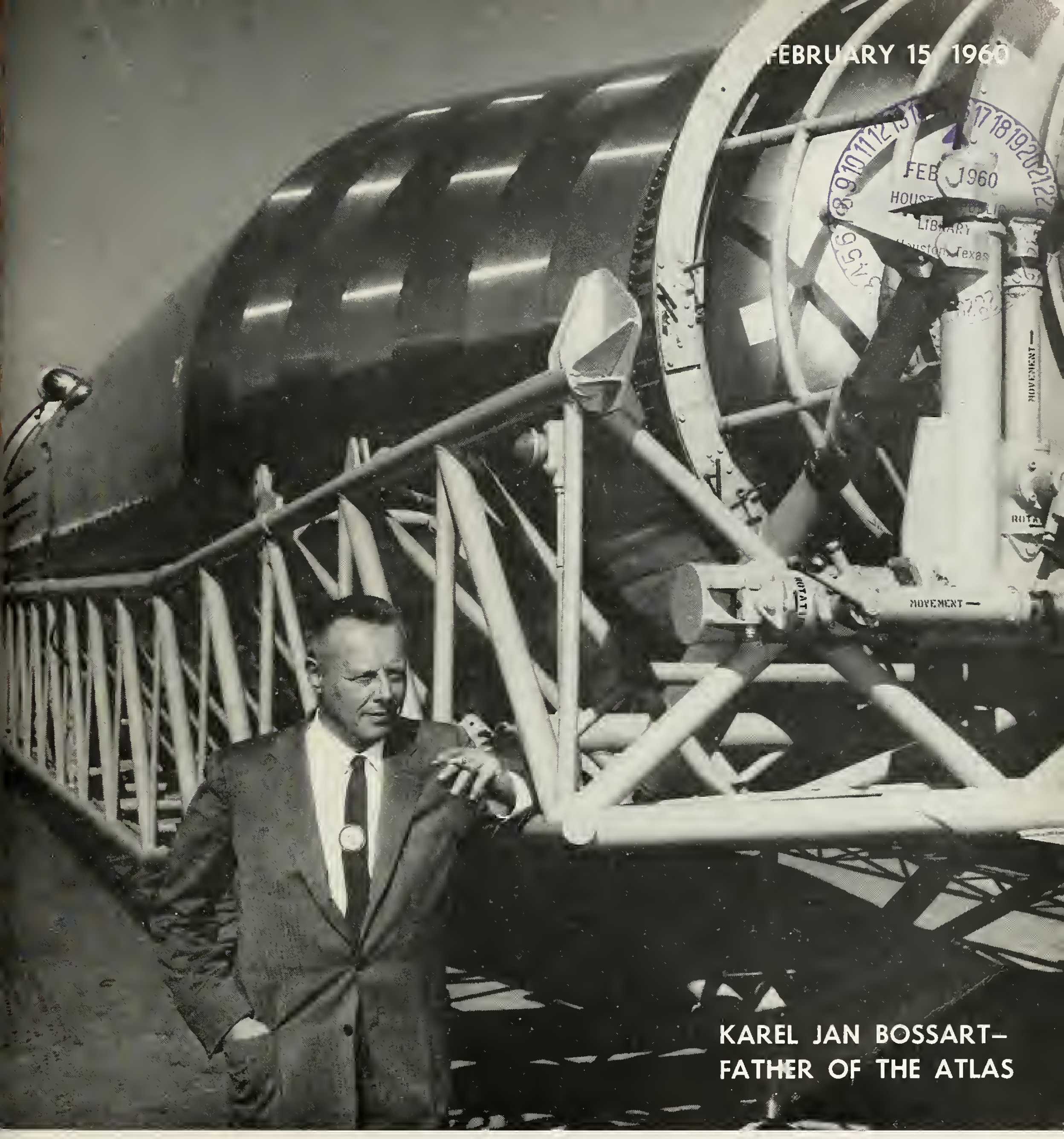
FEBRUARY 15, 1960

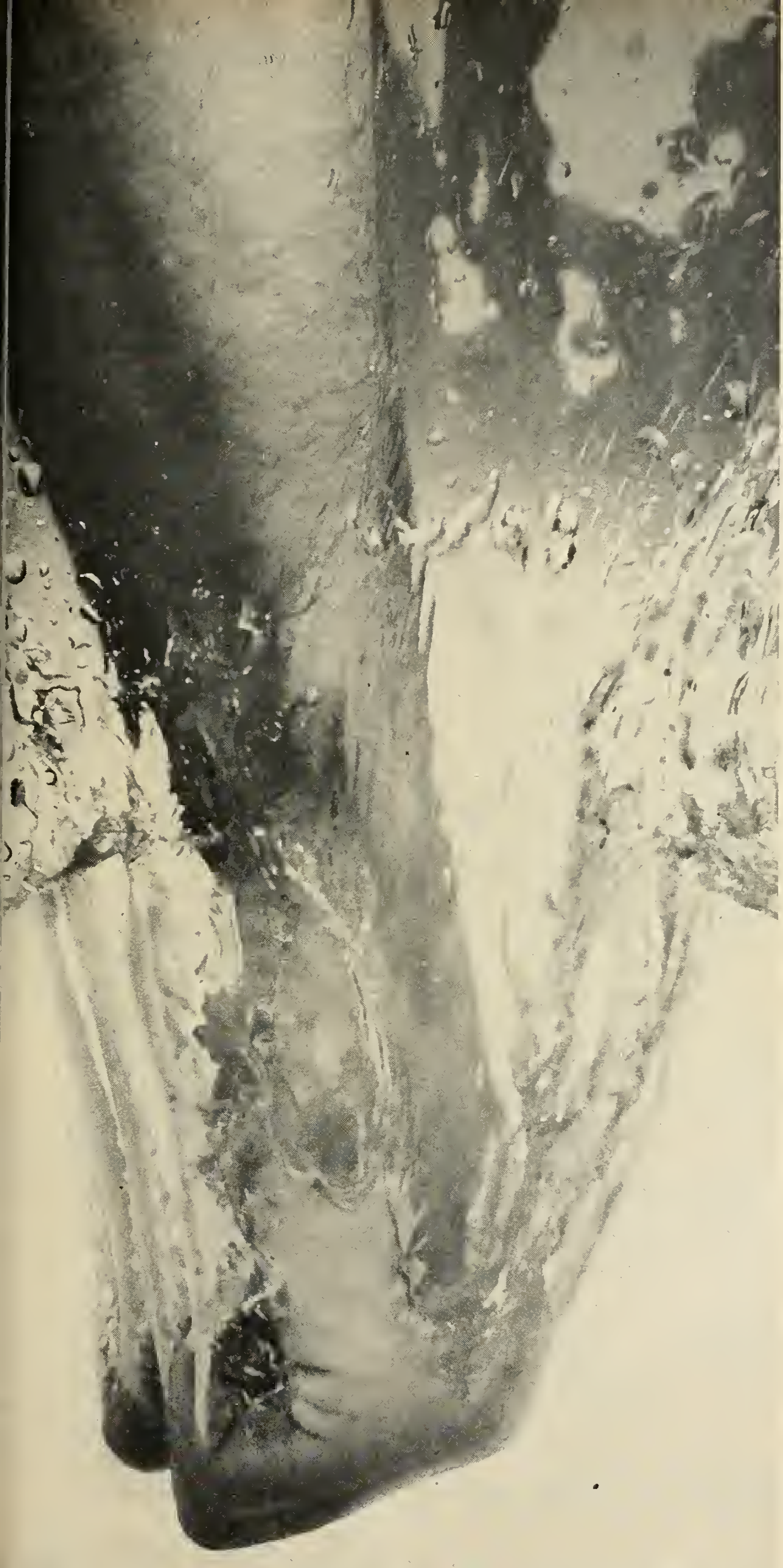


KAREL JAN BOSSART—FATHER OF THE ATLAS

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION



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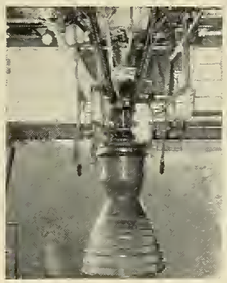
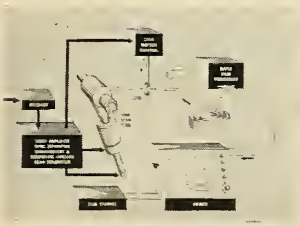
COVER: Karel J. Bossart stands before Convair *Atlas*, of which he is popularly called the "father." Bossart has been chosen to receive M/R's Goddard Memorial Trophy. See story on p. 13.



AEROJET, which developed and tested this 100-K static test hydrogen engine, is one of contenders for NASA contract for top-stage of *Saturn*. See report on page 10.



GROUND receiving equipment of Photoscan system developed by CBS Laboratories and called ideal for surveillance work. A report begins on p. 18.

MATERIALS engineer Harry B. Porter of NOTS proposes "Calorobics" as a term to cover the field of high-temperature materials technology. See p. 24.

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

31,000 copies this issue

FEBRUARY 15 HEADLINES

ASTRIONICS

ADVANCED MATERIALS

INTERNATIONAL

PROPULSION

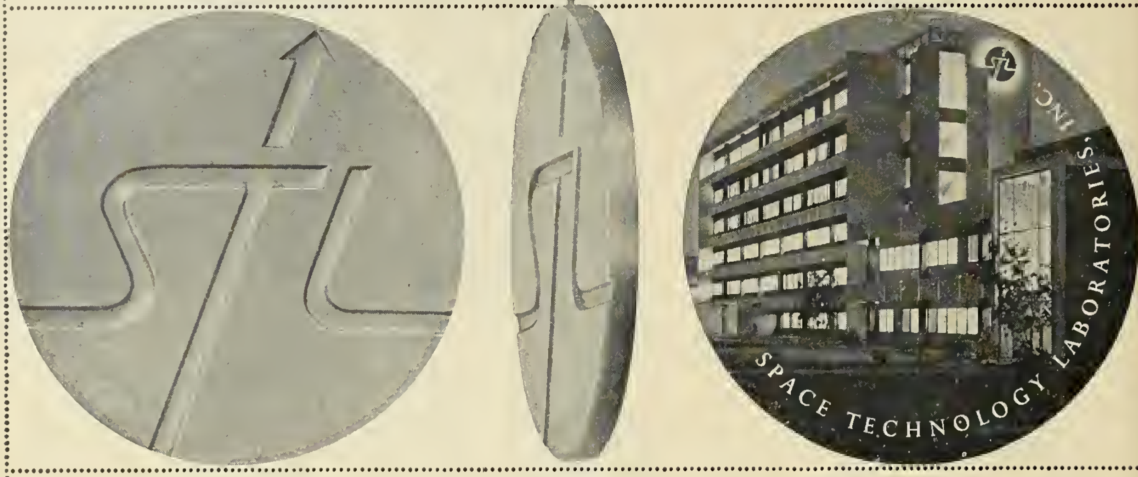
PRODUCTS AND PROCESSES

THE MISSILE WEEK

U.S. Reg. Pdg.

DEPARTMENTS

SCIENTISTS AND ENGINEERS: There are two sides to the STL coin...



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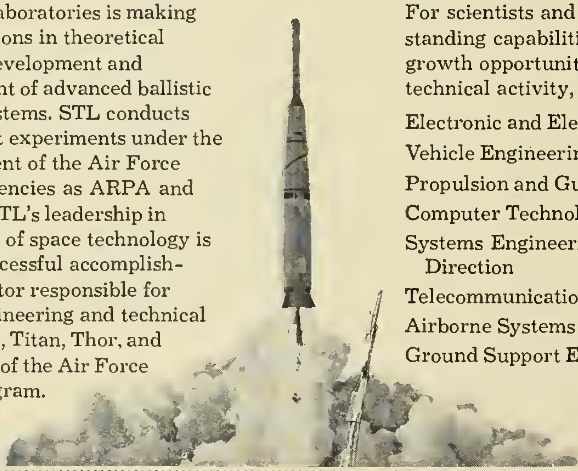

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SPACE TECHNOLOGY LABORATORIES, INC.

Washington Countdown

IN THE PENTAGON

Funding for *Midas* and *Samos* . . .
in the Air Force's FY 1961 R&D budget breaks out this way:

. . . About $100 million for the *Midas* early warning satellite.

. . . More than $160 million for the *Samos* reconnaissance satellite.

Some top Air Force leaders are pressing for more money for *Midas* in order to achieve an operational system earlier.

• • •

Project *Yo-Yo* . . .
is a Navy study aimed at possible development of a picture-taking reconnaissance satelloid. A *Yo-Yo* would make a single orbit and be recovered at sea.

• • •

Operational *Hound Dogs* . . .
have already been flown more than 500 miles. The first of the North American air-to-surface air breathers is already in the hands of SAC.

• • •

Mobile *Jupiters* . . .
are being sought by the Army. The Army also wants to put the Chrysler IRBM's in Alaska.

• • •

The SAC-*Polaris* Joint Command . . .
proposed by the Air Force is expected to come before the Joint Chiefs of Staff for a decision within the next few weeks. The Navy is ready to fight the proposal to its last boatswain.

• • •

***Jupiter* plus *Agena* . . .**
is reported to be the full drone the Army is planning to pit against its *Nike-Zeus* AICBM during forthcoming Pacific tests. The Lockheed-Bell *Agena* will climb to the desired altitude, stop its engine, coast into a dive and restart for a powered dive to simulate an incoming ICBM.

• • •

The Advanced *Lacrosse* . . .
R&D program is not dead but merely resting. The Army plans to go ahead with the postponed $200-million Martin program as soon as it can get the money.

Vulnerability to jamming . . .
to some degree is one of the key problems the *Advanced Lacrosse* is expected to lick. Meantime, four of eight planned *Lacrosse* battalions are scheduled to be sent to Europe and Korea as soon as their training is completed.

• • •

The Canaveral shot program . . .
boasts an average of a launching a day this week. The schedule includes a *Thor, Matador, Titan, Polaris, Snark* and an *Atlas*.

ON CAPITOL HILL

More money for defense . . .
primarily for *Polaris* submarines and an airborne alert, appears to be in the cards as the Missile Gap debate roars on. However, the Administration appears equally determined not to spend the extra funding even if Congress provides it.

• • •

Minor revisions . . .
in military procurement procedures may be enacted by Congress before it adjourns this year. However, no major changes are now expected to result from current hearings and studies in the Senate.

AT NASA

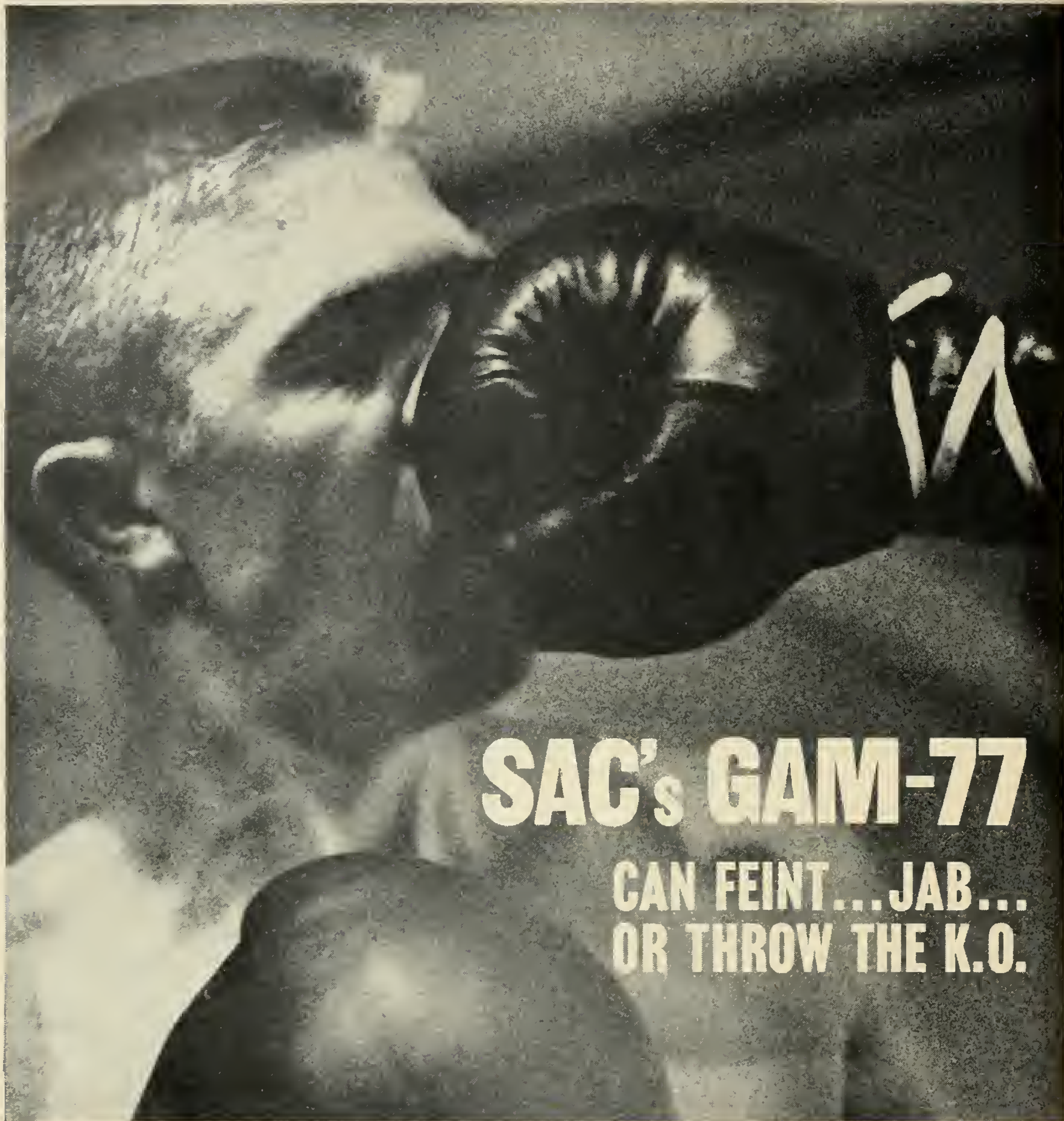
A doubled program . . .
for launching sounding rockets is under way at Wallops Island Test Center. NASA plans to launch 100 sounding rockets from Wallops during 1960—compared to about 50 last year. About eight a month will be fired during the next two years.

• • •

A wary eye . . .
is being cast by NASA officials at the Air Force proposal to develop a two-million-pound-thrust solid-rocket motor. NASA contends the White House gave it the authority to develop the nation's big boosters and the reason it isn't considering work on a large solid motor is that it lacks the money.

• • •

Another supplemental request . . .
NASA's second for FY 1961—may be in the works. So far, NASA budget requests for FY 1961 total $915 million. The agency also has submitted a $25-million supplemental request for FY 1960.



GAM-77 HOUND DOG air-to-surface missiles give SAC's B-52G intercontinental bombers the versatility of a champion boxer. Even while the aircraft carrying the GAM-77 missiles is airborne, a new target can be selected. Then reaching out at supersonic speeds after launch, the GAM-77's can flatten opposition for the bomber to deliver its own Sunday punch...or independently destroy the primary target. These jet-powered missiles vastly increase the striking power of the giant Boeing B-52...give it a triple-punch capability.

Guided by a self-contained inertial autonavigator—set before launch by the B-52's crew—the GAM-77 can't be jammed, can't be decoyed. The GAM-77 Hound Dog was designed and is being produced for the USAF by the Missile Division of North American Aviation.

MISSILE DIVISION

NORTH AMERICAN AVIATION, INC.

Downey, California

Industry Countdown

MANUFACTURING

Shear-off of nose cone . . .

is believed to have caused a *Titan* ICBM to disintegrate 57 seconds after launch Feb. 5. The failure came on the second attempt to test second-stage ignition. The nose cone was being tried out as a secondary test objective.

• • •

Titan's troubles . . .

which probably will be examined soon by Congress, may make it extremely difficult to meet the operational target date—set for May, 1961.

• • •

Leading contenders . . .

for the contract to build the frame for the "interim" 80K-thrust *Saturn* second stage are Convair and Douglas. The soon-to-be-awarded two-year job may be worth between $100 million and $200 million and could lead to contract for an "ultimate" 800K stage—and another $200 million.

• • •

Reorganization of weapons . . .

system management set-up by the Air Force is still considered a must. The chief obstacle: reconciling different philosophies of ARDC Commander Schriever and Gen. Anderson, chief of the Air Materiel Command.

PROPULSION

Considerable upgrading . . .

in the 300,000-lb.-thrust of the *Titan* booster is predicted if—and when—the big bird is switched to storable non-cryogenic fuels. A storable *Titan* would be heavier than the LOX and RP-1 fueled model, but would be able to deliver a larger megaton payload a greater distance (see p. 30 this issue).

• • •

Two sections . . .

fabricated individually are proposed for the Aerojet-General 2-million-lb.-thrust solid booster. Outside dimensions of the assembled rocket: 60-70 ft. high and up to 13 ft. in diameter. Aerojet already has fired small solid rockets constructed in sections.

ASTRIONICS

Russia has just opened . . .

a new planetarium at Astrakhan, which is located at the mouth of the Volga where it enters the Caspian Sea. The planetarium is also located between Kapustin Iar and Aralsk —the two major Red ICBM-satellite launching sites (See map page 26).

• • •

Defense systems department . . .

of General Electric—believed the first in industry set up solely for systems engineering of Army missile programs—is now reported to be working on several classified contracts and to have some more in the works. The special department was created at GE Philadelphia about six months ago.

• • •

Operational *Bullpups* . . .

are now showing 90-95% reliability. This is particularly signficant since the air-to-surface missile is unpacked, loaded and fired with no checkout. Navy claims $7 million savings in a year with this technique and is promoting its further application to other missile systems.

WE HEAR THAT—

Contract to engineer . . .

silo elevator-erector for a hardened *Atlas* ICBM is going to American Machine & Foundry, which developed similar mechanism for *Titan*. The contract is expected to be about $4 million . . . An Atomic Energy Commission official—Delmar M. Morris—is the new deputy director for administration of the ABMA-NASA facility at Huntsville . . . The Leach Corp. has acquired Electro-space Laboratories Inc., Pasadena, a developer of subminiature solid-state missile command receivers . . . Sales are improving at Fairchild Engine & Airplane Corp.'s Plastic Branch, which is doubling its plant capacity at Copiague, L. I. . . . Missile Gap Thought of the Week: "The danger is not in starting too many R&D projects," says J. R. (Russ) Clark, general manager of Chance Vought's Astronautics Division. "The real danger is in not starting enough. R&D spending is the seed corn. What is needed is the courage, vision and determination by a good farmer to weed out the less promising plants after they have sprouted and before they grow too far above the ground—regardless of the pressures to let the weeds grow and sap strength from the good plants." Russia reportedly is spending $8.1 billion this year on missile/space R&D.

H-O Engine Contract Race On

Bids due March 14 for NASA's 200,000-lb. thrust hydrogen-oxygen engine which will go on top of Saturn

by Paul Means

Bid Specifications

The prime requirement in the 200-K hydrogen engine is high reliability, the National Aeronautics and Space Administration told bidders at a conference Feb. 3.

Some sacrifice of performance and weight will be in order, NASA officials said, since the switch to hydrogen gives an increase in specific impulse from 300 to more than 400 seconds.

NASA said it gave the seven bidders these other instructions on drawing plans for the engine:

- *Don't go beyond the present state of the art; no new concepts in engine hardware are desired.*
- *Start and restart capability are required—without significant modifications in design.*
- *Expenditures for new facilities—particularly test areas—must be held to a minimum. If possible, modify existing facilities for the development job.*
- *Simulated altitude testing, when the time comes, will be performed at a government installation.*

As to the use of a gas generator or a regeneratively cooled nozzle, NASA officials were noncommittal. The length of the engine was also left open.

NASA set a diameter limit for contractors but declined to disclose the figure. However, since four engines must fit within the 220-in. diameter of the second stage, it is obvious that the engine must have about an 85-in. diameter.

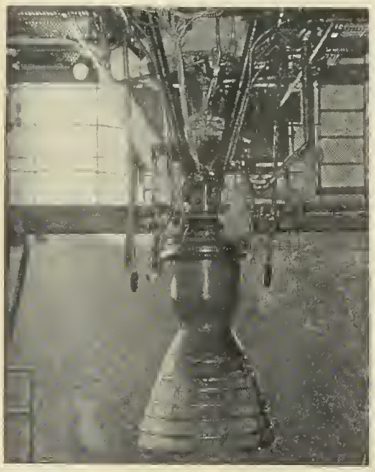
The race is on among major missile industry rocket engine manufacturers for supremacy in the liquid hydrogen engine field.

At stake is a NASA contract for a 200,000-lb.-thrust liquid hydrogen-oxygen engine which will eventually go on top of the *Saturn* cluster.

Companies entered in the competition—at NASA's invitation—are Bell, Aerojet-General, Thiokol, Pratt & Whitney, AiResearch of Garrett, Rocketdyne and General Electric. These companies were briefed last week at a NASA pre-bidders' conference. The formal request for bids will go out Feb. 15 and bids will be due March 14. NASA expects to let the contract by late April.

The project has been funded for $16 million so far; $8 million in the FY '61 budget under the liquid propulsion R&D item, and $8 million in the supplemental FY '61 budget under the Project *Saturn* item. The developmental funding, leading up to preflight rating tests in 1963, is expected to cost about $50 million.

The preliminary specifications given to the seven companies by NASA last week were sketchy in places, because no one has ever built a large thrust operational hydrogen engine before.



AEROJET'S LOOK Hydrogen-oxygen engine undergoes test at California facility.

The companies were told that four of the engines would have to fit in a 220-in. diameter frame—leaving room for about an 85-in. diameter engine—and were given the expected performance characteristics.

The NASA Specifications demanded high reliability of the proposed engine and use of a gas generator or regenerative cooling nozzles was made optional. No requirement was placed either on the length of the tankages.

- **NASA coppers its bet**—NASA and its new Huntsville team had taken a bold step when they decided to go beyond the present state of rocket engine art for *Saturn's* upper stages. If the job proves more difficult than expected, the decision might slow down the *Saturn* program considerably. But if the proposed engine's development proceeds on schedule, *Saturn* will be more powerful, and have greater capability than its original backers had dreamed possible.

But the NASA-*Saturn* team has not put all of its eggs in the large-hydrogen-thrust-engine basket. A bidders' conference was held at Huntsville last week for a contract to cluster the 20,000-lb. Pratt & Whitney version of the *Centaur* hydrogen engine to use as *Saturn's* interim stage. (See M/R, Feb. 8, p. 14.) These engines are expected to be ready for the *Atlas-Centaur* in mid-1961, and ready for *Saturn* in their four- and two-barrel configuration in 1962.

Contract to fabricate the 200-K engine into its four- and two-barrel configurations will not be let by NASA for some time yet, but it is thought that the winner of the NASA contract to fabricate the 20-K stages will take a long march on its competitors and

PRATT & WHITNEY'S 15,000-lb. thrust hydrogen engine is *Centaur's* second stage.

will be in a good position when the contract to fabricate the 200-K stages is bid on. Convair and Douglas are considered to be the strongest contenders in the 20-K engine stage fabrication race.

• **A look at the field**—Of the seven companies vying for the 200-K hydrogen engine contract, Pratt & Whitney, Aerojet-General and Rocketdyne are considered to be in the strongest positions, but the other four competitors all have considerable knowledge and facilities.

Pratt & Whitney's strong position results from its work on what will be the first operational hydrogen engine of any size. Aerojet-General has developed under an Air Force study contract a 100-K static test hydrogen engine which has been tested about 60 times. Rocketdyne has had success in building large hydrogen pumps for Project *Rover*, and is the largest producer of cryogenic engines.

Of the other competitors, Bell Aircraft has considerable experience in the cryogenic field, especially in developmental engine work with fluorine, and General Electric has done considerable work on starting cryogenic engines at altitude, stopping them, and then restarting them.

Thiokol, principally known for its work in the solid propellant field, nevertheless has considerable experience with liquid rockets—as does AirResearch of Garrett.

• **Availability may be key**—One consideration that might have bearing on who gets the contract is the availability of liquid hydrogen. The proposed engine will be tested at the facility developed by the eventual contractor, and large quantities of liquid hydrogen will be needed.

Air Product's plant at West Palm Beach Fla., the only large production facility in operation, services Pratt & Whitney's *Centaur* plant and might be able to supply Pratt & Whitney's added needs if it wins the 200-K contract. Linde is building a major West Coast facility, due to be completed in April at Torrance, Calif., capable of producing six tons a day. This could service prospective nearby facilities of any winning contractor, and especially the present California facilities of Rocketdyne, Aerojet-General, and AiResearch.

Zeus Dealt Another Budget Blow

—Nike-Zeus Funding—

(Millions of dollars)

	Appropriated	Direct Obligations	Expenditures
Fiscal Year 1958 and prior:			
Procurement of Equipment and Missiles (PEMA)	$ 34.1	$ 34.1	$ 10.6
Research, Development, Test and Evaluation (RDT&E)	32.0	32.0	21.1
Military Construction (MCA)	1.1	1.1	.2
Total	67.2	67.2	31.9
Fiscal Year 1959:			
PEMA	172.3 (1)	163.6	67.6
RDT&E	39.5 (2)	35.0	21.6
MCA	30.9	12.0	3.2
Total	242.7	210.6	92.4
Fiscal Year 1960:			
PEMA	137.0	0	86.0
RDT&E	239.0	237.8	204.0
MCA	61.0	60.0	21.1
Total	437.0	297.8	311.1
Fiscal Year 1961:			
PEMA	0	0	24.0
RDT&E	287.0	287.0	253.0
MCA	15.0	15.0	47.2
Total	$ 302.0	$ 302.0	$ 324.2
GRAND TOTAL	$1048.9	$ 877.6	$ 759.6

(1) Includes $42,000,000 transferred from ARPA.
(2) Includes $15,500,000 transferred from ARPA.

The Army's *Nike-Zeus* anti-missile missile program has received another blow—a temporary freeze on its spending program in FY 1961.

The freeze follows the administration's refusal to permit the Army to begin a multi-billion dollar production program for the Western Electric AICBM in the new fiscal year or to release $137 million voted by Congress last year for pre-production operations.

The Administration refusal has set the *Zeus* schedule back from one to two years. The original target date for producing an operational *Zeus* battery was 1963.

The new freeze on *Zeus* limits R&D spending in FY 1961 to $200 million—$87 million less than the budget includes for the program in new money. The Army also is being permitted to go ahead with using the $15 million more included in the budget for construction of *Zeus* testing facilities at Kwajalein and Johnson Islands in the Pacific.

Army Secretary Wilber M. Brucker told the House Military Appropriations Subcommittee that the freeze is causing "a great deal of dismay" because the amounts available will not be enough to go forward with the R&D program at full speed, as promised by the Administration.

He said angrily that he has carried the matter to the Secretary of Defense in order to "bring this to a head."

Informed sources said the freeze is only temporary while the Administration re-examines the *Zeus* R&D program again to determine how much will be needed—particularly in regard to missile drones that will be used in the Pacific tests. Some experts have estimated that the drones—modified Chrysler *Jupiters*—will not cost as much as the Army has thought they would.

The sources contend that there has been no change in the *Zeus* R&D schedule. However, wary Army officials add to this two words—"so far."

Brucker, in testimony before the House subcommittee, disclosed that the Army originally sought $1.537 billion in new money for FY 1961—$1.235 billion more than the Administration agreed to put in the budget.

The original request included $805 million for production and $389 million for construction of bases. The Army also originally sought $328 million for R&D—$41 million more than was granted.

Navy Preparing to Ask For 6 More FBM Subs

The Navy has told the Administration that if it gets a go-ahead now it can begin launching a *Polaris* submarine a month by 1962.

Average cost for each including all support equipment: About $150 million.

The Navy disclosed it already is preparing to ask the Administration to approve adding six more *Polaris* submarines to the FY 1961 budget, bringing the total in the budget to nine. That would bring the total in the 1961 budget to nine and the total number authorized to 18.

Total cost for the extra six including tenders and other support equipment: $975 million.

Adm. Arleigh Burke, Chief of Naval Operations, told the combined House Space and Preparedness Committees that he was hopeful that the Administration would agree.

"We have passed all the big milestones that we have set for ourselves," Burke said. "The last few tests of *Polaris* have been so successful that we believe it will soon be completely operational."

However, as the week ended, Gen. Nathan Twining, Chairman of the Joint Chiefs of Staff, made clear that he opposed increasing the *Polaris* sub construction program at this time.

Lanphier Hits Ike's Missile Policies During Plant Tour

SAN DIEGO—Maj. Gen. O. J. Ritland, commander of the Air Force's Ballistic Missile Division, confirmed that Convair's *Atlas* missile can carry a payload meeting military requirements to a range equal to or better than the 7600 miles demonstrated by the Russian firing into the Pacific.

Gen. Ritland said there is not a single area of the *Atlas* program in which the requirements have not been exceeded. His remarks were made as the *Atlas* production line was opened to the press for the first time.

Convair Vice President Thomas G. Lanphier, Jr. told newsmen who toured the production line that the *Atlas* "can fly as far, hit as accurately and carry as much weight as the *Titan*."

• Ike strongly attacked—Lanphier made a blunt attack on the Administration for missile policies which he said leave this country far behind the Soviet Union in offensive missile capabilities.

"The President of the U.S. is taking dangerous, very dangerous chances on our survival in the next few years," he said. "I don't think he has that right."

Lanphier said there is little that can be done now in narrowing the gap except to keep Strategic Air Command bombers on airborne alert over the next 24 months.

Lanphier explained that he was speaking as an individual, not as a Convair vice president. The bluntness of the remarks by the outspoken Convair vice president shocked some Eastern newsmen.

In the final assembly area and on trailers outside the plant, newsmen saw some 25 *Atlas* missiles. They were asked by the Air Force not to reveal the exact number of final assembly racks, which number about 15.

• Plea for more space work—Lanphier said the *Atlas* production line is operating at only 50% capacity. He said that with the addition of only a few more employees, Convair could double *Atlas* production almost immediately. But he pointed out that for military purposes, it was not just a question of turning out missiles but also of establishing bases and training crews, which required a lead time of not less than two years.

Convair executives urged, however, that greater use be made of the *Atlas* in space programs. "Only a handful of *Atlases* are being produced for space," Lanphier said. "The only person who can change that decision is the President."

Sam Hoffman, manager of North American Aviation's Rocketdyne Division, said thrust of the *Atlas* engines has been upped to 380,000 pounds from about 360,000.

He said NAA also is proposing newer engines for the *Atlas* which will be simpler, have increased thrust and employ more advanced propellants.

Discoverer IX Misses In Polar Orbit Attempt

United States hopes to recover a 300 lb. capsule from outer space were dashed last week when the Air Force *Discoverer IX* failed to go into orbit.

Although the giant *Thor-Agena* vehicle made an apparently faultless takeoff, radar reports four hours later disclosed that it had failed to achieve orbital velocity and had disintegrated in the atmosphere.

The Air Force is yet unable to determine whether the 19.2-ft. second stage ever separated from the booster rocket. The entire Lockheed-built *Agena* was to go into a polar orbit and release the re-entry capsule on its 17th pass over the earth.

At the same time, a trail of aluminum chaff was to be released to provide a radar target. Waiting aircraft were equipped with a trapeze apparatus to "grab" the capsule's parachute and recover the package in the air somewhere off the coast of Hawaii. A satellite recovery ship also stood by in case the air recovery failed.

The booster rocket with a Rocketdyne engine was fueled with a liquid propellant known as "RJ-1," slightly denser than the standard kerosene-base rocket propellant.

The next attempt in the *Discoverer* program is expected in about a month.

Military Space Role Sparks Congress Debate

The role of the Armed Services in space loomed again last week as a bitter issue in Congress. The House approved 92-2 a joint resolution concurring with the Administration plan to transfer most of the Army Ballistic Missile Agency and the *Saturn* program to NASA. The resolution was sent to the Senate. Rep. Samuel S. Stratton (D-N.Y.) warned before the vote that the transfer would have "a disastrous affect" on the nation's security during the late 1960's and early 1970's.

House Democratic Leader John McCormack (D-Mass.) went along with the resolution but said the House Space Committee is planning to "look very carefully" into the Administration's division of space between civilian and military agencies. He said the Administration is not carrying out the true "intent" of the National Space Act in this area.

Stratton hit directly at President Eisenhower's contention that the Armed Forces have no business in space beyond a few thousand miles "Does anyone in this chamber really believe that the exploration and conquest of space do not have the most profound military importance?" He asked.

The resolution, in effect, would waive the 60-day waiting period required by law before the transfer could take place. The actual transfer of ABMA personnel and the some $100 million of ABMA facilities is not scheduled to take place until July 1.

news briefs . . .

• Cape Canaveral—President Eisenhower made his first inspection of this R&D facility Feb. 10 a few hours after missilemen successfully fired a streamlined "hot rod" *Thor*, but failed to get off a routine *Atlas* shot. The engines of the *Atlas* shut off automatically a few seconds after ignition and the bird escaped damage. The *Thor* had a cone-shaped aluminum fairing and a souped-up Rocketdyne fibreglass-wrapped engine. It was redesigned specially for space shots.

• Washington—Influential House Democrats launched a drive for greater defense spending. Chairman Carl Vinson of the Armed Services Committee called for "drastic sacrifices now" to catch up with Russia in missiles. Chairman Clarence Cannon of the Appropriations Committee urged Congress to disregard "specious" Eisenhower Administration claims that the U.S. is "still the most powerful nation on earth" and vote more defense funds. He said Russian missiles "unquestionably" could now wipe out every American city and SAC base within 30 minutes.

• Washington—Republicans charged that Democratic downgrading of U.S. retaliatory power was serving the Russian cause and might invite a Soviet miscalculation which could lead to war. One GOP Congressman declared that if the critical barrage continues there is a danger Americans some day might say "I'd rather be Red than dead."

Bossart Wins M/R Goddard Trophy

'Father of Atlas' picked by M/R editors for outstanding contribution to U.S. missilery. Award to be presented at Missile/Space Conference, Feb. 16-17 in Washington

by William J. Coughlin

When a young man in the Belgian Army decided in 1930 that he would prefer life in the United States, this country acquired another immigrant. The Belgian Army's loss was the U.S. Air Force's gain.

The young Belgain soldier was Karel Jan (Charley) Bossart, named this week by the editors of MISSILES AND ROCKETS MAGAZINE to receive the Dr. Robert H. Goddard Memorial Trophy for his outstanding contribution to the development of the Convair *Atlas* intercontinental ballistic missile.

The trophy is awarded annually to an individual, group or firm which in the opinion of the editors of MISSILES AND ROCKETS MAGAZINE made the greatest achievement in advancing the missile, rocket and space flight programs of the United States.

This is not the first award Bossart has received for his work on the *Atlas* program. In 1958, he was given the Air Force Exceptional Civilian Service Award. He also recently received the Institute of Aeronautical Sciences' Sylvanus Albert Reed Award for his contribution to the *Atlas* program. If this continues, he will have to add a wing to his San Diego home for the trophies.

Recently, Charley Bossart relaxed in San Diego in an armchair interview with MISSILES AND ROCKETS and said just exactly what you would expect him to say about his accomplishments:

"A lot of other people at Convair should get part of the recognition I'm getting." Then he grinned and added:

"My wife says my head is getting too big."

Looking back over the history of the program in a relaxed mood, the "Father of the *Atlas*," shook his head over the dark days which the project frequently encountered but when asked if he would willingly go through it again, responded: "Oh, sure."

"CHARLEY" BOSSART at *Atlas* production line in Convair's San Diego plant. Numbers on the big missiles have been masked for security reasons.

Then he thought a moment and added a phrase which, while not new to philosophers, still rings true: "Accomplishment is your best reward."

The project that was to become the free world's first intercontinental ballistic missile originated in 1945, just after World War II, when the Air Force called for study programs on ground-to-ground missiles. The German *V-2s* had made their impression. The Air Force wanted studies made of short, medium and long-range missiles. There were two long-range study programs. One later became the air-breathing Northrop *Snark*.

Convair—or to be exact, what was then the company's former Vultee Field Division—proposed a 5000 mile ballistic missile.

• **Invulnerability**—Primary reason for the belief in the ballistic missile was its relative invulnerability to defense.

"We thought the reason for going to a long-range missile like that, instead of a bomber, was that a bomber couldn't get through," Bossart remembers. "We didn't think an air-breathing job would get through any better than a bomber."

The company got an Air Force contract for study and development of the missile. There was no requirement for hardware. The chief structural engineer at the division was assigned to the program as project engineer. His name was K. J. Bossart.

It was touch and go for a while. One day Bossart was informed he would be project engineer; the next day, he was told it had been assigned to someone else.

"That made me extremely unhappy," Bossart recalls, "but there was another switch and I got it."

Why did he want it so badly?

"I was intrigued by the possibilities," he says. "It was a challenge."

His appetite for missiles already had been whetted. As chief of structures, he had been involved in two surface-to-air missile programs, the *Lark* and Project *Bumblebee,* which later was to become the Navy *Terrier.*

It became immediately apparent to Bossart and the team he gathered around him that in probing so far into the unknown, some research hardware was necessary. One month after the contract for a pre-design study on a long-range missile was received from the Air Force, agreement was reached that Convair could build 10 MX-774 test vehicles.

• **Economy wave**—Then, in mid-1947, the military economy wave swept Washington. The Air Force had to decide which of its two long-range missile contracts to continue. The vote went to the *Snark.* The reason: the ballistic missile was too great a step in the state of the art.

With the funds remaining in the program, Convair would be allowed to build and fly three MX-774 test vehicles and then the program would end.

Altogether, the entire study project, including the three test vehicles, was accomplished at a cost to the government of only $2¼ million.

The three MX-774s were flown from White Sands, the first in July, 1948, and the last in December of that year. They were, indeed, advances on the state of the art.

The frame was an aluminum pressurized structure without stringers or ribs. Control was achieved by swiveling of the engines. Provision was made for separation and re-entry of the nose cone only.

"We had to jump from 200 miles to 5000 miles," Bossart says, "and it took a lot of imagination and new approaches."

Telemetering was a new art then and so was the principle of radio-inertial guidance. Everywhere along the line, Bossart and his team were pushing to and beyond the state of the art.

The first missile, Bossart remembers ruefully, was "nearly a flop." It went to 6000 ft. and then fell back. The second and third achieved beautiful launches but flamed out prematurely at 50 seconds, instead of the scheduled 75 seconds.

But the unconventional vehicles had pushed through all the critical regions where strength, rigidity and controllability might have presented problems.

• **Winner apparent**—Bossart and his crew were convinced they had a winner. But in December, 1948, they were out of business as far as the Air Force was concerned.

Fervent arguments convinced Convair management the program was worthwhile. The company put some of its own money into the project. Bossart and his associates pounded the corridors of the Pentagon trying to convince the Air Force of the worth of their weapon.

Somehow, Bossart's enthusiasm kept the 70 or so people on the team together during these lean days, even when many of them were offered better jobs elsewhere.

"They would come to see me," he recalls, "and say they had had a good offer from North American or Lockheed. I'd tell them I hoped we would be back in the missile business soon." Almost none left.

In 1950, the outbreak of the Korean war loosened the pursestrings in Washington and by 1951, the *Atlas* team was back in business. Breakthroughs on the nuclear warheads made it possible to scale the missile down until it was less than half of its original, unwieldy size.

In the summer of 1953, Trevor Gardner, then assistant secretary of the Air Force for research and development, called in Bossart and his team. If the *Atlas* were placed on a crash program, when could they come up with a missile?

Some compromises were made with the early specifications, particularly in regard to re-entry requirements. Against considerable opposition in the Department of Defense, Gardner pushed the crash program for the *Atlas.*

Western Development District, later to become the Ballistic Missiles Division, was set up to supervise the program. Bossart won't say so but this in itself was a considerable blow to the pride of the men who had fought so hard for the project in its lean days. Nevertheless, they pushed on and by December, 1954, design of the *Atlas* had been frozen.

"From then on, we went full speed ahead," Bossart says.

First hot test of the complete propulsion system was in mid-1956 at Edwards Air Force Base. First hot test of the full missile followed at Sycamore Canyon near San Diego and then came the first flight in June, 1957. First three-engined flight was accomplished in July, 1958.

There were further dark days when five successive *Atlases* failed. But there now have been 18 consecutive flights and it looks like the *Atlas* is on its way.

There are proposals for bigger and better *Atlas* weapons and bigger *Atlas* boosters for the space program.

And Charley Bossart? He is already looking ahead to deep space programs.

"The unknowns are even greater there," he says. To him, it's still the challenge that counts.

'Why' of Goddard Trophy

DR. WERNHER VON BRAUN, first winner of MISSILES AND ROCKETS magazine Goddard Trophy, in 1958 received the award from Wayne W. Parrish, President of American Aviation Publications.

The Dr. Robert H. Goddard Memorial Trophy is presented annually by MISSILES AND ROCKETS *Magazine in recognition of significant achievement in advancing the United States' rocket and space program. It is awarded to the individual, or group, selected by the editors of M/R on the basis of outstanding contributions, devotion, and leadership in the missile/space effort. Leaders in all areas of this effort—military, industrial, political—are considered in making the award.*

Selection for the Trophy is, we feel, a signal honor in a new science where failures make headlines and those who contribute to the successes often go unnoticed. It is fitting that it be named in honor of Dr. Goddard—the real pioneer in rocketry.

This is the third year the Trophy has been presented. The first recipient, in 1958, was Dr. Wernher von Braun, of ABMA. Last year's winner was Mr. S. K. Hoffman of Rocketdyne.

Army Facility Will Fight Interference

Five years and $40 million will be needed for environmental study by Army in southern Arizona; contract award is expected in near future

by **Charles D. LaFond**

FORT HUACHUCA, ARIZ.—Historically long overdue and, more recently, long delayed is the U.S. Army Signal Corps contract for an electronic environmental test facility (EETF) to be established here. Four teams remain in the running, headed by Vitro Corp., Pan American World Airways, Cook Electric and Sylvania. The contract award is imminent.

Since the Signal Corps specification for the program was specific in its requirements, approaches offered by the four teams are similar and proposed costs for the two-year, Phase-I task are roughly the same—nearly $25 million. (This amount has been funded since FY 1959.)

Essentially, the program at the EETF is divided into two parts: Phase I is to be approximately a two-year study of the effects and compatibility of electronic equipments in field use from squad level to division level within a corps. Phase II will be roughly a three-year extension of the program to study equipment operation in a whole corps within an army.

Results of Phase I testing will be thoroughly evaluated before starting the second phase.

• **Purpose**—Basic mission of the entire test program is to secure enough know-how concerning the use and interference problems of dense electronic-equipment populations to assure command control at all times. This is no small task, but the benefits of such a program will be far reaching.

The problem was first recognized—with fatal consequences by some—during World War II. A problem then, it is a nightmare now. We have simply run out of radio spectrum availability. Now we must learn to use more effectively the present allocations.

Fort Huachuca will be the brain center of EETF since it has been the electronic equipment proving ground for the Signal Corps since its reactivation in 1954.

In an isolated desert area against the foothills of a low mountain rim, it is located near the southeastern corner of Arizona, just a few miles from the Mexican border. The reservation itself covers 74,000 acres and has the use of an additional 35,000 acres of adjacent government owned land.

The entire test range will extend across southern Arizona from the Fort westward to Yuma Test Station (see map).

The area was chosen because its very isolation will permit establishing a controlled electronic environment and permit pinpointing any radio interfer-

MAP OF the electronics environmental test facility and drone ranges in southern Arizona.

ence from inside or outside sources. Terrain, local weather, and the existing limited interference from civilian radio and television stations were all considered.

Of primary concern will be the maintenance of a low-level of interference from these civil broadcast stations. To do this, there will be periodic cessation of operation at these stations. Cooperation with local and state authorities was sought and has been achieved. Immediate remedial action therefore can be taken to alleviate interference to or from these stations, depending on the situation.

Test frequencies used by the facility will be carefully monitored at all times.

• **Facilities**—The $25-million cost of Phase I does not include the range facilities and government furnished equipment.

A $12-million Drone Test Range will be turned over to the EETF prime contractor. Contracts already have been awarded for site preparation, building construction and equipment procurement. The various equipments needed will include photo, optical, microwave, telemetry, control facilities, etc. Many and different radar stations are being installed, plus a maze of landline communications to connect operational sites.

When completed, the EETF will have:

• A fully instrumented test range at Fort Huachuca and in a corridor between the Fort and Colfred Airfield (near Yuma).

• An electromagnetic environmental test area comparable to that found in a tactical situation.

Surveillance, drone and missile guidance, communications, and countermeasures problems can be thoroughly investigated as a result of this effort. (The new Republic SD-4 and Fairchild SD-5 high performance jet drones and their various sensory devices will be among the first test items.)

• **Future benefits**—The benefits from the successful completion of this program will be tremendous, not only militarily but for the entire country.

To better explain the problem, remember that in a modern division some 20,000 radio-frequency emitters will exist in a 60 square mile area.

Interference then is a problem. To further define it, the Army considers any interference of more than two seconds in length occurring more than once a minute as being significant.

Data obtained in the controlled environment of the test facility will be useful for reducing existing and predicting future interference, establishing equipment design criteria, providing operational concepts, and for frequency coordination and allocation.

Communications Satellite May Be in Orbit by End of 1960

Delayed repeater system will store messages on five special CEC recorders; other highlights of IRE Military Electronics Convention

Project *Courier*, a 500-lb. communications satellite with message capabilities comparable to a 500-page book, will probably be in an orbiting path between 600 and 700 mi. above the earth's surface by the year's end.

This was the opinion expressed by a high-powered panel of experts opening the 1960 Winter Convention on Military Electronics under sponsorship of the Professional Group on Military Electronics, Institute of Radio Engineers, in Los Angeles.

The delayed-repeater type satellite communication system will store messages on five special Consolidated Electrodynamics Corp. tape recorders for release upon command from ground stations.

The panel, consisting of James M. Bridges, director-Office of Electronics, Defense Research and Engineering, DOD; Paul Price, chief-Communications and Tracking Branch, Advanced Research Projects Agency; Dr. John R. Pierce, director-Research Electronical Communications Principles, Bell Telephone Labs; Dr. Hans K. Ziegler, chief scientist, Army Signal Research and Development Labs.; and Brig. Gen. John B. Bestic, USAF, Deputy Director, Communications-Electronics, Dept. of the Air Force, also indicated that Project *Echo*'s 100-ft. diameter balloon launches will soon be underway in line with the forthcoming *Courier* operations.

"Illumination" of *Echo* balloons will be accomplished by MIT's Lincoln Labs, plus facilities of GE, Bell and Cal Tech's Goldstone Lake facility in California's desert. Transmission of telephone messages between these sites will probably develop valuable experience for *Courier*.

Useful orbit for relatively simple communications satellites would be about 1000 mi. out from the earth, Dr. Pierce said, adding that it would require 20 or more satellites to establish a world-wide telephone system. The large number of relay vehicles would enable at least one to be available to all ground stations at all times.

The much-discussed "stationary" or "24-hour" satellite that would remain in essentially one spot over the earth's surface, would appear to be some time away, according to Dr. Pierce's remarks.

The concept is certainly feasible, he pointed out. But he paid present microwave equipment life is not yet satisfactory for "permanent" satellites; the all-important accuracy of positioning such a satellite has not been demonstrated; and there are still serious problems with directional antennas needed for radio transmissions from space vehicles.

The present major effort in Bell's Research Labs is development of a communications satellite, Dr. Pierce said, but more experience is needed with low-lying satellites before any high altitude projects are attempted. In this context, *Courier* would be considered a "low" communications satellite.

Bell Telephone's work in this area is paid for by an "adequately funded in-house program," he declared. If the concept works out as expected, there would be no reason for not having a privately financed communications satellite program. Such a system might be operated on the same general idea as leased telephone or telegraph lines.

The *Echo* balloons and accompanying test program are available to all who wish to participate, Dr. Ziegler noted. There will be many communications stations participating in the forthcoming tests, he added, and no limits of participants has been set.

Communications satellites should be used only for such purposes, Bridges commented, pointing out that "otherwise they are difficult to achieve." He noted further that the reliability of systems in the satellite have a direct bearing on the economy. If they are reliable, but only for a short time, it is difficult to find economic justification.

Picking up this line of thought, Dr. Pierce said that any communication satellite must have a reliability comparable to land lines, otherwise it cannot compete as an advanced or alternate system. Most probable and initial commercial use would be overwater message transmission where satellite advantages might outweigh often-troublesome transoceanic cables.

Carrying the reliability problem a little further, Dr. Ziegler singled out the example of *Vanguard*'s two-year operation from solar cells and suggested a similar approach might be "scaled-up" for future operations with the result "close to an economic solution."

Gen. Bestic declined to comment on the status of military communications satellites other than the military "is never satisfied if it is doing its job."

The USAF officer said he "was speaking for the Navy, too" when expressing extreme interest in all aspects of communications satellite operations because of the services' "common need" and concern over "whatever man puts up, man can shoot down."

Developments with possible application to CW doppler techniques in precision guidance, navigation techniques and high-precision ranging were outlined in a paper by Dr. M. L. Stitch and Dr. H. Lyons of Hughes Aircraft Research Laboratories.

Work is not complete, it was pointed out, but the presentation considered possible use of an ammonia type maser as a portable frequency standard. Present quartz-type crystal frequency standards in best form have a drift error of about 3600 ft. per hour of running if installed in a deep space vehicle. The Hughes approach, if successful, will have an error of about 108 ft. per hour—a 30X reduction.

In comparison to piezoelectric materials, cesium beam or gas cell, the maser approach offers short term stability on the order of 10-12 as compared to an average for the others of 10-9 and requires simpler electronics than the C_s beam or gas cell. Its disadvantages are in long-term stability, machining, and the requirement for $N^{15}H_3$ ammonia at $400 per gram—although a gram lasts about 500 hours.

Results obtained from *Explorer VI*'s telemetry system, "Telebit," and a system description, were given by R. E. Gottfried, Space Technology Laboratories. Far from optimum, the system has performed well, he said. Pretransmission data processing would be a major improvement in future systems to limit data to only that significant to the user. This would eliminate redundancy and costs. Increases in space experiments and knowledge will produce space profiles in which certain information is more important at a given time than other data. Capability to measure quantities or conditions that do not exist can be eliminated. Telemetry systems should be designed for easy function shift by either earth command or a stored program.

Principles of PERCOS, a performance coding system, were enumerated by Dr. Ernest A. Keller, Chicago Military Electronics Center, and conference members were told an inter-industry organization has been proposed as a data collection center to aid users in the evaluation system for components, modules, instruments or methods.

CEC's tape recorder for Project *Mercury*'s capsule can record about one million cycles per lb. of weight and an equal amount per watt hr. Problems of determining materials compatible to oxygen environment of the capsule were outlined by CEC's G. W. Boyer. Ozone-creating motors had to be encapsulated, and other ozone-sensitive materials eliminated by test. Dacron and neoprene proved satisfactory in some applications, but thermoset plastics did not.

Photoscan Is Ideal for Surveillance

Answers problem of information retrieval from military drones; high resolution image can be transmitted long distances to provide film record almost instantly

A new electronic image-transmission system recently demonstrated should provide the answers to surveillance-drone data-acquisition problems. Many unique features and unusual operational characteristics of the system, called Photoscan, assure its use in future airborne military operations.

High vertical and horizontal resolution, almost instantaneous long-distance transmission, and a photographic-film ground record having extremely high quality overcome the major disadvantages of more conventional surveillance.

Developed by CBS Laboratories for combat surveillance, the transmitter portion employs an unusual scanner called a Line Scan Tube. T-shaped, the tube generates a brightness at least 30 times greater than possible with any conventional cathode ray flying-spot tube.

Even under such intense bombard-

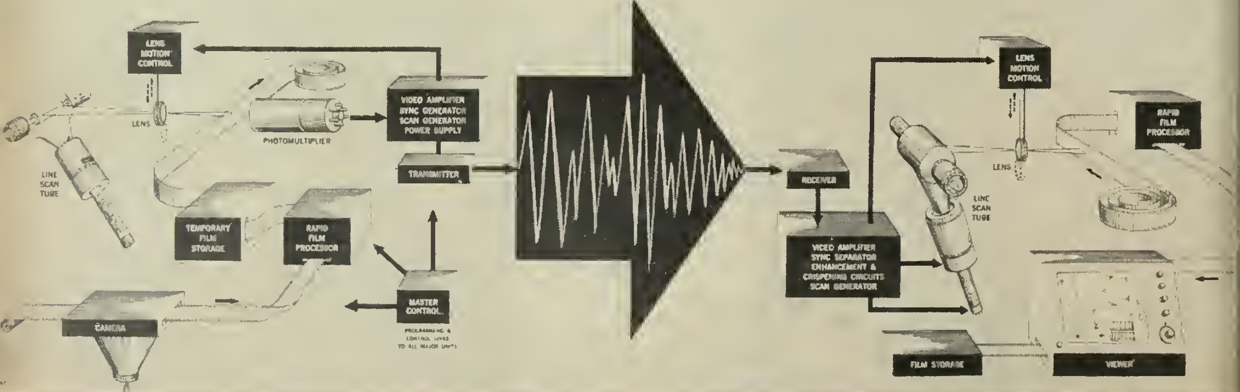


DIAGRAM shows the airborne scanner (left) and ground receiving equipment (right) which constitute Photoscan system.

ment, the new tube reportedly has an operational life of more than 1500 hrs. (A conventional tube operating under the same condition would die within minutes.)

All three services are interested in the system and at least one classified contract has been awarded for its further development and production.

A company spokesman also indicated the system probably would be tested shortly on the Fort Huachuca, Arizona, drone test range. The airborne equipment will be particularly applicable for use in the new SD-4 and SD-5 high performance jet surveillance drones.

Photoscan provides far higher definition than conventional television techniques. The latter has approximately 500 lines of resolution whereas the Photoscan picture has in excess of 10,000 lines, said CBS.

The sharpest television pictures today consist of 250,000 picture elements, whereas to meet the requirements of modern aerial reconnaissance, each Photoscan picture contains approximately 120 million picture elements, said Dr. P. C. Goldmark, CBS Lab president and director of research.

The new scanner processes the visual image obtained from an aerial camera or other sensing device and converts that image to an electronic signal which is then transmitted to another airborne relay station or directly to the specially designed receiving equipment on the ground. New electronic image-enhancement techniques are applied to the signal before reconstituting the original image for nearly instantaneous viewing and storage on film.

A key component of the system is the cathode ray tube developed by CBS. This tube contains a special phosphor-coated anode which spins at 1600 rpm within the high vacuum of the tube envelope. A fine electron beam from the tube continuously scans the rotating phosphor at a rate in excess of 10,000 times/sec.

The resultant luminous line is focused on film by a moving lens from which the light is transferred through a new type of optical system into a special photo-multiplier tube. The amplified video signal is then transmitted to distant receiving equipment where the image is reconstituted.

The anode drum rotates by means of an armature sealed inside the tube envelope, while the stator is mounted externally. The special bearings on which the armature spins, operate in the high vacuum within the tube. The bearings also employ a new technique in lubrication by solids, said the company.

The metal anode drum is surfaced with an extremely fast-decaying phosphor, applied by means of a process which minimizes phosphor grain size and provides high surface uniformity. The rotation of the phosphor-coated drum makes possible the rapid distribution and dissipation of heat created by the intense electron beam which, in a conventional tube, would lead to rapid deterioration of the phosphor.

Due to the rotation of the phosphor target, uniform grain distribution occurs in the transmitted picture.

Tiny Radiation Detector Called 1000 Times Faster

The unprobed secrets of nuclear forces are now being uncovered by means of a "solid-state ionization chamber" smaller than the head of a pin, a scientist at Hughes Aircraft Company has revealed.

The new device—an innovational radiation detector—has important applications in space exploration, military uses, nuclear power control, cancer treatment, industrial processes, basic nuclear research and other fields, according to the company.

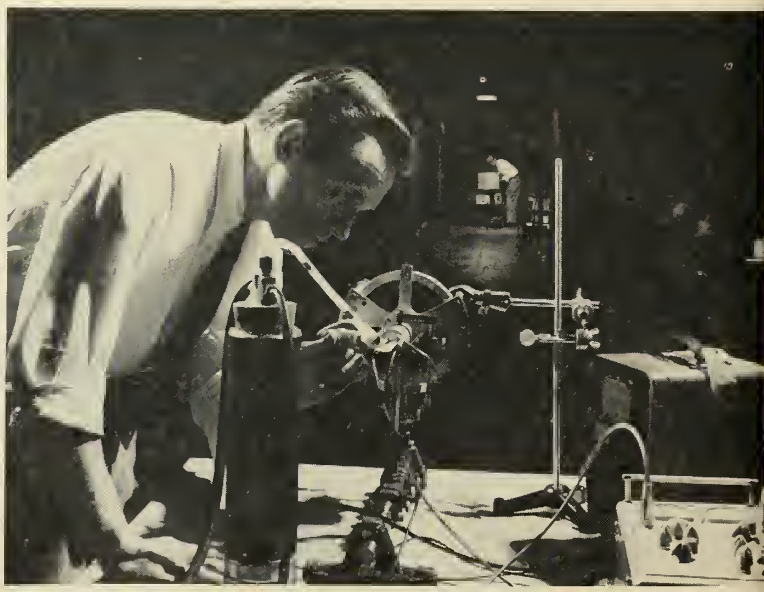
Dr. S. S. Friedland, a Hughes scientist, said that the detector measures the number and energy of atomic particles with far greater effectiveness than earlier detectors, is far less cumbersome, and costs less. It is essentially a tiny slice of doped silicon which when struck by a charged nuclear particle, emits a pulse which can be measured and analyzed.

One of the more important applications of the detector proposed by Friedland is in space exploration. A three-dimensional package containing hundreds or thousands of detectors, propelled hundreds of miles into space could transmit back to earth precise measurements of cosmic rays and the limits and nature of the Van Allen radiation belt.

Present methods use photographic plates inserted in the nose cone of a missile. Rays and particles penetrate the film and define their courses through the layers. After recovery of the nose cone containing the film, weeks and sometimes months must be spent in extracting the data from the plates. The proposed use of the Hughes detector coupled with an amplifier and telemetering devices would enable scientists on earth to immediately determine radiation measurements.

Hughes claims the detector can pick up particles 1000 times faster than previous models, and is so accurate it can analyze the energy of particles to less than 0.5% error, matching the performance of complicated equipment costing many thousands of dollars.

Tunnel for IR Radiation



BEHAVIOR OF infrared radiation in atmospheres vastly different from that of earth are studied in this Sperry Gyroscope Co. tunnel. Engineer in foreground measures efficiency of infrared detection device, his colleague adjusts device which emits controlled amounts of infrared light.

NBS Explores Structural Adhesives

Tensile tests conducted at temperatures down to —424°F on four types. Adhesives will have wide space vehicle application

An investigation into the low-temperature characteristics of four types of structural adhesives has been completed by the National Bureau of Standards for the Wright Air Development Center.

First developed about 15 years ago, these metal adhesives probably will be widely used in construction of future space vehicles.

Tensile tests were conducted at temperatures down to –424°F with filled epoxide, 3 rubber-phenolic, 4 vinyl-phenolic and 2 epoxy-phenolic compounds. The epoxy phenolics, both having a fiber glass supporting film, gave the best performance. The epoxide exhibited slightly less low-temperature strength, but faulty bonding apparently contributed to this.

Standard metal specimens were of 301 stainless steel and 2024T-clad aluminum alloy. Ten lap-joint panels (0.5 in. overlap length) were made by applying the epoxy-phenolic resin to the steel and the other adhesives to the aluminum sheets. Six samples from each panel were tested.

Each specimen was gripped 2 inches from the edges and stressed at a rate of 1300 psi until failure. The specimens were held at the test temperature for ten minutes before the load was applied.

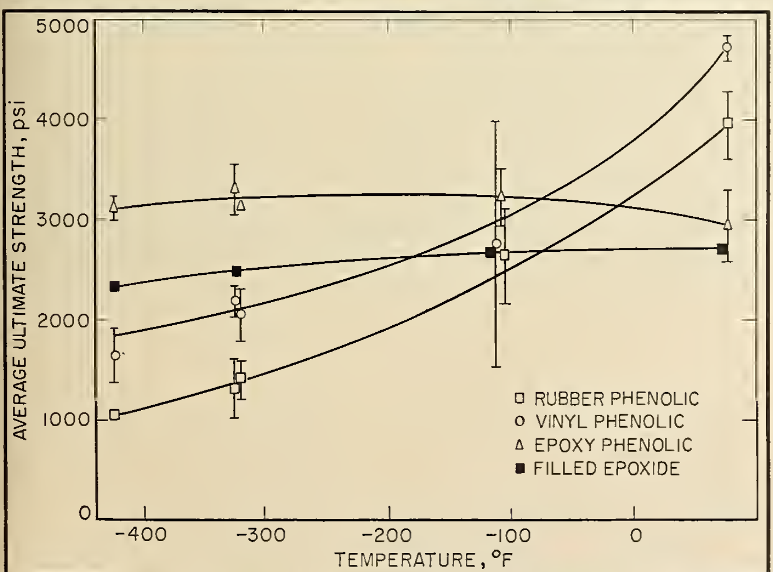
The average ultimate strengths of the four types at –424°F were rubber phenolic, 1065 psi; vinyl-phenolic, 1650 psi; filled epoxide, 2345 psi; epoxy-phenolic, 3120 psi.

Failures were classified either as adhesive or cohesive according to whether they occurred at the interface between the adhesive and adherend or within the adhesive and supporting film.

The rubber-phenolics and the vinyl-phenolics were predominantly adhesive failures while the epoxy-phenolics failed cohesively with about 30% occurring within the thickness of the glass fiber cloth.

The cohesive failure in the filled epoxy specimens appeared to happen only in the areas of effective bonding —which in some cases was as little as 70% of the lapped area. This could not be determined accurately because of the discontinuous nature of the bond.

None of the materials tested were specially formulated to withstand the test conditions involved.



ADHESIVE METAL bonds have a tendency to decrease in strength as temperature is lowered. Only epoxy-phenolics show slight increase.

Mellon Develops High-Strength Case Steel

by Frank G. McGuire

San Francisco—A high-strength missile steel, developed specifically for use in rocket motor cases, has been unveiled by the Mellon Institute for Industrial Research. Perfected after only a 2½-month program, the steel—designated 4137 cobalt-modified—provides ultra-high-strength, good ductility, low notch-sensitivity, good welding characteristics, and easy formability.

The 4137 Co modified formula is based on AISI 4100 composition, modified by the addition of 1% each of cobalt and silicon. The objective was to attain a steel heat treatable to a uniaxial 0.2% offset yield strength level of 223.0 ksi.

Two principles of research were followed during Mellon's development program: experiments had shown that the chances of obtaining very high bi-axial strength are greater in a low-alloy steel than in an over-alloyed steel; and the composition should be so balanced that a steel matrix heat treated to levels over 220 ksi and stressed, should distribute stresses evenly and yield homogeneously.

Nominal composition of 4137 is as follows:

Carbon	0.39%
Manganese	0.70%
Silicon	1.00%
Phosphorous	0.010%
Sulfur	0.010%
Chromium	1.10%
Molybdenum	0.25%
Vanadium	0.15%
Cobalt	1.00%

Describing results of tests on the steel, G. K. Bhat, of the Mellon Institute, cited a pressure vessel fabricated by the roll and weld method by Excelco Development Corp., Silver Creek, N. Y. This vessel, about 5′

long and 4½' diameter, had a longitudinal seam and featured considerable notch characteristics. Despite the seam and notches, burst pressure was 1000 psig, and burst occurred in the parent metal at the aft closure. Fracture was not at a weld or notch location.

Notch sensitivity of 4137 was studied by comparison of tension tests on edge-notched and straight tensile specimens heat treated to several strength levels. Stress concentration ratio in notched specimens is K=5. The steel is not notch sensitive up to tempering temperature of 700°F. Between 700°F and 800°F, a slight tendency is noticeable, but not severe.

Work is continuing at Mellon, where cases measuring 5.7" D, 27" long, deep-drawn, with wall thickness of 0.035" are being tested. It is believed that these will replace cases with 0.050" wall thickness, resulting in a 20% weight saving.

The 4137 Co modified steel is now being commercially marketed by Universal Cyclops Steel Corp. (under the designation Unimach UCX2), and several other companies.

• **Technical papers**—Other papers presented at the Golden Gate Metals Conference included:

Materials and Fabrication Problems Associated with High-Strength, Light Weight, Homogeneous Pressure Vessels, L. L. Gilbert and J. A. Brown, Aerojet General.

Stress Corrosion of Steels for Aircraft and Missiles, E. H. Phelps and A. W. Loginow, United States Steel.

Fracture Toughness of High Strength Steel Pressure Vessels, G. R. Irwin and J. A. Kies, Naval Research Laboratory.

Metallurgical Tests as a Contribution to Pressure Vessel Reliability, Dean K. Hanink, General Motors Corp.

NASA Program and Findings on the Effect of High Stress Concentrations on High Strength Sheet Alloys, G. Epsey, NASA.

Fabrication Techniques Applicable to Rocket Motors, John H. Peters, United Aircraft Corp.

Important Factors in the Future Applications of High Strength Steels, Eugene P. Klier, National Academy of Sciences.

Current Practices in Ceramic-Metal Joining, Leon Lerman, Sylvania Electric Products, Inc.

Theory and Practice of Glass-Metal Sealing, Joseph A. Pask, University of California.

Ceramic-Metal Joining Problems in the Missile Industry, J. Patrick Sterry, Boeing Airplane Co.

Space Age Brazing, John Long and George Cremer, Solar Aircraft Co.

New Techniques in High-Temperature Brazing, N. Bredze, Armour Research Foundation.

The Hortonclad Process of Vacuum-Pressure Brazing, D. C. Bertossa, Chicago Bridge and Iron Co.

The Application of Electron-Beam Melting to the Processing of Materials, Charles Hunt, Temescal Metallurgical Corp.

The Application of the Plasmatron to the Processing of Materials, Ben Lohrie, Plasmakote Corp.

Growth of Compound Semiconductor Crystals, C. S. Roberts, Fairchild Semiconductor Corp.

Application of Shear Spinning to the Fabrication of Solid Propellant Rocket Cases, L. E. Zwissler, Aerojet-General Corp.

Spark Machining, A New Technique in Fabrication, D. L. Curtis, Japax America Corp.

Solution of Fabrication Problems by Explosive Forming, L. Zernow, Aerojet-General Corp.

In addition to these, numerous other papers were presented in specific fields bordering on metallurgy, such as electronics, chemical and petroleum processing.

Titanium Use in Missiles Rose in '59, Cost Dropped

Titanium products for missiles accounted for about 15% of the metal industry's total 1959 mill product shipment output, according to T. W. Lippert, Marketing Director for Titanium Metals Corp. of America.

In line with the increased usage, cost of titanium mill products was reduced to $7.22 per pound at the end of 1959, compared to a 1958 closing price of $8.66.

Lippert said missile applications of the metal will expand in 1960, but will not account for as much material as manned aircraft because of the relatively limited production runs of missiles.

Atlas, Titan, Sidewinder, Bomarc and space project *Mercury* are some of the programs using titanium products to capitalize on the metal's weight-reducing potential.

Protecting Moly

LONDON—The government's Armament Research and Development Establishment at Fort Halstead has developed an "onion-skin" technique for protecting molybdenum from oxidation. It involves applying multi-layer electrodeposited coatings, alternately of 0.0002in. chromium and 0.0008in. nickel.

Coatings of 10 mil thickness tested at 1100° C. in an atmosphere of convected air are said to have given a life of up to 550 hr. It is believed that diffusion produces a coating similar to the Nimonic alloys.

What in Blazes Is High Temperature?

Fast-growing new field is lacking in logical nomenclature; expert proposes 'calorobics' as well rooted new word to cover the technology

by Harry B. Porter

CHINA LAKE, CALIF.—The advent of modern rocketry has given rise to a new concept of "high temperature." Where, a few years ago, temperatures of the order of 1000°F were considered "high," rocket design engineers are now thinking in terms of 6000° to 8000°F, and there is good reason to suppose that much higher temperatures will be employed in the future. Further progress in reaction propulsion will undoubtedly involve the development of higher-energy, hotter propellants.

Because of the rapid development of rockets and rocket materials, the problem of nomenclature has become increasingly difficult. A symptom of this condition is the recent rash of multiple adjectives and other poly-hyphened monstrosities in the technical literature. This should not be surprising, inasmuch as several different and distinct fields of technology are involved, and there is no common frame of reference for many of the terms used. As an example, the term *high temperature* has different meanings for polymer chemists, metallurgists, ceramicists, and thermodynamicists, because they are accustomed to thinking in terms of different temperature ranges.

In the following paragraphs, a few of the more ambiguous and frequently misunderstood terms are discussed.

High temperature. The term high temperature is inherently vague, inasmuch as it represents a relative value. It is obvious, however, that high temperature no longer means what it once did. Just what *does* it mean? Does a ceramic kiln or the afterburner of a jet airplane—around 2000°F—come under the heading of "high temperature"? How about that generations-old symbol of the ultimate in heat, the blast furnace, whose 3000°F gases could be used to "cool" a modern rocket nozzle?

High-temperature material. The term high-temperature material is as indefinite as high temperature, and has the added disadvantage of being ambiguous. Do we mean a material that is produced at high temperature, a material *at* a high temperature, or a material that does not decompose at high temperature. "High-temperature-resistant material" may be a little more meaningful, but here again we are confronted with an ambiguity, because there is no indication of the manner in which the high temperature is resisted. Does the material merely tolerate heat, in the sense that it retains its own integrity at high temperature without affording protection to the underlying material?

Which brings us to a couple of other terms that have been badly mistreated in the last few years: "heat barrier" and "heat shield."

Originally, heat barrier was used to describe an imaginary barrier raised by aerodynamic heating at supersonic speeds, analogous to the much-publicized "sound barrier" of transonic flight. Perhaps because of the fact that the "sound barrier" turned out to be only a hurdle, a somewhat abortive attempt was made to introduce the term "thermal thicket."

A heat shield was formerly a structure designed to protect a re-entry body from destruction by aerodynamic heating. It may absorb heat for a time by virtue of its heat capacity, or dissipate heat through ablation or by other means.

Through usage, or misusage, heat barrier and heat shield have come to be used synonymously. The terms would suggest structures whose functions would be to prevent the flow of heat—in other words, a thermal insulator. Since no insulator is perfect, a more precise term would be heat retarder.

In the combustion chambers and nozzles of rockets, however, protection must be provided against the total thermal environment, which includes erosive and corrosive conditions. To be effective as a heat barrier, or heat shield, in the rocket context, the protective structure must function as more than just a thermal insulator. It must also act as a physical barrier to the impingement of combustion gases and solid particles upon the protected components, and be sufficiently heat-tolerant to maintain its own structural integrity long enough to provide protection for the required period of time. It is evident that neither heat barrier nor heat shield adequately describes such a structure.

Structures whose function is to get rid of heat through absorption, fusion, vaporization, endothermic decomposition, radiation, etc., would more properly be called heat dissipators than heat barriers or heat shields.

Calorobics—A step in the direction of greater conciseness and clarity of thought would be to provide a frame of reference by adopting a name for the field which comprises: (1) research, development, and application of materials to be utilized in confining heat or in controlling the rate of heat transfer at temperatures comparable to those of the nozzles and combustion chambers of rockets and; (2) the development and application of engineering designs aimed at the optimum utilization of such materials, especially in the rocket environment. The name should be short, meaningful and easy to remember.

"Calorobics" (*Kăl′ ō rōb′ īks,* L. Calor = heat + ob = against, in opposition to) is hereby suggested as a name for the field. The adjective would be calorobic. Thus, a material possessing sufficient resistance to high temperatures and erosive conditions to permit its use in the rocket environment would be simply a calorobic material. To be more specific, one may use such terms as calorobic insulator, calorobic heat dissipator, etc.

In addition to saving wear and tear on the dispositions of technical writers and readers, the adoption of the name *calorobics* would serve to give identity to a new field. Calorobics has developed too far, and has become too important in the total rocket picture to be contained within any one—or all—of its parent technologies.

About the author

Harry B. Porter is the Supervising General Engineer in charge of Missile-Components Material Engineering and Research at the Naval Ordnance Test Station, China Lake, California. He joined NOTS in 1948 after 18 years as a civil engineer with the Army Corps of Engineers. He was associated with the Navy's Sidewinder development program in its early stages.

Russia's Big Missile Bases

Exclusive M/R report pinpoints for first time 10 ICBM sites with 100-300 missile launch potential. IRBM bases total 30—many with missiles ready to strike Red China

by James Baar and William E. Howard

New information compiled by MISSILES AND ROCKETS indicates that today Russia has in combat readiness or under construction a minimum of 10 ICBM bases and 30 IRBM bases.

Moreover, the Soviets have missile plants in at least 17 cities—with perhaps as many as five turning out huge H-bomb-tipped *T-3* ICBM's. They also are believed to have eight special rocket training schools for both launch crews and engineers.

The exact number of big missiles Russia has ready to shoot now is not specified in this new information, which comes entirely from unclassified sources considered extremely reliable.

However, the number of bases—many of which have been in existence four years—and the reputedly vast rocket manufacturing capability plainly indicate the Russians are building up a global striking force that is much greater than admitted by the Eisenhower Administration.

Indeed, if the pattern for base building developed by the United States is applied (and there is no reason to believe the realities of logistic support are much different for the Russians), the 10 Red ICBM bases could hold from 100 to 300 missiles; and the 30 IRBM bases from 300 to 600 missiles with ranges from 700 to 1500 miles.

• **Also aimed at Red China**—As shown on the map, (p. 26, 27) ICBM bases are scattered from north of Moscow along a great arc dipping through the southern Soviet heartland and curving up to the northern Pacific Coast. From these bases missiles can be launched over the top of the world or across the Pacific at the United States. They also could hit Australia.

IRBM bases are most heavily concentrated in Western Russia and the northwest Siberian coast. There are 22 indicated in this region from which Russia could strike at Great Britain, all of Western Europe, North Africa and the Middle East.

TURN THE PAGE for a color map showing the location of Soviet missile sites.

The remaining eight deployed in the Far East are tailored to strike not only at Alaska, Japan, Okinawa and Formosa—but also at Red China. Bases at Omsk which has 3000-mile TCBM's, and Irkutsk are believed to be zeroed in on Peiping and other targets in Red China in obvious preparation for keeping Russia's restless Communist neighbors in line.

Because of complex strategic requirements, and undoubtedly for logistic reasons, the Russians are known to be "mixing" missiles at several bases. Some IRBM's are combined with ICBM's; so are test, R&D and satellite shots. Many IRBM bases—particularly those in the north—have antiaircraft missiles, too. And in the west, IRBM bases also house short-range tactical missiles (probably mobile) as well as air defense units for Moscow, Leningrad, Kiev and other big cities.

• **First-hand accounts**—This first, comprehensive picture of Russia's missile buildup stems largely from accounts of former slave laborers and captive engineers and scientists who have been permitted to return to their homes in Western Europe. Many of these returnees actually worked on missile base construction jobs, or in missile plants.

They were permitted to leave the USSR either through a bureaucratic slipup or deliberately. In any event, their individual observations have been pieced together in reports that have appeared over the past six years in German, French and Italian newspapers and military and technical journals—some within the past few weeks.

Plotting of the sites was made possible through translations of these reports especially for M/R by Bernard

Soviet ICBM Bases

Far East

Anadyr (64°43'N 177°28'E) on northeast coast less than 600 miles from Nome, Alaska. This base also is believed to have IRBM's and antiaircraft missiles.

Okha (53°40'N 143°E) on northern tip of Sakhalin Is. in the Far East. Has IRBM's within range of Japan and missile sea test facilities.

Komsomolsk (50°30'N 137°E) also IRBM's. Located in heavily industrialized Amur River valley about 1000 miles NNW of Tokyo and 1300 miles NE of Peiping.

Irkutsk (52°17'N 104°20'E) major rocket manufacturing center which is believed expanding present IRBM base to launch ICBM's.

West Central

Mid Kalinin (57°5'N 37°30'E) 90 miles north of Moscow possible ICBM site. Now has antiaircraft missiles.

Magnitogorsk (53°21'N 58°40'E) east of Ural Mts. in central Russia. Also has 3000-mile TCBM's which could hit Red China or Japan.

Alma-Ata (43°15'N 77°E) in south central Russia near China border.

Aralsk (47°20'N 62°5'E) near Aral Sea. Also believed to be satellite launching and missile test site.

Kapustin Iar (48°27'N 45°35'E) 60 miles ESE of Stalingrad. Also satellite launching site.

Murgab Oasis (37°36'N 61°50'E) about 200 miles from the Iranian border. Also thought to be seat of extensive Kara Kum desert missile range.


LONDON
PARIS
NORWAY
SWEDEN
FINLAND
KOLA
MURMANSK
PEENEMUNDE
KURESSAARE
KRONSHTADT
SESTRORETSH
LENINGRAD
PRAGUE
SOVETSK
RIGA
YELGAVA
LUGA
SEROC
OSTROV
KOLGUYEV
NOVAYA ZAMLYA
ARKHANGELSK
OZERA
BUDAPEST
MINSK
KALININ
MOSCOW
NOGINSK
BOBRUISK
ROSLAVL
KIEV
LADA
YUGOSLAVIA
POLTAVA
ODESSA
KAZAN
U.
SAMARA
KYSCHTIM
KAPUSTIN IAR
MAGNITOGORSK
PETROPAVLOSK
OMSK
AFRICA
TURKEY
ARAL SK
IRAQ
ALMA ALTA
MURGAB OASIS
IRAN
SAUDI ARABIA
AFGHANISTAN
PAKISTAN
INDIA

RUSSIA'S MISSILE BASES

Huge Soviet ICBM and IRBM capability is indicated in number and deployment of bases. Bases were plotted on map from unclassified source material gathered by Bernord W. Poirier, foreign information specialist. See accompanying story for precise coordinotes.

▲ ICBM
■ ROCKET TEST
IRBM
ANTI-AIRCRAFT
* TCBM (3,000 Mi.)
○ SATELLITE LAUNCH
● EARLY WARNING
★ CITY

estimate may be conservative . . .

W. Poirer, a foreign information analyst. Prior to publication, M/R checked and re-checked this information with several highly qualified experts. They assessed it as "accurate." They felt that the number of bases listed is actually extremely conservative.

There are indications, through paved highways and railroad spurs which seem to lead nowhere, that the Russians could be building several more launching bases than pinpointed here.

The Russians themselves have never published the location of one of their bases, although their newspapers do report frequently on U.S. missile activity. Their reluctance to even name satellite launch sites appears to confirm the general belief that these are also ICBM sites.

• **The fourth command**—Russia's Army and Air Force are organized into a series of commands—Ground Forces (the Red Army); Air Forces (DA); and Air Defense. Western experts are convinced that all strategic missiles are under a fourth highly secret command.

This command may be headed by a former commanding general of artillery, Marshal Varentsev, who dropped from sight several months ago—just about the time it was pretty well established that all development of long-range missiles has been carried out under control of army artillery officials.

There is one minor disagreement on this latter point. The Institute for Strategic Studies, a Ford Foundation-sponsored group in England, reported in December that Soviet missiles have been organized under an "engineer general." ISS said this official also has control over "all factories in which nuclear bombs are manufactured, all testing sites, all factories in which rockets and guided missiles are produced and rocket and guided missile units."

Operational personnel for missiles, according to ISS, numbers 200,000 men. And ICBM's and IRBM's "have been in service since July, 1958." This agrees generally with M/R's findings.

ISS put the total number of Russian missile bases—with no breakdown as to type—at "about 100." This figure was challenged by American officials queried by M/R. They hold that the ISS report probably reflects figures "slanted" by British Intelligence for political reasons.

• **British overstatement?**—The major reason: Britain feels that if there should be a nuclear conflict, she would be caught in the middle and would die —win or lose. Hence, the British tend to overstate Russia's capability—to make the starting of an all-out war sound as foolhardy as possible.

Still, these U.S. officials do concede that much of the ISS report does agree with U.S. intelligence. To what extent or in what particulars, they cannot say, because of security.

It is axiomatic in every rocket tactician's handbook, however, that a nation's missile capability is only as good as the number of launchers it has to fire them from. Big rockets rolling off production lines are useless without bases. Thus, bases are one of the key factors in gauging Russia's missile potential—a consideration generally ignored in the current controversy over the Missile Gap.

Soviet IRBM Bases

Deployed toward Britain and Scandinavia

Kola (68°45'N 33°E) on Kola Peninsula near Murmansk. Situated in rugged terrain.
Ust-Taimyra—two bases—(76°15'N 99°E). Also radar and antiaircraft missiles.
Ostrov (69°25'N 48°29'E) on an island in Barents Sea.
Ozera (70°10'N 71°40'E) with radar post on north shore of Belyy Island.

Deployed toward Europe, North Africa and the Middle East

Lada (54°39'N 45°8'E) 35 miles NNE of Saransk on Insar River.
Kuressaare (58°18'N 23°33'E) on Saaremaa Island in the Gulf of Riga.
Minsk (53°48'N 27°21'E). Site is 20 miles WSW of site at Western edge of Pripet Marshes.
Kiev (50°27'N 30°31E). Within range of the central European gateway to Asia.
Seroc (52°35'N 20°55'E) 20 miles north of Warsaw, near junction of Bug and Narew Rivers. Only IRBM base in satellite country.
Riga (56°57'N 24°7'E). Also site of major missile production.
Kazan (55°47'N 49°E). A major industrial center.
Bobruisk (53°10'N 29°14'E) in Pripet Marshes 100 miles SE of Minsk.
Sovetsk (55°4'N 21°48'E) 30 miles NE of Kaliningrad.
Samara (53°10'N 50°6'E) about 70 miles west of Buzuluk.
Roslavl Kirov—two sites—(53°58'N 33°6'E) southeast of Smolensk.
Yelgava—two sites—(56°39'N 23°43'E) about 25 miles SW of Riga at important rail junction.
Luga (58°45'N 30°3'E) about 80 miles south of Leningrad.
Odessa (46°30'N 30°45'E).

Far East—deployed toward Alaska, Japan, Okinawa and Red China

Anadyr (64°43'N 177°28'E) in inlet off Bering Sea less than 600 miles from Nome, Alaska.
Omsk (55°N 73°20'E) probably has 3000-mile TCBM's to hit Far East.
Okha (53°40'N 143°E) on northern end of Sakhalin Is.
Nikolaevsk (53°10'N 140°45'E) former naval base 20 miles from mouth of Amur River.
Korsakov (46°30'N 142°52'E) on Aniva Gulf at southern end of Sakhalin Is. 750 miles from Tokyo and less than 1500 miles from Okinawa.
Komsomolsk (50°30'N 137°E).
Mil'kovo (54°35'N 158°44'E) on Kamchatka Peninsula. Probably has 3000-mile TCBM's.
Irkutsk (52°17'N 104°20'E).
Terpeniye (49°20'N 143°45'E) near Poronaisk on Sakhalin Is.

• **Breaking the taboo**—Only recently was Central Intelligence Agency Director Allen W. Dulles reported to have told the Senate Space Committee that Russia would have 35 ICBM's "on launchers" by the end of June. His is the first actual reported reference to bases by an Administration official. Dulles is also said to have admitted that even this figure was an estimate, which could be on either the low or high side.

The CIA chief is further reported to have said the Soviets are expected to have between 140 and 200 ICBM's operational by mid-1961. And that the Russians probably have two factories producing ballistic missiles at present.

By June, this country is expected to have nine *Atlas* missiles in combat condition and by the middle of next year, if all proceeds on schedule, there will be four *Atlas* and one *Titan* squadron ready—totalling 45 ICBM's. The U.S. by then also should have three *Polaris* submarines capable of launching 48 1200-mile-range, nuclear-tipped missiles.

This makes a total of 93 strategic missiles under U.S. control vs. Dulles' estimated 140 to 200 Russian ICBM's. But if the Soviets risk war, *Polaris* missiles would not be involved in an ICBM strike to knock out U.S. missile and SAC bomber retaliatory capability. So, the Soviet ICBM advantage will, by excluding *Polaris*, remain about 4 to 1.

• **Expanding total**—The unclassified information made available to M/R indicates that the Soviets are expanding their ICBM bases today at a rapid pace. They are believed now to be constructing ICBM launchers in the Mid-Kalinin area 90 miles north of Moscow. ICBM launch pads also are reported to be going in at Irkutsk near the Red China border. This base already has IRBM's and is situated near Lake Ozbaikal on a high plateau.

The oldest, and probably largest, ICBM installations are located in central and south central Russia. One at Kapustin Iar, 60 miles east southeast of Stalingrad, is next to a spur of the Moscow-Astrakhan-Gudermes Railroad. This is also a satellite launching site where rockets can be fired eastward over the Caspian Sea.

A second combined ICBM-satellite launch site is at Aralsk near the Aral Sea. ICBM activity is reported at Alma-Ata to the east and to the south at Murgab Oasis, which lies 200 miles from the Iranian border.

Situated in the center of these three bases is the city of Tashkent (not shown on map), which is a missile manufacturing center and headquarters for a rocket training school. In addition, the city has one of the country's largest observatories (the sky is cloudless there most of the year) and is probably the prime satellite tracking and computation center.

Just east of the Urals is another ICBM installation at Magnitogorsk. This base also may have missiles pointed at Red China.

The three ICBM bases in the Soviet Far east—Anadyr, Okha and Komsomolsk—are reported to be combined with IRBM's. Anadyr, the northernmost, is less than 600 miles from Nome, Alaska. Komsomolsk in the Amur River valley, a heavily industrialized area, is about 1000 miles from Tokyo and 1300 miles from Peiping. Okha on Sakhalin Island is also a missile sea test site.

• **Eye to East**—Considerable activity is reported on the Kamchatka Peninsula stretching southward from Anadyr. Long-range missiles—possibly ICBM's but more likely 3000-mile birds for China or Japan—are going in at Mil'kovo, which is between two rugged mountain ranges.

Russia's Far East missile lineup also includes two more IRBM bases on Sakhalin—at Korsakov on the southern end and at Terpeniye Bay midway up the island. Both are near naval installations. A naval base at Nikolaevsk on the mainland, a short distance from Okha, also has been converted into an IRBM site.

In northwestern Siberia, IRBM's are spotted at four sites within range of Scandinavia and Britain. The most distant—on the Taimyra Peninsula—has two IRBM bases along with radar early warning facilities and antiaircraft missiles. The Ozera and Ostrov bases are both on islands and also tied in with air defense.

• **Railroad launcher?**—A base on the Kola Peninsula near Murmansk had been believed to house strictly IRBM's. But there is speculation that the Russians may have used a railroad catapult here to fire the recent shots into the Pacific. The possibility has been raised that the vehicle was a prototype of the *T-4A Dyna-Soar* type boost-glide rocket.

In Western Russia new IRBM bases are reported under construction at Lada—near Kazan where there is another IRBM base—and at Kuressaare on the Estonian island of Saaremaa in the Baltic Sea.

Twin IRBM bases are located at Roslavl and Kirov north of Minsk and at Yelgava 25 miles southwest of Riga in Latvia.

The only IRBM base believed to be in a satellite country is at Seroc, 20 miles north of Warsaw, Poland. This base is within easy range of all European targets and RAF and SAC missile and bomber bases.

Bases clustered around Moscow and Leningrad presumably contain short-range ballistic missiles as well as IRBM's with London and Paris labels.

• **Plants and schools**—The pattern of Soviet missile activity emerges in the distribution of reported rocket plants and training schools, as well as test sites.

Irkutsk, Kalinin and Komsomolsk—ICBM bases—have manufacturing facilities. So do such IRBM areas as Kazan, Kiev, Riga, Omsk, Moscow and Leningrad. Moscow, of course, is a well known seat of technical learning with the National Academy of Sciences unquestionably supplying most of the design, engineering and scientific brainwork for the various programs.

Riga has one of the USSR's most advanced schools for rocketry. The Metallurgical and Astronautical Institute at Irkutsk is affiliated with the National Academy of Sciences.

It is considered likely that ICBM manufacture is conducted primarily at Irkutsk, Komsomolsk and Kalinin, while somewhat lesser operations are underway at Tashkent and Severdlovsky, which is north of Magnitogorsk.

Soviet Rocket Training Schools

Riga *(advanced rocketry)*
Saratov *(ballistics and astronautics)*
Novosibirsk, Kaluga
Sverdkovsky, Tashkent, Ufa
Irkutsk *(metallurgical and astronautical institute)*

Missile Plant Centers

Irkutsk	Kalinin	Kazan
Kharkov	Kiev	Ryninski
Riga	Omsk	Novosibirsk
Moscow	Leningrad	Komsomolsk
Kuibyshev	Saratov	Sverdkovsky
Tashkent		Ufa

Rocket Engine Development Centers

Irkutsk (STS)*, Ilmen area, Kalinin, Kazan, Riga (STS), Omsk (STS), Novosibirsk, Kuibyshev, Kiev (STS), Tomsk (STS), Kapustin Iar (STS), and Peenemunde (STS).

**Static Test Stand.*

Session Slated on Medical Electronics in Space Work

LONDON—The Third International Conference on Medical Electronics, to be held in Olympia, one of London's major exhibition halls, July 21-27, will include a session on medical electronics in space research.

Other subjects to be discussed include instrumentation for medicine and biology; isotopes and radiology; ultrasonics and microwave radiation; the respiratory system; the digestive systems, metabolism and biochemistry; the circulatory system; electronic aspects of sight, hearing and locomotion; and the motor and nervous systems.

The conference is being organized by the Institution of Electrical Engineers, Savoy Place, London, W.C.2., which is inviting papers from all over the world. Simultaneous translation facilities will be provided, and there will be an international scientific exhibition.

Recovery Phase Stressed in U.K.'s Man-in-Space Work

LONDON—Work is continuing on the "pyramid" project for a manned satellite at Armstrong Whitworth Aircraft, according to Dr. W. F. Hilton, head of the recently formed Astronautics Section of the Hawker Siddeley Advanced Projects Group.

Dr. Hilton discussed the project in a recent address before the Bristol Branch of the Royal Astronautical Society. He said he was currently concentrating on the recovery phase of the satellite programme.

The "pyramid" effort was first outlined at the B.I.S. Commonwealth Spaceflight Symposium last August.

Storables Stir Renewed Interest

In view of the industry-wide interest in storable propellants for large rocket vehicles, reported by M/R last week, we asked Aerojet-General Corp. to prepare a comprehensive report on these propellants. Aerojet, manufacturer of the Titan *ICBM propulsion system, has performed extensive research in storables.*

If Titan, *as many reports indicate, should be converted to storables, the missile would be modified substantially, including many changes in the propulsion system. Although the changes have not been spelled out, they would very likely include changing of all seals in the pumps, valves, etc., redesign of the propellant tanks and other modifications.*

A combination of nitrogen tetroxide oxidizer and a 50-50 UDMH-hydrazine fuel mix would nominally give Titan *a boost specific impulse of 288 sec. (1000 psia, shifting equilibrium, nozzle exit pressure 14.7 psia). The LOX/hydrocarbon combination previously used was about 300 sec. The additional propellant capacity, due to increased density of the storable liquids, is expected to compensate for the loss in specific impulse. Density impulse for the storable combination jumps to 348 sec., compared with 308 sec. for LOX/hydrocarbon.*

Since storability helps provide instant readiness, the most immediate application for storable propellants is in military systems. Proponents argue that the readiness factor eliminates a major advantage of solid propellants in weapon systems while maintaining most of the performance advantage of liquid propellants.

The same arguments are made for the use of storables to propel vehicles on the return trip to earth from space missions—a need that is bound to develop.

The author, Dr. C. M. Beighley, joined Aerojet in 1955 after eight years of rocket research and development at the Ohio State University Research Foundation, Purdue University Bell Aircraft Corp. and the University of Michigan. As principal engineer and head of the Research and Materials Department, Liquid Rocket Plant, at Aerojet, he is responsible for chemical and physical analysis to establish new processes and uses for materials.

by Dr. C. M. Beighley

The full impact of storable propellants upon present and future missile systems is just now beginning to be felt by industry. Some storable propellants formed the mainstays of early propulsion systems. But interest in these systems waned as the search for higher performance became more intense.

Liquid oxygen assumed a place of importance with solution of the problems associated with the use of a cryogenic oxidizer in engine components and ground handling equipment. But as new missile systems were proposed and system studies were undertaken, storable liquid propellant systems have once again received a good share of attention.

The problems associated with the use of storables are being solved, just as cryogenic handling problems were solved. In addition, some storables with very high performance characteristics are being investigated. One of the most promising areas appears to be that of boron compounds.

• **Pentaborane stir**—The greatest stir in the rocket industry is being caused by pentaborane (B_5H_9). Theoretical calculations—as well as limited small-scale testing—indicate exceedingly high specific impulse values for some pentaborane-oxidizer combinations. For example, the calculated performance of 98% H_2O_2 and pentaborane is 312-15 sec. This compares with 300 sec. for the conventional LOX-hydrocarbon combination.

A new concept in liquid propellant systems has evolved from consideration of two families of compounds as sources of boron nitride in rocket exhaust products. Boron nitride's theoretical high heat of formation makes increased rocket engine performance feasible by the use of boron and nitrogen compounds which yield hydrogen as a working gas in the combustion products, thus reducing the average molecular weight of product gases.

The two families of compounds, boron hydrides and nitrogen "hydrides" (ammonia, hydrazine, and hydrazine derivatives), are both ordinarily regarded as fuels. However, in the new concept, the boron hydrides behave as the fuels, and the nitrogen "hydrides" behave as the oxidizers.

Theoretical specific impulse values calculated for various propellants of these types range from 270 sec. for HEF-2 fuel and an oxidizer composed of hydrazine nitrate dissolved in UDMH to 347 sec. for tetraborane/hydrazine. In those propellant systems containing carbon, sufficient oxygen is included in the oxidizer to give complete combustion to carbon monoxide.

Another system of interest involves the use of pentaborane or other boron hydrides with mixtures of ClF_3 and ClO_3F. It is postulated that BOF is formed in the combustion process, which is a gaseous product. The high theoretical specific impulse and relatively high bulk density of this system promise to warrant further investigation. Calculated specific impulse for 50% ClF_3 & 50% ClO_3F/B_5H_9 fall within the range of 288-301 sec.; higher performance may theoretically be obtained with different mixture ratios.

What is a "storable liquid propellant? The term has been rather loosely defined in the rocket industry. One definition is that a storable propellant is any that is liquid under normal ambient operating conditions, thus eliminating cryogenic liquids.

But a further refinement of the definition includes the idea that the propellant may be stored with relative ease in some type of fairly standard container without becoming contaminated or requiring constant care (venting, replacing seals, etc.). Safety in storage and handling are further considerations.

Thus the storable propellant is one

that does not have an excessively high vapor pressure at ambient temperature and is not incompatible with so many materials that it is virtually not capable of being contained in the practical sense.

• **The mission**—What jobs can storable propellants perform? Some of them are propelling an 8000-mile ballistic missile, a 200-mile ballistic missile, an air-launched ballistic missile, an air-to-air missile, a satellite booster, a manned space vehicle, a manned satellite vehicle, a launch unit for a moon vehicle and a second-stage boost vehicle.

Since each prospective propellant has a unique set of properties, candidates for the role may be rated as to their storability, performance, and suitability for particular applications. In evaluation, each of these items is assigned a value, then a weighting factor is applied to the sum of the values for each of the major categories. In this manner, comparative values for any number of propellants or propellant combinations may be obtained.

For missions in which pre-packaged storable propellants are desired, for example, the most important properties are chemical stability and low corrosion rate. Other factors might be low vapor pressure, high density, low freezing temperature, low toxicity, and low shock sensitivity.

In this case, the properties desired are dictated by the propulsion system requirements: instant readiness, ease of handling, long-term storage, wide range of environmental conditions, envelope limitations, and systems safety.

With a suitable choice of propellants, pre-packaged propulsion systems can be designed to be exceedingly rugged—unimpaired by rough handling in the field, and unaffected by a wide range of temperature conditions.

In pre-packaged air-launched missiles, aerodynamic heating does not impose severe limitations on the system. The propellants stored in the missile tanks act effectively as heat sinks to absorb the heat generated during flight. The pre-packaged propellants also eliminate the logistic requirement associated with topping the tanks due to boil-off.

• **Serious contenders**—The high performance attainable with the newer storable propellants, and the even higher performance predicted for those still in the research stage, makes them serious contenders for many advanced astronautical and weapon system applications.

The advantages of storable liquid propellant rocket engines may be summarized as follows: excellent performance, simplicity of engine design, instant readiness, high reliability, safety, missile mobility, long term storage, suitable for volume/limited applications, wide temperature-cycling capability, minimum of ground support equipment and maintenance, and low cost.

Many of these desirable features are directly attributable to the fact that most storable liquid combinations are hypergolic. The resultant engine designs, therefore, are quite simple and exhibit high reliability. Elaborate ignition and control systems are eliminated. With hypergolic systems, combustion is achieved instantaneously. Propellants burn but do not detonate.

As more potential uses for rocket-powered vehicles are explored, the requirements for the various types of missiles become more specific. One result of this evolution has been to place more emphasis on performance.

The newer storable propellants can theoretically deliver specific impulses ranging from approximately 300 to 340 lb.-sec./lb. (1000 psia and sea level), as compared to around 300 lb.-sec./lb. for liquid oxygen and jet fuels.

The military logistic requirements are more specific and realistic in present design concepts and permit a wider use of existing storable propellants. For example, requirements for cost-per-pound of propellant, the use of an existing liquid (such as an aircraft fuel), and an extremely wide environmental operating range are no longer limiting criteria.

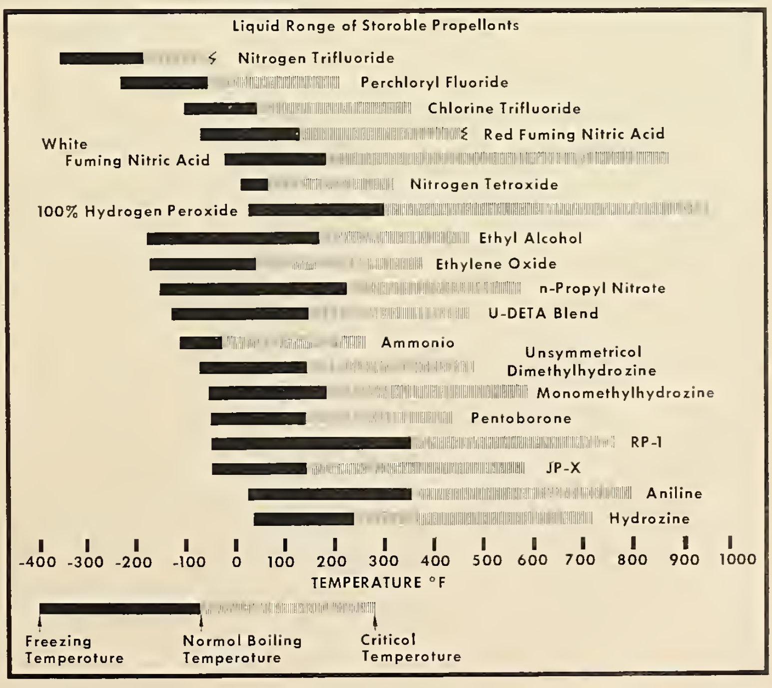
• **Relaxed requirements**—A change in thinking on these matters is particularly noted with regard to the operating temperature range requirement, which heretofore often demanded satisfactory missile performance over the range of temperatures from the arctic to the tropics. Today many missions are expected to be performed under a much more limited range of temperatures.

The missile may be maintained in a protected environment prior to launching—a silo, a submarine, or other type of permanent storage site—and the "field" conditions will not be so rugged as formerly.

The missile/space industry is finding that subsystems other than propulsion (such as guidance) are demanding controlled environments which are more stringent than those required by propulsion systems. Hence, controlled environments for pre-packaged missiles may be maintained in some cases by insulated shipping containers, refrigeration envelopes, or heating blankets.

Space missions present a whole new set of environmental conditions requiring new concepts for propellant storage facilities, particularly for those applications involving manned vehicles or long-term storage in orbiting space stations. Several storable propellant combinations appear to be particularly

Limits of the Liquid State



well suited to these applications.

Continuous research on storable propellants has produced not only a wide variety of oxidizers and fuels with a wide range of physical properties, but has also resulted in methods to alter properties of many compounds by use of additives, catalysts, or combinations of propellants so as to enhance their properties for rocket engines.

For example, if nitric oxide (NO) is added to nitrogen tetroxide (N_2O_4), the NO depresses the freezing point of N_2O_4 without reducing performance. A mixture of 77% N_2O_4 & 23% NO has a freezing point of −65°F. Without the NO, N_2O_4 would freeze at 12°F.

Greater progress is expected in this area of propellant improvement as more of the storable propellants are chosen for advanced missile systems.

The properties of an ideal storable propellant may be summarized as follows: high specific impulse, high bulk density, compatible with a variety of materials, stable combustion, hypergolic, broad liquid range, low viscosity, chemical stability, good heat transfer characteristics, low vapor pressure, thermal stability and non-toxicity.

Not all the criteria, of course, are met by each of the oxidizers and fuels classified as storable propellants, but a sufficient variety of these propellants exist, covering a broad range of the desired properties, so that a suitable choice may be made for nearly all applications. More research is required to develop a number of potential propellants for liquid rocket engines; however, increased effort to improve the state of the art of storable propellants is expected to produce the desired results.

Following are summaries of properties of common storable fuels:

• **Unsymmetrical Dimethylhydrazine (UDMH)**—The physical properties of UDMH approach the ideal for rocket applications. Its liquid range is broad; it is stable in long-term storage and under severe temperature and pressure conditions in rocket components; its cost and availability are satisfactory for a rocket propellant.

Extensive testing of this propellant in full-scale hardware has demonstrated that UDMH is easily handled without the use of special equipment. Industry-wide experience with UDMH has probably been more extensive than with any other high-performance fuel suitable for use with storable oxidizers.

• **Hydrazine (N_2H_4)**—Of the currently available storable fuels, hydrazine has the highest performance with all storable oxidizers. It is the most dense of the neat liquid fuels. The only physical property that limits its usefulness is its freezing point (+34°F). Hydrazine is the preferred fuel in uncooled engines for those applications where temperatures below 35°F are not encountered or can be compensated for.

In engines designed to avoid its explosive vapor phase decomposition, hydrazine can be used as a regenerative coolant because its heat transfer properties are not exceeded by any of the known storable fuels. Hydrazine has been demonstrated in full-scale tests and problems with its use have been defined. Further, it can be stored for long periods of time in pre-packaged propulsion systems.

• **Monomethylhydrazine (MMH)**—MMH has a broad liquid range and other properties favorable for long-term storage in pre-packaged systems. However, because interest in MMH as a rocket fuel is quite recent, its cost is relatively high and it is available only in limited quantities.

New manufacturing processes are expected to increase production and decrease cost in the near future. The performance of MMH, which is intermediate between UDMH and hydrazine, has been demonstrated in a number of full-scale tests. MMH does not have the detonable vapor-phase decomposition problems associated with hydrazine.

• **Mixed Amines**—Mixtures of amine-type fuels provide performance, density or physical properties that are not obtainable with the neat fuels. Experience with mixtures of hydrazine with UDMH and with MMH has shown that the vapor-phase problems of hydrazine are eliminated and that the performance is intermediate between that of the components of the mixtures. Some depression of the freezing point of hydrazine is also obtained with these binary mixtures, but ternary mixtures are required to obtain a freezing point at or near −65°F.

"Hydrazoid" fuel is such a ternary mixture. Only small scale tests have been made with this fuel.

Increased density can also be obtained by using mixtures of UDMH and diethylenetriamine (DETA). Although this two-component system does not give density values as high as the hydrazoid fuel, in full-scale tests the UDMH-DETA mixtures have been proved practical for current use. Viscosity data indicate that mixtures containing as much as 60% DETA are practical to temperatures as low as −40°F.

• **Ammonia (NH_3)**—Ammonia is readily-available, cheap, and has been tested extensively at full scale. From a physical property standpoint, if high vapor pressure can be tolerated, ammonia can be regarded as a storable fuel for pre-packaged systems. However, on the basis of performance or density, ammonia is not competitive with hydrazine or the hydrazine derivatives. It is not hypergolic with nitrogen oxide oxidizers unless lithium metal is placed in the fuel line just prior to firing.

Here are the properties of oxidizers:

• **Nitrogen Tetroxide (N_2O_4)**—Of the nitrogen oxide oxidizers, N_2O_4 is generally preferred to red fuming nitric acid (RFNA) and mixed oxides of nitrogen (MON). Its performance is high and its handling properties, cost and availability are favorable to its use in storable and pre-packaged propulsion systems.

Its major disadvantages are its high freezing point, 12°F, and vapor pressure. Extensive experience in full-scale tests has shown that values of combustion efficiency are obtained with little or no combustion instability.

• **Red Fuming Nitric Acid (RFNA)**—RFNA is preferred to N_2O_4 for applications in which low temperatures are encountered, or in which high density is an important factor. Like UDMH, the physical properties approach the ideal for a storable propellant. Its handling properties, cost, and availability are favorable to its use in storable and pre-packaged units. Extensive experience in full-scale tests with hydrazine, UDMH and other fuels has demonstrated that smooth combustion can be obtained at high levels of combustion efficiency. Corrosion is a problem, of course.

• **Maximum Density Fuming Nitric Acid (MDFNA)**—Experience with RFNA has been limited to acid containing no more than 22% of N_2O_4 (Type I_v). It has been shown, however, that the N_2O_4 content of the acid can be increased to 52%. Above this concentration a two phase mixture is formed; as N_2O_4 is added to the nitric acid, the density of the acid increases beyond the density of the components until a maximum density value is reached. This mixture is known as MDFNA.

For first-stage systems, volume-limited applications, and for conversion purposed, MDFNA may show increased mission accomplishment relative to neat N_2O_4 and RFNA.

The handling characteristics of MDFNA are similar to the standard types of red fuming nitric acid, except that its vapor pressure is higher due to the higher content of N_2O_4. Chemical company forecasts are that MDFNA can be supplied as readily as the standard types of RFNA. No difficulties associated with its use are foreseen.

• **Mixed Oxides of Nitrogen (MON)**—Mixtures of nitric oxide (NO) with N_2O_4 are of interest because the NO depresses the freezing point of N_2O_4 without reducing its performance. In fact, NO has a slightly higher performance than N_2O_4. MON-15, which contains 15% of NO, has a moderately freezing point (−25°F), and its vapor pressure at 125°F does not exceed 100 psia.

In applications where higher vapor pressures can be tolerated, higher concentrations of NO can be used to obtain lower freezing mixtures. At the same time, there is an accompanying decrease in density.

MON, therefore, is the preferred N_2O_4-based oxidizer for applications in which a higher premium is placed on specific impulse than on density impulse, and where the pressures that accompany the desired amount of freezing point depression can be tolerated.

MON is similar to N_2O_4 in storability and is suitable for pre-packaged systems. Experience in handling and use of this oxidizer in engine testing is less extensive than with N_2O_4 and RFNA, but sufficient data have been obtained to indicate no serious problems should be anticipated in the development of propulsion systems with this oxidizer.

• **Hydrogen Peroxide (H_2O_2)**—With hydrides such as pentaborane (B_5H_9), the performance of H_2O_2 is attractive. The H_2O_2 (98%)/B_5H_9 system has a theoretical specific impulse 7.9% higher than the N_2O_4/UDMH system, but has a 14% lower bulk density.

The major limitation of H_2O_2, however, is thermal instability. Although it is regarded as a currently available storable oxidizer for some applications, because of its inherent thermal instability, tanks and other storage vessels must be vented to release decomposition products, preventing its use in pre-packaged propulsion systems at present.

In addition, the high freezing point of H_2O_2 prevents its use in applications where low temperatures are encountered. Low-freezing-point mixtures are known (for instance, with ammonium nitrate), but the addition of freezing point depressants invariably increases the decomposition rate and lowers the performance. Extensive testing has been conducted at small and full-scale levels.

• **Chlorine Trifluoride (ClF_3)**—ClF_3 is a storable oxidizer that can be used in pre-packaged propulsion systems. Its primary advantage is the large increase in bulk density and density impulse. The bulk density of the ClF_3/N_2H_4 system is almost 25% above that of N_2O_4/UDMH, although the specific impulses of these two systems are almost identical.

A number of metals, including stainless steel and aluminum, are compatible with it, due to the formation of passive fluoride films. Consequently, its handling problems are not a serious obstacle to its use, and its availability and cost will improve as production rises. Some full-scale tests have been conducted.

• **Perchloryl Fluoride (ClO_3F)**—When ClF_3 is used with carbon-containing fuels such as UDMH or MMH, an oxygen-containing oxidizer should be mixed with the ClF_3 to allow the formation of CO and CO_2, rather than the fluorides of carbon.

Perchloryl Fluoride can be added to ClF_3 for this purpose. ClF_3 containing less than about 40% of ClO_3F suffers a sharp drop in performance when used with UDMH. Because of its high vapor pressure and high coefficient of expansion, perchloryl fluoride is not a practical storable propellant by itself. In mixtures with ClF_3 its properties, except vapor pressure, are essentially masked by the ClF_3. Small scale tests with a number of storable liquid fuels have been conducted.

• **Bromine Pentafluoride (BrF_5)**—Bromine pentafluoride is a compound of wide liquid range that is even more dense than ClF_3. Because of its high density impulse it can theoretically provide a significant improvement in mission capability for some volume-limited applications. BrF_5 is a storable material that can be used in pre-packaged systems. Its handling properties are similar to those of ClF_3. Theoretical calculations show BrF_5/B_5H_9 to be a high performance system. To date no tests have been performed on this oxidizer at Aerojet-General.

Calculated Propellant Performance

Oxidizer	Fuel	I^*_{sp}	Weight Mixture Ratio, Oxid./Fuel	Bulk Density g/cc	Density Impulse
N_2O_4	N_2H_4	291	1.35	1.21	354
	MMH	288	2.17	1.19	343
	UDMH	286	2.59	1.17	333
	U-DETA	282	2.74	1.21	341
	DETA	278	2.85	1.27	352
	Ethylenediamine	280	2.75	1.24	346
	TMB-1.3-D	279	3.55	1.22	340
	B_5H_9	296	2.95	1.08	318
IRFNA	N_2H_4	278	1.52	1.28	357
	UDMH	272	3.15	1.27	345
	U-DETA	268	3.26	1.31	351
MDFNA	MMH	280	2.40	1.30	364
	UDMH	278	2.93	1.28	355
	U-DETA	275	2.98	1.32	364
	DETA	270	3.14	1.39	376
	B_5H_9	294	2.80	1.14	336
MON-15	MMH	290	2.20	1.18	341
	UDMH	288	2.64	1.16	332
	U-DETA	286	2.90	1.20	342
	B_5H_9	302	3.06	1.07	322
H_2O_2 (98%)	N_2H_4	285	2.00	1.25	357
	B_5H_9	312	2.00	0.996	311
	"HiCal"	294	1.85	1.13	331
ClF_3	N_2H_4	292	2.79	1.49	436
	MMH	283	2.96	1.43	404
	UDMH	279	2.97	1.37	382
	U-DETA	275	2.95	1.41	388
	DETA	267	2.93	1.47	393
	TMB-1.3-D	264	3.09	1.37	362
	B_5H_9	288	7.1	1.47	423
ClO_3F	N_2H_4	295	1.46	1.21	358
	UDMH	290	2.70	1.16	337
ClF_3+ClO_3F: 70/30	MMH	289	3.28	1.38	398
65/35	UDMH	288	3.70	1.34	386
BrF_5	N_2H_4	244	3.35	1.86	455
	MMH	235	3.60	1.77	415
	UDMH	231	3.68	1.70	392
	DETA	220	3.68	1.84	404
	B_5H_9	246	11.45	1.99	489
N_2H_4	B_5H_9	329	1.27	0.789	260

*P_c = 1000 Psia; P_e = P_a = 14.7 psia; shifting equilibrium.

Aerojet to Build *Able Star*, Bigger, Restartable *Able*

Engine will have start-restart capability and double burning time

Aerojet-General Corp. is producing *Able Star*, a larger version of the workhorse *Able* upper-stage rocket with start and restart capability at altitude. It is Aerojet's first contract as prime systems manager on a major space program.

Able Star has 2.2 times the propellant capacity of *Able* and thus has a burning time of more than four minutes, compared with about two for *Able*. Thrust is increased somewhat from about 7800 lbs. to more than 8000 lbs. as a by-product of increasing the area ratio from 20:1 to 40:1.

Propellants in the *Able Star* will be a hypergolic combination of unsymmetrical dimethylhydrazine (UDMH) and inhibited red fuming nitric acid (IRFNA), a switch from white fuming nitric acid in the *Able*.

The area ratio increase brings specific impulse much closer to the theoretical 276 sec. (1000 psia chamber pressure, 14.7 psia nozzle exit pressure) than was possible in the smaller *Able*. The pressure-fed propulsion system has a single regeneratively cooled thrust chamber.

The Air Force Ballistic Missile Division awarded the contract last fall but kept the facts classified until last week. The amount of money involved was not disclosed.

Aerojet's major subcontractor is Space Electronics Corp., a subsidiary of Pacific Automation Products, in Glendale, Calif., which is responsible for fabrication, checkout and launch services of the electronic systems.

In the contract, Aerojet is program manager of all phases of the *Able Star* vehicle, including control, analysis, design, fabrication, checkout, ground testing and flight testing. On the *Able*, Douglas Aircraft Corp. was prime system manager and Aerojet built the engine.

Able Star was designed for use with a first-stage *Atlas*, *Thor* or *Titan* booster. The design enables it to shut down and restart at altitude while maintaining proper attitude orientation during the coast period. For placing a satellite in an orbital path of 300 to 600 miles, the shutdown-restart capability makes a third stage unnecessary.

The new vehicle is now undergoing pre-flight rating tests at Aerojet's Azusa plant. The first vehicle will probably be delivered to Cape Canaveral for flight test within six months.

After it passes flight tests, *Able Star* will be used on Project *Transit*, the Navy navigation satellite program; Project *Courier*, the Army communications satellite; and other space programs. The two former projects are ARPA programs due to be turned over to the individual services this year.

Aerojet's Systems Division, directed by Marvin L. Stary, is responsible for the *Able Star* program. Seba Eldridge, division chief of technical staff, is program manager.

APL Researchers Produce Resonant Burning Study

PRINCETON, N.J.—A thorough analysis of resonant burning, an unexplained headache that has plagued solid-propellant rocket designers since the early days of World War II, has been put forth by three Johns Hopkins University scientists.

F. T. McClure, R. W. Hart and J. F. Bird of Johns Hopkins' Applied Physics Laboratory presented their findings in a paper delivered Jan. 28 at the American Rocket Society's Solid Propellant Conference at Princeton University. About 600 attended.

"Since nothing particularly mysterious has been introduced into the description," McClure and associates declared, "it would appear that appropriate studies of the component parts of this synthesis could lead to its verification and to a more adequate quantitative description of the phenomenon."

Resonant burning in solid rockets has been responsible for many failures. The harmonic reinforcement of sound waves within the chamber appeared to operate similarly to the familiar phenomenon of harmonic vibrations on a bridge or other structure—the reason why the military requires marching soldiers to break step.

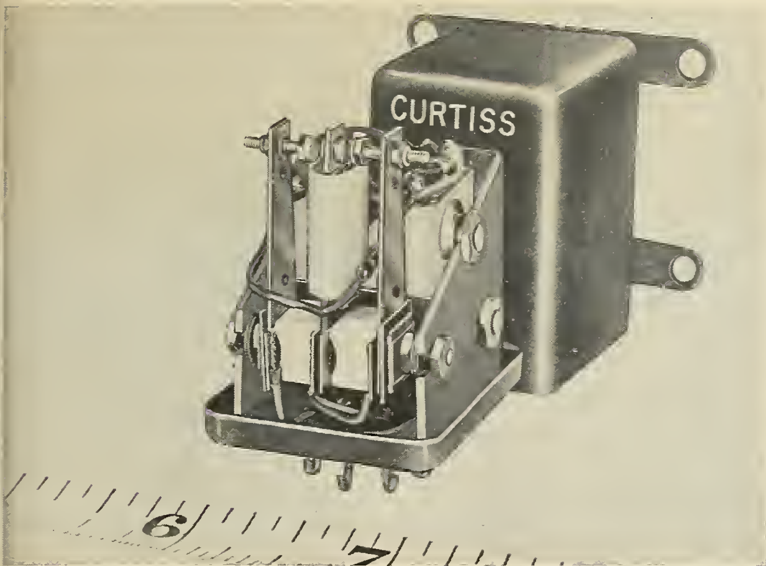
The Johns Hopkins scientists found that the thin burning zone in a solid rocket is generally capable of amplifying pressure disturbances at the surface. Thus self-sustaining oscillations take place when the gain balances the losses in the gas cavity.

The tendency to oscillate in a given cavity mode, McClure and associates found, is greatest for a web thickness such that the mode has an acoustic pressure maximum at the surface. The group reported considerable investigation by computer of the mode systems and the regions of instability.

The Johns Hopkins group said it had no clear explanation for the apparent efficacy of additives such as aluminum powder in suppressing resonance.

Mach 2 Sled Tests Minuteman

HIGHBALLING down the track at Holloman AFB, this Air Force three-chambered sled is capable of Mach 2 speeds. Propelled by Aerojet-General liquid engines, the vehicle accelerates at a force of eight to 10 g and has a total thrust of 114,000 lbs. It is being used to test the guidance system for *Minuteman*.



Relay Features Isolated Switching

A new Curtiss-Wright STR Series relay provides a unique combination of features to meet missile requirements. The STR relay affords instantaneous resetting, isolated load contacts, preset T/D 20-180 seconds, voltage compensation, ambient temperature compensation, single pole douhle throw contacts, and is hermetically sealed.

The relay will reset the instant it is de-energized, providing the same time delay period for each succeeding cycle. This operational advantage has heen achieved by using a special thermal element in conjunction with a pair of magnetic relays. This component comhination utilizes the heating and cooling intervals to obtain the total time delay period.

Voltage compensation is provided for operation on 22 to 32 volts dc. Temperature compensation is over the range of –65°C to 125°C. The unit may be operated under high shock and vibration.

Power drain is less than 3 watts after the timing period, 10 watts during timing. Contact rating is 2 amperes at 28 volts dc resistive load. Approximate dimensions: 1-5.8in. x 1-3/16in. x 1½in. with bracket or stud mounting.

Circle No. 225 on Subscriber Service Card.

U.K. Tape Recorder

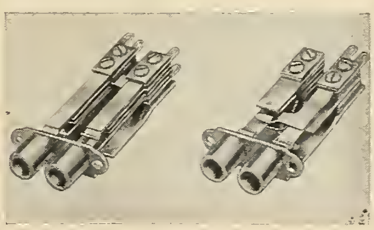
Royston Instruments Ltd., of Great Britain is manufacturing a subminiature magnetic tape recorder for handling flight data, primarily in missiles. The recorder measures 4½ x 5½ x 3", and carries 500' tape on spools in a reloadable cassette which also contains the purely mechanical take-up and supply spool drives and tape tensioning.

It can he supplied with tape speeds anywhere in the range of 30"/sec. down to 1/10"/sec. and records eight channels in line on a single head. Power consumption is about 5 watts. With an armoured steel cassette it weighs about 16 lh., but a solid light alloy cassette is usually strong enough for service even in missiles, and with this the total weight is reduced to 11 lb.

Circle No. 226 on Subscriber Service Card.

New Twin-Jacks

A long frame type "Twin-Jax," designed for high-quality communica-



tion equipment, has been developed by Switchcraft, Inc.

Frame is double width with two mounting ears on 1-3/8in. centers and the bushings (sleeves) are on 5/8 in. centers. The unit is availahle in two types: MT-388 (Military Type JJ-088) has a circuit shorting feature that is broken when a two-conductor plug is inserted into either sleeve, individually or simultaneously; MT-389 has three-conductor jacks interconnected, so that the circuit is broken when a plug such as Switchcraft No. 482 (PJ-051) is inserted in one of the Jacks.

Circle No. 227 on Subscriber Service Card.

Fluorinated Elastomer

Significant improvement in workability of a highly-fluorinated elastomer that is rated for service above +400°F and resists corrosive chemicals has been announced hy Minnesota Mining and Manufacturing Co.

The firm will continue to use the name "Fluorel" KF-2141 Brand Elastomer on the product, introduced a year ago, although the new version has a Mooney scorch rating almost three times that of the original product—which is in the ideal range for rubber processing. It provides a fast cure with good heat aging quailties. The synthetic retains all other characteristics including low compression set after curing.

Circle No. 228 on Subscriber Service Card.

Orbital Mass Spectrometer

Consolidated Systems Corp., a subsidiary of Bell & Howell/CEC, has hegun prototype testing of a miniature mass spectrometer to he placed in orbit within a satellite hy NASA in 1961 to measure elements of the exosphere.

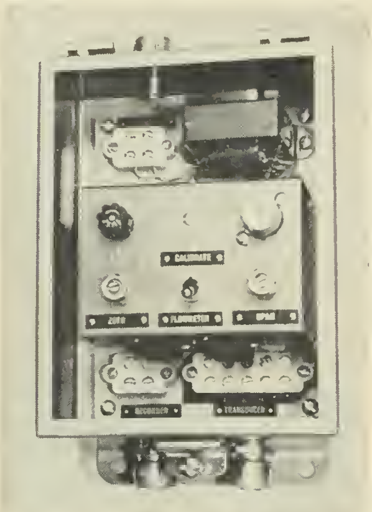
The double-focusing instrument will

be able to accept particles from wide hemispherical entrance angles and will have an energy spread of ±12 volts. It can measure ions, molecules, atoms, and free radicals to be encountered by the 35-in. diameter satellite in the region between 150 and 600 miles above the earth.

Circle No. 229 on Subscriber Service Card.

Strainer Gage Adapter

The SGA-100B Strain Gage Adapter, produced by the Ramapo Instrument Company, Inc., makes possible precision indicating, recording and controlling with strain gage transducers by utilizing equipment readily available in most installations. All necessary circuitry is included for the read-out of any strain gage type flow, pressure, weight, or force transducer on self-balancing dc millivolt potentiometers or recording oscillographs of suitable sensitivity.



Circle No. 230 on Subscriber Service Card.

Dial Groove Gages

Instant, accurate readings of internal groove dimensions permitting inspection without removing the work

from the machine and without using a micrometer are now possible with the new, economical line of E-Z Dial Groove Gages being introduced by Maxwell Industries, Inc.

Maxwell's lever action and dial indicator provide a measuring range from .2in. to 1.6in., with the small dial reading to the nearest hundredth of an inch and the large dial hand indicating the nearest half-thousandth of an inch. Each gage has an approximate range of .4in. in the smaller sizes while the larger sizes have a range of .8in. The unit reads accurate to fractions of .0005 in.

Circle No. 231 on Subscriber Service Card.

Two-Way Radios

Motorola is further expanding its extensively transistorized line of MOTRAC two-way radios with introduction of a 100-watt unit to operate in the low band (25-54 mc) frequencies.

The addition gives Motorola a complete line of units for operation in both low band and high band (144-174 mc) frequencies. Besides the new 100-watt unit, the company manufactures 25-watt and 50-watt models in low band, and 30-watt, 60-watt and 80-watt models for operation in the high band frequencies.

Like the other models, the new 100-watt unit will accommodate either positive or negative vehicular battery ground polarity.

Circle No. 232 on Subscriber Service Card.

Platinum Coating

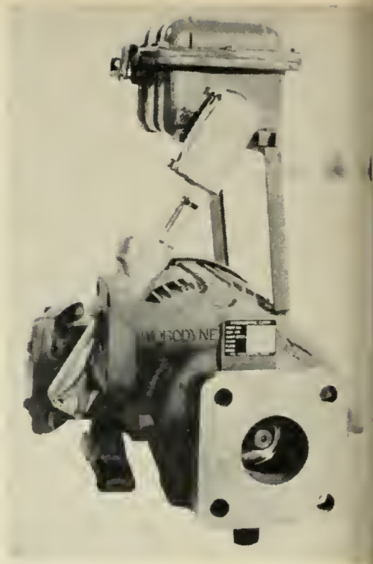
Using a technique developed by the Mond Nickel Co., Ltd., of Great Britain, the Baker Platinum Division of Englehard Industries Ltd. is now coating unglazed ceramic bodies with a continuous layer of platinum. The metal is applied in a liquid form, then fired to burn away the vehicle and bond the metal to the surface non-porous layers 0.005-0.01" thick can be applied and protect the refractory from corrosive agents.

Circle No. 233 on Subscriber Service Card.

Cryogenic

Hydrodyne Corp. has announced a line of utility pumps for ground support and test stands using cryogenic and other fluids.

The units are close coupled to an electric motor and have a range to 1500 gpm at differential pressures to 500 psi. The pump illustrated is 150

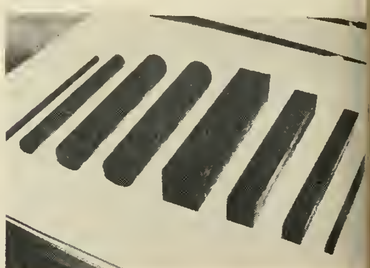


gpm with 20-foot head rise; 6-foot suction head (NPSH); 2½-in. suction; and 1½-in. discharge.

Circle No. 234 on Subscriber Service Card.

Microwave Absorber Bar

Radite No. 75, a new microwave absorbing plastic, is designed for use as both coaxial and waveguide terminations and attenuators. It can be turned bored, tapped, drilled, threaded or milled just like a metal; and it is rigid, non-porous, and allows working to fine



tolerances. Radite No. 75 is available in stardardized 12in. bar stock, (round ½in. to 2-1/8in. square: ½in. to 2-3/8in), and comes with detailed machining instructions. It also may be poured or moulded to any configuration and size desired as a special order item.

Circle No. 235 on Subscriber Service Card.

Pneumatic Programmer

A new pneumatic program transmitter with interchangeable cams offering a choice of 1, 8, 12, 24-hour and 7-day cam drives has been announced by the Weston Instrument Division of Daystrom, Inc.

The programmer—designated as Model 7002—handles one or two transmission systems, transmits a 3-15 psi pneumatic signal, and can be used with single or double cams. The unit is supplied with universal mounts—flush or surface—and encased in a dust and moisture-resistant metal cabinet. The case features a flush latch handle, entirely eliminating front projections. A door stop limits opening swing to 135°.

Circle No. 236 on Subscriber Service Card.

Teflon Zipper

The Zippertubing Company has perfected a teflon closure of "Z-Trac" design, the first zipper of this type to be marketed. It is designed for closures that must submit to extremely high-temperature conditions.

The Zippertubing Company is offering the Z-Trac closure on its ALAS

and ALSR high-temperature and chemical resistant Zippertubing and on the all-teflon jackets. On the all-teflon jackets, the Z-Trac is sewn with teflon-coated glass thread to a 6 to 10 mil sheet material of teflon-impregnated glass cloth. A pressure-sensitive tape can be heat-processed over the stitching to seal needle holes if liquid oxygen, red fuming nitric acid or similar agents are used a r o u n d the cable jacket.

Circle No. 237 on Subscriber Service Card.

Pressure Transducer

Dynisco, Inc., announces development of new high-frequency response differential pressure transducer Model PT 69. In this model both corrosive and conductive media can be applied to either side of a single diaphragm.

The transducer is fully compensated for temperature effects through the range of −65 to 300°F and is available in both uni-directional pressure ranges from 0 to 10 psid, to 0 to 3000 psid and bidirectional pressure ranges from ±5 to ±1500 psid. It measures 2½ x 2½ x 2¼ in.; total weight is 17 ounces.

Circle No. 238 on Subscriber Service Card.

Video Receiver Testers

A new team of microwave components that can provide an automatic testing system for crystal video receivers have been developed by American Electronic Laboratories, Inc.

The system incorporates a circularly polarized horn, high pass filter and a band pass "Waffle Iron" filter and waveguide switch. The switch permits disconnecting the antenna, and connecting an impulse generator, thereby injecting an artificial signal to test the receiving equipment and crystal in particular.

Circle No. 239 on Subscriber Service Card.

Vacuum Furnace

Marshall Products Co. has announced availability of a new high vacuum furnace, known as the Model 58-HD, for making hardness tests at temperatures up to 3000° F.

Heating element is a cylinder of sheet molybdenum 3 in. I.D. by 12¾ in. long. The element and its surrounding radiation shielding is provided in a single unit assembly for easy removal and access to the assembly and to the interior of the plated tank for cleaning and polishing.

Circle No. 240 on Subscriber Service Card.

new literature

SILICONE PRODUCTS. A 1960 guide to General Electric's complete line of silicone products is now available in an eight-page illustrated bulletin. Listing major product uses and benefits, this publication features GE silicones for: antifoam and release agents, lubricants, paper release, cosmetics and polishes, masonry water repellents, paint and paint additives, textile finishes, and electrical insulation. Another section is devoted to silicone rubber, including liquid RTV (room temperature vulcanizing) silicone rubber compounds.

Circle No. 200 on Subscriber Service Card.

THICKNESS TESTERS. Two portable thickness testers, Audigage Model 5 and Model 6, are detailed in an eight-page Bulletin A-200 available from Branson Instruments, Inc. Their ultrasonic gages permit measurement of thickness from only one side of a wide variety of materials—metal, glass, plastic—by relating a variation in thickness to the change in resonant frequency. An Audigage will detect laminar flaws, and check for corrosion loss. It is often used on pressure vessels, piping, storage tanks, boiler tubes, ship hulls and bulkheads, hollow forgings, extrusions, castings, as well as large plates and sheets.

Circle No. 201 on Subscriber Service Card.

TIME SEQUENCER. Magnetic Amplifiers, Inc. has made available an eight-page color brochure on a Static Time Sequencer which it says represents the newest development in solid-state magnetic switching. The Time Sequencer is a self-contained programmer which provides control/power signals for automatically performing test operations, such as missile countdown, in sequence. The equipment is also applicable to automated industrial process control.

Circle No. 202 on Subscriber Service Card.

BALL BEARINGS—A 140-page "Design and Purchasing Manual" on miniature and instrument ball bearings has just been published by New Hampshire Ball Bearings, Inc. and is available to qualified engineering and purchasing personnel. Complete specifications on 370 standard New Hampshire bearings from 1/10 to 5/8 in. OD are included, as well as 22 bulletins discussing factors in bearing life and operation.

Circle No. 203 on Subscriber Service Card.

ZIRCONIUM. A Zirconium Fact File in one package is being issued by the Zirconium Assoc. The Fact File will contain technical data, application and available forms of this unique metal as information is developed and compiled by manufacturers and fabricators. Data and sources of supply of zirconium for executives, technical and research personnel engaged in chemical processing, electronics, automotive, aircraft, missiles and other fields are given.

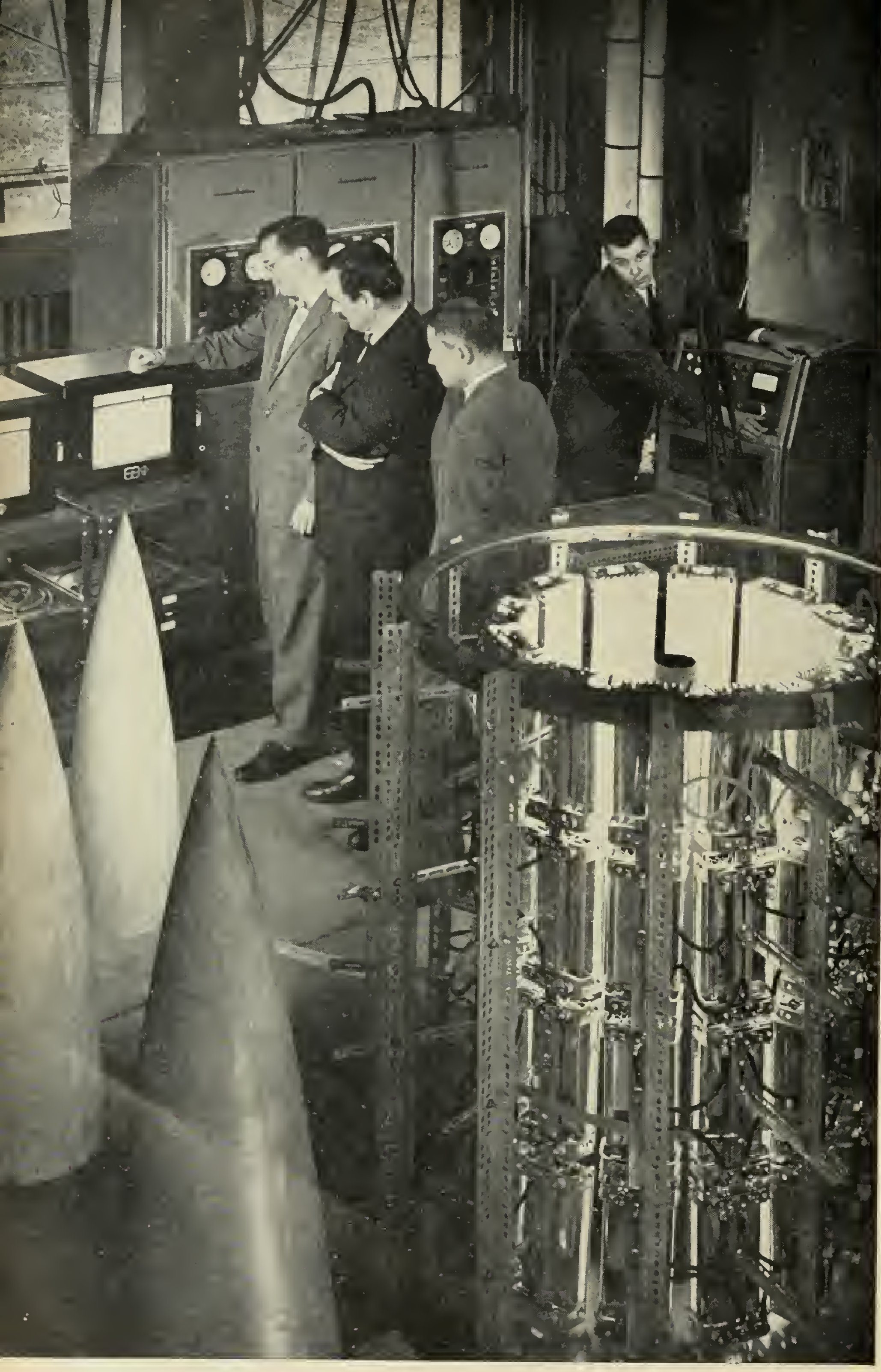
Circle No. 204 on Subscriber Service Card.

PHENOLIC LAMINATES. TRC, a new high-strength reinforced phenolic laminate which withstands temperatures in the 1000°F range without blistering or delaminating, is described in a bulletin published by Riverside Plastics Corp. The bulletin gives temperature vs. time data on flexural strength, flexural modulus, tensile strength and edgewise compression.

Circle No. 205 on Subscriber Service Card.

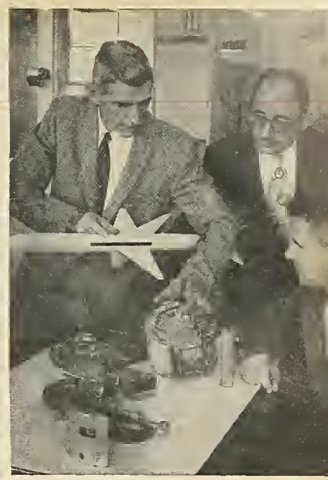
MAGNETIC PERFORMANCE AND DESIGN DATA—Magnetic Metals Company has available a 24-page Bulletin C-5 giving extensive design data, test data and magnetization curves for centricores (toroidal cores wound from thin magnetic tapes), stamped ring cores (made from laminations), and precision die-cut DU-laminated cores. Also included is data on Super Squaremu "79" Centricores for magnetic amplifier applications.

Circle No. 206 on Subscriber Service Card.



"MISSILES AND ROCKETS magazine is particularly valuable to us as it helps anticipate new and future trends through its concise technical news coverage." Fred R. Youngren, Manager, Raytheon's Aeromechanical Branch. In the picture above, Mr. Youngren (left) explains to Hal Gettings (center) of the editorial staff of Missiles and Rockets, the Raytheon thermal shock test process for ceramic radomes. It is through tests such as these that improved radomes have been produced to meet the requirements and conditions demanded by higher and faster missile flight.

WHO



lark C. Abt (left), Manager of Raytheon's Advanced Sys-m Studies Section and a regular reader of Missiles and ockets magazine, discusses some of the problems of anti-allistic missile defense with M/R Editor Hal Gettings. This articular section of Raytheon is working on the design and nalysis of systems to detect, track and intercept threatening ehicles from sea, the atmosphere and space. This program a natural outgrowth of Raytheon's extensive studies of r defense by means of surface-to-air and air-to-air guided issile systems.

"Even when a component is developed to a fine point, there is still a problem of extending the *state of the art*. The weekly issues of Missiles and Rockets keep us posted on the latest achievements of other companies in the missile/space field." Bertrand E. Chatel (left), Gyro Section Manager.

(above right) "High power output in a small reliable package is a basic requirement for electrical power units. Missiles and Rockets continually provides us information in related areas of engineering." John V. Kelly (left), Head of the Engineering and Mechanical Design Section.

READS MISSILES AND ROCKETS?

Well, for example . . .
TOP ENGINEERS AT RAYTHEON

Raytheon's Missile Systems Division has achieved outstanding success in pioneering and producing major missile systems. Two of these have been for the U. S. Navy air-to-air Sparrow III and the U. S. Army ground-to-air Hawk. These achievements, conclusive proof of unlimited capabilities, received their chief impetus when a Raytheon-developed guidance system installed in the Navy's experimental Lark achieved history's first successful interception in 1950 and first destruction of an airplane by a guided missile in 1951.

Much of Raytheon's success in guided missile systems since 1944 is credited to the tight integration of systems and component engineers. Close liaison of these groups provides systems engineers with rapid assessment of potential advances in "state of the art" of components and circuits, and also gives component engineers early indication of future requirements for meeting the needs of new, more complex missile and space systems.

Raytheon's Gnat gyros, for example, were first in the field, have been continuously refined, and now are mass-produced. Thermal effects of ever higher supersonic speeds are continuously being met by newly developed ceramic radomes—the largest being 4 feet long, 15 inches in diameter, and weighing 90 lbs. Highly reliable Electrical Power Units (EPU's) have been compacted into the smallest of spaces.

The further ability to carry these and other developments through flight test and into quantity production has resulted in the present top performance and high reliability for Raytheon's Hawk and Sparrow III missiles.

Experience of accomplishments in the broad field of missile and space sciences has promulgated study and development programs in solar energy conversion, ion propulsion, very-long-range ICBM tracking and identification radar, infrared missile applications and range instrumentation systems. Parallel advances also have followed logically, with studies of AICBM systems and investigation of means for defense against satellites.

TELL YOUR PRODUCT OR CAPABILITY STORY TO 29,000 MISSILE TECHNICIANS ... PAID SUBSCRIBERS ... THROUGH THE PAGES OF MISSILES AND ROCKETS MAGAZINE—THE TECHNICAL/NEWS WEEKLY OF THE MISSILE/SPACE MARKET.

M/R

missiles and rockets

AN AMERICAN AVIATION PUBLICATION
1001 VERMONT AVENUE, N. W., WASHINGTON 5, D. C.

Five-hundred prime contractors won $5,173 million—or 99%—of contracts of $10,000 or more awarded by the Department of Defense for experimental, developmental, test and research work in Fiscal Year 1959.

The total value of awards for such work in FY '59 was $5,246 million, compared to $4,077 million in FY '58.

North American Aviation, Inc., was at the top of a list of the 500 issued by the Office of the Secretary of Defense. The company was awarded $567 million during FY '59—10.9% of the total.

Lockheed Aircraft Corp. was second, with $511 million (9.8%); General Electric Co. third, $395 million (7.6%); General Dynamics Corp. fourth, $313 million (6.0%); and The Martin Co. fifth, $284 billion (5.5%).

• **'Spread' demanded**—The report was issued by the Pentagon as pressure built up among some key congressional Democrats for a bigger "spread" of defense R&D contracts. They cited figures showing that large firms are getting about 97% of all defense R&D funds.

A statement accompanying the Defense Department list did not give a total figure for awards to small business firms. It noted only that of the 397 business concerns on the list, 142 or 36% were small firms.

Besides the 500 listed contractors, the Department said, there were 1,251 business and non-profit concerns that received prime contracts of $10,000 or more, making a total of 1751 contractors in all. Of this total, 287 were government and non-profit organizations. Of the remaining 1464 contractors, 31 were foreign concerns, 589 were large U.S. business concerns, and 844 or 58% were small business firms.

Here is the list of 500, arranged in two sections. The first section includes the 397 business firms; the second section includes 103 government agencies and non-profit institutions:

SECTION I—397 BUSINESS FIRMS

Rank		Thousands of Dollars
1.	North American Aviation, Los Angeles	$567,744
2.	Lockheed, Burbank, Cal.	511,430
3.	General Electric, Schenectady, N. Y.	395,057
4.	General Dynamics, New York	313,061
5.	Martin Company, Baltimore	284,039
6.	Western Electric, New York	226,037
7.	Sperry Rand, New York	208,951
8.	Douglas, Santa Monica, Cal.	208,266
9.	Aerojet General, Cincinnati	161,955
10.	Boeing, Seattle	155,781
11.	Westinghouse, Pittsburgh	120,916
12.	General Motors, Detroit	85,828
13.	United Aircraft, East Hartford, Conn.	78,651
14.	Thiokol Chemical, Trenton, N. J.	73,871
15.	Pan American Airways, New York	71,380
16.	Raytheon, Waltham, Mass.	62,180
17.	Space Technology Labs., Los Angeles	61,030
18.	Avco Corp., New York	54,266
19.	American Bosch Arma, Hempstead, N. Y.	54,230
20.	Hughes Aircraft, Culver City, Cal.	49,480
21.	IBM, New York	47,809
22.	Bendix Aviation Corp., Detroit	47,410
23.	IT&T, New York	42,563
24.	Radio Corp. of America, Camden, N. J.	40,589
25.	Burroughs, Detroit	37,795
26.	McDonnell, St. Louis	32,441
27.	Republic, Farmingdale, N. Y.	27,962
28.	Sylvania, New York	27,401
29.	Collins Radio, Cedar Rapids, Iowa	24,929
30.	Goodyear Aircraft, Akron, Ohio	24,919
31.	Northrop, Beverly Hills, Cal.	23,086
32.	Hercules Powder, Wilmington, Del.	21,184
33.	Minneapolis Honeywell, Minneapolis	19,285
34.	Airborne Instruments Lab., Mineola, N. Y.	18,725
35.	Amer. Machine & Foundry, New York	17,997
36.	Bell Aircraft, Buffalo	17,885
37.	Thompson Ramo Wooldridge, Los Angeles	17,403
38.	Fairchild, Hagerstown, Md.	17,047
39.	Callery Chemical, Callery, Pa.	14,943
40.	Temco, Dallas	14,541
41.	Olin Mathieson, New York	13,738
42.	Philco, Philadelphia	13,025
43.	Litton Industries, Beverly Hills, Cal.	12,251
44.	Hayes Aircraft, Birmingham, Ala.	11,333
45.	Sangamo Electric, Springfield, Ill.	10,740
46.	Aeronutronic Systems, Glendale, Cal.	10,004
47.	Vitro Corp., New York	9,835
48.	Sundstrand, Rockford, Ill.	9,712
49.	Hoffman Electronics, Los Angeles	9,486
50.	General Mills, Minneapolis	9,421
51.	Marquardt, Van Nuys, Cal.	9,389
52.	Continental Electronics, Dallas	8,861
53.	Motorola, Chicago	8,377
54.	Land Air, Chicago	8,323
55.	Curtiss Wright, Wood-Ridge, N. J.	8,261
56.	Hazletine, Little Neck, N. Y.	7,808
57.	Rheem Mfg., New York	7,569
58.	A C F Industries, New York	7,554
59.	Vertol Aircraft, Morton, Pa.	7,471
60.	Melpar, Falls Church, Va.	6,816
61.	Sanders Associates, Nashua, N. H.	6,642
62.	Grumman, Bethpage, N. Y.	6,469
63.	Hallicrafters, Chicago	6,138
64.	Air Products, Allentown, Pa.	6,056
65.	Northern Ordnance, Minneapolis	5,500
66.	Atlantic Research, Alexandria, Va.	5,079
67.	Ryan Aeronautical, San Diego, Cal.	5,044
68.	Interstate Electronics, Anaheim, Cal.	4,982
69.	Control, Minneapolis	4,965
70.	Magnavox, Fort Wayne, Ind.	4,944
71.	Librascope, Glendale, Cal.	4,930
72.	American Radiator, New York	4,746
73.	Chrysler, Detroit	4,733
74.	Acoustic Associates, Mineola, N. Y.	4,595
75.	Cook Electric, Chicago	4,380
76.	Astrodyne, McGregor, Tex.	4,316
77.	Stavid Engineering, Plainfield, N. J.	4,259
78.	Clevite, Cleveland	3,691
79.	Universal Match, St. Louis	3,585
80.	Bell Helicopter, Ft. Worth	3,535
81.	Radiation, Melbourne, Fla.	3,464
82.	Brown Engineering, Huntsville, Ala.	3,445
83.	Food Machinery, San Jose, Cal.	3,409
84.	Little A. D., Cambridge, Mass.	3,404
85.	Telecomputing Corp., Los Angeles	3,373
86.	Emerson Electric, St. Louis	3,344
87.	Fairchild Camera, Syosset, N. Y.	3,323
88.	Cubic Corp., San Diego, Cal.	3,301
89.	Solar Aircraft, San Diego, Cal.	3,223
90.	Beech, Wichita, Kan.	3,196
91.	Eastman Kodak, Rochester	3,188
92.	Texas Instruments, Dallas	3,052
93.	Rohm & Haas, Huntsville, Ala.	3,024
94.	Polytechnic Research, Brooklyn, N. Y.	2,982
95.	Garrett Corp., Los Angeles	2,964
96.	American Optical, Southbridge, Mass.	2,642
97.	Borg Warner, Chicago	2,575
98.	Harvey Aluminum, Torrance, Cal.	2,507
99.	Continental Aviation & Engineer, Detroit	2,494
100.	LeTourneau (R. G.), Longview, Tex.	2,426
101.	Loral Electronics, New York	2,400
102.	Edo Corp., College Point, N. Y.	2,299
103.	Daystrom, Elizabeth, N. J.	2,280
104.	Aircraft Armaments, Cockeysville, Md.	2,257
105.	Gilfillan Bros., Los Angeles	2,252
106.	Ford Motor Co., Dearborn, Mich.	2,213
107.	Varian Associates, Palo Alto, Cal.	2,208
108.	Reeves Instrument, New York	2,143
109.	Dumont Laboratories, Clifton, N. J.	2,136
110.	Belock Instrument, College Point, N. Y.	2,092
111.	Emerson Radio, Jersey City, N. J.	2,046
112.	Litton Maryland, College Park, Md.	2,043
113.	Combustion Engineering, Chattanooga, Tenn.	2,008
114.	Maxson (W. L.), New York	1,960
115.	Electro-Optical Systems, Pasadena, Cal.	1,934
116.	Union Carbide, New York	1,887
117.	Dow Chemical, Midland, Mich.	1,870
118.	All American Engineering, Wilmington, Del.	1,853
119.	Coleman Engineering, Los Angeles	1,848
120.	Lenkurt Electric, San Carlos, Cal.	1,838
121.	Elgin Watch, Elgin, Ill.	1,805
122.	Barnes Engineering, Stamford, Conn.	1,767
123.	Tracerlab, Boston	1,733
124.	Flightex Fabrics, Cambridge, Mass.	1,724
125.	Allied Research, Boston	1,634
126.	Air Logistics, Pasadena, Cal.	1,632
127.	Technical Appliance, Sherburne, N. Y.	1,627
128.	Ampex, Los Angeles	1,579
129.	U. S. Steel, Pittsburgh	1,515
130.	TRG, Inc, New York	1,483
131.	Minnesota Mining, Minneapolis	1,469
132.	Hiller Aircraft, Palo Alto, Cal.	1,465
133.	Ceir, Arlington, Va.	1,453
134.	Cleveland Pneumatic, Cleveland	1,382
135.	Bulova, Woodside, N. Y.	1,376
136.	Pacific Car & Foundry, Renton, Wash.	1,310
137.	Arinc Research, Washington, D. C.	1,258
138.	Esso Research & Engineering, Elizabeth, N. J.	1,254
139.	Piasecki, Philadelphia	1,213
140.	Flexonics, Maywood, Ill.	1,199
141.	Autometric, New York	1,189
142.	Aeronca Manufacturing, Middletown, Ohio	1,188
143.	Technical Operations, Burlington, Mass.	1,169
144.	Hughes Tool, Culver City, Cal.	1,139
145.	Perkin Elmer, Norwalk, Conn.	1,130
146.	Telephonics, Huntington, L. I., N. Y.	1,115
147.	AFN Inc., Los Angeles	1,113
148.	Polarad Electronics, Long Island City, N. Y.	1,080
149.	Santa Barbara Research, Goleta, Cal.	1,077
150.	Ferrand Optical, New York	1,077

Rank		Thousands of Dollars
151.	Times Facsimile, New York	1,046
152.	Technitrol Engineering, Philadelphia	1,046
153.	Kearfott Co., Clifton, N. J.	1,044
154.	National Company, Malden, Mass.	1,040
155.	Goodrich (B. F.), Akron, Ohio	1,033
156.	Computer Control, Babson Park, Mass.	1,014
157.	Electronic Communications, Teterboro, N. J.	1,013
158.	Underwood Corp., New York	1,000
159.	Monsanto Chemical, St. Louis, Mo.	992
160.	American Electronic Lab., Philadelphia	987
161.	Edgerton Germeshausen & Grier, Boston	983
162.	Radiation Engineering Labs., Maynard, Mass.	968
163.	Bliss (E. W.), Canton, Ohio	964
164.	Eitel McCullough, San Bruno, Cal.	955
165.	Barnes and Reinecke, Chicago	949
166.	Developmental Engineering, Washington, D. C.	942
167.	Standard Oil (Indiana), Chicago	924
168.	Bolt, Beranek & Newman, Cambridge, Mass.	918
169.	HRB Singer, State College, Pa.	906
170.	Link Aviation, Palo Alto, Cal.	897
171.	Carrier Corp., Syracuse	893
172.	Textron, Belmont, Cal.	889
173.	Aerolab Development, Pasadena, Cal.	855
174.	Booz Allen Applied Research, Kenilworth, Ill.	843
175.	National Cash Register, Dayton, Ohio	833
176.	Firestone, Akron, Ohio	812
177.	Norman Engineering, Beverly Hills, Cal.	810
178.	McKiernan Terry, Dover, N. J.	802
179.	Stearns-Rogers Mfg., Denver	799
180.	Pickard-Burns, Needham, Mass.	792
181.	General Electronics Laboratories, Cambridge, Mass.	791
182.	Whirlpool, St. Joseph, Mich.	789
183.	Dynatronics, Orlando, Fla.	781
184.	Plasmadyne, Santa Ana, Cal.	771
185.	Kaman Aircraft, Bloomfield, Conn.	768
186.	Hamilton Watch, Lancaster, Pa.	768
187.	Reynolds Metals, Richmond	766
188.	Experiment, Inc., Richmond	765
189.	Allied Chemical, New York	761
190.	Wyandotte Chemical, Wyandotte, Mich.	755
191.	Dunlap & Associates, Stamford, Conn.	751
192.	White Motor Co., Detroit	739
193.	Laboratory for Electronics, Boston	732
194.	Geotechnical, Dallas	726
195.	American Cynamid, New York	720
196.	Watkins Johnson, Palo Alto, Cal.	715
197.	Consolidated Electrodynamics, Pasadena, Cal.	713
198.	Federal Electric, Paramus, N. J.	710
199.	Chamberlain, Waterloo, Iowa	707
200.	Microwave Associates, Burlington, Mass.	694
201.	Beechcraft Research, Wichita, Kan.	690
202.	Planning Research, Los Angeles	688
203.	Lear, Santa Monica, Cal.	686
204.	Applied Science, Princeton, N. J.	685
205.	Instruments for Industry, Mineola, N. Y.	684
206.	Gruen Applied Science Lab., Hempstead, N. Y.	681
207.	EPSCO, Inc., Boston	679
208.	Eastern Precision Resistor, Brooklyn, N. Y.	676
209.	Continental Motors, Muskegon, Mich.	673
210.	Design Service, New York	673
211.	Control Instrument, Brooklyn, N. Y.	665
212.	Admiral Corp., Chicago	654
213.	Stauffer Chemical, Azusa, Cal.	649
214.	C.G.S. Labs, Ridgefield, Conn.	649
215.	United Electrodynamics, Pasadena, Cal.	644
216.	Doak Aircraft, Torrance, Cal.	640
217.	Telemeter Magnetics, Los Angeles	635
218.	Cooper Development, Monrovia, Cal.	633
219.	American Marietta, Wheeling, Ill.	630
220.	Clark (David) Co., Worcester, Mass.	630
221.	Alco Products, Schnectady, N. Y.	626
222.	Kennedy (D. S.), Cohasset, Mass.	618
223.	Bermite Powder, N. Hollywood, Cal.	617
224.	Pennsalt Chemical, Philadelphia	615
225.	Robertshaw Fulton, Greensburg, Pa.	614
226.	Galloway (G. W.), Arcadia, Cal.	612
227.	Sanders and Thomas, Pottstown, Pa.	604
228.	Seeburg, Chicago	593
229.	Baird Atomic, Cambridge, Mass.	577
230.	Thompson (John I.), Washington, D. C.	573
231.	Smyth Research, San Diego, Cal.	570
232.	Struthers Wells, Warren, Pa.	570
233.	Webcor, Chicago	569
234.	Packard Bell, Los Angeles	564
235.	Electronic Associates, Long Branch, N. J.	560
236.	Consultants and Designers, Arlington, Va.	557
237.	Operations Research, Silver Spring, Md.	547
238.	Comstock & Wescott, Cambridge, Mass.	542
239.	DuPont (E. I.) de Nemours, Wilmington, Del.	540
240.	Gyrodyne, New York	505
241.	Dewey (G. C.), New York	500
242.	Ethyl Corp., Detroit	499
243.	Manson Laboratories, Stamford, Conn.	498
244.	Servo Corp. of America, New Hyde Park, N. Y.	494
245.	Aero Service, Philadelphia	491
246.	Alloyd Research, Watertown, Mass.	487
247.	Shell Development, Emeryville, Cal.	486
248.	Magnesium Products, Milwaukee	477
249.	Crucible Steel, Pittsburgh	473
250.	United Geophysical, Pasadena, Cal.	472
251.	Gulton Industries, Metuchen, N. J.	472
252.	Washington Technological, Rockville, Md.	467
253.	Universal-Cyclops Steel, Bridgeville, Pa.	467
254.	Electro-Mechanical Research, Sarasota, Fla.	465
255.	National Research, Boston	464
256.	U. S. Rubber, New York	460
257.	Budd Co., Philadelphia	458
258.	Benson Lehner, Los Angeles	457
259.	Progressive Welders, Pontiac, Mich.	452
260.	Fenske, Fedrick & Miller, Los Angeles	451
261.	Jamesbury, Worcester, Mass.	448
262.	Jansky & Bailey, Washington, D. C.	448
263.	Bridgeport Brass, Riverside, Cal.	436
264.	Titanium Metals, New York	436
265.	Turbo Machine, Lansdale, Pa.	436
266.	Hycon Manufacturing, Pasadena, Cal.	425
267.	Narmco Industries, San Diego, Cal.	422
268.	N. T. W. Corp., Los Angeles	420
269.	Tele-Dynamics, Philadelphia	413
270.	Hermes Electronics, Cambridge, Mass.	408
271.	Stewart Warner, Chicago	402
272.	Kaiser Industries, Oakland, Cal.	395
273.	Microwave Engineering Labs, Palo Alto, Cal.	395
274.	General Precision Lab., Pleasantville, N. Y.	391
275.	American Potash & Chemical, Los Angeles	389
276.	Consolidated Welding Engineering, Chicago	388
277.	Eagle Picher, Cincinnati	388
278.	General Applied Science Labs., Hempstead, N. Y.	380
279.	Caterpillar Tractor, Peoria, Ill.	376
280.	Sanborn Co., Waltham, Mass.	374
281.	Maico Co. (The), Minneapolis	364
282.	Western Gear Works, Lynwood, Cal.	363
283.	Willys Motors, Toledo	363
284.	International Latex, Dover, Del.	361
285.	Kellogg (M. W.) Co., Jersey City, N. J.	358
286.	Power Generators, Trenton, N. J.	358
287.	Otis Elevator, Cleveland	352
288.	Haloid Xerox, Rochester, N. Y.	351
289.	American M A R C, Inglewood, Cal.	350
290.	Arnonx Corp., Los Angeles	347
291.	MSA Research Corp., Callery, Pa.	347
292.	Ladish Co., Cudahy, Wisc.	346
293.	Jered Industries, Hazel Park, Mich.	345
294.	United Research, Cambridge, Mass.	344
295.	Research, Inc., Hopkins, Minn.	339
296.	Mallory Sharon Titanium, Niles, Ohio	335
297.	Darco Industries, El Segundo, Cal.	331
298.	Noble Co., Oakland, Cal.	330
299.	National Northern, West Hanover, Mass.	330
300.	Steinthal (M.) Co., New York	325
301.	Consolidated Diesel Electric, Stamford, Conn.	324
302.	Maxim Silencer Co., Hartford, Conn.	324
303.	Houston Fearless Corp., Los Angeles	321
304.	Ordnance Engineering Asso., Chicago	315
305.	Nuclear Development, White Plains, N. Y.	312
306.	Ingersoll Rand Co., Phillipsburg, N. J.	311
307.	Aerochemical Research Lab., Princeton, N. J.	309
308.	International Aerocoustics, New York	309
309.	Filtron Co., Flushing, N. Y.	307
310.	Consolidated Avionics, Westbury, N. Y.	306
311.	Ball Brothers Research, Boulder, Colo.	305
312.	Block Associates, Cambridge, Mass.	305
313.	West Coast Electronics, Beverly Hills, Cal.	305
314.	Colorado Research, Denver	304
315.	Isotopes, Inc., Westwood, N. J.	299
316.	Ewen Knight Corp., Needham, Mass.	299
317.	Huyck (F. C.) Sons, Huntington Station, N. Y.	295
318.	Aeroprojects, Westchester, Pa.	291
319.	Winzen Research, Minneapolis	288
320.	Kollsman Instrument, Elmhurst, N. Y.	287
321.	Harshaw Chemical Co., Cleveland	286
322.	Dresser Industries, Dallas, Tex.	282
323.	Permanent Filter Corp., Los Angeles	281
324.	Page Communications Engineers, Washington, D. C.	279
325.	Bausch & Lomb Optical, Rochester, N. Y.	275
326.	Ling Altec Electronics, Culver City, Cal.	274
327.	M & T Co., Philadelphia	271
328.	Mallory (P. R.) Co., Indianapolis, Ind.	270
329.	AR&T Electronics, Little Rock, Ark.	269
330.	Mine Safety Appliances, Pittsburgh	269
331.	Miller Metal Products, Baltimore	267
332.	Grand Central Rocket, Redlands, Cal.	265
333.	Bjorksten Research Labs., Madison, Wisc.	265
334.	Spaco Manufacturing Co., Huntsville, Ala.	262
335.	Townsend Engineered Products, Santa Ana, Cal.	261
336.	General Atronics Corp., Bala-Cynwyd, Pa.	260
337.	Reed Research, Washington, D. C.	260
338.	Brubaker Electronics, Culver City, Cal.	256
339.	Apex Machine Tool, Philadelphia	256
340.	CTL, Inc., Cincinnati	256
341.	Psychological Research Asso., Arlington, Va.	255
342.	Fairbanks Morse Co., Chicago	254
343.	Universal Winding Co., Providence	252
344.	Dynamics Research, Los Angeles	251
345.	Texas Nuclear Corp., Austin, Tex.	249
346.	Teague (Walter Dorwin), New York	249
347.	Breeze Corp., Inc., Union, N. J.	249
348.	Owens Corning Fiberglas, Toledo, Ohio	248
349.	Central Electronic Mfg., Denville, N. J.	248
350.	Tung Sol Electric, Newark	239
351.	North Electric Co., Galion, Ohio	238
352.	Goodyear Tire & Rubber, Akron, Ohio	237
353.	Campbell Contour Attachment, Long Beach, Cal.	237
354.	Feedback Controls, Waltham, Mass.	237
355.	Plesset (E. H.) Associates, Los Angeles	237
356.	Raymond Engineering Labs., Middletown, Conn.	236
357.	Carborundum Co., Niagara Falls, N. Y.	236
358.	Engelhard Industries, Newark, N. J.	236
359.	Stevens (L. E.) Co., Newport, Ky.	235
360.	National Scientific Labs., Washington, D. C.	232
361.	Worthington Corp., Harrison, N. J.	232
362.	Standard Mfg. Corp., Dallas	231
363.	Brush Beryllium Co., Cleveland, Ohio	231
364.	U. S. Testing Co., Hoboken, N. J.	231
365.	Fenwal Inc., Ashland, Mass.	229
366.	Gladding McBea Co., Los Angeles	228
367.	Canoga Corp. of California, Van Nuys, Cal.	227
368.	Zenith Radio, Chicago	227
369.	Oster (John) Mfg. Co., Racine, Wisc.	226
370.	Ashland Oil Refining Co., Ashland, Ky.	225
371.	Eureka Williams Corp., Bloomington, Ill.	224
372.	Aero Geo Astro Corp., Alexandria, Va.	223
373.	Royal Industries, Inc., Alhambra, Cal.	222
374.	United Shoe Machinery, Beverly, Mass.	222
375.	Scope, Inc., Fairfax, Va.	221
376.	Tenney Engineering, Union, N. J.	221
377.	Chesapeake Instrument Corp., Shadyside, Md.	218
378.	Berger Bros. Co., New Haven, Conn.	217
379.	Lionel Corp., Irvington, N. J.	216
380.	Nuclear Corp. of America, Burbank, Cal.	216
381.	Teletype Corp., Chicago	215
382.	Scandia Manufacturing Co., Baltimore	215

Rank	Thousands of Dollars
383. Stoddart Aircraft Radio, Hollywood, Cal.	214
384. Giannini (G. M.) Co., Pasadena, Cal.	213
385. Research Chemicals, Inc., Burbank, Cal.	212
386. Manufacturing Labs., Inc., Cambridge, Mass.	210
387. Documentation, Inc., Washington, D. C.	209
388. Schjeldahl (G. T.) Co., Northfield, Minn.	208
389. Packard Bell Computer, Los Angeles	208
390. New York Air Brake Co., Boston	207
391. Geophysics Corp., Boston	207
392. Stelma, Inc., Stamford, Conn.	206
393. Bomac Laboratories, Beverly, Mass.	205
394. Professional Design, Agawam, Mass.	204
395. Nordberg Mfg. Co., Milwaukee	203
396. Chu Associates, Littleton, Mass.	203
397. Hoover Electronics Co., Timonium, Md.	202

SECTION II—103 GOVERNMENT AGENCIES AND NON-PROFIT INSTITUTIONS

Rank	Thousands of Dollars
1. Massachusetts Institute of Technology, Cambridge	$88,659
2. California Institute of Technology, Pasadena	31,651
3. Johns Hopkins University, Baltimore	31,097
4. Rand Corp., Santa Monica, Cal.	13,236
5. Michigan, University of, Ann Arbor	11,690
6. Columbia University, New York	11,263
7. Stanford Research Institute, Menlo Park, Cal.	11,082
8. Cornell Aeronautical Lab., Inc., Buffalo	8,783
9. California, University of, Berkeley, Cal.	8,183
10. Leland Stanford University, Stanford, Cal.	7,744
11. Armour Research Foundation, Chicago	6,951
12. Illinois, University of, Urbana	5,202
13. New York University, New York	4,879
14. Princeton University, Princeton, N. J.	4,746
15. Chicago, University of, Chicago	4,364
16. Battelle Memorial Institute, Columbus, Ohio	4,032
17. Texas, University of, Austin, Tex.	4,007
18. Harvard University, Cambridge, Mass.	3,570
19. U. S. Department of Commerce, Washington, D. C.	3,484
20. George Washington University, Washington, D. C.	3,071
21. Penn State University, University Park	2,916
22. Minnesota, University of, Minneapolis	2,902
23. Washington, University of, Seattle	2,704
24. Ohio State University, Columbus	2,641
25. Woods Hole Oceanographic Lab., Woods Hole, Mass.	2,584
26. Cornell University, Ithaca, N. Y.	2,570
27. Dayton, University of, Dayton, Ohio	2,353
28. New Mexico College of Agric. & Mech. Arts, State College	2,092
29. National Academy of Sciences, Washington, D. C.	1,984
30. Duke University, Durham, N. C.	1,923
31. Franklin Institute, Philadelphia	1,900
32. Institute for Defense Analysis, Washington, D. C.	1,900
33. Maryland, University of, College Park	1,874
34. Southwest Research Institute, San Antonio, Tex.	1,718
35. Pennsylvania, University of, Philadelphia	1,630
36. Georgia Technical Research Institute, Atlanta	1,394
37. Brown University, Providence	1,345
38. Midwest Research Institute, Kansas City, Mo.	1,323
39. Pittsburgh, University of, Pittsburgh	1,317
40. Washington University, St. Louis	1,287
41. Illinois Institute of Technology, Chicago	1,268
42. Wisconsin, University of, Madison	1,147
43. Denver University, Denver	1,100
44. Colorado, University of, Boulder	1,067
45. Northwestern University, Evanston, Ill.	1,057
46. Carnegie Institute of Technology, Pittsburgh	1,049
47. U. S. Treasury Department, Washington, D. C.	1,015
48. Syracuse University, Syracuse, N. Y.	1,011
49. Polytechnic Institute of Brooklyn, Brooklyn, N. Y.	976
50. Analytic Services, Inc., Santa Monica, Cal.	968
51. Utah, University of, Salt Lake City	958
52. Yale University, New Haven, Conn.	952
53. American University, Washington, D. C.	908
54. Stevens Institute of Technology, Hoboken, N. J.	878
55. Mellon Institute, Pittsburgh	837
56. Alaska, University of, College	815
57. Case Institute of Technology, Cleveland	782
58. Texas A & M College, College Station	767
59. Wentworth Institute, Boston, Mass.	749
60. Smithsonian Institution, Washington, D. C.	711
61. Miami University, Coral Gables, Fla.	628
62. Rochester University, Rochester, N. Y.	621
63. U. S. Atomic Energy Commission, Washington, D. C.	604
64. Western Reserve University, Cleveland	596
65. Catholic University of America, Washington, D. C.	586
66. Southern California, University of, Los Angeles	585
67. Virginia, University of, Charlottesville	567
68. Arizona, University of, Tucson	540
69. Purdue Research Foundation, Lafayette, Ind.	514
70. Florida State University, Tallahassee	481
71. Tufts College, Medford, Mass.	472
72. American Institute of Research, Pittsburgh	465
73. Rensselaer Polytechnic Institute, Troy, N. Y.	458
74. Vanderbilt University, Nashville, Tenn.	453
75. North Carolina, University of, Chapel Hill	445
76. Massachusetts General Hospital, Boston	441
77. Oklahoma A & M College, Stillwater	429
78. Notre Dame University, South Bend, Ind.	429
79. Florida, University of, Gainesville	417
80. Southern Research Institute, Birmingham, Ala.	406
81. Northeastern University, Boston	394
82. Georgia Institute of Technology, Atlanta	370
83. Indiana, University of, Bloomington	354
84. Rutgers University, New Brunswick, N. J.	345
85. Iowa, University of, Iowa City	342
86. New Mexico, University of, Albuquerque	342
87. Cincinnati, University of, Cincinnati	328
88. Temple University, Philadelphia	324
89. Tennessee, University of, Knoxville	292
90. Lowell Technical Institute, Lowell, Mass.	284
91. Buffalo, University of, Buffalo	274
92. Oklahoma, University of, Norman	271
93. Mississippi State College, State College	266
94. North Carolina State College, Raleigh	261
95. Boston College, Chestnut Hill, Mass.	257
96. Baylor University, Houston	254
97. Oregon State College, Corvallis	235
98. Louisiana State University, Baton Rouge	231
99. Wichita, University of, Wichita, Kan.	229
100. Georgetown University, Washington, D. C.	229
101. Iowa State College, Ames	222
102. Michigan State College, East Lansing	217
103. New Hampshire, University of, Durham	209

Recent contract awards:

NAVY

$49,900—**Cleveland Consolidated, Mechanical Div of Cleveland Electric Co.,** Jacksonville, Fla., for dehumidification of magazines at the *Polaris* missile assembly, Charleston, S.C.

$43,488—**J. Young Construction Co.,** Beaufort, S.C., for construction of liquid oxygen storage and transfer facility.

$40,700—**Garland O. Banta,** Tustin, Calif., for construction of liquid oxygen transfer facilities, El Toro, Calif.

NASA

$124,000—**ACF Electronics Division of ACF Industries, Inc.,** Riverdale, Md., for production of radar beacons for use in Project *Delta*.

AIR FORCE

Minneapolis-Honeywell Regulator Co., has received a multimillion-dollar contract for building a simulator for space vehicle and advanced aircraft testing.

Pacific Automation Products, Inc., Glendale, Calif., for emplacement of ground support electronics equipment at three *Atlas* launch control centers. Subcontract from RCA. Amount not disclosed.

Gladding, McBean & Co., Los Angeles, for research and development of a refractory material for use in uncooled rocket flame deflectors. Subcontract from Marquardt Corp. Amount not disclosed.

Bendix Aviation Corp., for developing, building and testing a "hot gas" flight stabilization and control system for "semi-orbital aerospace vehicles and missiles." Amount not disclosed.

$1,000,000—**Kieley & Mueller, Inc.,** Middletown, N.Y., for production of all of the automatic flow-control valves for operational propellant-loading systems at four *Titan* bases. Subcontract from CompuDyne Corp.

$606,750—**Thiokol Chemical Corp.,** Elkton, Md., for research into large rocket engine propellants.

$71,192—**Control Equipment Corp.,** Needham Heights, Mass., for design and development of instrumentation for study of density pressure temperature and composition of upper atmosphere.

$45,922—**Grand Central Rocket Co.,** Redlands, Calif., for rocket motors for high-speed test track.

$39,947—**New Mexico College of Agriculture and Mechanical Arts,** for research and development of antennas for rocket trajectory and data transmission equipment and associated ground stations.

ARMY

Control Electronics Co., Inc., Huntington Station, N.Y., for 100 microwave duplexers. Amount not disclosed.

$463,694—**Douglas Aircraft Co.,** Santa Monica, Calif., for improved *Honest John* rockets without warhead.

$274,960—**Raytheon Co.,** Andover, Mass., for repair parts and replenishment repair parts for the *Hawk* system. (Two contracts.)

$234,641—**Western Electric Co., Inc.,** New York City, for *Nike* spare parts and components. (Two contracts.)

$169,280—**Gatewood Construction Co.,** Dallas, for construction of missile maintenance training shop.

$128,981—**Douglas Aircraft Co., Inc.,** Santa Monica, for shipping containers for guidance section of *Nike-Hercules* missiles.

$84,800—**Pirie J. Maloney Construction Co.,** Rumson, N.J., for construction of the maintenance shop with related site improvements and outside utilities for *Bomarc* at McGuire AFB.

$69,785—**Barnes Engineering Co.,** Stamford, Conn., for field measurements of reentry of missiles.

$56,424—**Crosley Div., Avco Corp.,** Cincinnati, for satellite decoders, drawings and specifications.

$56,357—**Sperry Rand Corp.,** Salt Lake City, for *Sergeant* missiles.

$46,473—**Douglas Aircraft Co.,** Santa Monica, for repair parts for *Nike* systems.

$46,318—**Harland Bartholomew & Associates,** Honolulu, for architect-engineering services for redesign of *Nike-Hercules* Battery Site 1, Oahu.

$28,082—**Waste King Corp.,** Los Angeles, for warhead fuze.

Misconceptions

To the Editor:

We read MISSILES AND ROCKETS with interest and find the information to be timely and significant. Grand Central was pleased, therefore, to note the mention of its activity in high energy and multi-million pound boost motors in the February 8 issue.

Recognizing the massive editorial problems in obtaining accurate information about programs and policies, it is with regret we find it necessary to point out some misconceptions possible to the readers of the story.

1. Grand Central Rocket Co. has been associated with Marquardt in joint work on a hybrid propellant system. We feel that the Marquardt-Grand Central Rocket hybrid system is one of considerable promise. We have not, however, proposed a hybrid system for the "multi-million-pound solid space booster." Marquardt and Grand Central did not propose as a "team" on this job.

2. Grand Central has made excellent progress on adaptation and further development of the Nitrasol propellant originally conceived at NOTS and has been able to demonstrate an exceptionally good I_{sp}. We do not, however, consider Nitrasol to have performance comparable to the "blue sky" propellants which Advanced Research Projects Agency is investigating within the 285 I_{sp} range. We are working with other materials that have good promise of the higher performance but are not prepared to discuss them until we have completed our studies and tests.

3. The article mentions Air Force plans, policies and intent. Interleaved between are comments regarding Grand Central Rocket Co. activities, as well as the activities of other companies. The inference could be drawn that Grand Central Rocket Co. is commenting upon the policy and practice of the Air Force and of our competitors. This inference would be incorrect. Grand Central does not engage in the practice of disseminating public information or comments on Air Force policy or on the thinking of our competitors.

Cledo Brunetti
Vice President
and General Manager
Grand Central Rocket Co.

Future Lies Ahead

To the Editor:

1960 SPACE RACE PROGRAM

January—*Titan* Falls in Swimming Pool at Fontainebleau Hotel.

February—Gates Hails Merger of Air Force and NASA as Boon to Missile Program.

March—Project *Saturn* Budget Upped to $3,467.75.

April—"Massive Inferiority" Doctrine Enunciated by President.

May—Administration Calls SAC Manned Bombers Best Deterrent to Soviet Space Stations.

June—Eisenhower Refuses to Let Soviets Use Great Salt Lake as Rangehead for 15,000-mile Missile.

July—*Saturn* Budget Doubled.

August—Ike says U.S. Mothball Fleet More Than Match for Soviet Missiles.

September—NASA and Air Force Separated to Speed Space Program—Gates says: "Organizationally, we've got them cowering."

October—*Titan* Falls on Fidel Castro—Increased Range Hailed.

November—Soviet Missile Base on Moon Termed "Gimmick" by Nixon.

December—Contract Let for Development of Longbow.

Charles V. Hopkins
925 Loring Street
San Diego 9, Calif.

Textbook Lack

To the Editor:

An interesting subject, that letter from Bombay (M/R, Jan. 25) about the need for textbooks. It reminds me of a talk I had recently with one of Holland's pioneers in astronautics, M. Vertregt. He complained that he could not afford American advanced textbooks. He also deplored the fact that even the Netherlands Astronautical Association could not afford to add them to its technical library.

It is, of course that awful dollar barrier (or should I say dollar curtain) that is to blame.

J. A. Redeker
Science Editor
Algemeen Dagblad
Rotterdam, Netherlands

Close, But No Cigar

To the Editor:

Look at the caption at the top of pages 56/57 in the July 20 M/R:

"Series of photographs of dog-carrying *Sputnik II* made it possible *to deduct* that the total length of rocket body," etc.

"TO DEDUCT"—Really! Gentlemen, you're making us feel ill. Whoever penned that little gem ought to be "destructed."

L. S. Eggleton
Montreal Chapter
Society of Technical Writers
and Editors

Webster lists "deduct . . . To draw as a conclusion as from reasoning." (Same Latin root, same meaning as "deduce.")—Ed.

Power Sees 'Aerospace Missile Force'

Manned air/spacecraft would serve as launch platforms; SAC chief says 300 accurate ICBM's could knock out U.S. bomber and missile sites in 30 minutes unless they're hardened

These are the Pertinent Power Points

The U.S. has about 100 sites from which nuclear-armed aircraft or missiles can be launched.

It would take an average of three each—or a total of only 300—Soviet ballistic 5000-mile ballistic missiles to wipe out these 100 sites in 30 minutes.

If the sites are hardened it would take "considerably more."

Khrushchev says that Russia is now in "serial production" of nuclear missiles at the rate of 250 a year. Some must be presumed to be nuclear.

U.S. deterrent strength must be measured in what we would have *after* an attack—not before it.

SAC considers the manned bomber and the ballistic missile as complementary weapon systems.

Advent of the long-range air-to-ground missile (*Hound Dog*) greatly enhances power and versatility of manned bomber.

The combination of the B-52 and the *Hound Dog* is only first step in marriage of manned bomber and missile.

Further—SAC is planning an "aerospace" force of manned bombers and missiles.

We are near a nuclear stalemate with Russia—but there is no real stalemate as long as the Soviets can tip the scales merely by taking the initiative.

General Thomas S. Power is commander in chief of the Strategic Air Command, responsible for maintaining the terrible retaliatory power which the West depends on to deter Soviet aggression. His New York speech on Jan. 19, urgently warning of Russia's missile striking ability, has intensified the debate over how big the Missile Gap really is. The President himself took occasion to criticize "parochial" generals who disagree with the Administration estimate. Because M/R believes that Power's military and geopolitical philosophy (and his analysis of our forces-à-vis the USSR) is vitally important, we are carrying his speech here virtually in its entirety.—Editor.

* * *

The American people today are faced with the most difficult and far-reaching decisions in the history of this nation. Through their elected representatives they must decide what course to follow in their quest for peace and what tools to furnish to insure the successful pursuit of that course.

Similar decisions had to be made after World War II when the United States emerged as the most powerful nation on earth and was thrust into the role of guardian of the newly won peace. It was then that we evolved a policy unprecedented in the history of this country, namely, the policy of deterring aggression through the threat of massive retaliation. To support this policy, we created a military tool, equally unprecedented as to character and scope—the Strategic Air Command. This combination of political strength and military superiority undoubtedly was the major factor in preventing another world war to this date.

But Soviet Russia, which ten years ago seemed as unlikely a challenger to our leadership as Communist China may seem today, almost overnight developed into a major threat, not only to our overall supremacy but to our very survival. For the Soviets had achieved the capability to undertake what neither Lenin nor Stalin ever dreamed would be possible—a devastating attack on the United States.

• **Three questions**—It is . . . well to ask . . . three pertinent questions. First, is our national policy of deterrence still feasible and desirable? Second, if we decide that it is, can our present and projected military posture support that policy adequately? And, third, with continued advances in military technology, will we eventually reach a point where a policy of deterrence is no longer possible?

It is vital to the future security of this country that we find conclusive answers to these questions even though the many variables and unpredictable factors involved leave considerable room for speculation and individual preferences. This applies, in particular, to the problem of determining the most promising approach for preventing aggression.

We can start out from the premise that everyone is agreed on the urgent need of preserving the peace. But this is where the agreement ends, because people have widely differing ideas as to the kind of peace they would accept and the price they are prepared to pay for it. Some people may be willing to buy peace, however meaningless, at any price, even at the expense of their human rights and freedom. I take a different position from their defeatist attitude; I maintain that death is preferable to life under Communism. Obviously, we both cannot be right; however, I am confident that the vast majority of our citizens shares my convictions.

As President Eisenhower said in his State of the Union Message early this month: "Still another avenue may be found in the field of disarmament, in which the Soviets have professed a readiness to negotiate seriously. They have not, however, made clear the plans they may have, if any, for mutual inspection and verification—the essential condition for any extensive measure of disarmament."

In this connection, let me also

quote a rather significant statement made at the Lenin School of Political Warfare in 1931—almost 30 years ago—by Dimitry Z. Manuilsky, who was a prominent member of the powerful Central Committee of the Communist Party and later head of the Ukrainian delegation to the United Nations. Here is what Comrade Manuilsky said, as reported by a former student at that school:

"War to the hilt between communism and capitalism is inevitable. Today, of course (that is, in 1931), we are not strong enough to attack. Our time will come in 20 or 30 years. To win, we shall need the element of surprise. The bourgeoisie will have to be put to sleep. So we shall begin by launching the most spectacular peace movement on record. There will be electrifying overtures and unheard-of concessions. The capitalist countries, stupid and decadent, will rejoice to cooperate in their own destruction. They will leap at another chance to be friends. As soon as their guard is down, we shall smash them with our clenched fist." We cannot ignore the fact that utterances of this kind have been made by the Soviets over the past four decades.

• **The best way**—Finally, we can endeavor to maintain an honorable peace through an overpowering posture of balanced military strength and . . . collective security arrangements, as we have done since the end of World War II. I do not claim that, in this or in any other manner, we can stay out of a war. But I am convinced that this is the most promising and, in the long run, least expensive way of averting nuclear war.

It is claimed that our policy of deterrence cannot cope with the growing threat of small wars so long as we devote most of our efforts and resources to the deterrence of total nuclear war. But, in my considered opinion, the principle of deterrence through military superiority is broad and flexible enough to permit its application to any kind of conflict, regardless of its place, scope and nature.

Our overall deterrent posture is a composite of a number of elements which go to make up military superiority. These include our own forces as well as those of our allies with whom we have collective security arrangements. A fundamental element of that deterrent posture is our strategic retaliatory strike force.

That strike force is not the only factor which deters aggression, but without a fully effective retaliatory force capable of inflicting on an aggressor damage which he considers unacceptable, there is no meaningful deterrent. At this time, SAC, which is

GEN. POWER earlier wrote a book, "Design for Survival," charging defense spending was inadequate. DOD banned it.

by far the principal element of the Free World's strategic retaliatory capability, receives less than 20% of the U.S. defense dollar and still smaller fractions of other resources.

Since military superiority is accepted as the prerequisite for a successful policy of deterrence, the question arises whether and for how long we can maintain an adequate margin of overall superiority. I am confident that, as of the moment, this margin is still large enough to deter the Soviets from risking war with the United States, despite their spectacular technological advances.

• **No Red SAC**—Indications are that, if the Soviets decided to launch a surprise attack . . . today, they would have to rely mainly on their long-range bomber force. Evidently, this force has neither the size and quality nor the global support facilities and centralized organization which give SAC's forces their unmatched strike capability. Moreover, this country has an extensive air defense system against manned bombers which would provide sufficient warning of their approach to permit the launching of SAC's alert force before it could be attacked on the ground.

The Soviets are well aware of the fact that a sizeable percentage of SAC's strike force is on an around-the-clock 15-minute alert and that even their most advanced defenses could not prevent that force from inflicting crippling damage on their military controls and installations.

Nevertheless, we can certainly expect that the Soviet leadership would take full political advantage of any military superiority over the Free World which it may be able to obtain in the future. If they could effectively threaten us from a position of such military superiority that we would feel unable to defend ourselves successfully against the weapons they command, our capability to resist Soviet advances by means of subversion and political blackmail would be greatly reduced, if not nullified.

Military superiority of this magnitude would be achieved through the accumulation of a sufficient stockpile of ballistic missiles to destroy our retaliatory forces before they could be launched. Surprisingly enough, this would not take very many missiles under present conditions. Published statistics show that the total number of installations and facilities from which we can launch nuclear-armed aircraft or missiles at this moment is only about one hundred. All of these facilities present "soft targets," that is, they could suffer crippling damage even in the event of a near-miss.

According to released data on nuclear effects, it would take an average of three missiles, in their current state of development, to give an aggressor a mathematical probability of 95% that he can destroy one given soft target, some 5000 miles away. This means that, *with only some 300 ballistic missiles, the Soviets could virtually wipe out our entire nuclear strike capability within a span of 30 minutes.* To further heighten this threat, only about half of these missiles would have to be ICBM's. The rest could be the smaller IRBM's which are considerably less expensive and easier to produce.

Because of their tremendous speed, averaging about 15,000 miles an hour, ballistic missiles offer unique advantages to an aggressor who plans a surprise attack. It stands to reason that this has spurred the Soviets' effort to augment whatever quantities they may already possess at the greatest possible rate. Khrushchev himself let it be known that Russia is now engaged in the "serial production" of these missiles and that one single factory is turning out some 250 missiles a year, presumably including ballistic missiles.

• **Until BMEWS**—Therefore, we must anticipate that the Soviets may have . . . a sufficient number of operational ICBM's and IRBM's for an all-out missile attack before we have in operation warning systems which could provide reliable and adequate warning of such an attack. We have such systems now under development, designed to give some 15 minutes warning, which would suffice to get most or all of SAC's ground-alert forces airborne. But until our Ballistic Missile Early Warning System becomes fully operational, SAC's capability to survive a missile attack with little or no warning will be the crux of the Free World's deterrent posture.

Hound Dog is a first step . . .

There is increasing public awareness of the mounting problem of survivability of our strike capability in a nuclear surprise attack. It must be understood that our deterrent strength is not determined by the forces which we have in being *before* such an attack but only by those forces which we can be certain to have left *after* the attack. From a deterrent point of view, therefore, the decisive factor is whether we can keep the Soviets convinced that, even under the most unfavorable conditions, our surviving strike force will be adequate to retaliate both instantly and decisively to aggression.

Fortunately, the complex technological problem of insuring the survivability of SAC's alert forces in a missile attack can be solved, at least partially, through a basically simple military tactic, namely, by keeping the alert aircraft in the air instead of on the ground. This tactic has been tested thoroughly and found to be entirely feasible. With adequate and timely preparations for meeting added demands for support, SAC can maintain an airborne alert long and effective enough to bridge what could otherwise become the most dangerous gap in our military posture since Pearl Harbor.

• *Atlas* **milestone**—In discussing . . . our strategic strike forces I have, so far, emphasized the manned bomber. I have done so because, for the present and some time to come, we must depend primarily on our manned weapon systems to carry out the strategic mission. But SAC is rapidly building up its missile capability and reached an historic milestone on the ninth of September last year when a SAC combat crew successfully fired its first operational *Atlas* ICBM. As the President pointed out in his State of the Union Message, this missile has proven equally successful in its last 15 test launches, with an accuracy of less than two miles.

I have little doubt that continued advances in missile design and techniques will further improve warhead yield, accuracy and reliability and that, eventually, we will have missiles in sufficient quantity, quality and variety to accomplish most of our strategic missions. In the meantime, however, we cannot afford to neglect, let alone shelve, our existing and well-proven manned bombers because SAC must always maintain a sufficient inventory of operational and combat-ready weapon systems to insure effective coverage of its target system at any time.

As missiles are phased into SAC's inventory, they will replace some of the older bombers which are ready to be phased out. But I want to make it clear that this cannot be done at a ratio of one-for-one because, contrary to widespread belief, one missile is not equivalent to one bomber with respect to strike capability, as reflected in nuclear yield and accuracy.

While bomber accuracies are measured in feet, those of missiles are still measured in miles. Of course, missile accuracies will improve but, over distances of 5000 miles and more, even dramatic improvements in guidance techniques cannot be expected to approach the standards possible with SAC's bombing systems and techniques. Lower accuracy can, to some extent, be offset by higher yield. Yet, the yield of a missile warhead, although far greater than that of the largest conventional bomb, is but a fraction of the nuclear payload of the bomber which, moreover, can carry a number of high-yield weapons to different targets.

An additional consideration that must be taken into account in comparing missile and bomber quantities is the fact that missiles are "one-shot" weapons while bombers can be "recycled" and used for as many missions as circumstances may require and permit. The point has been raised that manned bombers are so vulnerable to modern aerial defenses that only a relatively small number could be expected to penetrate to their targets and few if any of these bombers could be counted upon for a follow-on attack. It must be realized, however, that offensive techniques and tactics have profited from scientific advances as much as or, perhaps, even more than defensive techniques.

• **Attrition in perspective**—It is often taken for granted that today's . . . antiaircraft missiles and guidance methods would exact far higher losses than we suffered in our bombing operations during World War II. But if someone had tried, in the early days of that war, to predict the average attrition rate for tight formations of hundreds of bombers fighting their way through heavily concentrated flak and large numbers of fighters, he probably would have arrived at a very high estimate also. Yet, out of a total of about 530,000 heavy bomber sorties flown in World War II, only some 9500 aircraft were lost to enemy action, for an average attrition rate of less than 1.8 per cent.

I am not inferring that bomber attrition rates in a nuclear war would be anywhere that low. But neither do I believe that they would be anywhere as high as is sometimes claimed. In trying to predict bomber attrition rates, one of the most important contributing factors is frequently overlooked, namely, the unpredictable factor of tactics. I maintain that the commander and his tactics, more than anything else, determine the losses in any offensive action.

There are several other factors which should keep future attrition rates within acceptable limits despite continued improvements in antiaircraft defenses. As these defenses become more sophisticated, they must rely to an increasing degree on electronic systems which in turn, are susceptible to electronic countermeasures. Moreover, it should be borne in mind that attrition applies not only to the *offensive* but also to the *defensive*.

Throughout World War II, bombers generally disregarded the defenses because they were not considered worth attacking. However, if we should be forced into a nuclear war by an aggressor, the enemy's aerial defense system would become a priority target and would be attacked with the most effective countermeasure known today, namely, the hydrogen bomb. Each successfully dropped bomb would take out the defenses in a wide area and permit ever deeper penetration for successive bombers.

• **Potent marriage**—Penetration of enemy defenses will be further enhanced by . . . *"Hound Dog,"* a supersonic and very accurately guided air-to-ground missile with nuclear warhead. The B-52G bomber will carry two of these missiles—one under each wing—in addition to its regular nuclear payload. Tests with the *Hound Dog* have met all expectations. In fact, I had the pleasure of accepting the first production missile from the manufacturer about a month ago.

The *Hound Dog* will make it possible to attack the enemy's defenses from hundreds of miles away and thereby help the bomber to penetrate to its target. But this is only one of the advantages of the *Houng Dog* missile. Its primary significance lies in the fact that it will vastly increase the utility and flexibility of the manned bomber and permit a variety of new tactics, such as attacks on additional targets in different areas during the same mission.

I consider the B-52 and *Hound Dog* combination but the first step in the marriage of manned bomber and missile. The next step will be the use of the manned aircraft as an airborne and virtually invulnerable platform for air-launched ballistic missiles. It is, therefore, evident that SAC must continue not only to replenish its manned weapon systems but also to modernize them so as to keep pace with technological advances.

The addition of the *Hound Dog* and, later perhaps, of air-launched ballistic missiles will greatly extend the useful life of the current B-52. But, eventually, it must be replaced by a more modern bomber, and I am hopeful that, by that time, we can put into operation the spectacular B-70 which is now under development.

• **Balanced force**—Modernization of the bomber force is (not) a stopgap . . . because, for the foreseeable future, there will always be need for manned weapon systems. This will be true, for instance, in missions which entail reconnaissance and on-the-spot decisions based on human judgment or for attacks on mobile and concentrated, well-protected targets. The missile, in turn, will ultimately be assigned to most other strategic missions, especially those requiring rapid action and invulnerability to aerial defenses. This is why SAC is planning for an aerospace force of bombers and missiles in which one will complement and supplement the other . . .

The survivability of the missile poses a somewhat different problem from that of the bomber and must, therefore, be solved by different techniques. Since a missile cannot be recalled once it has been launched, it would be too risky to fire it until there is incontestable proof of aggression. Therefore, our ICBM's probably would have to "ride out" the initial attack. This problem is taken into account in our later missiles which will permit launching from silos deep in the ground, thus providing good protection . . .

• **Hardening gains**—Hardening . . . is both practical and highly desirable as it aggravates an aggressor's problem of destroying all or most of our missiles before they can be launched . . . Compared to the previously mentioned average of only three missiles needed for a 95% probability of destroying one soft missile site, the aggressor would have to launch a considerable number of missiles of more advanced design to obtain the same degree of probability that he can destroy one hardened site.

The aggressor's problem will be further compounded as increasing numbers of missiles are added to our operational inventory and placed in widely dispersed, hardened sites. The *Minuteman*, a greatly simplified missile now being developed for SAC, will be particularly suitable for this purpose. Additionally, it is planned to mount a number of *Minuteman* missiles on railroad cars and move them in a random pattern over the almost 100,000 miles of railroad trackage in this country which is suitable for this purpose.

Mobility is a most attractive defense tactic because the probability of destroying a mobile target with a long-range missile is extremely small. The advantages of mobility are fully exploited in SAC's airborne alert system and also underlie the basic concept of the *Polaris* weapon system. Mobile *Minuteman* missiles and bombers on air alert will have the added advantage of being beyond the reach of Soviet reconnaissance and countermeasures.

The concept of launching small medium-range ballistic missiles from a submerged submarine represents a most intriguing approach to the problem of survivability, despite the many unprecedented and still unresolved problems which it entails. We have great hopes for such a system but we also must remember that there are some inherent limitations as is true for any other type of weapon system. Also, it can be assumed that many if not most of the close to 500 submarines credited to the Soviets would be used to support a missile attack on the United States with simultaneous attacks on our nuclear fleet units on and under the seas. The *Polaris* must be prepared to cope with this threat.

• **Praise for** *Polaris*—These limitations should not detract from the fact that the *Polaris* concept holds considerable promise. I am confident that, once the *Polaris* submarines have become operational, they will add importantly to our retaliatory capability, and I hope that their target systems and schedules will be integrated effectively . . .

As this and our other programs for the future materialize, we will reach the point where no foreseeable magnitude and method of attack can destroy the effectiveness of our retaliatory capability . . . Conversely, however destructive our capacity for counterattack, there can be no doubt that, by that time, the Soviets will have achieved a similar degree of survivability for their follow-on strike forces.

This means that both sides will have the capability of inflicting tremendous damage on each other's civilian establishment and economy, but neither side will be able to prevent the other from striking back. We will then have arrived at a condition which is best described as "nuclear impasse" since that is as far as we can go in stabilizing the global balance of military power. It is important to understand that this condition will be much more stable than the one in which we find ourselves today and which is usually referred to as "nuclear stalemate."

The term "nuclear stalemate" has created much confusion because it infers that, in effect, the Soviets' and our nuclear capabilities cancel each other out and that, therefore, they would not dare attack us. But there can be no real stalemate as long as the Soviets are in a position to tip the scales in their favor merely by taking the initiative.

However, once we have reached the point where a surprise attack can no longer prevent or even minimize retaliation, the initiative would give a potential aggressor only a temporary and relatively limited military advantage which would gain him too little and cost him too much to make aggression worthwhile. Our future security demands that we reach that point as rapidly as possible, rather than stretch out defense programs designed to get us there before it might be too late.

This should not imply that we will have reached the ultimate in destructiveness of weapons and compression of time. It would be futile to speculate what miracles of science and what technological breakthroughs lie ahead and what they might do for the battles of tomorrow, ranging from the depths of the oceans to the far reaches of space. But there can be no doubt that we can maintain an effective deterrent only by making certain that no other country will ever reach the next higher technological plateau before we do . . .

J. Paul Walsh: Formerly deputy director of Project *Vanguard*, and systems manager for special projects at IBM's Federal Systems Division, joins C-E-I-R, Inc., as director of the Space Weapons Systems Division.

Dr. Walsh directed the operation that launched the first *Vanguard* satellite into orbit; later joined IBM as manager of the Navy marketing program in the Military Products Division. He spent 15 years with the U.S. Naval Research Laboratory participating in Operation Crossroads; conducting research projects on reactor compartments for the Nautilus and Sea Wolf. Operation Wigwam earned him the Meritorious Civilian Service Award.

WALSH

Richard A. Rossi: Formerly reactor physicist and assistant chief of AEC's Lockland Aircraft reactors operations, joins Cross-Malaker Laboratories as a senior engineer.

Frank K. Clark, Jr.: Appointed chief engineer at M. C. Jones Electronics Co., Inc., a subsidiary of Bendix Aviation Corp. He joined the Bendix Radio division in 1954.

Lawrence F. Boland: Former vice president, elected to the newly created position of executive vice president of The Beryllium Corp.

He is a director of the parent company as well as a director of Nonotuck Manufacturing Co., a wholly-owned subsidiary, and of Consolidated Beryllium, Ltd., a firm jointly owned by The Beryllium Corp.

BOLAND

Robert J. Tatge: Named manager of flight and electronic systems; **Henry N. Titzler**, manager, missile systems; **Raymond J. Gambon,** manager, environmental systems; and **Ernest A. Wilder,** manager, heat transfer, at AiResearch Manufacturing Division, The Garrett Corp.

Tatge, with the division since 1950, was formerly manager of central air data computing subsystems; Titzler was previously manager of contract administration; Gambon and Wilder transferred from Garrett sales offices in Atlanta and San Diego, respectively.

John P. Jasionis: Named technical operations manager of the research laboratory for the Electron Tube division of Litton Industries. Jasionis joined the firm after 13 years with Sylvania Electric Products.

Sidney Gerhard: Appointed chief engineer, Propulsion Test Facilities, a division of MB Electronics, a division of Textron Electronics, Inc.

Was previously chief engineer, test equipment division, Consolidated Diesel Electric Corp., and chief project engineer, hydraulic test equipment, Greer Hydraulics, Inc.

GERHARD

Dr. P. S. Christaldi: Joins G-V Controls, Inc., as manager of engineering. Was formerly product manager, Nuclear Systems, for Curtiss-Wright Corp.

Roy H. Lynn: Recently retired USAF lieutenant general, appointed president of ITT Communication Systems, Inc.

Arthur J. Wiltshire: Formerly chief engineer, Apex Reinforced Plastics, named chief project engineer at Structural Fibers, Inc., manufacturers of reinforced plastic and premix plastic products.

Notable achievements: development of the high-pressure bottle still used in conjunction with jet engine starters and ballistic missiles, and the MK. 32 torpedo launcher used in firing tracking-type missiles from surface ships.

WILTSHIRE

Lyle A. Backer: Named executive vice president of Thermal Controls, Inc. and O. K. Electronics, in charge of all operation from design to final delivery.

Kenneth L. Sayre: Joins Bjorksten Research Laboratories as senior project leader in the Organic and Plastics division. Was formerly with **B. F. Goodrich** Chemical Co.

Robert F. Leinicke: Joins McCormick Selph Associates' R&D technical staff as group leader for design and development of cool gas generators.

Robert S. Camera: Capt. USN retired, joins Piasecki Aircraft Corp. as executive engineer in charge of the engineering department.

LEINICKE

Raymond B. Slaney: Named manager of Space Technology Laboratories, Inc.'s operations planning department. Prior to joining STL in 1956, was assistant to the general manager at National Cash Register, electronics division.

Morgan E. McMahon: Elected manager of the engineering department Pacific Semiconductors, Inc., succeedi **R. A. Campbell,** recently elected vi president in charge of operations. M Mahon, who formerly served as manag of product engineering, will direct ove all department activities, with speci emphasis on the transistor program.

Elmo E. Maiden, manager of speci products was named assistant manag with special responsibility for the micr electronics program and establishment the micro-diode plant.

Clyde Skeen: Joins Temco Aircra Corp., as executive vice president an general manager. Was formerly vi president for weapons system progra management at Boeing Airplane Co. Aerospace division.

Dr. Joseph Neustein: Joins Electr Optical Systems, Inc., as head of the ad vanced power systems department of th Energy Research Division.

Previous posts: Manager of engin research at Aeronutronic division of For Motor Co.; U.S. Naval Ordnance Tes Station and an aeronautical researc scientist with the National Advisory Com mittee for Aeronautics, Lewis Fligh Propulsion Laboratory.

Daniel E. Murphy: Appointed directo of Consolidated Electrodynamics Corp.' Datalab division. He joined the divisio in 1958 as administration manager.

George Singer: Formerly genera manager of the microwave division o Kearfott Co., Inc., elected director o marketing and contracts for the Rante Corp., producers of microwave product and waveguide components.

Andrew J. Kutler: Formerly assistan plant manager at ERCO division of ACF Industries, joins Fairchild Engine an Airplane Corp.'s Astrionics division, a program manager of simulation devices.

The Martin Co.-Baltimore announce the reorganization of its Informatio Services into three sections, News Bureau Promotion/Publications and Communit Relations:

Fred E. Hamlin, information service manager the past year, is now directo of a comprehensive program which in cludes promotion and publications in addition to the department's previous functions of community relations and news media services.

Beverley L. Britton, who joined Information Services last May after 16 years as Navy public information officer heads the News Bureau.

John T. de Visser, who joined the firm in 1956, manages Promotion/Publications.

Kenneth D. Engle, who joined Martin in 1946, heads Community Relations.

—when and where

FEBRUARY

irst National Symposium on Nondestructive Testing of Aircraft and Missile Components, sponsored by Southwest Section, Society for Nondestructive Testing, and Southwest Research Institute, Hilton Hotel, San Antonio, Tex., Feb. 16-18.

hird Annual Missile/Space Industry Conference, National Rocket Club, Sheraton Park Hotel, Washington D.C., Feb. 16-17. (Dr. Robert H. Goddard Memorial Dinner, Feb. 17.)

IEE Symposium on Engineering Aspects of Magnetohydrodynamics, University of Pennsylvania, Philadelphia, Feb. 18-19.

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

merican Institute of Chemical Engineers, Biltmore Hotel, Atlanta, Feb. 21-24.

ngineering Materials & Design Exhibition, Industrial and Trade Fairs, Ltd., Earls Court, London, Feb. 22-26.

lational Association of Corrosion Engineers, Tulsa Section, 11th Annual Corrosion Short Course, Mayo Hotel, Tulsa, Feb. 24-26.

MARCH

Navy League Seapower Symposium, Sheraton Park Hotel, Washington, D.C., Mar. 1-3.

ASME Gas Turbine Power and Hydraulic Conference, Rice Hotel, Houston, Mar. 6-9.

Heat Transfer Symposium, Mechanical Engineering Dept., University of Florida, Gainesville, Mar. 7-8.

Society for Aircraft Material and Process Engineers, Midwest Chapter Symposium, Miami Hotel, Dayton, Ohio, Mar. 9-10.

Mechanical Properties of Engineering Ceramics, North Carolina State College School of Engineering and Office of Ordnance Research, U.S. Army, N.C. State College, Raleigh, Mar. 9-11.

National Flight Propulsion Meeting, Institute of the Aeronautical Sciences (classified), Cleveland, Mar. 10-11.

Electronics Industries Association, Defense Planning Seminar, Statler Hilton Hotel, Washington, D.C., Mar. 15.

Symposium on Optical Spectrometric Measurement of High Temperatures, sponsored by University of Chicago's Applied Science Laboratories; Jarrell-Ash Co.; National Science Foundation, University of Chicago, Mar. 23-25.

22nd Annual American Power Conference, sponsored by Illinois Institute of Technology, American Society of Mechanical Engineers and others, Sherman Hotel, Chicago, Mar. 29-31.

APRIL

University of Connecticut Sixth Annual Advanced Statistical Quality Control Institute, Storrs, April 3-15.

Solar Energy Symposium, sponsored hy American Society of Mechanical Engineers and Mechanical Engineering Dept., University of Florida, Gainesville, April 4-5.

1960 Nuclear Congress: "What Will the Future Development of Nuclear Energy Demand from Engineers?" sponsored by 28 engineering, technical, scientific and management organizations. Includes 6th Nuclear Engineering and Science Conference, 8th NICB Atomic Energy in Industry Conference, 6th International Atomic Exposition, New York Coliseum, New York City, April 4-7.

American Chemical Society, 137th National Meeting, Cleveland, April 5-14.

Advertisers' Index

CLASSIFIED

editorial . . .

Congress Begins Procurement Probe

Congress this last week began a series of hearings "to make full and complete studies of the procurement policies and practices" of the Department of Defense and the Armed Services.

Pursuant to Public Law 86-89, "such studies shall include examination of the experience of such departments in the use of various methods of procurement and the types of contractual instruments with particular regard to the effectiveness thereof in achieving reasonable costs, prices and profits."

Probably no action taken in recent years is of greater significance to the entire defense industry. "Reasonable costs, prices and profits" are the economic laws by which industry lives or dies.

The Congressional action just started had its inception last year when the Renegotiation Act was extended. At that time the Defense Industry tried unsuccessfully to prevent re-enactment. Failing in this, the Industry did succeed in getting Congress to agree to a study of both the Armed Services Procurement Act and the Renegotiation Act itself. It will be the first study of the Procurement Act since it was passed in 1947, followed by the Renegotiation Act in 1951.

That such a study is overdue has long been obvious. Both Acts were inherently measures passed when military procurement carried a heavy emphasis on production in large numerical quantities.

Times have changed and so has defense procurement. Orval R. Cook, President of Aerospace Industries Association, recently noted that research and development costs for many of today's major weapons have reached the point where they substantially exceed production costs. Obviously, contractual techniques and policies must be modified to serve this new concept of procurement.

Equally important is the need to put renegotiation into its proper perspective as an element of the procurement process—where it now is not.

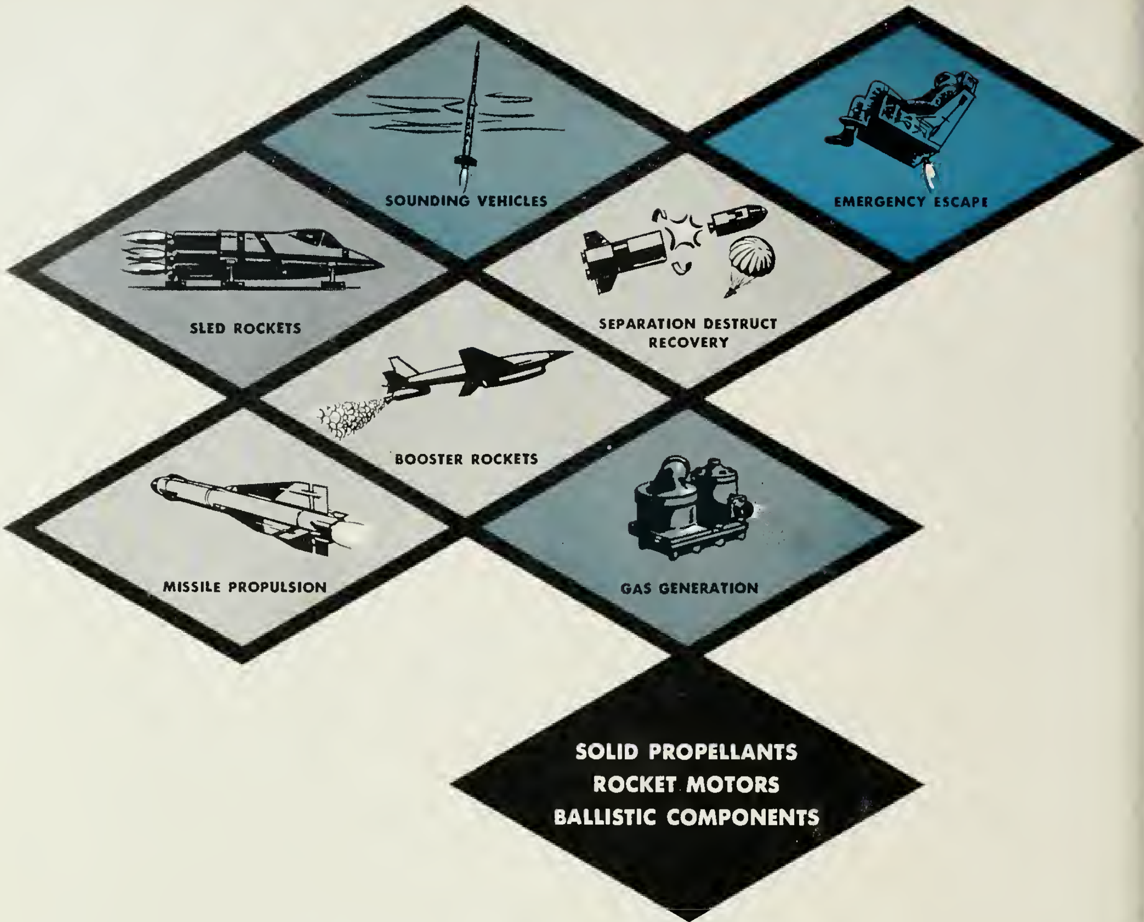
Under present procedures, the various departments of the Defense Department negotiate contracts under procurement laws designed to achieve reasonable "costs, prices and profits." They utilize contractual devices and techniques designed to provide the contractors with maximum incentive to reduce costs and prices.

Then what happens? Another government agency, the Renegotiation Board, moves in and determines whether these profits—honestly arrived at—are reasonable.

The first of the procurement hearings has been started by Sen. Strom Thurmond's subcommittee of the Senate Armed Services Committee. Following this, the House Armed Services Committee will begin its probe. The committees must report by Sept. 30. They will turn their findings over to the Joint Committee on Taxation, which will relate the data to the Renegotiation Act.

Regardless of what these hearings accomplish otherwise, they may achieve two things: (1) arouse the Defense Industry to the necessity of presenting its story jointly and forcefully to the Congress; and (2) convince Congress of the necessity of establishing one set of governmental policies to govern the procurement of defense production.

Clarke Newlon



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