*, the advanced *Honest John* without the bulbous nose; this utilizes the PADA system of spinning within a ring with the ring moving up the launch rail to create the rifling effect. *Slim John* is reported to have much support because it could use existing *Honest John* launch equipment and production tooling.

Another possibility is a modification of *Lacrosse;* although most Army officials would prefer not to go to a guidance system, they appreciate *Lacrosse's* extreme accuracy.

General Electric has systems cognizance of *Missile A*, although the FY 1961 budget carries only $5 million for components buying. There are no funds for *Missile B* in FY 1961; more than 50 firms, however, have submitted proposals for its Qualification Development Requirement Index.

• **Replacements**—Under previous plans, *Missile A*, would have been the division artillery direct support missile, while *Missile B* would have been a general support missile. Both free-flight, solid-propelled missiles could carry atomic warheads in the low-yield bracket—in addition to chemical warfare and high-explosive warheads.

The Army has stressed components development of *Missile A*, hoping that resultant techniques would bring faster development of *Missile B*. Stress has been on use of high-thrust multiple boosters, methods to automatically match thrust and drag, spin and launch techniques, and improved measurement of low-level winds.

The Army had planned originally that *Missile A*, the 105 Howitzer of the missile family, and *Missile B*, the division general support missile, together would replace *Honest John, Little John* and, to a large extent *Lacrosse.*

Missile C is to be the follow-on for *Sergeant*. The Army plans to reduce the warhead weight without sacrificing yield, and take advantage of expected advances in solid propellants.

• **Lead-time gap**—Lt. Gen. Arthur G. Trudeau, Chief of Research and Development, told the AUSA meeting that lead time in the United States is running seven to eight years, with the Soviets doing a comparable job in five years. He said this problem can be licked by:

–Faster and more intensive exchanges of information between industry and Army—at every stage of development.

–New procedures for expediting development—such as overlapping and telescoping phases of R&D.

–Conducting user and engineering tests concurrently or on a combined basis.

–Starting production engineering and tooling as early in the development cycle as possible.

Raul Castro Renews Threat Of Russian Rocket Attack

Cuba's Raul Castro is wagging Soviet rockets at the United States.

Speaking to the leftish Latin American Youth Congress in Havana, Major Castro said, with apparent assurance, that the Soviet Union would back Khrushchev's pledge to support Cuba with rockets against any U.S. attack. This has raised speculation that Cuba and the Soviet Union may be ready to announce a military alliance.

Fresh from a trip behind the Iron Curtain, Castro said "If there is no attack, there will be no rockets, but if there is an attack, there will be rockets."

In an apparent rebuttal of reports that Russia may put missile bases in Cuba, Fidel's younger brother said, "If Cuba is attacked militarily, they (the United States) will receive what they deserve not from here but from other places."

No Cuban bases were needed, he said, because the Soviets could launch rockets to the States from its own territory.

Big Test Cell to be Built at AEDC

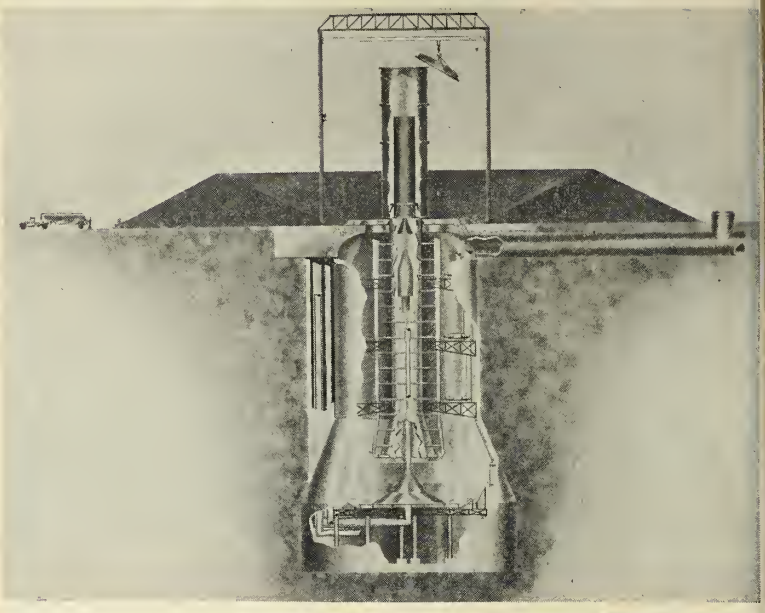
Construction of a test cell for firing rocket engines of up to 500,000 lbs. thrust will begin soon at the Air Force's Arnold Engineering Development Center, Tullahoma, Tenn.

The facility, scheduled to be operational in late 1962 or early 1963, will be able to handle both liquid- and solid-propelled engines in vertical positions at simulated altitudes of over 100,000 ft. It will be designed for later modification to handle engines of up to 1,500,000 lbs. thrust.

Completion of the cell will make it possible to study in detail various phenomena encountered by a missile in flight, without sacrificing the missile itself. It will provide space sufficient to permit installation of complete missiles, with engines in position and operating.

An exhaust-gas removal system will be tied in directly with the existing exhausters for obtaining altitude simulation, cooling water system, data reduction units and other auxiliary equipment.

A law providing funds for the cell was signed by the President last month.



HARDENED TEST cell will soon be built at AEDC to test rocket engines at simulated altitudes. Exhaust system is at upper right in artist's conception.

mergers and expansions

AEROJET-GENERAL has established a Spacecraft Division at Azusa, Calif. M. L. Stary, veteran rocket engineer, will be manager. The division is an outgrowth of Aerojet's Systems Division; it will design, develop, produce and flight-test all Aerojet vehicles used in space operations.

AERONUTRONIC DIV. of Ford Motor Co. has entered the automotive electronics field with the foundation of Automotive Electronic Equipment Operations. Lowell E. Krieg, former assistant to the general manufacturing manager of the Ford Division, is general operations manager.

HORKEY-MOORE ASSOCIATES, Div. of Houston Fearless Corp., has expanded its Testing Division facilities to include a fluid contamination analysis laboratory.

SPACE TECHNOLOGY LABS has established a Canoga Park Division to carry on programs formerly assigned to the Signal Equipment Laboratories of Ramo-Wooldridge Div. of TRW. Other R-W programs at Canoga Park will not be affected by the move. Dr. W. M. Duke, STL vice president and director of its research and development divisions, will head the Canoga Park unit. About 250 technical and administrative personnel will transfer from the R-W Division.

MAGNAVOX RESEARCH LABS dedicated their $1.5 million plant in Torrance, Calif. The Magnavox company projects income at $150 million for 1960, one-third of which will come from the Government and Industrial Division.

financial

Martin Co.—First half record sales and post-war record earnings were announced by Martin. Sales rose to $302 million from $248 million in the first half of 1959. Net income was $7.7 million, compared to $6.2 million the previous first half. Second quarter sales and earnings also improved, sales rising to $161.6 million from $126 million, profits to $4.2 million from $3.2 million.

Gabriel Co.—Second quarter reports showed a loss of $161,535 reflecting the write-off by the company of non-recurring charges of $379,488. Sales in the second quarter totaled $9.2 million compared to $7.8 million for the previous year second quarter. Sales for the first six months were $16.9 million compared to $14.6 million. Income showed a loss of $126,801 compared to profit of $472,815 for the first six months of 1959.

Marquardt Corp.—Working in a 28-week period ended June 17, sales were up 7% over the same period last year. Sales were $36.3 million, earnings were $599,597 from $860,647 the same period last year.

Temco Electronics—New contracts for Iconorama radar display systems, aircraft overhaul and aerosystems have almost completely offset the Navy cancellation of *Corvus* missile at Temco Electronics and Missile Company, the company says.

Chairman of the Board Robert McCulloch predicts more new business in the third and fourth quarter resulting from the merger of Ling Altec Corp. and Temco Aircraft Corp.

Ling-Temco Electronics Corp. achieved record sales and earnings for the second quarter ended June 30, with sales of $42.5 million and income of $1.1 million. Six month sales for the company were $76 million and earnings of $1.4 million. The company has a backlog of approximately $111 million.

missiles and rockets

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Astronauts may find their instrument panels being illuminated by flickering lights. An Air Force OSR contractor concludes that certain light-dark ratios allow greater visibility than steady light and reduce error probability. Investigators now have recommended specific flickering-light ratios for future use.

Bigger Horn Antennas?

A horn antenna up to three times as big as its present 50-footer is being considered seriously by Bell Telephone Laboratories. Mechanical distortion is one big problem facing designers of the extreme low-noise (2°K) configuration which is working well in satellite communication experiments.

Higher-gain Antennas Being Studied

Several companies are reported working on higher-frequency antennas with gains up to 70 db. Type of construction is not specified, but consensus is that they won't be paraboloidal.

Solid-State Generator Ready Soon

A one-watt, 1000-mc, solid-state power generator will be ready for commercial sale late this year by Pacific Semiconductors. Power level of the new device—slated for primary application in missile/space r-f transmitters—is reported to be 100 times greater than that of any previously available semiconductors for UHF use.

AEC Synchratron Hits 30-BEV Mark

The Alternating Gradient Synchratron at Brookhaven National Laboratory, the world's most powerful nuclear particle accelerator, is now in operation. The half-mile racetrack ran a beam of protons up to 30 billion electron volts on July 29. Cost of the AEC facility was $31 million. Next most powerful particle accelerator—the CERN Proton Synchratron, Switzerland—has been run at 28 BEV.

GROUND SUPPORT EQUIPMENT

Zeus Radar Vastly Improved

Improvements in *Nike-Zeus* target acquisition and tracking radar have contributed to stepping up development of the whole system. Chief gain, the Army says, is increased ability to discriminate, which continues after launch.

One-Point Ground System for GSE

A method for central grounding and radio-frequency shielding of missiles and support equipment has been recommended as standard by a Martin-Baltimore engineer. The one-point ground system, he says, would solve many problems in grounding, shielding, and filtering posed by the increasing complexity of missile electronics.

Agreements Made for Space Tracking Facilities

Goldstone's big 85-ft. space-tracking dish and facility will be duplicated at both Woomera, Australia, and Johannesburg, South Africa. Equipment will be supplied by NASA; JPL will handle construction. Sites will be roughly 120° apart geographically, providing continuous tracking of space probes at all times by at least one station. Recently, Goldstone has been successfully reflecting and receiving radio signals from *Tiros I*—even though "visibility" is only for 10 minutes. (See page 39.)

Auto-Checkout Saves Millions

Automatic checkout of electronics systems due for storage has saved the Air Force $2.5 million in one month. Used by the 2704th Storage Group, a Nortronics' Datica system was rushed into service to sort out serviceable radio gear from a mountainous backlog. The work accomplished would have required 12 months by standard test van.

PROPULSION

Hybrid Rocket Tests Look Good

Marquardt and Grand Central Rocket have demonstrated complete on-off capability with a 1000-lb.-thrust motor in their joint hybrid rocket program. A series of test firings with the first two motors in the program demonstrated that the thrust was packed into a smaller space than in any present rocket, Marquardt says.

Saturn Money Transfer Denied

NASA says there is no truth in the report that $23 million was transferred from the *Saturn* booster program to other space projects. The report followed a decision by the space agency to delay production of booster recovery hardware.

MATERIALS

Re-entry Steels Developed in England

Two new steels suitable for missiles and re-entry vehicles have been developed by Firth-Vickers Stainless Steels Ltd. No details on the composition were disclosed, but the materials are being used in the all-steel Bristol T-188, soon to start flight trials at above 1500 mph.

Lyon Lands Second Case Contract

Reliable motor-case development on a production scale is the object of a $500,000 contract awarded to Lyon Inc. by Detroit Army Ordnance District. It is the firm's second solid-motor chamber contract in 11 days. The first was a $1.45 million deal for *Polaris* second-stage cases. A deep drawing technique will be used to provide one-piece construction.

Alkali Metals Studied For Propellants

Work on the alkali metals lithium and sodium as propellants, with H_2O_2 as oxidizer, is in progress at Arthur D. Little, Inc., for the Air Force.

Combustion Viewed with "Hot" Tracers

Reaction Motors-Thiokol is investigating for the Air Force use of radioactive tracers to study combustion of advanced propellants. The aim is to cut development costs by reducing the number of burned large rocket motors.

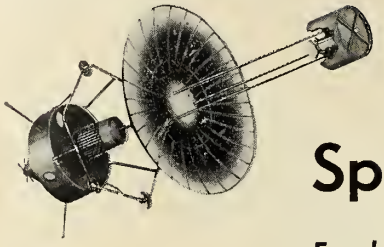
ASW ENGINEERING

Training Outlay to Grow

Here's one to ponder: the Navy estimates it will cost $1.3 billion annually within five years just to train fleet personnel in ASW.

Position Filled for Single Manager

Congress keeps telling the Navy it needs a single manager for ASW. Current Navy rejoinder is that it has one—Admiral Arleigh A. Burke. Reason: ASW spans the whole Navy and he's CNO.



Space Power Needs Urgent

Emphasis shifts toward solar-energized units; solar mechanical systems have time edge over nuclear units

LACK OF a primary electrical power source today is a key drawback in advancing both manned and unmanned space vehicles.

A shift in emphasis from nuclear to solar-energized systems appears to be taking place. The reasons: time factor, power needs, and international concern over the possibility of nuclear contamination. Rapid developments in thrust capability and satellite instrumentation are outdistancing power system progress.

Emphasis has been on nuclear systems such as the NASA/AEC SNAP programs. Early systems employ radioactive isotopes such as SNAP-3's polonium 210. This will be suitable for low-power, long-endurance requirements. Its weight-to-power ratio, however, is roughly 1 lb./watt.

The SNAP-8 program will use a reactor and provide from 35 or 70 kw. Weight will be 1400 lbs. or 2500 lbs., respectively, or 50-60 lb./kw. But the system won't be ready for flight tests for another 5 years.

What several space projects need in a short time, however, are lightweight systems in the 1-20 kw range.

AEC has bent over backwards to prove how safe SNAP-3 is. But there apparently is fear that an OK to fly it may provide carte blanche to the use of future generation reactor systems carrying large "hot" cores, which might be dangerous.

• **Trend to solar types**—The push for solar mechanical systems has been strong.

Thomas Timar, Boeing Airplane Co. suggested before the 14th Annual ARS meeting last November in Washington that solar systems ultimately will weigh well below 20 lbs./kw—10 times less than current state of the art would require.

Solar mechanical conversion systems will meet the demand for a lightweight, reliable sources of electrical power for satellites and space vehicles. So stated Donald H. McClelland, Senior Engineer, Electro-Optical Systems, recently before the National Aeronautical Electronics Conference in Dayton, Ohio.

Such solar thermal systems—where solar radiation is concentrated onto an absorbing surface to provide thermal energy for a heat engine—appear to offer weight advantages in the 1 to 20 kw region. The following various problems and techniques associated with current development work for these advanced space power units were stressed by the EOS expert.

Nuclear system development has encountered problems which indicate that solar systems could be available years earlier. Static converters, thermionic or thermoelectric, offer promise of eventual high efficiency operation—again a time factor.

The only converter system currently capable of providing satisfactory performance and reasonable weight in the 1-20 kw power range is one using a dynamic heat engine and electrical generators.

A typical solar mechanical power system, said the EOS engineer, embodies the following major components and subsystems:

–Concentrator—gathers solar radiation into a small focal image.

–Absorber—Transfers the concentrated solar energy to the working fluid by forced convection.

–Heat Engine—Converts the thermal energy in the working fluid into rotary shaft power.

–Generator—Converts shaft power into electrical output.

–Radiator—Rejects waste heat by thermal radiation.

–Energy Storage—Saves power for use when system is not exposed to solar radiation (shadow-phase operation).

–Control and Regulation Systems—Maintains constant power output, initiates start-up and orbital cycling functions, matches generator output to load requirements and maintains overall system reliability.

–Orientation System—Keeps concentrator aimed at sun.

• **Suitable mirror paramount**—The reflector or concentrator is one of the most important system elements because of weight and early development status. Concentrator size and geometry are directly related to conversion efficiency, power level and maximum cycle temperatures. The ultimate utility of solar power systems depends to a great extent on the ability to construct lightweight, accurate and (for large power systems) foldable solar concentrators.

McClelland, along with most leaders in the field, feels that the best geometrical configuration is the paraboloid-of-revolution reflector. The ability of the concentrator to produce with high efficiency at high temperatures is directly related to the concentration ratio (radiant flux density received by absorber/radiant flux density impinging on concentrator).

The maximum possible concentration ratio is achieved by a paraboloidal reflector. McClelland considered all practical factors into account—including investigations of parabolic cylinders, hemispheres, circular cylinder, conical and Fresnel lenses. He also included degradation of the actual concentration ratio by geometric inaccuracies in the mirror surface.

New materials problems abound in the fabrication of high strength, low weight structural elements for the collectors. The goal is accurate structures weighing 0.3 lbs./ft.^{3} or less having the necessary degree of rigidity to maintain the required geometrical configuration through all phases of construction.

The more promising approaches include—folding mirrors of metal or plastic segments, inflatable structures, foam-rigidized plastic-film mirrors and umbrella structures.

Each type has its problems and so far none have been adequately demonstrated in large sizes.

The surface accuracy of the first

three types is limited by materials properties and manufacturing tolerances. The accuracy of the umbrella is also limited by the number of ribs. But small mirrors using each of the techniques have been built and McClelland sees no great obstacles to the development of large ones within the weight limits.

• **Cavity absorber best**—To quantitatively evaluate the performance of a given concentrator, a determination of the concentrator-absorber efficency must be made. This quantity involves the relationship between the thermal energy transferred to the working fluid and the total solar flux intercepted by the concentrator.

It has been shown, said the EOS expert, that a cavity-type absorber will produce the highest overall concentrator-absorber efficiency. It also is more convenient from the thermal energy storage and heat removal aspects.

These absorbers efficiently pick up incoming solar radiation but inhibit reradiation losses from the heated inner surface because of the relatively small cavity opening. Maximum efficiency demands that the cavity opening be optimized for the particular concentrator and cavity temperature being considered.

• **Rankine efficiency cited**—The Rankine and Stirling cycles are the only thermodynamic cycles considered worth developing for space power applications.

McClelland leans toward the Rankine cycle since it ideally approaches the Carnot cycle in efficiency —the two isothermal processes are approximately achieved because of the constant temperature characteristics of a vaporizing or condensing fluid.

The two practical concessions are the irreversible energy addition to the fluid and the irreversible energy transformation as work out of the fluid.

Its main virtues for space power applications include:

—High heat transfer coefficients in the evaporator and the condenser due to the boiling or condensing liquid.

—Small magnitude of pumping work, since the working fluid is in a liquid state with low specific volume.

—Possibility of using working fluid as bearing lubricant.

A large variety of working fluids are available to provide a broad spectrum of evaporation and condensation temperatures and pressures.

The Stirling cycle consists of two constant temperature processes and two constant volume processes. Several practical approaches to a working Stirling cycle engine have been taken with the most promising being developed by the Phillips Corp., Eindhoven, Holland. The Phillips engine is a reciprocating gas system and it is being studied in this country.

• **Generators compared**—Two types of generators may be considered for solar-mechanical power systems—electrostatic and electromagnetic.

The electrostatic provides the lowest weight but it must operate in a vacuum. Thus, some means of lubrication must be devised together with either rotating seals or a magnetic coupling between the generator and the turbine.

The electromagnetic can be hermetically sealed in the same unit as the turbine. Furthermore, says McClelland, the working fluid can carry away the heat produced by losses in the generator. This generator is somewhat heavier than the electrostatic type.

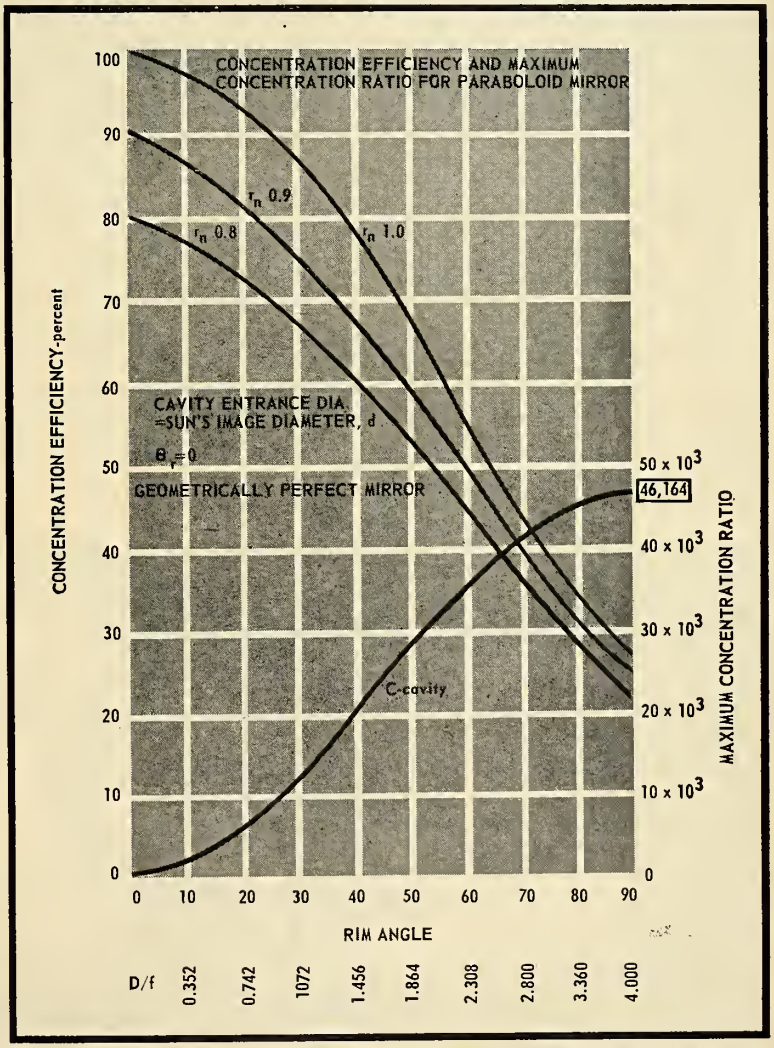
• **Thermal vs. electrochemical storage**—Because a solar power system must supply power while in shadow operation, some sort of storage system must be available. Of the two types considered, electrochemical and thermal, McClelland feels that the latter offers the greatest potential at the present stage of development.

Thermal storage units are generally fabricated as part of the absorber and utilize heat of fusion of a material. Overall system weight of such a unit is lower than the chemical type. It also is smaller in size and has a greater storage capacity.

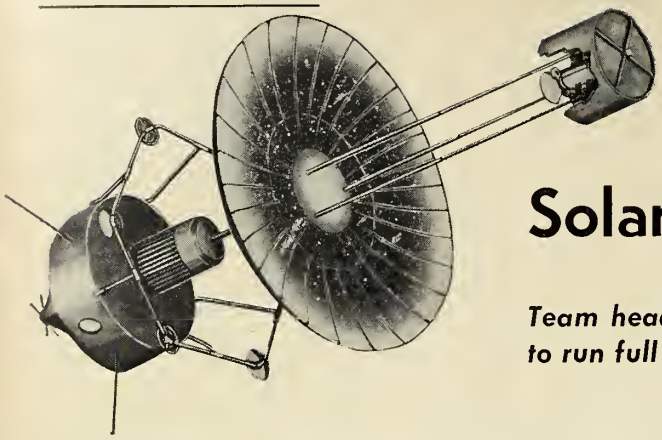
Lithium hydride (HF-1600 Btu/lb.) is the best known material for a thermal storage unit. LiH will limit maximum cycle temperature to something less than 1250°F—if higher temperatures are desired another material must be used.

The heat storage capacity of LiH

(Continued on page 29)



MAXIMUM POSSIBLE concentration ratio of a geometrically perfect paraboloid of revolution reflector is shown together with its concentration efficiency.



Solar Mechanical Engin

Team headed by Sundstrand developing system to run full year; later potential may be enormous

by Charles D. LaFond

DENVER—The biggest solar mechanical engine currently under development by the United States military is being designed by Sundstrand Corporation. It will fill a serious gap in the space-hardware development table.

Announced in June, a $1-million contract from the Air Force ARDC's Wright Air Development Division, makes Sundstrand's Denver Division responsible for research, design, and development of a breadboard 15-kw power system for space-vehicle applications. The potential of such a system could be tremendous in later production phases because of the diverse applications possible.

The contract was awarded to a team, of which Sundstrand is prime. Other companies participating in the 15-month program include Ryan Aeronautical Co., Goodyear Aircraft Corp., and Jack & Heintz. Ryan and Goodyear are principals in a 6-month development competition for the solar collector concentrators (mirrors). Ryan is developing rigid metallic dishes; Goodyear will design plastic inflated concentrators. Jack & Heintz will provide brushless alternators.

Expected to weigh 819 lbs., the solar mechanical engine will be designed to operate continuously and unattended for approximately one year, according to WADD.

Essentially, this will be a closed Rankine-cycle power conversion system, using rubidium as the working fluid. Rubidium was selected to achieve from 500-800°F increase in operating temperature over mercury, which is used in more conventional systems.

The Sundstrand system is similar in concept to NASA's Sunflower I 3-kw power system, in that both systems utilize the closed Rankine cycle with a combined shaft unit (turbine, generator, and pump on a common shaft). However, a unique system design approach, and use of the more advanced working fluid in the USAF 15-kw system, are believed to offer a significantly lower specific weight (55 lb./kw vs. Sunflower I's 233 lb./kw).

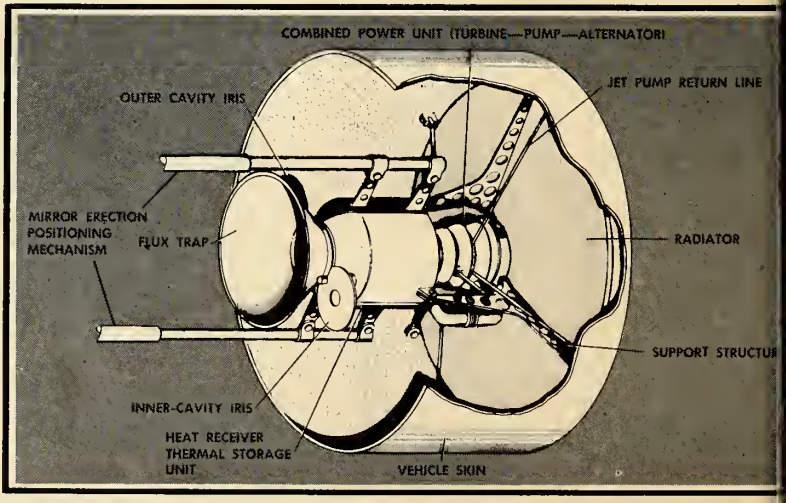
Use of solar energy in the past has been limited by the need for an efficient thermal storage unit. This problem also is being investigated by Sundstrand under a separate WADD contract. On the outcome of these investigations hangs much of the success of all similar power systems of the future, according to WADD.

• **40-ft. dish used**—As shown in the artist's conception, the power system when deployed will use a 40 ft. solar radiation concentrator. The big paraboloid, located between the satellite payload and the power unit, will be folded during transit and must be opened and oriented as soon as the orbit is established.

During deployment, the concentrator will be unfolded and the engine extended to a precise position for maximum operating efficiency.

Orientation of the concentrator and power package will be accomplished by a sun seeker, accurate to within 0.1 degree. Solar energy can then be directed by the concentrator to the power package for engine operation. A thermal storage unit in the power package will absorb sufficient solar energy to continue engine operation as the satellite passes through the shadow phase of its orbit.

A major unit in the system, the concentrator also is a major headache. Two mirrors are now being considered for use with Sundstrand's engine. Ryan is developing a deployable, rigid metal-leaf concentrator which uses lightweight aluminum construction. The second dish under consideration is a folded inflatable type, developed by Goodyear. At command, this package will be inflated in space and a para-



15-KW SOLAR ENGINE package will be extended from satellite and concentrator precisely erected for deployment in orbit. A sun-seeker will control orientation.

o Give 15 KW

boloidal portion rigidized by foaming. After rigidization, the unused portion of the balloon can be burned off.

Both types of concentrators show promise for this application. Each subcontract calls for delivery of 10-ft. models to the Air Force for exhaustive testing at the end of 6 months. The winner will continue development of the full-size dish.

Principal design problems to be faced in developing the big deployable mirrors are: 1) weight restrictions, 2) packaging, 3) deployment and space orientation, 4) maintaining accurate paraboloid after deployment, and 5) development of efficient reflective surface to withstand one year in space environment.

• **Solar flux trapped**—The power unit is a complex energy converter. Chief components of the engine are a cavity-type double boiler and flux trap, combined shaft unit and condenser-radiator. The flux trap and double boiler are both recent Sundstrand proprietary developments.

Serving as a kind of 1-way valve, the flux trap is the solar energy intake. The quantity of energy admitted into a specific size boiler opening can be increased by 20 to 25%, with a suitable flux trap. Size of the boiler opening is critical because of re-radiation losses. It's conceded that a larger opening would permit a greater amount of energy to enter the boiler; but it's noted that this would also allow an excessive amount of energy to escape. Thus, the more energy admitted through a minimum size boiler cavity opening, the greater the net gain.

Another advantage of the flux trap, Sundstrand believes, is realized in the geometric design tolerance of the concentrator. Fabrication cost of a concentrator increases rapidly with an increase in the required concentrator accuracy. The funnel effect of the trap diminishes this requirement.

In designing the double boiler, the primary aim is for high operating efficiency during collection of solar energy and optimum heat storage for use during the shadow phases of operation. Fabricated with an inner and outer cavity, the inner volume of the boiler is used for first-stage superheat and second- and third-stage reheat of the working fluid, rubidium. Sodium fluoride contained within the cavity provides for high-temperature heat storage.

The outer cavity, constructed around the inner cavity, is used as the initial boiler for the working fluid. Lithium hydride is contained within the outer cavity to provide for low-temperature heat storage. Through the proper arrangement and use of both inner and outer heat storage materials, a decided weight reduction of the system will be effected, company engineers say.

• **Superheated to 1750°**—Operation of the double boiler begins when solar energy, directed from the concentrator and flux trap, impinges against the walls of the inner and outer cavities. With the transfer of energy to the working fluid, its temperature is raised first to approximately 1200°F in the outer cavity and then to 1750°F in the inner cavity.

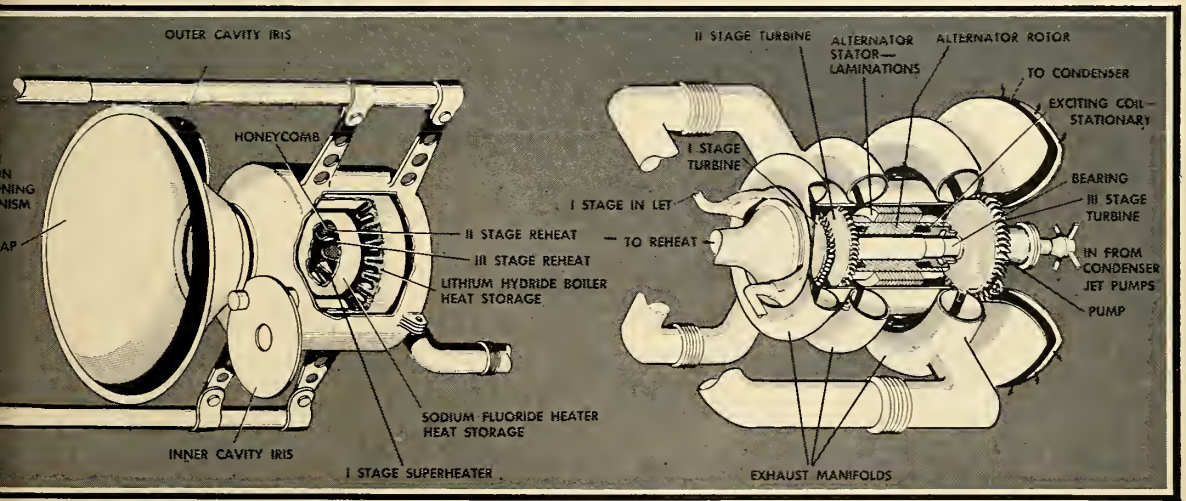
During the reheat cycles, the temperature is increased to 1600°F for the second-stage turbine and 1450°F for the third-stage turbine. These temperatures are maintained to prevent condensation of the working fluid during expansion and to assure efficient turbine operation.

During shadow-phase operation, the heat storage materials supply the energy required to maintain operating temperatures.

Solar flux directed to the boiler often may be greater than the energy needed to meet engine requirements. To control solar energy intake to the cavities, two irises are mounted between the flux trap and boiler—one independently operated iris for each cavity. This permits accurate temperature control of the working fluid and constant flow and pressure throughout the system. During shadow-phase operation, the irises are closed to prevent heat loss through the boiler opening.

Turbine configuration, said Sundstrand, must be well balanced and compact to enable one-year continuous operational life of the system. The turbine will be a three-stage, axial-flow, high-temperature unit.

For design simplicity, the first and second stages are mounted at one end of a common shaft, the generator is located between the second and third



MAJOR SUBSYSTEMS of Sundstrand's solar power unit: (Left) flux trap, heat absorber, and lithium-hydride thermal storage. (Right) the alternator and turbine assembly. Early design provided efficiency of about 21.7%; better performance is predicted.

LOW-SHOCK TRACKED MOBILITY FOR SENSITIVE ELECTRONIC EQUIPMENT

The tactical advantages of full off-road *tracked* mobility in military support vehicles have been well proved in many years of field operation. But the idea of transporting intricate radar and communications equipment and fully-assembled missiles over rugged terrain raises the question, "What about vibration and shock input to sensitive components?"

The answer – favorable. Carrying a simulated missile and sensitive oscillograph recording equipment, an FMC tracked vehicle ran a 2,000-mile shock test over our proving ground – on 60° slopes, over rough cross country terrain, and on high speed roads. Data returns showed that the vehicle's torsion suspension system effectively cradled the missile, with a low shock input factor.

For full details on these tests and other questions of adapting tracked mobility for your purposes, contact FMC, America's leading producer of military-standardized tracked vehicles.

For further information, write, wire or phone Preliminary Design Engineering Dept., FMC Ordnance Division, P.O. Box 367, San Jose, California. Phone: CYpress 4-8124.

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION

Ordnance Division

1105 COLEMAN AVENUE, SAN JOSE, CALIF.

fmc

Illustrated below are the M-113 and five vehicle adaptations of this basic tracked vehicle. All of the vehicles use the same military standard equipment, including engines, power train, and suspension components; thus reducing the military logistic burden and R&D costs in weapons systems.


M-113 Armored Personnel Carrier


Radar Vehicle


Van-type Vehicle


5th-wheel-type Prime Mover


Utility Crane Vehicle


Missile Launcher

FMC's New Liquid Propellant Metering System Achieves Accuracy to ±0.1%


Mobile metering and control unit for fueling liquid propellant missiles.

The crucial reliability of multistage missiles is influenced by the accurate measurement and delivery of liquid propellant to the missile tanks. For example . . . a small error in fuel weight could adversely affect the in-flight performance of the missile, causing possible failure of the entire mission.

Food Machinery and Chemical Corporation's Ordnance Division has recently developed a mobile liquid propellant metering and handling system which promises to solve many missile fueling problems. The advantages offered by this unique new system are many.

Accurately measures and records the amount of fuel delivered to the missile tanks. Original specifications called for a metering accuracy of ±0.2%. Extensive tests, recorded by precision test equipment, show that the system is capable of metering and delivering missile propellants with far superior accuracy—to ±0.1%.

Automatically compensates for factors influencing fueling accuracy. The fuel is continuously sampled and the flow corrected for variations in temperature and density. In addition, the fuel which vaporizes in the missile tanks is returned to the system, condensed, measured, and an equivalent amount added by the metering unit.

Adaptable to many different missile fuels. The system is designed to handle such storable liquid propellants as hydrazine, nitrogen tetroxide, Dimazine® (UDMH) and nitric acid.

Economical to manufacture and safe to operate. To reduce development, manufacturing and operating costs, the system makes maximum use of standard, interchangeable, and commercially available components. The simple and safe design eliminates human errors and danger to operating personnel.

Mobile and compact. All metering, pumping and control equipment is mounted on a single, portable trailer. The complete unit may be easily transported, rapidly positioned, and provides a single station for the monitoring of fueling operations.

The successful development of this mobile metering and handling system by the engineering staff of FMC's Ordnance Division is another achievement made possible by utilizing the unique combination of chemical and mechanical engineering talent available at Food Machinery and Chemical Corporation.

Circle No. 6 on Subscriber Service Card.

stages, and the centrifugal pump is located at the end of the shaft after the third-stage turbine. Pump location at this point on the shaft will benefit from the relatively low ambient temperature.

The complete rotating assembly of the combined shaft unit is mounted on two sleeve bearings, located outboard of the generator and inboard of the turbine wheels. This provides for an even load distribution on the bearings. Bearing lubrication as contemplated in the initial design will be accomplished by using the rubidium working fluid from the centrifugal pump.

Condenser-radiator location in the power package is just aft of the third-stage turbine. Attachment is directly to the turbine discharge ducting to permit immediate processing of the working fluid as it leaves the third-stage turbine.

Vanes between the side plates of the condenser will direct the working fluid toward the collection area at the outer periphery. This also provides the maximum heat radiation surface required for efficient condenser operation. The company believes that careful condenser design should eliminate intricate plumbing problems and weight associated with more conventional condenser construction. Four jet pumps, symmetrically positioned at the outer periphery of the condenser, will assist and direct the working fluid flow to the centrifugal pump. Jet pump operating fluid can be received from the generator cooling system.

Subcooled (675°F) working fluid from the condenser and jet pump will then be directed to the centrifugal pump which, in turn, supplies working fluid to the generator cooling system for bearing lubrication and to the boiler for system operation.

Generator cooling will be accomplished by directing coolant through channels in the housing around the electrical generator section. The coolant is then directed to the jet pumps and returned to the centrifugal pump.

• **Efficiency to be increased**—Alternator output at the nominal turbine speed of 24,000 rpm is 15.3 kw. This allows for 0.3 kw to be used for actuating flux-trap irises and control mechanisms in the power package. The alternator is a brushless, magnetic type unit with an all-metal rotor. Specifically designed by Jack & Heintz for high-temperature operation in a space environment, it employs ceramic insulation throughout.

In its earlier design state the solar engine efficiency was calculated to be approximately 21.7%. With recent state-of-the-art advancements such as the flux trap and double boiler, more efficient systems can be developed in the future, said Sundstrand.

• **Problems**—There are many problems to be surmounted in developing any solar thermomechanical space power system of this type. Foremost among these are the unknown properties of rubidium and the design and materials for the solar concentrators.

Rubidium, one of a family of alkali metals, has extremely desirable characteristics as a working fluid. Theoretically, a rubidium system can be built with an operating temperature approaching 1800°F at reasonable pressures.

But physical and chemical characteristics of the metal vapor are not fully known. For example, what will be its long-term effects on shaft bearings which depend on the fluid for lubrication? Also, what effect will it have on the alternator if leakage occurs?

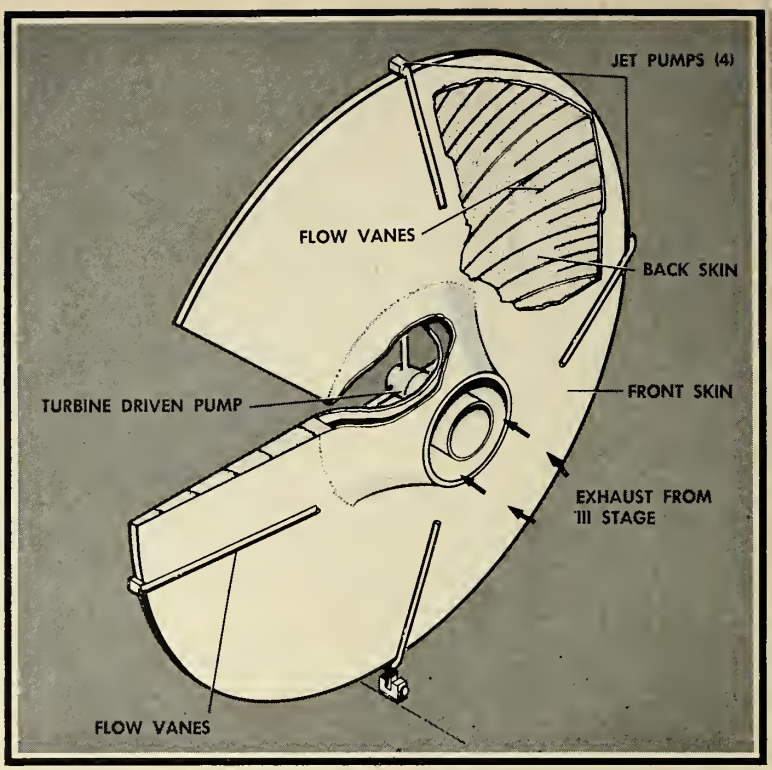
Concentrator development offers more unknowns. Meteorite puncture effects probably can be made negligible. But sublimation in a space environment could be disastrous. Precise orientation must be maintained.

How will these units be tested? We can go only so far in the laboratory, even with the environmental test facilities available to the Air Force. The only true test will be with a fullsize satellite system in orbit for one year.

Sundstrand, Electro-Optical Systems, and many others feel the solar mechanical power system approach will bear early fruit.

Nuclear proponents take issue with this hypothesis. They feel it will take five years just to develop a suitable turbogenerator for an operating system. Nuclear power systems will be flying before then, they say.

The consensus is that both types of space power systems are needed—and that the "who'll-be-first" attitude may best serve to spur more rapid development of each.



DISC-TYPE condensor-radiator assembly forms the aft section of the engine package (shown on p. 24), attached directly to the turbine discharge ducting.

Specifications For Sundstrand Solar Mechanical System

Electrical output:	15 kw
Total system weight:	819 lbs.
Working fluid:	rubidium
Boiling temperature:	1200°F
Superheat temperature:	1750°F
Condenser temperature:	675°F
Cycle efficiency (turbine shaft):	0.260
Over-all electrical efficiency:	0.217
Solar concentrator parameters:	
Diameter:	40.5 ft.
Mirror/boiler efficiency:	0.74
Total weight:	315 lbs.
Condenser disk diameter:	7 ft.
Turbine speed:	24,000 rpm

SOLAR POWER

(Continued from page 23)

is several times that of any other material which utilizes only solid-liquid phase changes. An appreciable volume change occurs upon freezing, which must be figured into the design.

• **Radiators mandatory**—The one large problem in the heat rejection process in space is the zero gravity condition. In addition, the rejection must take place entirely by radiation.

If the radiator is considered apart from the condenser, surface design problems relating to properties and meteorite puncture arise.

In the case of a direct condensation process where the condenser is an integral part of the radiator, induced centrifugal force and viscous drag have been considered as a means of insuring liquid delivery to the pump.

This also is desirable, he believes, from a thermodynamic standpoint since it enables the radiator to dissipate heat at the highest possible temperature consistent with given cycle fluid temperatures.

The disadvantage is that it may be subject to unstable and erratic flow. But this can be overcome by using a 1.5-loop condenser-radiator system in which the vapor from the turbine enters a mixing chamber where it is condensed by a stream of subcooled liquid. This provides a positive separation of condensate. Another possibility is a two loop system using a condenser-heat exchanger.

Satisfactory solutions to each of these appear to be forthcoming he said.

• **Remaining requirements**—The control system presents little or no difficulty since its functions can be accomplished with known techniques. Directional devices are another matter.

McClelland called for two types of orientation systems—a rough and a fine. The initial rough orientation must be capable of finding the sum even though there is complete misorientation during launch. A fine system is required to insure adequate performance throughout the life of the entire energy conversion apparatus.

The environment of space creates the usual materials problems. Plastics are subject to radiation and may sublime in the hard vacuum. Inflated structures face a very short life because of meteorite puncture.

According to McClelland, there are many problems yet to be solved before a reliable solar mechanical system will fly. But the order of difficulty seems no greater and possibly less than other proposed popular conversion schemes.

Systems under development today and those of the near future should provide the answers.

Lower Van Allen Belt To be Examined by NERV

Low-intensity radiation will cut trace on sensitive disc; man-in-space program is expected to benefit; payload is unique

by John F. Judge

Recovery aids for the NERV have been successfully flight-tested. The chute is radar-reflective.

THE WORLD'S highest-flying recoverable payload is expected to be launched from the Pacific Missile Range sometime next month by the National Aeronautics and Space Administration.

Designed to measure low-level radiation intensity in the lower Van Allen Belt, the probe has the unique ability to expose its payload to the surrounding space environment 1500 miles out —and then return it safely to earth.

Once beyond the atmosphere, the vehicle will telescope a 21-layer nuclear emulsion. Ionization particles in the 10-to-150-Mev range will cut a trace or this emulsion. These particles cannot be suitably measured by a Geiger counter. The need to analyze the emulsion after the flight precludes the possibility of telemetering the radiation data.

The information gleaned from the experiment will be added to that collected by past probes and satellites.

In August, 1959, NASA awarded a $560,000 contract to General Electric's Missile and Space Vehicle Department for four recovery vehicles designed to house the emulsion (M/R, Nov. 9, 1959, p. 9).

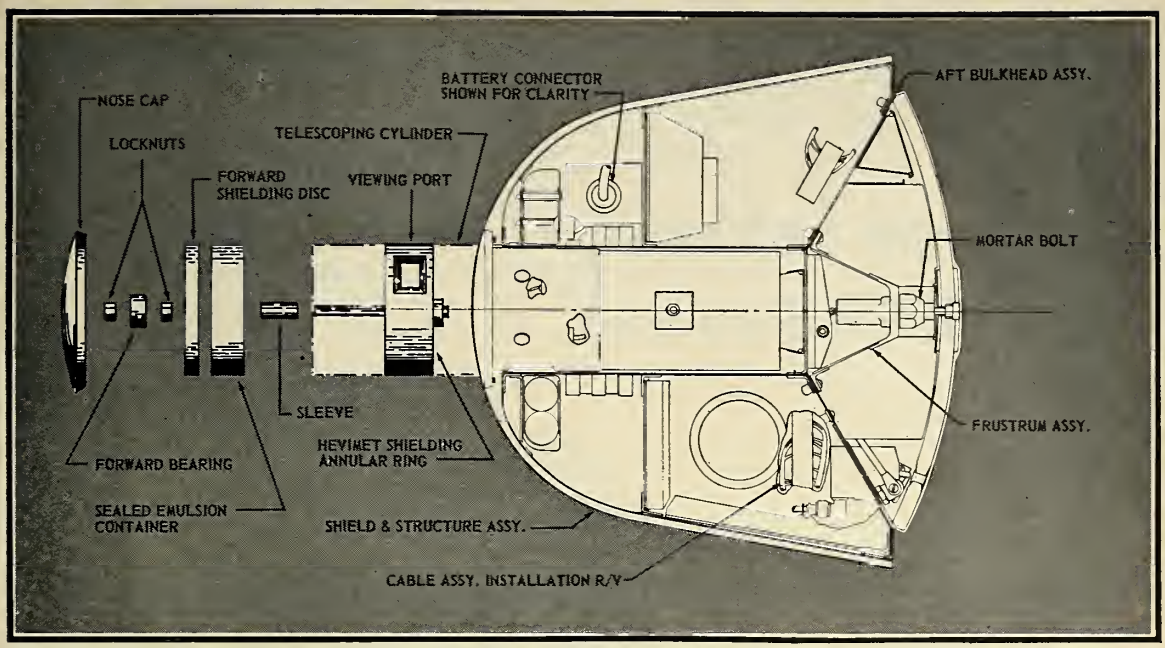
• **Ballistic trajectory**—The Nuclear Emulsion Recovery Vehicle (NERV) will be hurled to an altitude of 1500 miles by an *Argo D-8* research rocket. The 75-lb. package will impact about 2000 miles down the Pacific Missile Range.

At an altitude of about 200 miles, a linear actuator will extend a cylinder containing a disc of radiation-sensitive material, 3 in. in diameter and 1 in. thick. The disc will revolve past a small viewing port.

The emulsion continues to be exposed through the flight's apex and until NERV is around 200 miles from earth.

The capsule will be spin-stabilized while a time profile is taken of the low-intensity radiation. Its general path will coincide with the earth's magnetic lines of force.

Around the 200-mile point of de-



EXPLODED VIEW of the removable telescopic cylinder containing the emulsion. Package is heavily shielded, except for small view port which allows particles to enter and strike revolving emulsion. Re-entry protection was not described.

scent, the emulsion will be retracted for protection during re-entry. Just prior to re-entry, the vehicle's spin will be decreased so that the nose enters first. This will be accomplished by a set of weights on 9-ft. cords.

The Navy will pick up the package from the water. Because the emulsion would be damaged if exposed to the sea, the vehicle is waterproof.

• **A grain of sand**—The possible number of impact points covers a vast area of the Pacific. In view of this, a variety of location aids have been built into the vehicle and its launcher.

Just prior to lift-off, a radar tracking beacon in the fourth stage of the rocket will be activated. This is designed to provide a fairly accurate point-of-impact prediction.

At the 40,000-ft. descent mark a parachute will be deployed and a considerable amount of radar chaff will be ejected. The alternate gores of the chute will be radar-reflective. A high-intensity strobe light will be activated simultaneously with a radio beacon.

After water impact a fluorescein marker dissolves to further aid the searchers.

• **Recovery system checkout**—A successful water drop test was performed at Eglin Air Force Base, Fla., last December. In another test, an Air Force F-104 Starfighter dropped the package from an altitude of seven miles. The parachute retardation, programing and recovery aids all operated as planned. The probe contained the emulsion, but it was not extended during the drop and the water impact did not damage it.

The information from NERV should help determine the design factors involved in protecting man from radiation in deep space flights. In addition, it is anticipated that the emulsion will give a complete radiation profile, showing intensity versus altitude and the type of radiation.

General Electric says that later flights may use the *Scout* rocket. The presence of a guidance system would expedite recovery and the increased payload capacity of the *Scout* would be an added advantage.

The possible applications of the NERV telescopic system extend beyond the emulsion experiment. Such a vehicle would be ideal for sampling the atmospheres of planets. There is also the possibility of environmental tests in the hard vacuum of space. Material samples could be exposed under specified conditions in deep space and then brought back to earth for examination.

NERV with extended cylinder.

Blast Wave Simulations Reach A-Bomb Proportions

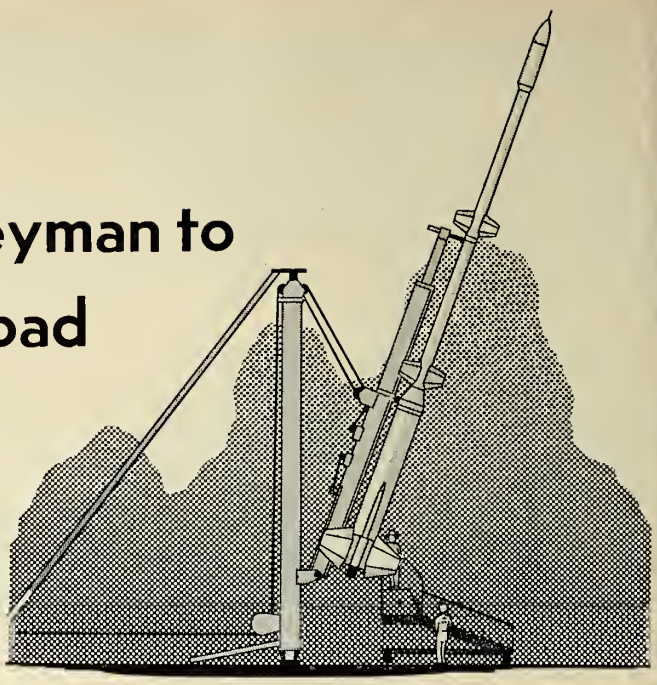
High-explosive blast waves similar to those generated by the Atomic bomb at Hiroshima may be produced under controlled laboratory conditions with relatively small charges.

The effect is the result of detonating a small charge in the apex of a conical tube. Scientists at the Naval Ordnance Laboratory, Silver Spring, Md., have found that the blast wave from such a device represents a sector of a spherical shock-wave generated by a much larger charge fired outdoors.

An amplification factor is used to determine the size of the charge required to simulate an open air blast. This is figured as the ratio between the solid angle of a sphere to that of the solid angle of the cone. The factor can, in theory, be increased to 160,000 to 1 by using a cone of 0.5°. Heat and friction loss will reduce the efficiency.

A-bomb simulation would require a cone 2000 ft. long with an angle of 0.5° and, because of an expected 35% efficiency, a 1000-lb. charge of T.N.T.

Four-stage Journeyman to Carry NERV Payload



Artist's drawing shows Journeyman being erected for launching

THE NERV PAYLOAD will be propelled by the *Journeyman*, a new four-stage sounding rocket developed by Aerolab Development Co., a subsidiary of Ryan Aeronautical. Aerolab calls the rocket *Argo D-8*.

First stage of the vehicle is a cluster of a Thiokol *Sergeant* and two auxiliary *Recruits*. Second and third stages are Grand Central *Lance* rockets. The final stage is the Hercules Powder Co.-Allegany Ballistics Laboratory *Altair*.

The *Journeyman* is capable of lifting a 60-lb. package to an altitude of 2100 miles, or a 120-lb. package to 1500 miles. The September firing will be the first for *Journeyman*.

The first-stage engine is the XM-20, used in the earliest model of the *Sergeant* missile. Although its exact specifications are classified, the thrust and burning time are known to be in the neighborhood of 45,000 lbs. and 25 seconds. Each of the *Recruits* generates about 35,000 lbs. for 1.5 second, giving the vehicle total takeoff thrust of 115,000 lbs.

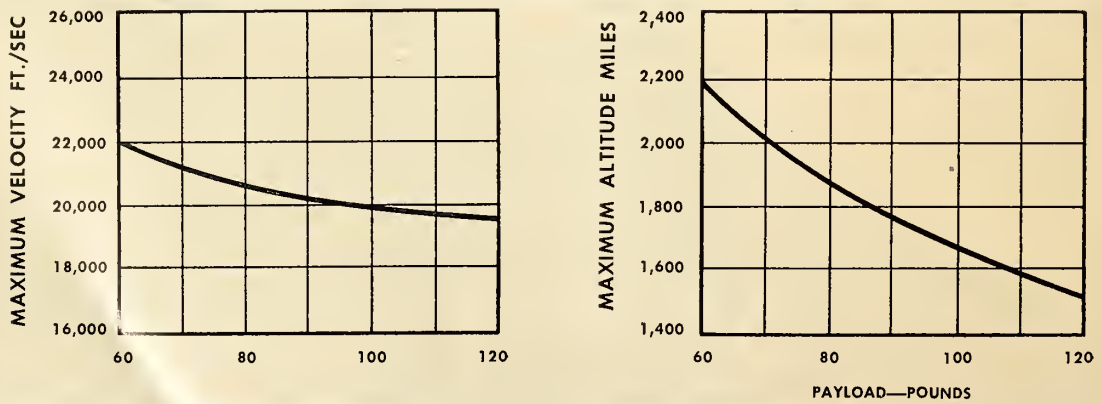
The second and third-stage *Lance* generates 38,800 lbs. thrust for 6.65 seconds plus a 1.35-second tailoff. It weighs 1682 lbs. loaded and 490 lbs. empty.

The *Altair*, also known as *X248*, generates vacuum thrust of 3060 lbs. for 38 seconds.

The vehicle stands 62 ft. high and weighs 13,932 lbs., exclusive of payload. Maximum acceleration occurs at third-stage burnout. With a 60-lb. payload, the maximum is 41 g's. The time from burnout to splash is 41 minutes.

The first launching next month will be from the Pt. Arguello, Calif., launching site on the Pacific Missile Range. The vehicle will travel south along the lines of force of the earth's magnetic field.

Navy ships will attempt recovery of the payload after re-entry is accomplished with the help of a parachute. Impact point will be calculated from the ballistic trajectory. Recovery is necessary because emulsion information is not telemetered.



CHARTS SHOW CAPABILITY of Journeyman's combination powerplant. It can push a 60-lb. payload to about 22,000 ft./sec., or a 120-lb. load to approximately 19,500 ft./sec.; take 60 lbs. to an altitude of 2100 mi., 120 lbs. to 1500 mi.

Turbopump Key to New X-15 Engine

Unit insures controllability and adequate fuel flow for Thiokol's XLR99 powerplant; turbine overhangs shaft

by William Beller

Key component in the rocket engine that will attempt to push the *X-15* spacecraft to 4000 mph late this fall is the turbopump.

This device accounts for the most significant flight feature of the 50,000-pound-thrust engine, its controllability.

The turbopump also satisfies the engine's enormous appetite for propellants—a ton of liquids a minute.

This controllable rocket engine is the XLR99, developed by Thiokol's Reaction Motors Division. The XLR99 is the only high-thrust engine in America designed and test-proven for manned space vehicles.

The engine comprises a turbopump, thrust chamber, gas generator, valves and an electrical control system, all compactly grouped. The overall package measures about 80 in. long, 40 in. in diameter.

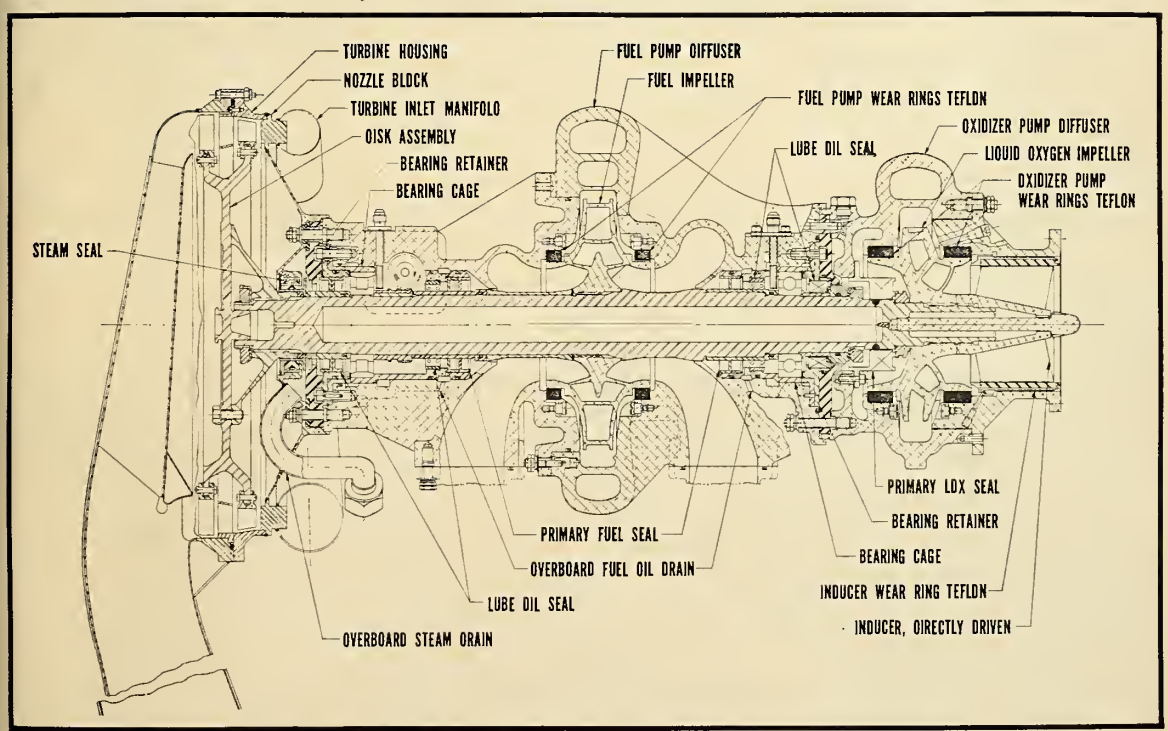
The turbopump is directly driven by a decomposed hydrogen-peroxide-powered turbine overhanging one end of a shaft. At the other end is a single-entry oxidizer pump. Midway along the shaft is a double-entry fuel pump.

The liquid propellants are fed from low-pressure, lightweight tanks through the turbopump into a regeneratively cooled thrust chamber and injector. The fuel used is anhydrous liquid ammonia, temperature –50° to –28°F. The oxidizer is liquid oxygen at –316° to –275°F. The monopropellant for the pump drive is 90% hydrogen peroxide, temperature 50° to 120°F.

Last June, an XLR99 was installed in an *X-15* when a hydrogen peroxide tank blew up during engine tests, severely damaging the craft. Probable cause was said to be a fuel leak or spark. Another XLR99 was subsequently flight-rated and delivered to NASA and the Air Force.

• **Engine characteristics**—During flight, the engine is under full control of the astronaut. He can throttle it to as low as 50% of full thrust, shut it down, restart it, and build the thrust back up to full value.

The thrust is controlled by altering the turbopump's speed, thereby affecting the propellant flow to the thrust chamber. The turbopump's speed is changed by means of a throttling valve upstream of a catalytic bed. Hydrogen peroxide passes over this bed and is



CROSS-SECTION OF TURBOPUMP for 50,000-lb. variable thrust rocket engine shows steam-driven turbine overhung on left end, double-entry fuel pump for anhydrous liquid ammonia at mid-shaft, and inducer and LOX pump at right end.

decomposed before entering the turbine, which drives the turbopump. Thus, a control linked to the valve is all that is needed to vary the engine's output.

Describing the design features of the turbopump to an American Rocket Society audience recently, RMD engineer Stephen R. Matos said the device can accept most propellant combinations safely. Thus it can be used on many engine systems and needs "no basic design changes or redevelopment" for such installations.

• **Clearance of parts**—One design problem was to prevent metallic contact between the aluminum oxidizer impeller and its magnesium casing over a wide temperature range. The solution, which was also dictated by safety considerations, was to provide generous axial clearances between the impeller and casing.

Wherever small radial clearances between a rotating and a stationary member were needed, a plastic shroud and wear ring were used. Matos cited this solution as a RMD design concept and development.

An example of its use is seen at the junction of the inducer shroud and the impeller wear ring. Here the running radial clearances vary from 0.001 in. to 0.004 in. and, although rubbing contact has been experienced, Matos reported that "there has never been a turbopump malfunction from this cause."

• **Turbine characteristics**—The turbine wheel is a single-disc, two-row impulse type. The cast blades are mechanically attached to the disc by pins. A lightweight, high-strength disc is achieved through using the relatively new Udimet 500 material.

Placing the turbine in the middle of the shaft was discarded early because of the problems of thermal stresses and expansions, pressure deflections, bearing failures, and hazardous rubbing conditions where axial clearances are critical.

Therefore, the disc was overhung at the shaft's end. It is stabilized by a supporting cone, another RMD development.

Many advantages accrue. Because the disc has no center hole, the stress distributions are uniform. Seals and bearings are accessible from the turbine end, thereby considerably easing the problem of inspection and parts replacement. Even under extreme conditions of turbine operation, the disc stays centered with respect to the shaft.

A safety feature is the liberal clearance between the turbine wheel and its housing.

• **Pump characteristics**—The oxidizer pump is a conventionally designed single-entry centrifugal impeller. It operates in conjunction with a direct-driven inducer. The inducer operates at a suction specific speed of 40,000 at a relatively low pump inlet pressure of below 50 psi.

The fuel pump, also of conventional design, is a single-stage double-suction centrifugal device with a volute casing. This case is made of magnesium alloy; the centrifugal impeller is an aluminum casting.

• **Bearings and lubrication**—Bearings used are stainless steel 440-c ball and roller types. Matos said that the radial clearance of the ball bearing is greater than standard to allow for differential expansions of the races at liquid oxygen temperatures.

A positive displacement pump provides recirculating oil at 40 psig to each of the bearings, which run flooded. Cooling is not needed because the heat is drained off into the turbopump casing.

At standby ready periods the displacement pump and pump lines stay at a primed condition so that the pilot can get an immediate reaction from his powerplant. At these times heat is added to the lubrication system. For this reason, even at idle, the oil pressure is never below 7 psig. This sustaining pressure also eliminates boiloff of the oil even at extreme altitude.

The XLR99's turbopump has already attained an enviable performance record. It has experienced without malfunction or safety infringement more than 38 hours' running time in 4100 test runs. These have been made on a total of only 25 assemblies.

What is most striking is that in the entire development program, the XLR99 engine, including its turbopump, experienced only one design cycle. After this, nothing was altered in the engine. In effect, the testing program became one of confirming standards of design performance, reliability and safety.

This development cycle contrasts sharply with the one of design, re-evaluation and re-design, characteristic of most turborocket programs.

Low-cost Rocket Designed

Rocketdyne Division, North American Aviation, has entered the weather sounding rocket market with a low-cost solid capable of propelling a 6-lb. payload to 230,000 ft.

Rocketdyne's Solid Propulsion Operations at McGregor, Tex., reported this week it has designed a 73-lb. rocket with 44 lbs. of ammonium nitrate propellant that would produce 660 lbs. of thrust for 12.7 seconds.

Outside diameter would be 4.125 in. Total length with payload would be 105 in. The star-shaped grain was designed to burn progressively—so as to provide low acceleration through the dense portions of the atmosphere.

The rocket would be shipped in a reinforced plastic shipping container that would serve also as a launching tube. The tube and rocket could be loaded into a standard 5-in. gun for firing, or one person could set it up and fire it directly from its shipping container, Rocketdyne said. Four 18-in. folding fins would fall into place to stabilize the rocket on leaving the tube.

The payload would be separated by use of a two-position latch unlocked by acceleration, followed by a spring action at 28,000 ft., at the end of the boost phase. Acceleration would rise from 6 g's at launch to a peak of 29.4 g's at burnout.

The extruded propellant, designated RDS-127A, has a specific impulse of 181 seconds (sea level, 1000 psia). The rocket case of mild steel and the cast nozzle weigh 22.46 lbs. The head closure is a metal stamping riveted with 10-1/8-in. rivets. Pyrotechnic pellets are used for ignition.

Rocketdyne gave these other data:

Performance

Acceleration, g's	
30 milsec after ignition	120
At burnout	29.4
Max. Chamber pressure, psia	800
Average thrust, lbs.:	660
Duration, sec.:	12.7
Total impulse, lb.-sec., 70° F.	7800
Nozzle throat area, sq. in.:	0.85
Nozzle expansion ratio	5
Flame temp, F	2340°
Payload velocity at burnout, ft./sec.:	4600

Dimensions, in.

Case diameter	4.125
Payload diameter	3
Propellant length	82
Propulsion system length	87.25
Total rocket length	104.75
Fin span	18.75
Fin length	10
Fin width	1.5

Weight, lbs.

Case and hardware	22.46
Propellant	43.00
Restrictor	1.54
Payload	6
Total initial	73

Continuous Mix Slashes Labor Costs

Aerojet uses Baker Perkins Ko-Kneader to cut Polaris propellant production force, enhance safety

The continuous mix method of producing *Polaris* propellant has reduced labor costs from 18 to 3 cents a pound, Dr. Karl Klager of Aerojet-General declared last week.

Klager, who heads the company's Propellant Development Division at Sacramento, said the unit cost can be reduced further with higher output.

Aerojet uses a Ko-Kneader machine manufactured by Baker Perkins Inc. of Saginaw, Mich. The machine confines mixing to a maximum of 20 to 25 lbs. of propellant at any one time in a 5-in.-diameter metal cylinder. Under the previous batch-mixing process, 2200 lbs. of propellant were mixed at a time.

The machine mixes material with an interrupted screw through the water-jacketed barrel at 5000 cps viscosity. Temperature is controlled at 80°F. The pasty mixture then passes four stream analyzers that check the quality of the mix.

Aerojet and Baker Perkins said the process produces a higher-grade product with greater safety and reduces the labor force required from 28 to five men. The process also has a shorter "down time" for maintenance. A Ko-Kneader mixing screw and barrel can be replaced in a day or so while a batch mixer requires a week for dismantling and reassembly, Baker Perkins said.

The machine shifts propellant manufacture from a slow, stop-and-go procedure to a closely controlled, continuous stream-flow operation, as in liquid or gas processing, Baker Perkins said. Volume of output can be increased in a ratio of three-to-one over the previous method. The Navy said the process is the "first large-scale application of the continuous mixing process."

An additional safety feature is the fact that material is retained in a continuous mixer for a matter of minutes, rather than the hours required in a batch mixer. Critical areas in the system are under constant observation by closed-circuit television.

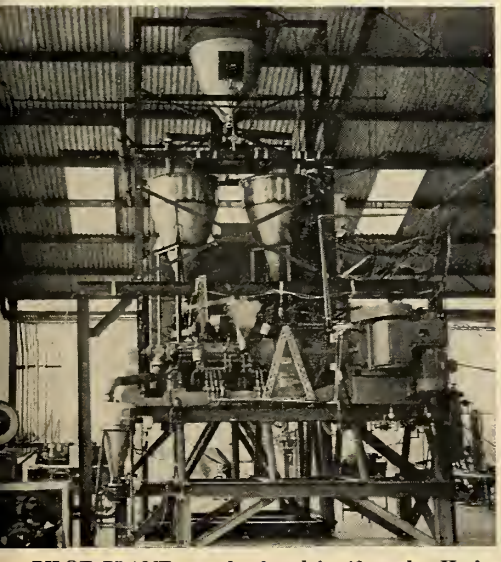
Aerojet propellant engineers calculated that the facility cost for a new continuous installation will be the same or less than that for batch processing at production rates over 500,000 lbs. per month. Operating costs for maintenance and labor are less for continuous mixing at rates exceeding 250,000 lbs. per month.

Several propellant manufacturers are developing continuous mixing processes.

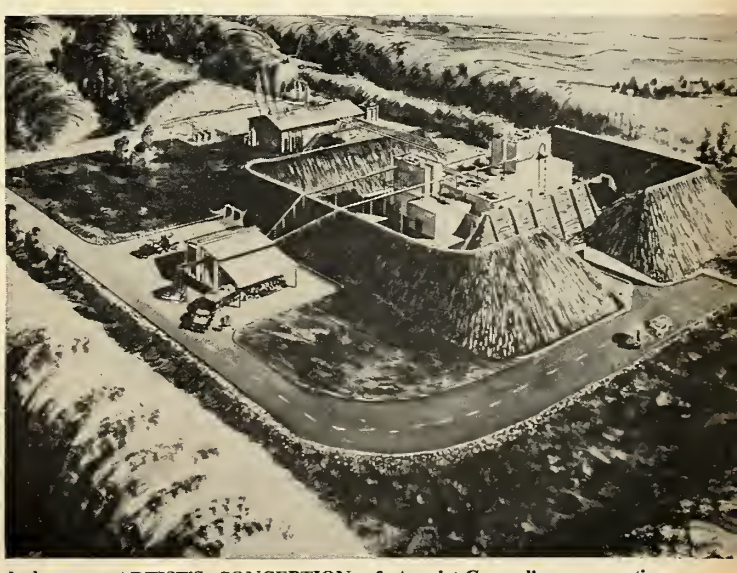
In addition to Aerojet, Thiokol has a plant in development at the Army's Longhorn Ordnance Works, Marshall, Tex., and Rocketdyne is at work on another at an Air Force-owned plant it operates at McGregor, Tex.

The Thiokol process is reported to be under evaluation as a method of producing motors for the Army's *Pershing* Medium Range Ballistic Missile. Rocketdyne's system, based on its high-velocity QuickMix, may be combined with electronic data equipment for completely automated control.

All of the competing processes greatly reduce production costs and improve uniformity of the product.

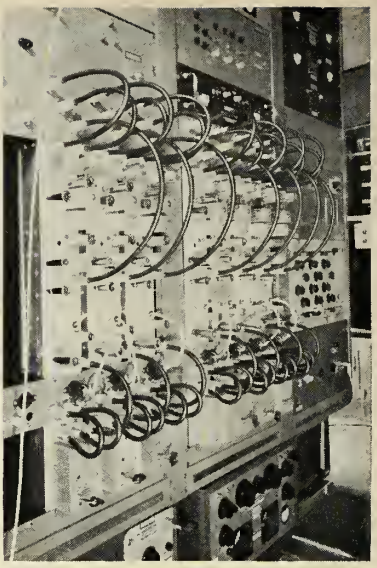


PILOT PLANT was developed in 40 weeks. Horizontal shape (above platform) is "barrel" of Baker Perkins Ko-Kneader.



ARTIST'S CONCEPTION of Aerojet-General's new continuous mix facility, activated for manufacturing Polaris fuel.

UNIQUE SYSTEM using seven 5-element Yagi antennas in conjunction with an electronic scanning device will be employed soon by NBS to observe ionosphere.



ON TRAILER near Yagi array is system's electronic rapid scanning device.

electronics

NBS Antennas Scan Electronically

New array will soon be used at Boulder Labs to study ionospheric phenomena; high resolution promises many other uses

A new unique electronic-scanning antenna array, says the National Bureau of Standards, will be an invaluable research tool in communications and meteorology.

Developed by the Bureau's Boulder Laboratories, near Denver, the high-resolution VHF receiving antenna system employs a narrow beam which sweeps rapidly over a 42° azimuthal arc. The continuous sweep is handled purely by electronic phasing control, says NBS—no mechanically moved parts are used.

• **Elements to be increased**—The array consists of seven 5-element Yagi antennas. These are optimized for a 30-db max. front-to-back ratio. (Side lobes are limited to below −20 db by using Dolph-Chebyshev distribution.)

Full sweep and return, at 1 mc with a 5.8° beam, takes 0.1 second. Since phase shift is changed rapidly, the main lobes rotate uniformly like fan blades and also move through the scanned sector one after another.

An oscilloscope, synchronized to an incoming signal, permits visual readout. Each 5° in azimuth is represented by 1 centimeter on the scope viewer.

To obtain a 1.5° beam width, NBS is now increasing the Yagi elements to 25 each.

• **Broad use seen**—The scanning array will be used primarily to study various ionospheric phenomena, said a Boulder scientist.

Particularly useful in support of ionospheric-scatter communication links, it can be used to pinpoint the direction of the transmitted scatter signal—a feat heretofore impossible. It will also be very useful in determining the best paths for the link.

In this type of VHF radio propagation, the transmitted energy is returned to earth via some combination of reflection and refraction from the relatively dense concentrations of electrons in the lower ionosphere. These scattered signals are weak and may arrive at the receiver site from any number of directions. This, plus the problem of multipath, makes it very difficult to finitely determine the precise direction of transmission.

Many thousands of miles of military scatter circuits have been installed during the last few years because their resistance to polar-blackout fading and other natural degrading influences permits an unusually high reliability.

With this array it would be practical to obtain instantly bearings of ionized meteor trails. The principle, said NBS, is applicable to a design of an antenna array for riometers used in cosmic noise research.

With some modification, the system could be used for multi-directional transmitting and receiving—its chief advantage being the small space requirements for the Yagis. And the high-resolution characteristic of the array offers high potential for many other uses.

OpDevFor Has Make-or-Break Power

by Donald E. Perry

NORFOLK—A severe shortage of test platforms—surface ships, aircraft and submarines—is delaying test and evaluation of many promising Navy R&D programs, particularly in ASW, from six months to more than a year.

This is the word from Headquarters, Command Operational Test and Evaluation Force here, the Navy's consumer research organization.

Industry and national defense are suffering because the work of this important Naval command has been stifled; only through OpDevFor can equipment deficiencies be corrected early, to avoid costly rejections, and only with its go-ahead can volume production be initiated.

Furthermore, this serious lack of tools to do the test and evaluation job is being aggravated by industry itself, the Navy says, in two important areas:

1. Time schedule requests for platform availability are frequently unrealistic because they are based on the assumption that there will be some engineering breakthrough in the state of the art of a program or an equipment.

2. Engineers fail to design for a Navy environment—with the average sailor in mind.

• **Power to make or break**—Oddly, there are many in industry who are unaware of ComOpDevFor's role in the Navy's mammoth management cycle for weapons development—even though the command's decisions usually make or break many industrial plans for going into production. Technically, it does not have the final decision on production; the Chief of Naval Operations can reverse a decision. But there are few such reversals on record.

In simple terms, ComOpDevFor is the organization which receives all Navy products of research and development, tests them in their operational environment and recommends that they be accepted for service use—so that largescale production and installation can be initiated. As such it represents the consumer—the Navy. It is not a development organization, but a partner in development.

Its officers and men are not technical or scientific people; they are experienced fleet-operating personnel. Its mission—and heaven help the company which doesn't realize it—is to insure that equipment, components, systems and weapons can be operated and maintained by the men and officers of the fleet.

"Too many in industry design equipment for the Navy which would take a scientist or a very skilled technician to operate and maintain it," says Capt. C. Blenman, chief of staff.

Capt. Blenman and others in the command feel strongly that simplification in design is too often neglected. Simplification is wanted for several reasons. Navy equipment, probably more than that of the other services, has to be quickly trouble-shooted. This means immediate checkout to locate faults; it's highly desirable that equipment be supplied in modules so that it can be replaced quickly.

• **Demand for technicians**—Most of all, the Navy has a personnel problem. Good technicians are hard to come by; the Navy doesn't have, and possibly never will have, enough of these specialists.

"Industry can help immensely if it realizes that its equipment must be (built) so the average technician and officer can operate it, trouble-shoot it, and maintain it," Captain Blenman says. He adds that industry is doing a commendable job in simulating the operational environment, but he cautions that "it would be good if the design engineer got some field engineering experience."

Navy has programs now to give its Civil Service laboratory and bureau design engineers this experience. There are a number of billets for them to ride ships and aircraft to give them a feel for the operational environment. However, the same can't be done for industry: the Navy feels that one firm would get an advantage over another if representatives observed different types of equipment, whose data must be privileged information. Industry's only recourse is to proselyte the experienced field technicians of Navy bureaus and labs—often by offering them bigger salaries.

ComOpDevFor is a four-pronged service organization. It's concerned with these areas:

1. Antisubmarine warfare (which absorbs 33% of its projects work and about 50% of its time) and manpower services.

2. Surface warfare.

3. Air warfare not applicable to ASW.

4. Combat direction systems (radar, CIC's, etc.).

• **How it evolved**—Rear Adm. William D. Irvin, ComOpDevFor, who probably will add another star soon with his new assignment as Chief of the Defense Communication Agency, explains that the Navy arrived at its present structure for the evaluation process by evolutionary movement.

During the last war the Navy was forced to mass-produce in step with development—a costly practice. It was also forced to develop tactics for utilization of new gear after it was in the hands of the user. Often, there were dire consequences.

In 1945, as the war was ending, the Navy organized a composite task force to develop methods of combatting the devastating Japanese Kamakazi. When the war ended it grew logically into a new organization—the Operational Development Force.

In May, 1959, almost concurrently with establishment of the Deputy Chief of Naval Operations (Development), the present Operational Test and Evaluation Force was erected from the structure of its predecessor.

• **Far-flung operations**—The force is made up of various types of operational ships and aircraft, assigned to and working under operational detachments. The latter are located geographically in areas best suited for their specialties.

Directing headquarters are on the Naval Base here. At San Diego, there's a headquarters staff division responsible for all test and evaluation activity in the Pacific Fleet. This organization also serves as an operational detachment for ASW project work carried out by Pacific Fleet ships. Four ships are under continuous command of this detachment; additional fleet ships are assigned on a temporary basis as the project load varies.

At New London, Conn., OpDevFor maintains a detachment in headquarters of the Underwater Sound Lab. This detachment, with five ships of destroyer and smaller types, gives fleet services to sound laboratories in the Middle Atlantic and New England states. Secondarily, it assists the bureaus in technical evaluation work in

(Continued on page 42)

Satellite Communication Demonstrated

Bell conducts successful moon-relayed voice conversation with JPL in California; advances proven

by Hal Gettings

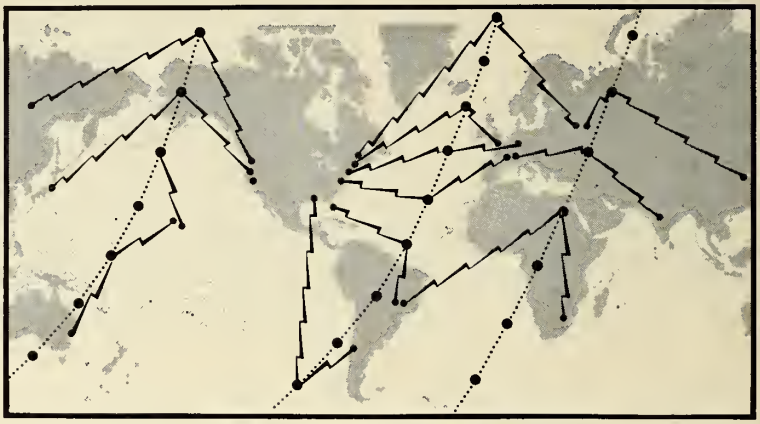
HOLMDEL, N.J.—A new era in commercial communications was foreshadowed here last week when Bell Telephone Laboratories successfully demonstrated the progress it has made on a communication satellite system.

Using the moon as a relay point, Bell engineers carried on a transcontinental two-way voice conversation with Jet Propulsion Laboratory in Goldstone, Calif. An operational system would use artificial satellites—either active or passive—as a relay link.

Equipment used in the initial demonstration was basic, but represented advances made very recently. Transmissions from Holmdel were made using a conventional 60-ft. parabolic antenna at a frequency of 960 mc. JPL transmitted on 2390 mc and used two 85-ft. antennas. The reciving antenna at Holmdel was BTL's recently developed parabolic horn (M/R, 4/11/60).

For the demonstration, the antennas tracked automatically by means of a programed tape. Antenna positions were corrected at one-minute intervals to keep them aimed at the moon. Tracking can also be accomplished by slaving the antennas to a radar or to a telescopic sight.

The high-sensitivity receiving equipment used represented three major advances in low-noise techniques.



GLOBAL NETWORK proposed by Bell would use 50 satellites in random orbits. It could be employed for world-wide commercial and military communications and TV.

HOLMDEL TRANSMITS signals with 60-ft. parabolic dish antenna. Horn antenna (right) is part of low-noise receiving system. Signals received by horn are amplified by ruby-maser amplifier located in cab at apex of horn.

The movable horn-reflector antenna —50 ft. long with a 20 x 20 foot opening—is the largest yet built. Side and back-lobe rejection is extremely high, resulting in minimum pickup of earth noise. Noise temperature of the antenna—when pointed above ten degrees in elevation—is in the neighborhood of 2°K. Comparable conventional systems have a noise temperature of around 1000°K.

A synthetic-ruby maser amplifier is used in the receiving system to further enhance its sensitivity. Noise generated by the maser is approximately one-hundredth that of ordinary electron-tube amplifiers.

Another improvement is a special demodulation circuit developed for space communications. This is an FM feedback loop in the receiver circuitry which gives a hundred-fold increase in signal-to-noise ratio.

Overall noise temperature of the complete receiving system is about 20°K—many times more sensitive than any ordinary system.

• **Large investment**—Bell has already invested over a half million dollars in its satellite communication system. Its research is aimed at establishing a global communication network with 50 relay satellites in random orbits at 3000-mile altitude. The satellites would serve as microwave relays to carry TV signals and hundreds of telephone calls around the earth. Facsimile mail and other services not yet foreseen

might also conceivably be handled by such a system.

Based on present trends, Bell anticipates that present communication facilities will soon be woefully inadequate. Overseas telephone calls—which totaled 3,000,000 in 1959—are expected to reach 100,000,000 by 1980. Such an increase would require 50 undersea cables across the Atlantic.

Worldwide television is impossible with present techniques. But satellites could provide global TV coverage and handle all requirements for commercial and military communications as well.

A global system, including TV capability, would cost an estimated $170 million. A system linking Bonn, Paris, London, and Hawaii with the United States would cost an estimated $82 million.

Present plans favor active repeaters over passive reflectors such as the NASA *Echo* satellites. Early experiments, however, will be run with the passive type.

The active repeater being considered is a four-ft.-diameter sphere weighing about 50 lbs. It would have a one-watt transmitter using a traveling-wave tube with a useful life of 10 years or more.

Power supply for the receiver and transmitter equipment would probably be nickel-cadmium storage batteries and transistor inverters. Batteries would be recharged by solar cells.

• **Work started 30 years ago**—The choice of Holmdel as the site of the experiments was particularly fitting. It was here 30 years ago that the late Karl Jansky set up the first radio telescope to discover the origin of solar noise. His work led utimately to the science of radio-astronomy.

The first serious proposal of artificial satellites for communications appeared in a British electronics magazine in 1945. Specific satellite communication possibilities were set forth by a Bell scientist in 1955—two years before a satellite had been put into orbit.

The probable extent of atmospheric noise at various frequencies and its effect on space communications was defined in 1957; in the same year, the first solid-state maser was built.

Since that time solar cells have been improved and have demonstrated their practicality as a satellite power source. Work has continued on the development of high-frequency, long-life transistors and longer-life microwave tubes for possible use in satellites.

It will still be some years before we have a satellite communication network, but the groundwork has been laid. Last week's experiments prove that such a system is no dream; it is, in fact, the next step in practical and profitable worldwide communications.

Goldstone Uses Now-silent Tiros I for Bouncing Signals

by Richard van Osten

CAMP IRWIN, CALIF.—Goldstone Lake Tracking Station has been bouncing radio signals off the still-orbiting-but-now-silent *Tiros I* weather reconnaissance satellite since late last spring.

The project began as an early evaluation and checkout by Goldstone operators, Jet Propulsion Laboratory and National Aeronautics and Space Administration, of basic systems to be used in Project *Echo*.

The most recent demonstration was a two-way conversation on Aug. 3 between this windy desert site and the Holmdel, N.J., facility of Bell Telephone Laboratories, in which voice signals were bounced off the moon.

The *Tiros*-reflected experiment was one of Goldstone's most difficult tasks to date, although the station has been heavily involved with space probes since it began tracking operations about two years ago. The *Tiros*-bounces also were among the first uses of the site's newly constructed transmission system which became operational early this year.

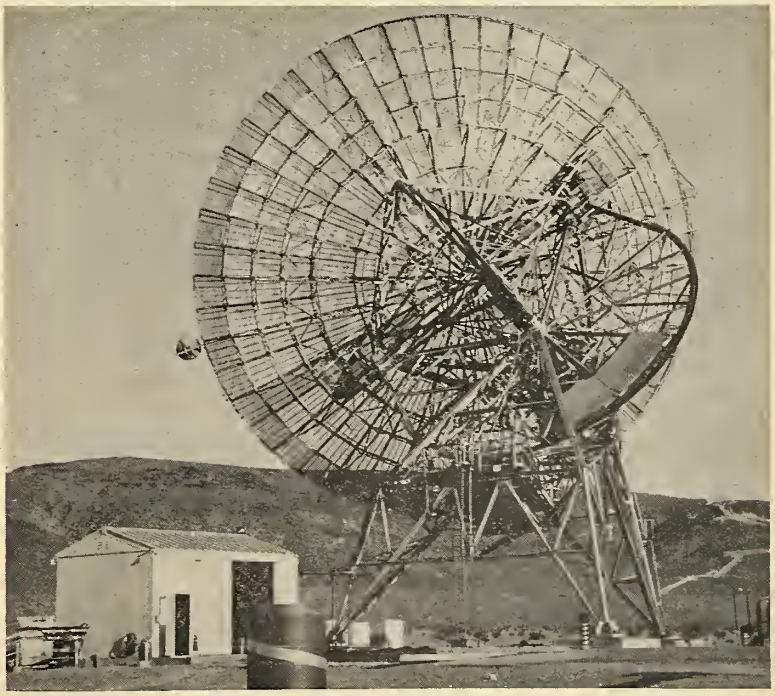
The relatively low orbital path of *Tiros*, something just under 500 mi., limits Goldstone's visibility of the satellite to about 10 min. when the vehicle's track over the earth brings it near the site's range. Lacking time to scan and acquire *Tiros* itself, Goldstone uses acquisition information supplied by the Vanguard computation center in Washington, D.C.

With the almost exact point-in-space of *Tiros* known, Goldstone's systems are able to track the satellite during its pass from horizon to horizon. While not always perfect, the percentage of success has been high.

The computed tracking data is punched into a paper tape. Playback of the tape supplies the input for positioning both the transmitter and receiver antennas.

Goldstone's new transmitting antenna is an 85-ft.-diameter parabolic dish. Mounted on an Az-El (for azimuth and elevation) mount, the antenna may be rotated 360° in azimuth and 91° in elevation.

Simultaneous tracking and operation of both antennas is simplified by slaving the transmitting antenna to the receiving antenna by servomechanisms. This automatically places the transmitter on the same target as the re-



RECEIVING ANTENNA at Goldstone is 85-ft. polar-mounted unit. Small antenna on left side of dish calibrates larger unit. Exclusive M/R photo by Richard van Osten.

ceiver. To correct for parallax and change coordinates from hour angle-declination to azimuth-elevation a special computer system was designed. Both antennas have a TV camera system which provides an optical means of checking antenna positions in relation to their target.

The transmitter is driven by a 10kw klystron power amplifier, working through a feed horn mounted above the antenna saucer to illuminate the parabola. Excitation of the power amplifier can be furnished by a crystal oscillator or self-excited oscillator. Frequency output of these units is multiplied 75 times and used to excite the klystron final amplifier.

• **Power varies**—Nominal output frequency is 2390 mc, as used in the moon-bounce conversation. *Tiros* bounces, however, are usually conducted at 2388 mc. At the 2390 mc frequency, beam width of the transmitter signal is about 0.25° spreading out to 2160 mi. in width at moon distance—almost equal to the moon's diameter.

The transmitter's nominal power is rated at 10Kw, but more often than not only about 8Kw is used. In the case of the moon-bounce, power was close to the full 10Kw. This was split down the middle into 5Kw carrier and 5Kw single side band.

Return signals, either from the moon or from *Tiros,* vary in strength in relation to the reflecting object's distance as well as other conditions. Despite the small size of *Tiros* (about 19 in. x 42 in.), strength of the reflected signal is fairly close to that reflected from the moon's surface. The difference in distance from the earth compensating for the relative diameters of the two surfaces.

In both cases, the weakest signal return has been barely 35 dbm (decibels below 1 milliwatt) above the threshold of the present equipment which is on the order of –145 dbm or 2×10^{-18} watts. This condition will be improved greatly in the future with installation of a more advanced low-noise amplifier.

Signals reflected from *Tiros* vary from 10^{-17} watts at the low end to 10^{-14} watts on the stronger side.

Bounces from the moon vary little with the frequency used. In the transcontinental telephone communications, Goldstone transmitted on 2390 mc and received on 960 mc from BTL. JPL engineers say that, under average conditions, the reflected signal is approximately –113 dbm at 2390 mc and –117 dbm at 960 mc.

• **Are you there?**—An interesting aspect of space travel communications was demonstrated by the time delay in the voice signal's return. For a simple, two-way transmission between an earth-based station and a space vehicle located at about 225,000 miles from earth, there is little delay. The demonstrated signal took 2.4 seconds to cover a 450,000-mi. round trip to the moon.

If, however, a second earth-based control station is added to the circuit and the situation is such that "advice" is needed from both points, things become more difficult. Multiple delay factors can garble messages so badly that communication would be impossible—especially if a three-way link is required. But the distance-delay relationship poses still another potential problem.

Assuming a space vehicle at X-million mi. from the earth, and assuming an emergency exists where advice from an earth base is required, it is possible that the time delay may create a serious psychological obstacle. Crew reaction might easily be one of panic and fear wondering "Why don't they answer?" Both the long delay and multiple station factors were clearly demonstrated at Goldstone by Walter Victor, chief of JPL's communications systems research section. The five-second delay between Goldstone-moon-Holmdel-moon-Goldstone seemed forever. Yet the distance was only about 900,000 mi.

• **Expansion plans**—But these are the things Goldstone is discovering and studying. As an arm of JPL and NASA charged with deep space exploration projects such an *Ranger* tracking, Goldstone is setting up also the first of a three-station Deep Space Instrumentation Facility.

The initial site is Goldstone. It will also serve as a R&D facility to determine the exact configuration of the other two sites.

Second DSIF site will be at Woomera, Australia. A JPL crew has been in Woomera since spring directing construction of an 85-ft. receiving antenna duplicating present equipment at Goldstone. Former Goldstone chief Walter Larkin is directing the "Down Under" work. It will later be headed by RAdm E. H. Conklin, USN (Ret.), and will go into operation by the year's end. A transmitting system, also similar to Goldstone's is planned for a later date.

A third station is planned for South Africa, probably near Johannesburg, and negotiations for the site are under way.

The stations are approximately 120° of longitude apart to provide continuous contact with space probes and eventually, space vehicles.

Highly stable platform . . .

SD-5 Drone Can Spy 200 Miles Away

Army's new system by Fairchild supplies field commander with five types of instantaneous data

The Army's newest drone surveillance system can provide commanders in the field with "real time" information from behind enemy lines—up to 200 miles away.

Designated *AN/USD-5,* the Fairchild drone flies at Mach 0.7 and is capable of sustained flights in excess of 200 miles.

Five sensory packages permit radar, infrared, photographic, photogrammetric and radiological detection and measurement. Television electromagnetic and nuclear sensory subsystems are being considered for future integration.

Two guidance systems allow the field commander to monitor enemy movements as they occur, or set the drone on a preprogramed flight. Information is relayed instantaneously to him in pictorial form through data processing equipment in one of two control huts.

Capable of target acquisition services for missiles in the *Pershing* class, the system also can provide information on the effects of local missile impact—either friend or foe.

The system can operate day or night in any weather and will not be fooled by camouflage. Its high speeds make it relatively safe from enemy interference.

• **Turbo-jet-powered**—*SD-5* is powered by a J60 Pratt & Whitney 3000-lb.-thrust jet engine. A 4000-lb.-thrust solid-propellant booster is used to launch the 4.5-ton drone from a zero-length launcher.

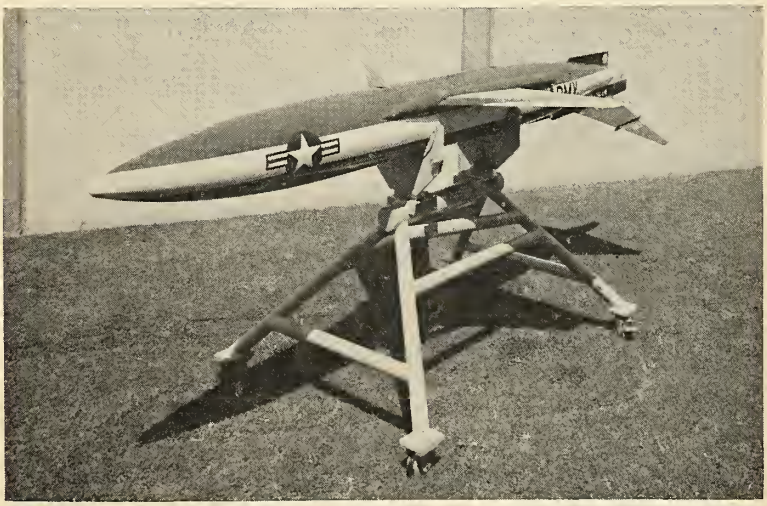
The delta-winged bird is about 36 ft. long and 24 ft. in wing span. Its design differs from a conventional target drone in that its surveillance missions require a highly stable platform, even under conditions of air turbulence.

• **Recoverable**—After accomplishment of mission, the drone can be recovered and reused. It is parachuted to a selected open area by twin parachutes deployed from a compartment above the fuselage. Pneumatic bags are released from under each wing and the nose, cushioning the landing. After cleaning, checking and repacking of the chutes and bags, the drone is ready for another mission.

ARMY'S NEWEST DRONE—Developmental model of AN/USD-5 gets finishing touches at Fairchild Engine and Airplane Corp. High-performance surveillance drone will be operational in mid '63.

Scheduled for deployment with troops in mid-'63, the *AN/USD-5* will cost $350,000 to $400,000 per unit, including ground support equipment. Launch facilities, including control and checkout huts and launcher, have been estimated at $2 million per site. RDT&E funds budgeted through Fiscal 1961 total $48.6 million.

Fairchild Engine and Airplane Corp. is prime contractor for the Army Signal Corps, under supervision of Army Combat Surveillance Agency, with technical direction by the U.S. Army Signal Research and Development Laboratory at Fort Monmouth, N.J.



SUPERSONIC TARGET MISSILE, Radioplane's RP-76-X4 drone is capable of operating at altitudes in excess of 60,000 ft. at speed of Mach. 1.4.

soviet affairs

By DR. ALBERT PARRY

High praise of the rocket gunners

who allegedly hit the U-2 continues in the Soviet press. In the process, bits of data on the missile branch of the Red armed forces are revealed. Good examples of this are in a series of articles by Victor Ushakov in *Izvestia* for July 14, 15, 16, and 20, and an article by Lt. Colonel S. Yelistratov in the July 16 *Krasnaya Zvezda,* the daily organ of the Soviet ministry of defense.

Introduction of rocketry

"has permitted a manifold cut in the personnel of the antiaircraft troops" of the U.S.S.R., according to a quote attributed by Ushakov to Marshal Sergei S. Biryuzov, head of Russia's antiaircraft defenses since 1954. The *Izvestia* writer then quotes Major Michael R. Voronov, commander of the rocket unit credited with shooting down the U-2, as claiming that "by its firing capacity, one rocket can now replace a whole artillery battalion of large-caliber guns serviced by nearly 600 men," whereas in the battery which ostensibly shot down the U-2 "one rocket is managed by only 3 men."

Most of these rocket gunners

are young technicians specially trained for missiles. But their commander, Major Voronov, is a World War II veteran who rolled with his antiaircraft guns all the way to the siege and capture of Berlin. "He is an old ack-ack man," Ushakov goes on. "All of his army life has been tied with our antiaircraft service." He praises the major's adaption to the Space Age: "In a short time, along with his subordinates, he mastered the new technology, which asks of the commander not only a knowledge of its tactical features and actual battle points, but also an ability to understand deeply the complex schemes of radar installations and computers."

The rocket said to have hit

the U-2 was reportedly fired by Senior Lieutenant Eduard Emilievich Feldblum. All three of his names denote his German (possibly Baltic) origin. "This was his *first* war-rocket, shot at the *first* battle target! This fact speaks volumes about the infallibility of our war technology and the high-grade training of our rocket-men." Regarding Feldblum's personality, Ushakov continues: "He is a young, cultured officer. He is known as 'our ace in aiming.'" To refute Western suggestions that the U-2 may have been hit by a fighter-interceptor rather than a rocket, Ushakov quotes Feldblum as saying that his rocket hit the tail of the U-2; that this "saved the pilot from an imminent death" and presumably was the reason so much of the plane itself came down intact.

Radar policing of Soviet skies

Is done by zones, each consisting of "several hundred kilometers of air space" and under a separate tracking command, Ushakov writes. The aggregate of the zones is called "the unified radar field." The separate commands are in constant touch with one another, "handing over" to their neighbors any flying subject as it leaves the confines of each given zone. Soviet radar men boast (according to Ushakov): "Our screens will spot even a metallic flea, even if such a flea appears in the stratosphere itself."

Training of Red rocket gunners

is described at some detail in the *Krasnaya Zvezda* article by Lt. Col. Yelistratov. Among other things, he says that he watched a "very clever" problem being given to a detachment of Soviet rocket gunners. The problem's author, "knowing well the capabilities of this detachment, also its most vulnerable spots, had tried in all possible ways to complicate the work" of the officers and men. "But the rocket-men's collective responded in harmony and with efficiency and knowledge," and solved the problem quickly.

COMOPDEVFOR

(Continued from page 37)

ASW and certain other specialties such as communications.

At Key West, OpDev Forces' major effort in ASW is concentrated. A Test and Evaluation Detachment has six ships of destroyer and smaller size. When it becomes necessary, other fleet ships are assigned on a temporary basis for the prosecution of a particular project. The Key West Detachment covers the field in ASW—from detection thru localization and classification to kill. Since mine warfare is directly related to ASW, they specialize in all phases of this as well.

Air Development Squadron One is located six miles north of Key West at Boca Chica Naval Air Station. This unit, made up of land planes, seaplanes, carrier based and rotary wing aircraft, specializes in all phases of ASW.

• **Handling assignments**—OpDevFor looks to the CNO for top management coordination of the RDT&E program. The developing agencies, which are the bureaus, report the readiness of their products for test and evaluation processing and request that CNO set up projects for prosecution of these tests. The CNO makes a formal project assignment to OpDevFor; this is equivalent to a work order.

OpDevFor then translates the project assignment into a detailed test or evaluation plan, which when fully developed will provide a pattern of tests and operations. Then the results obtained are analyzed, evaluation conclusions are reported, and there are recommendations on the product and a concurrent development of basic doctrine, tactics and training procedures needed for its utilization by the operating forces. The entire procedure is designed to make the CNO capable of rendering prudent decisions on programs implementation.

A little over half of OpDevFor's active projects are for fleet assistance to developing agencies, i.e., to bring the development along. They are called Fleet Assists. Today, in ASW alone, it is engaged in 51 of these; at the same time, it is prosecuting 42 operational evaluations—for a total of 93 active and current ASW projects.

ComOpDevFor feels that much more can be done quickly if industry cooperates in giving the various cognizant bureaus realistic schedule dates for test and evaluation. For it takes nine months to put a system of moderate complexity through the OpDevFor process. And if the command gets the requirements far enough in advance the waiting cycle can largely be eliminated.

Capsule to Closely Simulate Space

The test space capsule which AiResearch will build for the Air Force may come closer to matching conditions of space travel than anything else constructed to date.

Under a Wright Air Development Division contract, totalling $235,000, AiResearch will develop a cabin, life support system and monitoring equipment by spring, 1961.

What makes this capsule unique is that it is both lightweight and mobile and can be placed on a centrifuge, in altitude chambers and other environmental simulators. Several factors can be simulated at one time, such as isolation and g forces, or radiation and altitude. Stresses of launch, orbit and re-entry for long or short flights can be tested in succession.

The Los Angeles subsidiary of The Garrett Corp. says the cabin will be fabricated from aluminum alloy in an all-welded construction. Ground-based and fully-sealed, the structure will be a cylinder 6 ft. in diameter and 8 ft. long.

The cabin will be capable of sustaining a limit load factor of 20 g's along the longitudinal axis and three g's along the other two axes. These combined with an external pressure differential of 13.3 psi at 250°F.

Entry and exit will be made through a removable airlock, which can be occupied by an observer for periods up to four hours. Two closed TV systems will monitor tests.

Components of the life support system will consist of pressurization, atmospheric control and temperature control for pressure suit and the compartment environment.

One of AiResearch's recent projects has been a survey of the extent of knowledge the U.S. possesses in the life science field.

As the chart shows, the biggest problem facing space flight researchers is lack of knowledge about combined stresses. Some of these will be studied with the AiResearch capsule.

Area of Interest	Stressors	Inadequate for Manned Space Flight		Adequate for Manned Space Flight of: Hours				Days						Years	
				1	3	10		1	3	10	30	100		1	3
Biophysics	Temperature Limitations	X	X	X	X	X	X	X	X	X	X	X			
	Pressure and Partial Pressures	X	X	X	X	X	X	X	X						
	Relative Humidity	X	X	X	X	X	X	X	X	X	X				
	Accelerations														
	Linear	X	X	X	X	X	X	X	X	X	X	X	X	X	
	Angular	X	X	X	X	X									
	Radial	X	X	X	X	X	X	X							
	Accelerations As Above After Weightlessness	X	X	X	X	X									
	Weightlessness	X	X	X											
	Radiation														
	Gonadal Dosage Effects	X	X	X	X	X	X	X	X						
	Total Body Effects	X	X	X	X	X	X	X	X	X	X	X			
	Air Ionization in Space Vehicle	X	X	X	X	X	X	X	X	X	X				
	Noise	X	X	X	X	X	X	X	X	X	X	X			
	Vibration	X	X	X	X	X	X	X	X	X	X				
	Effects of Combined Biophysical Stressors	X													
Biochemistry	Metabolism	X	X	X	X	X	X	X	X	X	X				
	Energy Requirements	X	X	X	X	X	X	X	X	X	X	X			
	Water Cycle	X	X	X	X	X	X	X	X	X	X				
	Food-Waste Cycle	X	X	X	X	X	X	X	X	X					
	Air Cycle	X	X	X	X	X	X	X	X	X	X				
	Atmosphere	X	X	X	X	X	X	X	X						
	Toxicology														
	Materials, Finishes and Processes	X	X	X	X	X	X	X	X	X	X				
	Drugs	X	X	X	X	X	X	X	X	X	X	X	X	X	
	Odors	X	X	X	X	X	X	X	X						
	Chemicals and Fuels	X	X	X	X	X	X	X	X	X	X				
	Effects of Combined Biochemical Stressors	X													
Psycho-Physiology	Maintenance of Muscle Tone	X	X	X	X	X	X	X	X						
	Physical Effort Required for Tasks	X	X	X	X	X	X	X	X	X					
	Work-Sleep-Recreation Cycle	X	X	X	X	X	X	X	X	X					
	Fatigue														
	Physical	X	X	X	X	X	X	X	X	X	X	X			
	Emotional	X	X	X	X	X	X	X							
	Disorientation	X	X	X	X	X	X	X							
	Effects of Combined Psycho-physiological Stressors	X													
Space Vehicle Operation	Cabin Space Requirements	X	X	X	X	X	X	X	X	X	X				
	Man-Machine Relationship	X	X	X	X	X	X	X							
	Emergencies														
	Fire and Explosion	X	X	X	X	X	X	X	X	X	X	X			
	Decompression	X	X	X	X	X	X	X	X	X	X	X	X	X	
	Illness and Injury	X	X	X	X	X	X	X	X	X	X	X			
	Major Environmental Control System Failure	X													
	Attitude Control Failure	X													
	Integration of Environmental Control Systems With Other Vehicle Systems	X													

contracts

NASA

Collins Radio Co., Dallas, or investigation of communication problems involved in landing an unmanned space craft on the moon. Subcontract from McDonnell Aircraft, St. Louis. Amount not disclosed.

$65,000,000—Douglas Aircraft Co., Inc., Santa Monica, for development of the S-IV stage of the *Saturn* space vehicle. Includes design, research, development and manufacturing phases.

$7,609,987—The Chrysler Corp., Detroit, for engineering services for *Saturn*, *Mercury* and *Juno II* programs.

$5,719,534—Brown Engineering Co., Huntsville, for engineering, fabrication and related services on the *Saturn*, *Juno II*, *Mercury* and *Pershing* programs.

$4,251,400—Hayes Aircraft Corp., Birmingham, Ala., for engineering, fabrication and associated services in connection with *Saturn*, *Juno II* and *Mercury* programs.

$1,382,540—Lockheed Aircraft Corp., Marietta, Ga., for engineering, fabrication and related services on the *Saturn* project.

$607,928—Redstone Machine & Tool Corp., Huntsville, for fabrication services in connection with *Saturn* and *Mercury* projects.

$601,580—Spaco Manufacturing Co., Huntsville, for manufacturing and assembly work on *Saturn*.

$213,500—Watland, Inc., Chicago, for microfilming and the operation of a technical documentation facility.

$154,000—Reynolds Electric & Engineering Co., Inc., Freeport, Texas, for maintenance, modification and checkout of electrical equipment at the Marshall Center.

AIR FORCE

$7,155,222—Philco Corp., Philadelphia ($3,138,848) for engineering, installation of equipment in modernization of air communications technical control facilities ($4,016,374) for modernization of worldwide communications stations.

$3,314,675—General Electric Co., Heavy Military Electronics Dept., Syracuse, for production of advanced high-power search radars.

$3,291,300—Eitel-McCullough, Inc., San Carlos, Calif., for klystron-type electron tubes.

$950,000—Northrop Corp., Norair Div., Hawthorne, Calif., for research in boundary layer control, low drag.

$583,413—American Hydrotherm Corp., L.I., N.Y., for non-personal services for on-site operation, maintenance and supply support of the SAGE utilities system.

$302,521—The M & T Co., Philadelphia, for non-personal services for on-site operation, maintenance and supply support of the SAGE utilities system.

$283,000—General Precision, GPL Division, Pleasantville, N.Y., for modification kits for radar navigational sets.

$250,000—Ruska Instrument Corp., Houston, for manufacture of dead weight gauges to be used on missile sites.

NAVY

$3,500,000—Chance Vought, Aeronautics Division, Dallas, for installation of an electronic guidance system in *Regulus I*.

$587,321—Telerad Manufacturing Corp., Flemington, N.J., for work on the URM 64-A.

$500,000—Universal-Cyclops Steel Corp., Bridgeville, Pa., for process development in the production of molybdenum alloy sheet.

$130,000—The Siegler Corp., Hallamore Electronics Div., for installation of telemetry equipment on Pacific Missile Range's new instrumentation ship, the yet unmanned AG-161.

ARMY

$1,508,622—Sperry Utah Engineering Laboratory, Salt Lake City, for *Sergeant* training material and publications.

$759,398—Nortronics Div., Northrop Corp., Anaheim, Calif., for *Hawk* missile repair parts.

$680,889—Eidal Manufacturing Co., Inc., Albuquerque, N.M., for trailer chassis.

$646,000—Convair Div., General Dynamics Corp., San Diego, for research on re-entry radar.

$456,474—Greenhut Construction Co., Inc., Pensacola, Fla., for construction of *GAM* facilities at Columbus AFB.

$443,971—Aerojet-General Corp., Downey, Calif., for research and development of rotor assembly machines.

$298,699—Nortronics Div., Northrop Corp., for engineering services.

$285,031—Aerojet-General Corp., Downey, for classified work.

$249,521—Aerojet-General Corp., Azusa, Calif., for R&D of airborne instrumentation.

$204,953—Cubic Corp., San Diego, for R&D on fabrication, installation and checkout of electronic trajectory measuring system.

$200,000—Hughes Tool Co., Aircraft Div., Culver City, Calif., for development of refractory composite material systems.

$199,805—Hughes Research Laboratories, Div. of Hughes Aircraft Co., Malibu, Calif., for R&D of rocket liner material.

$172,698—Rocket Power/Talco, Div. of Gabriel Co., Pasadena, for catapults.

$164,307—Raytheon Co., Andover, Mass., for replenishment spare parts for *Hawk* system.

$159,582—Consolidated Western Steel, U.S. Steel Corp., Los Angeles, for motor case assemblies.

$158,933—Douglas Aircraft Co., Inc., Santa Monica, for *Nike-Hercules* launching area items and adaption kits.

$146,755—Ling Electronics, Div. of Ling-Altec Electronics, Inc., Anaheim, for vibration testing system.

$124,837—Thompson Ramo Wooldridge, Inc., Canoga Park, Calif., for telemetering systems.

$113,408—Aerojet-General Corp., Azusa, for study of stress-corrosion cracking of high-strength alloys.

$95,369—Sperry Utah Engineering Laboratory, *Sergeant* equipment and repair parts.

$92,900—M. W. Hills Construction, Salina, Kan., for construction of re-entry vehicle, Schilling AFB.

$90,193—Associated Aero Science Labs, Hawthorne, Calif., for civilian technical assistance at Redstone Arsenal, Ala.

$80,241—Rocketdyne Div., North American Aviation, Inc., Canoga Park, Calif., for classified work.

$71,805—Information Systems, Inc., Los Angeles, for R&D of a magnetic-optic converter.

$70,771—Preshaw & Thompson, Inc., Van Nuys, Calif., for baroswitch test sets.

$61,000—University of Southern California, Los Angeles, for basic research in radiation.

$57,830—Autonetics Div., North American Aviation, Inc., Downey, Calif., for R&D of a digital computer.

MISCELLANEOUS

$92,695—Thompson Ramo Wooldridge, Inc., Cleveland, for SNAP-1 endurance testing program.

$55,244—Aeronautics Div., Chance Vought Aircraft, Inc., Dallas, for study of possible consequences of accidental loss into the ocean of power source devices (*Pluto*, *Rover*, SNAP) designed for use in space.

reviews

THEORY OF THERMAL STRESSES, Bruno A. Boley and Jerome H. Weiner, John Wiley & Sons, New York, 586 pp., $15.50.

This text is probably one of the most complete treatises yet written in English on the subject of structural stresses under elevated temperature conditions. The authors are both teachers and consequently the book leans heavily on the theoretical side. But this is good for students and practicing engineers who have learned to eschew the handbook approach when a problem must first be understood before it is solved.

The book is divided into four parts. In the first the fundamentals of thermoelasticity are developed. In part two, the authors give an account of heat transfer theory, and with methods of solving heat conduction boundary-layer problems.

The interesting part for engineers is the third. This one deals with the more practical aspects of thermal stress analysis, mainly from the strength-of-materials viewpoint. Part four deals with the newest science of inelasticity theory; temperature is a parameter.

THE EXPLORATION OF THE SOLAR SYSTEM, Felix Godwin. Plenum Press, New York. 200 pp., $6.50.

The book discusses the development of exploratory colonies on the Moon, Venus and Mars, as well as aspects of interplanetary travel and the setting up of space stations.

PHYSICS OF THE UPPER ATMOSPHERE, Edited by J. A. Ratcliffe, Academic Press, New York. 586 pp., $14.50.

There is little doubt that this book will be a standard reference for geophysicists and for workers concerned with flight through the upper atmosphere.

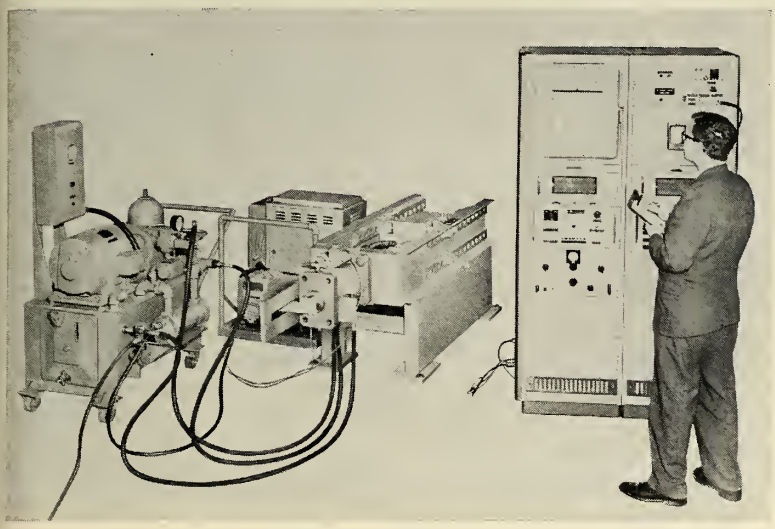
Each of the contributors to the volume has written a monograph about his speciality. And each contributor is a highly regarded authority in his field.

Sidney Chapman wrote about the thermosphere; M. Nicolet, properties and constitution of the upper atmosphere; Homer E. Newell, Jr., the upper atmosphere studied by rockets and satellites; Herbert Friedman, the sun's ionizing radiations.

D. R. Bates contributed theses about the airglow, general character of auroras, and the auroral spectrum and its interpretation.

Henry G. Booker contributed radar studies of the aurora; J. A. Ratcliffe and K. Weekes, the ionosphere; E. H. Vestine, the upper atmosphere and geomagnetism; J. S. Greenhow and A. C. B. Lovell, the upper atmosphere and meteors.

To make the book as modern as possible, and to take advantage of the work done during the IGY, the authors joined together at a late date to write the final chapter, "Advances during the IGY 1957/58." Thus the volume includes information available up to December, 1959.



Advanced Metal Testing Machine

A materials-test machine for advanced cycling or fatigue testing of specimens or structures under compression-tension and elevated-temperature conditions has been introduced by the CompuDyne Corp.

Called the Dynatest, it is capable of cycling up to 20 cps, and of following a typical program heating rate of 200°F. per second. The maximum heating rate is dependent upon the configuration of the specimen.

The Dynatest is an electrohydraulic unit with individual closed-loop systems for force and heat loading. It employs a high-speed ram that delivers up to an 8 in. stroke at a velocity of 1 in. per second at rated load.

The standard force-loading channel has multiple ranges from 200 to 50,000 lbs. full scale, and a selector switch that permits ranges to be changed without mechanical adjustment. Steady-state accuracy of the force-loading system is ± 0.5% of the selected range. Dynamic accuracy is within ± 1% of selected range.

Circle No. 225 on Subscriber Service Card.

Test Indicators

A line of test indicators are available in 0.001 and (subdivided in 0.0005 by a dot), also in 0.0001 graduation from Mueller Laboratory.

The movement of the indicator is always clockwise when changing direction of pressure on the contact point. The contact point will not slip and operates in a 186° arc. 1/32 contact points are available in carbide and hardened tool steel. Contact points are threaded for interchangeability.

Circle No. 226 on Subscriber Service Card.

Turbine Fuel Flow Control

A turbine fuel control weighing only 1.875 lbs., complete with shut-off solenoid, has been added to the extensive family of similar controls built by The Garrett Corp.'s AiResearch Manufacturing division.

Capacity of the unit's gear type pump is 200 lbs/hour of JP-4 at 200 psig and 4250 rpm. The control will also handle gasoline or diesel fuel.

Fuel flow scheduling and limiting is pneumatically regulated from the compressor during acceleration. For a metered flow variation of 10 to 60 lbs/hour a 4% speed drop is typical.

Circle No. 227 on Subscriber Service Card.

Subminiature Housing

Mitronics, Inc., manufacturers of custom metallized products have developed an extremely subminiature metallized housing with an O.D. of 0.030 in. and an I.D. of 0.012 in.

This ceramic part is 0.008 in. thick including the metallized portion. The part is metallized with molybdenum manganese and nickel plated on both flat surfaces. The part can be hermetically sealed by brazing or soft solder.

Circle No. 228 on Subscriber Service Card.

Airborne Tape Programer

An Airborne-type tape programer is available from the EECo. Anaheim Electronics Division.

The TP-813 Tape Programer is mechanically and electrically interchangeable with similar units. It has a tape capacity of 75 ft. of 35 mm mylar film or equivalent to a 20-minute program at standard speed of 0.748 in. per second. Contacts of the TP-813 are rated at 0.4 amperes.

Circle No. 229 on Subscriber Service Card.

Motorized Grinding Unit

A compact, precision, motorized fixture that enables through-feed or form grinding operations to be efficiently performed on cylindrical parts with conventional surface grinders is available from Products Supply Co. It can be used for either production or tool-room operations.

Called the Mini-Grind fixture, the device utilizes a unique outside diameter driving and adjustable roller clamping arrangement that provides absolute concentricity and avoids the use of centers, chucking devices or indicators.

Circle No. 230 on Subscriber Service Card.

Liquid Level Controller

Consolidated Vacuum Corp. is marketing a completely automatic Liquid Nitrogen Level Controller, Type BC-003, for electronically regulating the flow of liquid nitrogen and other coolants. Designed primarily for use with the new CVC multi-coolant-type vacuum baffles, the controller can also be used in any similar application where low temperature cooling is required.

Circle No. 231 on Subscriber Service Card.

Ratemeter-Spectrometer

A ratemeter-spectrometer featuring high versatility, moderate cost and compact size is now available from Tracerlab. The single channel Model SC-80 incorporates a super stable high voltage power supply, linear amplifier, pulse height analyzer and precision ratemeter, and as an optional feature, can be provided with a four-speed threshold drive for automatic spectrum scanning.

Circle No. 232 on Subscriber Service Card.

Superalloy Available

A WI-52 cobalt-base high-tungsten superalloy that possesses greatly improved high temperature strength in the

1800°F range with good ductility and corrosion resistance is now commercially available in both shot and ingot form from WaiMet Alloys Co.

Refining techniques and precise control of the important alloying elements have increased 1800°F stress rupture life by 18% and rupture elongation by 160% over previous alloy variations.

Circle No. 233 on Subscriber Service Card.

Rupture Disc Line

A wide selection of rupture discs designed to give peak performance under a variety and combination of stresses is offered by Fike Metal Products.

One of the developments is the H-O and H-O-V rupture disc. This disc is designed to withstand operating pressures closer to rupture pressure than has been considered acceptable for conventional prebulged rupture discs.

Constructed from various thicknesses of ductile metals, Fike rupture discs range in size from 1/8 in. through 30 in., for pressures up to 50,000 lbs.

Circle No. 234 on Subscriber Service Card.

Removable Contacts

The Electronics Division of DeJur-Amsco Corp. has introduced a series of miniature rectangular continental connectors with crimp termination removable contacts.

The removable contact features an extra-wide, three-tine spring clutch on pin and socket to provide maximum holding area between contact and molded block. All sharp-edged, "molded-in" metal inserts have been eliminated. Socket and pin contact material is phosphor-bronze, gold plate over silver plate.

Circle No. 235 on Subscriber Service Card.

Temperature Test Chamber

Associated Testing Laboratories has begun marketing its new Econ-O-Line low-high temperature test chamber.

The chamber, with internal working dimensions of 14 in. by 14 in. by 14 in., utilizes liquid carbon dioxide and spans a temperature range of −100°F to 350°F. The unit uses a United Electric Indicating Controller and guarantees accuracy to within a range of plus or minus two degrees Fahrenheit.

Circle No. 236 on Subscriber Service Card.

Free Turn Ball Valve

Dyna-Matics Corp. has introduced a "Free-Turn" ball valve designed for critical service with a wide range of both non-corrosive and corrosive liquids and gasses under extreme pressure and temperature conditions. The valve provides tight, positive sealing without seal drag during operation. The elimination of seal friction and wear makes possible a wider choice of packing materials for positive sealing in a variety of applications.

Circle No. 237 on Subscriber Service Card.

Small Accelerometer

A tiny 3-axis accelerometer with potentiometer output is being produced for missile applications by Humphrey, Inc. This single accelerometer provides information on linear acceleration along three different axes, replacing multiple instruments at savings in size, weight and cost. Total weight of the unit is about one-half pound and size is approximately 2½ in. diameter and 2 in. long.

Circle No. 238 on Subscriber Service Card.

Thermostatic Air Valve

A miniature thermostatic air valve weighing 2 oz. developed by Solrac, Inc. is now in production.

Primarily used as a power limiting device when installed in the exhaust outlet of a gas turbine engine, the unit has been successfully tested in a cryogenic application at −300°F.

With 35 psi air applied at the inlet an output variation of 1 psi per 2°F temperature change is obtainable through an adjustable range of −350°F to +1750°F.

Circle No. 239 on Subscriber Service Card.

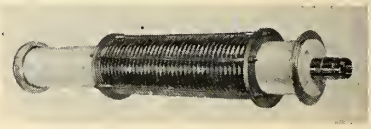
Dehydration Cartridges

Instrument type dehydrator units designed for connection directly into the system line to protect delicate sealed instruments, relays, sparking contacts and other similar components from moisture, contamination, oil vapor, fuel vapor and corrosive or explosive gases have recently been introduced by Robbins Aviation, Inc. Fiber glass pads also control downstream particle size to less than 10 microns.

Circle No. 240 on Subscriber Service Card.

Flexible Coaxial Section

Telerad Manufacturing Corp. is in full production of 3⅛ in. flexible coaxial section capable of 3 mega-watts peak



pulse power. The flexible section encompasses vibration in three planes from 5 to 500 cycles per second and meets all vibration requirements of MIL-E-5422. All units have a very low SWR. The coaxial sections utilize special flanges to reduce RF leakage.

Circle No. 241 on Subscriber Service Card.

Electronic Tapwelder

A precision electronic tapwelder manufactured by the Hanjohn Co., joins resistance alloy wires of 0.025 in. to 0.0007 in. diameters at production line speeds. The weld is stronger than the parent wire, and accurate to 1 turn.

The unit welds without pressure, hence does not flatten, stretch or distort the wire, or embed it in the core.

Circle No. 242 on Subscriber Service Card.

Wee Wire-Wound Resistor

A Type 375-P encapsulated, precision wire-wound resistor which measures 1/8 in. dia. x 1/8 in. long,

is available from Kelvin Electric Co. Units are shock, moisture and temperature proof, exceeding mil-specs. Wattage rating is 0.05, 100 K oms max., 50 volts max., temperature range, −65°C to +125°C, standard tolerances from 1% to .05%, standard temperature coefficient ±0.002%/°C. Connections are welded.

Circle No. 243 on Subscriber Service Card.

Detonator Field Tester

Explosive igniters, detonators, primers or squibs may be checked quickly and safely with a tester developed by Kinetics Corp.

A simple digital readout on the Kinetics instrument will indicate whether the device will operate properly or misfire. The tester employs a sensitive bridge circuit. Maximum test current is limited to 10 milliamperes, so there is no danger of setting off igniters during the test.

Circle No. 244 on Subscriber Service Card.

new literature

POLYALKYLENE GLYCOLS—A 52-page booklet, describing the properties and uses of Ucon polyalkylene glycol fluids and lubricants, has been published by Union Carbide Chemicals Co. The booklet contains comprehensive data on the 32 types of Ucon synthetic fluids and lubricants available from Carbide. Included are physical properties, physiological properties, physical and chemical analytical methods, storage and handling instructions, and a special section on the selection of the proper Ucon fluid or lubricant for any given application.

Circle No. 200 on Subscriber Service Card.

EPOXY ADHESIVES—An 8-page booklet issued by the Epoxylite Corp. describes five high-temperature epoxy resin formulations suitable for long-time service in the 450-500°F range. Two of the formulations are potting compounds, three are adhesives. All are variations of unique high-temperature system which combines handling ease (room temperature processing), long pot life (in excess of 16 hours), and fast cure (as short as 30 minutes at 400°F). The advantages and disadvantages inherent in the materials are described.

Circle No. 201 on Subscriber Service Card.

THERMOCOUPLE ACCESSORIES—A fully illustrated catalog which describes a complete line of thermocouple fittings, pressure sealing glands and thermocouple accessories is available from Conax Corp. Included are the Conax patented bare wire thermocouple glands that provide low mass, fast response and a simple, positive method for sealing two or more bare wires from the full vacuum to 10,000 psi. at temperatures from −300°F. to +1850°F.

Circle No. 202 on Subscriber Service Card.

SAFE/ARM INITIATORS—McCormick Selph Associates has published a four-page brochure describing their new Safe/Arm Initiator systems. The brochure describes the Safe/Arm system and its operation; shows a comparison of conventional vs. Mc/S/A Safe/Arm concepts; gives advantages of the system and, provides firing and arming characteristics as well as environmental data.

Circle No. 203 on Subscriber Service Card.

SWITCH BROCHURE — Burroughs Corporation's Electronic Tube Division has prepared a detailed twenty-four-page brochure on their new BEAM-X switch. This brochure, containing more than fifty illustrations, covers theory of operation, circuit design information, characteristic curves and the many applications of the BEAM-X switch in the fields of counting, coding, distributing, converting, multiplexing, switching and sampling.

Circle No. 204 on Subscriber Service Card.

MILITARY COMPONENTS—Ohmite Manufacturing Co. has published a new edition of its Military Components Catalog, Number 50A. This 36-page catalog is designated formally as a catalog, but more accurately, can be considered as a manual on U.S. military specifications covering those components which Ohmite manufactures. The catalog covers the latest versions of the following specifications: MIL-R-26, MIL-R-22, MIL-R-19365, MIL-R-93, MIL-R-9444, MIL-R-10509, MIL-R-19074, MIL-R-6749, MIL-R-6274, MIL-R-3965, MIL-R-5757, and MIL-R-6106.

Circle No. 205 on Subscriber Service Card.

RECORDING OSCILLOGRAPH—A Type 5-123 Recording Oscillograph is illustrated in an eight-page bulletin offered by the Electro Mechanical Instrument Division of Consolidated Electrodynamics Corp., a subsidiary of Bell & Howell Co. The rack-mounting oscillograph is designed for maximum reliability, flexibility, ease of installation, operation, and maintenance. The Type 5-123 is capable of providing visible records up to 60 times faster than any other printout process.

Circle No. 206 on Subscriber Service Card.

GSE PROGRAM—The full scope of the Fruehauf Trailer Co.'s Ground Support Equipment Program, including the design, research, development and production phases, is described and illustrated in a 20-page, 3-color brochure. Participation in practically every major missile program is illustrated in the fold-out center section of the brochure showing the many and varied types of ground support equipment produced by the company's two divisions.

Circle No. 207 on Subscriber Service Card.

LEVELING DATA—Keuffel & Esser Co. has published a new brochure which describes the components and operation of its Optical Leveling Kit. The booklet contains full data on industrial alignment problems and solutions, including foundation or bed leveling, profiling, differential leveling and checking movement of equipment. It also provides product data on all component parts and available accessories such as tripods and related instrument supports.

Circle No. 208 on Subscriber Service Card.

ALLOY PROPERTIES—Detailed information on alloys for abrasion, impact, corrosion and heat resisting services is contained in a new series of data sheets issued by Coast Metals, Inc. Each sheet provides complete engineering data on a single alloy, including: the available forms, such as welding rod, automatic welding wire and cast shapes; physical properties and nominal chemical composition; typical applications and recommended finishing procedures.

Circle No. 209 on Subscriber Service Card.

HIGH TEMP ALLOY—A four-page engineering-data folder on SUPERTHERM, new high-temperature alloy with exceptional performance capabilities in the 1800-2300°F range is available from Electro-Alloys Division of American Brake Shoe. The brochure presents specifics on physical constants, expansion coefficients, general characteristics, mechanical properties at room temperatures and high-temperature properties.

Circle No. 210 on Subscriber Service Card.

HEAT SHAPED TUBING—Expanded Teflon tubing which recovers its original dimensions when heated, giving a tight shrink fit over other parts or tubing, in electrical, chemical or mechanical applications, is described in an illustrated, how-to-do-it bulletin—Bulletin 3E—available from Pennsylvania Fluorocarbon Co. Applications and method of use are described for this expanded, shrinkable Teflon tubing which is made in eleven colors and retains its chemical inertness, thermal stability and excellent electrical properties.

Circle No. 211 on Subscriber Service Card.

names in the news

BARNETT

ASHWORTH

BUDNIK

UNDERBERGER

SKWAREK

Ralph V. Barnett: Appointed to the newly created position of vice president by Librascope Division-General Precision, Inc. Was director of military relations in the firm's Washington, D.C. office.

Harold T. Ashworth: Named director of manufacturing for Raytheon Co. Was manager of manufacturing for the company's Missile Systems Division.

Cass A. Budnik: Former assistant manager of industrial construction with Kaiser Engineers, appointed director of field services and general manager of the *Titan* Installation and Activation Division of American Machine & Foundry Co.'s Government Products Group.

George M. Underberger: Elected project engineer at Transco Products Inc., responsible for development and expansion of the firm's microwave components and subsystems. Was formerly manager of General Precision, Inc.'s Kearfott Division Systems Engineering Laboratory.

Frank J. Skwarek: Vice president of engineering for Polarad Electronics Corp., chosen to head the firm's newly-formed Defense Products Division. **Kenneth O'Neil** will be in charge of military sales for the new division.

John W. Suurballe: Joins the Systems Research Center of Lockheed Electronics Co. as a member of the research staff. He will be engaged in studies leading toward solutions in communications and mathematics.

Howard E. Roberts: Named manager, research and product planning, for the Whittaker Controls Division of Telecomputing Corp.

C. Harold Hannan: Who joined Miniature Precision Bearings, Inc., in 1957 as assistant chief engineer, promoted to director of research.

Robert G. Wilson: Elected manager of the lunar soft landing study program at North American Aviation's Missile Division. Formerly the division's assistant chief engineer, has had 20 years experience in aircraft, missile and space vehicle design and engineering management.

Dr. Arthur Goldsmith: Former research assistant, named director of engineering for Wilcox Electric Co.

Andrew A. Dukert: Joins the recently-organized Research Products Development Dept. of Pennsalt Chemicals Corp., as a plastics application engineer. Has had 25 years' experience in the plastics field, most recently as a consultant for Acme Plastic Products Co.

F. Sutherland Macklen and **Dr. M. Shaw:** Appointed director of engineering and manager, respectively, of the solid-state laboratory of the Ovitron Corp. Macklen was formerly vice president in charge of engineering for the Fairfield Engineering Corp.; Shaw was head of the physical chemistry research laboratory of Chrysler Corp.'s missile division.

Ralph A. Russi, Jr.: Former manager of materials processing for Motorola's Semiconductor Products Division, elected vice president in charge of research and engineering at Tang Industries, Inc.

Robert A. Ferguson: Assistant to the vice president in charge of sales at Latrobe Steel Co., named manager of marketing.

R. T. McCoy: Joins the technical staff of Micromega Corp., where he will be engaged in research and development work in the field of solid state microwave. Was formerly with Hughes Aircraft, where he worked on radar guidance for the advanced *Falcon* missiles.

Harry E. Cornish: Douglas Aircraft Co.'s acting program manager on the Missileer project named program manager.

Dr. S. J. Gerathewohl and **Dr. Richard S. Young:** Elected head of operational development and chief of flight biology, respectively, for NASA's Office of Life Sciences Programs. Dr. Gerathewohl comes to NASA from the Army Surgeon General's office, assigned to ABMA. Dr. Young also comes from ABMA, where he directed space biology projects.

Lewis I. Terry: Appointed laboratory manager by Dearborn Chemical Co., responsible for all analytical services and quality control. **Richard A. Larrick,** former head of the materials testing and analytical laboratory at General Electric Co.'s Hudson Falls plant, succeeds Terry as director of analytical services.

Michael L. Mandeville: Former executive vice president, appointed president of the International Division, U.S. Industries, Inc., succeeding **R. S. Wright,** now vice president-International Trade of the parent company.

Brig. Gen. Harley S. Jones (ret.): Executive vice president of Republic Aviation Corp. elected to the board of directors.

John J. Morrissey: Named manager of Dana Corp.'s Marion (Ind.) Division. Was formerly vice president and general manager of General Drop Forge Corp., wholly-owned Dana subsidiary.

Malcolm A. Pleton: Filtors, Inc. applications engineer, promoted to assistant chief engineer.

Phillip H. Goodwin: Appointed executive vice president and general manager of National Electronics Facilities Organization, Inc. Was formerly marketing manager, weapons systems, of the Government and Industrial Group, Philco Corp.

Harold R. Fosnot: Former manager of operations for Graver Water Conditioning Co., appointed general manager of American Machine & Foundry Co.'s Maxim Evaporator division.

R. C. Chapman: Elected executive vice president and member of the Board of Directors of Crescent Engineering & Research Co. Formerly headed his own management consulting firm.

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editorial . . .

The Leaden Feet of NASA's Mercury

THIS WEEK M/R points out (page 12) the slippage, the high costs and the dubious judgment used in the NASA *Mercury* program, designed to put man in space for the first time—if the Russians don't beat us to it.

Mercury was the first major operation undertaken by the new space agency after its creation in 1958, when public pressure due to Soviet successes forced the Administration to take some action in space exploration.

It now appears that the entire Astronaut program was developed because it looked like a cheap and quick method of getting man into space; that it was approved on the very highest level because of promises the program could be accomplished at a minimum cost and within a short time—one year.

It has been neither cheap nor quick. To date $250 million has been appropriated for *Mercury*. The original year is stretching out into two—and probably will be actually more like two and a half.

Further, it appears evident that Project *Mercury* may reach a glorious climax and then expire quietly. *Mercury* is a dead-end project.

George M. Low, chief of NASA's Manned Flight Program, says in a written statement to the Senate Space Committee that lunar landings are included in NASA's manned flight program. But he adds:

"The *Mercury* capsule is not suitable as a return vehicle for a lunar mission."

He added that such a capsule must be capable of entering the atmosphere at higher speeds and that some aerodynamic guidance would be necessary, presumably guidance of a *Dyna-Soar* type.

Mercury will, of course, accomplish some things. It will, hopefully, prove what we now feel to be a certainty—that man can survive in space. It may prove that he can remain lucid, perform a few simple operations, retain his equilibrium and his lunch. And—there is no other way to prove these things except to send an actual living man into space. There will be benefits in the techniques of capsule design, in tracking, communications and recovery, in living with weightlessness.

There are many reasons for the delays in the original schedule and for the gross underestimate of the cost of *Mercury*. Most of them stem from the same basic fact—lack of experience.

When NASA undertook the *Mercury* program it was a brand new agency, converted from the old National Advisory Committee on Aeronautics. No one from the new administrator down had either factual or theoretical knowledge of a space flight program.

Some such knowledge existed in the Air Force and in the Army, both of which had quietly and secretly made studies in conjunction with three or four industrial primes. But not much of it, apparently, went into *Mercury*.

It seems to us that this is another example of the lack of judgment which has marked so much of our missile/space program.

Through either myopic inperception or vacillation we delay in doing anything.

Then we frantically seize upon a program which is "quick and cheap." This was true of the "cheap and quick" *Vanguard*. It appears to be true of *Mercury*.

At least one other program was available when *Mercury* was started—*Dyna-Soar*. No one claimed *Dyna-Soar* was "quick and cheap." But it now appears that *Dyna-Soar* could have been available in about the same time period as *Mercury*. And NASA will probably turn to a *Dyna-Soar* configuration for later space flights.

Are we seriously competing to explore space —evaluating the tremendous rewards of being there first? Do we, the richest nation in the world, decide wisely and do it the best possible way? Or do we hunt out the "cheap and quick" for public appearance and political reasons?

Clarke Newlon

new

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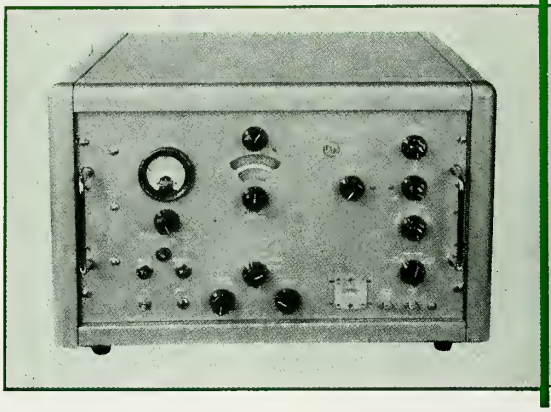

Advanced Features Include:

- ☑ ELECTRONIC SWEEP
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- ☑ DIRECT READING FREQUENCY DIALS

"If a man's work be true and good...challenging comparison will be his strength."

David Charles

The FXR Model X775A X-Band Sweep Signal Source, challenging comparison, is unsurpassed for the measurement of VSWR and reflection coefficient. The Model X775A utilizes a permanent magnet BWO as the rf source. A unique built-in AGC amplifier produces a flat rf level, with respect to a bolometer detector, over the entire swept frequency range. Both ends of the swept frequency range can be accurately preset on separate direct reading frequency dials.

Specifications for the FXR Model X775A:

- **FREQUENCY RANGE:** 8,200mc to 12,400mc.
- **SWEEP RATE (RESOLUTION):** 300mc/sec to 300kmc/sec, linear with time.
- **SWEEP WIDTH:** to 4,200mc, direct reading, continuously adjustable.
- **OUTPUT TYPES:** cw, square wave modulation (internal 800cps to 1,200cps).
- **OUTPUT POWER:** 0 to 20mw minimum cw into matched load, continuously adjustable. With AGC-detected output flat to ±0.5db (when used with matched bolometers and directional couplers).
- **FREQUENCY DIAL ACCURACY:** ±1% — fixed frequency operation (at specified grid voltage).
  ±2% — sweep frequency operation.
- **OUTPUT CONNECTOR:** 1 X ½ waveguide.
- **POWER REQUIREMENTS:** 115/230V, 50/60cps, 200 watt.
- **DIMENSIONS:** 12⅞" high X 21¾" wide X 18" deep.
- **WEIGHT:** 78 lbs.

For more details, contact your FXR representative.

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