APRIL 6, 1959

X-15 AND BIG MAMMA

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

2-4

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	Volts	Amps.	Volts	Phase	VA Rating			
32B92	27.5	126	115	1 3	1500 1800	20,000	37	—
32B81	27.5	100	115/200	3	1500	Unlimited	65	—
32B77	27.5	180	115/200	3	3000	Unlimited	75	—
32B79	27.5	400	115/200	3	7000	Unlimited	115	—
32B76	27.5	20	115	3	500	70,000	25	—
32B122	27.5	150	115/200	3	2500	50,000	65	—
32B41	27.5	150	115/200	1 3	2500 3000	50,000	68	—
32B52	27.5	35	115/200	1 3	500 500	40,000	25	—
32B106	27.5	95	115	3	1400	35,000	44	—
32B27	27.5	285	115/200	1 3	3500 4000	50,000	76	—

GENERAL PURPOSE INVERTERS—400 CYCLE OUTPUT

Type	Input		Rated Output			Max. Altitude at Rated Output	Approx. Wt. Lbs.	Designed to Gov't. Part No.
	Volts	Amps.	Volts	Phase	VA Rating			
12128	27.5	1	26	1	6	35,000	2.2	AN3496
12126	27.5	2	26	3	10	35,000	2.3	E1615
MG-54	27.5	22	115/200	1 3	250 250	50,000	17	E5109
12142	27.5	22	115	1 3	250 250	35,000	13	E1617
12143	27.5	22	115	3	250	35,000	13	—
32E01	27.5	35	115	3	500	50,000	26	AN3533-1
32E00	27.5	51	115	1 3	500 750	50,000	34	AN3534-1
MG-65	27.5	52	115/200	1 3	750 750	50,000	35	E52805-2
MG-61	27.5	126	115	1	1750	50,000	54	53C6767
1518	27.5	126	115	1 3	1500 1800	20,000	37	—
32E06	27.5	160	115/200	1 3	2000 2250	50,000	56	E1725
32E03-3	27.5	150	115	1	2500	50,000	58	53B6227
32E03-9	27.5	160	115/200	1 3	2500 3000	50,000	58	E54807
32E09	27.5	160	115	1 3	2500 3000	50,000	60	—

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

APRIL 6 HEADLINES

MISSILE SUPPORT EQUIPMENT

ASTRONAUTICS ENGINEERING

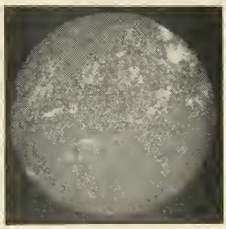
MISSILE ELECTRONICS

THE MISSILE WEEK

DEPARTMENTS

COVER: B-52 has carried *X-15* aloft for second time for aerodynamic checkout and crew training.

FIRST picture of entire sun taken with light of Lyman-alpha line—fundamental line of radiation . . .



NAVY scientists used special camera in nose of *Aerobee-Hi* rocket fired to 123 mile altitude . . .

COMPARED with ground shots using sun's calcium K light (2), hydrogen red (3) and white (4).

PICTURES give new clues to sun's effect on radio broadcasting and weather on earth.

When Russia Puts Men in Space

Professor Fred Singer, whose series of scientific articles on the effects of nuclear explosions in space currently appearing in this magazine is bringing sharply into focus the real significance of such blasts, also suggests that the Russians are very likely to place a two-man satellite in orbit this summer—and that the U.S. public should be psychologically prepared for such an eventuality.

Dr. Singer, associate professor of physics at the University of Maryland and one of the U.S. scientists who for some years suspected the existence of a radiation belt around the earth before its actuality was verified, said:

"Try to imagine the headline: 'Russians Put Two Men in Orbit.' Not just one; they are capable of putting up two and they know the jolt it will produce on the world. This may happen during the middle of the year. Imagine that these men are able to converse in English, are able to recognize signals from the ground, that they will perform all sorts of functions ranging from broadcasting propaganda to answering questions addressed to them, to reporting forest fires and so on. Imagine this to go on day after day, even at night. It is hard to overestimate the impact, especially with our highly efficient media of mass communication."

Up to this point Dr. Singer is in reasonable agreement with most U.S. military leaders concerned with the space exploration field—that is, that the Russians probably have or soon will have the capability of placing man in orbit and that such a feat would have tremendous propaganda value.

But beyond that point the scientific and military minds do not concur. Dr. Singer feels the man in orbit would have little military significance and tells why. He points out that you cannot "drop" a bomb from a satellite. Since the satellite itself is falling freely in space, the bomb would simply remain alongside and could blow up the satellite. The bomb, he points out, would require a velocity of just about 25,000 feet per second to be launched to a target directly below the satellite, although it would need a lesser force for other trajectories.

Dr. Singer also feels that a space station is a sitting duck. It can be detected, as he points out, by reflected sunlight, by radar or by its own infrared radiation. Its orbit, governed by the laws of planetary motion, can be accurately predicted. And, to be brutal, a manned satellite is vulnerable to the smallest puncture which would destroy its air-tight integrity—and most especially it is vulnerable to nuclear weapons. For example, Dr. Singer reports, using data now available from Project *Argus* and other unclassified sources, it can be calculated that a two-megaton bomb produces a lethal radiation dosage of 500 Roentgens over a sphere of 130 miles radius, certainly a menace to a manned space vehicle.

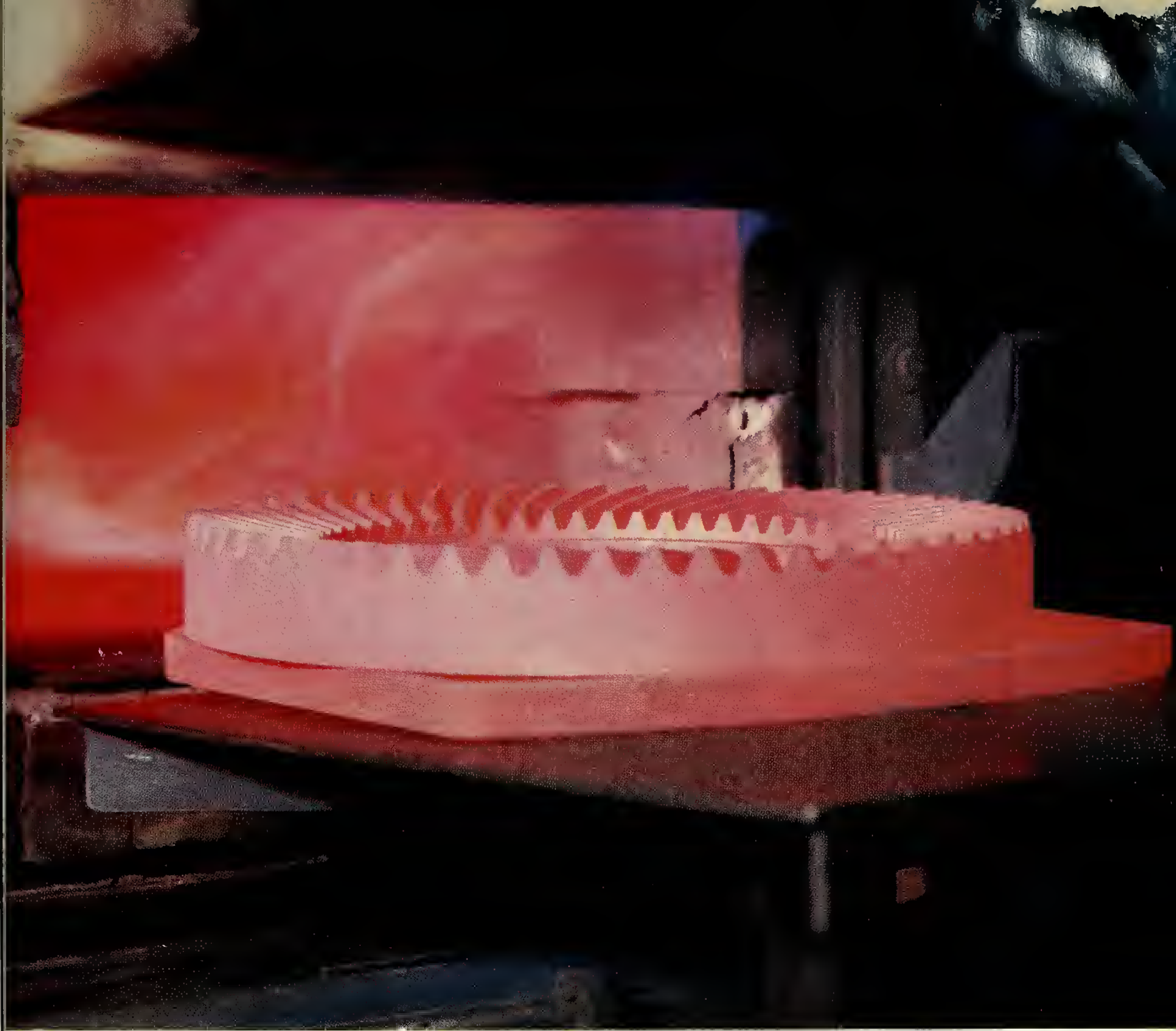
Military men, on the other hand, feel that the tactical value of a manned satellite might be considerable. For one thing, its reconnaissance value, using the human eye and brain instead of a machine, would be incalculable. They think, too, that such a satellite probably would carry sufficient rocket power to change its own orbit and that, contrary to being a sitting duck, it might be very difficult to find indeed—for a time, at least. And finally, that such a satellite might very well carry a launching instrument which could impart the necessary force to launch a small object earthward. With ground vectoring this might be done with great accuracy, sufficient to hit New York City or Washington, perhaps.

Actually, the exact military significance or potential of such a manned satellite at this time makes very little difference, it seems to us. It most certainly wouldn't be used to drop a bomb on New York or Washington, though if it dropped a capsule containing a Russian flag and a bottle of vodka, the propaganda shock would be just about the same.

We live in a world which through several decades now has seen aerial bombing destroy military targets and centers of population. A man in the sky overhead, like the hidden menace of the dark, is instinctively frightening. It is easy to foresee that a manned satellite could be magnified out of all reasonable proportion to its immediate military significance. The public should be told now that such an event is a possibility, and given an idea of what can be expected when it does happen and just what the import might be.

We would like to suggest that the Department of Defense Office of Public Affairs, which frequently is employed to less useful purposes, join forces with our civilian scientific agencies and begin an educational campaign on the significance and immediate military potential of the manned satellite. We think they would find the nation's press media cooperative and it would be a great national service.

Clarke Newlon



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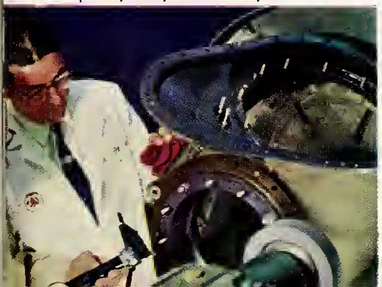

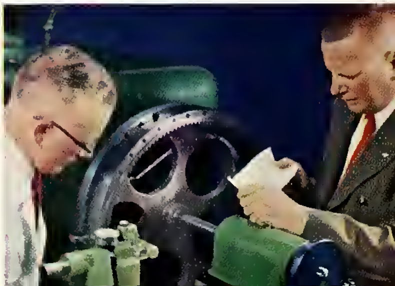

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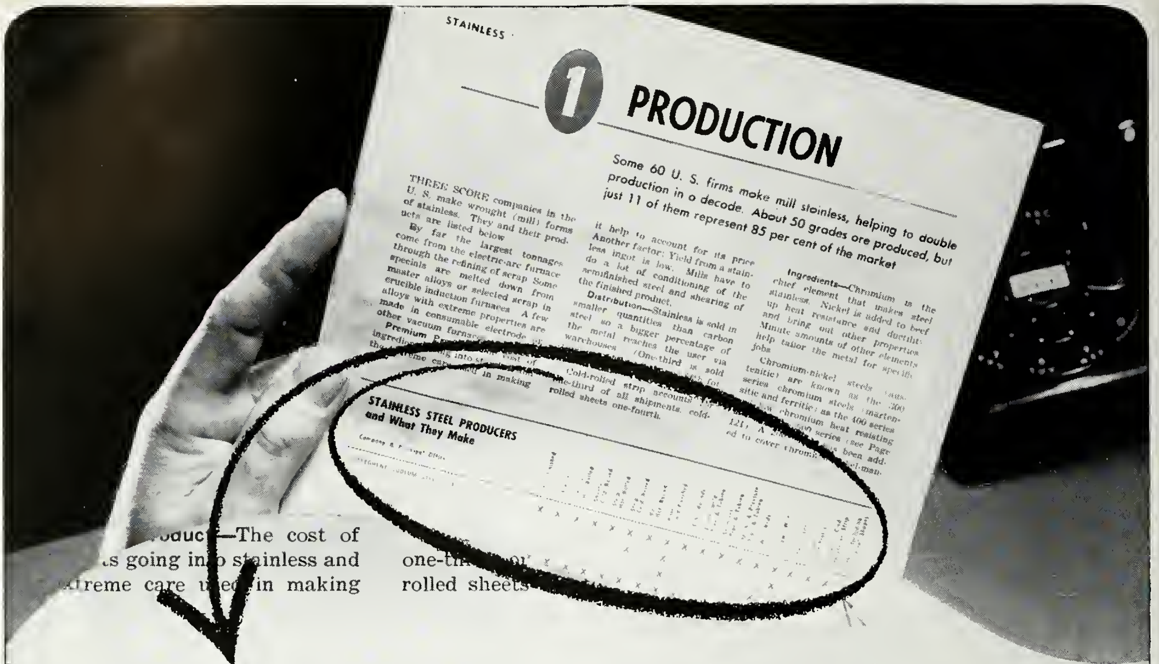

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[illegible]						X		X						X				

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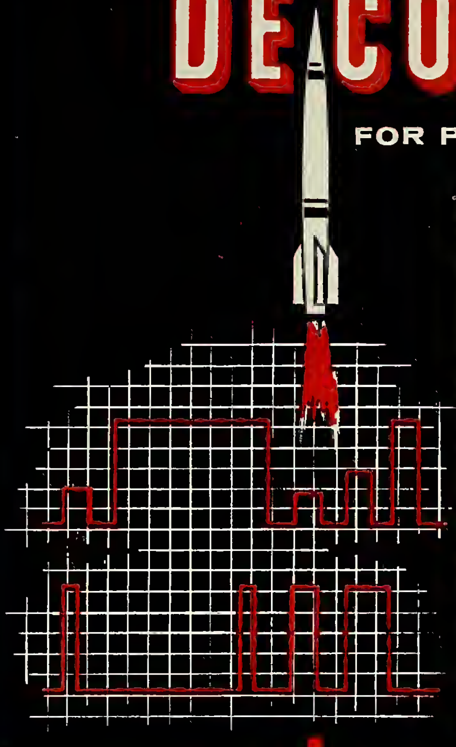

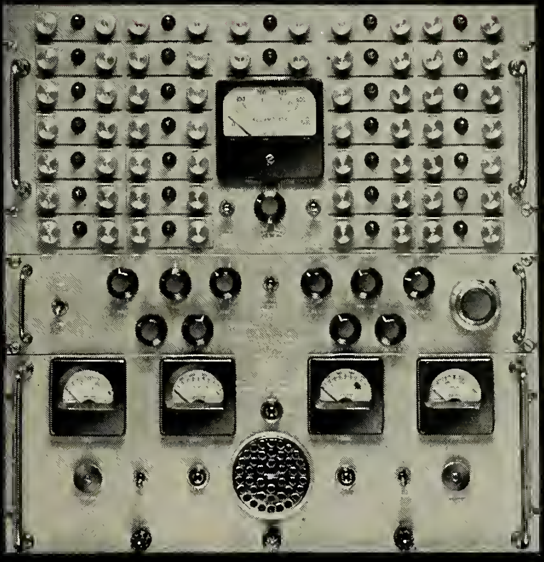

The new Arnoux Model TDS30-1 Decommutation System is completely self-contained within three chassis assemblies consisting of: Gating Unit (TOP), Pulse Selector (MIDDLE) and Regulated Power Supply (BOTTOM). The unit handles 28 channels of information and occupies only 19½ inches of panel height in a standard relay rack. Overall depth behind panel is 13 inches.

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the missile week

washington countdown

IN THE PENTAGON

Navy supporters are spreading the word that the *Polaris*-launching submarine will be operational by mid-1960—months ahead of schedule. The Navy has officially said the new missile subs will be operational by the end of 1960.

• • •

Kwajalein—The old Japanese World War II base in the Marshall Islands—will be used as a testing ground for Western Electric's *Nike-Zeus* AICBM. The *Zeus* missiles will be launched against target missiles fired across the Pacific Missile Range from Vandenberg AFB. The Army plans to begin building testing facilities on the U.S.-held island this summer.

• • •

The Air Force is considering stationing its *Atlas* ICBM's in concrete bathtub-shaped bunkers instead of inverted silo-shaped holes as previously indicated. The concrete bathtubs would be covered with steel roofs which would be stripped away to enable the missile to be erected and fired.

• • •

One of the chief topics of conversation at a secret meeting of top Air Force officers on the West Coast is reported to have been expansion of the huge Pacific Missile Range with emphasis on an equatorial launch site.

• • •

The nuclear submarine's latest polar junket appears to have eliminated one major worry of designers of missile-packing submarines. that's communication. The Skate is reported to have been able to receive low-frequency radio signals while travelling near the surface under the polar ice pack. It transmitted radio signals by raising its antenna through the thin ice found between Arctic ice floes throughout the year.

• • •

Project Discoverer is being speeded up. Previously one shot a month was planned. Now the number may be increased to an average of two. The second shot in the West Coast launchings is expected in about a week.

• • •

Dr. Herbert York, has divided his new research and engineering office into five operating systems and seven technical fields. York also will have six other boards, offices and groups reporting to him. However, the organizational chart still gives no indication of York's relationship with his old home—ARPA.

ON CAPITOL HILL

The House Space Committee plans to begin hearings later this month on NASA's proposed half-billion dollar budget for FY 1960. Watch for charges that the new budget is a blind for budget-balancing and for efforts to increase it. Reason: It actually calls for spending less than $200 million in FY 1960—all the rest is to be used as obligational authority.

• • •

The Senate Space investigating Subcommittee headed by Sen. Stuart Symington (D-Mo.) will resume its inquiry into possible duplication of federal space agencies about mid-April. The much-heralded investigation only just began when it was interrupted by the Congressional Easter recess.

AT NASA

The United States may look to the use of a ship to launch a satellite into an equatorial orbit at an early date. Until now U.S. scientists have thought construction of a launching site on some equatorial island would be necessary. But the success of Project *Argus* has opened up the possibility of developing seaborne satellite launchers.

AROUND TOWN

Much of the confusion as to the full meaning of the results of Project *Argus* may be cleared up later this month. IGY scientist are scheduled to make the first formal scientific report on the high-altitude atomic tests at the annual meeting of the National Academy of Sciences.

• • •

Possible meteorite in the wind: Soviet Scientist at the Academy of Sciences at Alma-Ata are working on whether plant life could be transplanted from Earth to Mars. Air Force scientists have done some work along this line at Randolph Field.

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industry countdown

STRUCTURES

Outfitting *Polaris* nuclear submarines with missile launching equipment is reported to be one reason for the new acquisition by Lockheed Aircraft of Puget Sound Bridge & Dredging Co., Seattle. Facility also will be used for ground support and missile-space vehicle development work.

• • •

Readiness of Minneapolis-Honeywell's *Asroc* (anti-submarine rocket) is indicated in Navy request to Congress for $26.2 million. Half would go for 11 shipboard installations and remainder for 86 pieces of *Asroc* hardware.

• • •

Projection by AIA of Pentagon's 1960 FY funding is $2.5 billion for missile R&D and testing and $2.7 billion for missiles going into service use or inventory.

• • •

Look for Navy to make ICBM bid with *Polaris* cluster. New facilities at China Lake, Calif., ordnance station reportedly are being readied for end-of-year tests of *Polaris* boosters (probably clustered in three) for 5000-mile capability. Navy also is reported interested in modified *Polaris* for air-launched ballistic missile.

PROPULSION

New entry in high-energy chemical field for missile propulsion is Celanese Corp. of America, which will apply know-how in polymers and synthetic organic chemicals to solid fuels. Heading up new operation is Julius P. Zeigler, former chief of chemicals, propellants and explosives engineering development for Army ammunition command.

• • •

Hush-hush cryogenic storage insulator will be licensed on non-exclusive basis to industry by developer, National Research Corp., Cambridge, Mass. Insulator is reported to be 15 times better than powder and "twice as good" on performance-to-density basis as best commercial materials available.

• • •

Compressed air "reactor gun" to propel body in weightless space travel is being developed by ARDC. Motion would be controlled by shooting gun in opposite direction operator wishes to move. Tryouts are being in C-131B aircraft flying kaplerian trajectory.

ELECTRONICS

Outlook is for defense spending on electronics maintenance, procurement and R&D to jump from $5.5 billion in FY 1959 to $12.3 billion in FY 1970. EIA expects Pentagon expenditures to total over $100 billion on electronics in next 11 years with big expansion in missile funding accounting for the rise.

• • •

Accustomed to working with detailed specifications, industry is getting new indoctrination in *Pershing* system. In guidance, for example, Eclipse-Pioneer is working on the "submit it for test, we'll give you the specs later" philosophy of ABMA. E-P's guidance system, incidentally, will not go on the first few birds. ABMA will use the time-tested earlier LEV3 by Waste King to insure maximum reliability of initial test vehicles.

• • •

With 1960 FY funds, the Air Force will support two new communications systems tying into the early warning network. They are: CADIN (Canadian Air Defense Integration Network) and BADGE (Base Air Defense Ground Environment) located in Alaska.

• • •

Another round in transistors vs. tubes is shaping up. Eight tube manufacturers have formed Ad Hoc Electron Tube Council. CBS-Hytron, General Electric, Philco, RCA, Raytheon, Sylvania, Tung-Sol Electric and Westinghouse. The founders, say one primary aim is to promote tube use in electronic applications "where they offer superior properties."

ASTROPHYSICS

Nomination for first moon "man" is General Electric's "Handyman"—electro-hydraulically operated robot. Has "human" grasp so deft it can pick petals from flowers. Used in radioactive work, GE says "Handyman" would respond to remote control over 238,000-mile distance to Moon.

• • •

More data on *Argus* will be forthcoming April 27 when IGY group at NAS reveals first results of *Explorer IV* program which monitored high altitude atomic explosions.

• • •

Before *Argus* was known officially by that name, Lockheed reports its workers had nicknamed the project "Black Angus." Argus is the name for a 100-eyed Greek monster.

More about the missile week on page 16

Weapon System Concept Faces Trial

House group is set to quiz industry and Pentagon spokesmen in lengthy hearings airing charges of monopolization and profiteering

by Jim Baar

WASHINGTON—A hard-hitting House subcommittee is about to begin the most intensive investigation so far of the system under which private industry is being granted stewardship over developing the nation's missile arsenal and other advanced weapons.

The results could have far-reaching effects on industry, government, the nation's security and the future of U.S. space exploration.

Nearly a half-dozen bills already pending in Congress are aimed at either supporting or undercutting the growing use of the weapon system concept of military procurement. Any final action on them appears fairly certain to await the investigation's outcome.

But the interest of Congress in military procurement methods is rapidly increasing.

The House Armed Services Investigating Subcommittee headed by Rep. F. Edward Hébert (D-La.) will open its inquiry April 13 with testimony from officials of Lockheed and North American. Next on the schedule: Boeing and Martin.

In all, more than a dozen of the nation's major defense contractors are expected to be summoned to testify along with smaller firms. Tentative plans call for summoning government officials next.

• **Probe's purposes**—The investigation—scheduled to run through July—is aimed at determining among other things whether the weapon system concept has resulted in:

• Abdication by the Pentagon to a few industrial giants of true control of procurement.

• Squeezing out of competition and increasing monopolization of the market.

• Profiteering through arbitrary award of subcontracts to subsidiaries.

Moreover, the investigators plan in the course of their work to lay open for public inspection the tangled Pentagon forest with its many byways for contractors seeking military contracts.

The subcommittee staff began work on its investigation a year ago after receiving complaints from both large and small contractors charging abuses. It has received many more since then.

• **Concept assailed**—Meantime, a number of Congressmen have attacked the weapon system concept with increasing vehemence. They have charged that the Pentagon is resorting less and less to competitive bidding. And they contend that as a result millions of dollars in tax dollars are being wasted —or worse.

Also, two Congressional subcommittees already have investigated various aspects of the weapon system concept.

Hearings by the House Military Operations Subcommittee into management of the Air Force ICBM program by the Ramo-Wooldridge Corp. are expected to conclude this month.

However, none of the investigations so far has approached the matter in as sweeping a manner or has aimed at as much completeness as the forthcoming Hébert investigation.

• **Sample questions**—As a start, the Hébert subcommittee has sent all scheduled witnesses a format of questions that they should be prepared to answer.

It includes such questions as:

• What kind of contracts do you grant to subcontractors?

• Are they negotiated? What is the competitive situation?

• Do you take technical proposals?

• How do your subsidiaries participate in seeking subcontracts?

The subcommittee plans to move ahead slowly, carefully studying all testimony before proceeding to each phase of the investigation. The investigators are fully aware that any charges that may be brought out must be capable of standing up against the strong arguments of weapon system advocates both in industry and the Pentagon.

• **System's defense**—The Air Force —the most ardent admirer of the weapon system concept—began adopting it about five years ago. Since then its use has spread and flourished until today it is the dominant method used in one form or another throughout much of the military services for development of advanced weapon systems.

From the beginning it was designed to combat one of the greatest evils of military procurement: failure to have all the pieces ready to put together at the right time.

Such failures in past years were legion. Sometimes they were merely funny. Other times they were nearly disastrous.

Former Defense Secretary Robert M. Lovett once said the failure of many needed planes to arrive in Korea early in the Korean War was caused by the lack of a sufficient number of one particular 25-cent part.

The planes were built by one contractor. The Pentagon had contracted with another manufacturer for the 25-cent part.

Weapons system advocates contend that with today's ever-more-complicated weapons there is greater and greater need for a procurement method under which all the parts arrive on time.

Public hearings open April 27 before the House Ways and Means Committee on a 27-month extension of the government's authority to renegotiate defense contracts to recapture any excess profits. In asking extension, Defense Department proposed a change which would allow contractors to keep savings resulting from cost-cutting economies by requiring renegotiation board to take this into account. Another change would provide for judicial review tax courts decisions in renegotiation cases.

Better observation of the universe from the Southern Hemisphere is the aim of an observatory to be set up near Santiago, Chile, by the universities of Texas, Chicago and Chile. Dr. Gerard P. Kuiper, chairman of the University of Chicago astronomy department, is head of the cooperative project.

Boeing's better-than-400 nautical mile range Super *Bomarc* interceptor is under contract negotiation for continued development and manufacture. More than $100 million of original $300 million contract has been spent, Boeing says. It calls for production of only a limited number of *Bomarcs*. Static and flight tests are scheduled soon.

Government contractors will have access to a new $200,000 "Tom Thumb" metals extrusion and forging facility for experimental production of space materials at Wright Air Development Center, Dayton. Plant has high vacuum consumable electrode arc-melting furnace of 6000 amphere capacity, 8-inch sheet capacity rolling mill and 600-ton extrusion press.

Financial reports: Boosted by a quadrupling in volume of missile-space work, Lockheed Aircraft Corp.'s 1958 net profit rose to $18.5 million on record sales of $968 million. In 1957 profits were $16.3 million on sales of $868 million. End-of-year 1958 backlog was $1.156 billion—10% less than 1957 unfilled orders of $1.280 billion.

At $1.511 billion, 1958 sales of General Dynamics Corp., fell off the 1957 peak of $1.562 billion. Net earnings were $36.7 million compared to a 1957 net of $44.2 million. However, the company's estimated backlog at the beginning of this year was $2.095 billion—up considerably from the $1.75 billion of orders a year previously. Additional contracts under negotiation totalled $645 million.

Northrop Corp.'s earnings of $3.1 million for the first half of the year ending Jan. 31 were up from the same period of a year ago, despite a drop in sales to $116 million. The corresponding 1957 net was $2.8 million on income of $125.5 million. Unfilled orders of $264 million were up $22 million from the close of the last FY on July 31, but down from the Jan. 31, 1958, backlog of $275 million.

Record sales and earnings gave Chance Vought Aircraft a 40% improvement in 1958 over the previous year. Sales were $333.2 million and earnings $8.9 million against 1957 sales of $237.3 million and net of $6.1 million. The company's end-of-year backlog was $370 million with cancellation of the Navy *Regulus II* program clouding the outlook for 1959 somewhat.

Bell Aircraft Corp.'s net of $4.7 million was 9½% above 1957 on sales of $182.8 million. The sales figure, however, was 9½% below 1957 sales of $202.2 million.

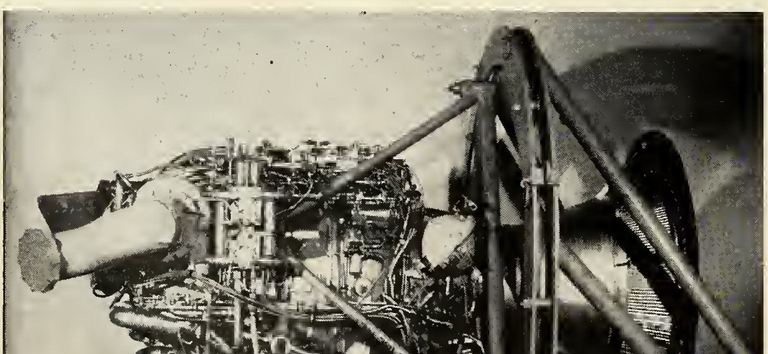
Marquardt is emphasizing that it is not lining up with any specific company in the TR-101 (*Penny, Hilo* drones proposal, *M/R*, Feb. 23, p. 21). Marquardt's customer relations department sent telegrams to industry contacts saying that it furnished propulsion information "to many companies" during proposal activities but that it "has not joined forces exclusively."

In manned space flight, how good is "reliable?" J. M. Wuerth of North American's Autonetics Division says to make the odds 1000-to-1 to return alive from an 8½-month trip to Mars in a spacecraft with 10,000 critical components, the Mean-Time-Between-Failures of the components must "exceed 7 million years." Individual components would not have to last that long, but the rate of failure can not be more than one out of 7 million parts in a year's time.

The AF has recovered data capsule ejected from a *Thor* nose cone. Test March 26 at Cape Canaveral established "reliability and accuracy" objectives on 1,600-mile flight. Eighteen-inch plastic capsule contained instrumentation to record atmospheric friction on 15,000 mph plunge back to earth.

The sequence of rockets to be used in testing out Project *Mercury* before the capsule actually goes on top of an *Atlas D* is: *Little Joe, Redstone*, and the *Jupiter*.

Gladding, McBean & Co. makes it clear description of 97% and 99% pure alumina for fabricating missile radomes (*M/R* March 16) has no connection with *Sparrow III* radomes. Reference to alumina was to illustrate the type of high-purity oxides which may be used in new GMB fabricating process.



UNDERGOING extensive testing is Reaction Motors 50,000 lb.-thrust liquid rocket engine for the *X-15*. The engine can be started, throttled, shutdown and restarted without endangering the pilot under any single malfunction.

A Hard Look at Space Logistics

AF-sponsored conference told it may be 5-10 years before man can be kept alive in space; planners banking on better component reliability

by William O. Miller

WASHINGTON—The cost of ground support equipment in the final analysis probably will be the limiting budgetary consideration in development of the U.S. program for the exploration and exploitation of space.

This is the current thinking of top Air Force planners—a conclusion reached at last fall's Space Logistics conference at Maxwell AFB (M/R Oct. 6, 1958), a report on which was released to *M/R* this week.

At this meeting, key AF personnel huddled with representatives of industry and other government agencies to "get a feel for the future so that we can better anticipate the problems," as Brig. Gen. L. B. Kelley, AF Director of Logistics Plans, put it.

Only an expansion of present logistics and supply systems is expected to result from growth of the ICBM and IRBM programs. But many basic changes are foreseen as man moves into space. These involve modifications in estimates of requirements, funding, procurement and procurement lead time, production, packaging, transportation, storage and special handling techniques.

AF planners are looking to an advancement in component reliability to reduce or even eliminate a number of peculiar and common type items in the requirement area with accompanying reductions in procurement funding, storage etc. They point out that initial supply may have to be provided in one complete package in consonance with reaction time—without the re-supply effort (follow-on) and consequent delays through requisitioning, accounting and shipping actions.

The more exotic systems will bring the new high-energy propellants to the fore, and additional problems will develop in production, storage, distribution and handling. Hence it is believed necessary to build up production capacity to keep abreast of technical developments. Special handling techniques and specific type tanks or containers will be required because of the corrosion, radiation, refrigeration and toxic aspects of these propellants.

To point up the critical nature of this problem, one spokesman said that a severe shortage of liquid oxygen caused a seven-months delay in the development of the rocket engine for the *Navaho* missile booster.

The choice of ground-based tracking stations poses many problems and probably will be aimed at utilization of existing facilities—commercial or military.

• **Water-borne launch sites?**—Modified aircraft carriers may find a new use as mobile water-borne launch sites. The major consideration here is not only to optimize the mission requirements: with the advent of nuclear power plants, sea-borne launch sites would minimize the problems of radiation and decontamination.

AF thinking was geared for the purposes of this 10th annual seminar to the idea that the first-stage booster for launching space vehicles is considered part of the ground support equipment. Those attending the seminar pointed out that for reasons of economy these boosters are apt to take the form of gigantic, air-breathing, manned vehicles operating at Mach 4 speeds and requiring a continuing supply support system similar to that envisioned for the B-70 weapon system.

They added that while chemical boosters should present no problems technically, the vehicle and the propellant would have to be larger.

• **Maintenance puzzles**—Maintenance problems are enormous—whether the plan calls for repairing and replacing parts while the vehicle is in orbit, or bringing it back to earth for such work.

Since more than 70% of the hardware at a fixed launching site is ground support equipment, it was argued that the specification, design, development, production, standardization and maintenance of such equipment should receive the same emphasis as the vehicle. These developments must be carried out concurrently with the space vehicle and be compatible with it.

Extensive training programs should be developed for each piece of peculiar or special equipment. Each space vehicle will require special clothing and handling characteristics. The use of exotic fuels will make it necessary to learn how to live with and handle their toxic, corrosive, storage and instability effects.

The report calls reliability the paramount requirement for space ship design, not only because it will determine success or failure, but also because we refuse to consider man as an expendable item, and because we find that the cost in dollars of unreliability in space vehicles is almost fantastic.

Reliability in the 95-98% bracket must be obtained for space vehicles, the report says, and this will be accomplished not by evolutionary design improvement, but only by revolutionary change in design philosophy. The cost per pound of orbiting equipment or personnel has been estimated at $1000. Failure of a 5¢ item could cause destruction of a 500-pound unmanned satellite representing a half-million dollars. It would cost $10,000 to deliver a 10-pound spare part to a vehicle or the moon.

• **Maintainability**—Another important design consideration is maintainability, determined to a large degree by the design of the vehicle. Accessibility is the most important factor for in-flight repairs. Removal of one component should not involve removal of other components—quick disconnects, button fasteners or other easily operated devices will aid here. Parts should be standardized to the maximum, even to the smallest subassembly or part.

New concepts will have to be developed also in the area of post-launch maintenance of manned or unmanned satellites, or moon stations. These will be based on reliability, automatic systems and functional checking by remote control, some duplicate circuitry with automatic or remote-controlled switching from a faulty circuit.

Maintainability also would be enhanced by restricting satellites during early years to a single major purpose.

• **Weakest link**—The report said it appears that a fully automated, completely reliable unmanned weapon system will have been achieved at least concurrently with the achievement of a man-in-space vehicle. Despite more optimistic predictions, a paper presented at the seminar by Col. C. H. Roadman provided an R&D schedule (see timetable) indicating from five to 10 years work will be required before man can be kept alive in space.

Under ideal conditions, equipment and supplies for one man in space for seven days totals 283 pounds. This, Col. Roadman said, can be compared with a 707-pound requirement using presently available equipment and methods.

Man, Col. Roadman said, will be the weakest link in space travel, and engineers must adapt their plans to the unavoidable requirements of the human organism. The cabin must be a "terella"—a synthetic little earth. Another spokesman coined the term "man-unit," which can be defined as a man and the consumables he will require for the duration of his mission in space, as the principle of personnel transfer.

• **Moon base**—A manned lunar station might serve as (1) an observation post, (2) a weapon system platform, or (3) a forward "base in space," according to the report.

Phase I of a program to establish a base on the moon would be an orbit around the moon and probe landings—no manned landings. Phase II, during which first landings would be carried out, is considered most hazardous. It consists of supply support for landing, erection and equipping of a lunar station. Advance planning should stress engineering design and development of lightweight equipment without sacrifice of durability and ease of erectability. Regeneration systems must be provided to utilize all types of waste and algae systems for food supply.

Generation of breathing oxygen and atmosphere from metallic sources and electricity through solar energy must be developed. It is assumed that solar or a lunar source of energy will be available for such devices as an electric catapult and return transportation from the moon when the lunar base reaches an operational phase.

Preceding the operational phase, for which scheduled periodic trips and supply support are contemplated, AF planners see a third phase during which the first landings would be exploited and the moon explored. Supply during Phase III would be from the initial package and from unmanned vehicles.

• **Problem areas**—It is suggested that investing comparatively few dollars now on engineering items for lunar occupancy, dynamic mockups to determine weak links and "single managering" logistics support could keep the costs and economic problems within relative percentage limits:

Survivability and cost—Maintaining one man as opposed to a number with various skills must be studied to provide a maintenance concept.

Stockpiling—Large quantities of certain fuels and materials must be considered in the national policy.

Reliability—An unbelievable level of reliability is needed to insure low cost and low re-supply requirements.

Data processing—Communications and computer operations must be positive and accurate to insure availability and shipment of correct items.

Inventory—Excessively large inventories are inevitable if standardization of nomenclature and use of "off-the-shelf" hardware are not enforced.

Concurrent development—Problems can develop if there is not concurrent development of support equipment, supply techniques and a supply system for lunar operations.

Another conclusion reached was that we have yet to determine the exact nature of the military requirement for human occupants in earth orbiters. If this requirement does not materialize, the report says, the supply support aspects are reduced to "throw-away-and-replace" as opposed to fix-in-orbit or recover-repair-and-relaunch.

• **Recommendations** — Recommendations of the seminar were:

1. That space vehicle design stress self-sufficiency, convertible equipment or multiple uses of equipment, miniaturization and weight reduction for subsystems.
2. That qualified logisticians be incorporated from the beginning into teams developing new space activities.
3. That basic design of frames and components for unmanned satellites be standardized, with separate kits installed specialized missions.
4. That satellites be restricted to single major purposes during early years.
5. That operational manned space activity not be undertaken until the requirements for manning have been demonstrated conclusively and human beings have been tested adequately in a real space environment.
6. That the technical and professional competence of military personnel be further raised, that skill needs be spelled out earlier, and that use of skills be more closely controlled.
7. That terrestrial space facilities normally be sited in areas already owned by the government and most compatible with future space systems growth, rather than with current approved plans, and that space facilities be designed with nuclear devices in mind.
8. That since space programs for many years to come are likely to emphasize quality rather than quantity, logistics arrangements be tailored accordingly.

R&D TIME TABLE NECESSARY FOR KEEPING SPACEMAN ALIVE

ACCELERATION	Up to two years' study is needed on human performance under g-forces and protection from g-forces.
WEIGHTLESSNESS	Four or more years will be required for studies, and only limited studies can be made until a suitable test bed is available for long-duration studies.
THERMAL EFFECTS	Up to three years will be required for chamber, vehicle, and performance studies.
WATER, NUTRITION, AND WASTE DISPOSAL	Up to five years will be needed for studies, which will include development of regenerative, carbon, and nitrogen cycles.
RADIATION	Up to two years will be required once a recoverable orbiting satellite is available.
ESCAPE	Up to two years will be required following determination of feasibility of escape.
ISOLATION AND CONFINEMENT	Five to ten years will be needed to overcome deficiencies discovered and a test vehicle will be needed.
PRESENTATION & PROCESSING OF INFORMATION	Up to five years will be needed for laboratory and substantiating flight tests.
CREW SKILLS, SELECTION AND TRAINING	Up to five years will be needed to determine requirements and to select and train personnel.

BRITISH ASTRONAUTICS

- **Laport using new HPT manufacturing process**
- **BLACK NIGHT resignations protest lack of policy**
- **Speculation on high altitude radiation reports**

by G. V. E. Thompson and K. W. Gatland*

LONDON—The British Firm of Laporte Chemicals Ltd. has started manufacture of high-test hydrogen peroxide (HTP) at their new plant at Bayonet Works, Warrington, Lancashire. They are using a new process developed by the company's R&D department at Luton, Bedfordshire.

Laporte have previously made peroxide at their Luton works by electrolysis of a solution of ammonium sulphate and sulphuric acid, to give ammonium persulphate solution, which was concentrated by evaporation, heated in a packed tower, and the hydrogen peroxide released removed as vapour.

In the years since the war, increasing interest in hydrogen peroxide has resulted in considerable research on large-scale manufacturing methods, particularly those not dependent on electric power supplies. Most of the work has been concerned with autoxidation of organic intermediates, and the new Laporte process is of this type.

The intermediate chosen is 2-ethyl anthraquinone. It is used in solution in a mixture of an aromatic hydrocarbon and a cyclohexyl ester, solvents respectively for the quinone and the corresponding quinol. The first stage of the process is catalytic hydrogenation in a vertical vessel, and the catalyst (palladium on a granular support) is in suspension in the solution.

After filtration and cooling, the reduced solution is fed to the base of another reactor, where it is oxidized by a stream of air in concurrent flow. In this reactor, the 2-ethyl anthraquinol formed by reduction of the quinone is oxidized back to the original substance, and hydrogen peroxide is produced in the process. No catalyst is needed.

The hydrogen peroxide is removed from the organic solution by aqueous extraction, and concentrated by vacuum distillation. Stabilizers and corrosion inhibitors are added and the organic solution is recycled.

This process was first studied in Germany before World War II, and I.G. Farbenindustrie built a pilot plant at Ludwigshafen. Laporte's plant is the largest of its type in the world. After the preliminary design of the plant had been carried out, information about its operating characteristics was obtained by setting up a representation of the process on the E.M.I. EMIAC I analogue computer.

The investigation was done as a joint project of Laporte and E.M.I. (one of the leading British electronic firms). The EMIAC computer was originally designed for work on guided missiles.

Laporte's plant cost nearly $7,000,000 and will double the company's output of HTP. Rocket motors using HTP as propellant have been designed by the de Havilland and Armstrong-Siddeley companies.

• **Rocket experts resign**—The British rocket and aircraft industries have been shocked by the resignations of P. H. Leyton, chief rocket development engineer to the firm of Saunders-Roe Ltd., and Maurice Brennan, the company's chief designer.

Leyton, who was in charge of development of the *Black Knight*, Britain's most advanced rocket to reach the firing stage, joined Saunders-Roe in 1956; Brennan, whose resignation closely followed Leyton's, had been there since 1936.

The *Black Knight* project has been very successful so far (see M/R, March 2, p. 31) and surprise was voiced when Leyton's resignation was announced. He leaves at the end of March, but is not remaining in the astronautics industry. He will become director of engineering at Black and Decker Ltd.

Because of widespread interest, Leyton sent a letter to The Times of London explaining his reason for leaving the *Black Knight* team—the absence of an official policy on space research. He said that this lack set an insurmountable handicap.

Nevertheless, Leyton noted, to find that despite satellites orbiting the earth and passing the moon and despite the *Black Knight* successes there is still no official space research policy indicates "an official lack of understanding which is proof against the most ardent technical ardour."

• **Second successful launching**—The second *Black Knight* ballistic rocket was successfully fired a few days before Leyton's resignation. As before, it was a night firing at the Australian rocket range at Woomera. An altitude of about 350 miles was reached, and all the instrumentation operated successfully.

• **Whose particles?**—The recent suggestion by Russian radiation experts I. Shklovskii and V. Krasovskii that the high-energy particles trapped in the earth's magnetic field in the inner Van Allen belt are the result of high-altitude nuclear tests was at first dismissed as propaganda.

With the disclosure by the New York Times of the high-level explosions made in U.S. tests, some British circles are now wondering whether the radiations detected by the *Explorer* satellites before these U.S. tests may not be due to atom bombs exploded by the Russians at high altitudes *before 1958.*

There is no evidence that the Russians have done this; on the other hand, even in 1957 they possessed rocket vehicles capable of undertaking the task. Another question being asked is whether the U.S. tests were in fact as secret as was made out, since *Sputnik III* was well equipped for radiation measurements.

** M/R's contributing editors in the United Kingdom. G. V. E. Thompson is editor of the Journal of the British Interplanetary Society. K. W. Gatland is an aircraft design engineer and author of scientific books.*

VANGUARD TESTING:

Backbone of Present Ballistic Missile Art

Check-out 'primer' developed by Martin gives pattern for industry to follow

by William E. Howard

BALTIMORE—In the rapidly-evolving art of pre-flight testing big rockets, concepts originated by the men who put together *Vanguard* today are helping cut critical months from the operational readiness of U.S. ICBM's.

Basic procedures laid out by Martin Co. engineers have set the pattern for improved techniques speeding up the check-out of *Titan*, *Atlas* and other big missiles.

Refinements have long since dated the pioneer work. But the *Vanguard* test "primer" is so valuable that only now has its step-by-step procedure been declassified—and then only in outline form. These outlines have been made available to M/R.

Meyer Borghese and Bart Wong, who prepared the outlines, make it clear that Martin was forced to develop a test philosophy adapted to the hurry-up timetable for the U.S. satellite program. Pressure was increased with the launching of *Sputnik*.

Accordingly, to reduce field testing to a minimum, Martin established a program to demonstrate, as fully as possible, system performance and integrity before delivering vehicles to Cape Canaveral. This meant that most of the testing would be done at the Martin plant in Baltimore.

• ***Viking* verticle tests used**—To achieve their objective, *Vanguard* engineers borrowed a book from the past—an idea for verticle testing conceived 10 years ago by another Martin engineer, Preston Layton, when he was field manager of *Viking* at White Sands, N.M.

Layton, now head of the Princeton University propulsion lab, had constructed a gantry to determine whether *Viking* gyros and other components would behave in ground tests as well standing up as they did lying down.

Vanguard engineers decided the same type of facility would speed check-out of their vehicles. So they erected at Baltimore a seven-story tower, resembling a grain elevator, which can hold two completely assembled three-stage rockets simultaneously. This was to become the key test "tool."

The 29 x 37 x 97-ft. monument to Layton's idea is constructed of heavy steel and enclosed by sheet steel and fibreglass. It has five working levels spaced at instrumentation sections of the rockets. The levels are completely equipped with power, heat, water and a communication and public address system. An outside two-ton crane handles the delicate job of hoisting the vehicles into the facility and fits the stages together.

• **Shakes and gusts**—In the tower, the "birds" are subjected to complete dynamic tests to verify pre-design analysis. The assembled vehicles are suspended in air and shaken in the "free-free" (in flight) and cantilevered (erected on launching stand) with the propellant tanks filled to different levels to measure bending deflections.

Structural tests simulating aerodynamic and wind gust effects are conducted in a separate tower nearby. Full scale models are constructed for these checks.

Wong, who was senior engineer of the guidance and controls group until leaving Martin recently, says the overall test approach "permitted, to a large extent, the combining of development tests with manufacturing tests, thus allowing for the de-bugging of an advanced improvement in the state-of-the-art system under the direct supervision and guidance of design engineers."

• **Long, tough chore**—How many man-hours go into the complete functional testing of the myriad complex components in each of the 72-ft. *Vanguards*, the Martin men don't say. However, Borghese, who is mechanical department group engineer, concedes it is a "long and complicated task" requiring about six weeks.

Precise instructions for test technicians govern almost every moment of this time, from the day manufacture is completed until the firing switch is closed sending the bird on an orbit-placing flight that takes just 10 minutes. In addition, there are detailed procedures for practically all operations performed by the field crew, including erecting the rocket on its launching stand.

• **Horizontal tests first**—A step-by-step closeup, as described by Borghese and Wong, starts with the first and second stages being wheeled out of the manufacturing plant. While on their dollies, horizontal testing of each system is performed.

Equipment utilized includes: a rocket test console consisting of a fire panel, gyro monitor, controls monitor, controls tester, signal generator and scope panel and junction box; first- and second-stage functional test console; first- and second-stage firing simulator; ground service panel; igniter simulator; jet control box; first- and second-stage grid and pointer; gyro simulator, and gyro tilt table.

All the equipment supplies pressures and voltages to the rocket systems and indicates their reaction to stimuli on lights and meters.

Tests are applied to the first- and second-stage hydraulic and control systems; the first, second and third-stage separation systems; range safety and tracking equipment; first and second-stage propulsion system control units, circuits, solenoid valves, pressurization and propellant systems; and alignment of the first and second-stage thrust chambers.

• **Compatibility tests**—Once horizontal tests are completed, the three stages are assembled in the verticle test tower. Here "acceptance" tests are initiated to assure complete compatibility of the interconnected systems of the entire rocket. They include: spin mechanism clearance—third-stage; third-stage alignment; first and second-stage controls system; rocket electrical systems; radio interference tests of range safety and tracking systems; propulsion system marriage test, and cut-off, destruct and separation systems tests.

Again the rocket test console and other equipment used in the horizontal tests are employed in the verticle test tower. Alignment of the three stages is also accomplished.

• **Second-stage tank pickling**—When this series of verticle check-outs is completed, the first stage is removed and placed on its dollies and the WIFNA tank of the second stage is pickled.

Pickling is intended to prevent excessive scaling which may clog the mesh filters during flight, causing reduced performance or premature cut-off of second-stage burning. Borghese gives this pickling formula: The tank is filled with a 6% WFNA solution comprised of 205 gallons of demineralized water and 9 gallons of WFNA (MIL-N-7254, Type 1) per pickling cycle of 8 hours. After draining it is flushed three times with an inhibiter consisting of 70 GM of sodium dichromate and 180 GM of sodium acid phosphate in 1500 ML of demineralized water. The tank is then flushed with 205 gallons of demineralized water.

The entire process is repeated as necessary until a "specified" drop in size of scales is obtained.

As soon as pickling is completed, the entire missile is delivered to the government for shipment to the Cape. On arrival, the entire series of horizontal tests is repeated to determine if any components were damaged in transit.

• **Second-stage static firing**—The next step is a static-functional test, including static firing, of the second-stage propulsion system. This test, performed on the launch pad, is designed to simulate an actual flight and demonstrate correct functioning of all sequential operations from first-stage cut-off through third-stage spin-up and separation.

During this test, first-stage operation is simulated, along with third-stage spin-up, ignition and separation. The control system is operable, however, with servo packages installed.

A 240-minute countdown precedes the simulated lift-off of the first stage. Then it proceeds for another 620 seconds to represent the actual *Vanguard* flight into space.

Engineers and technicians at this point are in the nearby blockhouse monitoring the "flight" for proper functioning of all components. At the test's completion, if all runs smoothly, the second-stage is put back on its dollies while the first stage is placed on the pad. Then the second stage is hoisted on top and spliced to the first stage with six explosive bolts.

The first stage is then fueled up and fired for approximately 50 seconds while lashed to the stand.

Upon successful completion of static firing, the rocket is completely assembled and for 10 days undergoes pre-flight tests similar to the ones conducted in the Baltimore test tower.

• **Preparing for launch**—Suddenly, the moment for launching approaches and the giant 7-story gantry surrounding the 22,500-lb. rocket swarms with activity. Three moveable platforms on the gantry are jammed with equipment. An elevator hums restlessly up and down inside while a crane atop the gantry switches equipment with a long steel arm to where it is needed.

The gantry, too, has a link with the *Viking* past of *Vanguard*. The same one which Layton constructed at White Sands was dismantled and reassembled at the Cape to fire *Vikings* 13 and 14 in the successful December, 1956, and May, 1957, TV-O and TV-I shots of *Vanguard* components. TV-I was a lift-off of the *Vanguard* third stage.

• **Shot into space**—On launch day, the countdown begins 6 hours and 40 minutes from time zero with the Minitrack transmitters switched "on" and the satellite operating.

Approximately six hours before launch, the rocket propane tanks are charged. The second-stage UDMH tank is serviced and white fuming nitric acid is pumped into the tank in the second stage. First-stage tanks are fueled with LOX and kerosene.

Helium and hydrogen peroxide are also put into their respective tanks in the first stage. The helium sphere in the second stage is filled.

If all the checks are good, the command to fire is given.

VERTICAL tower at Martin-Baltimore subjects *Vanguard* to complete dynamic tests to verify pre-design analysis. The 97 ft. high tower has five working levels spaced at instrumentation sections of the rocket.

Vacuum Jacketing Cuts Fuel Losses

CEC reports its jacketed lines reduces boil-off by half, compared to those insulated with other materials

PASADENA, CALIF.—A major source of boil-off loss in cryogenic fuel transfer systems for missiles can be minimized by jacketing the lines in high vacuum, according to engineers at the Rochester Division of Consolidated Electrodynamics Corp.

Six or more gallons of fuel often is lost for each gallon delivered to the missile with present transfer systems. According to CEC, vacuum-jacketed lines have reduced boil-off by 50%, compared with lines insulated with asbestos, glass and cork.

In the CEC lines, a small fuel-carrying pipe is installed inside a larger one. The area between the pipes is evacuated to a pressure of 1 x 10^{-5} mm of mercury, or lower. This reduces heat transfer by conduction and convection. The outer surface of the inner pipe is highly finished to reflect radiant heat.

Bayonet-type joints held to a 0.005-inch diameter tolerance are provided between pipe sections to produce positive leakproof connections. The flange in each female joint is designed to capture completely the O-ring inserted between sections. All mating surfaces are machined to a 63 micro-inch finish.

• **Other types tested**—Heat transfer with this insulation is as small as 3 BTU/ft/hr. Other types of insulation that have been tested at the National Bureau of Standards Cryogenics Engineering Laboratory at Boulder, Colo., had the following heat transfer values by comparison:

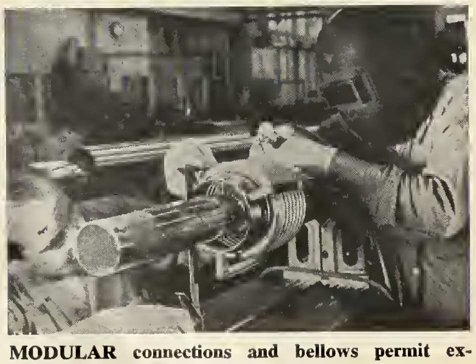
1. A reflective type composed of 13 concentric polished aluminum cylinders with spacers of light gauge stainless steel—186 BTU/ft/hr.
2. A rigid cellular 4¼-inch-thick glass insulation having a density of 10 pounds per cubic foot—72 BTU/ft/hr. (Heat transfer decreased only slightly for greater thickness of insulation.)
3. The same as 2., with insulation 2¼ inches thick—79 BTU/ft/hr.
4. Steam-blown glass fiber with a density of eight pounds per cubic foot —42 BTU/ft/hr.
5. Flame-blown glass fiber of three pounds per cubic foot density—40 BTU/ft/hr with 2-7/16-inch thickness and 22.9 BTU/ft/hr with 10-5/8-inch thickness.

• **Chill-down required**—One of the difficulties with conventional insulations is that the insulation itself requires a chill-down period during which large amounts of the liquid may boil away. In some cases, it was found that increasing the thickness of the insulation caused additional boil-off during the chill-down period. Condensation and resultant freezing within the insulation at times destroyed the insulation's thermal qualities.

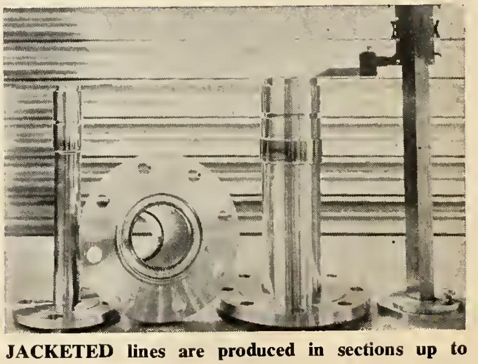
Uninsulated pipes, used initially to expedite the activation of missile test facilities, build up their own insulation in the form of snow coating. Boil-off is considerable during the chill-down period. If the ice buildup is rapid, excessive flaking results, exposing surfaces to added boil-off. Heat transfer losses from uninsulated lines are about double those of the reflective type shell, the least efficient of the insulating methods described above.

CEC also has developed modular vacuum-jacketed connections and bellows to permit expansion and contraction of the lines from heating and cooling. In addition, it permits a slight deviation from a straight line often necessary at missile-launching installations. These permit any configuration required at the launching or test site. Jacketed lines are produced in sections up to 40 feet in length and in various diameters.

To support and to permit optimum use of the vacuum transfer lines, CEC also is producing high-vacuum pumping systems, gauges, vacuum-jacketed valves, and leak detectors.



MODULAR connections and bellows permit expansion and contraction of lines.



JACKETED lines are produced in sections up to 40 ft. in length.

Months before Pearl Harbor, JPL had tested America's first liquid rocket engines using spontaneously igniting propellants. By April 1942, a simple nitric acid-aniline propulsion system was designed into and successfully tested in an A-20-A Bomber for a jet-assisted takeoff. For high-altitude atmosphere research purposes, JPL then used the hypergolic liquid rocket system in the WAC CORPORAL. Placed as a second stage on a V-2 rocket, this became the BUMPER WAC rocket that established a World's altitude record of 242 miles in February 1949.

At the request of U.S. Army Ordnance, the Jet Propulsion Laboratory now began to develop a long-range guided ballistic missile system, incorporating the proven, smooth-burning light-weight acid-aniline system. These achievements sparked the development of a whole series of rocket vehicles. In 1954, the Army accepted the JPL developed CORPORAL, which became America's first tactical guided ballistic missile system; its accuracy exceeded design requirements.

Under the direction of the National Aeronautics and Space Administration, the experienced Jet Propulsion Laboratory research and development team is now working on storable, high-performance hypergolic liquid propulsion systems with which space vehicles may soon orbit the moon and planets.

jpl

CALIFORNIA INSTITUTE OF TECHNOLOGY

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A Research Facility of the National Aeronautics and Space Administration

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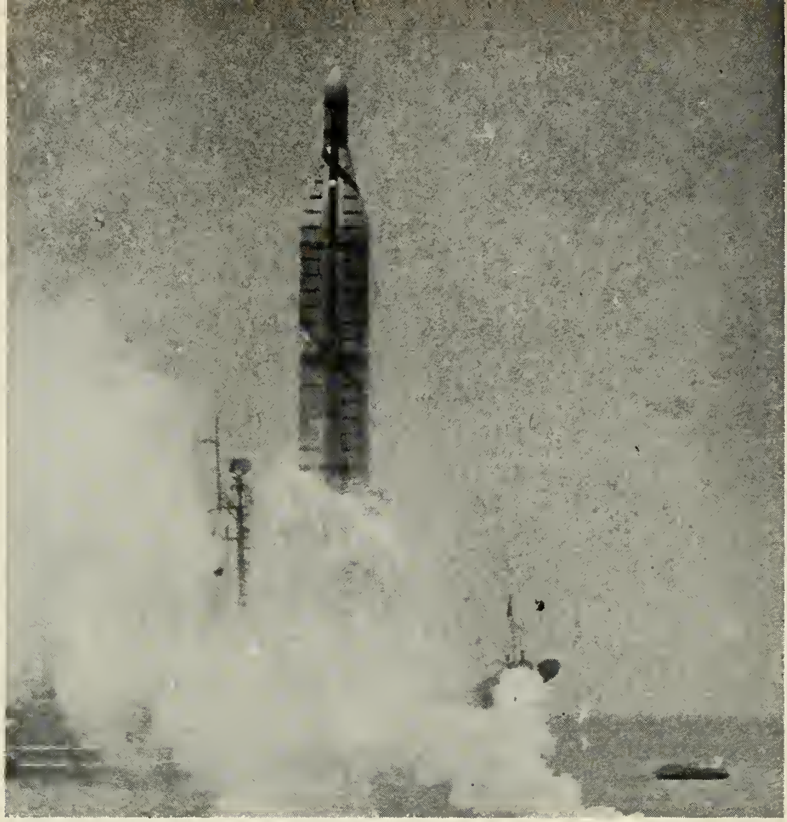

(left) Pop-up test of Navy Polaris IRBM.

(below) Nation's first successful re-entry tests were conducted with the Lockheed X-17.

STRUCTURES AND DESIGN

Expanding the Frontiers of Space Technology

Design is a challenging and growing field at Lockheed dealing with varying phases of mechanical, electrical and structural problems.

Some of the most difficult structure problems in the missile industry were successfully met by Lockheed design engineers for the Navy Polaris IRBM, where the unique launching environment—water—aggravates the normal critical missile requirements of strength minus weight.

Major emphasis in structures concerns the design of re-entry bodies, thrust termination, and underwater launching devices. Other significant work has been accomplished in the mechanical design of vehicle frames, flight controls, hydraulic, ignition and separation systems; and in the electrical design of equipment for test, check out, arming and fusing, guidance, and telemetry.

As systems manager for such major, long-term projects as the Navy Polaris IRBM; Army Kingfisher and Air Force Q-5 and X-7 and other important programs, Lockheed engineers and scientists face a double challenge – to improve existing designs and devise solutions to new problems.

Scientists and engineers of outstanding talent and inquiring mind are invited to join us in the nation's most interesting and challenging basic research and development programs. Write: Research and Development Staff, Dept. D-29, 962 W. El Camino Real, Sunnyvale, California.

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NASA Expands NACA Procurement Set-Up

Procurement chief says agency is decentralizing contracting and prefers doing business with established companies

BRACKETT

by Erica M. Karr

The National Aeronautics and Space Administration is the newest of the big government agencies. It is charged with development of the nation's civilian program. Ernest W. Brackett, recently appointed director of procurement and contracting, is responsible for getting NASA the tools it needs for the job. Brackett, a graduate of Cornell University, served as head of the procurement office of the Air Technical Service Command at Wright Field during World War II. After separation from service, he became civilian chief of the Air Force contract branch at the Pentagon. Later, he returned to Wright Field and served on the staff of the director of procurement and production. In his new post, Brackett is developing a procurement program for NASA. M/R obtained the following interview with him in an effort to answer some of industry's questions about the program.

Q. Will you explain the procurement set-up in NASA?

A. When Congress passed the law which set up NASA, it provided that it would take over the functions, facilities, and personnel of the National Advisory Committee for Aeronautics which had been in existence for many years. NACA had a good procurement organization. However, with the new organization set-up of NASA a much different type of contracting will be done.

For instance, NACA used to purchase test equipment, machine tools, and standard items for the work of the NACA laboratories. We will now be purchasing this and in addition will be making research and development contracts. Many of them are on a cost or cost-plus-fixed-fee basis, which is something NACA had not done.

NACA had three laboratories; one at Langley Field, Va., the Lewis Laboratory at Cleveland, Ohio, and the Ames Laboratory in Mountain View, Calif. Procurement in the past has been carried on at all three of these and they will continue to do so.

There is also procurement being done at High Speed Flight Station, Edwards Air Force Base, Calif. In addition, we are making contracts at Headquarters, NASA—most of these contracts being research and development. NASA also expects to build another laboratory in Beltsville, Md. When that is completed the contracting which is now done at NASA headquarters will be moved to Beltsville.

Q. Will NASA decentralize its procurement to local districts like the Ordnance or Navy?

A. Yes, NASA's plan is to decentralize procurement and eventually a very small part, if any, will be carried on through Washington headquarters. The Washington headquarters will be a staff function in procurement similar to the Pentagon staff principle.

At headquarters we will determine procurement policy, review and approve contracts and provide surveillance over the decentralized procurement offices. The plan is that NASA engineers and scientists also will be decentralized to the various laboratories and they will have certain projects assigned to them. The contracts to carry out those projects will be made by the laboratory which has charge of them.

For instance, the project to carry man into orbit, known as Project *Mercury*, is assigned to Langley Field. Our contract for the development of the space capsule with McDonnell Aircraft Co. was made at Langley.

Q. How does the contract procedure differ from that of ARPA or Defense Department?

A. ARPA does not make any contracts. It determines fields and projects where contracts should be made. These are assigned to the Army, Navy or Air Force which actually make the contracts. In NASA the technical people determine what projects should be covered by contract and they ask us to make contracts for them.

The NASA organization is divided into two sections. In one section are the technical people—engineers and scientists who determine requirements. The other is Business Administration. This includes budget, fiscal, personnel, and procurement and supply. Procurement does not determine any requirements. We only buy what the people who make the requirements determine they need.

Q. How long does it take NASA to make a contract?

A. We are attempting to effect our procurement without many of the details which larger organizations have. Where an organization is small, it is usually able to function faster because there are less formalities and less checks and balances, which are inherent in any large organization.

The space capsule contract with McDonnell was negotiated, written, and distributed within three weeks after selection of the contractor. We also have negotiated and placed in effect some contracts in less time than that.

Q. What is the system for review and approval of contracts in NASA?

A. There will be set up in procurement headquarters a committee to review all contracts over a certain amount made by any of the laboratories or at headquarters. Probably the minimum amount will be $100,000. It is quite possible that approval authority will be vested in the director of procurement and supply, although it may be that certain large contracts will be approved by Dr. T. Keith Glennan, the Administrator.

Q. What is NASA going to do for small business?

A. NASA plans on having an affirmative small business policy. I believe, not only because statute requires it, but for the benefit of NASA and American industry that small business should be assisted in every way possible. We already have made some substantial contracts in research and development with small business concerns. There are certain types of procurement, however, which only companies with a large amount of facilities and large staffs of engineers will be able to handle.

To date, we do not have a small business program in effect. We are waiting for a new man to report who is to take over this function and I think it only fair to wait until he has a chance to study the problem before we attempt to formulate a program.

Q. Is NASA's procurement running smoothly?

A. So far we have not run into any big obstacles. We do have a backlog of work. There are approximately 10 letters of intent which have been issued within the past few weeks and these we anticipate definitizing into contracts in the next few months. We have some new people reporting and we hope within 10 days to be in good shape.

Q. How can a firm obtain business from NASA?

A. NASA does not have to be sold something. They only buy what they need. My suggestion would be that any company interested in doing business with NASA obtain copies of Form 129, Bidder's Mailing List Application, a form we use for a business firm listing the items it has to sell and other information about its people and capacity.

A copy of this with any literature should be sent to one of the following: Sherwood L. Butler, Procurement Officer, Langley Research Center, Langley Field, Va.; E. C. Braig, Procurement Officer, Lewis Research Center, 21000 Brookpark Road, Cleveland 35, Ohio; Alvin S. Hertzog, Procurement Officer, Ames Research Center, Moffett Field, Calif.; M. E. Bowling, Procurement Officer, NASA High Speed Flight Station, Box 273, Edwards AFB, Calif.; and NASA Headquarters, 1520 H St., N.W., Washington, D.C. Any company interested in construction work should file a DD Form 1072, Construction Contractor Experience Data, which we will supply upon request.

The principal type of contract we now are making at headquarters is research and development. Companies that have a research and development set-up should tell us that fact. We take these forms when we receive them and place them in our source or bidder's list. When a project comes along, we take out our bidder's list and see what companies are interested in that type of procurement and they are invited to submit proposals if it is negotiated, or are sent invitations to bid if it is an advertised procurement. Companies may submit unsolicited proposals in the research and development field if they have an idea they think would be good for our type of work.

Q. What type of contracts and what forms will you be using?

A. We will purchase everything we can by formal advertising. This includes any standard commercial item or one which has a firm specification. We are now procuring liquid hydrogen for a four-year period by formal advertising. When it comes to research and development, we have nothing more than a performance specification and there are many details that have to be worked out by negotiation. Practically all these will be cost-plus-fixed-fee appropriations.

We are under the same statute for procurement as DOD—Public Law 413. The Department of Defense has as its implementing procedures the Armed Services Procurement Regulations and we have adopted these as our guide. Our standard contract clauses will be largely those found in the ASPR.

Q. What qualifications do you look for in a contractor?

A. We need contractors who are established in their particular line; those that have the necessary facilities and experienced people such as engineers. We would like to place our contracts with companies that have done work in the same field and have demonstrated their capability. Because of the crash program we have, we do not think it wise to place contracts with new and untried companies.

Q. Will you use some of the contractors who are making missiles and rockets?

A. Yes, we will be using some of those contractors. In fact, we will ask the military departments on some occasions to buy for us certain items they already are purchasing.

Q. Are you going to administer your own contracts and what will your system be?

A. Where one of the military departments has a contract administration set-up in a plant and we make a contract with that same contractor, we expect to ask that department to administer for us. This will avoid duplicating staffs and save the government money. For the most part, they will be administering our contracts just as they administer their own and this should make it easier for contractors. Otherwise, we will administer the contract ourselves.

Q. How do you determine what company should be selected as a contractor for a negotiated contract?

A. I think I can best illustrate this by telling you what we did with the space capsule contract. There were 30 companies which NASA considered interested in this procurement. These companies were invited to a conference, and the project was outlined to them.

We then sent a request for proposal to these companies and 13 submitted proposals. These were evaluated in two sections: (1) their technical sufficiency and (2) for the business side, which included such things as the fee and estimated cost. Before the evalution took place, a procedure was drawn up and points assigned to different phases of the proposal. Each proposal was then rated on a point basis by a board. The board reported the findings and recommendations to Dr. Glennan and his staff. As a result of this, McDonnell was selected. But some of the smaller contracts may not be treated in quite so much detail.

Q. What is the amount of the 1959 and 1960 budget for procurement?

A. The Fiscal 1959 budget for research and development is approximately $204,600,000. For construction and equipment, FY '59—$48,000,000 with a prospective supplemental budget of $24,200,000. The 1960 budget, if the funds are appropriated which have been requested, will be $331,100,000 for research and development and $57,800,000 for construction and equipment.

Q. How many contracts has NASA issued and what are the amounts?

A. We have issued 26 new contracts of over $25,000 which totaled approximately $126,103,000. In addition, we have outstanding 10 letters of intent. The amounts that those will total is not yet determined.

Q. Industry has been unhappy about NASA's restrictive patent provisions and has been clamoring for an arrangement like the one it has with the Defense Department. What is the status of this?

A. NASA will not attempt this year to have the provision changed. We want first to see how it works out in operation.

House Group Urges Reliability Program

Job is to recognize that reliability must be balanced against other factors

by Betty Oswald

WASHINGTON—How to improve the reliability of missiles, parts and components is still an important headache, the surveys and investigation staff of the House Appropriations Committee said in Part I of a report published as a part of Volume I of the Defense Department's Appropriations hearings for fiscal 1960. Part II of the report is classified.

The job—as the staff sees it—is to improve reliability while at the same time recognizing that it is only one of many performance factors which must be balanced against each other and against cost. To do this, the staff has recommended a major program as follows:

(1) Reliability requirements for missile parts, assemblies components and systems should be written into military specifications wherever practicable. In cases where specifications can't be written, the staff wants contracts to require suppliers to adopt and maintain definite programs of indoctrination, workmanship, review and inspection in support of reliability.

(2) Defense Department should arrange for cooperative centralized planning of tests to acquire an accumulate environmental data of maximum value to missile programs generally. The staff found that Office of Director of Guided Missiles had failed to take an active enough position in the reliability effort.

(3) Further development and use of simulators for simultaneous environmental testing and for simulated flight testing of parts, components and completed missiles.

(4) An active program is needed for the interchange of information among missile agencies and contractors on performance of components and parts and on capabilities of suppliers.

(5) A consistent set of terms, definitions and practices relating to reliability is needed. The report recommends that Defense Department set up a joint project to get the job done.

(6) Both Defense Department and the contractors should continue and enhance education and training in all aspects of reliability for all levels of personnel, including management.

(7) Army, Navy and Air Force should continue and expand research on the mathematical and statistical aspects of reliability and of the publication of suitable engineering handbooks.

(8) Defense Department should encourage and stimulate broad programs of basic and applied research, independently of specific missile programs. Emphasis should be on new principles and techniques, mechanisms of failure, and the properties of materials.

(9) Office of Secretary of Defense should arrange surveys of the relative effectiveness of the different approaches of Army, Navy and Air Force.

(10) OSD should take greater initiative in identifying and assessing common problems in reliability and in developing integrated programs for their solution.

Industry Putting Increased Emphasis on HEF Processes

But the physical and metallurgical problems still remain largely unanswered with techniques being debated

by Frank G. McGuire

LOS ANGELES—The missile industry is giving increasing attention to the possibilities of high-energy forming (HEF) of metals—a process that can be expected to achieve tremendous growth.

But the problems involved in HEF are towering, too, according to experts at Lockheed, Convair, Aerojet-General, NOTS, Colorado School of Mines, Grumman, Ryan, Propellex Chemical Corp., Nitroform, Inc., Winchester-Western Div. of Olin-Mathieson and many other firms, government agencies and universities.

They are seeking answers to such questions as: "Should we or shouldn't we use explosives?" "What should we use as a transmitting medium—and how much of it?" "What are the physical and metallurgical factors involved?"

This last question involves a more lengthy answer, perhaps, than all other questions combined. Questions of stress, strain, radial displacement, deformation, dislocation, critical impact velocity, initial velocity, center deflection, and many other considerations, are still under hot debate.

The practical results to be expected from a given set of circumstances, however, are a little less controversial in nature. According to Dr. John S. Rinehart, director of the mining research laboratory at the Colorado School of Mines, "the thing that impresses me most about the high-energy forming process is that the results are so exactly reproducible, and capable of being scaled up or down to meet requirements."

• **Several approaches**—In actual use, there are several approaches to the problem of forming a piece of metal by the high-energy process. They involve: applying a sudden release of energy directly against a workpiece, forcing it to assume the configuration of a die; applying the energy to a transmitting medium, which in turn acts on the metal, forcing it to assume the shape of the die; or applying the energy to a piston, which works on a medium, which then acts upon the workpiece, forcing it to assume the shape of the die. Some consider the latter the most conservative approach.

During the 11th Western Metals Congress held here recently, the question of explosives arose during a technical session. In using explosives as a source of sudden energy, some experimenters had chosen dynamite, others had picked various commercial and military types.

R. A. Cooley, executive vice president of Propellex Chemical Corp., cited the possibility of using propellant powders for explosive forming, since they can attain burning rates as low as one foot per second. Joseph L. Bird, president of Nitroform, Inc., stated that his firm's experiments had shown both propellant powders and dynamite to be almost valueless. He said the company is now using RDX and primacord. Some firms cited initial trials with shotgun shells. To all of this, Aerojet's Dr. L. Zernow retorted: "Use the cheapest."

The power of various explosives has a definite bearing on the results to be obtained. TNT, for example, has a detonation wave with a velocity of 24,000 fps, and the gas bubble formed by the explosion has an initial pressure approaching 900,000 psi.

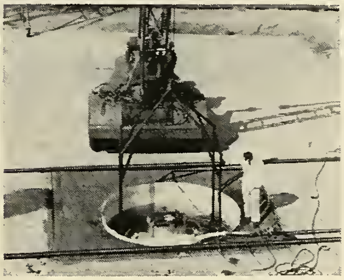
• **Rapid exploding**—Experts in the HEF process are still debating the merits of a rapid explosion, applying the maximum force to the workpiece over a minimum of time. C. O. Williams of Winchester suggests that "one of the greatest problems . . . is to prepare a charge which contains in sheet form a very slight amount of high explosive per surface unit but which will support continuous detonation. . . . We often hear that we should hit the workpiece with maximum force in a minimum amount of time in order to assure maximum elongation. Perhaps in many instances the opposite is true." Winchester has, in the past 18 months, produced 35,000 parts by the explosive forming method.

In explosive forming with high explosives, the initial impact of the shock wave accelerates the workpiece away from the wave, which keeps the metal moving through inertia until the workpiece fills the configuration of the die cavity. The time period from detonation to complete formation of the part is measured in milliseconds. The void between the workpiece and the surface of the die is vacated by means of a vacuum line operating through a porous metal section at the base of the die.

Lockheed Aircraft Corp., possessor of an AMC contract to explore the HEF process, says its work is purely experimental and that it is engaged in no production work. Glen N. Rardin, project engineer at Lockheed, said: "We are making hundreds of shots, just determining the basic curves of what each shot does. We've not yet proven whether the pressure bubble or the shock wave does the work." Dr. Zernow of Aerojet later commented that: "The pressure bubble can be virtually discounted." In the series of HEF experiments conducted by Aerojet, he noted, work had been done on metal plate up to two inches thick, as well as on armor plate.

The reproducibility of parts was emphasized by Ryan Aeronautical Co., which reported that a part formerly requiring an eight-hour setup time for tooling was now being produced after a fifteen-minute setup time and 1/3000th-second for actual forming. "Once we have the right backing, proper waterhead and proper charge and placing, we can get a run of parts just as identical as it is possible to make them," a Ryan spokesman said, adding that the firm expects to have 30 to 40 parts in production by the HEF process within a month. He also noted that a dimensional variation of less than 1/2000th inch is routine, and that cost of tooling is 1/10th the cost of conventional tooling.

BOEING AND RYAN are typical examples of companies engaging in research for HEF of metals. *Bomarc* fuel tanks will be produced by this method.



• **Practical application**—In its very simplest form, the setup for explosive forming consists of a female die, a workpiece and an explosive charge. The charge can be either suspended over the workpiece, thus in effect using air as a transmitting medium; or, in sheet form, the explosive can be placed directly on the workpiece. (This latter variation is also being considered for the joining of dissimilar metals to produce composites.)

Using water as a transmitting medium, as pioneered by Convair-Fort Worth, the process takes place in a tank or pit. Male or female dies can be used and the water is kept from filling the die cavity by use of a seal between the die and workpiece. (Other transmitting media besides air and water are feasible, but their use has generally been considered unnecessary in view of the slight advantage to be gained, compared with costs of, for example, oil.)

Another of the numerous variations possible involves the use of a parabolic reflector in conjunction with a shaped charge. By this method, shock and pressure waves force the workpiece into the die. The exact deformation desired is dependent upon the accuracy in shaping the reflector and charge in order to direct the explosive force in direct proportion to the change wanted.

Hemispheres and cylindrical shapes are producible through use of a "free-forming" high explosive arrangement using no die. A blank is placed over an open die ring, above which is a hold-down cylinder having the same diameter as the die. In the cylinder is a polyethylene bag containing water and the charge. Tank ends up to 10 feet diameter are formed in this manner.

In still another method, a diaphragm such as rubber sheeting is placed over the workpiece, which is held in a platen press. Force from an explosive is transmitted to the liquid medium, thence to the diaphragm and thence to the workpiece.

Small parts may be formed by the simple act of firing a blank cartridge into the cavity. This works especially well with small cylindrical sections requiring a bulge, or like deformation, to be worked into the shape. In this instance, a closed die is feasible. Systems involving hydraulic pistons avoid direct use of the expanding gases to act upon a tubular workpiece. In such an arrangement, a blank cartridge is fired, actuating a piston which forces hydraulic fluid into the tubular blank, causing the bulge into the die cavity. This method is also usable for blanking, shearing, cupping and forming.

• **Non-explosive forming**—The smaller portion of effort in the HEF field is devoted to other than explosive methods. Convair-San Diego, casting a "dissenting vote," cites the ability of hot expanding gases, hydraulic pressures, collapsing magnetic fields, and other sources of sudden energy to do substantially the same job as explosives.

J. B. Ottestad, Project Engineer of Convair's Dynapack project concerned with high-energy forming, termed the machining industry "archaic" in its concepts. He spoke of the Hyge machine developed at Convair for the forming of metals through high-energy rates. The machine uses no explosive charge and is composed of two chambers connected by an orifice capable of being closed off by the end of a piston. A small pressure in the lower section, chamber "A," presses the piston against the orifice, sealing it. When a gas under pressures up to 2000 psi is suddenly released into the upper section, chamber "B," the piston is driven with extreme rapidity against a transmitting medium which acts upon a workpiece, forcing it into a die.

The Hyge machine, Convair says, can be utilized for sheet-metal forming, forging, extruding, compacting of metal powders or ceramics, blanking and shearing and casting under high pressures.

In considering the "newness" of the entire approach of high energy forming of metals, C. O. Williams, of Winchester, noted that a British patent issued in 1897 just about covers every major method of forming by high-energy rates today. However, until the need for using high-strength alloys in present-day vehicles arose, there was no economic justification for using explosives. In recent years, however, "the missiles have re-focussed attention on explosive forming."

What's Coming in Materials Research?

A leader in the field says costly and less glamorous production research has been neglected but novel techniques are being developed for fabrication and screening of new materials

by Arthur R. Lytle*
Vice President and Director of Research
Union Carbide Metals Co.

NEW YORK—The popular concept of the future is a sky full of jet planes and missile-type objects. Fulfillment of this vision will require finding answers to a multitude of questions—some political, some economic, some social, but, at present, mostly technical.

One necessity will be an optimum combination of minimum gross weight with maximum payload. This will demand the use of materials in the most advantageous way—words that are easy to say but very difficult to implement.

With these thoughts in mind, what should be done about research of materials for future missiles, re-entry space vehicles, jet engines, etc.? This is a very difficult question to answer because in this field, more than in almost any other, objectives of research cannot be spelled out and trends in technology are not only not clear but may be appreciably distorted from our present viewpoint.

**This paper, slightly condensed here, was prepared for presentation to the Society of Automotive Engineers National Aeronautic Meeting recently in New York City.*

Nevertheless, let us take a broad look at our present position in respect to the more familiar materials.

• **Ultimate in alloys**—In the future, as in the past, we probably will have to place our main dependence on wrought and cast metals. To meet increasingly severe demands, metallurgical technology has been progressively advancing through the iron-base, stainless, titanium, nickel and cobalt-base alloys and is now rapidly entering the refractory, heavy metal area typified by columbium, chromium, molybdenum and tungsten.

As exemplified by bucket alloys for turbo-superchargers and jets, as well as vanes, performance of metals and major developments in design have progressively raised the limiting operating temperature of engines to about 1815°F. This, of course, is for long-time service, not short-life missiles. To reach this limit, it has been necessary to impose all known controls such as vacuum melting and casting, very close control of such strengthening agents as aluminum, titanium, zirconium, boron and also of the heat-treating process.

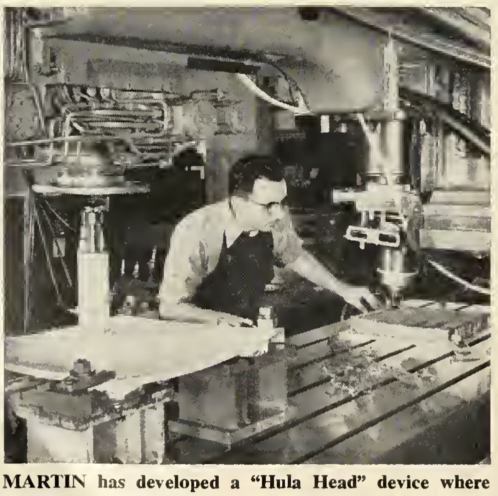
It is now generally agreed that not more than 100°F extra can be wrung from these alloys—and that only under the most rigorous conditions. Thus, barring a major, unexpected new development, the ultimate capabilities of these alloys have been attained.

• **Refractory metals**—For this reason, several years ago interest started focusing on the refractory metals and extensive studies have been underway in many laboratories. Despite imposing problems varying all the way from ore procurement to scrap recovery, some very significant improvements have already been made in performance of these metals and their alloys, thus bringing nearer their broader use.

The graph on page 33 shows the current optimum performance of various base metal systems at high temperature to their strength/weight ratios. In the cases of the higher-temperature metals and alloys, such as molybdenum, these are tests in vacuum or in inert atmosphere and hence represent idealized results which, it is hoped, the practical, oxidation-resistant or protected alloys yet to be developed may approach.

It does show clearly that in different, progressively higher-temperature ranges, each of these metals has excellent potential, justifying higher performance expectations. Simultaneous protection against excessive oxidation and development of high-temperature strength without detriment to fabrication capability, has not yet been accomplished; but current work is definitely promising to the extent that, for instance, columbium-base alloys usable at least for temperatures around 2000°F are expected within the next one to one and one-half years.

Typical target data for this general



MARTIN has developed a "Hula Head" device where the cutter head performs a hip movement as it machines complex honeycomb parts. Modified stylus with five pick-up points converts a 3-axis cutter to a 5-axis.

UNIQUE NORAIR MANAGEMENT METHODS CUTTING SPACE-AGE AIRCRAFT COST !

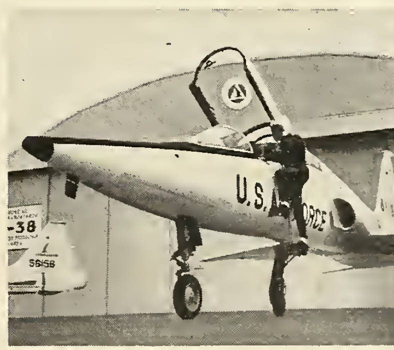
T-38 Talon is the first of Northrop's new family of high-performance, low-cost aircraft produced at Norair, Hawthorne, California. Using an inherently economical design as a base, Norair management is reducing costs even further by applying three Norair-created methods.

Pace – Performance And Cost Evaluation – is Norair's new way to measure group effectiveness. Its successful application to the T-38 program has created wide military and civilian interest.

Norair's Target Cost Control constantly monitors all areas of cost – from preliminary design to final assembly. Such a continuing control system keeps production costs at a minimum, assures maximum efficiency.

Years-Ahead Production Techniques utilize Norair's 20 years of airframe experience. In the area of honeycomb structures – for example – Norair-designed high-accuracy forming, contour milling, and adhesive bonding techniques trim T-38 costs – producing higher-quality hardware for less money.

Norair combines these and other management methods with its completely integrated research and development facilities. Result: earlier and more effective answers to the problems of free-world defense in the space age – at minimum cost.



NORAIR *formerly Northrop Division*
HAWTHORNE, CALIFORNIA
A Division of **NORTHROP CORPORATION**

type service are 50,000 psi at 2550°F for 10 hours intermittent service. Fortunately, coatings hold good promise of protection up to at least 2500°F with a possibility of 3000°F useful performance, thus permitting utilization of the inherent strength of columbium- and molybdenum-based alloys.

Much of this work is being guided by new studies wherein determination is being made of the service life at temperatures near the melting point. In this work, the maximum load for one, two, and five minutes' life before fracture is determined, and new facts are coming to light on the relative effects of such phenomena as solid-solution hardening, persistence of cold work, etc. Such studies may make it possible to design metals and alloys especially for such ultra-short service, a possibility that does not hold now.

• **Production problem**—All the above work, so far, has been carried out in laboratories, some however on a moderate scale. General experience at the research laboratory level is that alloys can be produced on the test tube scale to meet very demanding services. The big problem that is almost always with us is the transfer and extrapolation of this experience for large-scale production of such metals of the quality and quantity needed for the expected usage.

Serious consideration is being given to setting up a sheet rolling program for refractory metals similar to that which has been underway on titanium alloys for the past two to three years. Such a program would be aimed at reproducing, on a commercial scale, findings of research studies on how to melt or sinter ingots, forge, extrude, roll or swage them to plate or bar, and preserve surface finish and mechanical properties—all within specified chemical and dimensional ranges.

A similar situation exists with many other materials. For instance, several special grades of graphite have been produced by research and development to meet certain rigid military requirements. However, before they can be made available in the sizes or quantities necessary for these needs, special equipment and facilities will have to be set up.

• **Production research neglected**—Although work in this area is not embraced in all definitions of research, it is an essential step and quite frequently requires the highest type of imaginative, resourceful thinking. It might be considered as production research, a much neglected area.

The unfortunate fact is that the tremendous importance of this phase of an overall program on most materials is less clearly recognized and much less glamorous than the creative phase. It is also the most costly portion of the program, involving larger quantities and frequently full-scale equipment.

SLIP-CASTING process has resulted in some novel tungsten parts.

IMPACT extrusions of columbium-base alloys permit normal fabrication.

Fortunately, this attitude has been changing in recent years and more effort and attention are now being placed on advanced research and development.

• **Non-metals handicapped**—Corresponding major advances have also been made in the non-metal materials —ceramics, plastics and graphites. Each of these has labored under very restrictive handicaps such as low strength, lack of toughness and low melting point, but these have been offset by the very desirable properties of high oxidation resistance, high-temperature stability, lightness, resistance to ablation, etc., so that the net result has been increased usage in such areas as jetavators, nozzles and leading edges.

• **Novel fabrication techniques**—Much attention has been given to the possibility of doing things in new ways —finding other ways whereby metal can be taken from, let us say, the ingot to the final product or even by-pass the ingot stage.

In some instances, such as powder metallurgy, this has been done primarily for economy purposes but, in the area in which we are now thinking, these moderately-novel fabrication techniques will be necessary in order to actually make an acceptable product at all. Most of the metals and structural materials with which we are going to be concerned in the future are not readily amenable to conventional fabricating techniques.

• **Slip-casting tungsten**—Tungsten can be produced in powder form to a very high degree of purity and has been fabricated into wire by well-known powder metallurgy techniques. Nevertheless, production of solid, fairly good-sized members of tungsten is quite difficult.

We have only recently learned how to melt even small ingots and many difficult problems can be envisioned in fabricating tungsten ingots. As an alternate, slip-casting has been developed for tungsten and currently experimental slip-castings of rocket nozzles and other complex parts weighing over 100 pounds are under test.

Earlier tests demonstrated the good performance of slip-cast metal ceramic nozzles, so it is known that the process is compatible with the desired high performance. Slip-casting techniques may be applicable to other metals and materials and could offer a very flexible, practical and easily-adapted production method for complex parts.

• **Gas-plating research**—There are other ways of putting metal into a desired form. Several methods of gas-plating, currently in the research stage, are extensions of, and appreciable improvements over, the older gas-plating methods. They show promise of producing built-up surfaces and possibly even stock for subsequent rolling and fabrication.

Nickel, cobalt and tungsten have been built up to reasonable thicknesses with densities of over 95%, sufficient for subsequent working. These processes have the merit again of forming complex shapes without the intervention of forging, rolling, etc.

A somewhat similar result can be attained with the new plasma arc torches, techniques again providing means for building up uniform, laminated or complex coatings or agglomerates either for subsequent processing or as final products.

All these processes are applicable to molybdenum, chromium, tungsten, and columbium alloys as well as to more prosaic conventional metals. The plasma torch has wider range, being useful also for very high-temperature non-metallic refractories as well as lower melting point materials.

It thus offers a tremendous research potential in producing novel constructional assemblies, by-passing the casting and fabricating difficulties of these metals or enabling the fabrication of desired complex structures to meet unusually severe service in local areas. The photographs on page 32 illustrate typical structures built up by this technique. In most of these, tungsten is the essential constituent.

• **New horizons**—Explosive forming and shock extrusion undoubtedly will open up entirely new eras. They have shown capabilities and advantages in the primary breakdown of some of the refractory metals.

Some metals, particularly tungsten, are malleable after the primary crystal structure has been broken down, and some of these extremely high-energy-rate upsetting and forming operations can bring about extreme plastic deformation in some metals when, under normal types of deformation, cracking and fracture would predominate.

• **Graphite for rockets**—The need for newer novel fabrication techniques in other fields is exemplified by the demands of the new generation of rockets. Graphite has the unusual capability of supporting load at temperatures on the order of over 5000°F and hence is destined to play a major role in these new designs.

However, increased resistance to oxidation and erosion is important for this service. Currently, appreciable gains have been obtained by impregnating graphite with silicon with subsequent conversion to a Si3N4-SiC complex, an extremely inert high-temperature material.

Other processes produce coatings of tungsten, tungsten alloys or titanium carbide. A variety of processes such as metallic cementation, gaseous diffusion, chemical replacement and high-temperature arc plating are applicable to this field, and some have already proven themselves.

The gain from this work, of course, is production of a composite material preserving the desirable high-temperature characteristics of graphite and protected by the serviceability performance of the coating materials.

• **Welding stability**—Under novel fabrication techniques, we must not neglect the problem of weldability. In the welding industry, this has always been with us, ever since moderately complex or stressed assemblies were welded, but the missile era introduces an entirely new degree of difficulty.

Actually, the problem is not in welding but in the stability of the welded structure in service.

These new problems arise from two major differences from normal practice, namely, use of newer metals and the premium on strength/weight ratio.

In the case of the new metals, the ability to be welded and preserve adequate mechanical properties is thus superimposed on the elementary problems of strength at temperature and of oxidation resistance. Real imaginative thinking will be necessary.

Similarly, the great emphasis on strength/weight ratio in structural metals, and the progressively increasing usage of sheet materials in missile design, are going to reintroduce on a large scale the problems of welding high hardenability steel or require the development of alternate methods of welding to circumvent the problem. To meet the desired yield strength/weight ratio of about 1,000,000, steels having yield strengths in the order of 250,000 to 300,000 psi are already being considered and, especially for solid fuel casings, metals having yield strengths of up to 400,000 psi are being sought.

In the past such steels have been considered, almost by definition, unweldable; but already, cold-worked stainless steels with yield strengths of 300,000 psi are being successfully fabricated in some forms by welding.

The precise conditions attainable in electronically-controlled spot, seam and resistance welding lend great flexibility in choice of metals. The focused electron beam technique or one with similar characteristics may permit welding even the very hardenable die steels that are presently being considered.

• **Plasticity factor**—Of course, use of these steels with retention of full high-yield strength, sometimes approaching the ultimate strength, introduces lack of residual available plastic capability.

In many designs, especially where design stress approaches strength level of the material, allowance for unanticipated stressing is placed on yielding of the metal. If this has already been used during cold working, it may be unavailable for offsetting errors in design, so the designer will have to understand his stress conditions very completely or else design for the material.

• **Welding missile parts**—Besides being an essential aid to fabrication, welding under the proper conditions can be a major aid in production. One of the major problems in the missile business is the need for large members, but only a few of them. This is true of wide sheets, long extrusions, complex forgings, etc.

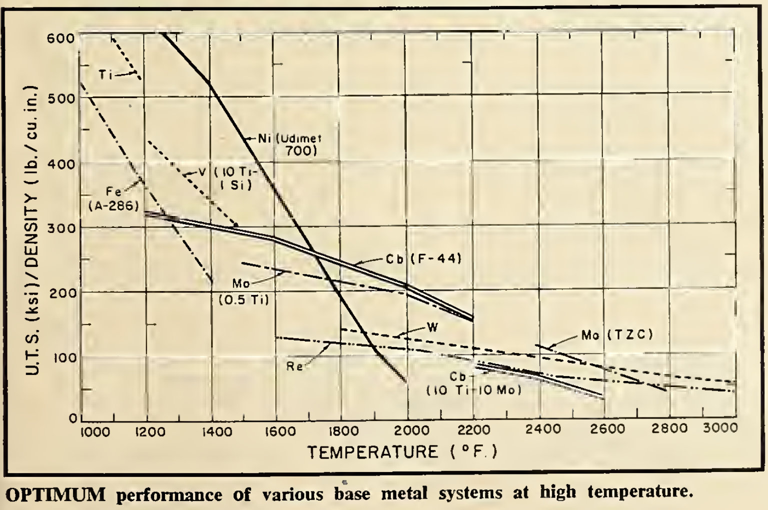
If suitable welding processes could be developed, applicable to the several metals, forms, etc., such large members could much more economically, and in much less time, be fabricated from smaller or shorted members.

Typical instances are the welding of short length of strip for making continuous strip and the welding of rails to mile-long continuous sections. These are desired products that could not be made in a plant of reasonable size.

So, when long extrusions are needed of new alloys, not amenable to normal extrusion processes or to normal ingot size, welding could play a very important part. Similar approaches could overcome the problem of wide sheets of difficult-to-form metals, producing them from harrower sheets of the desired tolerance and composition. Here considerable research may be needed in new or less widely used welding methods but the gains in money and time may be very appreciable.

• **New processing methods**—One of the objectives of present research is new processing methods to enhance the mechanical properties of materials.

In the metals field, one process of great interest is extremely high vacuum melting, promising remarkable improvements in purity, fabricability and ingot soundess. These methods, varying from electron beam melting to consumable arc melting at extreme low



OPTIMUM performance of various base metal systems at high temperature.

pressures, are already being broadly and intensively studied. There is, however, the counter-part of extremely high-pressure melting, an area which has only recently been investigated, but which shows considerable promise.

Presently, there are two objectives that should be gained by high-pressure melting. First, using high-pressure, it should be possible to suppress the volatilization of low melting point metals. Such high melting point metals as titanium, tungsten and columbium can be deoxidized or treated with low melting point or high vapor pressure metals such as magnesium, calcium, and lithium which are unsurpassed as deoxidizing agents. Under favorable conditions, even alloys of such metals might be preserved to normal ambient temperatures.

• **Freezing to alter crystals**—A second and possibly equally important hope for this type of metallurgy is that otherwise-unstable primary high-temperature phases may be stabilized or some fundamental rearrangement of the crystal structure may be induced during freezing to appreciably alter the properties of the metal.

As an example, it may be possible that the known body-center-cubic and, hence, ductile structure of beryllium which cannot be retained at room temperature otherwise, may be at least partially stabilized by pressure. However, no tests have been reported to demonstrate this.

The possibilities of this new type metallurgy in altering the mechanical and possibly high-temperature performance of the critical base alloys have been only preliminarily touched.

• **New materials**—The biggest hope for the future lies in the invention, creation or evolution of new materials possessing properties that are designed for specific needs. The materials picture at present is gradually developing into a recognizable over-all pattern and engineers are now trying to coordinate the demands of structures with the properties of materials.

Among the novel materials which are in relatively early stages of research but which may play a very important part in the future are such materials as inorganic polymers. Currently, this is a speculative project in its earliest stages because the mechanism whereby polymerization can develop or be forced in many inorganic systems is not now experienced or recognized.

However, polymerization has been achieved to a limited extent in some Si-O and metal-O-C linked systems; in other words, metal chelates and PN Cl_2 polymers are known. Undoubtedly, great advances still can be made in these and other systems.

By such polymerization it is hoped to gain, in materials that are not normally amenable to structural use, some semblance of the mechanical characteristics of organic plastics.

These materials, if satisfactory structurally, should develop stability at higher temperature and possibly, by combination, extend the temperature range of organic plastics in this whole general area. In their own right, they should possess basically different thermal, electrical and optical properties than their organic counterparts and hence should meet different needs.

FIRST LARGE beryllium part ever forged successfully is on bed of 18,000-ton forging press at the Wyman-Gordon North Grafton, Mass., plant. Larger forging presses, including a 50,000-ton press, will be used to shape bigger and more complicated forms of beryllium in the future.

• **Macro structure control**—The entire matter of composite structures, whether these are composed of plastics reinforced with metal fibers, ceramics stabilized by metal, or other supports, or metal powder compacts reinforced with other metal wire or mesh, is a fruitful field for future research, as herein is the effort to control macro rather than micro structure.

Such efforts are attempts to improve the strength/weight or strength/modulus ratios while preserving some inherent advantages of one of the constituents—for instance, the unusual thermal characteristics of plastics, i.e., their high heat capacity, low heat conductivity, and the character of their decomposition products, favor their use under extreme conditions of temperature and erosion.

However, their load-carrying capacity suffers appreciably. There are many problems to solve.

Are there better plastics than the phenolic-base type for ablative service? Can further advantage be gained from these materials by raising their modulus of elasticity, toughness and strength levels?

Glass fiber reinforcement has temperature limitations and asbestos has supplied added increments in performance, but other modes of strengthening seem applicable for further significant increments. How to introduce greater load-carrying capabilities into plastics may be a research project of considerable significance.

The same line of reasoning applies to the other composite-type structures. Of great assistance may be the effect of silicones in providing a high degree of bonding between plastic, metal, or inorganic material.

Apparently the Si-O bond is compatible with numerous other materials and is of tremendous value in improving the engineering utility of structures made from diverse materials. Solutions to these problems require coordinated plastic, metal and engineering skills, but the rewards from successful research should be great.

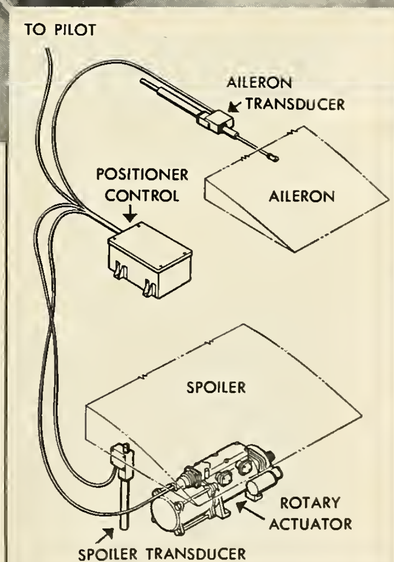
• **Graphite filaments**—A fairly recent development has been the announcement of graphite fibers and cloth. By processing synthetic organic filaments and cloth through novel graphitizing procedures, a textile material has been produced which is 99.9+% graphite, retains the relatively phenomenal tensile strength of 10-15,000 psi and is remarkably resistant to bending, folding, creasing, etc.

The significance of this is that it should now be possible to introduce

(Continued on page 49)

Advanced electro-mechanical systems

AiResearch Spoiler Servo Control System for Canadair's CL-28 and CL-44



A substantial increase in aileron effectiveness is achieved by the AiResearch Spoiler Servo Control System which augments the function of the aileron by increasing the rate of roll of the aircraft. Full spoiler surface travel is achieved in 0.5 seconds by electromagnetic clutching of the 4 H.P. power servo.

The added control surface of the Spoiler Control Servo System operates on the inboard side of each aileron. This AiResearch electromechanical system automatically synchronizes the spoiler control surface to move simultaneously with the aileron by utilizing a magnetic amplifier and position transducers in the closed loop servo system.

This new Spoiler Control System is but one of the many types of electro-mechanical systems developed and manufactured by AiResearch. Other recent examples include radar antenna positioning equipment, magnetron and Klystron tuning devices, and safe-arm mechanisms for missile igniting.

The company's more than 20 years of experience in the development and manufacture of electro-mechanical equipment extends into aircraft, ground handling, ordnance and missile systems of all types. AiResearch capability and system responsibility can meet your specific electro-mechanical requirements. Your inquiries are invited.

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Nuclear Explosions in Space

Second of four articles by
PROF. S. FRED SINGER

- *Trapped radiation will be problem for manned vehicles*
- *Close burst to ICBM could make its bomb inoperative*
- *Defender may have to revise anti-ICBM strategies*

WASHINGTON—The obvious questions which are raised by atomic explosions in space have a practical military significance and are of great concern to engineers who are faced with the design of manned vehicles or missiles for travel above the atmosphere.

For example, at what distance from a burst will a satellite be vaporized or a man be incapacitated? Can an atomic explosion trigger off the nuclear warhead of a missile?

It has been generally believed that all of these effects were of no concern if the atomic burst is far enough away, either in space or in time.

But now, because of the *Argus* tests, this is no longer true. Because of the earth's magnetic field, another effect exists which lingers for hours or days after the actual explosion and which spreads all over the earth—trapped radiation forming an artificial radiation belt above the atmosphere. In this article we will try to assess this effect as well as the more direct effects in the immediate vicinity of the burst.

It may seem strange to the nonspecialist that such assessment is possible without recourse to classified data or even actual experiments. It turns out however, that order-of-magnitude calculations are in many cases sufficient to give a clearcut yes-or-no answer. In most practical cases, they show that an effect is either many times too large or many times too small.

Such order-of-magnitude calculations do not depend on the detailed design of atomic bombs or, for that matter, on any classified information. Yet, it is just such order-of-magnitude calculations which are of great importance to the space vehicle designer who is concerned with bomb effects.

• **Effects in a vacuum**—There are new and different phenomena involved in an atomic burst in space, in a near vacuum. In the absence of air the problem is much simpler; there is no shock wave, no blast effect, and thermal radiation is not very significant in relation to other radiations.

However, nuclear radiation from the fission of the uranium or plutonium is released and not attenuated by an atmosphere. The nuclear radiation intensity decreases only because of distance and varies as the inverse square of the distance.

Nuclear radiation is of course most dangerous to complicated molecules, and in particular to living cells. Thus, as has been remarked: "Man emerges as the most vulnerable component of a space weapon system." A dosage of 500 roentgens is considered lethal, while 20 to 50 roentgens will induce sickness. The usually accepted radiation tolerance limit is 150 milliroentgens per day which is about 10 times the average cosmic ray intensity above the atmosphere.

Instrumentation is relatively insensitive to nuclear radiation. Probably the most critical electronics item is a transistor. However even a p-n-p transistor will stand 6x10^{6} roentgens before its performance deteriorates appreciably.

Metals are particularly resistant, but if they do come too close to the nuclear burst the tremendous energy will simply vaporize them.

• **Effects of close bursts**—To assess accurately the effects of atomic explosions in space, it is first of all necessary to know the types of radiations, their energies and, of course, their intensities. It is not difficult to obtain this information using unclassified data on the physics of fission.

For this purpose we can cite some facts about fission by referencing "Nuclear Physics" by I. Kaplan. (Addison-Wesley, 1955)

A uranium nucleus which has absorbed a neutron will fission and break up into two smaller fragments. Most frequently the fragments are krypton of atomic weight 93 and barium 143. The velocity of the fragments is of the order of 10^{8} cm/sec corresponding to a total kinetic energy of over 160 Mev (million electron volts).

In the fission also an average of 2.5 neutrons are released having a most probable energy of 0.8 Mev and a mean energy of 2 Mev; this multiplication of neutrons makes a chain reaction possible. A small fraction of neutrons, about 1%, are delayed and released after about 0.01 seconds; (this fact makes the operation of a controlled nuclear reactor possible). Prompt gamma rays are released having an energy of about 5 Mev.

• **Fragments interesting**—The two fission fragments are of particular interest. They are highly unstable and will undergo several radioactive decays before they reach a stable nucleus condition. In each decay they emit a negative beta particle, an electron. The energy of the beta rays can be calculated from nuclear theory and averages about 5 Mev. Since the fission fragments are far removed from nuclear stability, some beta ray energies can be very high, of the order of 10 Mev. These energies can also be calculated from nuclear theory.

Now let's take as our reference a fission bomb of 1 kiloton TNT (equivalent) yield. A simple calculation tells us that this release of energy corresponds to 4.2 x 10^{19} erg or 2.5 x 10^{25} Mev (this is a conventional energy unit in nuclear physics). If we make use of the fact that each fission releases about 200 Mev then we derive the total number of fissions as 1.3 x 10^{23}.

The weight of the fissioned atoms is only 0.1 pounds, but the amount of fissionable material in the bomb is of course much greater. For a small bomb, plutonium is a better material since each fission gives three neutrons. The critical (i.e., minimum) mass of a plutonium bomb has been estimated as about 10 pounds by T. Magnusson ("Construction and Operation of Atomic Weapons," *Kosmos*, Vol. 34, pp. 180-208, Stockholm, 1956.)

Knowing the number of fissions, we can calculate the output of neutrons, gamma rays, and beta rays (electrons). The latter are emitted with a wide range of energies, but it seems reasonable to assume about one high energy electron (about 2 Mev) per fission with the rest at much lower energies where their effects are of little importance.

• **RAND data**—It is well to mention that independent confirmation on the intensity of atomic bomb radiations in space comes from an unclassified report by the RAND Corporation to the House Space Committee. In this report the lethal range of a 20 kiloton bomb is given as 13 miles when exploded in free space.

A lethal dosage is 500 roentgens corresponding to an energy dissipation in one gram of tissue of 2.9 x 10^{10} Mev. Since high energy electrons lose about 1.5 Mev in traversing 1 cm of tissue, the fast electron flux from the bomb must be about 2 x 10^{10} electrons per cm^{2} at a distance of 13 miles. Hence the total output of the bomb would be about 10^{24} electrons; this result is in close accord with our independent calculation.

Knowing the energy released in the bomb burst and knowing that the specific heat of most metals is of the order of 0.1 calories per gram per degree centigrade, we can easily calculate at what distance from a bomb explosion a satellite would be heated by, say, 100°C, or would perhaps be melted or vaporized. The energy flux from the explosion is simply spread out over a spherical surface so that at a distance of 100 yards the flux would be 4 x 10^{10} ergs per square centimeter, enough to vaporize one gram or a 0.15 inch thickness of aluminum.

To calculate the lethal range of an atomic burst in space, we can use the RAND formula which gives radiation dosage (in roentgens) $R = 4200P/d^2$ where P is the bomb's power in kilotons and d the distance in miles. For example, a 1 kiloton bomb will produce 500 roentgens at a distance of 3 miles. It should be remembered that this formula assumes no shielding, hence no absorption of the nuclear radiation.

• **Effects on nuclear warhead**—Not nearly so straightforward but very intriguing is the question whether a nuclear explosion can "set off" a nearby nuclear warhead. In principle, of course, it is not possible to induce a chain reaction in a nuclear warhead since the pieces of uranium which make up the bomb are separated so that they do not form a critical mass.

However, and this may be a very important point, the individual masses may be large enough to "amplify" each fission, i.e., a fission produced by an incoming neutron will set off many other fissions before it finally dies down. This amplification effect could lead to a great release of internal energy which may overheat and damage the bomb mechanism to make it inoperative. This appears to me to be the only way in which an atomic warhead can be affected.

To give an illustrative calculation, we may assume that at a distance of 0.3 mile from a 1 kiloton bomb explosion the neutron flux is 10^{13} per cm^{2}. If the amplification factor is taken to be 100 (it might be only 10 or it might be much greater, depending on the design of the bomb) and remembering that 200 Mev is released per fission, each incoming absorbed neutron will produce 1/30 erg of energy. Thus, energy releases of the

In the April 13 issue: Nuclear Explosions in Space and Their Direct Effect upon Radar and Long-Range Communications including ICBM Detection.

In the April 20 issue: Nuclear Explosions in Space and How They Can Be Detected by a Great Variety of Scientific Techniques.

order of 10^{12} ergs per cm^2 are quite possible and can lead to appreciable temperature changes, of the order of 200°, inside the bomb.

But again, we must remember that the nose cone itself may provide some shielding against nuclear radiation, except of course at very short distances from the burst.

• *Argus* **tests**—Perhaps of the greatest interest, especially in view of the *Argus* tests, are the long lasting effects of atomic bursts in space, caused by radiation trapped and retained in the earth's magnetic field. With the information on what is released, namely a 1 kiloton bomb exploded at 300 miles in the South Atlantic, together with a study of magnetic conditions in that area, one can make quite good estimates of the intensity of this trapped radiation.

Only the high energy electrons (beta rays) emitted from the fission fragments are of any significance for trapped radiation. The fission fragments themselves are unimportant, the gamma rays escape from the earth's field since they are uncharged, and most of the neutrons will escape. In any case, the decay of the low energy neutron only gives an electron of about 0.5 Mev which is not very effective.

We therefore have released in the explosion about 1.3 x 10^{23} high energy electrons. Of these, only a few percent remain trapped. A conservative estimate would be 1% after one hour. The rest are all dumped into the atmosphere. After about one hour, these electrons are somewhat diffused into a volume around the earth which is estimated to be 10^{26} cm^3. (This is a very conservative estimate and assumes that the line of force along which the particles are released sweeps up to a distance of two earth radii, i.e., it assumes that the release point was at a magnetic latitude of 45°.) The concentration of trapped electrons will then be 10^{-5} per cm^3 giving a flux of 3 x 10^5 per cm^2 per second or about 30 times greater than the maximum of the natural radiation belt. Hence, there should be no problem at all about detecting the presence of this trapped radiation from the *Argus* bursts.

• **Lifetime**—In order to assess the importance of the trapped electrons on manned or unmanned missiles and satellites, we must be able to calculate their lifetime.

This calculation of the length of time for which a particle remains trapped in the earth's magnetic field is an exceedingly difficult theoretical problem. The lifetime T depends on the nature, energy and trajectory of the particle, on the density of neutral atoms and of ions in the outer atmosphere, and on the degree of "noisiness" of the magnetic field which in turn is related to "activity" on the sun and therefore quite variable.

It may be preferable, as has been suggested by N. C. Christofilos and by the writer, to inject electrons artificially and measure the lifetime experimentally.

For 2 Mev electrons which do not travel too far from the plane of the magnetic equator we derive the approximate lifetimes. (See Table A)

(These values are substantially less for lower energy electrons and for particles whose trajectories extend far along the line of force into the denser atmosphere.)

Thus it is shown that the lifetime increases as we deal with radiation released at higher altitudes or higher latitudes, i.e., along a line of force which sweeps out to a greater altitude above the equator.

Basically, the reason is that the atmospheric density decreases so rapidly with altitude, and particles which remain in the equatorial plane will have a considerably longer lifetime than particles which dip down to lower altitudes. For particles trapped on lines of force which start at intermediate and high latitudes, the atmosphere probably is not the determining factor for lifetime. Instead, it is believed that the "noisiness" (i.e., wiggles) of the rather weak magnetic field causes scattering of the particles and eventually removes them from the trapped condition. This explains the absence of trapped particles near the poles.

In the case of occasional injections, as for example from atomic bombs, the lifetime gives the decay of the radiation with time. For continuous injection, however, the lifetime is very important since it determines the intensity. In fact, the concentration of particles is given roughly by the product of injection rate per unit volume and lifetime.

• **Capabilities**—Of course, as pointed out in the first article of this series, we can arrange to have nearly 100% of the particles trapped by proper adjustment of the release point. Furthermore, a larger bomb will release a correspondingly larger number of particles. One might therefore conceive of megaton bursts giving particle fluxes of the order of 3 x 10^{10} per cm^2 per second, which would be quite intense. In fact, such fluxes are near the theoretical limit of what can be trapped in the earth's magnetic field, which can store only a certain maximum concentration of particles. This is set by their reaction on the magnetic field itself. The particle energy density can be at most a fraction, say 10%, of the magnetic field energy density; or, expressed differently, the drift current of trapped particles cannot produce a magnetic field greater than about 10% of the earth's field B. Since the latter varies as the inverse cube of distance, the energy density which is $B^2/4\pi$ varies as $1/r^6$. (See Table B)

• **Shielding problem**—Without shielding such fluxes can be lethal in an exposure lasting only 1 second. Shielding against the trapped electrons is relatively easy, but care must be taken since about 1% of the electrons produce X-rays which penetrate deeper.

The effects of trapped electrons on nuclear warheads, however, seem hardly significant. The photofission process requires photons, and therefore electrons, of at least 5 Mev, and the efficiency of the process is very low in any case. A missile which spends only a few minutes above the atmosphere should survive even the maximum possible flux of trapped electrons.

TABLE A

Altitude (miles)	400	1000	2000	4000
Air Density (gm/cm^3)	4×10^{-16}	3×10^{-18}	10^{-18}	3×10^{-19}
Lifetime	3 hours	3 weeks	2 months	6 months

(Reference: Physical Review Letters, Vol. 1, pp. 171-173, 1958)

TABLE B

Distance from center of earth (measured in earth radii)	1.2	1.5	3.0	5.0
Max. particle concentration per cm^3 (assumed 1 Mev electrons)	83	22	1.34	1.6×10^{-2}
Max. particle flux per cm^2 per sec.	2.5×10^{12}	6.6×10^{11}	10^{10}	5×10^{8}

(Reference: Transactions American Geophysical Union, Vol. 38, pp. 190, 1951)

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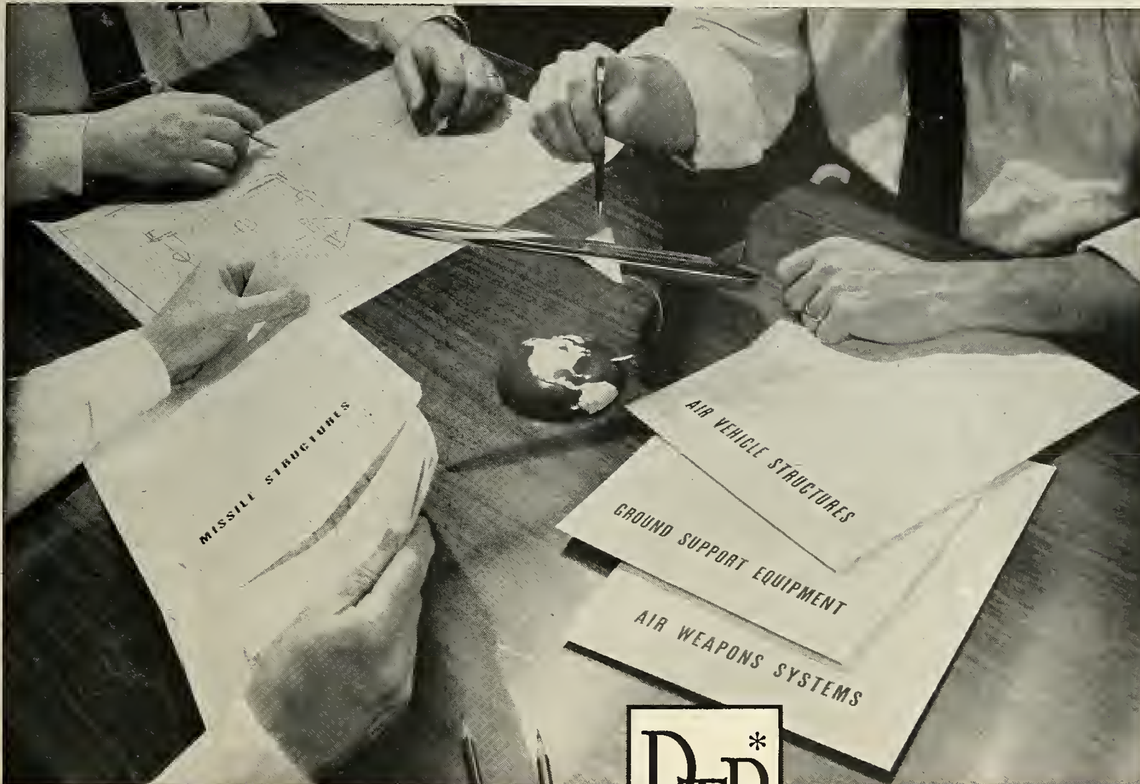

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Design of a radiation shield requires the following data: (Reference: "Radiation Shielding," Price, Horton and Spinney, Pergamon Press, 1957)

(1) types, energies and intensities of the radiations;
(2) rate of attenuation by shielding material; and
(3) acceptable level inside the shield

In close proximity to a bomb burst we deal with gamma-rays and neutrons at an energy level of one to a few Mev, and with low energy (less than 1 Mev) and high energy electrons.

For Gamma rays the absorption is roughly exponential but because of "build-up" it becomes more effective as the thickness of shield increases. Typical values for steel are:

Thickness of steel (inches)	1.4	2.6	3.5	4.2
Attenuation to	50%	20%	10%	5%

A fast neutron shield should contain (a) heavy elements to produce inelastic scattering (as well as attenuate gamma rays) (b) hydrogen to slow down neutrons to thermal energies, and (c) an absorber of thermal neutrons, perhaps lithium or boron, which does not itself emit a very penetrating gamma ray.

For energies less than a few Mev, electrons have a reasonably well defined maximum *range*. A rule of thumb gives the range (in gram/cm^2) as one-half the energy (in Mev). Thus a 2 Mev electron has a range of 1 gm/cm^2, or about 1/16 inch of aluminum.

• **Implication**—The implication of all this discussion to missile defense is quite apparent now. The trapped radiation appears to be a problem for manned missiles but no defense at all against nuclear warheads.

On the other hand, close exposures in the vicinity of a bomb burst can be serious, particularly for manned vehicles. And in the case of ICBM's carrying delicate atomic bombs, close bursts may make the bomb mechanism inoperative.

Of greater importance, however, than direct effects on incoming missiles may be the effect of atomic bursts on the atmosphere, and thereby on the detection of the missile. In other words, bomb effects appear to be favoring the aggressor rather than the defender and may require a careful study of anti-ICBM strategies.

New Details on Radiation

Coincidentally with the start of Prof. Singer's exclusive series of articles in M/R on "Nuclear Explosions in Space" last week, the National Aeronautics and Space Administration released details of the origin of the Van Allen radiation belts and their properties.

At a conference, some of the nation's top scientists disagreed upon many points, but essential agreement was reached on the following:

• The belts are made up of charged particles in trapped orbits which spiral about the lines of the earth's magnetic field in the manner of a helix, travelling back and forth from magnetic pole to magnetic pole.

• The particles in the outer belt are of solar origin, replenished periodically by streams of hot, energetic gases from the sun.

• Origin of the particles in the inner belt is unknown. The two major theories advanced were that they are (1) of solar origin, and fed into the inner belt from the outer belt by some as yet unexplained mechanism or internal motion, or (2) they are created by beta decay of cosmic rays.

• The lifetime of the particles ranges from many years out at 1000 kilometers to a few seconds at a few hundred kilometers.

• The protons have energies ranging from 400,000 volts to over 40 million volts, and the electrons from 20,000 volts to over 6 million volts.

• The particles can be grouped into two categories: hard and soft. The soft have low energies, while the hard have enough energy to penetrate a quarter-inch aluminum slab.

• There is a greater proportion of hard components to soft components in the inner belt than in the outer belt.

• U.S. and Russian space experiments show the soft components of the outer belt to be electrons. U.S. experiments indicate that the hard components are either electrons, protons, or both.

• There is a direct casual relationship between the heavy injection of high-energy solar gases into the outer belt and the aurora borealis and the aurora australis.

The above information was determined from the measurements made by *Explorers I, III,* and *IV,* and *Pioneers III* and *IV,* as well as information released by Soviet scientists from their experiments.

• **Belt locations**—The first of the two belts lies between 1000 and 3000 miles from the surface of the earth and the other between 8000 and 35,000. (These distances are at the points that the rockets penetrated the belts.)

The second belt's outer edge varies in distance from the earth, depending on whether it is in a state of quiescence or whether a large amount of solar gases is being injected into it.

This was indicated by information received from *Pioneer IV* that the outer belt extended some 9000 miles farther out from where it was when *Pioneer III* passed through it. *Pioneer IV* also encountered rapid fluctuations of radiation intensity even farther out.

• **Cause debated**—There was a split opinion as to what caused the inner belt. It is believed that it might be caused by the "entire gas content of this outer region" undergoing "a rather complicated internal motion which will assist it in taking a whole layer, a whole bundle at one level and allowing them . . . to appear at a different level."

On the other hand, Nicholas Christofilos of the University of California, father of the *Argus* experiment, agreed with Dr. S. Fred Singer that the inner belt was formed by beta decay of cosmic rays. Christofilos reasons that the high-energy particles of the inner belt have been established to be protons, that cosmic rays—not affected by the earth's magnetic force—penetrate the outer layer, and come in contact with the earth's atmosphere causing nuclear disintegration, and that neutrons bounce back into space where they disintegrate into protons and electrons, which are then captured by the earth's magnetic field.

One evidence Christofilos gives to support his theory is that the thin shell created by Project *Argus* had not moved more than 20 miles several weeks after the explosion, "which means if there are such convection currents (to move particles from the outer to inner layer) . . . this current to go from the outer to the inner belt will take an order of a year," which "appears unlikely since the inner belt lifetime is of that order or less."

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The Case for Components Research

The chief of Norden's Ketay Department warns of dangers in 'off the shelf' missile assembly; tells of company's drive to increase reliability

by Charles D. LaFond

WASHINGTON—The controversy may be long and only time will provide the answer, but proponents of the more-component-research philosophy are finding strong spokesmen.

Recently, Rear Adm. John T. Hayward, Assistant Chief of Naval Operations in charge of research, said that 60% of the Navy's research money should be spent for component development.

In Congress, it has been suggested that a research tithe by all prime contractors should be mandatory in future military procurement contracts. Presumably, a share of this 10% allocation would be spent in component research. How much depends on whose philosophy wins.

One of industry's most vigorous proponents of components—Bernard Levine, general manager of the Ketay Department of United Aircraft Corporation's Norden Division—also has long argued that too much emphasis is placed on development of whole missile systems.

During a recent M/R interview, Ketay's chief revealed what his department—one of the biggest names in the manufacture of precision electromechanical rotating control components and instruments—is doing and plans to do to perfect the building blocks of the missile system.

Q. **Based on current advancements in the missile industry as a whole and in the electronic-component field, in what area will the Norden Division, particularly the Ketay Department, direct its future production and research?**

A. The Norden Division will stress its activities primarily in inertial guidance and weapons systems. I represent a segment of the Norden Division which is a self-contained unit in the components business. We presently have a five-year forecast primarily in rotating components for data transmission and control. We feel that the great future lies in doing functions which have to be done, such as in integration, data transmission and so on. We are after increased reliability, greater accuracy, with smaller units. As you know, there are too many components now available and marketed that are very, very unreliable.

Q. **How much is being done by the government to develop better components?**

A. Well, they are buying some research, but we are currently investing our own money for about 30% of each research dollar at Ketay.

Q. **Your firm has done extensive work in developing small, highly stable gyros. Is there still a problem area here?**

A. One-inch gyros are now available, but there is a need for a lighter weight and cheaper missile. Too much of the missile is not power-planned. A lot of the components have to be ac-driven. But the gyro and the gyro pickoffs should be dc. Both should be battery-operated.

Q. **In your approach, you will continue to attempt to do more with less?**

A. Yes, we probably will have available early next year a completely floated gyro, in a one-inch frame which has an infinite resolution pickoff. We think this will be a great step forward for someone who wants to get a system up in the air rapidly with minimum of weight other than payload.

Q. **You spoke of Ketay's five-year forecast. Just what does this mean? Can you tell us some of the more important research areas in which you are now making advances?**

A. United Aircraft Corp. believes every phase of its operation should have a five-year program of the things it has to work on. This helps to give the corporation a position of technical excellence and helps to insure progress. I can go over some of our current and projected R&D work. These are in progress and will be finished this year.

We are working on an ultra-precision motor tachometer. The tachometers of today, that do integration, are accurate to 0.1% or 0.05%. We are aiming for an accuracy of 0.01% with a unit the size of a dime. The need for an electromagnetic integrator to promote the use of analog computers has long been a serious requirement and is generally acknowledged as the weakest link in the computer chain. The development of this device will re-establish the position of the rotation-components integrator in this field.

Also, we want to develop a boosterless resolver. We are investigating the procedures necessary to obtain a resolver capable of operating in a computing chain without benefit of isolation amplifiers—so that the phase shift of each resolver is approximately zero degrees and attenuation in the computer chain is minimized.

In conjunction with the use of booster amplifiers we are developing a resolver with an accuracy of 0.01%, which will minimize the error-causing effects of leakage inductance and magnetic heading displacements.

Q. **You mentioned the need for new components to meet missilery requirements for unusual environmental conditions. What are you doing to meet high-temperature or cosmic-radiation problems?**

A. Well, with heat we have a real problem—that is, when we take magnetic material above 500°C and through the Curie point. We have a 300°C synchro, but what we now want is a 600°C type. We are developing a synchro capable of operating in an ambient temperature range of from –55° to +500-600°C.

We have initiated a program for the development of nuclear-resistant components. Our problem here is to obtain satisfactory operation of our units in environments of integrated nuclear flux. I can't tell you any more about it now, but this is part of a long-range study.

Q. **You have indicated frequently in our discussion by implication and by your intensity when replying that all is not as it should be in component development. Just how do you feel about it?**

A. I go on a crusade about that. We all read in the newspaper where this airplane did so and so, and this missile did so and so. Every once in a while you will read where a missile didn't fire or a plane crashed. It is only then that people become aware of the fact that in this airplane, missile or whatever there are little components that make the thing work. It often only takes one component malfunction to make the system fail.

In other words, if a gyro stops functioning your missile suddenly goes awry. When one of the *Atlas* missiles was fired last summer, a news release indicated that it was the gyro that stopped spinning. What happened to the missile? It started shaking itself to pieces, and it just crumbled down to earth. The average person thinks about these things only in large glamorous chunks. They never stop to realize that it's all the little components that make up the bigger system.

If no one invented the self-starter, you might not like to drive your car. At best, only men would drive cars. It is this type of thing that we have dedicated ourselves to bring to the forefront in hopes of making better progress possible in automatic controls. This is something that is overlooked too often by the average person.

Q. It seems to me you can never reach a point of 100% reliability. There is always the element of human error. Why not concentrate in those areas where the chance of failure is the highest?

A. We are. You have to design reliability. I had a meeting with some of the military people at the Air Development Command, in Baltimore, after the first *Sputnik* went up. They were in an uproar because the Russians got there first. Yet they were the first to admit that the reason for our failure was that we had put tremendous emphasis on entire weapons systems, but had not taken the time to develop a better automatic control system or a better gyro.

In other words, a lot of people in the military assume that someone else will be developing a better product. They might be right or they might be wrong. The trouble is that we shouldn't let these things happen by chance.

Q. But in the beginning the task was to develop missiles in a hurry. It takes many firings of different kinds of missiles to produce enough data to know just what we need and where we have failed. Had we spent more time developing better components, we might still be waiting for our first operational missile complex. Don't you think that this component-research problem is now coming to the front because we employed the single

Energetic Champion of the Component Approach

by Erica M. Karr

Ketay's manager, 34-year-old Bernard Levine, is himself a good example of miniaturization. Packaged in a medium-sized frame, the characteristics that make up the man have combined to produce an "optimized" lead component in the Ketay operation. He is both a top-rung engineer and an able administrator with the ability to see the long-range picture along with the smallest detail.

He delegates authority willingly but doesn't let go of the rein completely, playing an active role in all final decisions.

The main basis of Levine's success, however, is his ability to get top performance out of his people. This is due partly to an instinctive ability to understand what makes them tick as individuals and to adjust his approach accordingly. Sensitive to their problems and aware of their capabilities, he draws from his men the extra effort that makes "best" out of "better" and "better" out of "good."

Levine credits part of this to his knowledge of psychology. But perhaps more important is an infectious enthusiasm. From a professorial-looking, modest introvert, the Levine personality Jeykllizes into vigorous, forcible fervor when a subject interests him.

Ketay's head man takes matter-of-factly his ascension to the top rung at a comparatively early age. He points out that his field is also a young one. But he explains that the direct cause was his conviction that the development and production of components could be profitable and had a tremendous future potential. "A system is no more reliable than the weakest of the components that make it up," he emphasizes.

Before Levine took over, according to a Pentagon engineering negotiator, Ketay was in the red. The company, which started as the Ketay Manufacturing Corp. in 1945, was merged into Norden-Ketay and finally evolved as the Ketay Department of United Aircraft's Norden Division with its purchase by UA last year. Today it is in the black. Its 800 employees at Commack, L. I., turn out an estimated $11-13 million gross business a year. Since its management by Levine, the Pentagon can count on deliveries on or ahead of schedule.

One reason for Ketay's pre-Levine difficulty was the imbalance of R&D work as related to production. The firm took on much of the Pentagon's special micro-lot "cat and dog" development work—six of these, and a half-dozen of those, mighty few with much in the way of production potential. Levine struck a balance and concentrated on development of high-production items.

Another Levine-generated plus was the production upswing which resulted from the spirit of competitiveness he awoke in the organization. Production lines with their weekly standings were posted prominently in the shop. Once a week while the laggards toiled, the winning line knocked off work to share a coffee and cake session with the boss. Although the reward was financially minor, jobs were tackled with a new vengeance while Levine found an ideal way to become more closely acquainted with his men.

Said one Navy contracting officer: "I've visited a lot of plants and I have yet to see Ketay's equal for cooperative spirit and general good will."

weapons concept and now have gone into a new phase?

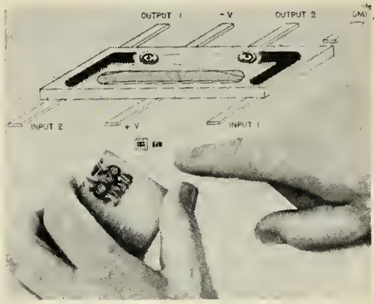
A. Yes, but too late. In this great problem of components, I think that when someone builds an individual weapon system for a plane or missile, they now find they need a hundred components offering high nuclear resistance and capable of operating in temperatures up to around 600°. No one in industry can really afford to invest his own money in finding out how to make them; the department building the system can't afford to pay for it out of its own budget.

So, basically it requires government-funded research, done separately, which is what Admiral Hayward, I believe, is pushing now. Some parts of the government have always pushed it, but it isn't as glamorous as flying missiles. It's very hard to go to Congress and convince the Congressmen that you should put $2 million into something that looks like a little motor.

In the last ten years, I would say, the major emphasis has been "get the weapons system out and use whatever components are available." So-called off-the-shelf items were employed and their hasn't been too much breakthrough in the last few years.

TI's Circuit Has 12 Components

New York—A major advance in ultramicroscopic semiconductor solid circuitry that promises to change many of the design concepts of computers and similar equipment has been introduced by Texas Instruments. A complete multivibrator circuit containing 12 electronic components has been



formed integrally with a single piece of silicon or germanium less than 1/4 x 1/8 x 1/32 inch overall. It was demonstrated at the recent IRE show here.

Such circuits allow a fantastic possible component density of up to 34 million components per cubic foot. For comparison, the newly announced "micro-module" circuits are capable of densities somewhere in the order of 500 thousand per cubic foot while conventional printed circuit techniques provide a maximum density of a few thousand per foot.

According to TI President Pat Haggerty, the ultimate use of the ultramiscroscopic methods would allow the equivalent of all the computers in the United States to be contained in one unit the size of an average room.

The first circuit developed was a standard multivibrator with two diffused-base transistors, two capacitors, and eight resistors. An oscillator has also been designed which contains nine components.

The new solid circuits are expected to find greatest potential application where large numbers of repetitive circuits are required, such as in the computer field, and for missiles, rockets, satellites and all space vehicle instrumentation where weight, size, and extreme reliability are critical factors.

In announcing the new semiconductor circuits, Texas Instruments stressed that commercial models are not yet available in either sample or production quantities, although they are expected to be ready some time this year.

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propulsion engineering

Aerojet's Dan Kimball is not sure a nuclear rocket is practical. He says this is the consensus of many propulsion scientists, and asks Congress to authorize $50 million to be spent over several years to find out if nuclear propulsion is practical. Kimball told the House Committee on Science and Astronautics that very little has been done in the field so far. He also ventured that the U.S. is ahead of the Russians in solid propellants, about even in liquids—a statement based on Central Intelligence Agency reports to Aerojet.

The Committee wants to be sure CIA and other agencies are passing information along to industrial concerns that can use it. However, says Kimball: "We learn nothing new from the USSR."

Nuclear fuels get more research attention by NASA than recent reports indicate. A NASA staffer says the organization's effort in nuclear propulsion is "almost as great as the effort in chemicals, it's just that we can't talk very much about nuclear work." Publicity is scarce for two reasons: (1) Some of the work is justifiably classified for military reasons and, (2) NASA has to clear publicity on nuclear work with so many other people that it's sometimes not worth the effort.

The Air Force thinks scandium's melting point is 2822° F., instead of the 2192° F. that now appears in the literature. That explains the $60,000 contract to Union Carbide Metals to produce and study one pound of the very lightweight metal. Difficulty of production and high cost could be overruled by the phenomonally high melting point, if the AF is right.

The new storage tank insulating powder that's 26 times more effective than a vacuum is a major factor in almost all of Linde Company's recent bids on liquid gas storage tanks and production facilities. The closely-guarded material and Linde's commercialization of the ortho-hydrogen to para-hydrogen process (Propulsion Engineering, March 30) makes liquid H_2 as easy for Linde to handle as LOX is for many producers. Present vented liquid hydrogen tanks have a tremendously high loss rate—measured as a high rate/day—but the new powder makes possible unvented H_2 tanks with a loss rate of only *0.9%/year*. No cold liquid nitrogen shield is required.

Until patents are in the clear, Linde will not even hint at the powder's composition. It's known, however, that it grew out of work on the earlier CS-5, SI-4, and SI-12 powders. The material is so good that Linde is even trying to talk Air Force BMD out of its plans to build LOX plants at most missile sites. Linde was asked to bid, but offered to build loss-proof storage tanks instead. Negotiations are up in the air, a Linde official says, because "there are some good arguments on both sides."

If the armed forces want oxygen fluoride, Pennsalt Chemicals will make it for them. But nobody will make this near-perfect oxidizer for carbon-based fuels until a market is guaranteed. Pennsalt says the lab technique of reacting fluorine with water won't do as a commercial process. A cheaper, easier to handle route to OF_2 would have to be found.

Although Pennsalt won't say whether its labs are going ahead with research even without a requirement from the military, the requirement probably will come. The reason: Although flourine is the oxidizer to use with H_2 for maximum I_{sp}, its combustion product with carbon is high molecular weight carbon tetrafluoride; low molecular weight carbon monoxide comes from combustion of carbon with oxygen rather than fluorine; thus, OF_2 is the ideal oxidizer for hydrocarbons, and it's easier to liquefy than oxygen or fluorine alone.

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west coast industry

by Fred S. Hunter

Questions have arisen, from time to time, regarding the structure design of the *Atlas* ICBM. Convair broke new ground in this area by developing a structure with a skin so thin that the interior has to be pressurized to preserve the shape of the body as propellants are consumed in flight, or when the missile is being transported on the ground. Structure weight was minimized. Mass ratio was improved.

But, said detractors, the structure was too fragile—"You could dent it with a hammer." So, recently, when the Scientific Advisory Board, engaged in a re-evaluation of all missile programs, arrived at Convair-Astronautics to take a reading on the *Atlas,* they found that Convair had thoughtfully placed a number of hammers within easy reach of a finished missile. "Go ahead, hit it," invited Convair. The SAB members swung lustily. Not a dent was registered.

The Air Force has engaged in a tremendous airlift to England with the *Thor* IRBM, transporting thousands of pounds of missiles and ground equipment in C-124 and C-133 aircraft. It also takes the *Titan* ICBM from Denver to the Missile Test Center at Cape Canaveral by C-133. But the *Atlas* still makes the trip from San Diego to Florida by truck, a nine-day journey entailing a total cost of $14,000. This is because the *Atlas,* a couple of feet greater in diameter than the *Titan,* is too tight a fit for the C-133's currently in operation.

But an updated C-133B model of the big Douglas turboprop transport will become available in 1960, and it incorporates enlarged, rear-loading doors, which are being installed specifically to simplify the loading of *Atlas.* With the C-133B, Douglas estimates the total cost of shipping an *Atlas* from San Diego to Canaveral by air at $9,200—a saving of nearly $5,000 as compared to surface transportation. Flight time will be seven hours, compared to nine days by truck. The $9,200 total includes indirect as well as direct operating costs, and also covers the return flight (with transporter) of the C-133B to San Diego. If cargo is carried on the return flight, the missile-delivery costs will be even less.

Most of the Douglas Aircraft Co.'s missile effort—*Thor, Genie, Honest John,* the *Nikes*—has centered in the Santa Monica Division, noted over the years as the home of the company's famed transport aircraft. But now we have the traditionally Navy division at El Segundo making important motions on the missile front. Four missile design sections have been added to El Segundo engineering, and a missiles project engineering office established. Previously, El Segundo has done some work on missile components for the Santa Monica Division, but now it will also come up with some design proposals of its own.

Pacific Missile Range expenditures during 1959 will total approximately $91 million, Rear Adm. Jack Monroe, PMR commander discloses. Construction of facilities, such as the new satellite launching pads in the Navy's Point Arguello area, will add up to $36 million; payrolls $25 million; equipment $16 million; aircraft and maintenance $11 million, and other expenses $3 million. Range management personnel has been built up during 13 years of operations at Point Mugu, and currently totals 5,000, divided about equally between military and civilian.

One of the countdowns on the *Discoverer I* at Vandenberg AFB was stopped at 15 seconds before launch, thus proving that the basic *Thor* system can be controlled when required, and also dispelling the fear—expressed by some British factions—that once the 9-to-12-minute terminal countdown is started, it might not be possible to halt operations.

RCA Demonstrates Thimble-Size Tubes

WASHINGTON—In a recent demonstration before representatives of the electronics industry, military, and press, RCA introduced prototypes of its thimble-size electron tubes.

Called "Nuvistors," the tiny tubes are capable of operation in temperatures from –320°F to +350°F. Since they are larger and require high power, the Nuvistors are not expected or intended to replace resistors. But for higher frequencies or for high-temperature operation the new tubes are said to be superior to transistors.

"Development of the new design represents a major breakthrough in tube size, pfierformance, power drain, an dreliability," said D. Y. Smith, vice-president and general manager, RCA Electron Tube Division. "It opens the way to mass production of high-erformance, thimble-size tubes having improved ruggedness, reliability and efficiency.

The new tubes are expected to lead important developments in such instruments as television sets, communications receivers, and computers. The tubes will contribute to building more compact and efficient electronic equipment for defense and industry, Smith added.

RCA will furnish developmental samples to the electronics industry within the next several months, Smith said. A small-signal triode and a small-signal tetrode will be offered first, and these will be followed at a later date by a beam power tube. According to present plans, RCA expects to start limited commercial production of the tubes in 1960 and mass production will follow later in the year. Prices then are expected to be competitive with other tubes and transistors.

The high-efficiency triodes and tetrodes are expected to find wide use in the logic and computing circuits of electronic computers. The power tetrode, capable of high peak current at low plate voltage, offers advantages for memory-core-driver applications. The beam power tube could be utilized in series voltage regulators, low-power transmitters, servo amplifiers, and high-power sound systems.

Preliminary tests indicate that Nuvistor tubes should meet the very critical military reliability and environmental objectives better than larger, traditional-design tubes. The materials used will maintain the excellent resistance of the electron tube to damage from nuclear radiation, Smith said.

. . . METALS

(Continued from page 34)

graphite as a high-temperature strengthening reinforcement or as a filament to achieve increased electrical and thermal conductivity while improving strength and minimizing failure due to shock loading.

The characteristics of such laminates made with suitable binders are striking. A laminated bar fully processed to over 99.5% graphite permits appreciable bending without fracture, a very unexpected performance of graphite.

• **Screening missile materials**—Simultaneously with the problem of creating new products, the designer and materials man is confronted with the continuing need for screening of potential or suggested materials.

Because of the extremely rigorous and critical conditions involved in such testing, practically the only dependable method is to test in actual missile structures or in very costly models under closely simulated service conditions.

Extremely expensive and time-consuming, this seriously restricts the number of materials or assemblies which can be tested. Some materials, of purely speculative value, may not be tested and some entire classes of materials may not be explored.

There is, therefore, a critical need for screening devices which could in a relatively short time test materials under simulated conditions and select those that have high promise. There have been developed recently the so-called arc plasma torches, at least one variation of which seems to be fully capable of being developed as a moderately flexible screening test for missile materials.

These torches can develop temperatures on the order of 15,000°F and gas velocities up to Mach 1-2, are large enough to enable testing of reasonable size assemblies, and can maintain such conditions for reasonable periods, measured in minutes. As they are still in early stages of development, there is considerable optimism that higher gas velocities will be attainable, thereby closely approaching the extreme service conditions that must be withstood.

The test has the added advantage that not only can the character of the atmosphere be changed within a fairly broad range, but erosion and corrosion phenomena can be studied by introducing compounds and solids into the flame which duplicate those produced by solid or liquid fuel propellants.

• **Filamentary crystals**—As an example of the need for initiating and continuing research in the new and advanced areas of materials in order to develop an untrammeled perspective, we might cite the example provided by filamentary crystals or "whiskers."

For seven years their astonishing strengths have been recognized and they have been characterized as representing nearly perfect crystallization—being generally free from dislocations, the lattice defects responsible for the relatively limited strength of many conventional crystalline materials.

Presumably because of this, they possess almost theoretical strength, in the order of 1,900,000 psi for iron, which is about 100 times the strength of ordinary crystals of iron, for instance.

Such materials behave elastically up to their maximum strength. So, in appropriate applications, they presumably would be useful to much higher than normal stress. Perforce the high elastic limits available in this sort of material is obtained with the exclusion of the usual plastic properties. This may inhibit the utilization of the high elastic strengths in many applications.

• **Unconventional methods**—It is of considerable interest that in some basic solid state studies of graphite, methods have also been evolved for the production of graphite filamentary crystals. These have indicated tensile strengths on the order of 3,000,000 psi, a 1000 to 1 increase over properties of normal graphite.

In the intense desire of design engineers to employ materials having maximum strength/weight ratio, these findings on perfect crystals of metals and other materials have occasionally suggested the possibility that larger, massive structures could be processed to have these characteristics.

However, it is now generally recognized that bulk material having the properties of whiskers will be produced only by unconventional methods yet to be developed. Some entirely new concepts have evolved recently based on work which has shown that in some cases the crystal structure of such strong whiskers in not as perfect as had previously been thought. This work, however, collaterally has indicated that some imperfect crystals have the unusual properties, while others do not—hence, less obvious factors may play a part in the phenomenon of high strength.

In spite of this uncertainty, the possibility that nearly theoretical strengths may be developed in bulk materials containing dislocations is encouraging.

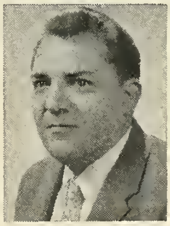
The total research effort in this general field is increasing in intensity and breadth as it portends fuller explanations of the basic problems of materials behavior.

people

Edmond C. (Collins) Buckley, former chief of the Instrument Research Division of the Langley Research Center, has been appointed Assistant Director for Space Flight Operations at National Aeronautics and Space Administration Headquarters, Washington, D.C. Buckley joined the National Advisory Committee for Aeronautics, predecessor of NASA, in 1930. Reporting to the Director of Space Flight Development, Buckley is responsible for planning and directing use of support systems for space research activities, including global tracking stations, data acquisition systems and networks, ground communications networks, and launch site facilities.

Jack Gray has been promoted to Senior Contract Administrator for Temco Aircraft Corp. Gray, formerly Contract Administrator, replaces **Howard Clark**, who was named Business Manager on the *Corvus* missile program. Gray will be in charge of administration of all subcontracts held by Temco.

In a recent appointment, **Charles Nater** became chief engineer of the Instrument Div. of Beckman & Whitley, Inc., San Carlos, Calif., manufacturers of high-speed cameras, meteorological instruments, and missile components. His earlier career was mainly with Canadian Westinghouse Co. of Hamilton, Ontario. Prior to this he was production superintendent at Holman Vulcan Ltd. and chief engineer of the industrial development department of the Ministry of Economy of the Republic of Guatemala.



NATER

Philip LeBoutillier, Jr. takes over as Deputy Assistant Secretary of Defense (Supply and Logistics), succeeding **Cecil P. Milne**, who has been nominated by the President to the Assistant Secretary of the Navy (Materiel). Milne, formerly vice president and general manager of Massey-Harris-Ferguson, Inc., has served as Deputy Assistant Secretary of Defense since November, 1957. LeBoutillier will assist the Assistant Secretary of Defense for Supply and Logistics, **Perkins McGuire,** who is responsible for the areas of transportation, supply, communications, petroleum, procurement, production, planning and requirements, and small business.

NAVY

$101,701,000—Grumman Aircraft Engineering Corp., for development and production of the A2F-1 carrier-based jet attack plane, to be armed with *Eagle* missiles.
$13,500,000—Philco Corp., for continued production of *Sidewinder* guided missiles.
$6,000,000—General Electric Co., for continued production of *Sidewinder* guided missiles.
$391,000—Beckman Instruments, Inc., for electronic data handling systems for *Talos* automatic check-out equipment.

ARMY

$12,870,000—Malan Construction Corp., New York City, for construction of ICBM sites at Offutt AFB, Neb.
$12,083,720—California Institute of Technology, for *Sergeant* research program and wind tunnel.
$10,911,000—The Firestone Tire & Rubber Co., for guided missile system.
$9,950,000—Western Electric Co., Inc., for planning on *Nike-Zeus* program.
$8,900,000—Western Electric Co., Inc., for *Nike-Hercules* ground and test equipment (two contracts).
$3,116,264—Raytheon Manufacturing Co., for the *Hawk* program.
$2,745,000—Rocketdyne Div., North American Aviation, Inc., for classified work.
$1,589,029—Brown Engineering Co., Huntsville, Ala., for engineering services.
$1,098,768—Intercontinental Manufacturing Co., Inc., Garland, Tex., subsidiary of U.S. Hoffman Machinery Corp., for XM-30 Jato (*Hercules*) solid sustainer motor metal parts.
$914,830—Phelps Construction Co. and H. Clinton Rodgers, El Paso, Tex. (joint venture), for up-range service area development at White Sands Missile Range.
$747,737—Rheem Manufacturing Co., Downey, Calif., for classified (Zebra) work.
$670,695—Macco Corp., H. C. Smith Construction Co. and Kemper Construction Co., Paramount, Calif. (joint venture), for silo launch test complex, phase I at Edwards AFB.
$450,000—The Budd Co., Philadelphia, for ground transportation units for the *Redstone* (subcontract from Chrysler).
$394,074—Telemeter Magnetics, Inc., Los Angeles, for a high-speed digital memory system.
$330,345—Bovee Inc., Paramount, Calif., for LOX generator facility at Vandenberg AFB.
$246,242—Douglas Aircraft Co., Inc., for *Nike* launching area items. (Ryan Aeronautical Co. received a subcontract from Firestone for liquid fuel rocket motors for *Corporal* missiles. Amount was not disclosed.)

AIR FORCE

$3,817,183—Motorola Inc., Military Electronics Div., for 168 radar guidance beacons and command data links for *Bomarc*.
$2,612,343—Pan American World Airways, Inc., for increase in funds (awarded by Patrick AFB).
$2,400,000—The Martin Co., for expansion of the *Mace* program.
$999,019—Hewlett-Packard Co., Palo Alto, Calif., for various electronic items.
$493,870—Sperry-Rand Corp., Sperry Electronic Tube Div., for electron tubes.
$437,000—Sylvania Electric Products, Inc., for electron tubes.
$387,120—General Electric Co., Missile and Space Vehicles Dept., for R&D of a converter to permit conversion of thermal energy to electrical power.
$332,896—Sperry-Rand Corp., Sperry Gyroscope Co., for radar set components, spare parts and data for Navy aircraft and Project *Black Knight*.
$268,470—General Electric Co., Scranton, Pa., for electron tubes.
$264,345—The Hickok Electrical Instrument Co., Cleveland, for electron tube test sets and handbooks.
$248,800—Grand Central Rocket Co., for Viper 1-B rocket engines and igniters.
$242,700—Eitel-McCullough, Inc., San Carlos, Calif., for electron tubes (two contracts).
$223,720—Tung-Sol Electric Inc., Newark, N.J., for electron tubes.

About the Cover

Pictured on the cover this week is the *X-15* cradled under the wing of the mother B-52 during their maiden flight together March 10.

The *X-15* made its second captive flight April 1. It was again carried to 38,000 feet for aerodynamic checks and for crew familiarization of the two-hour inflight check-out.

Scott Crossfield, North American test pilot, remained in the *X-15's* cockpit for the entire flight. AF-NASA programming calls for another static test before the rocket plane is released for its first glide test.

when and where

APRIL

Fifth National Military-Industrial Conference, Palmer House, Chicago, Apr. 6-8.

American Welding Society, 1959 Welding Show and 40th Annual Convention, International Amphitheatre and Hotel Sherman, Chicago, Apr. 7-10.

International Conference on Fracture, Sponsors: Air Force Office of Scientific Research/Solid State Sciences Div., Office of Naval Research, National Science Foundation, National Academy of Sciences/NRC, Massachusetts Institute of Technology, Cambridge, Mass., Apr. 12-16.

Air Force Association, World Congress of Flight, Las Vegas, Apr. 12-19.

Aeronautical Training Society, 17th Annual Meeting, Desert Inn, Las Vegas, Apr. 16-17.

Institute of Radio Engineers, 11th Annual Southwestern Conference and Electronics Show, Dallas Memorial Auditorium, Dallas, Apr. 16-18.

Third National Conference, Aviation Education, Riverside, Calif., Apr. 17-18.

Institute of Radio Engineers, Spring Technical Conference on Electronic Data Processing, Cincinnati Section, Engineering Society Bldg., Cincinnati, Apr. 21-22.

Institute of Environmental Engineers, 1959 Annual Meeting, La Salle Hotel, Chicago, Apr. 22-24.

American Society of Mechanical Engineers, First National Metals Engineering Conference, Hotel Sheraton-Ten Eyck, Albany, N.Y., Apr. 29-May 1.

American Rocket Society, Controllable Satellite Conference, Massachusetts Institute of Technology, Cambridge, Apr. 30-May 1.

MAY

Air Force Office Scientific Research/Chemistry Div. and Electromechanical Society, Symposium on Electrode Processes, Philadelphia, May 3-7.

Institute of Radio Engineers, 11th National Aeronautical Electronics Conference, Dayton, Ohio, May 4-6.

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