missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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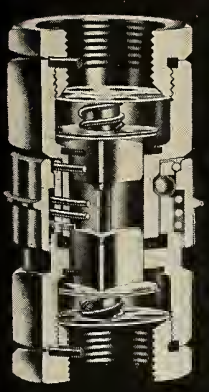

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

30,400 copies this issue

FEBRUARY 8 HEADLINES

ASTRIONICS

ADVANCED MATERIALS

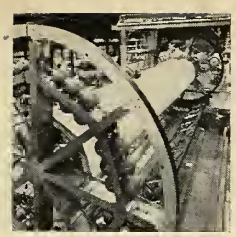
PROPULSION ENGINEERING

INTERNATIONAL

PRODUCTS AND PROCESSES

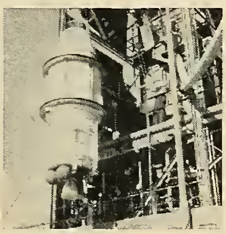
THE MISSILE WEEK
U.S. Reg. Pdg.

DEPARTMENTS



COVER: Booster top for the *Saturn* is assembled at NASA's Huntsville, Ala., facilities. For a report on how the vital program has finally picked up some momentum, see p. 14.

ALL-PLASTIC solid propellant rocket proposed by Norair. The company says its research indicates the project is feasible and plastics may be dominant high-temperature material. Story starts on p. 25.



ADVANCED *Agena* satellite vehicle is hoisted into place for test firing. Lockheed has admitted newsmen to its Santa Cruz, Calif., *Agena* facility for the first time, praises Bell engine. See p. 34.

AIR FORCE controllers at ARDC's Sunnyvale, Calif., satellite center are in contact with launch site, four tracking stations, Hawaii control center. See story on p. 36.

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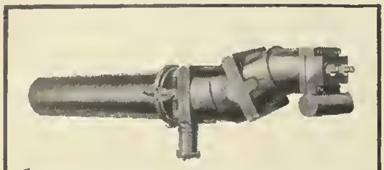
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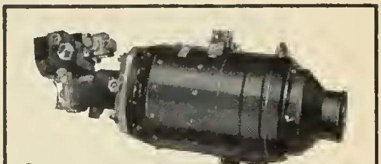
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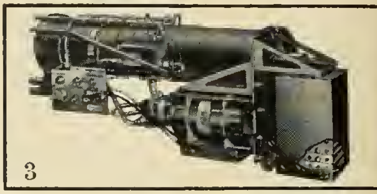
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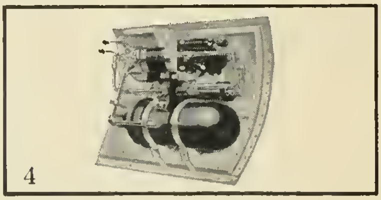
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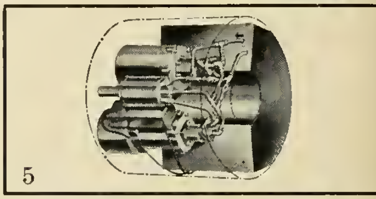
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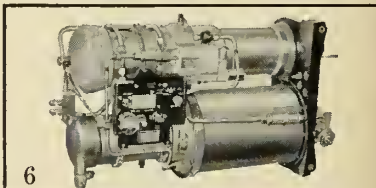
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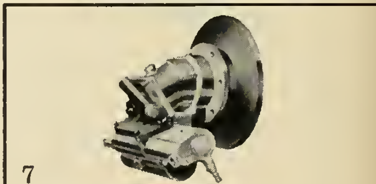
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Washington Countdown

IN THE PENTAGON

A new ABMA . . .
is scheduled to be built from key parts of the old when the agency and its $100-million complex of facilities is finally transferred to NASA. The Army is planning to use a cadre of ABMA personnel to rebuild the agency for development of its longer range missiles.

• • •

The last four *Polarises* . . .
launched from Cape Canaveral are understood to have impacted squarely in their designated target area. Accuracy of the Lockheed test vehicles on the 900-mile shots is being measured in yards instead of miles.

• • •

Two million pounds of thrust . . .
is the new specification being put on the proposed Air Force solid booster. The plans to pump money into the program are now on the desk of Dr. Joseph Charyk, Assistant Air Force Secretary for R&D, awaiting approval. (See this issue, pages 29-31)

• • •

The big Soviet rockets . . .
launched into the Pacific are estimated to have had about 1 million pounds of thrust. The big question posed by military experts is whether the Red rockets were single-chambered vehicles or were clustered.

• • •

***Titan* testing . . .**
at Cape Canaveral now is expected to be pushed at a rapid rate. Meantime, launching silos for the Martin ICBM at Lowry AFB, Colo., are reported to be one-fifth completed.

• • •

Fumes-in-the-wind note . . .
Vandenberg AFB is now referring to itself in press releases as the Vandenberg Aerospace Center.

ON CAPITOL HILL

Government reorganization . . .
in the missile/space field is rapidly snowballing into a major congressional and campaign issue. However, it remains doubtful whether anything beyond some slight tinkering with the present machinery will result.

Military role in space . . .
is considered the most likely to get attention from Congress. Democratic leaders are understood to be very concerned over statements by the administration that the military has little reason to go into space beyond a few thousand miles.

• • •

Military procurement . . .
will get a thorough going over beginning this week by the Senate Armed Services Subcommittee headed by Sen. Strom Thurmond (D-S.C.). The subcommittee has before it a series of bills calling for the drastic overhaul of present procurement practices.

AT NASA

An impact bag . . .
is the latest device to be added to the man-in-space *Mercury* capsule. After the heat shield separates from the capsule during re-entry, the perforated impact bag will billow out and cushion the landing.

• • •

Top possibility . . .
to succeed NASA Chief T. Keith Glennan when he retires at the end of 1960 is considered to be Assistant NASA Administrator Richard E. Horner. The 42-year-old former Air Force official is considered to be the mostly likely candidate for the job no matter who occupies the White House next January.

• • •

Solids Expert Elliott Mitchell . . .
has been named to head NASA's new propulsion staff. However, the agency's propulsion R&D will continue to be mainly in the field of big liquid engines for such projects as *Saturn* and *Nova*.

INTERNATIONAL

Japanese sale . . .
of $277,000 worth of *Kappa 6* research rockets to Yugoslavia is still to be made final. Representatives of YAA—the Yugoslav Astronomical Association—are understood to want to tour Japanese facilities first.

• • •

French antigravity research . . .
is being imported by the United States. Dr. M. J. Pages, the French antigravity expert and father of the "space submarine," is reported to have been hired by an unidentified U.S. firm.

AAS on Technical Meetings

To the Editor:

I read with interest your recent article (M/R, Jan. 11, p. 14) on the cost of technical meetings. The American Astronautical Society, which is the only professional Society in the U.S. dedicated *solely* to the Astronautical Sciences, is well aware of this problem. However, it is sometimes very difficult to get coordinated schedules with all the Societies now getting into space. Our Society was holding comprehensive meetings on Astronautics as early as 1954.

It is interesting that the study showed a lack of overlapping, and I think the various Societies should be commended for their effort here.

The publication of material presented at these meetings is a severe problem for all Societies. However, the AAS has since 1957 published the Proceedings of their meetings, and in 1959 these Proceedings were produced in hard-back copies as *Advances in the Astronautical Sciences* by Plenum Press. It is now our policy to publish the Proceedings after each meeting. To my knowledge we are the only professional society dealing in the Space Sciences that offers this service to the technical community.

George R. Arthur
President
American Astronautical Society
516 Fifth Avenue
New York 36, N.Y.

Back to Mt. Tranquillon

To the Editor:

Everyone knows that the State of California is overwhelming with superlatives. This is the home of the largest horned toad in the world, as well as the world's biggest barrel hoop and the world's most superfluous freeway (between Sepulveda Boulevard and Sepulveda Boulevard).

However, in your Dec. 28 issue you have added a new superlative. As seen in the picture caption, lower right on page 17, your geographical researchers have discovered 21,500-foot Mt. Tranquillon in the wilds of Pt. Arguello. This mountain obviously qualifies as the highest yet discovered in the (contiguous) continental U.S., and is enough to make the State of Alaska look to its laurels.

As a tribute to the magnificent climate of California, one notes that, even at this altitude, there is no trace of snow or ice, and trucks may be easily driven to the summit on our wonderful all-weather roads.

Jackson W. Granholm
1516 El Dorado Drive
Thousand Oaks, Calif.

As a matter of fact, if it were 21,500 feet high Mt. Tranquillon would cast a shadow over Alaska's 20,300-foot Mt. McKinley—popularly thought of as the U.S.' highest. M/R has been similarly chidden before (Letters, Jan. 25, p. 56), will send this to the Wayward Comma Dept.—Ed.

AEROJET-GENERAL CORP.

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Industry Countdown

MANUFACTURING

Upgrading megaton wallop . . .

of *Atlas* apparently is behind Avco's entry into its nose cone program—primed by General Electric. An "advanced" Avco re-entry vehicle was aboard the Jan. 26 *Atlas* fired successfully from the Cape. A larger warhead already is being developed by Avco for the *Titan* ICBM and the Air Force could be trying a somewhat similar configuration for *Atlas*.

• • •

R&D costs for an ICBM . . .

are estimated now at 60% of the total cost of the weapon. Aerospace Industries Association also notes that this has caused a pronounced shift in the missile/aircraft industry personnel. A survey of 30 prime contractors shows that out of 451,000 employes in 1959, 65% were involved in engineering, tooling and other indirect specialties and only 35% were in direct manufacturing jobs. This, says AIA, is the highest ratio of indirect to direct workers of any major manufacturing industry.

• • •

Pressure is building up . . .

in Congress for a greater "spread" in defense contracts. Several key Democrats are concerned over DOD figures showing 73.8% of procurement dollars are concentrated in 100 firms. Other figures being cited show that large firms get about 97% of all defense R&D work.

• • •

Overland train . . .

idea for *Minuteman* ICBM is still being debated. The Army Transportation Corps has developed a cross-country diesel-powered train, but it's reported the Air Force is looking elsewhere for a mobile land system which would travel farther afield than its railroad launcher for *Minuteman* . . . General Motors, which is said to have come up with some cross-country designs, is now making the prototype transporters to carry *Minuteman* missiles on highways.

• • •

Douglas Aircraft is spending . . .

$4 million to consolidate all its missiles and space systems engineering work in one enlarged facility at Culver City, Calif.

PROPULSION

New *Redstone* engine . . .

feature allows troops in the field to vary propellant mixture ratio to suit the mission. The control was tried for the first time in a tactical launch Jan. 26 at White Sands with an A-7 engine.

ASTRIONICS

Companies deeply . . .

involved in thin-film R&D for integrated solid-state subsystems are disputing the belief that molecular electronics is the total answer for the future. Rather, they feel, advanced systems will incorporate the best of both approaches.

• • •

At least one . . .

guidance system contract has been killed and two more are in doubt as a result of an Army Signal Corps program assessing the feasibility of failure prediction prior to designing electronic inertial systems. Motorola has the contract. All three services are closely watching the results.

WE HEAR THAT—

Downrange "Bumblebee" . . .

radar for the Pacific Missile Range is almost ready. One of the contractors for the vastly improved system is RCA . . . Marquardt Corp. is ready to merchandise its know-how in the A&E field through a new Facilities Engineering Division . . . A new department serving the radar systems market has been set up by Texas Instruments . . . Expansion in the reinforced plastics field for missiles and space vehicles is under way at Horkey-Moore Associates . . . Advanced Intelligence Corp. is a brand new company being established at Rancho Sante Fe, Calif., for the calibration of large optical instruments . . . Surprise of the Week: Lockheed's acquisition of a 50% interest in Grand Central Rocket Co.

Von Braun Praises NASA Leadership

Expert says he's 'satisfied' with transfer and civilian agency's 'clear decisions' on Saturn, asks for—and is promised—more trained personnel

Dr. Wernher von Braun praised his new NASA bosses before the House Space Committee last week and found himself in sharp disagreement with his old boss, Maj. Gen. John B. Medaris. (See M/R, Feb. 1, 1960.)

The Huntsville rocket expert said he was "thoroughly satisfied" with his organization's transfer from the Army ABMA to NASA, and urged Congress to confirm the President's action as soon as possible.

Complimenting NASA for making "clear decisions" immediately upon taking over the *Saturn* booster program, Von Braun said "they got the President to approve almost all of the $100 million we needed."

He said that his team and the space agency also had quickly arrived at a "unanimous decision" on *Saturn's* upper stages.

Von Braun disagreed with Gen. Medaris' recent recommendation for a single military missile-space agency. He told the Committee that the civilian space program needed large boosters before the military space program, and therefore it was reasonable that NASA should develop *Saturn* and *Nova*.

He disagreed with Medaris that military space was being, or would be, downgraded, pointing out that the military could use *Saturn* after it was developed when they have a need for it.

In answer to a question as to whether he liked the present space setup, Von Braun answered in the affirmative, but added "if enough money goes into it, any organization will do."

Von Braun declined offers from the Committee to add more money to *Saturn's* program this year, stating that he now had about all of the money he could profitably spend. When pressed further, he said that additional money could be spent, but that it probably would be wasted.

Two criticisms that Von Braun had of the present program were: (1) the additional money that NASA has procured for *Saturn* can't be spent until July and that some of it could be used earlier; and (2) he needs more trained personnel.

Rep. George P. Miller (D.-Calif.) told Von Braun that the Committee would move to see that the Huntsville team got 100 more executive positions.

Von Braun said under the accelerated program the first test vehicle would fly in FY '61, and three in FY '62. Ten vehicles will be fired before the first completely operational *Saturn* leaves the pad in the second quarter of 1964, Von Braun said.

The *Saturn* vehicle will have three different configurations, according to Von Braun. The first, C-1, will have a cluster of four 20,000 lb. liquid hydrogen engines as its second stage, and two of these engines as a third stage. This configuration, which will be operational after 10 firings in 1964, will be able to put from 23,000 lbs. to 25,000 lbs. in orbit.

The second configuration, C-2, will have four 200,000 lb. hydrogen engines as its second stage, and the two Pratt & Whitney configurations on top. Von Braun said this configuration would lift a 45,000 lb. payload, and could soft-land payloads on the moon and send two men on a figure-eight trip around the moon and back.

Von Braun said that all of the *Saturn* boosters will be recoverable and that they hope to use them over again.

The father of the *Explorer* program said that *Saturn* spending should reach a constant level in 1961 for two or three years. A proper evaluation of the *Saturn* system, he predicted, could be made in 1962, and that could determine how much money would be spent on the program after that.

The space agency plans to manufacture the clustered booster at the rate of six a year, but Von Braun said this could be accelerated to 20 a year "when and if we find we need them."

Von Braun said that the U.S. would not catch up with Russian space accomplishments until 1964, and that he thought the Soviets probably were working on much larger rocket engines than they are presently launching.

"It wouldn't surprise me at all," von Braun testified, "if the Russians make a soft lunar landing and put a man in space this year."

Though he felt that *Saturn* is now adequately funded, Von Braun told the Committee that more money could be spent for space research in other areas. "There is aways a danger of putting most of the money into weapons systems or space vehicles like *Saturn*, and not putting enough money" in (other important projects).

Titan Passes Ignition Test

The trouble-plagued *Titan* ICBM Feb. 2 had its first successful second-stage ignition, breathing new hope into a program which has been severely criticized from a management standpoint.

It was the fifth successful launch of the ICBM, but the first successful since May 4. In the interim, Air Force criticized Martin management of the program but pronounced the big bird technically sound.

The 41-foot second stage separated and the Aerojet-General 80,000-lb. thrust-engine ignited at an altitude of about 40 miles. Its 24 tons of weight made it the largest space-fired vehicle to date. Impact was about 2000 miles down range at a "preselected" target area.

The *Titan's* guidance system, designed by Bell Telephone, successfully performed its functions of relaying the missile's position to ground guidance control and receiving and decoding steering commands.

The radio inertial system used in this firing is slated to be replaced by an A. C. Spark Plug all-inertial system before becoming operational.

The first and second stage engines of the *Titan* are built by Aerojet, generating a total of 380,000 lbs. thrust with LOX and JP-6.

The complete vehicle launched was the same one that automatically cut itself off on the pad Jan. 28. There was no damage to the missile or the stand.

The perfect launching is expected to improve the overall program picture which suffered a severe blow in the explosion on the stand Dec. 12. This was the climax of a series of delays and mishaps reaching back to May 4, date of the fourth successful firing.

The technical soundness of the missile has never really been doubted, even by its most vehement detractors, and the unqualified success of the latest shot supports this claim.

Air Force plans call for a total of 14 *Titan* squadrons, which, with 13 *Atlas* squadrons, will provide a maximum number of operational missiles during the critical five years immediately ahead.

The two-stage bird is slated to be "technically operational" in October, 1960. No information was released concerning the next *Titan* launching, but the complete guidance systems and nose cone separation tests have yet to be made.

The Martin Company will use the *Titan* as the basis for booster of the *Dyna-Soar* system. The Air Force awarded the booster portion of the manned glide-vehicle to Martin last November.

Record Crowd Due for Missile/Space Meet

Moderator for the Marketing Panel of the National Missile Space Conference in Washington will be Lt. Gen. Mark E. Bradley, Deputy Chief of Staff, Materiel Hq. USAF, conference officials have announced.

The panel will be held Wednesday afternoon, Feb. 17, at the Sheraton Park Hotel, conference headquarters.

Registrations for the two-day conference, Feb. 16 and 17, are considerably ahead of those of previous years, officials said, and total attendance is expected to be well above that of 1958 and 1959.

Other panels will be headed by Dr. Fred Singer, Professor of Physics, University of Maryland; Theodore F. Koop, CBS vice-president, and Kurt R. Stehling, Aeronautical Research Scientist, NASA. Panelists include:.

Sir Leslie Knox Monro, former Australian Ambassador to the U.N.; Dr. Homer Joe Stewart, NASA; Sen. Thomas Dodd, Conn.; Congressman James C. Fulton, Pennsylvania; Rear Admiral Thomas F. Connolly, Bureau of Naval Weapons; Andrew G. Haley, past president, International Astronautical Federation; Dr. Donald Michael, Brookings Institution; Clarke Newlon, Missiles and Rockets Magazine; Dr. Dorothy Simon, Avco; Bernard Haldane, Fairleigh Dickinson University.

Dr. Leo Steg, General Electric Co.; Martin Decker, president, Decker Corp.; Dr. Vincent Cushing, Fairchild; Congressman Victor L. Anfuso, New York; Dr. I. M. Levitt, Franklin Institute; Norman L. Baker, Space Business Daily; and Brig. Gen. Donald D. Flickinger, USAF, ARDC.

Objective of the conference is to promote policies, programs and legislation necessary to establish and maintain United States leadership, and to stimulate civil and military space programs for the benefit of mankind.

The conference will culminate in the Goddard Memorial Dinner on Wednesday night and presentation of the Dr. Robert H. Goddard Memorial Trophy by Missiles & Rockets Magazine. Chief speaker for the dinner will be Lt. Gen. Bernard Schriever, Commander of the Air Research and Development Command.

Luncheon speakers Tuesday and Wednesday will be Krafft Ehricke, Convair, and Arthur Kantrowitz, Avco.

Among co-sponsors of the conference, with the National Rocket Club, are:

American Machine and Foundry Corp., Arthur D. Little, Inc., Avco Corp., Continental Aviation and Engineering Corp., Convair Division of General Dynamics, Cooper Development Co., Crucible Steel Corp., Decker Corp., Electric Auto Lite Co.

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Washington Technological Associates, Inc., Western Gear Corp., Westinghouse Defense Products, Thiokol Chemical Corp., and Douglas Aircraft Co., Inc.

—news briefs—

• **Washington**—President Eisenhower accused military leaders critical of the U.S. missile/space posture of being too parochial. He said in his opinion the present programs were eminently capable of deterring a Russian attack. The President predicted that the relative positions of the two countries would be about the same three or four years from now as they are today.

• **Washington**—Despite the insistence of his civilian boss that he was "unrealistic," SAC Commander Gen. Thomas S. Power refused to back down from his warning that Russia could knock out U.S. retaliatory power with 300 missiles in 30 minutes. Power told Congress he stands behind "every statement" in a recent speech which Defense Secretary Gates called unrealistic. Power also said Congress should provide extra funds to keep the highest percentage possible of his bombers airborne at all times.

• **Moscow**—Russia wound up its Pacific missile testing Jan. 30 with a second shot into the same impact area as its Jan. 20 launchings. No range or miss distance was indicated for the second shot. A Soviet scientist, Prof. Georgi Duboshin, indicated that there would be more Pacific shots and that they were preliminary to interplanetary space probes.

• **Washington**—Administration defense critic Sen. Stuart Symington (D-Mo.) introduced legislation to abolish the secretaries of the Army, Navy and Air Force. He said his bill would set up a modern structure of unified or integrated commands under a single chief of staff. The Defense Secretary's powers would be strengthened and the secretaries for each service would be replaced by undersecretaries.

• **Huntsville**—On his retirement Jan. 31 as chief of the Army Ordnance Missile Command, Maj. Gen. John B. Medaris revealed he would become chairman of the board of Electronic Teaching Laboratories, Washington, D.C.

• **Asheville, N.C.**—Celanese has begun production at its Amcel Propulsion Inc. Division on a major order for the Air Force of a high explosive compound which could become a double-base solid rocket propellant. The company is starting a big drive to hire scientists and engineers for the Amcel facility.

More catch-up than speed-up . . .

Mighty *Saturn* Program Shifts into Middle Gear

New NASA request for $98 million in program brings total FY '61 authorization to $246 million; but program still not seen as all-out

by James Baar

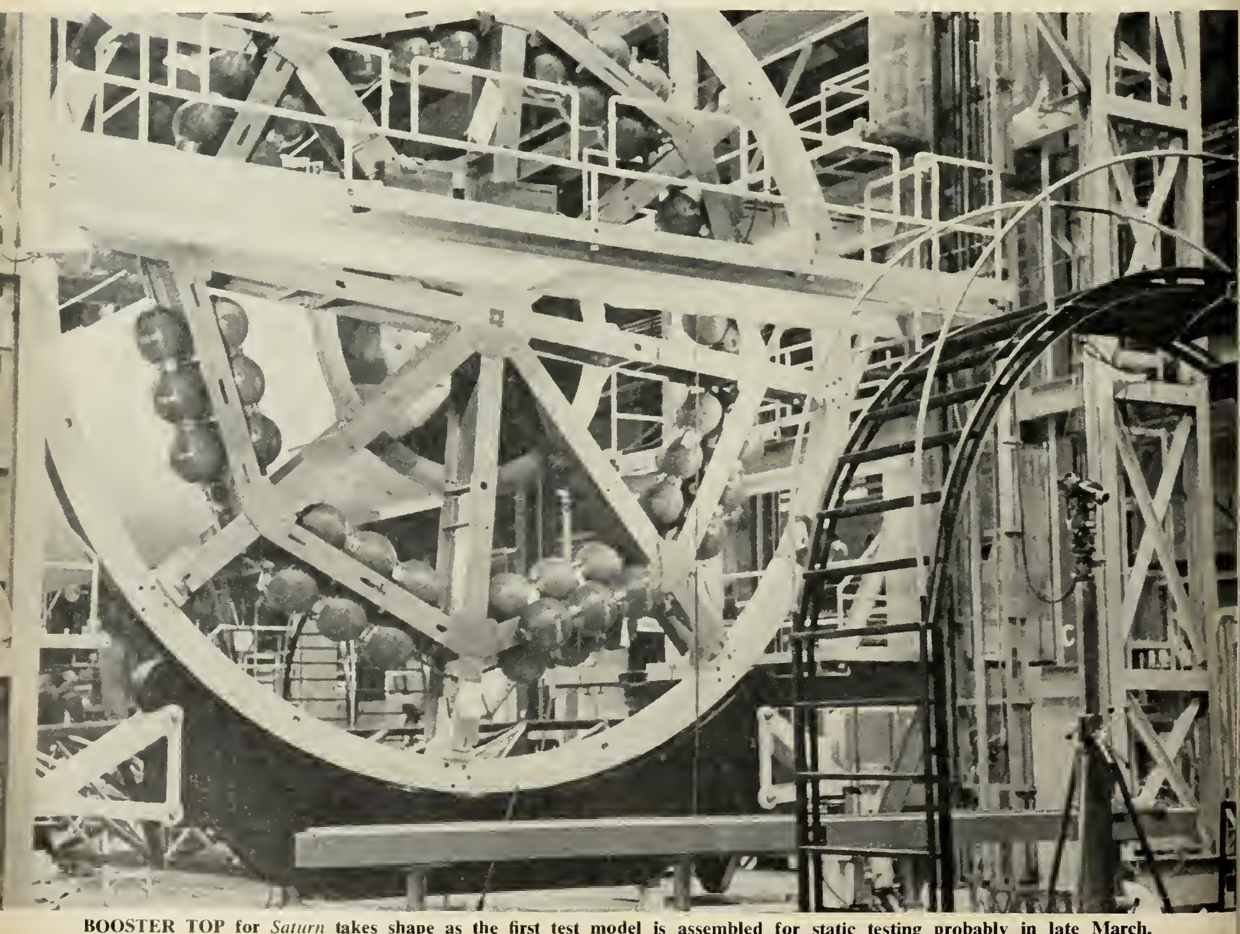
HUNTSVILLE, ALA.—The Administration's long-delayed burst of energy this week in advancing the mighty *Saturn* program appears more and more to involve mostly catch-up rather than speed-up.

The new NASA request submitted to Congress asking for an extra $98 million for *Saturn* in FY 1961 brought the total new money sought for the coming fiscal year to $246 million.

NASA officials said the total request would enable them to push forward a *Saturn* program aimed at:

- Launching the first operational *Saturn* of any kind in late 1962—an alleged one-year gain.
- Launching 27 *Saturn* vehicles between 1962 and the end of the decade.
- Building a second *Saturn* launching pad and a second static testing pad, providing the program with some back-up.

It was widely noted that the new figure of $246 million is only a shade below the maximum $250-million program for FY 1961 advocated months ago by Dr. Wernher von Braun, boss



BOOSTER TOP for *Saturn* takes shape as the first test model is assembled for static testing probably in late March.

of the *Saturn* program. And Von Braun told the House Space Committee this was about all he could "profitably" use in FY 1961.

Officials also stressed in Washington that Von Braun has been authorized to use overtime in the program for the first time. Meantime, at Huntsville and Washington, contractors received information on which to base bids for development of huge second and fourth liquid hydrogen stages for *Saturn*. And the first *Saturn* booster was assembled for the first static test probably in late March.

• **Altered aspect**—The overall appearance was that the *Saturn* program has been greatly accelerated. However, an analysis of the proposed funding offered an altered aspect:

• The one-year saving brings the first operational launching only to the approximate time when a launching would have taken place under the orginal ARPA-Army "moderate program" before slippages occurred.

• The 27 *Saturn* vehicles are some dozen or more less than planners originally sought to build. Some had advocated even more.

• The extra launching and test pads are not expected to be available for at least two years. Meantime, an explosion on the present static pad would cripple the whole program.

• The present overtime that has been authorized amounts to possibly $3 million—enough to prevent further slippage when bottlenecks occur, but not enough to speed the program one day.

• Not a dime extra has been requested from Congress for the current fiscal year. Von Braun had sought an extra $60 million.

Therefore, the effect of the proposed increases will generally be to put a rather bobtailed overall *Saturn* program back on the original schedule set up by ARPA and the Army in 1958.

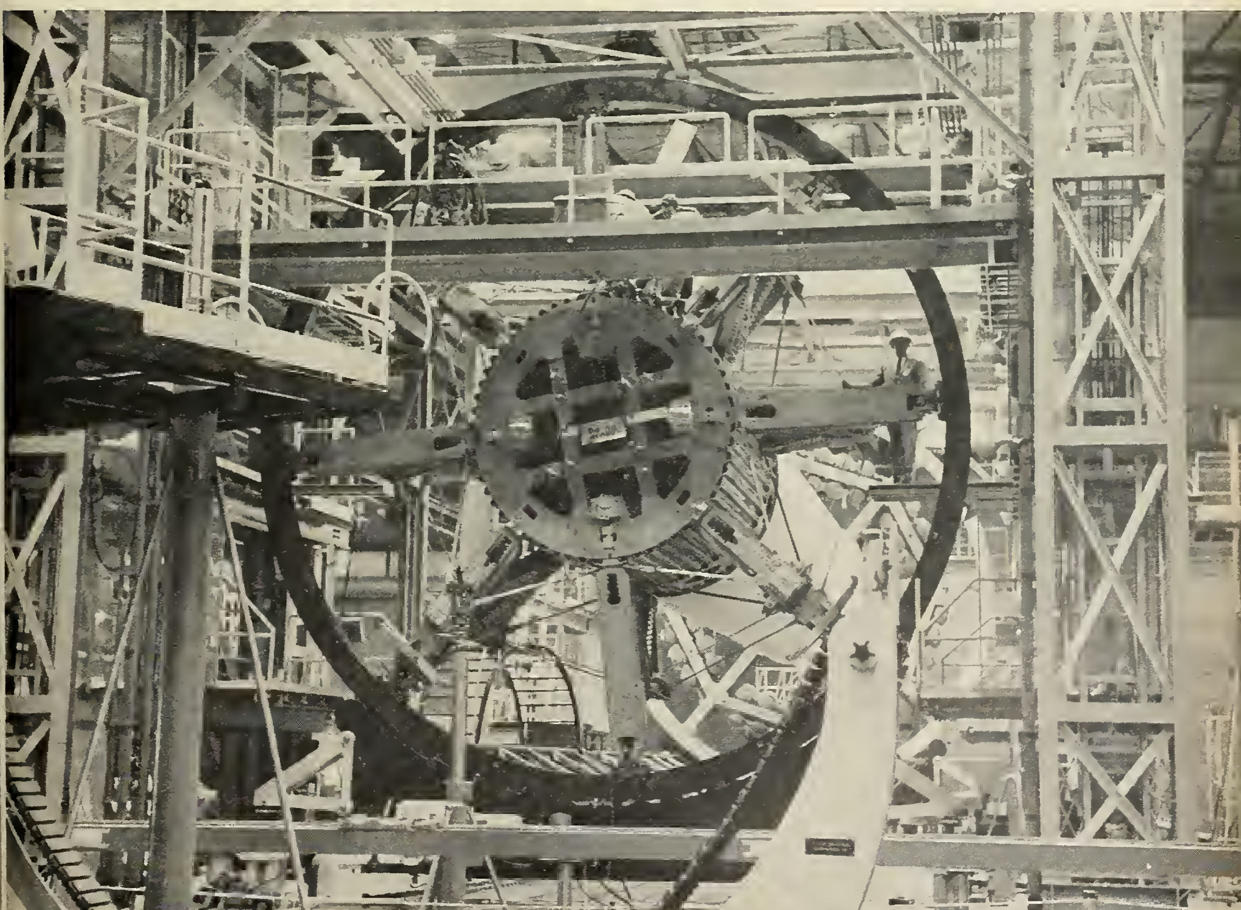
However, the fact that the Administration has even gone this far is considered a victory for official and non-government critics who see the 1.5-million-pound-thrust *Saturn* booster and subsequent *Saturn* space vehicles as America's best hope for gaining at least some lost ground in the East-West space race.

Many do not realize how near a thing the killing of the *Saturn* program was last year before it was transferred subject to congressional approval from the Defense Department to NASA along with most of the Army Ballistic Missile Agency at Redstone Arsenal.

At one brief point, only the program's funeral was left to be arranged by the Administration's budget balancers in their search for "marginal military programs" that might be cut.

Until then, ARPA had been able to get funds for *Saturn* on the thinly-disguised argument that the Armed Services needed it to launch large communications satellites about 1965. The Defense Department could not get money for *Saturn* on the grounds that it is needed to beat the Red Air Force into space because the White House does not recognize any need for military space activities beyond a few thousand miles.

Thus, in the end, *Saturn's* military backers had to turn to NASA in order to assure the greatest acceleration possible for *Saturn* under the prevailing circumstances.



BOOSTER BOTTOM waits for its eight H-1 engines to be attached in ABMA's fabrication shop at Redstone Arsenal.

• **Medaris approved**—Maj. Gen. John B. Medaris said on retiring last week as commander of the Army Ordnance Missile Command that he approved the transfer of *Saturn* to NASA only as "the least obnoxious alternative."

"It was better than having it clobbered, for instance," he snapped.

On these grounds, the switch in the eyes of *Saturn's* supporters has already been partially successful. Here is how the new *Saturn* budget requests for FY 1961 now look:

The original request called for a total of $148 million including $8 million for development of a high-energy upper stage.

The supplemental request calls for a total of $98 million including $33.5 million for construction and equipment, $53.3 million for industry R&D contracts, $8 million more for upper stage development and $3.2 million for salaries and overtime.

The new construction money includes funds for the second static test stand at Huntsville and the second launching pad at Cape Canaveral.

Thirty-six firms sent representatives to the first conference on *Saturn* upper stages Jan. 26-27 at Huntsville. Seven attended the second conference at NASA headquarters in Washington Feb. 3.

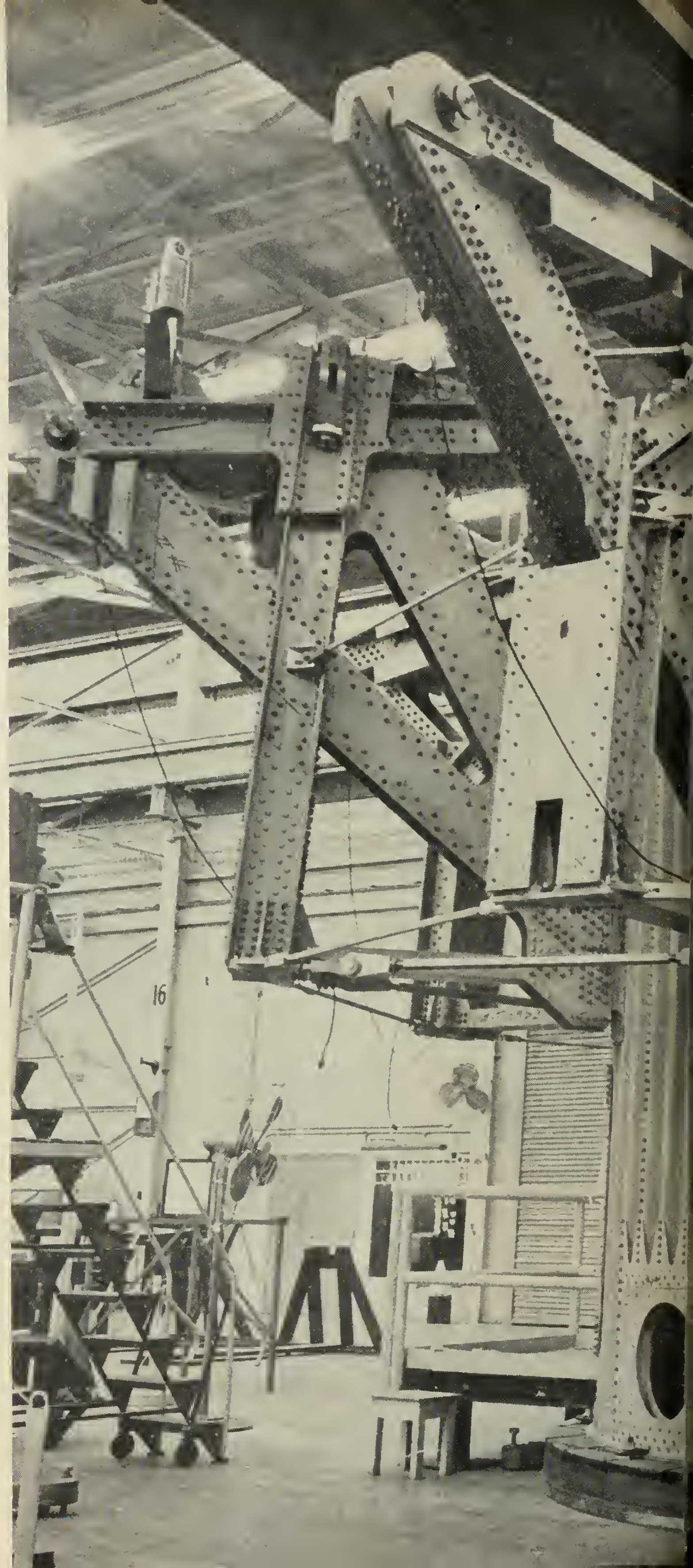
The first conference was on the 80,000-pound-thrust fourth stage. The second conference was on the 800,000-pound-thrust second stage.

Bids on the fourth stage are due Feb. 29. A contract is expected to be awarded about April 1. No dates for closing the bidding on the second stage have been set. At least one more conference is still to be held on it.

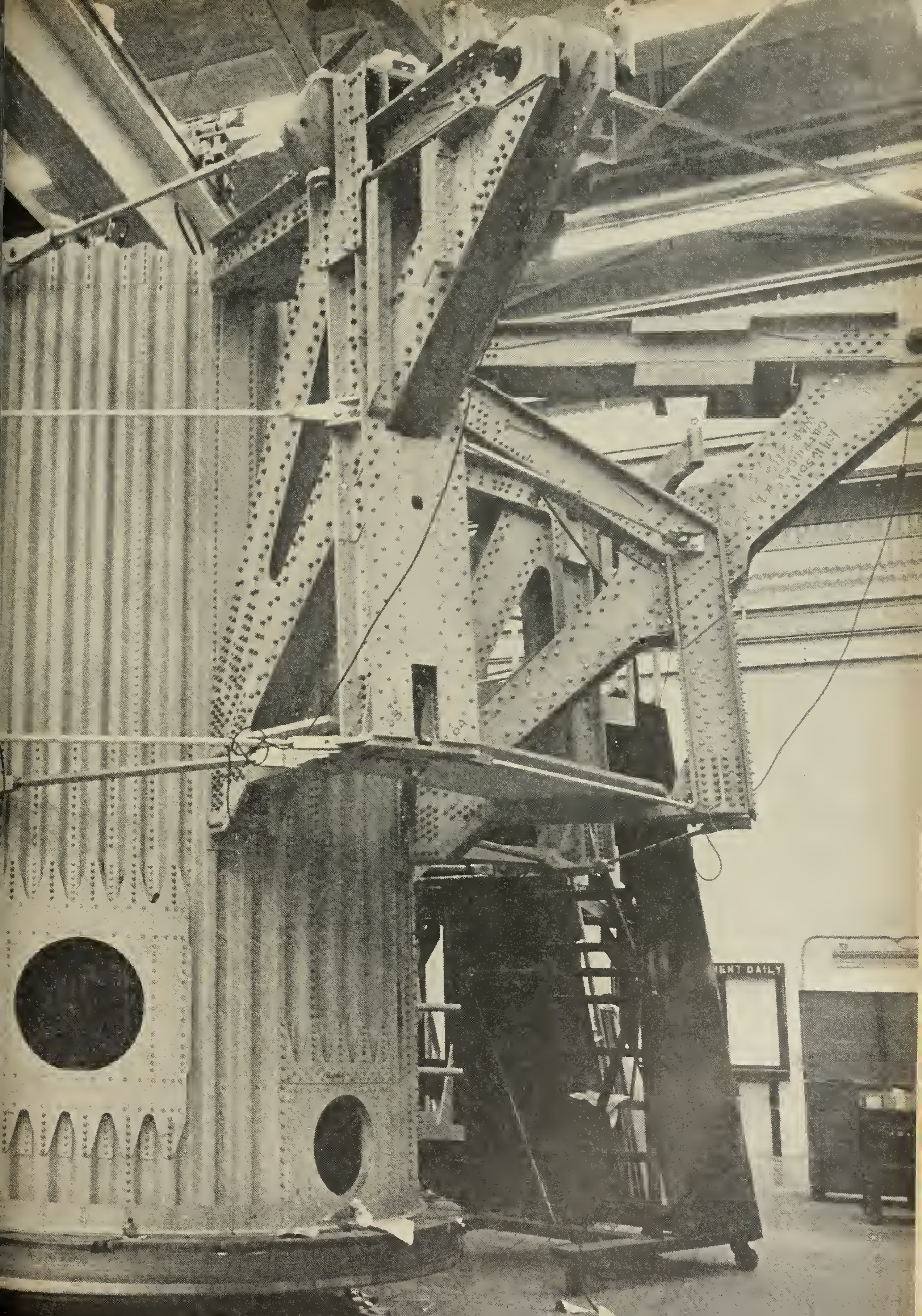
Contractors who were represented at all or part of the two-day conference at Huntsville included:

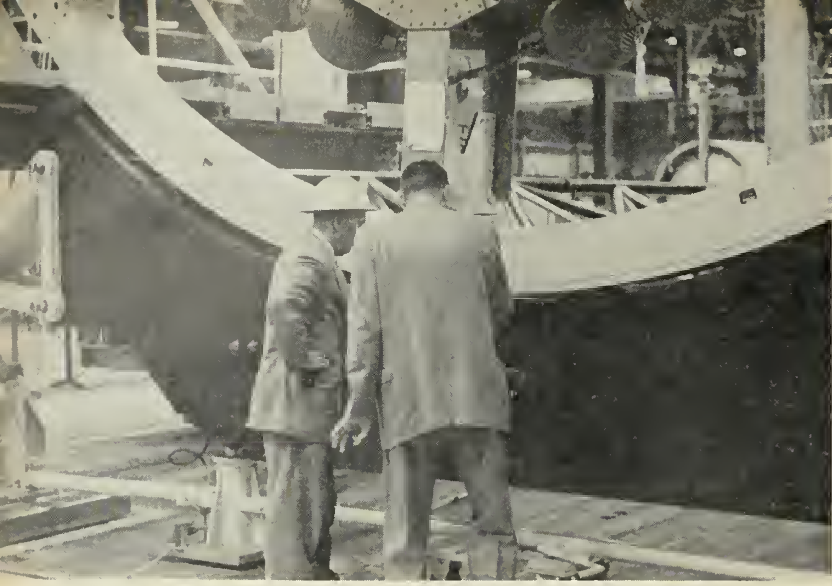
Bell Aircraft, Bendix Aviation, Boeing Airplane, Chance Vought Aircraft, Chrysler Corp. Missile Division, Convair Division of General Dynamics, Douglas Aircraft, Avco, Firestone Tire and Rubber, General Electric, Lockheed Aircraft, Martin Co., McDonnell Aircraft, North American Aviation, Northrop Aircraft, Raytheon, Sperry-Rand, United Aircraft, Beech Aircraft, Brown Engineering Co., Garrett Corp.;

Minneapolis-Honeywell, Reynolds Metals Co., Allison Division of General Motors, Hickock Electrical Instrument Co., Pratt-Whitney Aircraft, Goodyear, Grumman Aircraft, General Precision, Inc., Aeronutronics Division of Ford Motor, American Ma-



TAIL SECTION of 22-foot-wide *Saturn* gives some idea of the staggering proportions of the 1.5-million-pound-thrust booster. The tail section is topped with eight 70-inch-wide Alcoa aluminum tanks clustered around one 105-inch tank.





HELMETED BOSS, Assembly Operations Chief Max Nowak, discusses progress with associate at the top of partly-assembled *Saturn* booster.

chine and Foundry, Acme Scientific Co., Hayes Aircraft, Walter Kidde, Linde Co., and Fairchild Engine and Aircraft Co.

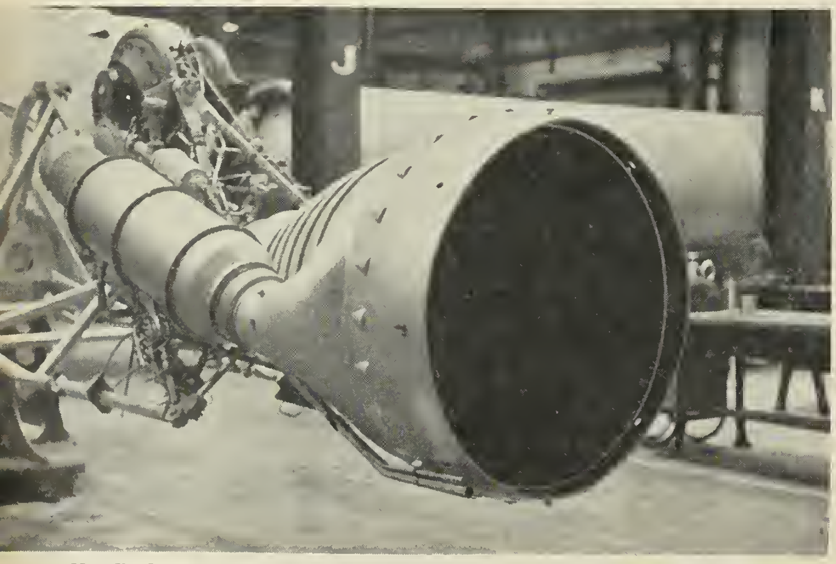
Contractors at the one-day conference at Washington included: Bell, Aerojet-General, Thiokol, Pratt & Whitney, Air Research of Garrett, Rocketdyne and General Electric.

The new second stage—expected to take more than four years to develop—will be a cluster of four 200,000-pound-thrust engines. The new fourth stage—expected to take two years to develop—will be a cluster of four 20,000-pound-thrust engines. It will have a 20-foot diameter—only two feet less than the booster itself.

The third stage will be two 200 K engines. The fifth stage will be two 20 K's.

Under the new schedule, the first *Saturn* with any operational capability in late 1962 is expected to carry the new fourth stage and a dummy fifth stage. Under the old ARPA schedule, the first operational *Saturn* would have carried the much bigger modified *Titan* as a second stage.

The first operational *Saturn* is expected to carry only the eventual fourth and fifth stages.



H-1 ENGINE mock-up sits on floor of ABMA fabrication shop. Each Rocketdyne engine will provide about 188,000 pounds of thrust.

The first 175-foot static test stand has just been completed at ABMA's Test Laboratory in preparation for the first booster test. Assembly of the first booster itself began late last month as individual static tests of its Rocketdyne H-1 engines continued on facilities near the new test tower.

Rocketdyne already has delivered a sufficient number of H-1's for construction of the first eight-engine booster

The day is not far off when the huge 75-foot booster—biggest in the Free World—will be hauled by truck to the test tower and erected with the help of a giant crane. Then with a thundering roar that will shake the earth for miles the booster will be ignited while men cross their fingers.

The finger-crossing is much needed. There is little room for error. If the booster should explode, that will be that for some time to come.

Report Says *Blue Streak* IRBM May Be Cancelled

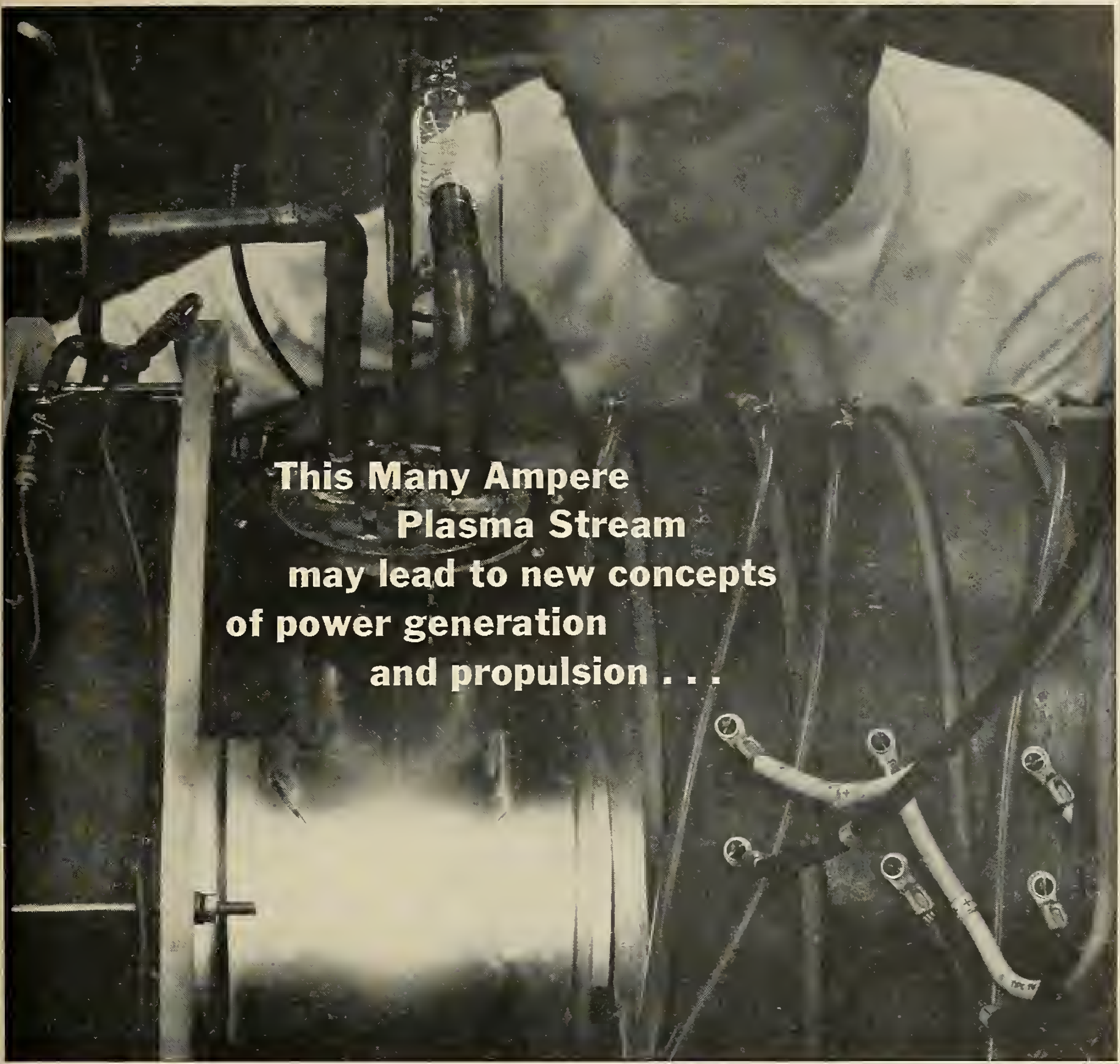
London—A rumour now in circulation says that the new Minister of Defence, Mr. Watkinson, is being pressed to announce the cancellation of *Blue Streak*, the British IRBM.

The Royal Air Force is reported to be alarmed at the vulnerability of such missiles, even if sunk in concrete firing pits, and to believe that few would be likely to remain fit for launching after the first enemy attack. Cancellation should take place soon, before expensive firing trials are started at Woomera.

It is by no means certain that this rumour is true, although a certain amount of resistance to the introduction of missiles is to be expected from the aircraft diehards and from those officers who do not look forward to the personnel changes which must follow.

If the *Blue Streak* program were to be cancelled, heavy compensation payments would have to be made to de Havilland, Rolls-Royce and Sperry Gyroscope. It would also rule out a British satellite-launching vehicle.

Alternatives to *Blue Streak* could be submarine-launched *Polaris*-type missile or a longer-ranged version of the *Blue Steel* stand-off bomb. Either would take several years to develop and further delay the defence program. Furthermore, a considerable amount of capital has already been sunk in ground facilities for *Blue Streak*, both in Britain and in Australia. It thus seems unlikely that cancellation will occur, particularly in view of the excellent performance which is expected of *Blue Streak*.



A many-ampere source of ions, this device is believed to be the most powerful in operation in any laboratory. Already it is providing new insight into thermonuclear fusion. It may lead to new concepts in propulsion including a method of producing thrust for missions beyond the earth's atmosphere.

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NASA Gives Congress 10-Year Plan

$113 million boost asked for FY 1961 for big boosters with 'prestige' programs Mercury, Saturn and Nova getting increases

by Paul Means

In an effort to add appeal to its civilian space program, the Administration last week moved to accelerate eye-catching projects which in time can gain back some of the international prestige lost to the Russians during the last two years.

Two moves in this direction were NASA's request for Congress to increase its Fiscal '61 budget by $113 million (to $911 million), and formulation of a 10-year space program which involves shooting off 263 space vehicles at a cost of about $15 billion.

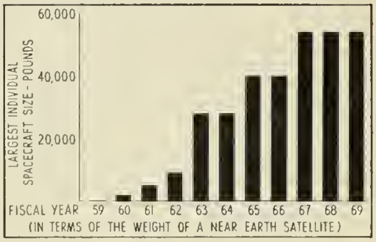
The supplemental, sent to Congress just two weeks after the regular NASA budget, asked for $98 million for the *Saturn* cluster recently acquired from DOD, and $15 million more for the F-1 *Nova* engine.

• **The big three**—Net result is that the three eye-catching projects—the two super booster projects *Saturn* and *Nova,* and the man-in-space Project *Mercury*—have all been accelerated by increased spending. But the Bureau of the Budget's economizing axe cut $123 million out of NASA's other not-so-eye-catching projects.

The supplemental brings the total *Saturn* budget for FY '61 to $246 million—just $4 million short of the figure Dr. Wernher von Braun had asked for. Dr. von Braun made this request last year when *Saturn* was under ARPA management, and hadn't expected to come close to his mark because of DOD's downgrading of super-booster projects. A change of agencies and the chemistry of an election year has given the Huntsville team money beyond their wildest (practical) dreams.

The *Nova* supplemental brings its budget to $41 million in FY '61, and total funding to date now exceeds $71 million.

Payload Weights



Mercury, which had been in critical financial shape during 1959, was funded for $122,750,000 in the FY '61 budget, $19 million in the supplemental FY '60 budget, and has received to date about $300 million.

• **Budget cuts**—But a Spartan regimen is still prescribed for some of NASA's less sensational but equally important projects. NASA officials revealed in testimony before the House Space Committee that their initial budget requests had been cut by $132 million. Some $121 million was carved from part of the FY '61 budget that didn't include *Saturn,* and $11 million was cut from the FY '60 budget.

The figures given reveal that NASA asked for $783 million in its non-*Saturn* part of the new budget, but Bureau of Budget would only allow $662 million. In the FY '60 supplemental, NASA asked for $34 million. The bureau pared this to $23 million.

• **Ten-year plan**—The NASA 10-year plan, apparently predicated on the theory that future administrations will be more generous in support of space research, indicates that the $911 million Fiscal '61 budget is just a starter. Figures indicate that the NASA budget will average $2 billion a year for the rest of the decade.

This point was emphasized before the Committee later in the week by Dr. Wernher von Braun. (See page 12). Admitting that his organization's *Saturn* project now was adequately funded, von Braun stated that he felt more money should be spent for space research in other areas.

"There is always a danger," von Braun told the Committee, "of putting most of the money into weapons systems or space vehicles like *Saturn* and not putting enough money" in less eye-catching but equally important projects. The rocket expert said he would like to see more money in

10-Year Launch Program

(Fiscal Years)	1960*				1961				62	63	64	65	66	67	68	69	
	1	2	3	4	1	2	3	4									Total
Redstone				1	2	3	2										8
Atlas				1	2	1	2	1	6	1							14
Juno II			1		1	3											5
Thor-Able			2														2
Atlas-Able				1	1												2
Scout				4	2		2		6	6	6	6	6	6	6	6	56
Thor-Delta			1	1	1	2	1	1	5								12
Thor-Agena 8									1	6	6	6	6	6	6	6	43
Atlas-Agena 8							1		3	4	5	6	3	12	12	12	88
Atlas-Centaur								1	5	4	5	6	9				
Saturn					1				3	5	1	4	4	4	4	4	30
Nova															1	2	3
Total		12				29			28	23	25	28	28	28	29	30	263

* Last 2 quarters only.

TOTAL COST—$13-15 BILLION

some of these areas—especially in the area of supporting research.

NASA Administrator T. Keith Glennan told Congress the program is one that will overtake the Soviet space lead—but not for about five years. Glennan estimated that NASA will be able to do what the Russians can do now in about 18 months. Since the Russians are not going to stand still, Glennan estimates that it will be 1965 before the two competing programs are on a par.

• **Ahead in '66**—During the latter half of the 1960's, according to Glennan, the U.S. space effort should hit its stride and go out ahead of the Russians for good.

In bulk figures, the program calls for the firing of 8 *Redstones*, 14 *Atlases*, 5 *Juno IIs*, 2 *Thor-Ables*, 2 *Atlas-Ables*, 56 *Scouts*, 12 *Thor-Deltas*, 43 *Thor-Agena Bs*, 88 *Atlas-Agena Bs* and *Centaurs*, 30 *Saturns*, and 3 *Novas* during the next 10 years.

The first year of the new decade will see attempts to launch the first meteorological satellite, the first passive reference communications satellite, the first *Scout*, the first *Thor-Delta*, the first *Atlas-Agena B*, and man's first flight into space (ballistic trajectory).

Deep space shots during 1960 include the *Thor-Able* interplanetary shot to the orbit of Venus (February), another *Atlas-Able* attempt to orbit the moon (April), and a back-up *Atlas-Able* lunar probe (October).

Project *Mercury* experiments during 1960 include the final *Little Joe* shot, 5 *Redstone* shots (some manned), and four *Atlas* orbital shots. Satellite shots during 1960 include four *Juno IIs*, one *Thor-Able*, three *Scouts*, and three *Thor-Deltas*.

Significant aspects of the 10-year program by fiscal year include:

• FY '61—The first lunar impact, the first *Centaur* launch, and the first manned *Mercury* orbit;

• FY '62—Deep space probes of Venus and Mars, and launch of the first *Saturn* boosters;

• FY '63—Firing of a three-stage *Saturn*, an unmanned soft lunar landing, and an unmanned orbiting astronomical laboratory;

• FY '64—An unmanned moon orbit and return, and unmanned Mars and Venus reference probes;

• FY '65-'67—The first launch in a program leading to manned circumlunar flight and manned permanent near-earth space stations; and

• FY '70+—Manned flight to the moon.

The cost of this ambitious program has been placed by NASA officials at between $12-$15 billion. But soaring costs could put the price tag at well over $20 billion. Considering that figure is only the launching cost of the NASA budget, not taking into account other future expenditures for construction and equipment, salaries, and research and development on newer space vehicles and engines, it is apparent that NASA's annual budget within a very few years could run over $3 billion.

Best available estimates are that the NASA budget will reach $1.5 billion by FY '63, and top $2 billion by FY '65. At least one or two of the space agency's budgets in the late sixties could go as high as $4 billion.

• **Non-political**—The 10-year plan was developed under the direction of NASA's Director of Program Planning and Evaluation, Dr. Homer Joe Stewart. It is calculated to have two results: (1) to stop mounting criticism that the nation has no organized space program; and, (2) to lay down a long-range program that won't be affected from election to election.

Many feel that one of the important needs of the nation's space program is a continuity of effort and support not affected by changing Administrations. Dr. Glennan enunciated this doctrine last week before a GOP fund-raising "Dinner With Ike" at Jackson, Mich.

Pointing out that the nation's space program should not be a partisan political issue, Glennan told the GOP contributors that our "rockets . . . do not bear the insignia of the Republican Party or that of the Democratic Party. They do not carry the name of one of the military services or the name of my agency, NASA. They carry only these words: United States."

• **Future changes**—The plan, according to Dr. Stewart, is to be used as a guide and may be revised as our technology improves.

In presenting the plan before the House Space Committee, NASA Associate Administrator Richard E. Horner pointed out that besides the "uncertainty of financial resources that might be available in the future, there must also be taken into consideration the well recognized fact that the nature and depth of future research and development in any complex technical field are heavily dependent upon the character of prior accomplishments . . . our succeses or miscues . . . will have a commanding influence on the integrity of our plan."

One area in which success might significantly modify the plan is research into newer fuels for rocket engines. The plan does not take into account research presently being conducted on fluorine, nuclear, ion and plasma engines.

• **Variables**—Fluorine engines will probably never be used because extensive research in this field started too late. But nuclear, ion and plasma engines should be operational in this decade, and would then have to find their way into the plan.

Another variable which could modify the plan is *Nova*. *Nova* presently is a 1 to 1.5 million pound thrust engine being developed by Rocketdyne, which is not expected to be ready until the late sixties. The decision has not yet been reached whether to cluster this engine, or whether to use it at all. *Nova*, with its accelerated funding, could be ready earlier than expected, or be cut from the program altogether if newer forms of propulsion systems (nuclear, ion or plasma), improve rocketry to the point where such a large booster is not needed.

The U.S. space program, according to Horner's testimony, will begin to improve rapidly during the 1963-1967 time period because of the *Saturn* cluster. By 1967, the space agency will have the capacity of putting 25 times more weight into satellite orbit than now possible.

Mercury Schedule

Project Mercury

	FY 1960		1961				
	3	4	1	2	3	4	Total
Little Joe ..	1	1					2
Redstone ..			2	3	2	1	8
Atlas		1	2*	2*	2*	5*	12

*Orbital.

Deep Space Missions

Fiscal Year	1960			'61			'62	'63
	3	4	1	2	3	4		
Thor-Able	I	.	.	.	.	.	.	.
Thor-Delta	.	.	.	.	.	.	.	.
Atlas-Able	I	L	L	L	.	.	.	.
Atlas-Agena	.	.	.	.	.	L	4L	2
Centaur	.	.	.	.	.	.	..	2P

L—Lunar
P—Planetary
I—Interplanetary

3-Yr. Satellite Program

Fiscal Year	1960			'61			'62	'63
	3	4	1	2	3	4		
Juno II .	S	..	S	2	S	..	..	..
Thor-Able	M	..	..	..	..	..	..	..
Scout ..	..	S	S	S	2S	..	2S	2S
Delta ..	C	M	S	S	..	..	C	..
	..	..	..	..	..	..	3S	..
Thor Agena B	..	..	..	..	..	..	2M	S
	..	..	..	..	..	..	S	..
Atlas Agena B	..	..	..	..	..	..	..	C
	..	..	..	..	..	..	..	2S

S—Scientific
M—Meteorological
C—Communications

Molecular Warning: 'Research or Die'

Over 20 subsystems developed so far; operational systems are now the goal—Air Force warns parts makers to face up to the need for participation

A joint Air Force-Westinghouse Electric Corp. demonstration of product advances in the "molecular-electronics" applied research program revealed that not only has feasibility been proved, but that the researchers are aiming for operational employment of such systems in from 3 to 5 years.

To further emphasize the tremendous impact of this revolutionary breakthrough, the Air Force program chief, Col. W. S. Heavner, issued a startling warning to the electronics industry. In substance, he said that now is the time for parts manufacturers to make up their minds—accept the inevitability of molecular-electronic systems and initiate research of their own to compete, or die. Admittedly, he said, we shall be using resistors, capacitors, inductors, transistors, etc., in many systems for a long time to come, particularly for high power. But this will represent only a portion of tomorrow's industry, said Col. Heavner.

• **New facts of life**—The business facts of life are that the concept of using molecular structure and atomic field characteristics in materials to perform whole system functions has advanced to the point of producing over 20 functional systems.

These are basic systems ranging from audio, video, dc, and tuned amplifiers to multivibrators and logic switches. Furthermore, these tiny working systems can be reproduced simply and within normal manufacturing tolerances.

The $2-million program will be accelerated, said Heavner, to develop more basic systems and, as soon as possible, to combine these basic elements for even more functionally complex electronic equipments. First on the list probably will be a molecularized radio receiver.

Over 1000:1 size and weight reductions will be possible over anything now available, according to Dr. S. W. Herwald, vice president-research for Westinghouse. Electrical efficiencies obtained are of the order of 70%.

Because such systems would employ a vastly reduced number of total parts, reliability is substantially increased. In addition, the solid-state functional unit itself is very stable and inherently reliable. With use of thermoelectric techniques for power, complete system reliabilities should very closely approach 100%.

• **Break proof**—For future automation, Westinghouse indicated that its controlled dendritic process for growing near-perfect semiconductor ribbons could be made both automatic and continuous over long periods. These multi-zone crystals are the basic building blocks required in molecular-electronic systems.

Plating, etching, and alloying techniques are employed before cutting the dendrites into tiny "parts." By controlling the arrangement of domains and interfaces, or the flow of energy within the semiconductor, the "part" can be made to perform an electronic function by controlling or transforming energy. The concept obviates conventional requirements for circuit elements.

The idea that is so hard to grasp is that the final structure performs a system function. If a piece of material were broken off the element, the system would still function. Only the parameters of the system would be changed.

Navy Demonstrates Satellite Relay

Radio signals bounced off moon's surface to provide complete high-frequency link between Washington and Hawaii

The Navy last week publicly demonstrated the feasibility of using space satellites for communications relay.

In this case, the satellite used was the moon. Radio signals were bounced off its surface to complete a high-frequency link between Washington and Hawaii. Although still an experimental system, the CMR (Communications Moon Relay) has been used by the Navy for operational traffic since last November. It is used to fill the gap when normal traffic circuits are disrupted by periodic ionospheric disturbances.

The Navy experiments show that it is practical to use man-made satellites for communications relay. Several projects in this area are already under way —*Courier, Decree, Steer,* and *Tackle* —under direction of the Advanced Research Projects Agency. Some of these are passive reflectors, like the moon; others will carry radio receiving and transmitting equipment and serve as delayed repeaters.

Satellite relays offer several advantages for long-range communications:

• They are not dependent on the ionosphere for reflection and, consequently, are not subject to the disturbances which often cause fadeouts in conventional circuits.

Messages handled by relay are far more secure from enemy interception and interference. Both sender and receiver must have the satellite in view —a fact which severely limits possible geographical locations for jamming or interception.

Frequencies used are in the upper end of the spectrum where more bands are available and noise less of a problem. Reliability is a significant advantage at these frequencies.

The CMR system is presently capable of handling multichannel radio teletypewriter and two-way voice and facsimile circuits. It uses the UHF band of 435-445 mc, and a bandwidth of 16 kc. Both stations have separate transmitter and receiver facilities with 100 kw transmitters and 84-foot steerable high-gain (40 db) antennas. Effective radiated power is 440 megawatts.

• **New systems**—Future operational systems, using the moon or artificial satellites, will be vastly more sophisticated and efficient than the experimental relay. Present equipment—mostly off-the-shelf components—must be manually operated and corrected. Corrections for doppler shift, for instance, are cranked in by hand and the antennas steered by an operator.

Future systems will logically include automatic programming to track the antenna and schedule transmissions during suitable portions of the satellite orbit. Proposed 24-hour satellites will remain stationary over one point on the earth's surface to provide uninterrupted relay service. Multiplexing techniques will provide a large number of channels on each link.

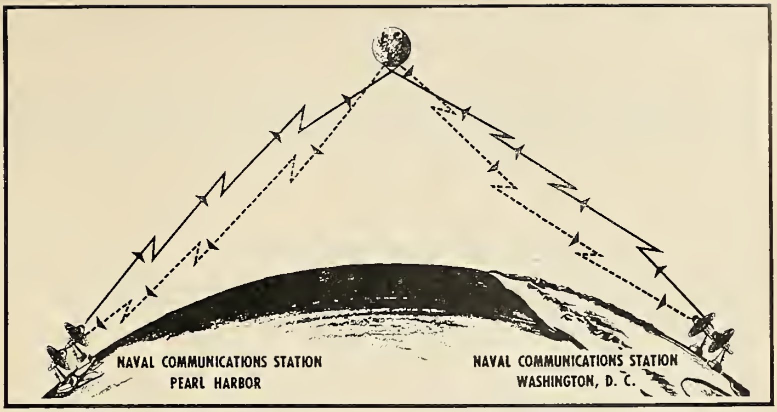
The Navy project grew out of discoveries by Naval Research Laboratory where the feasibility of using moon reflection techniques for communications was demonstrated in 1951.

In 1954, NRL relayed the first CW radio signals via the moon, which was followed a short time later by the successful transmission of voice messages over the earth-moon-earth path. In November 1955, the first transmission and relay via the moon of single-channel one-way radio teletypewriter messages was made from Washington to the West Coast; and in January 1956, from Washington to Hawaii.

The first tests—using makeshift non-steerable antennas and a low-powered transmitter—provided communications of only a few seconds to several minutes. Their primary value was in proving the practicality of systems with high-powered transmitters and directional steerable antennas.

Based on this success, the Chief of Naval Operations directed the establishment of a moon relay circuit between Washington and Hawaii to be used for evaluation of the capabilities and limitations of moon-bounce relays under operational conditions.

In May 1956, the Navy's Bureau of Ships awarded a single research contract to Developmental Engineering Corporation, Washington, D.C., for the development and delivery of an operating communications system to meet performance specifications.



RADIO SIGNALS are relayed by reflection from moon. Transmission time via the relay from Washington to Hawaii was 2½ seconds.

• **Limited**—Operation of the lunar relay systems is limited to periods when the moon is simultaneously visible at both terminals, ranging from a few hours up to a maximum of about 12 hours. Operating schedules are established by determining the time of moonrise at the western terminal and moonset at the eastern terminal.

During these periods, and when the circuit is not being used in research projects, the Navy expects to use it for handling regular traffic to and from Hawaii.

The system is now considered to be under operational evaluation, but is in readiness for use in transmitting operational traffic when solar disturbances affect conventional radio circuits. The system was first used in such an instance last November when particularly bad ionospheric disturbances disrupted regular communications.

Navy says that eventually the moon relay principle may be adapted to sending and receiving messages from ships at sea or to man-made satellites.

Cost of the pilot system, including construction of facilities and other construction, was approximately $5.5 million.

Major subcontractors to DECO in the CMR project include Scatter Communications, Inc., Bethesda, Md.; Continental Electronic Mfg. Co., Dallas, Texas; D. S. Kennedy & Co., Cohasset, Mass.; ITT Laboratories, Nutley, N.J.; General Bronze Corp., Garden City, N.Y.; and Eitel-McCullough, Inc., San Carlos, Cal.

THIS PHOTO of USS Hancock (CVA-19) was the first official photograph to be transmitted by radio facsimile via moon-bounce.

Outlook Good for Frequency Control

Ad Hoc Group of the International Telegraphic Union has already set aside bands for space use and other agreements are likely to be made without difficulty

The 1960's will be the decade when lawyers and diplomats take their place alongside engineers and scientists in an attempt to effect laws regulating the space frontier.

The first "space laws" that will be obeyed generally by world powers will deal with frequencies for space transmission. The early spade work was accomplished last fall by the International Telegraphic Union.

Other laws to be considered by the ITU include provisions for shutting down radio emissions from satellites and other space vehicles at an appropriate time, and of identifications for radio emissions from satellites and other space vehicles.

• **Basic problem**—The basic radio problem created by the space age is the need to find frequency bands for space use in a radio spectrum already burdened by military and commercial communications.

An Ad Hoc Group of the 100-nation ITU decided at Geneva to reserve for space use those bands already being used by the U.S. and USSR. These bands are:

• 5 Mc/s, 10 Mc/s, and 20 Mc/s in the upper guard band of Standard Frequency Service transmission, with a bandwidth not to exceed 2 kc/s, for ionospheric research;

• 19.993-5-7 Mc/s, and 20.003-5 Mc/s, with a total bandwidth of about 20 kc/s for ionospheric research and telemetry;

• 21 Mc/s with a bandwidth of about 5 kc/s for ionospheric research;

• between 27.5 Mc/s and 30 Mc/s with a bandwidth of about 50 kc/s for ionospheric and meteorological research, and telemetry;

• 39.986 Mc/s, and 40.002 Mc/s with a total bandwidth of about 40 dc/s for ionospheric research, telemetry and tracking:

• between 130 Mc/s and 140 Mc/s with a bandwidth of 1 Mc/s for telemetry and tracking;

• 183.6 Mc/s with a bandwidth of 1 Mc/s for telemetry and tracking.

The five nations on the Ad Hoc Group—the U.S., the U.S.S.R., France, the United Kingdom, and Czechoslovakia—agreed to the above frequency allocations and bandwidths for space with the stipulation that the transmissions are to be on a non-interference basis to other services.

• **Reds object**—The Russian and Czechoslovakian delegations recommended that the ITU not allocate specific frequency bands for space research above 200 Mc/s at the present time. Though they had no objections to these higher frequencies being used by other countries, the Soviet delegates felt that further technical information and experience should be available before such allocations were made.

The U.S., French and British delegations made the recommendation that the following frequency bands above 200 Mc/s be allocated for space research:

• about 400 Mc/s with a bandwidth of 1 Mc/s for telemetry and tracking;

• between 15,000 Mc/s and 16,000 Mc/s with a bandwidth of 100 Mc/s for space relay research and meteorological research;

• between 30,000 Mc/s and 32,000 Mc/s with a bandwidth of 300 Mc/s for space relay research and meteorological research;

The French and British delegations proposed allocation of a frequency band at the top of the hydrogen-line band (1400 Mc/s-1427 Mc/s), but the U.S. delegation believed that it was not feasible to share any part of this band for space research.

The U.S. delegation proposed the allocation of three band of 20 Mc/s width between 1700 and 2500 Mc/s, but the French and British delegations only wanted two allocations of 1801-1821 Mc/s and 2084 to 2104 Mc/s.

The U.S. and British delegations proposed the allocation of a 100 Mc/s bandwidth between 8000 Mc/s and 9000 Mc/s, but the French had certain reservations.

The Group as a whole agreed that it will be necessary to convene an Extraordinary Administrative Radio Conference of the ITU in late 1963 to make provisions for new services and methods of telecommunications using space vehicles. They suggested that the conference decide on allocation of frequency bands for the various categories of space telecommunication, consider whether some frequencies for space use are any longer needed, and adopt certain regulations to provide for identification and control of radio emissions from space vehicles.

The Group also requested that the ITU's Radio Consultative Committee (C.C.I.R.) study the desirability of identifying radio emissions from space vehicles, and also the desirability of providing regulations for the shut-down of radio emissions from space vehicles.

And it asked that those nations launching satellites—namely the U.S. and the U.S.S.R.—keep the ITU informed of frequencies used and technical progress achieved in use of telecommunications for space reesarch.

• **Permanent signals**—The problem of permanent power sources in satellites first arose when the U.S. Navy launched *Vanguard I.* The satellite's batteries were charged by solar cells, allowing it to send signals back to earth ad infinitum.

Because of its almost perfect orbit, *Vanguard I* still provides useful information. But when the value of its information is ended, there is no way to turn off *Vanguard I's* transmitter.

And a great many satellites in space with permanent power sources would clutter up valuable frequency bands for many years to come.

Explorer VII, the long-life radiation experiment satellite, has a destruct mechanism which will turn its transmitter off after one year of operation.

Methods which can be used to terminate a satellite's signal are: (1) using a circuit breaker; (2) applying too much voltage to a transistor, or (3) using a time fuze or mechanism.

• **Hopeful**—Since the Soviet Union is the only other space power, the outlook is good that the ITU will be successful in regulating space transmissions.

The communications experts point out that to date neither nation has much of a vested interest in space, and that the ITU so far has had little difficulty in bringing about international agreements on frequency allocations. (See M/R, June 1, p. 26.)

Norair Proposes All-Plastic Rocket

by **Frank G. McGuire**

HAWTHORNE, CALIF.—An all-plastic rocket utilizing a plastic solid propellant and a minimum of metal parts has been presented for industry consideration by the Norair Division of Northrop Corporation. Some of its advantages would be resistance to radar and infrared detection, low fabrication costs, good insulating qualities, light weight and high strength.

Although the firm has not formally proposed the project to a government agency or settled on a particular configuration, materials research indicates that the project is feasible.

A paper presented at the 15th Annual Conference of the Reinforced Plastics Division of the Society of the Plastic Industry listed materials for the vehicle. Northrop's Harry Raech, Jr., of the Materials Research Laboratory, enthusiastically endorsed the use of plastics, commenting: "We are entering a period where it is possible that metals will be as rare in missile structures as wood now is in aircraft."

Properties of Modified Phenolic Laminates

Material	Edgewise Compressive Strength, Psi Ambient	1000F
181 Glass Cloth/192 Resin	10,000	300
Refrasil C-100-28 Cloth/192 Resin ..	32,600	6,100
181 Quartz Cloth/-192 Resin	5,700	1,600
28 x 28 Graphite Cloth/192 Resin .	2,150	340

• **Increased efficiency**—The nose cone of the proposed vehicle would be a quartz-fiber-reinforced phenolic, about 40 times as effective as the same weight of copper in heat dissipation. The motor casing would be a filament-wound fiberglass epoxy, which Raech estimates would be twice as efficient as a metal casing. An exit nozzle of graphite-cloth-reinforced phenyl silane would provide good stability and ablation-resistance at 5000°F or higher.

Propellant utilized would be polysulfide/perchlorate, insulated with a liner of asbestos phenolic. The outside liner of rigid plastic foam would have an erosion shield of refrasil-reinforced modified phenolic. All guidance equipment would be potted in silicone rubber, and the payload compartment constructed of fiberglass honeycomb sandwich, chosen for its low thermal conductivity and its high strength/weight ratio.

The only metal parts used in the vehicle, says Raech, will be electronic components and a few fasteners.

• **Heat resistance emphasized**—Thermal properties of plastics represent "one of the most compelling reasons" for considering their use in structural members, according to Northrop, because of the unusual environmental situations in which such a vehicle would have to have exceedingly high performance.

The paper, representing work conducted at Norair's Materials Research Laboratory, covers a considerable number of structural materials feasible for use in a rocket vehicle, pointing out that any such material should possess the highest possible specific heat and the lowest possible ratio of thermal conductivity to mass.

Although plastics would be expected to provide better insulation than metal, their high specific heat—equivalent to that of most metals—is an unexpected bonus, according to Raech. He points out that reinforced plastic is second to no other material in specific strength properties.

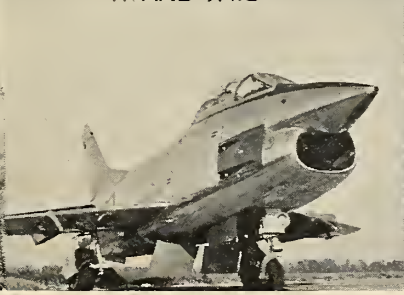
Two classes of heating problems are expected to arise in the proposed vehicle: short- and long-time effects. The former is taken to mean time in seconds or a few minutes. This class is the less serious of the two; materials already developed can cope with it. Up to 800°F, there are a number of re-

SUPPLY THE POWER

POWER FOR THIS

stol Siddeley Maybach diesel en-
s power Britain's fastest express train
e British Railways "Bristolian." Two
MD 650 engines, developing a total of
0 hp, give the "Bristolian" a top speed
ver 90 mph.

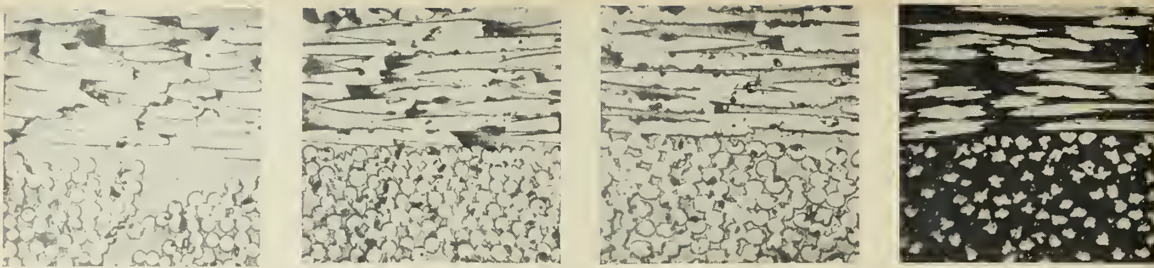
... AND THIS



The Bristol Siddeley Orpheus, the world's most advanced lightweight turbo-jet engine, powers this Fiat G 91, NATO standard lightweight strike fighter. The Orpheus is in service in six different aircraft and is specified for eight others.

... AND THIS

The Bristol Siddeley Proteus powers the Britannia airliner. Four Proteus give this 130-seat aeroplane a speed of over 400 mph—a range of over 5,000 miles. Britannias are in service with twelve airlines and with RAF Transport Command.



PHOTOMICROGRAPHS illustrate failure of reinforcing fibers in refrasil and quartz materials. Glass and graphite display no degradation, presenting smooth rounded filaments and showing no discontinuities. The siliceous materials, display a "crystalline" structure with cracks and crevices. Whether the faults are true devitrification or are stress-induced is impossible to determine.

inforced plastics capable of doing the job.

Even short-time temperatures as high as 6000°F can be satisfactorily met with sacrificial cooling. This approach utilizes heat of fusion or vaporization for surface cooling and is most useful in contact with high-velocity, high-temperature gaseous streams. Its utility is demonstrated by a typical fiberglass ablation surface, which will absorb approximately 6000 BTU's for each pound ablated.

• **Divided opinion**—Two schools of thought exist on this subject. One holds that structures should, in their entirety, contribute to pyrolytic cooling. The other feels that a method using pyrolytic resins bound together and supported by a relatively stable net such as refrasil cloth would be more effective. This latter group favors formation of bound graphite, which, in maintaining integrity, acts as a thermal barrier while still allowing transpiration of cooling vapors of pyrolysis from substrates.

Strength/Weight Ratios Of Some Structural Materials

Material	Specific Tensile Strength, Inches X10-6
Aluminum, 7075 T6	0.72
Magnesium, AZ51X	0.55
Steel, 4130	0.69
Fiberglass Cloth (181) Epoxy	0.85
Fiberglass Filament Winding	1.40

In the long-duration applications, an intensive search is under way for reinforced plastics which can operate effectively in temperatures over 500°F for extended periods. Presently, temperatures over 800°F can be met, but these will be greatly exceeded in future space vehicle environments.

Norair is conducting an intensive applied research program, utilizing its ability to carry on extended-duration tests at temperatures ranging from −100°F to 2000°F.

• **Fiber weakness**—One of the major problems involved in the search for high-temperature reinforced plastics is the relative weakness of the reinforcing fibers. In certain areas of structural stress, the fiber rather than the resin has imposed limitations.

In a study of various reinforcing fibers, Norair took photomicrographs of several fibers, which revealed glass and graphite suffering no degradation. Both materials maintain smooth rounded filaments and show no discontinuities.

Both refrasil and quartz, however, showed a crystalline structure with cracks and crevices. It cannot be determined whether these flaws result from true devitrification or are stress-induced. Raech notes that anticipated strength levels have not been achieved in the laboratory.

• **Epoxy gains**—Progress in epoxies has been considerable; the versatility of these polymers has been greatly expanded in the past year. Great hope is held out for some of the most recently developed combinations.

Previously, epoxies could not be depended upon for lengthy service at temperatures over 300°F, despite their relatively high strength levels. This situation has improved somewhat, and current service levels are over 400°F.

The belief that 750°F is the upper

*Some Properties of Laminates For Use To 800F**

Resin	Temperature, °F	Time, Hours	Tensile Strength, Psi	Edgewise Compressive Strength, Psi
Epoxy, Epon 828	70	..	55,000	54,000
Epoxy, Epon 828	400	200	25,000	5,000
Phenolic, 91LD	500	½	52,000	40,000
Phenyl Silane, 37-9X	600	½	34,000	22,000
Phenyl Silane, 37-9X	800	½	.....	9,700
Silicone, DC 2106	70	...	46,700	16,100
Silicone, DC 2106	500	½	30,700	5,000
Silicone, DC 2106	800	9	18,100	3,000

*All laminates made with 181 E-Glass fabric, properties given for the warp direction.

Thermal Properties Of Some Space Materials As Measured At About 200° Fahrenheit

Material	Conductivity k $\frac{BTU}{°F \text{ in hr ft}^2}$	Specific Heat C $\frac{BTU}{lb\ °F}$	Density d $\frac{lb}{in^3}$	Specific* Conductivity 1/kd $\frac{in^2}{BTU\ °F\ ft^2\ hr}$	Heat Sink** Coefficient Cd $\frac{BTU}{in^3\ °F}$
Aluminum, 24S	98	.22	.098	.105	.022
Beryllium	85	.52	.066	.179	.034
Copper	211	.09	.320	.015	.028
Graphite	79	.17	.050	.253	.085
Magnesium	84	.25	.064	.187	.016
Steel, 4130	11	.13	.290	.313	.038
Fiberglass Epoxy†	.89	.24	.063	17.9	.015
Fiberglass Polyester	.97	.28	.066	15.7	.018
Fiberglass Phenolic	.87	.25	.059	19.7	.015
Fiberglass Silicone	1.02	.24	.059	16.5	.014
Refrasil Mod. Phenolic	2.3	...	.060	7.3	...
Urethane Foam, Rigid	.48	.41	.006	347	.002

*Higher values connote efficient insulators weightwise.
**Higher values connote efficient heat sinks weightwise.
†All laminates reinforced with fabric.

limit of temperature stability for purely organic systems is being attacked through research into polymers not based on carbon linkages. This stems from development of the metal chelate concept and of coordination bonding.

A continuous effort is being made to upgrade the conventional thermosetting resins—the epoxy, polyester and silicone types—with Hooker Chemical Co. achieving 90% of initial strength at 500°F. The figure is 40% for equivalent hydrogen-glycol-polyester laminates. Strength retention in Hooker's work is 65% after 100 hours at 500°F, as contrasted with 30% for corresponding hydrocarbon polyesters.

Scientists at Quantum, Inc., have produced organic polymers with good temperature stability at over 750°F. These were of the ammeline and melamine families. It is believed that future work may produce polymers stable in the 1000°F to 1400°F range.

Similar work at the University of Florida has produced a synthesized series of hydrazine polymers, all of which are stable at over 700°F. One of these, a co-polymer of perfluoroglutaroimidine and perfluorobutyramidine, is expected to exhibit stability at 750°F.

• **Metal research**—Organometallics now under study are expected to show desirable properties after further work.

Thermal Stability Points Of Some Polymers

900F	*Dicyclohexyl Phosphino Borane Trimer Polyaluminoxanes*
750F	*Melamine Phosphorus Pentachloride Naphthazarin Theiosemcarboazone-Nickel Complexes Perfluoroglutaroimidine-Perfluorobutyramidine Copolymers Phthalyl Bis-(B-Hydroxethyglycene) Zinc Chelates Zinc Coordination Polymers*
700F	*P-Biphenyl Isocyanurate*
650F	*Bis (5-Phenylhexamethyltrisiloxanyl) Ferrocene Trichelated Aluminum Polymers*
625F	*Diphenyl Silane Polymers*
575F	*Alkyl Phosphines 3-Methylvinylcyclohexane Phosphinoboranes Phosphorus-Nitrogen Polymers*
550F	*Epoxies (Improved)*
525F	*Sulfur-Nitrogen Compounds*
500F	*Melamine-Sulfamide Formaldehyde Polymers Polyphenyls*
475F	*Dodecamethylstannopentane*
450F	*Fluorinated Alkyd Polyesters*
400F	*Diamminedichlorozinc Polymers Ferrocene-Bromosilane Polymers Pentaphenylantimony-Nickel Carbonyl Polymers*
300F	*Nickel Salicylaldehyde Diamine Polymers*

A number of companies and government facilities are researching with aluminum, iron, nickel, phosphorous, silicon, sulfur, tin, zinc and other materials in an effort to perfect these organometallics.

Trichelated aluminum polymers expected to be stable at 680°F have been prepared at Morton Chemical Co., and are being evaluated at Norair. Similar work with polyaluminoxanes at U.S. Borax Research Corp. has produced polymers withstanding 900°F, which appears to be the temperature limit of existing reinforced plastics, although extensive work is under way in numerous laboratories.

Temperature resistance qualities of reinforced plastics are being constantly raised, through work supported to a large extent by the Defense Department.

Recalling that nearly all the commonly used metals of today have temperature limits of 2000°F, Raech concludes: "It may not be too much to expect that the high-temperature materials of the future may be the plastics. Time and research alone will tell."

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propulsion engineering

GCR Starts Production of Nitrasol

Action makes company formidable contender in AF's big booster program. Decision of contractor imminent with hybrid system possible

Grand Central Rocket Co. of Redlands, Calif., last week started pilot production of a new high-energy propellant—Nitrasol. The action apparently boosts GCR as a formidable contender in the Air Force competition for the multimillion-pound-thrust solid space booster. (M/R, Nov. 30, p, 21.)

The booster—which now stands a better than average chance of becoming a hybrid liquid-solid—is undergoing final evaluation of bids by Air Research and Development Command. Bid deadline was Dec. 15. A decision on the competition, which would give the Air Force its own boost system independent of National Aeronautics and Space Administration scientific vehicles, is expected to be announced at any time. To date, it is believed, no specific requirement has been spelled out for these motors.

Funds for the project would come from Air Force money programmed for R&D in improving existing solids combinations. It is estimated that the first phase of the big booster program (which is essentially a feasibility study) would cost between $4 and $8 million. Three to five motors presumably would be delivered. The entire cost over a three-year period would be in the neighborhood of $35 to $40 million.

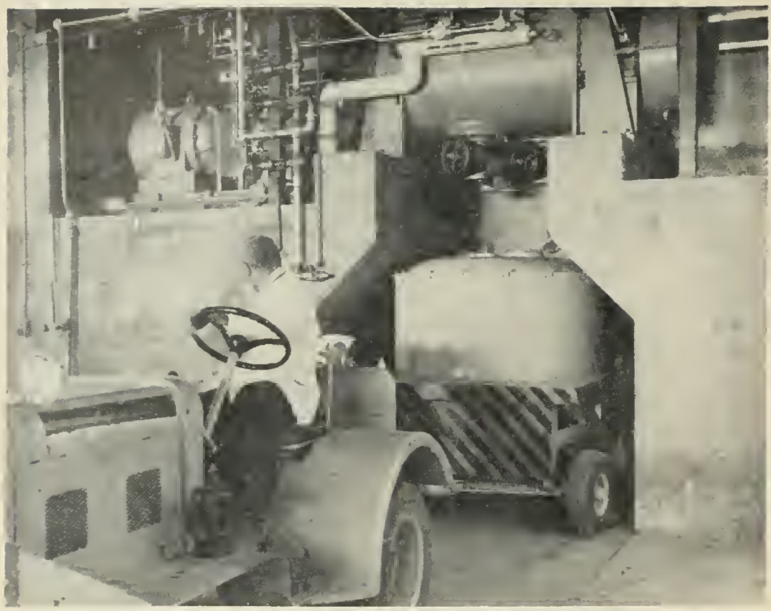
• **Hard look by Congress**—The big solid undoubtedly will get a careful scrutiny from Congress during forthcoming appropriations hearings, with the Air Force undoubtedly having to prove its need for such a system.

The main point which will be stressed is that Air Force needs such a vehicle within three years to carry out its military responsibilities in altitudes up to 600 miles. The Administration has told AF to leave the area beyond 600 miles for scientific research by NASA.

Many in industry feel that unless additional funds are forthcoming, the Air Force will be borrowing from Peter to pay Paul with existing solids research suffering while R&D funds go to the big booster.

Grand Central reportedly has measured I_{sp} of between 250 and 260 seconds with the Nitrasol mix, originally developed by Naval Ordnance Test Station at China Lake, Calif. An AF spokesman said the Nitrasol competition is decidedly in the running for the big booster and also is being considered for product improvement of several missiles.

He said Nitrasol has just as interesting physical characteristics, as it has high specifics and it could easily become competitive with the "blue sky" propellants which the Advanced Re-



GCR is now operating the world's largest mixer at Redlands.

search Projects Agency is investigating within the 285 I_{sp} range.

• **Ganging up?**—M/R has learned that Marquardt Corp. has teamed up with GCR. The team approach, which both companies will not confirm or deny, reportedly is a hybrid design with the solid inert—thereby insuring safety in transport, which could be done in sections. As one spokesman said, "casting at the site is a crutch that no one really wants to go to." However, the GCR/Marquardt proposal reportedly includes site casting if the Air Force so wishes.

Many in industry believe Air Force will go to a 2- or 3-million-pound booster rather than stay in the vicinity of 1 million pounds of thrust. This is based on the fact that many solids people believe the Air Force system could be available before either the clustered *Saturn* with eight H-1 engines, or the single chamber 1-million-pound E-1 engine. Both are Rocketdyne products.

Some solids proponents point out that a 100-million pound/sec. unit would cost only ⅕ as much to develop as a comparable liquid size unit. Production costs, they say, would only be one-half as much.

Grand Central has said it can build a large grain free of stress at ambient temperature, which would ease storage and transport problems. Factors stressed on behalf of the liquid-solid hybrid system are: controllability with half the plumbing of pure liquid systems, safety, more BTU in a given package, and the old argument—simplicity.

It is understood that Marquardt's part of the team includes liquid and mechanical systems and nozzle. GCR would do loading selection of solid propulsion materials.

• **Funding offer**—An unusual feature of the whole big booster competition is that when the Air Force asked for bids ata a secret meeting last November at Edwards AFB, it stressed that it was interested in "sharing the cost"—not only in new facilities, if the contractor has need for them, but in actual R&D and production.

Other bidders include Thiokol, Aerojet, Hercules Powder, Astrodyne, Atlantic Research and Olin-Mathieson. A few of these companies have also submitted proposal advocating solid-liquid hybrid systems.

One company's bid reportedly is the "dollar-plus," which his competitors are criticizing as an effort to get a contract which could prove detrimental to the entire propulsion industry. The complainant said such a bid could well lead to opinions from Congress that the propulsion industry is "getting fat on contracts" and should furnish more than its fair share of facilities expansion and R&D costs. "This couldn't be farther from the truth," the spokesman said, "as I look at our own production. far below our plant's capabilities."

• **Varied proposals**—Papers presented at recent technical meetings have proposed many large booster systems. At the American Rocket Society's November meeting, John Gustavson of GCR outlined details for construction of a 2.4-million-lb.-thrust solid motor which would burn 72 sec. at a thrust-to-weight ratio varying from 2.5 to 7.9. The 691,000-lb. booster would be 90′ long and 12.5′ in diameter and would perform at 265 I_{sp} between sea level and altitude burnout.

Earlier, at a symposium on Advanced Propulsion Concepts held in Boston, Dr. Harold Ritchey of Thiokol proposed a solid booster of 10-million-pounds-thrust and 60 sec. duration. It would have a total impulse of 600-million-pound-seconds, comparable to a liquid rocket generating 3 1/3-million-pounds-thrust for 180 sec.

Aerojet-General (M/R, Jan. 11, p. 13) proposed a huge booster which could place 25 tons of useful payload in orbit within eight years. In the neighborhood of five million pounds thrust. it would have a diameter of about 20 feet. The firm said it has spent approximately $250,000 in company funds during the past year to study big booster systems.

And on Jan. 29, Rocketdyne engineers outlined at an American Rocket Society meeting a series of approaches for building a two-megapound thrust booster that would burn 90 sec.

Lockheed Acquires 50% Of Grand Central Rocket

Announcement was made last week by Lockheed Aircraft Corp. that it has reached an agreement to acquire 50% interest in Grand Central Rocket Co.

No terms of the agreement were disclosed beyond a statement by Lockheed Chairman Robert E. Gross that the company expects to pay cash for the GCR common stock which it acquiries.

Gross said the acquisition is aimed at rounding out Lockheed's missile, satellite and spacecraft capabilites. Recently, Lockheed Electronics Company was formed as a wholly owned subsidiary, combining Stavid Engineering, Inc., acquired in May, 1959, and Lockheed Electronics and Avionics Division, formed last March.

Only last week, GCR started up the world's first pilot production facility of the high-energy propellant, Nitrasol, regarded by many as a formidable contender. (See preceding page). The propellant mix is also believed to have a good future in product improvement of many existing solid motor systems.

GCR, founded in 1955, became a subsidiary in 1958 of Petro-Tex Chemical Corp. of Houston, jointly owned by Food Machinery and Chemical Corp. and Tennessee Gas Transmission Co. Under current plans Lockheed and Petro-Tex will share equal ownership of GCR. No personnel changes are contemplated.

Rocketdyne Details Solid Booster Plan

by Jay Holmes

PRINCETON, N.J.—A group of engineers for Rocketdyne has proposed three approaches to building a solid-propelled booster generating two million lbs. thrust. The proposal was outlined at the American Rocket Society Solid Propellant Conference here Jan. 29.

Although the North American division's spokesmen did not say so, most listeners assumed the plans outlined were in their company's proposal in the current Air Force competition for a large solid booster.

J. E. Medford, a senior analysis engineer at Rocketdyne's Solid Propulsion Operations in McGregor, Tex., read the paper, which was co-authored by A. B. Boyd, design engineer and W. M. Burkes, design supervisor.

The paper, entitled "Grain Design and Development Problems for Very Large Rocket Motors," outlined ways of building a two-megapound rocket that would burn 90 sec. Assuming specific impulse of 250 sec. and pressure of 500 psi, they came up with plans for a motor 15′ in diameter and from 64′ to 66′ long depending on internal grain design. Propellant would weigh 360 tons.

• **Going with the grain**—The three designs Medford discussed are the single grain, the compartmented grain and the modular grain. The single grain would be a simple scale-up of present large solid rockets with the propellant bonded to the case. It would have to be cast at the launch site. A compartmented grain would also be case-bonded and cast on site. But it would be separated into compartments by support structure. The modular grain would be an assembly of several propellant modules cast and cured as separate pieces. The modules need not be cast on site.

The Rocketdyne engineers declared that all three approaches are feasible but that the case-supported single grain is preferred because it is the simplest to fabricate. However, propellants with good physical properties will be needed for such a design.

Medford said new butadiene-based propellants under development at McGregor have physical properties that make them ideal for use in a very large motor. The company said butadiene propellants have greater resistance to tear and strain, less tendency to slump and better case-bonding capabilities than present-day polyurethane propellants.

Both the compartmented and modular designs offer solutions to the structural problems involved in using propellants of lesser physical properties, they added. In addition, they concluded, the modular grain provides the advantage of favorable conditions for fabrication, inspection and quality control.

The Rocketdyne proposal was the third in about a week to come to notice. M/R learned this week (page 29) that Grand Central Rocket Co. has started pilot production of a new high-energy propellant in an effort to jockey for position on the Air Force big solid booster competition. And United Aircraft's United Research Corp. announced it has invented and perfected a method of building up a large solid rocket from segments (M/R Feb. 1, p-11). Thiokol, Aerojet-General, Hercules Powder Co., Olin Mathieson and Atlantic Research Corp. also attended an ARDC briefing on the proposal at Edwards AFB last fall. However, Atlantic Research decided not to bid.

For all three designs, the Rocketdyne engineers assumed that the motor case would consist of a wound glass fiber, reinforced plastic cylindrical section with a metal flange at the aft end, which connects by tension bolts to a formed metal aft head. The case would be helically wound on site to avoid transportation difficulties.

The case would operate at a stress level of 70,000 psi. Medford and associates did not detail how the fiber-glass-plastic combination would be bonded to the metal aft head.

For the case-supported single grain, the Rocketdyne group postulated a five-pointed star cut in the 90″ radius cross-section. Web thickness would be 36″, inner radius would be 18.8″ and fillet radius would be 2″. They calculated that the grain would slump 0.327″ at the innermost boundary due to its own weight 100 minutes after being set on end.

• **Compartmented grain**—The star point stress concentration also may be eliminated by the design of a compartmented grain. Such a grain is separated into sections so that it no longer acts as a homogeneous mass. The star point stress is eliminated by adding an expansion joint at the star base or the base corners.

An additional advantage in adding a joint in is the reduction of grain sliver—the unburned propellant remaining at the start of thrust decay.

• **Modular grain**—Although both case bonded and mechanically suspended modular grain approaches are possible. Medford and associates considered only the mechanically suspended. Such a design has many advantages, they said, which include:

• Casting and curing by conventional methods in a company's own home facilities, making possible cost savings.

• Small mass and accessibility allow easier and more thorough inspection.

• Defective individual pieces can be scrapped at relatively small monetary loss.

• Modules could be cast in transportable size.

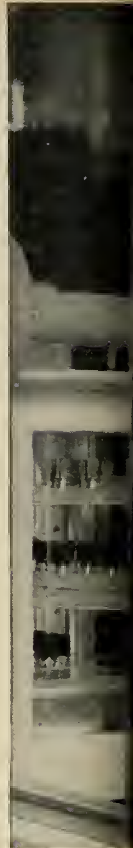
The Rocketdyne engineers suggested casting the modules around a support structure, which would have male and female fittings at either end. Then the modules could be connected end to end to form a column.

Different arrangements of internal support can be used in different modules, depending on the geometry, burning surfaces, physical properties and load to be carried. Non-burning surfaces would be coated with inhibitor to prevent uneven burning.

Motor Design Summaries

	Monolithic Grain	Compartmented Grain	Modular Grain
Thrust, lb.	2,000,000	2,000,000	2,000,000
Duration sec.	90	90	90
Pressure psi	500	500	500
Assumed I_{sp} sec.	250	250	250
Case OD ft.	15	15	15
Case Cyl. length ft.	53	53	51
Overall Motor length ft.	66	66	64
Propellant Wt. lb.	720,000	720,000	720,000
Total Wt. lb.	775,000	790,000	800,000
Mass Ratio	.93	.91	.90

WHO READS MISSILES AND ROCKETS?



Well, for instance . . . ENGINEERS AT WESTINGHOUSE DEFENSE PRODUCTS

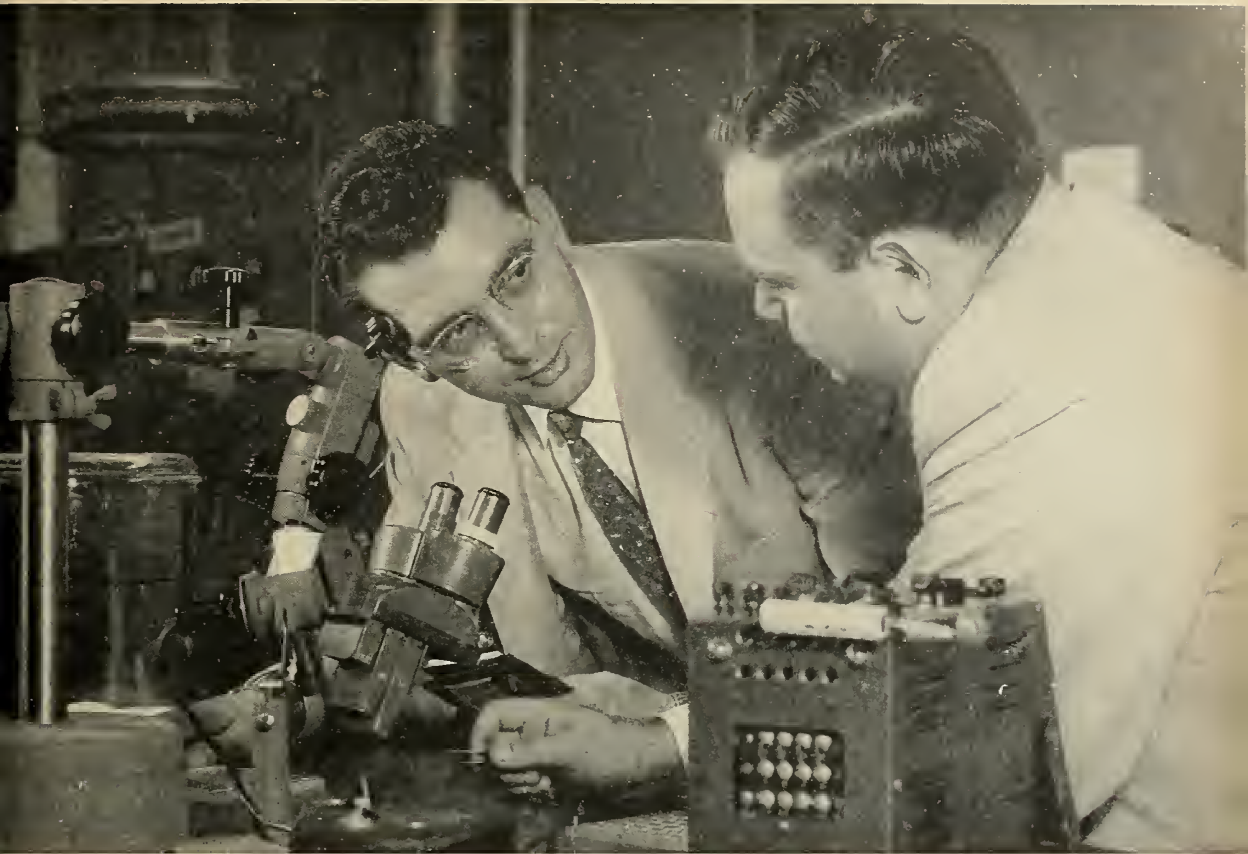
Molecular electronics—a technological breakthrough at Westinghouse—is producing electronic systems *1,000 times smaller and lighter* than anything now in existence.

Through molecular electronics, drastic reduction in weight, size, power and heat dissipation requirements will permit space vehicles and satellites to perform a greater number and wider range of tasks. Greatest advantage is the vastly improved reliability achieved by the replacement of numerous components by a single solid state unit.

Recently, the Air Research and Development Command of the U. S. Air Force awarded a development contract to Westinghouse as a part of a broad program effort in this new electronic area. Experimental "hardware" is being fabricated by Westinghouse for infrared, reconnaissance, communications, telemetry, flight control and other military applications.

"Missiles and Rockets deals exclusively with astronautics. Spawned by aviation, missilery and outer space exploration today is an industry by itself." — George Shapiro (right), Fellow engineer of the Westinghouse Astronautics Institute, located at Air Arm Division.

"One company can't build the entire bird . . . it takes thousands of p s and scores of companies. Missiles and Rockets keeps us informed of e products and capabilities of the other companies throughout the ind try — a most definite aid in selecting contractors." — Harvey Sa n (right), Manager, power systems, Westinghouse Advanced Syst s Planning group.



Gene Strull (right), Manager of the Semiconductor Divi-
's Solid State Advanced Development Laboratory at the
tinghouse Air Arm Division, discusses molecular elec-
ics with Charlie LaFond of the editorial staff of Missiles
Rockets magazine. Westinghouse engineers have devel-
l on a single semiconductor wafer, a system that performs all the functions of much larger conventional and transistorized electronic systems. Typical application is a tiny light sensing device for satellite telemetry less than ½" in diameter and 1/100th of an inch thick, one of several subsystems including pulse generators and multiple switches, already built and demonstrated by Westinghouse.

is fast-growing, dynamic industry (missiles and
onautics) demands week-to-week technical and
s coverage. Month-old news and developments
of little use to today's engineer." — Jim Currie
t), Radar Engineering Section Manager, Westing-
se Electronics Division.

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Lockheed Shows Advanced *Agena*

Test firing made of Bell liquid engine which will have restart capability in space. In-flight test due next month at Canaveral on Atlas

by William J. Coughlin

SANTA CRUZ, CALIF.—An advanced *Agena* satellite vehicle capable of engine restart in space was unveiled in a test firing Jan. 27 at Lockheed Missiles and Space Division's $10-million 4000-acre test site on Eagle Mountain.

Lockheed said the new liquid-fueled engine system is the first which will permit a heavy military satellite to change its orbit. It described the advanced satellite and its Bell Aircraft Corp. engine as a breakthrough in space technology.

Agena, first satellite to change attitude on orbit according to program. thus also becomes the first capable of changing orbit.

Initial in-flight test of the system will come next month when it is to be boosted into orbit from Cape Canaveral by a Convair *Atlas.*

The large *Agena B* carries approximately 17,000 lbs. of inhibited red fuming nitric acid and UDMH, double the fuel capacity of the basic *Agena,* which is 19 ft. long and five feet in diameter. Size increase of the *Agena B* resulting from the double tankage is chiefly in length. Engine thrust of both *Agena* vehicles is 15,000 lbs.

Restart is accomplished by using a solid-propellant charge to fire up the turbine pump. Solid propellant also provides the small kick necessary to solve the zero-weight problem of the fuel on restart in the satellite's gravity-free condition.

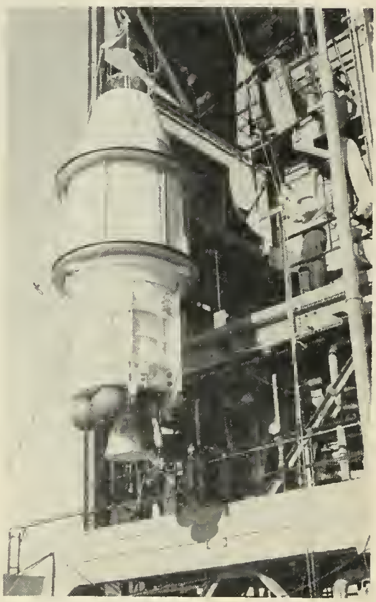
Engine gimballing is provided by an electro-hydraulic system. Attitude control is by compressed air jets.

Development test firing of the *Agena B* engine came as newsmen were admitted to the previously classified Lockheed facility for the first time.

Other highlights of the test base tour:

• Disclosure that Lockheed is carrying out research and development test work on a small liquid rocket engine of its own.

• Unveiling of a new "soft stand" used in *Polaris* firings to permit the missile to go through the motions of flight while securely tethered in the test stand.



LOCKHEED'S *Agena* vehicle is hoisted into place for test firing.

Willis Hawkins, assistant general manager of LMSD, said significance of the restart *Agena B* engine is twofold: it permits much heavier satellites to be placed in orbit and makes it possible to place them in higher-altitude, circular orbits.

This is how the restart engine is expected to work:

The *Atlas* booster drops off after burnout when the *Agena B* is near orbit altitude. The satellite continues to coast upward as it stabilizes itself to a horizontal position in reference to the earth's surface. This stabilization is not only to orient the satellite in relation to the earth but also to properly aim the propulsion system. This is accomplished by an infrared horizon scanner.

The engine then is fired for a period to bring the satellite to orbital speed, injecting it into orbit at the perigee. When apogee is reached, a timer restarts the engine to change the original elliptical orbit to a high-altitude near-circular orbit.

Restart can either be programmed or on ground command.

• **Beginning of *Midas***—Initial test of the *Atlas-Agena B* combination at Cape Canaveral is, in fact, the first of the Project *Midas* series.

The restart engine is of considerable significance to both the *Midas* and *Samos* programs, which are based on the work being carried out in the *Discoverer* series for the Air Force. Little has been said about these programs but they are known to have both defensive and offensive capabilities.

At a press briefing during the Lockheed-Air Force tour, Lt. Gen. Bernard A. Schriever, chief of the Air Research and Development Command, said the *Discoverer* series, which he called a "testbed" program, has been aimed at control and stabilization of specific payloads in a specific orbit.

Commenting on *Midas* and *Samos,* Gen. Schriever said military checkmate now can be achieved by exploiting advantages that were less important in past military history.

"One," he said, "is military intelligence." He described *Midas* as a warning system operating in the same regions of space as intercontinental ballistic missiles to give rapid notice, by immediate infrared detection of hot exhausts, of ICBM launchings.

Of *Samos,* he would say only that it was a surveillance satellite; he was obviously reluctant to be drawn out on other potentialities of the program.

• **Stressing urgency**—Gen. Schriever said development of these space systems must be pushed with the same urgency as the ICBM programs. He said consideration is being given to stepping up the *Midas* program, although it will remain in a research and development stage for some time. He said *Samos* is "adequately" funded at the moment.

The ARDC commander pointed out that while the Army has mission responsibility for defense against missiles, the Air Force has the responsibility for early warning against ICBM's.

He did not comment on any Air Force interest in missile defense.

Midas definitely can use the restart technique of the *Agena B* in achieving circular orbit, assistant general manager Hawkins told the press.

• **Success revealed**—The engine fired at the Jan. 27 demonstration was undergoing its seventh firing in the development program. Restart was not demonstrated. But it was disclosed that the *Agena B* has been successfully restarted numerous times under near-vacuum conditions at the Arnold Engineering Development Center at Tullahoma, Tenn.

The firing was one scheduled in the normal test program, with an induced malfunction programmed into the firing. This was achieved by closing a valve in the propellant feed system. Despite this, the engine was expected to achieve a full duration firing of more than 240 sec. Shutdown came at 163 sec., however, when a small fire broke out in the engine area. It was quickly blanketed with carbon dioxide and damage was minor.

The firing was on one of three test stands in the sprawling Santa Cruz test facility. Two are Air Force stands being used for development and acceptance testing in the *Discoverer* satellite series, and the third is for captive testing of the Navy's *Polaris* missile.

The Lockheed-designed "soft stand" used in *Polaris* firings is equipped with four large steel struts or mounts which lock onto a steel collar around the middle of the missile being tested. These are anchored at the lower ends to hydraulically-operated assemblies similar to aircraft oleo structs.

• **Freedom of movement**—This arrangement permits the missile to move during the firing, allowing movement longitudinally and laterally as well as angular motion in pitch and yaw.

There is enough play to allow checkout of the control system within plus or minus 5-deg. of movement. This means the rear of the missile could move as much as a foot or a foot and a half during captive firing.

Movement is sufficient to produce vital data on missile dynamics which otherwise could not be obtained except on launch. Data recorded during runs on the stand has been proven out against data obtained during actual flight tests on the Atlantic Missile Range.

The system permits taking out of light-off shock as well as monitoring of guidance system responses more easily. Degree of restraint can be modified during a firing to simulate a complete trajectory.

As the missile gets lighter and center of gravity shifts, restraint can be lightened. Electronic signals to simulate, say, a crosswind buffeting, can be fed into the circuit to check control system reaction.

"Failure of the flight control system to correct the error during a test stand run merely results in a squibbly tracing on an oscillograph," a Lockheed engineer points out. "The same failure during an actual launch would mean loss of the vehicle."

• **Vast facilities**—Missiles and satellites are shipped to the Santa Cruz test facility from the production plant at LMSD's Sunnyvale headquarters, 50 miles distant. Modification and initial checkout are accomplished at Sunnyvale.

Components testing and captive firing then are conducted at the Santa Cruz test base before the vehicles are shipped to their destinations.

Company spokesman declined comment on the firing of a small liquid rocket engine, which newsmen witnessed in the component test area, other than to say it was "development test work" on a Lockheed engine. One source suggested it might be a scale-model engine.

Facilities at the test site include administrative, engineering, assembly and shop areas together with the two test stand complexes, all totaling some 85,500 square feet.

The Navy *Polaris* area has one test stand and one blockhouse while the Air Force satellite area at the moment has two stands and a common blockhouse and components test laboratory. A second blockhouse is under construction.

There also is a pyrotechnics test area for testing explosive bolts and separation devices.

Since April, 1958, there have been some 75 firings on the satellite program alone. It was estimated that 15 million data-seconds have been taken since October, 1958. There have been 136 cold flow tests on the program as well as 50 ground support equipment tests.

A 250-acre lake, well-stocked with trout, provides the main water supply for the base, which is spread over the heavily-wooded 4000-acre site 90 miles southwest of San Francisco.

The test base employs some 500 engineers, technicians and administrative personnel.

Mercury Drop Tests Are Nearing End

High reliability has been established; drogue chute has been reinstated in program which now has 44 drops scheduled and has perfect record to date

SALTON SEA, CALIF.—Testing of the *Mercury* capsule landing system is due to end later this month, with completion of the 44 drop tests now scheduled. Tests to date have been 100% successful.

The program includes low- and high-altitude drops, simulated aborts, deliberate attempts to foil the system, and at least one unplanned parachute abort which was successfully countered by the reserve system.

Radioplane, a division of Northrop, is under contract to McDonnell Aircraft for the landing system of the manned capsule in the National Aeronautics and Space Administration's *Mercury* program.

• **Simple and reliable**—Consisting of parachutes, chaff package for radar reflection, sofar bomb, and other recovery aids, the system is designed for simplicity, with a view toward complete reliability. At one point, the drogue parachute was eliminated from the program. This chute stabilizes the capsule after initial re-entry, and plans called for use of the roll jets on the capsule to serve this purpose.

But the chute has since been reinstated, and is expected to remain in the program.

In its 35th test drop, the capsule had a simulated abort, assuming the main parachute had torn free after partial inflation, leaving the capsule in free fall. The reserve system is actuated by a force-sensing device, which determines that lack of a load on the parachute risers indicates malfunction.

The astronaut in the capsule has the option of employing the reserve parachute system if the automatic force-sensing device does not do so. This decision will undoubtedly be determined by the rate-of-descent instrument in the astronaut's compartment.

Housed in two separate compartments, the parachutes can be deployed independently of each other. If the main parachute should malfunction by failing to leave its compartment, the reserve chute would not be blocked but could deploy independently.

Deployment of the drogue chute is accomplished by use of a mortar.

In sequence, the 35th drop test, which simulated an abort of the main chute, was as follows:

- Capsule, 2160 pounds, and sled launched from 31,100 feet by C-130.
- Sled separation from capsule. (Sled is for handling ease in aircraft only.) T plus two seconds.
- Sled parachute deployment. T plus four seconds.
- Capsule drogue parachute deployment. T plus six seconds.
- Antenna fairing ejects, extracting main ringsail parachute at 10,000 feet. Sofar bomb ejection. T plus 77 seconds.
- Main ringsail parachute inflates. When load on chute reaches 1800 pounds, it is disconnected in simulated abort. T plus 80 seconds.
- Pilot parachute deployment to initiate extraction of reserve parachute. T plus 88 seconds. Altitude 7800 feet.
- Water impact at 30 f.p.s., reserve parachute disconnected by explosive charge. T plus 348 seconds.

DROP OF *Mercury* capsule in Salton Sea tested Radioplane landing system.

Impact force of the capsule is approximately eight or nine g, with slight variations possible due to the impact angle. On a number of occasions, Radioplane personnel have tried to foil the landing system by tumbling the capsule upon its ejection from the aircraft. These have been countered successfully each time.

Beginning in August, 1959, Radioplane has dropped "boilerplate" versions of the capsule from altitudes ranging from 2500 to 31,000 feet. There have been no unsuccessful tests. The 44 tests scheduled do not include those from Wallops Island or Cape Canaveral, merely those at Salton Sea Test Range in southern California.

- **Dimensions**—The capsule measures 10 feet high, with a six-foot base diameter and 26-inch neck. A revision over the early configuration places the exit hatch at the narrow end of the capsule, rather than near the base. This prevents the exit hatch from being covered with water in an ocean-recovery operation. Consideration is also being given to adding flotation bags around the capsule on water entry, to eliminate the danger of a capsize of the capsule.

Ground support services in the drop test program have been supplied by the Naval Parachute Facility at El Centro. This includes photo instrumentation, documentation coordination, flight test aircraft and crew support.

AF Space Center Now Operational

ARDC's 6549th Test Wing takes over satellite center. Move is considered a big step in Air Force becoming U.S. Space Force

SUNNYVALE, CALIF.—The U.S. Air Force took a big step toward becoming the U.S. Space Force last week with the announcement that its new satellite center here had taken over control of Project *Discoverer*.

For the first time, launch, tracking, acquisition and recovery phases of a satellite program are under one military headquarters.

This is the 6549th Test Wing (Satellite) of the Air Research and Development Command—which is, in fact, the first space wing of the Air Force.

"With the development of a working military satellite system—the end product of the *Discoverer* series—operation of the system in the Satellite Test Center will be a responsibility of the Deputy Commander for Space Systems Operations," an Air Force announcement said.

- **Far-flung system**—Project *Discoverer* currently is under the Deputy Commander for Systems Development Test, who runs the streamlined space center.

The space wing also includes a launch squadron at Vandenberg AFB and tracking squadrons at Vandenberg, New Boston, N.H., and Kaena Point, Hawaii. A recovery control group at Hickam AFB, Hawaii, operates the Hawaiian Control Center.

Heart of the space wing is the new Satellite Control Room, the command post which is headquarters for command surveillance and direction during launch, orbital and recovery activities. *Discoverer IX* is the first assignment.

- **'For a new age'**—The $1.2-million building in which the control room is housed was dedicated on Jan. 28 by Lt. Gen. Bernard A. Schriever, ARDC commander. Known as the Satellite Test Center, it also contains administrative, planning, operational and communications offices covering more than an acre.

Gen. Schriever called it "a new facility for a new age."

He said it will play an ever bigger role in handling the growing network of space programs, including the forthcoming Project *Midas* and Project *Samos* satellites.

Operation of the center now is a joint responsibility of the 6594th wing and the Lockheed Missiles and Space Division, prime contractor and systems manager for *Discoverer*.

The center is located adjacent to LMSD facilities on land donated by Lockheed. Construction now under way will add another 46,000 sq. ft. and bring total cost of the sprawling center and its equipment to $2.2-million. This figure does not include the $1.5-million worldwide communication system.

• **Controlling new generation**—The expansion will provide what personnel at the center call a "third-generation" control room to handle additional satellites. The *Discoverer* program first was monitored from the now-defunct Development Control Center in Lockheed's Palo Alto scientific research laboratory.

During launch, orbital and recovery activities in the *Discoverer* series, both Air Force and Lockheed personnel man the six consoles in the control room. From here, they direct and coordinate activities at the launch site, four tracking stations and in the Hawaiian Control Center. The HCC controls a tracking station, the C-119 recovery aircraft squadron, and a RC-121 radar aircraft.

Tracking and acquisition are carried out by the stations by Vandenberg, Point Mugu, Kodiak, and Kaena Point, and by two Navy telemetry ships, one stationed between Alaska and Hawaii and the other off the Lower California coast.

Data reduction is done at Vanderberg and the LMSD and scientific research laboratory although the Satellite Test Center later will be equipped for this purpose.

• **Who mans consoles**—Within the Satellite Control Room the tests are under the direction of Air Force test controller Lt. Col. Charles G. Mathison and Lockheed Test Director Stanley K. Hutchin, who are stationed at two upper consoles.

Four lower consoles are occupied by two Air Force Assistant Test Controllers and two Lockheed Assistant Test Directors. These men make the standard decisions and give the routine orders; command decisions are made by the Test Controller and Test Director. Seventh member of the team is a communications officer seated at a desk between the two upper consoles.

Each console constains a closed-circuit TV screen, a push-button communications panel, and a speaker-receiver headset.

The TV screens survey both satellite and ejection capsule plotting boards and incoming teletype messages. The communications panel provides push-button selection of voice lines to all stations. The communications officer also controls a central assignment panel which can established any combination of voice lines to any or all consoles.

• **Links with outside**—Three large Vu-Graph screens faced by the consoles keep the control team posted on current weather conditions at all stations, as well as maps, plots and other information flashed from the adjacent program information center (PIC).

Above these screens are clocks indicating local time at all stations, an elapsed-time indicator and a synchronized electronic system time indicator. This is a digital clock which is recycled at midnight Greenwich time each day.

Lighting in the control room is variable and can be cut as low as five candlepower to reduce eye strain during long vigils.

Voice lines are available to all tracking stations, to Vandenberg and to Cape Canaveral. The link with the Air Force Ballistic Missile Division's space activities status center in Los Angeles is provided by an Engineered Military Circuit (EMC).

The satellite center also is connected with all tracking stations by 60-word teletype and 100-word-per-minute data teletypes. Four transmitting teletypes in the communications center include two with "secure on line" capability to handle classified messages, and one commercial TWX machine. Teletypes also provide back-up communication when voice circuits fade. Every voice line can be switched to the 100-word teletype to bring in information from the tracking stations, thus avoiding the cost of dual lines.

The control room also is linked with the computer and data reduction centers. Two Remington Rand 1103A digital computers are employed here.

Two tape recorders, controlled remotely from the lower consoles, record all hot-line conversations.

The satellite center does not at any time have direct contact with or control over satellites, but makes and transmits the command decisions concerning them.

The operation, as outlined by Lt. Col. Mathison, covers five phases:

• Pre-launch. Coordination of all activities and preparation, including simulation of launch injection into orbit and satellite tracking.

• Launch. During this phase, launch responsibility is passed to the Vandenberg blockhouse while Vandenberg, Pt. Mugu and the down-range ship provide exit data which is passed along to the other stations so they can anticipate the where and when of acquisition.

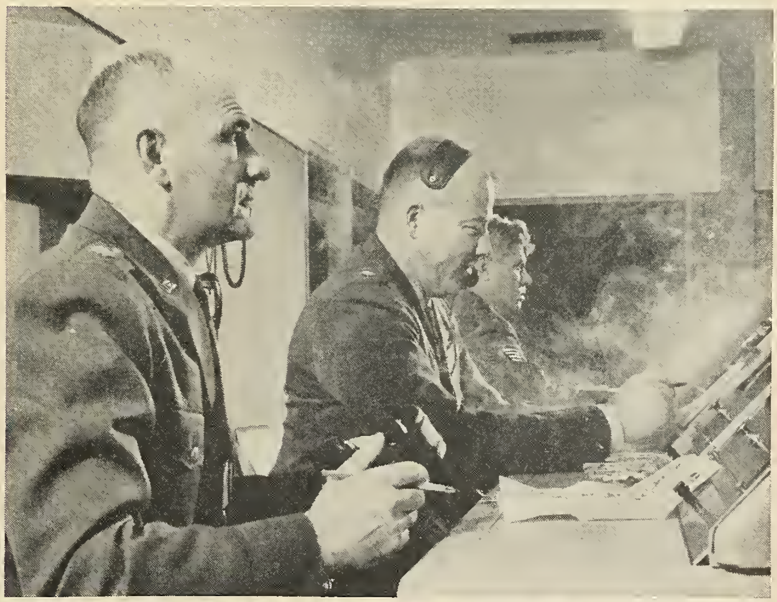
• Orbital. Tracking stations acquire and feed back the volumes of data from the satellite.

• Recovery. Recovery area is pinpointed and forces positioned. Recovery is controlled through the Hawaiian Control Center.

• Post-orbital. Collection and evaluation of all data.

Contract for the system in the third-generation control center now under construction was awarded to the Space Communications Division of Radiation, Inc., located at nearby Mountain View. The present center can handle only two satellites at a time and also is being used for developing and evaluating equipment and techniques.

The new center will have a considerably expanded capability. In general, it will handle more orbits, more data and will permit more commands. Computers with considerably increased capacity will be employed as the programs become more sophisticated and more automatic equipment, including an automatic plotting board, will be used.



THESE CONTROLLERS are in contact with launch site, four tracking stations, and the Hawaiian Control Center, all part of the new satellite center.

U.K. Firms May Be Tougher Rivals for U.S.

London—The recent reorganization-by-merger of the British aircraft/-missile industry is likely to mean tougher competition for Britain's chief rival in overseas markets—U.S. manufacturers.

The consolidation into two main groups—carried out at the "suggestion" of the British government—has so far been achieved only on paper. Now comes the extremely difficult and painful task of carrying out its aims—elimination or reduction of the duplication of effort and dissipation of resources on too many projects, that have been the industry's major postwar weaknesses.

Competition between the two groups—Hawker Siddeley-de Havilland and English Electric-Vickers—is likely to be encouraged by the government, but observers here believe it would be a mistake for them to fight for overseas markets. They feel it would be far better for them to work together to combat American competition.

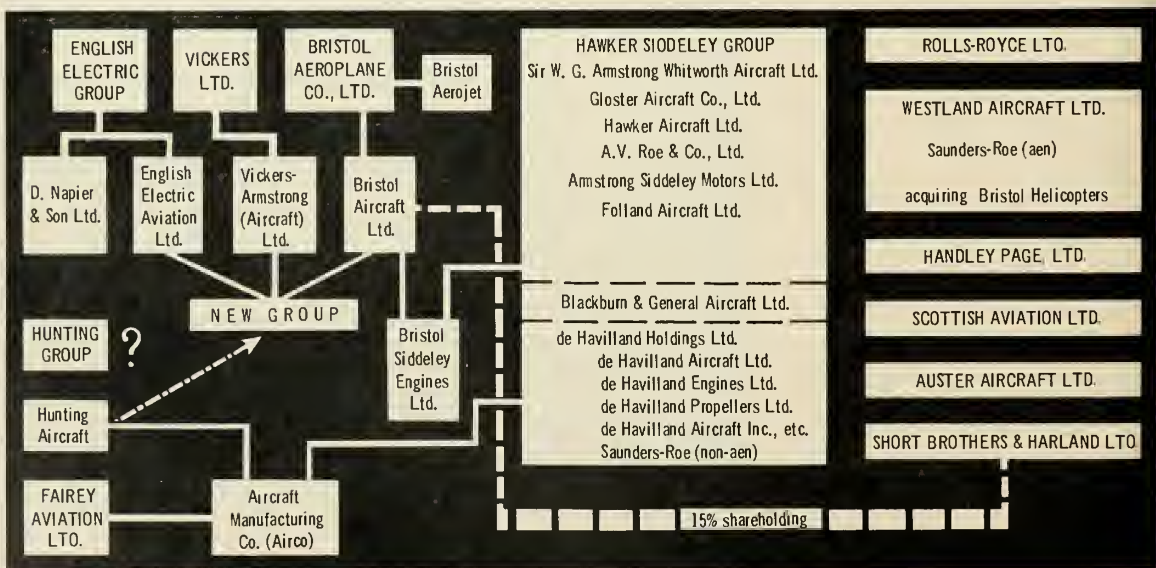
• Second shoe falls—The Hawker Siddeley/Folland Aircraft/Blackburn/-de Havilland merger was followed by another major amalgamation, when the three largest remaining individual firms (Vickers Ltd., English Electric and Bristol Aeroplane Co.) decided to merge their guided weapon/aircraft interests in a new company, not yet named. The shares of this will be held in the proportions 40, 40 and 20% respectively; there will be no issue of share capital but an agreed financial adjustment. This new company will have three wholly-owned subsidiaries: Vickers-Armstrongs (Aircraft) Ltd., English Electric Aviation, and Bristol Aircraft.

All three of the parent bodies have interests outside the missile/aircraft field, and will retain their independence in these respects. Some activities will be disposed of—thus Bristol is selling its helicopter interests to Westland Aircraft (who recently acquired Saunders-Roe).

• Rest of the industry's future—Apart from these two big combines, only a few firms remain, and pressure from the Minister of Aviation is likely to cause these to disappear soon. Hunting Aircraft will probably go into the new Vickers group, Fairey Aviation will be acquired by Westland, leaving only Handley Page (likely to remain independent as long as Sir Frederick Handley Page is still alive and in control) and Short Brothers & Harlands (whose position is complicated by a large Government shareholding and the unemployment problems of Northern Ireland).

As regards the groups (Hawker Siddeley, Vickers and Westland), these are already interconnected through holdings in various subsidiaries, so further rationalization may follow. The Minister of Aviation, Duncan Sandys, is believed to favour the concentration of the industry into only two groups, and this has nearly been achieved. With so many changes in the past few weeks, it would be only a small step for all the groups to combine in a single organization, but this would be unlikely to receive the Minister's approval. Nor would it find favour with the Labour opposition—despite their policy of nationalization, such an arrangement would have all drawbacks of a monopoly without the "virtue" of state ownership, and employees would find it very difficult to change their jobs.

Britain's New Missile/Space Line-Up



AT LEFT is newest amalgamation of aircraft/missile firms. AT CENTER, the Hawker Siddeley group. AT RIGHT, the dwindling list of independents. The lines indicate some interconnections and likelihood Hunting will join the new group.

Japanese Forces to Be Missile-armed in 5 Years

by Kazuo Takita

TOKYO—The three arms of Japan's self-defense forces will be equipped with guided missiles by the end of Fiscal Year 1965.

This is envisaged in Japan's projected second five-year defense build-up program, which will go into effect in 1961.

Prime Minister Nobusuke Kishi is believed to have discussed the draft of the program with U.S. defense officials when he visited Washington recently as head of a Japanese delegation to sign the newly revised Japan-U.S. Security Treaty on Jan. 19.

According to an official announcement by the Japanese Defense Agency on Jan. 16, the surface-to-air *Tartar* missile will be installed on a 2600-ton destroyer to be built in FY 1961.

The Convair *Tartar* will be purchased from the U.S. for $5,833,333 on a three-year installment basis, under the MSMS (Mutual Security Military Sales) aid program. The official contract is expected to be signed in late March.

Construction of the missile destroyer, to be completed in 1963, is part of Japan's self-defense reinforcement project for 1960, revealed by the Defense Agency on Jan. 16.

The reinforcement program, based on a defense appropriation of $41,-250,000, is centered on a $2,500,000 missile development plan to buy 60 Philco/GE *Sidewinders* from the U.S., and to send a 45-man Ground Self-Defense Force team to train with Western Electric *Nike-Ajax* at Fort Bliss, Tex.

The Air Self-Defense Force will shortly begin maneuvers with *Sidewinder* air-to-air missiles at Gifu, attached to F-86D and F-86F jets.

Plans are under study to create four ground-to-air Boeing *Bomarc* missile corps and assign them to Yokohama; Hokkaido, northernmost island of Japan; and Kyushu, southernmost island, by the end of FY 1960.

Four *Nike-Ajax* battalions will be organized in the Tokyo-Yokohama area; Nagoya; Kobe-Osaka area; and Shimonoseki in Yamaguchi Prefecture; two Raytheon *Hawk* battalions in the Tokyo-Yokohama area, and four *Nike-Hercules* battalions in key cities in Japan proper.

Eight to 12 antitank missile companies will be stationed in Hokkaido and various other places by the end of FY 1961. Defense Agency officials are studying a plan to import 600 antitank missiles annually from France.

west coast industry . . .

By FRANK G. McGUIRE

Frustrated attempts to get a readable signal through excessive static are by no means limited to the electronics brotherhood. There is a similar problem in getting a simple answer—based on hard engineering facts—from organizations with an axe to grind. We recently had occasion to try rounding up as many facts as possible on the state of the *Atlas* and *Titan* programs. We contacted as many people and organizations connected with these two massive projects as possible, to avoid getting an unbalanced picture.

Consider the situation which arose when we asked a simple question. Question—"Can *Atlas* be launched from a *Titan* silo or vice versa?" Answer from the *Atlas* camp: "Yes, but not vice versa." Answer from the *Titan* camp: "No, but the reverse is true." Answer from a third party familiar with both systems: "Neither can be launched from the other's equipment."

The objective of this kind of thing? Simply to make one's own product seem more versatile, and therefore better, than the competition's. The middle path—which we hope represented as clear a signal as possible—was spelled out in last week's M/R. But we do wish industry wouldn't present such a static-ridden signal to the press and public. It only aggravates the difficulty in getting industry's story across to Congress and John Q. Taxpayer.

Marquardt Corp. has established . . .

a Facilities Engineering Division to provide architectural and engineering services to government and commercial enterprises. The new organzation will plan, design and construct space environmental laboratories, launching complexes, and test facilities. Leigh E. Dunn is director of the new group, and will continue as director of the Test Division.

Experience of the Facilities Engineering Division includes design, project direction and construction of the Air Force/Marquardt jet laboratories in Van Nuys and Ogden. Another project was the Tory II reactor research test facility at AEC's Nevada Test Site at Jackass Flats.

Electro-Optical Systems has sold . . .

a minority portion of its stock to the Aerojet-General Corp. EOS, winner of the contract for development of an ion engine for the Air Force (M/R, Feb. 1, p. 24), has been active in plasma propulsion systems, solar energy conversion, advanced power systems, solid state physics, advanced electronics and space defense systems. The new capital will be used to broaden the company's R&D base, as well as to develop proprietary items.

Lockheed's Employe-Benefit Program . . .

costs the company 87¢ per employe-hour. For every dollar spent in 1945, the firm paid out $1.58 in 1952, and $3.69 in 1959. The benefits work out to an average of $1800 per year per employe.

Fuss about Vandenberg/PMR relations . . .

often overlooks the routine cooperation that is part of the everyday job. Tri-service cooperation was demonstrated recently when a school near VAFB wanted an F-86. AF couldn't assign a helicopter to the airlift job, but called on Navy for help. Navy assigned a Marine 'copter to the mission, and the school got its Saberjet from Air Force, via Marine helicopter which was assigned by Navy.

San Diego's efforts to reduce dependence . . .

on defense procurement have gotten underway with establishment of a five-year program to diversify industry. The close of the 1950's saw the Southern California city listed as the fourth largest metropolitan area in the eleven western states. Military payrolls dump $1 million daily into the economy. The drive is paralleled in Los Angeles, which has similar diversification plans.

DuPont's 'Teflon' 100 Now Available

Du Pont is commercially producing a new plastic, "Teflon" 100, the company has announced. It is expected to find wide markets in the electronics and chemical processing industries.

Known as an FEP-fluorocarbon resin, the new material can be extruded or molded in the thermoplastic processing equipment. It was developed as a supplement to Du Pont's present line of "Teflon" TFE-fluorocarbon resins, which must be processed in a manner similar to powdered metals.

Like the TFE resins, "Teflon" 100 is virtually immune to chemical attack, has excellent electrical insulating, anti-stick, and frictional characteristics, and will not absorb moisture. "Teflon" 100 differs somewhat from the TFE resins in heat resistance. TFE resins are rated for continuous service at temperatures up to 500°F and at higher temperatures for more limited periods of time. The usual continuous service ceiling for "Teflon" 100 FEP resin is about 100°F lower. Both materials resist extreme cold—down to —450°F.

Robert A. Kellar of Du Pont's Polychemicals Department described the new product as a "major technical breakthrough" resulting from 15 years of research studies. He said Du Pont spent $19 million for research, development, and operating costs during the eight-year period prior to the start-up of a commercial plant for "Teflon" 100 at Parkersburg, W.Va.

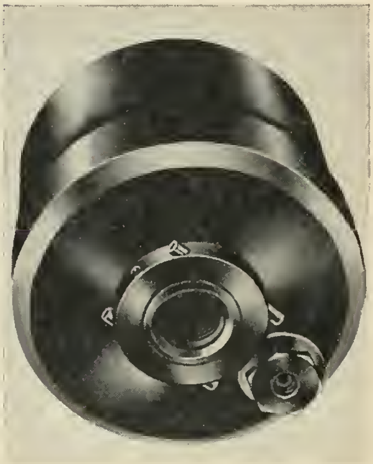
Price of the new resin is $11.60 a pound in truck-load quantities. Prior to commercial production, small quantities from a pilot plant were provided to about 150 interested firms at a price of $19 a pound.

Specific uses for "Teflon" 100 FEP-fluorocarbon resin cited by Kellar include jackets for coaxial and multi-conductor cable, aircraft wiring, molded electronic components, laboratory tubing, and chemical equipment linings.

He noted that these FEP resin applications will greatly expand the market areas served by "Teflon" fluorocarbon resins. The older TFE resins are widely used for electrical insulation, chemical-resistant hose, and lined pipe, bearings, seals, piston rings, packings and gaskets. Introduction of "Teflon" 100 FEP resin is expected to accelerate the development of uses which were not practical with TFE resins because of processing difficulties.

Du Pont's Film Department is marketing films made from "Teflon" 100. Coil-wound devices, capacitors, and printed wiring and circuitry are viewed as promising uses for the film.

Circle No. 225 on Subscriber Service Card.



Pressure Regulator Has Space Applications

An oxygen pressure regulator has been designed and developed by Airaterra, and is available for immediate application.

It is suited for use in conjunction with space capsule atmosphere-purging regulators, or to supply constant pressure to oxygen breathing demand regulators.

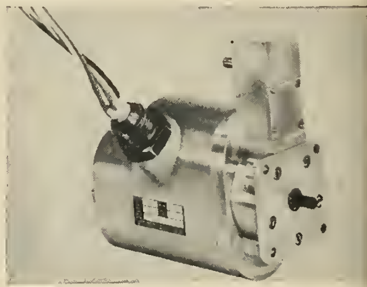
It weighs only 11½ ounces, and is 2¾ in. long with a diameter of 2½ in. Its psi ranges are 100 plus or minus 10 outlet, and 100 to 10,000 inlet.

The aluminum oxygen pressure regulator is piston type for high reliability. It is single-stage and has a metal-to-metal throttling seat. Also of great importance is its zero leakage lock-up capability.

Circle No. 226 on Subscriber Service Card.

Immersible Valve Actuator Develops 100 in. lb. Torque

A new small motor-driven actuator designed for operating a ball valve submerged in gasoline develops 100 in. lb. of starting torque, with a nominal



running torque of 25 in. lb. The unit is housed in a cast aluminum alloy case designed to withstand 20 psi. pressure without leaking.

A special optional feature is a manual over-ride device which permits operation of the actuator with a wrench in the event of power failure. The actuator shaft rotates 90° ± 1½° and incorporates a Geneva movement to insure accurate valve positioning with excellent repeatability. This particular version operates on 115 vac, 400 cps power.

The actuator weighs 2.6 lbs., is 5" long, and fits in a 3" square envelope. It exceeds appropriate MIL specifications. Various modifications may be made to suit the actuator to similar applications.

Circle No. 227 on Subscriber Service Card.

High-Current Switching Diode Claimed Fastest

What has proved to be the fastest high-current silicon switching diode for computers is now in volume production at Sperry Semiconductor Division of Sperry Rand Corp.

Labelled "the 1N920-1N923 series," this newest advance in high-conduction, fast-recovery diodes has met the most severe requirements of high-current pulse circuits for computer switching, pulse clamping, gating, blocking and diode logic circuits. These 0.3 micro-second, ½-ampere devices are available immediately in quantity, and set new standards wherever advanced performance characteristics are required.

Selections from this line have been used widely in the Univac Larc computer, recently announced by Remington Rand, which operates at very high speeds, 25 to 200 times faster than other existing commercial computers. Thousands of these Sperry diodes are built into the Larc's critical memory driving circuits.

In addition to the UNIVAC Larc

application, Sperry diodes in this series have found wide acceptance by the industry in more than a dozen other high-speed computer prototypes.

The new diodes are said to approach a "universal", "all-purpose" diode—excellent for general high-conduction applications as well as for the more exacting computer uses. Available in four voltages, they effect 0.3 usecond switching of ½-ampere pulses with a peak power dissipation of 800 milliwatts. Designed for high-temperature operation (to 175°C), the 1N920 series features high forward conductance (500_mA at 1 volt maximum drop) and low leakage (50_uA maximum at 150°C).

All units feature a maximum recovery time of 0.3 microseconds to return to 10K ohms when switched from a forward current 2 microsecond pulse of 500_mA to a reverse voltage of –50 volts (–30 V for 1N920), with a loop impedance of 1K ohms. Faster switching speeds are obtained at lower currents.

Circle No. 228 on Subscriber Service Card.

Tiny Unit Protects Motors From Heating

Development of the smallest inherent overtemperature protector, the Klixon 5891, is announced by the Spencer Products group of Texas Instruments Incorporated, Metals and Controls Division. Designed specifically for sub-fractional hp motors 1" in diameter and larger, the device is equally suitable for small solenoids and transformers.

The protector maximizes system reliability by preventing permanent interruption of equipment output, and by safeguarding against excessive temperatures that damage or destroy system components.

Responsive to both current and temperature, the protector is designed

with a compensating heating element to ensure that the snap-acting, disc-type sensing element will follow closely the temperature changes of the component to be controlled. Temperature levels of protection are 150, 175, and 200°C. Maximum contact capacity is 5 amperes at 27 volts dc or 120 volts ac. The units conform to military specifications, MIL-M-7969 and MIL-M-8609, and when mounted in equipment they comply with MIL-E-5272.

To be most flexible in installation, the basic design of the Klixon 5891 has no flanges or mounting projections. The protector can be inserted into a cavity secured to the windings, or held by a clip. Envelope dimensions, 0.28 x 0.20 x 0.60", are kept to a minimum by using welded on leads to customer specifications. Weight, excluding leads, is 1 gram.

Circle No. 229 on Subscriber Service Card.

Missiles Now Charted On Heat-Sensitive Paper

A new heat-sensitive chart paper for recording in-flight performance of high-speed satellites and missiles employs heat rather than pressure for accurate markings. The paper was designed to produce faster, more legible permanent tracings of oscillographic signals.

Hycar latex, a product of B. F. Goodrich Chemical Co., in combination with carbon black, gives the paper a smooth flexible base onto which an extremely low-density top coating, high in air content, is applied. When heat is applied, the top coating becomes transparent—allowing the black base to show through. The composite structure is waterproof and prevents greying of the coating at high humidity. This maintains the background whiteness necessary for accurate readings.

Called "Heatrace" by its developer, the Nashua Corporation, Nashua, N.H., the chart paper is used by Minitrack stations around the world. Originally designed for electrocardiographs and other types of hot-stylus oscillographic recorders, Hycar-based recording paper has improved characteristics which offer advantages such as greater sensitivity to a heated stylus, improved durability, and more accurate and legible tracings—all invaluable to industrial and Space-Age instrumentation.

The paper's durability is of prime importance where extensivc handling is required. In cardiograph recordings, for example, the records of the patient's heartbeat must be of the direct reading type and are subject to considerable handling in the course of their study as a diagnostic aid.

Heat-sensitive papers such as Nashua's "Heatrace" are being used more and more in diverse applications for recording the signals and events in connection with compilation of scientific data from complex electronically controlled systems says Goodrich.

Circle No. 230 on Subscriber Service Card.

Silicon Mesa Transistor Line Now Available

Hoffman Electronics Corporation announced today it is now in production on two newly-developed silicon mesa transistors that outperform similar-type devices now on the market.

Because of design features, resulting in unusually high small signal current gain, either of the devices will replace up to three transistors of the same classification in many circuit applications, G. William DeSousa, vice-president marketing of Hoffman's Semiconductor Division, said.

The new diffused junction, drift field mesa transistors (JEDEC No.'s 2N696 and 2N697) are designed for use as high speed switching units operating at medium power levels and as very high frequency amplifiers.

The NPN type devices are the first to be introduced in a new family of silicon transistors now being developed at Hoffman, DeSousa said.

Hoffman's U-shaped base-emitter configuration allows for the first time utilization of virtually all the transistor's emitter area. The minimum high

frequency gain at high currents is 6 or more at 29 megacycles, nearly three times the 2.5 gain of comparable units. This higher gain, he said, is due to tighter control of the base width in fabrication.

This design, coupled with an exclusive photographic fabrication technique, also has lifted current and frequency characteristics of the new device above industry specifications.

The new transistors are capable of useful current gains at 40 megacycles, indicating efficient operation in the ultra high-frequency band when operated in a grounded base configuration.

The photographic technique developed by Hoffman, used in fabrication instead of conventional mechanical methods, gives greater precision of geometric control and results in better and exceptionally uniform characteristics.

The new transistors, with their high current gain and operating frequencies, were designed particularly for military applications such as computers, radar and data processing equipment for missiles. Commercial applications include small signal amplifiers, high speed switching devices for computers, data processing equipment and video amplifiers.

Both transistors are basically control devices for small to large signal switching amplification. The only difference between the two is a higher DC pulse current gain in the 2N697. This measures a minimum of 40 and a maximum of 120 compared to a minimum of 20 and a maximum of 60 in the 2N696.

The company's quality and reliability standards require pre-aging the transistors at 300°C before hermetically sealing them in a controlled inert gas atmosphere to stabilize the electrical parameters.

Total power dissipation of the two transistors is two watts at 25°C case temperature.

The transistors have a maximum collector-base voltage of 60V, collector-emitter voltage of 40V and an emitter-base voltage of 5V.

In saturation, with a base current of 15 milliamperes and a collector current of 150 milliamperes, the emitter-base voltage is less than 1.3V and the collector-emitter voltage is less than 1.5V.

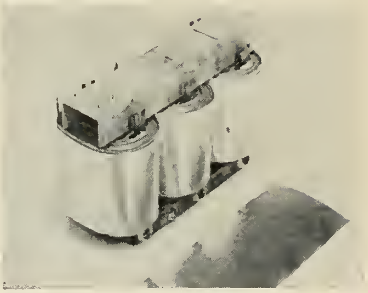
Circle No. 231 on Subscriber Service Card.

Aluminum Coated Wire Operates at 1900°F

Flexible aluminum-oxide-insulated strip and wire good for temperatures as high as 1100°F and, in certain forms, as high as 1900°F, is now available from Permaluster, Inc.

The anodized wire or strip in all gages and sizes is made by the same Permaluster continuous anodizing process already successfully applied to high-temperature wire for the aircraft/missile and electronic industries. This process provides a coating highly flexible and capable of withstanding a great deal of deformation without fracturing or crazing the film.

With its melting point of 3800°F, aluminum oxide provides excellent protection to permit using metal strips in



such units as transformers without cooling. The film thickness can be carefully controlled from as low as 0.00008" to 0.001". Aluminum-oxide-insulated aluminum strips can now be used in large or small electronic units to give both savings in space and weight reductions of up to 50% compared to conventional materials.

The flexible aluminum oxide insulation can also be applied to other metals. One example is nickel-plated copper strip or wire (nickel plate is needed to eliminate galvanic action and diffusion in high-temperature operation). It can also be used on silver for applications close to the approximate 1900°F melting point of the bare conductor.

Circle No. 232 on Subscriber Service Card.

150 lb. Vibration Fatigue Tester Modified

Two versions of an improved Vibration Fatigue Testing Machine, in which a vertical table movement is controlled entirely by a piston operated mechanism, have been announced by All American Tool & Mfg. Co. They are Models 150 VP-D and 150 VP-T. Table load capacity is 150 lbs. at 10 g's of acceleration. For g values higher than 10 the load must be reduced. Maximum capacity is approximately 23 g. Vibration is produced in simple harmonic motion.

Acceleration and deceleration are regulated by the Range Selectro, an automatic frequency control device. On Model 150 VP-D, starting at 10 cycles per second, frequency may be increased uniformly to 60 cps (600 to 3600 vibrations per minute). On Model 150 VP-T the available range is

from 5 to 100 cps (300 to 6000 vibrations per minute). Any range of frequencies within this total range may be used, such as 15 up to 45 cps and back. Range Selector can be cut out and frequencies held at any desired point within the available range. Frequencies can also be changed manually.

Circle No. 233 on Subscriber Service Card.

Automatic Welding Wires Are Now Available

Air Reduction Sales Co. is now marketing automatic welding wires for use with the submerged arc welding processes. Alloys in this line are made from selected heats of steel, with analysis carefully controlled to fuse with the parent metal under automatic welding conditions and give comparable physical and chemical characteristics across the base metal, the affected zone and the weld metal.

Welding wires offered are low-carbon, general mild steel, high tensile steel, highest tensile steel, mild steel killed, general tensile and medium carbon steel. Wires are available in coils. Each coil is carefully thread-wound to facilitate unwinding, and a constant controlled tension is maintained during coiling to assure a neat coil that will support itself and keep its designed shape and dimensions.

Coils are available in weights of 25/30 lbs., 55/65 lbs., 75/100 lbs., 120 or 180 lbs.; or in fibreboard drums of 250, 500, or 750 lbs. for interrupted production welding.

Circle No. 234 on Subscriber Service Card.

Accelerometer Provides Wide Sensitivity Range

Wide application in telemetry and vibration work is forecast for a new high-sensitivity MV 300 accelerometer developed by de Havilland Propellers, Ltd.

The instrument has a full-scale output of 25V, and models are available with sensitivities ranging from 0.5V to 8V per g when working into a 0.5 megohm load, with natural frequencies from 137 to 34 c/sec. It is intended for use between −60°C and +100°C, and has a maximum zero error of 1.5% of full scale and a maximum temperature coefficient of 2.5 mV/°C. The moving element is the laminated armature of a differential transformer pickoff. Stops capable of withstanding shock loads and overloads of about 100 g are fitted, and external adjustment is provided for zero error and sensitivity. The damping medium is silicone oil.

Circle No. 235 on Subscriber Service Card.

New Literature

PRIMARY BATTERIES. A technical bulleting, "The Yardney PM Silvercel aBttery, a re-usable primary!", has just been issued by Yardney Electric Corp. It describes a new silver-zinc battery system, which combines the features of both primary and secondary batery types, offering the highest energy output yet achieved; fast manual activation (full power in 5-30 minutes, with no bulky activation mechanism); long activated stand time; and recyclability. The 6-page illustrated brochure on the PM Silvercel battery describes all electrical and physical characteristics; gives applications data; and compares performance with other battery systems through graphs and charts.

Circle No. 200 on Subscriber Service Card.

TITANIUM WELDING. The best methods for welding titanium piping and tubing by the gas tungsten-arc process are explained in a 24 page report published by the American Welding Society. A most complete description is given from an explanation of the welding process to the selection of electrode and filler metal. The contents of the report include: process, power supply, electrodes and filler metal; titanium grades, joint design and preparation, cleaning; gas shielding, welding techniques; heat treatment; and weld quality tests.

Circle No. 201 on Subscriber Service Card.

STEEL. A techincal bulletin on engineering and maintenance applications of a pre-hardened, machinable high strength steel, Viscount 44, has been prepared by Latrobe Steel Company. Viscount 44 is furnished pre-hardened at a hardness range of Rockwell C 42-46. It meets high strength requirements up to 200,000 psi without further heat treatment. Basically an AISI—SAE Type H-13 steel with a high vanadium content, plus carefully controlled and evenly dispersed alloy sulphides, the Latrobe product has achieved outstanding performance when used in a wide range of engineering and maintenance applications.

Circle No. 202 on Subscriber Service Card.

POWER CONNECTORS. A twelve-page catalog on Series 14, 16, EZ and GA Continental Connectors has just been released by the Electronic Sales Division of DeJur-Amsco Corporation. These four series are miniature rectangular power connectors designed for heavy duty applications in guided missiles, aircraft and electronic equipment requiring high dielectric and mechanical strength combined with high precision and reliability. Complete specifications, outline dimensions, illustrations and general information are covered in the technical catalog.

Circle No. 203 on Subscriber Service Card.

contracts

NASA

$252,210—**Electronic Associates, Inc.**, Long Branch, N.J., for an analog computer system.

MISCELLANEOUS

$1,500,000—**General Dynamics Corp.'s Electric Boat Div.**, for installation of an integrated electronic package on a missile tracking ship to be used on the Atlantic Missile Range.

$892,173—**Servomechanisms, Inc.**, Los Angeles, for true airspeed computers. Subcontract from **Douglas Aircraft Co.**

$444,000—**Potter Instrument Co.**, Plainview, N.Y., for high-speed printing equipment to be used in connection with a classified project.

NAVY

$2,050,000—**The Martin Co.**, Orlando, for follow-on production of transmitters for the *Bullpup*.

$520,000—**Raytheon Co.**, Waltham, Mass., for guidance components for the *Polaris*.

$54,586—**Feedback Controls, Inc.**, Natick, Mass., for data transmitters and receivers.

AIR FORCE

$688,000—**Aeronutronic Div., Ford Motor Co.**, Newport Beach, Calif., for designing an expanded tracking system for satellites.

$163,228—**The Marquardt Corp., Pomona Div.**, for design, fabrication and testing of test consoles for control unit in the *Minuteman*. Subcontract from **North American Aviation, Inc.'s Autonetics Div.**

$105,102—**North American Aviation, Inc.**, Downey, Calif., for repair of 131B weapon system.

$103,845—**Sterling Precision Corp.**, Port Washington, N.Y., for turntable gyro test.

$69,919—**New York University**, New York City, for research on theory of feedback communication systems.

$43,500—**University of Michigan**, Ann Arbor, for research directed toward study and analysis on the radiative properties of plasmas including the effects of heavy ions.

$39,831—**New York University**, New York City, for study of magneto-hydrodynamics with application to phenomena occurring in the vicinity of our planet and in space.

$22,000—**U.S. Transistor Corp.**, Syosset, N.Y., for germanium PNP alloy junction transistors.

ARMY

The Gabriel Co., Rocket Power/Talco Division, Mesa, Ariz., for development and delivery of booster rockets for launching reconnaissance drones. Amount not disclosed.

$82,599,690—**The Martin Co.**, Orlando, for continued research and development of the *Pershing* weapon system.

$3,300,000—**The Martin Co.**, Orlando, to provide publications and training for Missile Master maintenance personnel.

$9,779,887—**Raytheon Co.**, Andover, Mass., for repair parts for *Hawk* missile system. (Three contracts.)

$2,198,253—**California Institute of Technology**, Pasadena, for continued research and development on the *Sergeant* missile.

$1,932,728—**Chrysler Corp.**, Detroit, for *Jupiter* engineering services.

$899,600—**Chrysler Corp.**, for the *Jupiter* missile system.

$766,854—**Chaney & Hope**, Dallas, for construction of strategic missile facilities at Altus AFB.

$735,738—**Raytheon Co.**, Andover, Mass., for repair parts and replenishment repair parts for the *Hawk*. (Six contracts.)

$293,621—**Douglas Aircraft Co., Inc.**, Santa Monica, for launching area items. (Two contracts.)

$265,746—**Western Electric Co.**, Winston-Salem, N.C., for *Nike* spare parts and components.

$250,000—**Scientific-Atlanta, Inc.**, Atlanta, Georgia, for equipment to be used for field testing radar antennas.

$99,171—**Autometric Corp.**, New York City, for study of the lunar survey system.

$86,662—**Plasmadyne Corp.**, Santa Ana, Calif., for tunnel development.

$75,633—**Electro-Optical Systems, Inc.**, Pasadena, for the study, development and test of a microbaroswitch.

$70,000—**North American Aviation, Inc.**, Canoga Park, Calif., for rocket engines.

$69,062—**Sprague Electric Co.**, North Adams, Mass., for research and development work for 18 months to design and fabricate experimental and preliminary development models of stable ceramic capacitors.

$47,952—**North American Aviation, Inc.**, Downey, Calif., for digital computer.

$32,640—**Bomac Laboratories, Inc.**, Beverly, Mass., for electron tubes.

$30,000—**Johns Hopkins University**, Baltimore, for study of dielectrics for outer space.

M.I.T. Expands Materials Research with U.S. Grants

Several branches of science and technology will collaborate in extensive materials research at the Massachusetts Institute of Technology, under a pair of grants totalling $599,200 from the National Science Foundation.

The two-phase program will be directed by Dr. John C. Slater, Chief of M.I.T.'s new Laboratory of Chemical and Solid State Physics.

Under the first grant changes taking place at varying low temperatures in ferromagnetic, ferroelectric and organic materials will be investigated.

The second grant, $199,400, will finance research in neutron physics. The Institute's nuclear reactor and special auxiliary equipment will aid in this phase.

Synthetic Rubber Will Protect *Minuteman* Motors

The motor cases in *Minuteman's* third stage will be protected by a synthetic rubber liner developed by Goodyear Tire and Rubber's Aviation Products Division.

The liner is fabricated in varying degrees of thickness ranging from 0.1 to 1.2 in. and burns out with the solid-propellant grain. The insulator is about 5.5 ft. long and over 3 ft. in diameter.

Morgan E. McMahon: Formerly manager of product engineering, appointed manager of Pacific Semiconductors, Inc.'s engineering department, succeeding **R. A. Campbell,** recently elected vice president in charge of operations. He will be responsible for overall engineering activities with special emphasis on the firm's transistor program.


McMAHON

Elmo E. Maiden: Named assistant manager of the engineering department with special responsibility for the PSI micro-electronics program and the establishment of the micro-diode plant.

Karel J. Bossart: Assistant to the vice president-engineering for Convair Division of General Dynamics Corp., chosen by the Institute of Aeronautical Sciences to receive the Sylvanus Albert Reed Award for 1959. He was cited by the I.A.S. "for significant contributions to the design and development of the *Atlas* ICBM." He headed the Convair engineering team that developed the free world's first ICBM, starting in 1946.


BOSSART

Dr. Charles K. Leeper: Formerly manager of the development division of Nuclear Development Corp. of America, named director of Atlantic Research Corp.'s Mechanical Engineering Division. Will also be responsible for the operations of the Prewitt Aircraft Co., a recent affiliate.


LEEPER

Other additions to Dr. Leeper's staff: **Dr. A. W. Armstrong,** formerly senior research engineer at Convair, acts as consultant to the design engineers, and handles the precontract and report work, as well as the estimating, scheduling and internal liaison.

Eugene C. Mooring: Formerly assistant chief of the Plastics Section Testing Division of Douglas Aircraft Co., will handle fabrication and application of plastics to missiles and rockets.

Newton F. Spraggins: Former president of Rudolph, Inc., named engineering supervisor in the Mechanical Engineering Div.

John L. Lavoie: Formerly with North American Aviation's Rocketdyne Div., will head the rocket design group of the company's Research Mechanical Engineering Div.

Fred F. Richards, Sr.: Elected section manager of production for Temco Electronics, division of Temco Aircraft Corp. He will be responsible for assembly of guidance apparatus, power supplies, antennas, radar devices and subminiature telemetering equipment.

John C. Keyes: Promoted to manager of the satellite systems engineering department at Philco Western Development Laboratories. He will direct WDL's part in the *Discoverer* satellite, systems engineering, range design and operation, systems design and integration and the advanced applications sections.


KEYES

Thwing-Albert Instrument Co., elects **John Fachet,** vice-president-manufacturing; **Ralph E. Green,** vice-president, technical sales and quality control; and **Charles A. Paul, Jr.,** secretary.

George A. Zink: Appointed director of process developments for the newly-created defense systems division of General Motors at Warren, Mich. He will engage in research and experimentation aimed toward the design and development of weapons systems and related activities.

W. S. "Stan" Johnston: Assumes overall responsibility for all airfoils operations of the Tapco Group of Thompson Ramo Wooldridge, Inc., which includes operations at the Harrisburg and Danville, Pa., plants.

Dr. Jay Tol Thomas: Appointed director of engineering for the Boston Division of Minneapolis-Honeywell Regulator Co.

Previous posts: Manager of the Systems Laboratory, Sylvania Electric Products Division where he specialized in infrared and ultraviolet detection of electromagnetic propagation, phased-array radars and weapon system management.


THOMAS

Charles W. Creaser, Jr.: Appointed head of Antenna Systems, Inc., a newly formed company engaging in design and production of precise antenna systems and related accessories. The founding group is composed mostly of former staff members of D. S. Kennedy & Co. Areas of interest will include scatter communication, tracking, radar and radio astronomy.

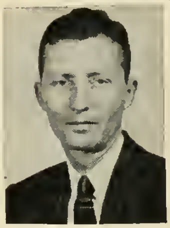
Allen G. Gatfield: Named assistant engineering director at Rixon Electronics, responsible for technical direction and guidance of all active project engineers. Was formerly project manager, Components and Instrumentation Laboratory, ITT Labs.

John F. Cain: Named president of Greer Hydraulics, Inc., designers and manufacturers of hydraulic systems, components and missile ground support equipment. The company, currently situated at New York International Airport, will shortly move to new headquarters and plant nearing completion in Los Angeles.


CAIN

Alfred L. Fenaughty: Elected vice president and general manager of Computer Control Co.'s Western Division, responsible for all activities including digital systems, engineering and product development.

Previous posts: Manager, computer developments, Remington Rand UNIVAC Division of Sperry Rand and Engineering Associates where he worked on advanced techniques and systems.


FENAUGHTY

Walter J. Yuss: Named general manager and **W. J. Drummy,** manager of engineering and sales for Adel Precision Products, designers and manufacturers of hydraulic and pneumatic equipment.

Lee W. Topham, chief engineer will direct design and development operations.

Russell A. Hughes: Appointed chief applications engineer for Pacific Scientific Co.

Henry Erfurt: Elected to head the newly established Epsco, Inc.'s Washington, D.C. office.

George Anisman: Named research and product planning manager of Telecomputing Corp.'s Whittaker Controls Division. Was formerly manager of applications engineering for Sundstrand Turbo Co.

Ralph S. White: Elected general manager of Electronic Systems Development Corp., a subsidiary of Solar Aircraft Co. He will be responsible for the manufacturing and business functions of the firm. Was previously assistant to the division manager of Beckman Instruments, Inc.

Fred Horowitz: Joins U.S. Transistor Corp. as development and project engineer. Horowitz, a solid state physicist, was formerly with the Zenith Corp.

Dr. H. Norman Abramson: Named director-applied mechanics for the Southwest Research Institute.

Dr. Joseph Fugger: Appointed senior scientist with the tactical weapons operation of Aeronutronic division of Ford Motor Co.

Previous posts: scientific coordinator in chemistry, McGraw-Hill Co.; research specialist, Boeing Airplane Co.; and a research group leader, Thiokol Chemical Corp.

Dr. C. C. Baum: Former vice president and director, elected president of the TE Company, engaged in research and development of prototype products and systems involving electronic, optical and mechanical units. Succeeds **Dave Evans** who resigned to head the Dave Evans Enterprises.

Paul W. Crapuchettes: Former chief engineer, promoted to technical director of the Litton Industries Electron Tube Division. He is also manager of the Magnetron Product Line.

Charles E. Applegate: Appointed a staff specialist-new products at Sylvania Electronic Systems division of Sylvania Electric Products, Inc., responsible for new product planning, and development programs. Was previously a member of the senior engineering staff of Arthur D. Little, Inc., and earlier associated with the sales and engineering divisions of Leeds & Northrup Co.

The Institute of the Aeronautical Sciences announces the winners of a number of important aeronautical awards for 1959:

The Hill Space Award goes to **Dr. James A. Van Allen** for the discovery of the radiation belts above the earth which now bear his name.

The John Jeffries Award to **Brig. Gen. Don D. Flickinger, M.D.,** USAF, M.C., "for outstanding contribution to the advancement of aeronautics through medical research."

The Lawrence Sperry Award, to **Dr. James E. McCune,** senior scientist of Aeronautical Research Associates of Princeton, designed to honor a young man of outstanding achievement in the aerospace field.

William S. Ivans, Jr. and **Robert E. McDowall:** Elected directors of Cohu Electronics, Inc.

O. K. Kowallis: Promoted to director of research for Wiancko Engineering Co., and will be responsible for all phases of engineering research and development.

Robert L. Nakasone, holder of several patents on electronic instrumentation devices, replaces Kowallis as chief engineer.

Aeronutronic Realigns Research, Management Jobs

Aeronutronic Division of Ford Motor Company has announced a major change in its basic and applied research activities, and a shift in key management positions.

Dr. Montgomery H. Johnson has been elevated to a top-level scientific advisory position and Dr. Lloyd P. Smith, general operations manager, will head Aeronutronic's Research Operations. This department is a consolidation of all basic research functions.

Four key personnel appointments within Research Operations were announced in the reorganization: Dr. Arthur J. Ruhlig, manager of Physics and computing; Cravens L. Wanlass, manager of Solid State Devices; Dr. Leon Green, acting manager of Aerothermochemistry and Materials; and Dr. Lawrence Davanau, manager of Planning.

IAS Meeting Stresses Space Effort

More than half of the sessions at the 28th Annual Meeting of the Institute of the Aeronautical Sciences, in New York, Jan. 25-27, were concerned with the space effort.

As a service to M/R readers, abstracts of some of these papers are presented. Copies may be obtained from the IAS, 2 East 64th St., New York 21, N.Y., for a nominal fee.

Status of Electric Propulsion, Robert H. Boden, Staff Scientist, Rocketdyne Div., North American Aviation, Inc.

Five years ago the thinking about electrical propulsion systems was limited to few individuals in a small number of industrial organizations and governmental agencies. The concepts of the electrical systems were often colored by those of the chemical rocket. Within this span of five years many of these ideas have become clarified. As a result, these ideas have germinated into promising electrical rocket systems.

The source of the energetic particles from which the thrust is developed is plasma generated from electrical discharges. The one exception to this is the surface contact ion engine in which electrons are stripped from the propellant on a heated metal surface. The engines in which the particles are brought to the enery level required by the mission of the vehicle in which they are applied have three basic subsystems: the energy source, the power converter, and the thrust chamber.

The paper reviews the basic analyses of the electrical rocket engine. Four energy sources: conventional, the fission nuclear reactor, solar and the fusion reactor, power conversion; and three basic thrust devices: electrostatic, electrothermodynamic and magnetohydrodynamic, are reviewed and compared. Major emphasis is upon the thrust device.

Electric Energy Sources and Conversion Techniques for Space Vehicles, Volney C. Wilson, Res. Lab., General Electric Co. IAS Paper No. 60-31.

Electric generators for space vehicles must be dependable, have long life and be lightweight. For long life the primary energy source should be solar energy or atomic energy. Of the various ways to convert heat into electricity the most promising systems for space vehicles utilize thermionic converters. Their operation is described. A consideration of the characteristics of thermionic converters explains why they are promising for space vehicle power supplies.

Solar Sailing, Theodore Cotter, Physics Dept., Univ. of Michigan.

The history of the solar sailing idea is briefly recounted. The propulsion characteristics of an ideal solar sailing space vehicle under the influence of solar thermal radiation are described. Three classes of maneuvers are discussed quantitatively: satelloid maneuvers, escape into interplanetary space, and interplanetary trips. Two engineering realizations of a solar sailing which are proposed: a centrifugally stressed spinning disc, and a cantilevered disc. Techniques for launching and orienting each of these are suggested. Effects due to the space environment, as they bear on the practical usefulness of the solar sail, are estimated. It is concluded that solar sailing is an extremely promising concept for space propulsion, and that there are no major technical obstacles to an early trial of such a device.

Pebble Bed Nuclear Reactor for Space Vehicle Propulsion, Myron M. Levoy and John J. Newgard, Reaction Motors Div., Thiokol Chemical Corp. IAS Paper No. 60-39.

Pebble bed nuclear reactors are applicable for nuclear space rocket propulsion, within limits. They may be used for low-flow, low-thrust space vehicles with gross weights in the range of 20,000 lb. to 100,000 lb. and initial accelerations from earth orbits of 0.2 to 0.4 g.

The reactor and nuclear vehicle schemes are discussed and advantages are considered. Savings in fabrication and construction costs and reactor design simplicity are indicated. Problem areas are also discussed, such as the power flattening requirements, hydrogen density perturbation effects on system reactivity, and peripheral flow build-up.

Thermal Stresses in Missile Nose Cones, A. J. A. Morgan, Pres., Aeronautical Engrg. Res., Inc., and Carlos H. Christensen, Mathematician, Digital Sect., Computation Lab., Army Ballistic Missile Agency. Fairchild Fund Paper No. FF-24.

A general computational scheme is developed for the determination of the thermal, and other displacements and stresses within multi-material bodies with axial symmetry. The formulation is of the quasi-steady type; it is made in terms of general curvilinear coordinates; hence, within the class considered, it is not restricted to a particular body shape or to "shell-like" structures. The generality of the method is increased by supposing that it may be necessary to use a discontinuous metric tensor to describe the geometry in two adjoining regions of the body.

Some Aspects of Designing Aluminum Structures for Thermal Environments, John M. Cord, Project Engr., Adv. Design, Bell Aircraft Corp., and A. Bruce Burns, Senior Res. Engr., Missiles and Space Div., Lockheed Aircraft Corp. IAS Paper No. 60-7.

Design aspects of aluminum structures subjected to thermal environments consisting of elevated temperatures are reviewed, and the nature of the design of thermal environment for typical aircraft is noted. The problems associated with extending the structural use of aluminum for aircraft in the Mach 2.0 to Mach 3.0 region are discussed in the light of current experience.

A simplified method for determining the room temperature strength of aluminum alloys after exposure to more than one elevated temperature is introduced, and the results of a test program to substantiate the method are presented. This method is based on a cumulative strength deterioration relationship which takes a form generally similar to the familar cumulative damage or life fraction method for fatigue strength. Applications of the cumulative deterioration relationship and its relationship to the overall elevated temperature structural design problem is discussed.

Heat Protection by Ablation, Robert M. Wood, Ch., and Ronald J. Tagliani, External Thermodynamics Gp. Leader, Thermodynamics Sect., Missiles and Space Systems Engrg. Dept., Douglas Aircraft Co., Inc. IAS Paper No. 60-8.

A model consisting of a metal load-carrying structure covered with a protective coating is discussed and chosen as an efficient method of dissipating the severe heating encountered by hypersonic vehicles in transient flight. The concepts of heat and temperature of ablation are used together with other coating material properties for describing the effectiveness of different protective coatings in different thermal environments.

The assumption of an equivalent square wave heat-time input for any actual environment is discussed and justified for radically different environmental situations, including ICBM, Mars entry, anti-ICBM, manned entry, and nozzle applications. Using the square wave heat input assumption the unit coating weight required is presented as a function of intensity and duration of heating for several different protective coatings.

Three domains of heating are categorized: (1) almost complete ablation, wherein the most important material property is heat absorbed per pound of material lost; (2) partial ablation, wherein density and conductivity are as important as ablation properties; and (3) no ablation, wherein ordinary thermal properties are all important.

The results are summarized by the graphical presentation of the relative coating weights required with a number of popular protection materials for a number of different environmental situations, thereby emphasizing the need for different thermal properties with various environments.

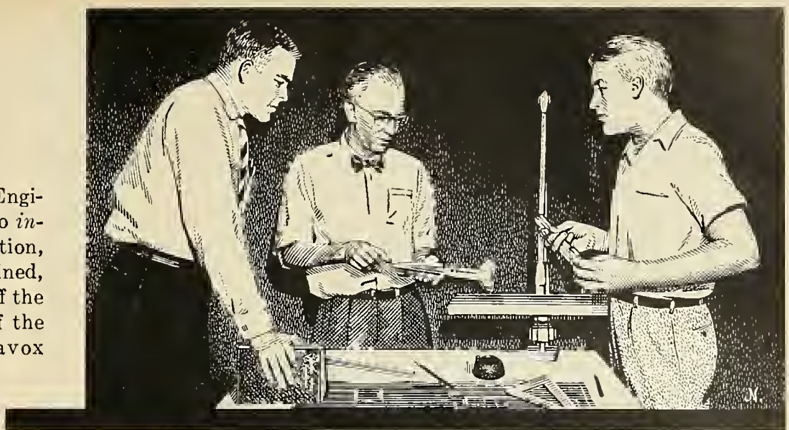
The Application of Solid Propellant Rocket Motors to Boost Space Vehicles, Giulio C. Panelli, Res. Specialist, Missiles and Space Div., Lockheed Aircraft Corp.

This paper describes work performed by the author and associates at Lockheed under a contract with the NASA. The work includes a comprehensive performance analysis of large, solid-propellant rocket motors as first-stage boosters for vehicles designed to perform space missions. Studies have been performed from a vehicle standpoint and include variations of significant design and performance parameters. Detailed investigations have been conducted in structural designs, trajectory techniques and in propulsion design. Brief studies were made with respect to cost and logistics.

The results of the study show that the solid-propellant rocket booster is feasible from performance and design standpoints. A liquid-propelled, three-stage vehicle weighing one million pounds can place 34,400 pounds of payload in a 300-nm orbit. A solid-propellant-boosted three-stage vehicle of the same size can place 42,000 pounds of payload in the same 300-nm orbit. A solid-propellant rocket motor to be used as a booster for this vehicle can be built at the present time with no further advances in technology.

Considerations in the Design of Chemical Rocket Powerplants for Space Applications, Stanley Lehrer, Sect. Supvr. Technical Planning Dept., Reaction Motors Div., Thiokol Chemical Corp. IAS Paper No. 60-24.

This paper discusses a number of the im-



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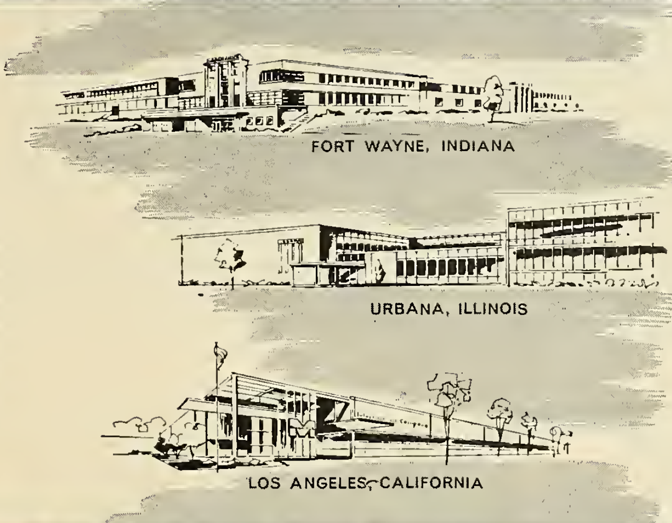

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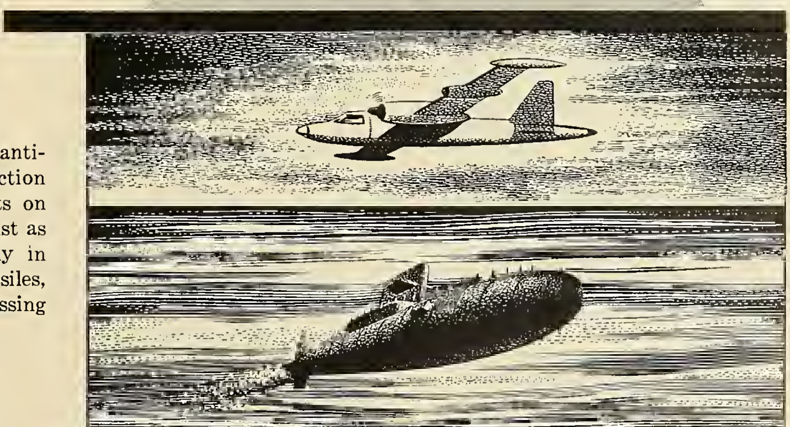

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portant factors to be considered in the design of space engines including:

1. Selection of engine type and basic design parameters.
2. Selection of propellants.
3. Multiple start-shutdown capability.
4. Throttling schemes—as related to performance and cooling.
5. Environmental factors.

Other pertinent consideratione discussed include:

1. Use of advanced high-temperature materials and lightweight corrugated or other composite constructions.
2. Suitability for manned application.
3. Optimum propellant tank pressurization techniques.
4. Powerplant installation considerations.

Cryogenic Propellant Storage for Round Trips to Mars and Venus, George R. Smolak, Res. Engr., Propulsion Systems Div., and Richard H. Knoll, 1st Lt. USAF, Lewis Research Center, NASA. IAS Paper No. 60-23.

For the more ambitious space missions being considered, such as manned expeditions to Mars, the use of storable chemical propellants of moderate specific impulse results in prohibitively large and heavy space vehicles. Sizahle gross weight reductions would result if the higher-specific-impulse cryogenic propellants (hydrogen, fluorine, and oxygen) could he employed. The effective use of these cryogenic propellants for long-duration space missions depends strongly on whether practical means can be devised to keep evaporation losses to a tolerably low level.

The paper discusses the sources of heat to which the cryogenic propellants are suhjected and various means that can be employed to minimize evaporation losses. For a round trip to Mars, it is shown that radiation shielding, insulation, and vehicle orientation can be used effectively to keep the cryogenic losses to an acceptable amount. The thermal protection devices employed and the propellant losses for each phase of the Mars trip are discussed.

Propulsion Requirements of a Manned Lunar Mission, Douglas E. Serrill, Proj. Mgr., Space Res. Systems, and H. J. McClellan, Staff Engr., Flight Technology, Aerospace Div., Boeing Airplane Co. IAS Paper No. 60-30.

Man's main motivation for a visit to the moon is one of exploration. The worth of this exploration cannot he defined in detail with any assurance of payoff; however, this exploration is inevitahle just as was the climbing of Mount Everest. It can he very clearly stated, however, that man's eventual landing on the moon is completely dependent on good, sound, hard-hat propulsion developments.

There are several ways to accomplish manned lunar missions, including single straight-shot launch systems capable of carrying the payload to the moon and systems utilizing earth orbital assembly of the payloads required for the continued trip to the moon and return. This paper does not compare the various concepts for accomplishing the mission, but rather discusses a few of the major propulsion requirements required to support any one of the waye of doing the job.

Ultrasonic Welding and Improved Structural Efficiency, J. Byron Jones, and Harold L. McKaig, Aeroprojects, Inc. IAS Paper No. 60-10.

Ultrasonic welding is an effective means for producing leak-tight junctions of structural integrity in the high-strength, high-temperature, refractory metals and alloys, particularly in thin gages of these materials. Data are presented for ultrasonic weld strength in a number of structural materials, weld seam leak-tightness, fatigue, and for strength degradation produced hy ultrasonic welding in certain high-strength stainless steels and titanium alloys.

The ultrasonic welding process is described briefly, representative microstructures are illustrated, and the functional components of various types of equipment —spot-type, ring, and continuous-seam welders—are schematically illustrated.

Role of the Satellite in Space, Fred L. Wipple, Dir., Smithsonian Astrophysical Observatory and Prof. of Astronomy, Harvard Univ.

Artificial earth satellites and space prohes offer an entirely new tool for astronomical research, a tool with almost unlimited potentialities. Research areas of immediate interest are:

a) The interplanetary medium including meteorites, gas, ions, and plasma.

b) Solar activity. Of particular interest are emissions of the far ultraviolet, X-rays, infrared, long-wave radio, cosmic rays and possibly gamma rays.

c) Lunar and planetary investigations both by observation from near the earth and hy actual exploration.

d) Interstellar space and nearby stars to be studied by the same gamut of radiations as mentioned for the sun.

e) The Milky Way and other galaxies. Results in this area will depend upon the transparency of space at great distances, which is not known at the moment.

f) Basic physical experiments involving time, relativity, and gravity, involving instrumentation with clocks, inertial eystems and other fundamental measuring equipment.

From these studies will come hasic information for engineering in the space sciences, about the origin of life on this and on other planets and for an underetanding of the evolution of the planets, the origin of stare and the development of galaxiee. Indeed, great progress should be he made towards an understanding of the nature and evolution of the cosmos as a whole. Artificial satellites will he as important a step forward in astronomy as was the invention of the telescope.

On Meteorological Observations from Satellites, Sigmund Fritz, Ch., Meteorological Satellite Sec., U.S. Weather Bureau.

One of the main values of satellites for meteorology is their world-wide view of the earth from high elevations. World-wide observations of clouds, and of the radiative heat budget of the earth, will soon he available. Among other meteorological measurements being considered for the next few years are the temperatures of the stratoshere (spectroecope) and the distribution of precipitation (radar). Most of these obeervational programs will he managed by the NASA.

Satellite Systems for Commercial Communications, J. R. Pierce, Dir. of Res., Bell Telephone Labs. IAS Paper No. 60-40.

To be used for commercial communications, a satellite communication eystem should he competitive in cost and quality with any alternative system and should eupplement present facilities. Thie would seem to limit its application to hroadband transoceanic links. High reliability and a long assured life seem necessary.

Passive systems require large powere and antennas. The life of passive satellites is as yet unevaluated. No experimental data are available on the life of radio equipment or orientation and station-keeping equipment for active satellites. However, prospects for long-life, low-power, very hroadband microwave equipment and power supplies seem good. The delay in a 24-hour "stationary" satellite system may give some trouhle because of delay in one hop and more serious trouble in two hops.

Clearly, much research is necessary before the commercial possibilities of various proposed systems can he evaluated. Bell Laboratories is doing experimental work on both passive and active satellite communication.

The Effects of Vehicle Deceleration on the Ablation Characteristics of a Glassy Material, Jerome B. Fanucci, Res. Engr., Missile and Space Vehicle Dept., General Electric Co.

An analysis of the ablation characteristics of a material which melts and then vaporizes is presented. The ablation characteristics of the liquid film at the stagnation point are analyzed hy an integral technique. This method has heen compared, for the case not including body forces with other theories, and shows excellent agreement. Some results for zero-pressure gradient bodiee are also presented.

Boundary-Layer Displacement and Leading-Edge Bluntness Effects in High Temperature Hypersonic Flow, H. K. Cheng, J. G. Hall, Principal Aerodynamicists, T. C. Golian, Assoc. Mech. Engr., and A. Hertzberg, Hd., Aerodynamic Res. Dept., Cornell Aeronautical Lab., Inc. IAS Paper No. 60-38.

Two important features of hypersonic flow over slender or thin hodies are the displacement effect of the boundary layer and the large down-stream influence of leading-edge bluntness. The present paper contributes new theoretical and experimental results which give increased understanding of these effects.

—when and where—

FEBRUARY

Institute of Radio Engineers, American Institute of Electrical Engineers, Seventh Annual Solid-State Circuits Conference, University of Pennsylvania, Philadelphia, Feb. 10-12.

American Society of Mechanical Engineers, American Institute of Electrical Engineers, February Joint Meeting: "Solar Power for Space Vehicles," Department of the Interior Auditorium, Washington, D.C., Feb. 11.

Annual Meeting of American Institute of Mining, Metallurgical and Petroleum Engineers, Sheraton Atlantic Hotel and Statler Hilton Hotel, New York City, Feb. 14-19. (**Metallurgical Society Forum on Navy Materials Problems,** Feb. 15).

National Society of Professional Engineers Winter Meeting, Broadview Hotel, Wichita, Kan., Feb. 18-20.

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editorial . . .

Prodding the 'Reluctant Dragon'

It has become almost customary for retiring military officers to leave the ranks of the Armed Services with parting critical barrages aimed at the civilian leadership our national system imposes upon them.

This is not unnatural. We have entered two world wars woefully unprepared, and after each we have disarmed with enthusiastic thoughtlessness. Korea caught us disgracefully weak—and there is considerable doubt whether we really could cope with a similar situation, should it occur today.

Very little of the blame for decisions which led to these situations or events can be laid at the door of the military—unless you wish to blame them for not being persuasive or forceful enough in their protests.

Maj. Gen. John B. Medaris, who has just retired as chief of the Army's Missile Command, made no exception to the custom of parting blasts—and his were pretty well circulated in the public press and on the air.

But Medaris was exceptional in one way, at least by comparison with two recent Army predecessors—Generals Gavin and Taylor. Medaris did not lay the blame on interservice favoritism, did not proclaim his own command or service as the unsung and unrecognized savior.

He placed the blame for the nation's space floundering on the national leadership, and he proposed a remedy—a unified military command. NASA, he thought, could go—because the only excuse for NASA was to take projects from the competitive area and a joint command would do the same thing.

His chief charge—that the Administration's "reluctant dragon" attitude toward space is leading to disaster—is one that has been in the spoken and unspoken thoughts of a great many Americans for months; the almost willful refusal of the White House to recognize the fact that we are in a monumental fight for national survival.

The General's contention that the Services have a great deal of business exploring space, and his call for a unified Space Command, deserve serious thought and consideration.

Most of the great explorations of history were made either by the military, in cooperation with the military, or because there was a military purpose (hidden or otherwise) behind them.

There are reasons why this has always been true—and reasons why it should always be true. One is the sense of driving urgency which compels the military man to be first and strongest because that is the sworn dedication of his life. To him, second place is failure, a dangerous failure. Another reason is the military man's willingness to risk his life and to endure great hardships simply because it is his duty. That's why he is there; if he doesn't feel that way he shouldn't be in the military—and this is a thing people, in peacetime, tend to forget.

This is not to gainsay the dedication or the courage of the men who do not happen to wear the uniforms of the services. Nor to downgrade the skills they have and the contributions they make. Nor there is no place for NASA. There is.

But it is to say that when the United States awakens to the fact that letting Russia win first place and possible control in the space race by default could cost us our freedom, when we arrive at that point and want the strongest possible program to catch up—then we could most nearly guarantee success by giving responsibility for it to a military command, preferably a united command. It is largely a matter of drive and motivation.

Clarke Newlon

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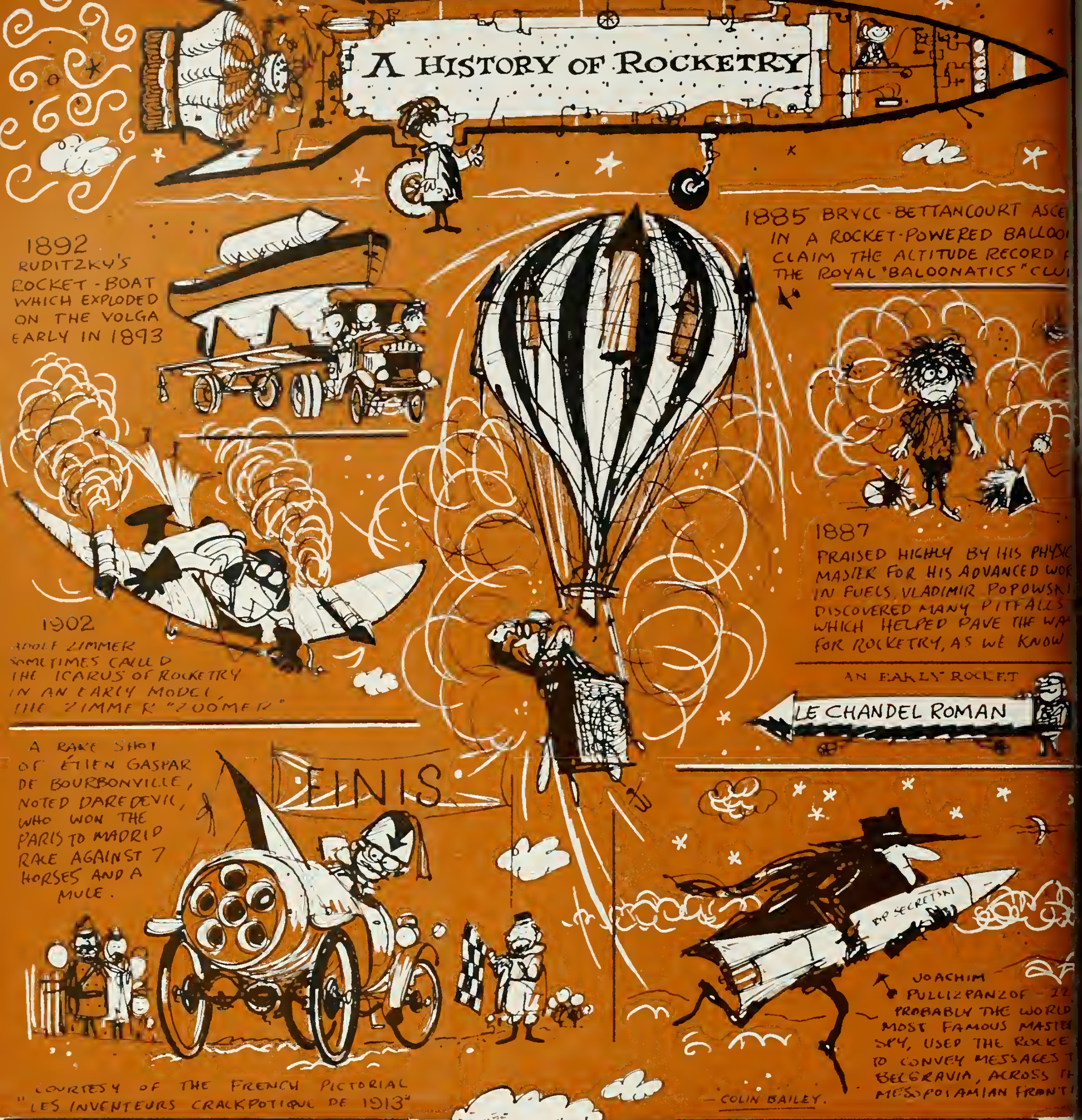

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1885 BRYCE-BETTANCOURT
IN A ROCKET-POWERED
CLAIM THE ALTITUDE RECORD
THE ROYAL "BALOONATICS"
1887
PRAISED HIGHLY BY HIS
MASTER FOR HIS ADVANCED
IN FUELS VLADIMIR POPOWSK
DISCOVERED MANY PITFALLS
WHICH HELPED PAVE THE
FOR ROCKETRY, AS WE KNOW
1902
ADOLF ZIMMER SOMETIMES CALLED THE ICARUS OF ROCKETRY IN AN EARLY MODEL THE ZIMMER "ZOOMER"
AN EARLY ROCKET
LE CHANDEL ROMAN
A RARE SHOT OF ÉTIEN GASPAR DE BOURBONVILLE, NOTED DAREDEVIL, WHO WON THE PARIS TO MADRID RACE AGAINST 7 HORSES AND A MULE.
FINIS
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JOACHIM PULLIZPANZOF
PROBABLY THE WORLD
MOST FAMOUS MASTER
SPY, USED THE ROCKE
TO CONVEY MESSAGES
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