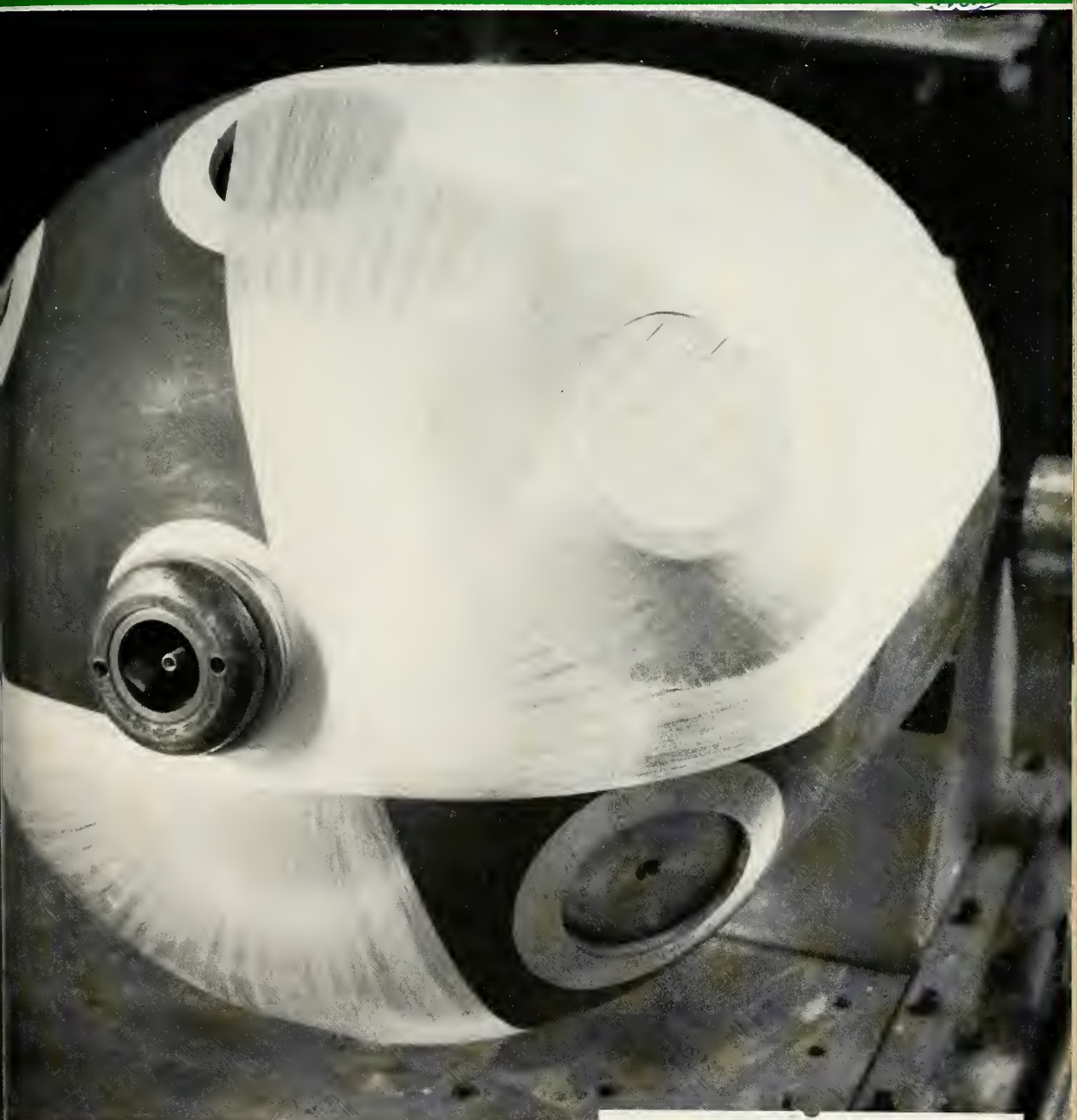
NOVEMBER 28, 1960

missiles and rockets

HE MISSILE/SPACE WEEKLY



oodrich's *Filament-trussed Rocket Chamber*

ransit May be Operational Before '62 . . .

SPECIAL M/R REPORT—

Missile/Space Materials Gap Widens . . . 25

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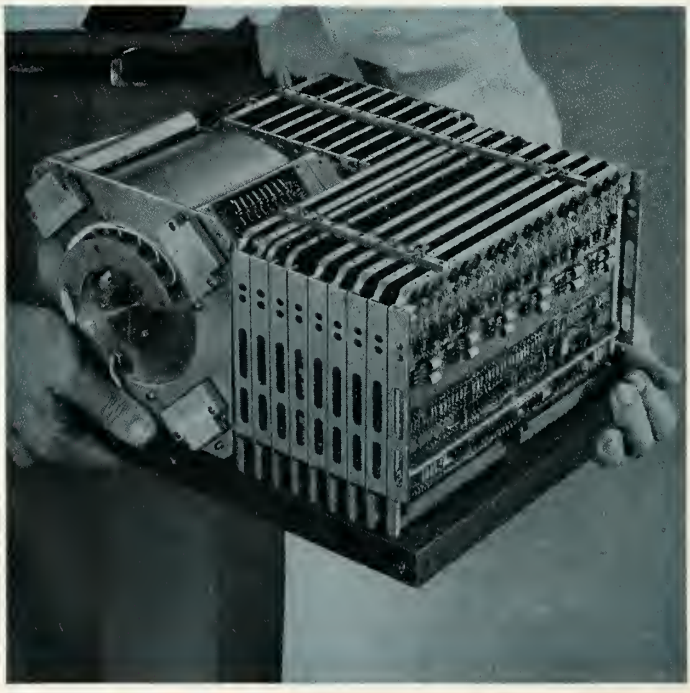

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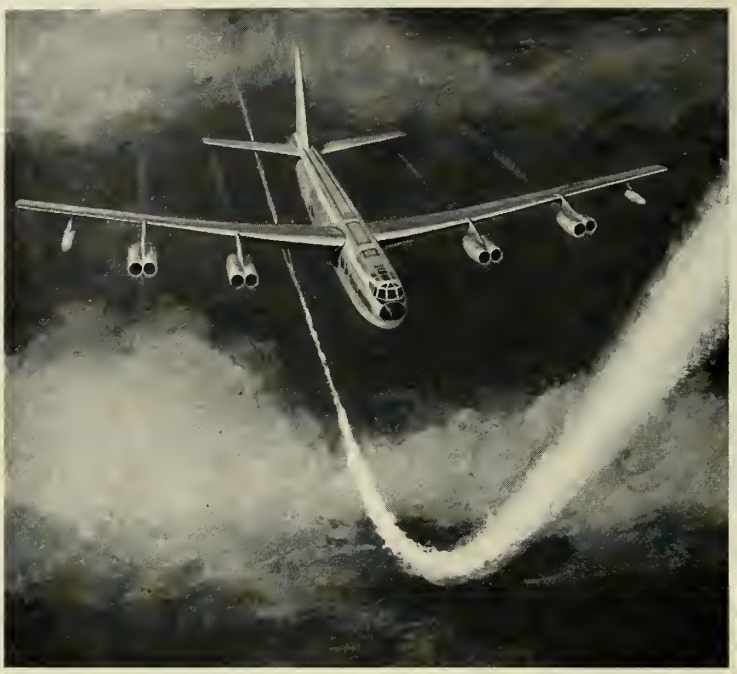

KEARFOTT is producing

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THE MISSILE / SPACE WEEKLY

missiles and rockets

Volume 7, No. 22 November 28, 1960

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THE COVER

Weird effect is created by filament-winding of rocket chamber at B. F. Goodrich. Photo shows port reinforcements and application of longitudinal windings. See story, p. 28.

NOVEMBER 28 HEADLINES

SPECIAL REPORT—

DEPARTMENTS

* U.S. Reg. Pdg.

32,917 copies this issue

D-65 protected Cannon Plug fro
Atlas blast. Photo is unretouche

NEW FLEXIBLE D-65

flame resistant flexible coating protects ground support and missile equipment from rocket blas

Proved in Atlas test firings: protection at up to 5400° F. for 62 seconds—ease of application at the scene by ordinary paint brush, spray or dip methods—ease of removal and recoating—flexibility after curing. These are some of the advantages of new Dyna-Therm D-65 insulation that promise reduced ground equipment refurbishment time and faster missile refire. Case in point: this standard GMAB electrical connector manufactured by Cannon Electric Company. Coated with D-65 and exposed to Atlas blast, it was found undamaged when coating was cut away as shown. Similar test of coated umbilical cord at 5400° F. for 62 seconds found cord undamaged, D-65 coating still flexible.

D-65 has been successful in insulating neoprene cables, metal and plastic instrumentation housing, piping and general structure, in flight application and ground support equipment.

Dyna-Therm D-65 was developed by Dyna-Therm Chemical Corporation and is marketed exclusively in the U.S. and Canada by Swedlow Inc. Prime contracto for the Atlas is Convair-Astronautics, a Division o General Dynamics Corporation.

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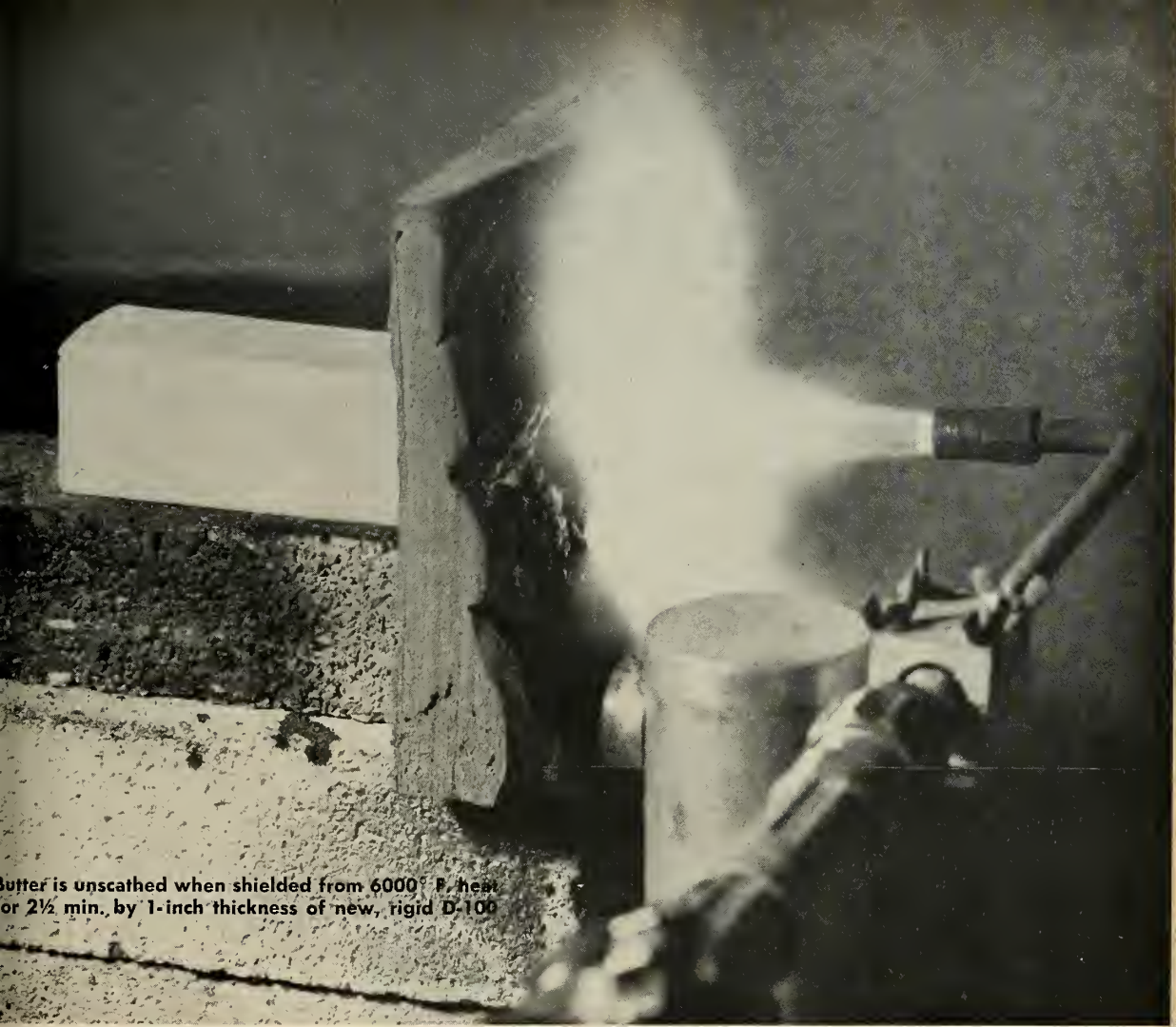

NEW RIGID D-100*

ulti-purpose foam withstands 10,000+°F. heat/flame; gives lasting insulation at missile installations

e functional value and useful range of Dyna-Therm t/flame resistant coatings is vastly increased by v, special-purpose, rigid D-100 foam, which does uble duty — serving as a protective shield against nperatures exceeding 10,000°F., and also acting as igh-performance insulating agent.

A two-part, 100 percent solids formulation, new 00 has limitless storage life; foams instantly when ked; and can be sprayed**, spread, or poured to ain the exact thickness or depth desired.

The dual properties of new D-100 foam make it al for use on blast-exposed rigid fixtures and ap-ratus at missile pads; for fire walls, fire doors; and for a diversity of other heat-sensitive installations at launching sites.

Patent applied for

***Specially designed equipment for automatic metering/mixing, and spraying of D-100 foam is available from Dyna-Therm Chemical Corp.*

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letters

Worth Waiting For

To the Editor:

You will be gratified to know that least half of your readership has gleeful called to my attention, in case I mig have missed it, your bouquet (in Technic Countdown) in M/R, Oct. 24, p. 1 under the heading "Not Too Little, Ju Too Late." I cannot help but be disa pointed that, having decided to mentic the *Proceedings of the 1959 Comput Applications Symposium* at all, you cou not have found some more constructi comment to make about them. Inciden ally, our performance wasn't quite as ba as you state; the *Proceedings* were maile out to attendees of the Symposium and a vance purchasers in July, when they cam off the press.

If I had not been personally involve in the preparation of the *Proceeding* and were not familiar with the circun stances in which they were produced, would have to admit that yours was shot that hit the mark. However, witho burdening you with a lengthy series c excuses, I have to point out that the edi ing was essentially a one-man job, carrie out on a shoestring budget by an indivic ual whose responsibilities in the operatio of a contract research establishment ha to take precedence over everything els In view of this, I hoped that the qualit of the result would be the predominar point of interest, rather than the delay i publication. Since in our initial mailin we sent you only a summary and at stracts, I enclose a copy of the complet *Proceedings* so that you may judge fc yourself.

All in all, it is more in sorrow than i anger that I wish you had grounded thi particular missile.

Andrew Ungar, Asst. Supervisc
Computer Applications and Op erations Research
Armour Research Foundation c Illinois Institute of Technolog Chicago

Our "missile" was as Mr. Ungar note aimed solely at the delay in publishing th document. We did have a complete cop of the Proceedings for review, and it i only because of its noteworthiness that w commented for the information of ou readers. We consider that Mr. Ungar di an excellent job; no doubt the dela would have been avoided if he had bee given more assistance.—Ed.

Missile Train Concept

To the Editor:

Please refer to your article on pag 17, M/R, Oct. 17, entitled "'Father' c the *Minuteman*-on-Rails."

With due credit to Mr. Blades an AMF, the idea of mobile missile train originated long before they became in terested. I am enclosing a copy of memo dated May 1, 1958, entitled "Pro posal for Casey Jones Concept Missil Weapons System," which was submitte

o the Electro-Motive Division of Gen-ral Motors management for ideas origi-ating on April 25, 1958. This idea was resented to the Missile Committee of eneral Motors on May 20, 1958.

It was not until June, 1959, 13 months ater, that M/R published its first article n this concept. It might be pointed out hat the only organizations mentioned n this article were AAR and ACF.

My principal reason for bringing this p is to point out some of the features f this program which I believe are being verlooked. As outlined, these are:

1) Defensive capabilities of mobile rains equipped with radar and anti-air-raft missiles

2) Piggy-back design for transfer to ruck or aircraft

3) Foreign application program

4) Ability to concentrate offensive or efensive positions in a new area within ours

5) Design so that missile obsolescence oes not obsolete the entire train.

Ollen Kay
San Diego, Calif.

Neither Rain nor Snow . . .

o the Editor:

Please find attached my renewal of MISSILE AND ROCKETS at the special air-ail rate for Argentina.

I would like to take this opportunity o say that of all the magazines I sub-cribed to while in Argentina M/R is the nly one I received regularly and on time.

George H. Muller
Ford Motor Argentina S.A.
Buenos Aires

Correction

In an article titled "Rigid Drift ests Give Useful Gyro Data" in I/R Nov. 14, two formulas on p. 28 nd 30 were incorrectly printed and herefore meaningless. The correct ersions are as given below:

andomness:

$$= \pm \left(\frac{\sum_{i=1}^{N} y_i^2 - \frac{1}{n} \sum_{j=1}^{N/n} T_j^2}{\frac{N}{n}(n-1)} \right)^{\frac{1}{2}} \text{degrees/hour}$$

here y_i = a drift reading at any position,
T_j = the sum of the drift readings at a position,
n = the number of drift readings at each position, and
N = the total number of drift readings.

esidual Sigma:

$$\pm \sigma_r = \left(\frac{\sum (\widehat{y_i} - \overline{y_i})^2}{\frac{N}{n} - 1} \right)^{\frac{1}{2}}$$

here $\widehat{y_i}$ = magnitude of fitted curve at a position, and
$\overline{y_i}$ = average of the drift readings at a position.

The Countdown

WASHINGTON

Pocket Operation

With the latest *Mercury* failure (see p. 17) knives are out in the Pentagon to cut the slipping civilian man-in-space program off at the pockets. ($241 million has been appropriated to date with another $100 million still needed.) COUNTDOWN hears a lot of speculation that the Kennedy Administration may kill *Mercury*. But it is also possible that the program could be incorporated into a greatly beefed-up space-flight effort, perhaps focused around the Air Force's *Dyna-Soar*.

Where's the Monkey?

Back in August, ARDC's Gen. Schriever said a primate would be sent into orbit in a *Discoverer XV* in mid-September. Now the Air Force is letting it be known that this long delayed shot is in the pipeline for "after Jan. 20." What happened? Some say the slippage was deliberate—to keep the AF from competing with *Mercury*, particularly before the election. Others contend technical problems and the fact that engineers were pulled off the animal capsule to work on *Discoverer XIII* made the shot impossible before next year.

Spotlight on Bambi

Rand Corp. will give ARPA a two to three day briefing shortly on prospects for the secret Project *Bambi* —ARPA's advanced study program for possible development of an anti-missile missile launching satellite. Subjects on tap: feasibility, cost and most attractive avenues of approach.

Booster Speedup Possible

Look for a speedup in the timetables for the *Nova* and *Saturn C-2* launch vehicles if the Kennedy Administration sticks to its pledge for a greater effort in space. A plan is now in the works to produce an early *Nova* scale model at NASA-Huntsville next year.

In the Pentagon

Close observers detect signs of a trend in the Administration-elect away from any radical shakeup in DOD organization—particularly anything affecting missile/space R&D . . . Plans now call for hanging four *Skybolts* on SAC B-52's, which could mean a production run of 2000 when the ALBM becomes operational—probably in 1964 . . . Date for the first full-scale *Minuteman* shot from a silo at the Cape is Dec. 12.

'Beetle Juice' Ahoy

Navy has converted a 12,000-ton cargo ship to haul operational Lockheed *Polaris* missiles to sub tenders stationed at Holy Loch, Scotland, and other advanced bases. The Betelgeuse—nicknamed the "Beetle Juice"—can tote 16 birds.

Pershing II vs. Polaris II—Cont.

Despite the denials of Defense Secretary Gates, the Army's proposed *Pershing II* is still considered in the running as a possible NATO MRBM. The Army is expected to mount a new push for the 1000-mile Martin missile, for its own use as well as NATO's, as soon as the Kennedy Administration takes office. Some insiders are speculating that Army R&D Boss Gen. Arthur Trudeau's recent trip to Western Europe may have included the gathering of ammunition in support of *Pershing II*.

INDUSTRY

Big Dyna-Soar Contract Due

Within the next few weeks—possibly before Jan. 1—the Air Force will award a large contract for the *Dyna-Soar* guidance system. The contract will be directly with the AF, making its recipient an associate rather than a subcontractor to Boeing.

Nuclear Rocket Facility

Any day now the NASA-AEC nuclear propulsion office will name a contractor for a four-month study of the master plan for a National Nuclear Rocket Testing Facility. Construction would begin in FY '62 and could be at the AEC's Nevada test site.

Ground or Orbit?

Word is out that Convair and Douglas are making studies (at $1 apiece) for NASA's RIFT (reactor in-flight test) plans. They are trying to help resolve the question of whether the first launch of a nuclear rocket should be from the ground or from orbit.

Look at the Enemy

A report by the American Society of Mechanical Engineers analysing the Soviet technological system finds these five "grievous" errors: "Russian management fails to recognize that one mind cannot possibly pre-guess the outcome of scientific venture. The Soviet tries to combine propaganda with progress. They have a dire shortage of individual imagination. Their scientists have to work under extreme political pressure."

INTERNATIONAL

Red Arms for Cuba

State Department study of the Russian beef-up of Castro's military forces shows Cuba has enough weapons for an army of 25,000. Items include 104,000 automatic weapons, 200 machine guns, 55 tanks, 100 3.5 rocket launchers—no tactical or long-range missiles.

French Space Shot

From its North African missile range at Colomb-Béchar France expects next year to launch a space capsule containing some small animals. Vehicle will reach an altitude of 900 miles.

The Long Road Ahead

How far is the U.S. behind Russia in sending biological systems into space? Taking a hard look at *Sputnik V*, ARDC's Gen. Flickinger believes the recovery of two dogs and other specimens in a capsule ejected from that satellite indicates a know-how in maintaining sea-level atmosphere and complex monitoring systems "at least 3½ to 5 years" ahead of the U.S. —even given the same payload weight right now.

The Missile/Space Week

Decision on NATO MRBM Likely to Await Kennedy

Backing and filling during the last week over future NATO armament clearly indicated:

–A delay of possibly six months or more on deciding whether a specia NATO force armed with H-bomb-tipped, medium-range ballistic missile (MRBM's) will be created.

–A similar delay on a decision as to whether NATO nations will buy land based or seaborne *Polarises*—or possibly an alternative such as the propose 1000-mile-range *Pershing II*.

Meantime, the Joint Congressional Atomic Energy Committee sent fiv of its members on a European tour to study the entire question of establish ing a nuclear-striking force within the NATO Alliance.

Also, President Charles de Gaulle won a second vote of confidence in th French Assembly for his plan to establish a separate French nuclear strik ing force outside of NATO.

Previously the Eisenhower Administration had hoped that the NATC Council of Ministers could reach a decision on proposals for a NATO Stra tegic force armed with nuclear weapons when the Council meets Dec. 16 ir Paris.

However, the Administration itself is understood to have failed to reacl agreement on an American position. Therefore, the entire question is ex pected to be left for the new Kennedy Administration to handle.

First Polaris II Sub—Ethan Allen—Launched

Fifteen-hundred-mile-range *Polaris II* missiles will go on patrol around Russia early in 1962 aboard the 6900-ton Ethan Allen, first of the new class of FBM subs launched at Groton, Conn., last week. The Ethan Allen, the sixth *Polaris* sub to be launched, is 1300 tons heavier and 30 feet longer than the George Washington and her four sister ships. Nine pacifists were arrested at the launching. Two of them swam out to the Ethan Allen and boarded the bow as she slid out into the Thames from the Electric Boat Co. yard.

Hints on Red ICBM Bases, Antimissile Missiles

The Russians this week offered the world a few hints about their missile progress. But as usual they were open to question.

Hint No. 1 came from Andrei I. Yeremenko, Soviet Deputy Defense Minister. He implied in the official Soviet English-language publication *International Affairs* that Russian ICBM bases are "well camouflaged or hidden underground" and scoffed at the idea that high-flying reconnaissance planes could find them.

Hint No. 2 came from Marshal Vasilly Kozakov of the Soviet Artillery. He said in *Izvestia* that "Russian forces now have rockets which can hit offensive pilotless devices at great altitude."

Some observers speculated that hint No. 1 could mean that Russia has any number of hidden ICBM bases unknown to the United States, and that hint No. 2 could mean Russia has developed an anti-missile missile.

On the other hand, hint No. 1 could be merely bluster. And hint No. 2 could merely mean that Russia has finally developed a missile similar in capability to the Western Electric *Nike-Hercules*.

Alaskans Watch Nike-H Make History

Thousands of residents of Anchorage, Alaska, became the first city dwellers this last week to watch a *Nike-Hercules* go into action from an operational defense site set up to protect them from attack.

The *Nike-Hercules* ripped from an operational site near Anchorage on the slopes of the Chugach Mountains, leaving a long white trail in the Alaskan sky. It struck a simulated target 73 miles away.

allute Flies Again

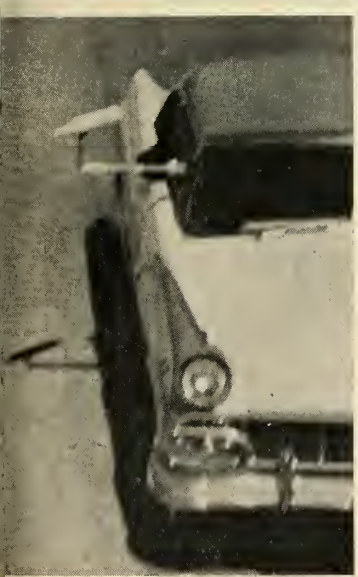
Goodyear's *Ballute,* a re-entry recovery system, racked up its second traight success 170,000 ft. over the Air Force's Eglin Gulf Test Range last veek. The packaged nine-foot-diameter coated fabric balloon was released rom the third stage of a three-stage *Cree* test missile ascending at a speed of Mach 1.5. The *Ballute* popped into shape within a tenth of a second, stabized the 500-lb. re-entry vehicle and then reeled out on a cable to gain the esired drag during the missile's final 35,000 ft. of ascent. A parachute, deloyed when the vehicle's speed fell below the Mach 1 mark, completed the ecovery.

Making Ranger Germ Free

To insure that the U.S. won't be guilty of contaminating the moon, NASA planning to sterilize its *Ranger* lunar-landing space vehicle. Lockheed Missile and Space Division last week received a contract for a prototype terilization gas transfer system. It will be used on the ground to pump a ixture of ethylene oxide and freon-12 gases into the *Agena-B* payload section to render it germ-free. The fumigant will be flushed out and neutralized rior to launch.

Martin Hints at Expansion

Martin Co. Stockholders will vote on a proposed 2-for-1 stock split Jan. 9. Company directors, who also increased the present quarterly dividend from 40 to 50 cents, indicated the increase in shares, if approved, would create a reserve which could be used for future acquisitions to diversify the corporation. Three million of the company's 6 million shares are now outstanding. The split would increase the no par capital stock to 12 million shares.



Polaris Weathervane

ORD ON Bayshore Freeway tests Poris performance at subsonic speed (60 ph). Missile model hangs from car indow. Lockheed is gathering data on hat happens to pieces when bird blows o in flight. "Weathervane" of car windream gives answers.

Solar Pressures Squeeze Echo

The orbit of the Project *Echo* balloon has taken a more elliptical shape due to solar pressures.

The satellite's apogee is now approximately 1290 miles. Its perigee is 666 miles and is dropping about three kilometers per day due to solar pressures.

The balloon is estimated to be about 60% to 70% inflated. Its radio reflecting quality is still good, according to Jet Propulsion Laboratory technicians at Goldstone Lake, Calif.

The *Echo* vehicle has been visible for a few minutes during recent midnight passes and is beginning to work out of the "shadow" area of current orbit. It should again be visible in about two weeks.

The primary power supply for the beacon has apparently failed and the olar cell standby system is providing power for intermittent transmissions hen cells collect sufficient power.

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Transit May Beat Schedule

System Could be Operational before 1962

- *First two shots performed well, accuracy problem seems to be solved*
- *Transit 3-A launching expected in near future; several more R&D shots to come will check auroral zone*
- *Principal remaining problems are in improving knowledge of geodesy, life-testing component reliability*
- *Hardware for operational version—much smaller—is being developed*

by Hal Gettings

NAVY'S *TRANSIT* navigation satellite program may move ahead of schedule if its success record continues.

Although no one will make any official guesses, performance and data gained from the first two *Transits* indicate that it may be possible to cut short the R&D phase and get the operational system in the air sooner than the planned 1962 target date.

Scientists at Johns Hopkins Applied Physics Laboratory—the Navy's system contractor—feel that the big problem of accuracy has already been solved. Refraction error corrections—the biggest unknown in the development phase—have been checked out and verified. The better-than-½-mile accuracy goal of the R&D satellite has been confirmed in several different ways, including cross-checks with optical sightings.

Dr. Richard Kershner, director of APL's Space Development Division and chief of the *Transit* program, says that the inherent measurement accuracy of the system is even better—that accuracies of 1/10 mile for the operational system are realizable. Practical utilization of such pinpoint accuracy is, of course, predicated on expected advances in geodesy over the next few years.

• **Accomplishments to date**—Both *Transit 1-B* and *2-A* have performed well and yielded considerable significant information. Primary purpose of *1-B* was to check out refraction error determinations. This was done by simultaneous comparison of the refraction of two different frequencies. Measurements were confirmed by another pair of frequencies, as well as by the optical cross-check.

These tests were considered conclusive except that no measurements have been made in the auroral zone or during periods of intense auroral activity. Such measurements will be made with subsequent R&D vehicles. These will probably require receiving and tracking stations at near-polar locations and monitoring over a 3-4-month period.

Because of *1-B*'s lower altitude, some question remained as to the validity of refraction measurements. *Transit 2-A*, with its higher orbit, resolved this question and quieted critics.

R&D TRANSIT has band of solar cells and painted spiral antennas (white lines). In smaller operational model, most of surface will be solar cells, different type of antennas will be used.

Consensus is now that refraction in medium latitudes and under most conditions is no problem.

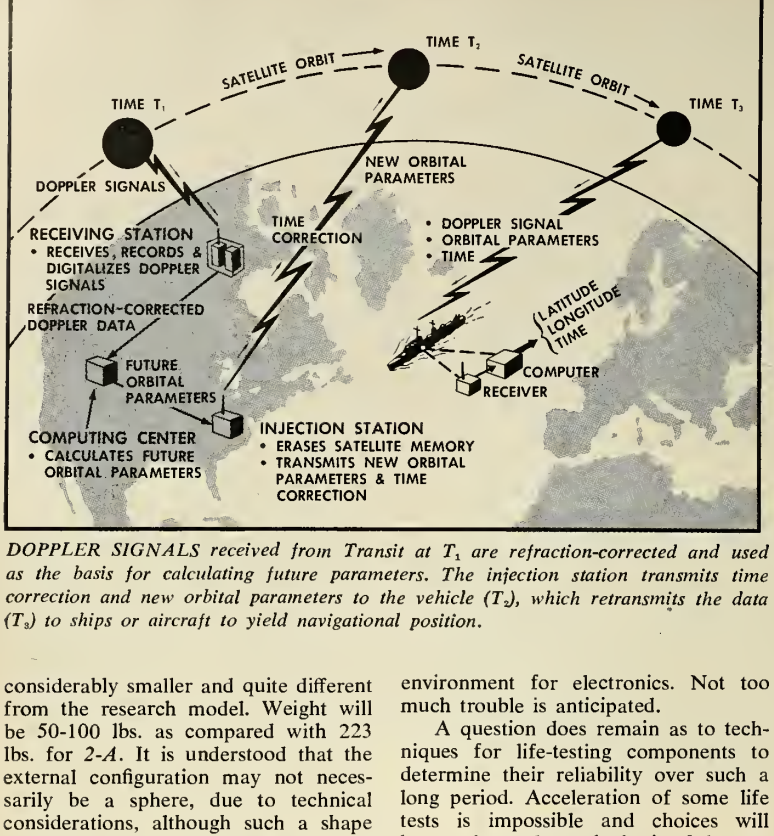
The next shot in the series, *Transit 3-A*, is expected in the near future. Navy will not say exactly how many more R&D satellites are planned. It is known, however, that several—possibly as many as six—are on the schedule. Final number will depend on how much necessary information is gained from the next few vehicles in orbit.

Transit 2-A is being tracked by seven ground receiving stations in addition to the headquarters station at APL, in Howard County, Md. Three of these are located in Continental U.S.: Austin, Tex., Seattle, and Las Cruces, N.M. Van-mounted stations are located in Argentia, Newfoundland, and near Ottawa, Canada. A sixth station is at Lasham, Hampshire, England, and a seventh at San Jose dos Compos, Brazil.

• **Some problems remain**—The potential accuracy of the *Transit* system is greater than present knowledge of geodesy—including gravitational characteristics—will allow us to use. Considerable research is necessary in this area before projected accuracies can be utilized. Coming out of such research will be more exact knowledge of the earth's shape, distances between land masses, and of the gravitational field. Consequently, the big effort in the program during the next year will be in extending the ground station network and determining by long-period tracking the solution to the geodesy problems.

• **Operational hardware in development**—Work has already started on hardware development for the operational version. Dr. Kershner says it is "going well" and on schedule. Primary emphasis is on the development of a suitable memory unit for the satellite. This must be simple, cheap, small, and reliable. Early R&D models used a magnetic core, but this is not considered suitable for the operational system. Best prospect so far, according to informed sources, is a magnetostriction delay line for the memory function. Although such a device has yet to be proved out completely, it looks particularly good for the intended use.

• **Operational system smaller**—The operational *Transit* satellite will be



DOPPLER SIGNALS received from Transit at T_1 are refraction-corrected and used as the basis for calculating future parameters. The injection station transmits time correction and new orbital parameters to the vehicle (T_2), which retransmits the data (T_3) to ships or aircraft to yield navigational position.

considerably smaller and quite different from the research model. Weight will be 50-100 lbs. as compared with 223 lbs. for *2-A*. It is understood that the external configuration may not necessarily be a sphere, due to technical considerations, although such a shape would appear to be preferable.

A resulting smaller surface would obviously necessitate several differences in the antenna and solar cell arrangement. Most of the exterior area would be required for solar cells; therefore, the painted spiral antennas of the R&D vehicles would not be used.

Other changes include elimination of weighted de-spin yo-yos in the operational models as well as in later R&D satellites. A malfunction in the operation of the yo-yo in *2-A* showed that they were not necessary; the magnetic dampers were able to despin the vehicle down to less than one rpm.

The biggest difference between operational and R&D models will be in the payload. Redundancy will be virtually eliminated. The operational version will carry only one oscillator and two transmitters. Improvements in the reliability of batteries will make possible a lighter weight power storage unit. R&D instrumentation will not be necessary.

• **Reliability a problem**—The expected five-year life of operational satellites puts a heavy load on reliability requirements. Due to space and weight limitations, redundancy can be used only to a limited extent. However, previous experiments have shown that outer space is not an unfavorable environment for electronics. Not too much trouble is anticipated.

A question does remain as to techniques for life-testing components to determine their reliability over such a long period. Acceleration of some life tests is impossible and choices will have to be made on the basis of shorter-term reliability. The philosophy seems to be that if the best components available are put together with the best techniques known in the simplest circuitry possible, there is a fair expectancy of high reliability. There is no gold-plating in *Transit*.

Electronic circuitry will be completely transistorized. Nickel-cadmium batteries will probably be used, since they appear to be the best bet for high reliability under the charge-discharge cycling requirement of satellite application. It's hoped that previous problems experienced with this type will be solved in the near future, as a result of intensive studies now going on.

• **Launched by Scout**—A big bonus of the lighter payload weight will be the use of smaller and cheaper boosters to put the satellites in orbit. Such boosters as the *Scout*—or later models becoming available by 1962, such as the NASA *Super Scout* or Air Force *Blue Scout* with guided upper-stage—will be sufficient for the mission. The Navy has not yet indicated what its choice will be.

• **Operational system**—The operational *Transit* system will consist of four—or possibly more—satellites simultaneously in 500-600 mile orbits around the earth. Each satellite is expected to cost about $1 million launch. System costs will run about $ million per year, based on a five-ye life. To keep the four satellites in th air will require an average of 1½ launches per year. The balance of th annual costs will go for ground statio installation and operation. The Nav will foot the bill for the entire progran

Radio frequencies for the oper tional system have not yet been dete mined. A request has gone in to FC for allocation of 162 and 324 m bands, but no assignments have bee made at present. Final hardware d velopment cannot proceed beyond certain point until frequency assig ments are confirmed.

• **Military plus civilian benefits**—Although the primary purpose c *Transit* is to provide a precise naviga tional aid for *Polaris* submarines, th Navy expects to use it also for surfac craft. In addition, civilian ships an aircraft will be able to use the syste Costs of the required receiving an computing equipment will be relativel small.

No *Polaris* submarines have ye been equipped with *Transit* receivin and computational equipment. An ex perimental system is being used aboar the missile test ship Observation Islan to track R&D vehicles. Data from th satellite is not used to actually navigat the ship, but the Doppler shift is re corded and plotted to determine jus how accurately it could have navigate with *Transit* data.

With four satellites in orbit, naviga tional fixes can be obtained anywher on earth on the average of once ever hour and a half. Data received fron the satellite, based on the Dopple frequency shift, will provide the navi gator with all the information he need to precisely plot his position withi a few minutes. A basic receiving sys tem, without the computer, will allow manual plotting within a period of tw or three hours—sufficient for mos merchant marine use.

Based on tracking information re ceived by ground stations and reduce at a computing center, precise orbit and error corrections will be deter mined on a continuing basis. Data wil be fed back to the satellite to correc its transmitted information. In addition tables of correction information will b issued periodically to users.

The concept of using the Dopple shift of a satellite radio signal fo world-wide navigation was first pro posed by Dr. F. T. McClure of APL Two other APL scientists—Dr. W. H Guier and Dr. G. D. Weiffenbach—earlier conceived the possibilities o such a system when they first use Doppler tracking to determine the or bits of other satellites. ■

Polka-Dotted 'Baby Echo' To Explore Upper Atmosphere

by Jay Holmes

A 12-FT. "BABY ECHO" balloon painted with white polka dots will be the first satellite launched by the all-solid *Scout* vehicle, possibly next week.

Langley Research Center, National Aeronautics and Space Administration, built the balloon, which will measure density of the upper atmosphere. Density can be calculated from the drag it imposes on the satellite.

The balloon will use a four-ply sandwich material, made up of two layers of Mylar and two thin deposits of aluminum, with total thickness of 2 mils—about four times the thickness of the wispy aluminized Mylar used for *Echo I*.

The air-drag satellite, designated *S-56*, will be the first satellite launched from NASA's Wallops Island station. Although the *Scout* satellite is an outgrowth of the *Echo* passive communications satellite, no communications experiment is planned for the smaller balloon.

However, the stiffer material will undergo a test in the 12-ft. balloon that may lead to its use in a larger communications balloon satellite later in the year. A major drawback of *Echo* for communications relay is the fact that its surface is no longer permanently smooth and signals reflected are no longer perfect. NASA engineers hope the stiffer material may overcome this difficulty.

• **White for reflection**—The *Scout* balloon will have 18% of its surface painted with white polka dots to reflect solar heat and maintain the internal temperature at the desired level. The tracking beacon will be powered by four solar cells, located about the sphere in the shape of a regular tetrahedron so that at least two are always in sunlight.

The initial orbit is programed for a nominal apogee of 1094 miles and a perigee of 370 miles.

Meanwhile, NASA sources indicated that from four to six major launchings will take place in December and possibly seven more have target dates in the first quarter of 1961. NASA spokesmen emphasized, however, that none of the dates are firm.

The air-drag *Scout* satellite will probably be the next to follow last week's *Tiros II* and *Mercury MR-1* launchings. Also likely in December are *P-31*, the *Atlas-Able* lunar orbiter; and *Mercury MA-2*, an *Atlas* ballistic test.

• **Some slippage**—Also on the tentative December schedule were *Mercury MR-2*, the ballistic shot with a chimp in the capsule, and *S-45*, the ionosphere beacon satellite to be launched by a *Juno II*. But NASA Administrator T. Keith Glennan left them out of a list he gave on a television program Nov. 20, indicating they have slipped into January at least. An interplanetary magnetic-field probe, *P-14*, to be launched by a *Thor-Delta*, also had been scheduled for December but has slipped into the early months of next year.

Other shots tentatively in the first quarter are *S-55*, a micrometeorite hazard measuring satellite, to be launched by a *Scout* from Wallops Island, and *S-15*, a gamma ray astronomy satellite, to be launched by a *Juno II*.

A number of *Mercury* launchings also are to take place in the first quarter. For the purpose of contractor delivery and planning, NASA has scheduled two *Mercury Atlas* tests and two ballistic manned flights.

For the remainder of the year, 24 major launches are programed. These include eight *Mercury* launches, five scientific satellites, four deep space probes, three *Centaur* vehicle tests, one *Saturn* booster test and three backup vehicles. ⌗

NASA's Tentative Schedule

December, 1960

Mission	Launch Vehicle
Mercury MA-2	Atlas
Mercury MR-1	Redstone
Lunar orbiter P-31	Atlas-Able
Air density S-56	Scout

First Quarter, 1961

Ionosphere beacon S-45	Juno II
Mercury MR-2	Redstone
Tiros backup	Thor-Delta
Mercury MR-3	Redstone
Mercury MA-3	Atlas
Micrometeorite S-55	Scout
Interplanetary P-14	Thor-Delta
Gamma ray S-15	Juno II
Mercury MA-4	Atlas
Mercury MR-4	Redstone

Blow for Mercury

Surprise Failure Adds To Delay in Program

WITH ALL SEVEN astronauts looking on, failure in the supposedly reliable *Redstone* booster rocket caused another indefinite and embarrassing delay in the slipping *Mercury* man-in-space program.

Spokesmen for the National Aeronautics and Space Administration declined to speculate on how much time was lost by the Nov. 21 failure, but it is believed that the first manned ballistic flight now will come on April 15, 1961—at the earliest.

The *Redstone* shut down for some unexplained reason a few seconds after ignition for its first test lift of a production McDonnell capsule. As programmed, the escape tower then jettisoned itself and landed in a sand and palmetto area about 1200 ft. west of the *Redstone* pad at Cape Canaveral. The booster and capsule remained on the pad.

The tower was to have jettisoned on the conclusion of powered flight, at 35 miles altitude, 140 seconds after liftoff. The abort sensing system was being tested only on open loop. The escape system could only have been operated by ground command.

The LOX was vented and the alcohol propellant was drained by the following day, making possible a detailed examination of the booster and capsule to determine what went wrong. There was no explosion and both appeared undamaged.

• **Troubles mount**—The failure was the third in a row for the ill-starred *Mercury* program. Last July 29, an *Atlas* exploded during the test lift of a capsule about 65 seconds after launch. The cause was never established.

On Nov. 8, the escape system failed to operate in a *Little Joe* flight from Wallops Island, Va.

George M. Low, NASA chief of manned space flight, said the prospects are better for determining the cause of the *Redstone* shutoff because intact hardware is available for examination. A new flight will be scheduled, he said, when the trouble is found and fixed.

By late last week, NASA spokesmen said they were zeroing in on the *Redstone* trouble and a new flight would be scheduled in a matter of weeks.

The second *Mercury Atlas* is on the pad for launching next month. It will be a repeat attempt to perform the experiment programed for MA-1, the July shot. This called for a lift to an altitude of 110 miles followed by a sharp re-entry angle, leading to a splash only 1500 miles downrange, subjecting the capsule to as many as 16 g. ⌗

X-15 Moves Nearer Space Flight

Powerplant has yet to be 'given its head'

- ***New XLR-99 engine will test man's reaction to space-equivalent conditions***
- ***Biomedical instrumentation package telemeters and records vital data on the pilot's physical condition***
- ***Second-generation pressure suit give complete protection in a single layer, pro vides relatively good mobility***
- ***Modified checkout and dressing van model for other programs***

by Heather David

WITHIN A FEW MONTHS, the biggest man-rated engine capable of reaching near space will be put to its first full-capacity test.

In its first two flights, the Thiokol XLR-99 engine recently installed in the *X-15* performed admirably. Scott Crossfield, North American Aviation test pilot, flew the plane to a 50% capability. His contract prevents him from making a full-velocity test run with the 57,000-lb.-thrust engine.

In the second flight on Nov. 22, the XLR-99 demonstrated that it could stop and restart in flight. Crossfield shut it off for 15 seconds, then restarted it and ran it for another 75 seconds.

Only when the *X-15* is turned over to government pilots will it be flown to new records of speed and altitude.

Even then, in many ways the flight will not be new. The first full-powered flight will have been "flown" before—in a centrifuge, in a heat chamber, in an altitude chamber. The *X-15* is probably the most thoroughly tested man-machine system for astronautical research. *Dyna-Soar, Mercury* and their successors will bear marks of the life support systems in the *X-15*.

Lt. Col. Burt Rowen, Human Factors Coordinator for the *X-15* program, Capt. R. N. Richardson and the 16th Physiological Training Flight and the AF flight surgeons have had to prepare for many of the emergencies of spaceflight. Among them have been altitudes exceeding 130,000 ft., g-loads up to 7 or 8 g's, possible radiation exposure, and—sometime early next year—periods of weightlessness lasting several minutes.

In spite of much talk and extensive research in bioinstrumentation, the biomedical telemetering system used in the *X-15* is the only human operational system of its kind. The pilot's respiration, skin temperature, EKG (electrocardiogram) and helmet and suit pressure have been recorded on on-board oscillographs and telemetered during flight.

• **Miniaturization sought**—Several study contracts have been let for a compact blood pressure sensor. An arm-type cuff has given very good results in the TF 102 trainer, but space is at a premium in the *X-15*. In spite of the difficulty of getting a blood pressure reading remotely, the Air Force is still interested in finding a way, according to the Coordinator.

Col. Rowen told M/R that the current biomedical package, which measures 5 in. x 6.5 in. x 11.5 in, will soon be installed in the No. 2 plane, which carries the new 57,000-lb.-thrust engine. This plane, powered by Thiokol's XLR-99 engine, will carry man to over 4000 mph at altitudes above 100 miles.

Contracts are now being negotiated to miniaturize the package, according to the Human Factors Coordinator. Several companies have submitted bids—among them Texas Instruments and North American, who built the original package. Also under scrutiny is a printed circuit-type system developed by Lt. Pulanski of Edwards AFB. This package measures only 1/3 of the original system.

Although the *X-15* pilots have not yet encountered any harmful radiation, with the proposed altitudes of the new plane there is always that possibility. By the first of the year a radiation monitoring and detection device, especially developed for the *X-15* by the AF Special Weapons Center, will be installed in the cockpit of one of th planes.

All the pilots have undergone base-line count of body radiation. Aft flights of any altitude, the pilot mu undergo a whole body radiation cou at Los Alamos.

All new instrumentation and pre sure suits will first be extensively teste in the TF 102 used as a trainer fo *X-15* flights.

• **Fast-change suit**—Now undergo ing evaluation in the TF 102 is a "se ond-generation" pressure suit whic will replace the cumbersome MC- suit now used. Contrasted to the fou layer garment which took 20 minute to put on, the new suit is one piec and can be donned in minutes.

The changeover from the old su will coincide with the turnover of th new engine to the government pilots says Col. Rowen.

Unlike the *Mercury* suit, both *X-1* suits use nitrogen to maintain pressur in the lower part of the suit. Oxyge fed into the helmet is kept at a highe pressure than the nitrogen to preven any possibility of escape of nitroge into the sealed helmet. B-52 oxyge is breathed until just before the *X-1* is launched.

Another improvement in the new suit is the change in the helmet fac plate from a clear plate to a heated gold-tinted material which prevent fogging or icing.

One of the most important phase of the training for *X-15* flights has beer in the centrifuges at Aerospace Medica Laboratories, Wright-Patterson AFB, and at the Navy's Aviation Medical Acceleration Laboratory at Johnsville, Pa.

The *X-15* controls were linked by electronic devices to the centrifuge, making it possible for the *X-15* pilot to

ABOVE: *Maj. Bob White leaves X-15 after recent run at Edwards AFB. Man beside him holds portable cooler plugged into suit.*

fly" the centrifuge on *X-15* flight lans. Since the first flights in 1957, lmost every kind of emergency and ight condition has been simulated, ıcluding flight with the bigger engine.

Since the *X-15* pilot cannot recline) resist g forces, his ability to ride ut high g's—perhaps as much as 7 or —must be supplemented by a g-suit. he MC-2 suit, and the new suit, has built in g-suit. An accelerometer iggers the inflation of bladders around ıe thighs, calves and waist. This keeps ıe blood circulating in the upper part f the body so that the pilot doesn't ackout.

The new suit is also made by the avid Clark Co., Worcester, Mass., evelopers of the MC-2. Each suit is ilormade and covered with a mesh-ke fabric allowing bending. But, since e *X-15* pilot sits during flight, the it is curved in the back and legs so at he won't be straightened out under ll pressure. Hence, he has a crab-ke walk.

The Bendix Co. and the Air Force ve developed a portable heat breaker hich the pilot can carry while wait-g to get in the plane. Since the suit airtight, the heat generated by the an's own body could weaken him minutes.

Although the cooler was developed r the *X-15* program, the Air Force ys this device also can be used on her programs.

• **Laboratory on wheels**—The 30 by 9 ft. support van designed by apt. R. N. Richardson and the 16th ysiological Training Flight has been successful that the idea has been ployed in the *Discoverer* and *ercury* programs.

Before each flight, the air-condi-ned van is parked next to the B-52 mother ship. The pilot gets a complete checkout in his suit for anti-g, pressurization, oxygen, ventilation and communication.

The 16th Physiological Training Flight, commanded by Capt. Richardson, has been credited for its work in the *X-15* program. The Flight has been responsible for the van, and the pressure chamber tests of the suits and pilots. In August, the month Maj. Bob White flew the altitude record, the 22-man Flight put in 260 man hours in support of the *X-15* program alone.

• **Escape**—The problems of escape from a crippled vehicle at supersonic speed have been all-too-well illustrated in a recent jet accident. Fortunately for the pilot, the air was relatively calm. Nevertheless, although he lived he suffered mass hemorrhaging from q force or dynamic pressure.

The *X-15* escape system has been designed so that the pilot initiates seat ejection. To avoid the q force impact, he must wait until the plane slows to below 600 mph.

Although there has been some theorizing about the value of capsule ejection for future flights, Scott Crossfield is reported as saying that he felt just as safe sticking with the plane until it slowed down.

During every flight an H-21 helicopter is stationed near the landing area for medical support. A flight surgeon, who also serves at the base hospital, rides in the helicopter and meets the pilot. A flight surgeon and ambulance are also assigned to the launch area, the intermediate emergency area, and landing area for each flight. Four fire trucks line the landing field. ⁂

X-15s Nov. 16 Flight Plan with XLR-99 Engine

1. Launch SAS 4-4-8 Ignition 70%, reduce to 50%.
2. Accelerate & Climb to 2.0 Mn at 50K.
3. 1.2 Mn Open Speed Brakes.
4. 47K 1.8 Mn .5g pushover to level at 50K.
5. 50K 2.0 Mn 2.5g space positioning turn.
6. 20 sec. fuel remaining. Pullup to 2.5-3g to 20° θ. Pushover to .00g or slightly positive and hold to burnout. Note: Do not exceed 300 FPS rate of climb above 65K.
7. Burnout (Approx. 58K at 2.3 Mn). Close Speed Brakes.
8. Head EAFB 70° banked turn (α = 12°) max. alt. 78K. Burnout above 58K or 2.3 Mn—full deflection steady sideslip to the right.

   OR

   Burnout below 58K or 2.3 Mn —full deflection steady sideslip to the left.
9. Glide 30K and .95 Mn SAS 4-4-8 4.00g momentary pullup. All SAS OFF pitch & yaw pulses.
10. Jettison at Chase request. Stop H2O2 at 800 psi source.
11. Downwind—Lake alt. & wind. Check ventral arm—pressurize tanks. Base leg SAS 2-4-8, Jettison ventral, landing gear osc ON Flaps, gear and LAND.
12. Landing Slide. SAS OFF.

Plan for Second Flight with XLR-99 Engine

1. Launch SAS 4-4-8 Ignition 70%—Retard to 65% if thrust oscillations are encountered.
2. α = 10° during roundout at 43K
3. Accelerate & climb to 2.0 Mn at 50K (α = 10°)
4. 1.2 Mn Open Speed Brakes
5. 45K .5g pushover (α = 2.5°) to level at 50K
6. 50K 2.0 Mn 3.2g space positioning turn (α = 12°)
7. Rollout of turn (Mag heading = 320°), Hold 3.2g
8. Maintain θ = 20° to burnout
9. Burnout (Approx 56K at 2.75 Mn) Close Speed Brakes
10. Head EAFB 70° Banked Turn (α = 10°) Max alt = 73K
11. Glide 30K & .95 Mn SAS 4-4-8 4.0g momentary pullup ALL SAS OFF Pitch & Yaw Pulses
12. Jettison at chase request. Stop H202 at 800 psi source
13. Downwind—Lake Alt & Wind Check Ventral Arm—Pressurize Tanks Base Leg—SAS 2-4-8, Jettison Ventral Landing Gear Osc—ON Flaps, Gear & Land
14. Landing Slide

U.S. Army may choose soon . . .

Foreign Firms Seek Antitank Sales

Seven manufacturers in Europe and Australia offer nine missiles with widely varying characteristics; light weight vies with kill power

SWEDISH SOLDIER ready to fire a French SS-10. The Nord Aviation antitank missile is used by both Land and Naval forces in Sweden.

by Bernard Poirier

THE FIERCE INTERNATIONA scramble among missile manufactur who want a share in the antita market has been joined by Pye, Lt of Royston, England.

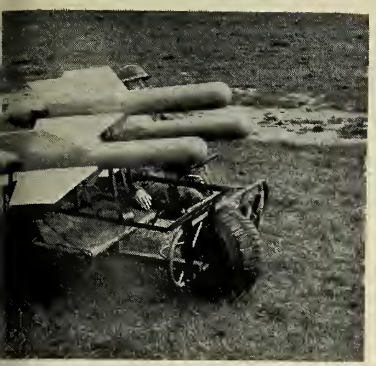
(COUNTDOWN on Nov. 14, reveal the hot competition to win the U Army's nod for an antitank syste After several months of evaluation, t Army may now be near a decision.)

With several NATO nations, cluding the U.S., in a buying moo British firms like Pye and Vickers to advantage of the recent Farnborou Exhibition to display their weapons greater detail than previously.

In all, seven foreign companies some with U.S. affiliations—from fi European countries and Australia a offering nine missiles for consideratio Among the makers, the *Cobra* man facturer has a license agreement wi Daystrom, Inc., and the French man facturer of the *SS* series has at lea a tentative license agreement with Ge eral Electric. The Government Aircra Factories (of Australia) have made similar move with Fairey Engineeri for European sales of their *Malkara*.

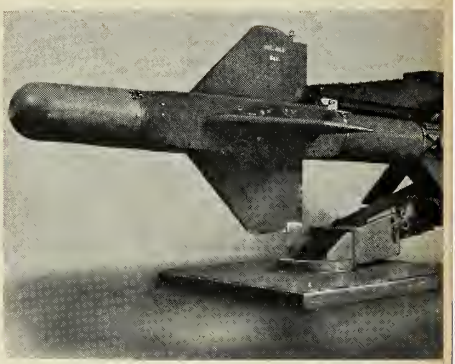
The nine missiles involved can l divided into five basic categories a cording to weight. The true antitar "featherweight" is the Swedish *Banta* weighing in at 13 lbs. Three "ligh weights" are the 20-lb. *Cobra* b Boelkow Entwicklungen, the 23-l *Mosquito* (*Cobra IV*) by Contrave Oerlikon and the 26-lb. *Vigilant* b Vickers-Armstrong. Because of the common conception, the *Cobra* and th *Mosquito* are quite close in final co figuration.

The sole "middleweight" is th 33-lb. *SS-10* offered by Nord Aviatio S.A. of France. "Light-heavies" ar the 80-lb. Pye *Python* and the 62-lb Nord *SS-11*. The real haymakers ar the Nord *SS-12* at about 150 lbs. an the Government Aircraft Factor *Malkara Mk. 1* at 206 lbs.



EXCLUSIVE M/R photo of Pythons in motorcycle concept by Belgian firm.

MAN-PORTABLE Vigilant under evaluation by British Army is highly accurate.



FIRST REPORTS on Australia's Malkara Mk. 1 indicate easy repair despite weight.

• **Boelkow, Nord experienced competitors**—The *Python,* latest to reach the evaluation status, joins the *Bantam, Mosquito, Vigilant,* and *SS-12.* Already operational are the German *Cobra,* the Australian *Malkara* and the French *SS-10* and the *SS-11.*

Most of the competition is reportedly centered between the light *Cobra,* with a range of about one mile, and the heavier, longer-range *SS-11.* The German bird uses plastic construction wherever possible to lighten the round and enhance its advantage of easy portability in any terrain. The *Cobra* warhead weighs only 5.5 lbs. and the missile, like all other original missile models, is wire-guided.

In an attempt to offset the portability acclaimed by *Cobra* users, the French have developed and tested wireless guidance and optical guidance with infrared scanners. Nord has also come up with an attractive Waist Belt Fire Control well adapted for use in rugged terrain, (M/R, Aug. 29, p. 49). The *SS-11* has been fired from aircraft, helicopters, torpedo boats and tanks to prove its versatility.

Other manufacturers are not sitting idly by to be outdone in originality. Vickers recently illustrated the use of the *Vigilant* under combat conditions with airborne parachute troops. The missile is lightweight enough and durable enough to take the roughest handling and remain dependable.

• **Bigger parts, easier field repairs**—Alan S. Hulme, Minister of Supply for Australia describes the *Malkara* as "a weapon of uncanny accuracy and extremely high lethality." It has been test-fired from light and heavy vehicles, motor torpedo boats and landing ships. It is a two-stage solid-fuel weapon with a boost acceleration of 20 g's and a range of over 12,000 feet.

The *Malkara* features easy interchangeability of major components, accessibility of internal components, and steel clamp rings of the U-section to join the mating parts of the body, providing a joint which can be quickly assembled by one man.

The Australians designed the missile to be robust enough for use throughout the range of climatic conditions.

In the fire control field, however, Nord has developed several separate module concepts with which several different *SS* models can be integrated in one missile battery. Nord is the most experienced manufacturer in the field; its *SS-11* has been widely accepted and is in use in a dozen countries. Continuous activity by Nord has produced an effective minimum range of 550 yards for the *"11"* and—when wire-guided—a maximum range of 3830 yards. Antitank weapon makers realize that minimum range is a very important consideration for some battle conditions.

West Germany gave the French company a big boost in prestige when it ordered a substantial number of *SS-11* missiles. However, West Germany still has use for the *Cobra 1,* manufactured in Germany. This missile was actually conceived by the Swiss firm Contraves-Oerlikon, which explains the similarity of many characteristics of the *Cobra* and the *Mosquito.*

The German *Cobra* remains one of the best entries on the market. The world-famous German initiative was liberally applied to the technical concept of the weapon, making it one of the lightest, most reliable weapons for many battle conditions. It is easily carried or fired by one man. Germany has sufficient production facilities (and others are possible elsewhere) to provide reliable missiles in large numbers at a relatively low cost, sometimes quoted around $1000 per bird.

The German weapon's weight and low cost are attributed in large part to extensive use of plastics. Its fins, for instance, are of foamed styrene covered by fiberglas—a material widely used in its body as well. It is slower in flight than the *SS-11,* whose propelled duration is 22 secs. But the *Cobra* is under power for a longer period over a shorter range, and hence seems to have a proportionally longer period of controlled maneuverability under propulsion. The *Cobra* needs no launching apparatus for land deployment.

There have been some reports that the *SS-10* and the *SS-11* cannot be fired over water. But the reverse is true: armed forces of several different countries have successfully fired both missiles at sea targets from land sites and from vessels under way. Moreover, these tests were so satisfactory that Sweden plans wide deployment of the *SS-11* on patrol ships and Nord is currently developing a new version for special naval applications.

• **Motorcycle weapon last used in 1917**—In describing the versatility of the *Python,* Pye has revealed the newest application of a mobile missile platform. Three missiles can be fired from a motorcycle, and several vehicles manufactured by Fabrique Nationale de Liège, Belgium, have been converted for this purpose.

The British firm summed up what many missile makers are trying to prove when it said, "The size of the *Python* has been chosen as the best compromise between the requirements of a very high chance of kill from each hit, (these can result in large warheads, heavy and complicated missiles and ground equipment) and mobility, coupled with simplicity and economy."

Some other manufacturers argue that light weight is the decisive factor because it enables the operator or gunner to more easily get a good firing position in any terrain in order to get a shot off. But still others claim that the most important factor is destructibility—which necessitates a heavier warhead, thus a heavier missile.

There are other questions to be argued: shelf life, versatility, dependability, rough handling, etc. The battle goes on and on. ⌘

Technical Countdown

ELECTRONICS

New Lab To Study Nature of Light

The nature of light will be studied in a photo-optronic laboratory now being constructed by The Electrada Corp. Reported to be one of the first commercial undertakings of its kind, the lab will be equipped to perform precise measurements of physical and chemical effects of light within the microsecond-micron range. Special devices will be installed to study the effect of light upon crystals and photo-conductors.

Nickel-Cad Batteries Improved

Several improvements are being made in nickel-cadmium batteries to better fit them for their anticipated role in the operational *Transit* navigation satellite. Two areas of previous trouble—leakage and breakdown of paper separators—reportedly have been solved. Other improvements are being studied to insure the required five-year operational life.

Photo Pickoffs Now Seen Practical

New materials and circuit designs may lead to practical use of photoelectric force and motion transducers for missile applications, says White Avionics Corp. In the past, there have been problems with long-term stability and large displacement required by sensors. Now, control of light source for long periods is accomplished by maintaining a tungsten element at low temperature and providing feedback control from a photo-conductive diode. Semiconductor advances permit significant improvements in miniaturization and reliability.

GROUND SUPPORT EQUIPMENT

New AMR Range Vessel Added

The Twin Falls Victory, a precision-radar tracking ship, has been added to the Atlantic Missile Range fleet. New equipment will allow the $10-million ship to make absolute trajectory measurements referred directly to the launch pad rather than to the ship itself. First missions will be in *Polaris* and *Pershing* programs.

Solar-Storm Data Being Checked

Naval Research Lab. scientists are hopeful that the *Greb* radiation satellite—which rode piggyback into orbit with *Transit II-A*—will yield some pertinent data on the recent intense solar storm. The satellite passed over the Blossom Pt., Md., station just before and after a flare and no change in X-ray or Lyman-alpha radiation was observed. Tapes from other tracking stations have yet to be analyzed.

Water by 'Electrodialysis' for ICBM Bases

Electric-membrane desalting units will supply pure water for *Titan* and *Atlas* hard bases in New Mexico, South Dakota, and Oklahoma. The Air Force has ordered twelve of the Ionics, Inc., units—costing close to $1 million—to desalt highly mineralized local water for base use.

'Tall Tom' Almost Ready for Air Test

The preproduction prototype of the Air Force AN/ULD-1 Electronic Reconnaissance System (Tall Tom) is scheduled for installation in its airborne test vehicle soon. The $20-million highly classified program—in being almost three years—is now completing its bench-test phase.

Little Things Add Up

Approximately 2100 miles of wire and cable will be used in the 150-missile *Minuteman* base at Malmstrom AFB, Mont. Wire and cable cost is expected to run close to $12 million.

PROPULSION

New Cooling Method for Nuclear Rocket

Regenerative cooling with liquid hydrogen isn't sufficient to keep temperature of a nuclear-rocket nozzle down to the desired level of 1440°R, a NASA study has found. Indications are that regenerative cooling will be supplemented by high pressure drop, high wall temperature, refractory wall coatings, thin highly conductive walls, film cooling or a combination of several such methods.

A-2 2nd-Stage Propellant In Production

The Naval Propellant Plant at Indian Head, Md., is going into production on the double-base propellant for the high-energy second stage of the 1500-mile A-2 *Polaris*. Propellant will be shipped to the Hercules Powder Co. plant at Bacchus, Utah, for pouring into fiberglass-plastic cases.

ADVANCED MATERIALS

High Yield From Modest Input

More than $150,000 worth of valuable metals is reclaimed each year by Varian's five-man reclamation department from klystrons and other tube subassemblies. Varian says the figure actually is conservative. Most of the salvaged metals are gold, silver, and copper.

Aluminum Chosen For Rover Test Stand

Aluminum alloys, considered less susceptible to radiation damage, will be used for the structure of the Project *Rover* nuclear-rocket test stand at the AEC's Nevada Test Site. Aetron Division, Acrojet-General, will do the $7 million to $8 million architect-engineering job.

New Beryllium Ore Discovery

Commercial grade beryllium ore is being taken from the 150-ft. level of the old Redskin Mine, west of Pike's Peak. U.S. Beryllium Corp. is leasing the property on a 15%-royalty basis. The mine is on Colorado's Badger Flats, regarded as having the greatest potential for the ore in the U.S.

Cartridge Cases Obsolete?

The Army has developed a combustible cartridge case that eliminates the litter of spent cases in confined spaces such as tank turrets. The new case, 10 times lighter than its brass predecessor, minimizes the gases released from fired ammo and leaves no residue in the gun tube. Picatinny Arsenal, Armour Research Foundation, and the Ballistic Research labs at Aberdeen collaborated in the five-year development program.

ASW ENGINEERING

Reliability Problem in Hydrofoil Controls

BuShips is so concerned about the problem of reliability of hydrofoil controls that representatives of the agency are touring the nation to persuade industry to take a fresh look at the problem and generate new ideas for its solution.

Hystran*
RESSURE VESSELS

70% HIGHER $\frac{\text{STRENGTH}}{\text{WEIGHT}}$ THAN STEEL

Now available in production quantities!

Spherical bottle for nitrogen storage in space satellite. 480 cu. in., 10 in. dia., 10 lbs. total weight. 3000 psi operating pressure, 5000 psi proof, 6667 psi min. burst after proof plus 25 operating cycles. Leakage guaranteed less than requirements of MIL-R-8573A.

Qualification test chamber designed to standard U.S. Navy specification. 18 in. diam., .041 wall thickness. 7.78 lbs. total weight including fittings and liner; 4.72 lbs. net weight of fiberglass-plastic. Tested to 650 psi burst, with hoop stress of 146,473 psi at burst. Actual strength-to-weight ratio of 2,035,000 in.

1300 cu. in. bottle for storage of high pressure nitrogen in ground-to-air missile. 8 ft. long, 5 in. dia., weight 32 lbs. including end fittings. 3000 psi operating pressure, 6000 psi proof, 9450 psi min. burst after proof and 30 operating cycles. Leakage guaranteed less than MIL-R-8573A.

80 cu. in. bottle for storage of concentrated sulphuric acid. 5 in. dia., weight 1 lb. including Teflon liner wound into structure. 150 psi operating pressure, 300 psi proof, 750 psi min. burst. Minimum life of 1000 operating cycles from 0 to 150 psi. Leakage guaranteed less than MIL-R-8573A.

2700 cu. in. bottle for nitrogen storage in space satellite. 2 ft. long, 13 in. dia., weight 31 lbs. including fittings. 3000 psi operating pressure, 3750 psi proof, 6000 psi min. burst after life of at least 400 operating cycles from 0 to 3000 psi. Leakage guaranteed less than MIL-R-8573A.

This is Hystran, Lamtex's new space-age material that is solving high pressure storage vessel
is considered impossible or impractical with previously available materials such as aluminum,
titanium! A fiberglass reinforced plastic material, Hystran is filament-wound on automatic
es developed and built by Lamtex. The unretouched close-up photo shows the smooth finish
cise control of filament angles and spacing, resulting in a perfectly uniform, predetermined
tion of fiberglass and plastic, particularly when winding the calculated end shape. Equal
control on each fiberglass filament is automatically maintained during winding, insuring
progressive fiberglass failure under high stresses.

In addition to the superior strength, weight and physical properties of Hystran, Lamtex's
ion-proved design and fabrication methods offer considerable savings in engineering time
ling costs, plus a new degree of flexibility in the choice of sizes and shapes of pressure
. Standard procedures and production facilities are now available at Lamtex to handle—on a
ion basis, not prototype or experimental—filament winding of pressure vessels and other
al shapes up to 7 ft. dia. and 30 ft. long.

COMPARE THESE SPECS!

MATERIAL	DENSITY lbs/cu. in.	TENSILE STRENGTH psi	STRENGTH / WEIGHT in. x 10^6
Aluminum	.097	80,000	.83
Titanium	.163	160,000	.98
Highly Heat Treated Steel	.283	240,000	.85
HYSTRAN	**.072**	**165,000***	**2.29**

*Biaxially stressed hoop tension

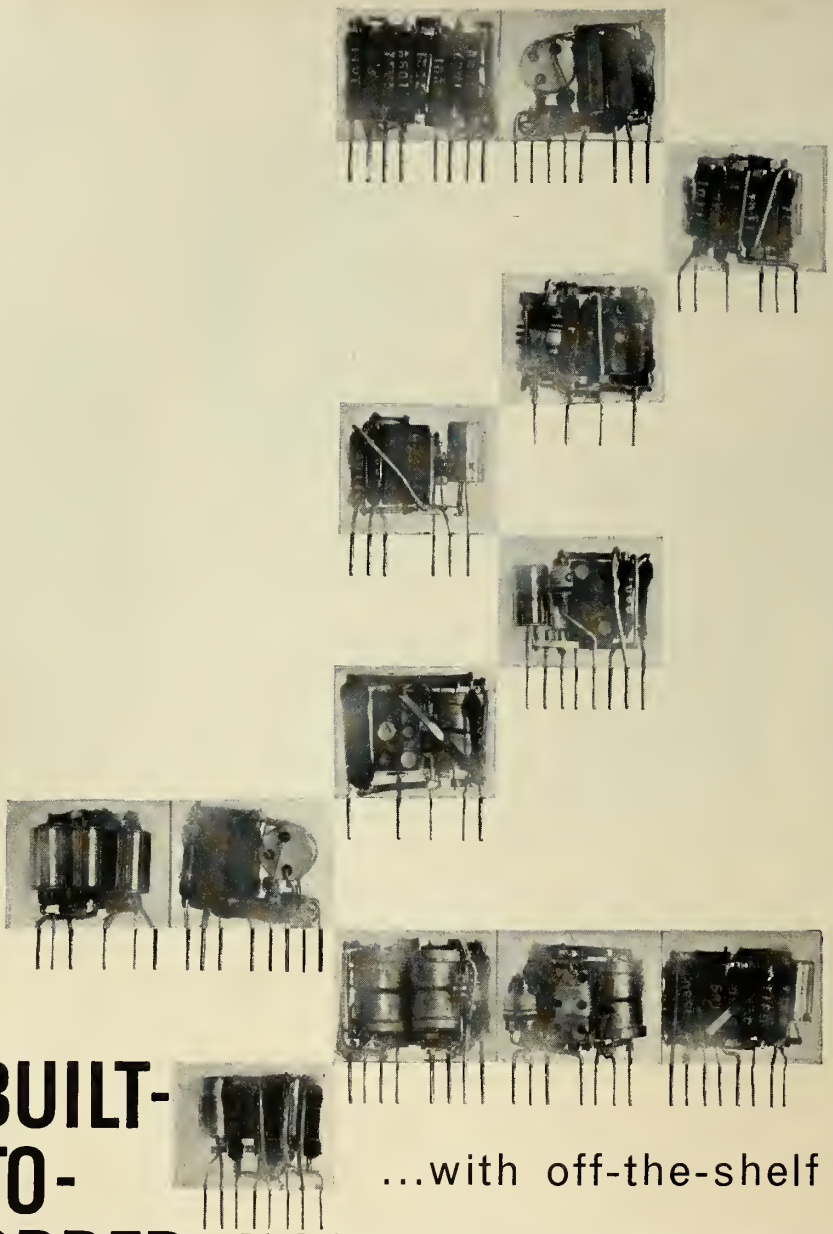
FOR COMPLETE DATA, SEND FOR BULLETIN 14D

Advancing the State-Of-The-Art in Reinforced Plastics...

At Lamtex, it begins with R&D! The achievement of significant technological progress in the highly specialized, rapidly changing field of reinforced plastics depends largely on truly creative, "dig-down-deep" R&D. To obtain it, you must gather a staff of skilled specialists with outstanding records of past accomplishments and unlimited potential for future progress. Then give them the tools to work with, and the creative environment to work in—and you're well on your way toward advancing the state-of-the-art. This is what we've done and will continue to do.
Lamtex Industries, Inc., Motor Avenue, Farmingdale, L. I., N. Y.

LAMTEX

AN FILAMENT WINDING | CUSTOM MOLDING | FIBERGLASS-EPOXY TUBING | ROCKET MOTOR CASES & NOZZLES | RADOMES | MISSILE NOSE CONES | UNDERSEA VEHICLES



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...with off-the-shelf components

Delco Radio can design, develop and deliver digital computers with the speed you need, for airborne guidance and control as well as a wide variety of other special applications. ■ With off-the-shelf Delco transistorized building block modules, we have, for example, built a computer for a military application in less than three months. ■ These miniature modules contain standard components. They satisfy all MIL-E-5272D (ASG) requirements, which assures extremely rugged, reliable computers. Continuing life tests on these computer circuits now exceed four and one-half million transistor hours *without a failure*. And where space is no problem, you can have these same, reliable digital circuits packaged on plug-in circuit cards. ■ Delco Radio has six sections of highly experienced people with the necessary capabilities to produce complete computer systems: Application Analysis, Systems, Logic, Memory, Circuit Design and Advanced Development. May we review your requirements? Just contact our Sales Department. ■ *Physicists and Electronics Engineers: Join Delco Radio's search for new and better products through Solid State Physics.*

PIONEERING ELECTRONIC PRODUCTS THROUGH SOLID STATE PHYSICS

DELCO RADIO
DEPENDABILITY
RELIABILITY

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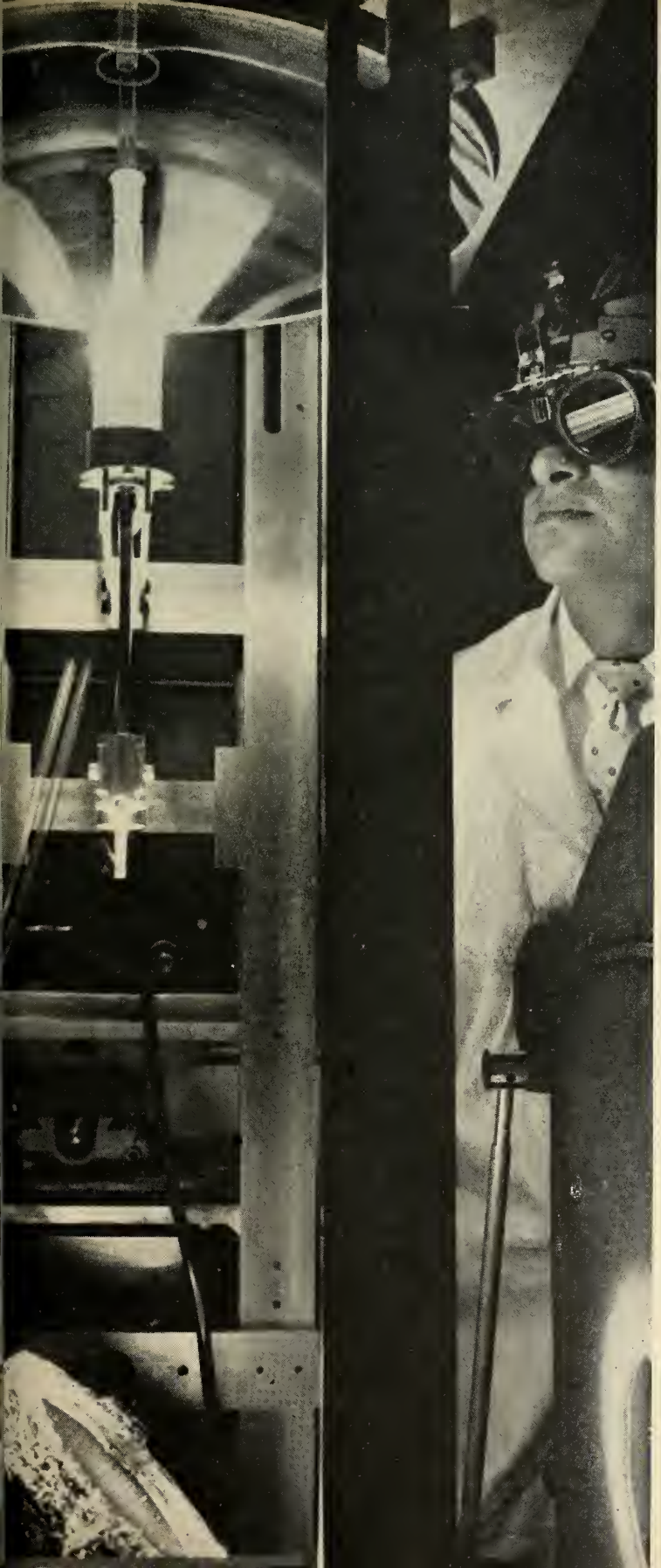


MISSILES AND ROCKETS

ADVANCED MATERIALS

SPECIAL REPORT

■ MISSILE/SPACE MATERIALS Gap worsened during year: no breakthroughs; interesting developments, but few of lasting engineering value

■ GLASS FILAMENT WINDING—a detailed account of how one company manufactures the hottest items in the rocket business today

■ CERAMICS—a progress report describing the last frontier in high-temperature materials

■ STEEL—Industry moves closer to the magic 300,000 psi motor case through intensive research and integrated testing procedures

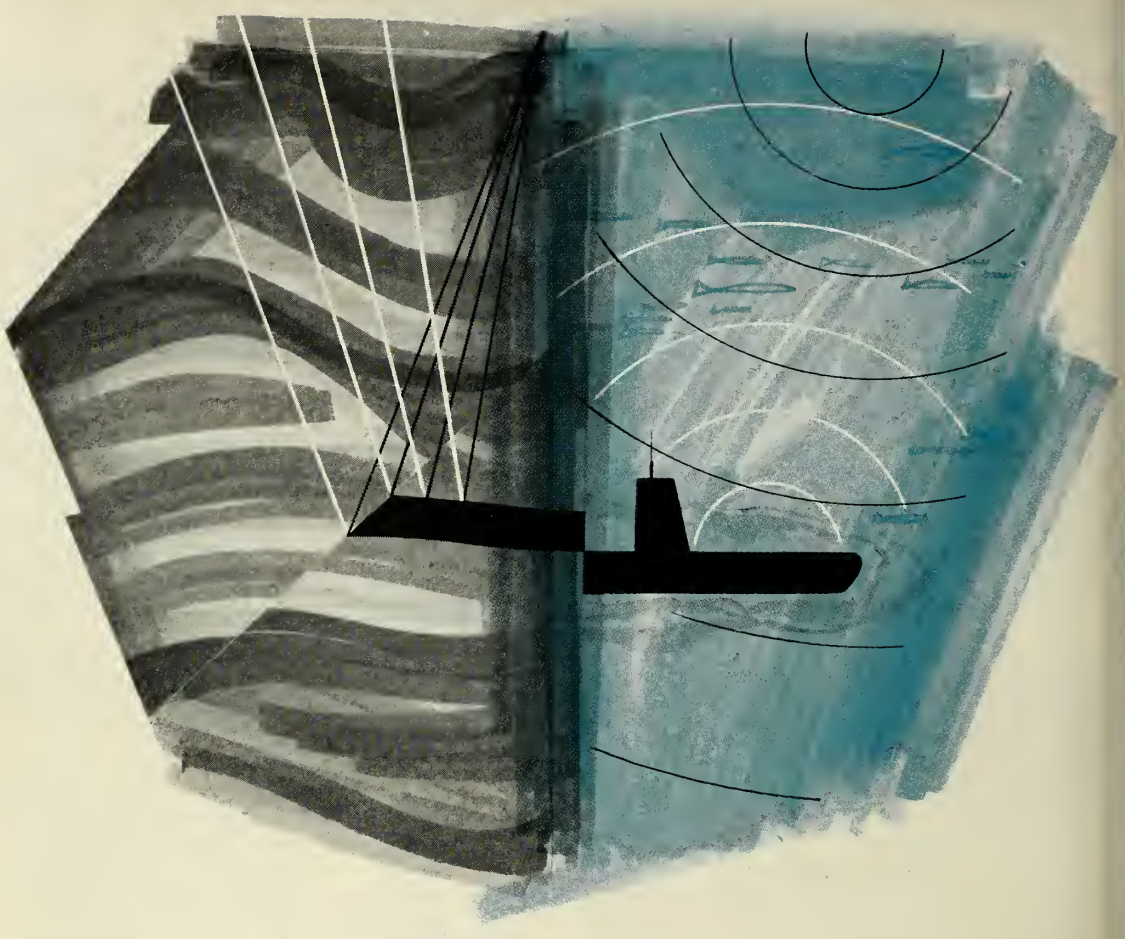
■ RESEARCH—Specialized analytical techniques focus on fundamentals in the effort to understand materials and increase their usefulness

■ SELECTIVE PLATING—Intricate missile parts saved from the scrap heap by a unique process of plating which eliminates the familiar immersion requirements

■ DRAG DEVICES—An analysis of the materials available for re-entry decelerators and design problems

■ MANNED VEHICLES—The stringent demands of space force designers into new and unfamiliar materials fields.

GROWING crystals in an arc-image furnace at Stanford Research Institute.



OIL AND SUBMARINES?

Yes—reflected "sound" detects them both!

For fifteen years Dresser Electronics has pioneered the development and manufacture of oil exploration instrumentation . . . seismic systems based on reflection techniques.

Now these same instrumentation techniques are being adapted to anti-submarine warfare. Dresser Electronics systems engineering is also at work in airborne telemetry . . . civil defense . . . process control . . . blast detection . . . mobile hospitals—projects throughout military, industrial and defense areas. *The unique approach of this systems-oriented company may solve your problem.*

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SIE DIVISION / ONE OF THE DRESSER INDUSTRIES

10201 Westheimer, Houston 42, Texas

Materials Gap Widens

Few Significant Developments in Past Year

- *Assessment of balance between technology and science leads to understanding of Materials Lag*
- *Materials frequently lack complete engineering documentation necessary for classification*
- *Disproportionate effort in solving single problems sacrifices rigorous, professional experiments*
- *Establishment of a materials technology based on fundamental knowledge deemed necessary*

by Dr. George J. Mills

Manager, Materials Research Operations, Aeronutronic Division, Ford Motor Company, Newport Beach, Calif.

THERE HAS been no significant change in the status of engineering materials in the past year. We are still a long way from having an available stockpile of technology to cope with present and future problems.

The key to understanding the current "materials lag" is a determination of the important elements and their interaction in the research, development, production and engineering application cycle—the balance between science and technology.

• **Superficial progress**—Although a substantial number of interesting developments have occurred during the year, few so-called "major breakthroughs" of lasting engineering or scientific value have appeared. Still, some encouraging steps have been made.

In the ablation materials field, specific materials are now offered for engineering design, and others have passed the testing phase. Current rocket nozzle applications do not appear to pose insurmountable problems, thanks to the improved state of the art in graphites and coating methods. The demand for thermal insulation is being met with foamed ceramics, plastics and a variety of fibrous materials. Requirements of solid rocket cases are now comfortably satisfied, with the titanium alloy and filament-wound approaches proving advantageous in specific systems.

But aerospace technology, which obviously has not been standing still in the past year, seems to have reacted faster to the advancing sciences than materials technology. The pressure is on materials for impact energy absorption, rigid and inflatable space structures, long-time vacuum and radiation exposure, chemically erosive propellant exhausts and severe re-entry environments.

These requirements will be met—as they have been in the past, but with a considerable effort entailing large expense and tight scheduling. The effort will also call for commitment of research and engineering talent resources—and these are not inexhaustible.

Two serious problem areas are now clearly evident in our struggle for engineering materials to satisfy these unconventional requirements. The first concerns so-called "developmental research."

• **Too much too soon**—In technical literature, our laboratory shelves are being deluged with a variety of curious shapes, compositions, formulations, composite configurations and test coupons representing empirical processing evaluations.

In the past, some of these "materials" served a useful purpose, since many preceded the development of a useful functioning item.

Frequently, however, these materials lack complete engineering documentation or even the most meager information for classification into potentially useful fields of application. Duplication and subsequent repetition of these efforts on related problems is a common occurrence.

Too often these "technical breakthroughs" are being offered as proprietary items with the claim that they solve the variety of problems that have been plaguing us. The common attitude of "try it out and see if it works" is an admission of ignorance in the understanding what is being offered—because the fundamental nature or behavior of the material has not been established.

The point here is that considerable technology has been generated and is available. But it is ill-defined and scattered throughout our laboratories. It is of pertinent value only to the materials specialists working on the particular developmental problem.

This reveals an inherent and serious weakness in our approach to the materials technology field: we are devoting a disproportionate effort to solving single problems—at the sacrifice of rigorous, professional experiment.

Competent engineering and scientific personnel are being encouraged by this approach to devote an unreasonable amount of time to promotion of pseudo-scientific discoveries incompletely documented with basic facts.

This introduces the second problem area—the adequacy of our research efforts in providing the sound principles.

More serious thought and action should be devoted to establishing integrated basic-applied research programs in various materials areas. There should be prime emphasis on interaction with specific disciplines. Long-term and more lasting values are to be derived from broader understanding of the origin of materials phenomena. Their characteristics are thereby more readily amenable to direct control, and their behavior can then be knowledgeably predicted.

Better understanding of the electrical and mechanical properties of matter in the solid state, and the synthesis of new materials will always

(Continued on page 54)

Filament Winding Stretches Productic

- *Researchers move closer to ultimate glass fiber strength in manufacturing structures*
- *Uniform loading and resin impregnation of fibers is critical to satisfactory final product*
- *Resin systems with elongation characteristics compatible to fiber are increasing in importance*
- *Goodrich winding technique leads to optimum pressure vessel reproducibility.*

by G. A. Zimmerman
Mgr., New Products
and
C. P. Krupp
Mgr., New Products Development
Aviation Products Division
B. F. Goodrich Co.

RESEARCH, DEVELOPMENT and actual manufacture of many rocke and missile components on a produc tion basis has shown that glass fibe filament winding can often yield bette and more economical results than th techniques it replaces—not just i parameters of direct cost, but in time weight, strength, durability, repro ducibility, and reliability.

The basic design approach at B. F Goodrich has developed as a result o thorough investigation of the condi tions affecting overall efficiency of a wound product. These studies have shown that to take full advantage o the physical properties of filament-wound materials and obtain optimum structural efficiency, certain conditions must be achieved.

• **Fiber tension**—Uniform loading and impregnating of fibers with resin is essential. This is done through application of direct tension. Prior to winding, enough tension must be applied to straighten out the fibers in the yarn and permit each fiber to be impregnated and encapsulated with resin.

RIGHT: *Circumferential plies and skirt attachment shoulders are wound on a 54-in.-diameter rocket chamber.*

FAR RIGHT: *Longitudinal plies of glass fiber filaments, impregnated with resin, are applied by this rotary-type winding machine.*

ollar And Cuts Time

During winding, sufficient uniform tension must be applied on all fibers to obtain uniform density in the wound section. The tension serves to flatten the yarn and squeeze excess resin from within and between the fibers to provide a uniformly loaded material.

Fibers in direct tension are necessary for uniform loading; it is important that the method of winding be such that the fibers are always parallel to the forces to be applied and do not produce shear forces in the resin laminate by shifting under load.

Balanced construction in winding patterns is dictated by the internal chamber pressure requirements. The winding pattern or number of individual yarns required should be in relationship according to the basic pressure vessels formulas for thin-wall vessels, in order to restrain longitudinal and circumferential forces.

$$\text{Circumferential Hoop Stress} \quad \frac{D \times P}{2T}$$

$$\text{Longitudinal Stress} \quad \frac{D \times P}{4T}$$

Minimum bridging of winding patterns is vital if we are to achieve the ultimate in mass efficiency. If the winding pattern produces a cross-over condition (or herringbone effect) in single ply coverage, resin pockets will develop at cross-over points.

Under optimum conditions all yarns, in the longitudinal direction, will lie in a parallel, side-by-side attitude so that minimum thickness will be obtained in every ply. This condition cannot be achieved over the end domes; consequently, there is a compromise.

• **Closure technique**—Minimum thickness variation over elliptical ends can be obtained by winding with a multiplicity of yarns laid side by side, forming a tape that is as wide as practical. Each subsequent wind should be carefully indexed the width of the tape. As the chamber size increases, the number of ends of yarns is increased.

As the number of these ends increases, the importance of tensioning control on each yarn end increases.

Absolute control of winding patterns must be exercised to minimize strength variations from unit to unit, and to assure maximum case reliability. It is essential that winding techniques be so controlled that each case contain the exact number of winds required by the design calculations.

The B.F.G. winding technique is based on "individual thread count," which is probably the most practical method of insuring uniformity and product reproducibility.

Accurately controlled resin content, or resin-to-glass ratio, is the most critical control variable in filament winding. Factors involved here include resin pickup during impregnation, viscosity of the resin bath, tension during winding, winding pattern, degree of "B" staging prior to cure, and the rate of heat transfer during cure.

These variables are all individually controllable to a degree; it is control of their combinations that requires the major effort to establish precise tolerances.

Existing resin content of maximum density is vitally important in determining mass stress levels in a chamber. It also directly affects the mechanical properties of the plastic laminate.

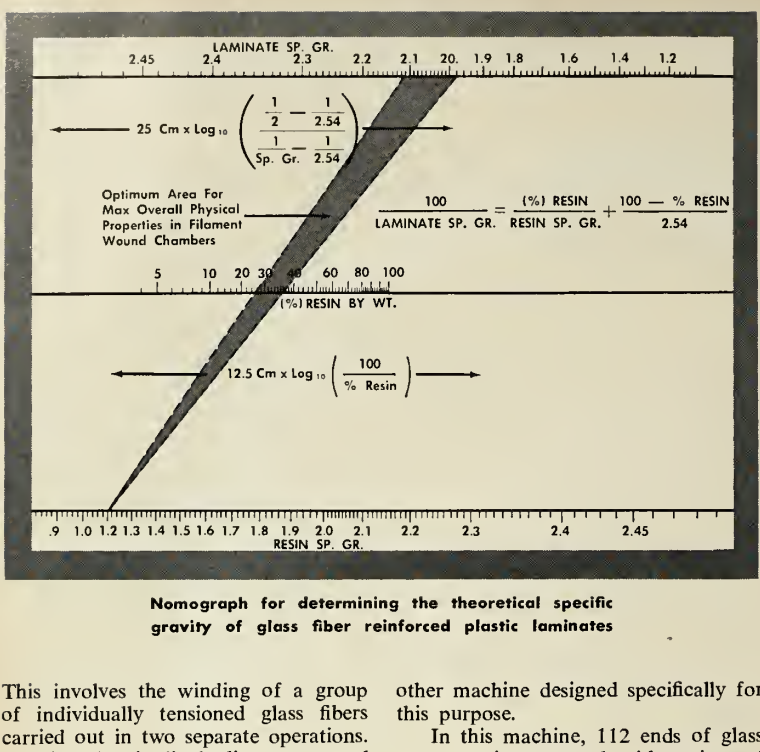
To assure maximum density, effective control must be exercised over the winding procedures, especially the tension during winding, the resin viscosity, and the curing characteristics of the resin system.

• **Resin problems**—Maximum glass-to-resin bond brings maximum mechanical strength of a plastic laminate. Mechanical strength is affected both by the finish or coupling agent and by the type of resin system used on the glass yarn. If to provide maximum surface reactivity, these coupling agents must be effectively applied during manufacturing of the glass fiber. When these finishes are subsequently applied on heat-cleaned glass, the resulting physical properties drop substantially.

The commercially available Silane types, such as 801 or 890, are the best in overall properties and are used extensively in filament winding work.

Resin systems with elongation characteristics compatible with the glass fiber are becoming increasingly important as the design strength level of a filament wound chamber goes beyond the 70,000 psi figure. In this respect, many commercially available epoxy resins are marginal when maximum mechanical and heat distortion propetries are to be maintained.

The preceding analysis of conditions that must be achieved logically led to development of the B.F.G. Biaxial Method of filament winding.



Nomograph for determining the theoretical specific gravity of glass fiber reinforced plastic laminates

This involves the winding of a group of individually tensioned glass fibers carried out in two separate operations.

First, longitudinal plies are wound on a rotary-type winding machine. The mandrel is covered with a rubber insulation liner on which the plies are wound. The axis of the mandrel or form is inclined so that the top of one port or pole fitting, and the underside of the opposite end pole fitting, are in a parallel plane. The container itself is rotated around an axis perpendicular to this plane, and intersects the exact center of the container. The winding pattern does not develop a helical angle to the winds. It consists of winds in a straight plane, from pole to pole, that are indexed at each pole a sufficient amount to advance the tape one tape width at the outer periphery of the container.

This produces a completely unidirectional cord pattern in the cylindrical section of the container. With one revolution of the container, two actual plies are generated—each ply opposing the other in angle.

After the container makes one complete revolution, thus producing two complete opposing plies, a single circumferential wind is put on to give maximum density to the longitudinal plies already applied. Subsequent longitudinal plies are put on according to the design strength requirements, with a circumferential ply interspersed on every two plies.

The second step in the Biaxial Method is circumferential winding. After completion of the longitudinal winds, the container is moved to another machine designed specifically for this purpose.

In this machine, 112 ends of glass yarn are impregnated with resin and wound under demand conditions in a sufficient number of plies to meet design requirements.

Shoulder areas must be reinforced, because of the low value of interlaminar shear of filament-wound cases. Reinforcing with fiberglass cloth impregnated with epoxy resin provides a strong shoulder area capable of withstanding stresses and loads. Where port reinforcements are required, they are introduced between longitudinal winds. This gives extra strong support and makes a durable port opening. After curing, the port openings are machined to exact size.

• **Method's potential**—One of the outstanding advantages of filament winding is that it permits building in a variety of physical properties through proper selection of raw materials. Selection from several basic glasses, such as the regular "E" glass, and a newer glass with a very high modulus of elasticity, can help establish desired properties of the finished wound product.

Studies of the properties of commercially available individual "E" glass filaments show remarkable consistency in the nascent state.

Initially, just about everyone concerned with filament winding turned to "E" glass because of its availability. The fiber was first used in electrical insulation applications and then in textiles. In addition, its good handling qualities are desirable in winding techniques. Structural characteristics include:

Ult. Tensile Strength	230,000 psi
Flexural Strength	280,000 psi
Specific Weight	0.078 lb/cu. in
Modulus	7.5×10^6 psi
Elongation	2–3%
Compressive Strength	70,000 psi

These individual filaments, when coated with a moisture-resistant coupling agent and typical epoxy resin, will develop a maximum mass stress level of approximately 250,000 when used in the most optimum type of unidirectional laminate.

The design requirements of a structure determine the resin system used to impregnate the glass fibers for filament winding. This selection is the most critical, yet the most versatile, factor in a filament-wound structures. Many resins are available, each noted for particular physical properties in the finished product. However, so many varieties of each resin are available that an almost infinite choice of properties can be achieved.

Complete quality control is an absolute must in every phase of filament winding—from selection of raw materials to shipping of finished product. Quality must be built in, not inspected in, and consequently B.F.G. maintains continuous surveillance by both automated controls and skilled engineers. This is the only way that near 100% reliability can be assured.

In the fabrication process alone there are as many as 60 check points, with a number of quality control activities to be carried out at each point.

Previous work in the aviation and missile fields has strongly emphasized this need. As a result, B.F.G.'s Operational Research Group and Computer Scientific Group have coordinated their reliability studies. The "state of the art" in reliability is under constant study, and necessary procedural changes and system upgradings are made whenever and however practical.

Rocket motor cases represent only one of the many successful applications of the Biaxial Method of glass fiber filament winding. The manufacturing flexibility of this technique enables the creation of spherical, hemispherical, conical, open or closed and cylindrical vessels, irregular shapes and flat surfaces.

Products can be produced in an extensive variety of shapes. Heat, strength and weight properties can be built in as desired through proper selection of materials—a factor that assures the ultimate in air-borne thrust chambers, rocket chambers, cones and pressure vessels. ⌗

WESTINGHOUSE AEROSPACE PROPOSAL:

STRUCTURAL MATERIALS DEVELOPMENT
FROM SPACE COLD TO RE-ENTRY HOT

FORMING MOLYBDENUM CUPS: PROOF OF METALS COMPETENCE

Here's a typical example of exacting Westinghouse materials competence in the aerospace age. Note: Westinghouse integrated a number of advanced techniques to accomplish this metallurgical feat.

At the Westinghouse Metals Plant in Blairsville, Pennsylvania, this is one of many tests performed to prove the forming and fabricating quality of the product. Metallurgists deep-draw cups in pure molybdenum at room temperature. Such an operation was impossible just a few short years ago.

Let's just briefly review the development of workable molybdenum sheets.

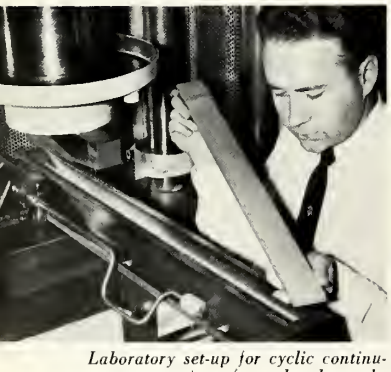
First, basic metallurgical research developed the vacuum-melting process for obtaining pure metal.

Then, Westinghouse scientists developed the cyclic continuous compaction technique for compacting pure molybdenum powder into $\frac{1}{4}''$ x 2″ x 30″ bars. These bars were sintered to 95% of their theoretical density. The sintered bars were then hot-rolled into .060″ strip.

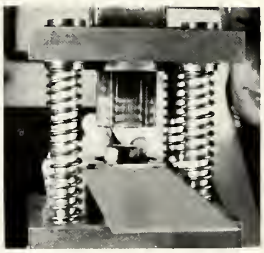
From the cryogenics laboratories came the strength and ductility data of extreme low-temperature tensile testing of molybdenum. These low-temperature studies revealed why molybdenum was a brittle, unworkable metal. They provided the basic leads for developing an easily workable metal for high-temperature applications in the 3100°F range.

Many other calorobic and cryogenic materials including metals, alloys, plastics and ceramics—as well as associated fabricating techniques—are on hand at Westinghouse. The following pages describe some of the immediately helpful areas.

These advances in materials development and fabrication may provide you or your colleagues with a long-sought solution to long-life space structures.



Laboratory set-up for cyclic continuous compaction of powdered metals.



Removing molybdenum cup punched at room temperature.

Cup-forming sequence as shown by interrupted samples.

Typical molybdenum cup showing excellent room temperature formability.

ONE-STOP SERVICE FOR COMPLEX METALS

Name your materials development problem. The Westinghouse Metals Plant at Blairsville, Pa. has an "everything under one roof" approach that simplifies and speeds the mastery of metals.

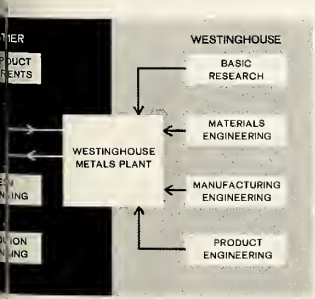
The Metals Plant is a flexibly knit group of skilled manpower, brainpower, and fabricating facilities designed to develop new metallurgical materials and many new processes. Emphasis is on wrought alloys and cast-metal products, as well as rolled sheet and plate.

This Westinghouse plant proves new ideas and designs in pilot plant operations. And, after completing experimental and development work, they can process the actual materials and manufacture end-products at this fully integrated plant.

Complete metalworking facilities include vacuum- and atmosphere-induction furnaces, vacuum-arc melting furnaces, bell-type furnaces, a skull melting furnace and special quenching facilities. Other metalworking facilities include heavy equipment for metal conditioning, forging, pressing and rolling. For the precision parts or intricate shapes, facilities for skull-melting, shell-molding, lost-wax investment casting and sintered metal processes are available.

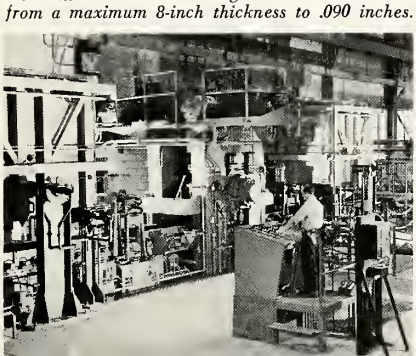
Services offered include materials development, metallurgical engineering, chemical and physical analysis, pilot plant studies, and metal production. Because we integrate and centralize developmental operations and manufacturing under one roof, new data and new ideas are quickly turned into practical application.

Photos below show representative sampling of the multi-purpose facilities available at the modern Westinghouse Metals Plant. We may already have developed the materials or processes to meet your structural design demands.

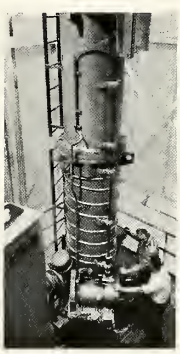


All these integrated Westinghouse resources aid your metals development.

Hot mill main stand is designed to roll slab down from a maximum 8-inch thickness to .090 inches.



This cold-hearth furnace melts high-purity metals without contamination to meet today's demand for refractory metals.



5,000-lb. heat of special alloys is produced from this unique melting furnace.

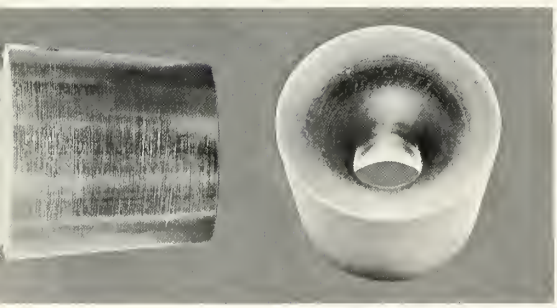
NEW METALS, NEW ALLOYS FOR AEROSPACE VEHICLES

Wherever metals men gather, talk inevitably centers around the search for an ultimate material. So it is at Westinghouse. We're investing heavily in space-age materials that defy the destructive elements of corrosion, fatigue, creep rupture, and erosion.

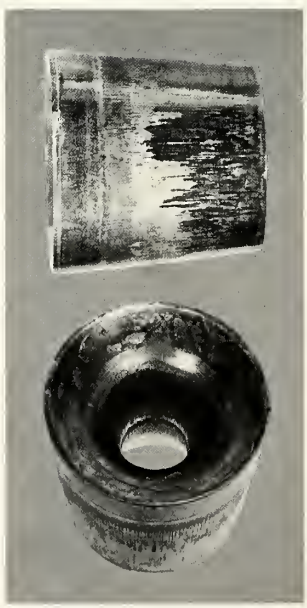
The Westinghouse Metals Plant has logged an impressive inventory of metallurgical knowledge about high melting-point metals and alloys. This knowledge has helped improve actual performance of many products. Refractory metals such as columbium, molybdenum, tantalum, and tungsten have been investigated in great detail.

Alloys come in for their fair share of data accumulation and evaluation. Large families of magnetic alloys such as Hipernom and Hipernik®, refractory alloys such as Nicrotung and Discaloy®, and special alloys such as Nivco and Kovar® have found practical application in many aerospace projects.

We would welcome an opportunity to discuss your metals development requirements.



Atlantic Research Corporation rocket nozzle test throat insert machined from arc cast ingot.



A high temperature and a high deformation rate was used to make this pure tungsten nozzle on the Dynapak.

This Model 1200 Dynapak is capable of delivering 160,000 ft. lbs. of energy.

...AND THE PROCESSES THAT MAKE THEM PRACTICAL

As new metals are born, techniques and equipment must keep pace, too. At the Westinghouse Metals Plant, development of new metals and processes saves customers heavy capital investment. A strict adherence to design requirements assures customers close control of their product.

To prove the practicality of much of our metals knowledge, Westinghouse has developed a number of metallurgical processes. Out of these processes emerges some highly favorable fabrication data.

Item: techniques for vacuum-arc melting pure tantalum and tantalum-tungsten alloys, molybdenum and molybdenum-tungsten alloys, niobium and its alloys, and pure tungsten.

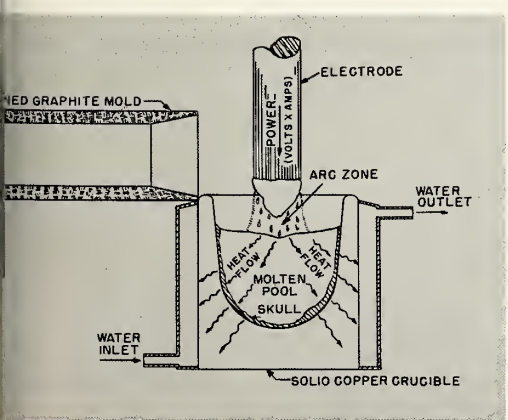
Item: techniques for producing "cast to shape" parts by the "skull" casting method. Parts weighing 45 pounds have been cast of niobium and its alloys, and pure tungsten.

Item: protective-atmosphere forging of easy-to-oxidize metals to permit hot working at 3500°F.

Item: techniques for forging tungsten shapes. Pure tungsten bars are forged directly from an arc-cast ingot using an inert atmosphere forging chamber to protect the material from oxidation at temperatures above its recrystallization temperature.

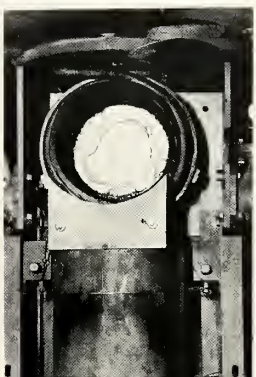
Item: powder metallurgy techniques for producing high-temperature rocket-nozzle inserts from such refractory metals as molybdenum and tungsten.

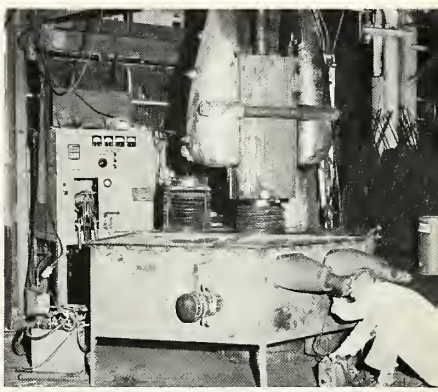
So we have the means of developing materials to withstand both high and low temperatures. Space cold or re-entry hot. And our object? Why, contracts, of course. For materials development and component production. Interested parties should refer to coupon on last page of this advertisement.



Schematic cutaway shows position of internal components of skull furnace while forming molten pool.

Interior of skull furnace after pouring.





This controlled atmosphere chamber permits the true "hot working" of refractory metals.

CERAMIC MATERIALS: ANY SIZE, ANY SHAPE, AT BREAK-THROUGH MELTING POINTS

Westinghouse's Ceramic Engineering Department has developed an entire new family of materials for space-age applications. Westinghouse scientists are already probing the areas of high thermal shock for combinations of such calorobic materials as:

		Melting Point °F
Silica	SiO_2	3100
Zircon	$ZrSiO_4$	4100
Zirconia	ZrO_2	4900
Boron Nitride	BN	5430
Zirconium Boride	ZrB_2	5540
Zirconium Carbide	ZrC	6400

Performance characteristics such as high melting point, good thermal insulation, heat and erosion resistance, capacity to withstand high temperature gradient and relative immunity to combustion products, suggest the following applications for these materials:

leading edges of hypersonic craft · fuselage—outer wall panel · nose cones · rocket nozzles · radar windows · thermal insulators · wearing parts (bearings, etc.) in high temperature areas · jet vane control · flame holders · ramjets

Current and past development projects in the Westinghouse Ceramic Engineering Dept. include:

ferrites · ceramic permanent-magnet materials · ceramic insulating and protective coatings · ceramic-to-metal seals · nuclear fuels · infrared transmissive glasses · thermistors · voltage limiting resistors · refractory structural materials (i.e. cermets and pure oxides)

Westinghouse formed these ceramic rocket nozzles for test firing in a MERM (materials evaluation rocket motor).

The ceramic material in this 10" O.D., 11" long rocket nozzle was designed to operate in the exhaust of a high energy aluminized fuel solid propellant rocket.

WESTINGHOUSE PLASTICS PROTECT VITAL PAYLOADS

Example: Tape-wound laminates from Westinghouse's Micarta Division at Hampton, S.C., solve the problem of light, strong, ablative heat shields for re-entry. In plastics, as well as metals and ceramics, Westinghouse can provide development and manufacturing service for both calorobic and cryogenic applications.

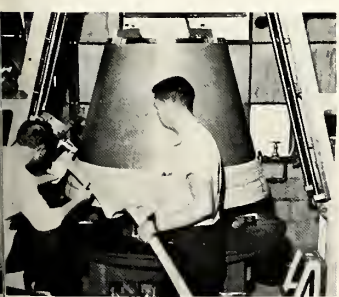
Shown below is an example of how Westinghouse materials development has helped solve the nose cone re-entry problem.

Laminated plastic tapes are spiral wound on nose cones to form the heat shield. The spiral tape system is extremely versatile. Fabric thickness can be increased from inside edge to outside edge, to give a tapered cross section.

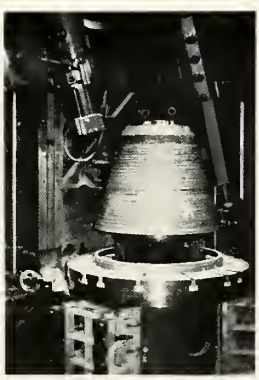
Fundamental component of laminated-molded plastic heat shields for re-entry bodies is the resinous binder. Westinghouse's Micarta Division's 7H186 is a specially-developed phenolic resin which exhibits extreme thermal stability. This resin has been used in conjunction with glass, quartz and leached glass reinforcements to produce oriented laminated-molded heat shields.

The nose cone shown below will ablate at a controlled rate.

The Micarta Division of Westinghouse is developing new materials for rocket motor housings, exhaust jets, satellite components, aero-dynamic foils, air frame components and numerous other space-age applications. For more information, please use the handy coupon on the last page of this advertisement.



Spiral winding the laminated plastic tape an Flare Sectian.



Machining the wrapped sectian.

The completed nase cane sectian.

This plastic campressar hausing incarparated inta a jet engine shawed remarkable perfarmance under actual aperating canditians. Weighs less than canventianal aluminum ar magnesium allay units. Outperfarms them taa. Pressure malded af glass-cloth palyester, the hausing alsa casts less, machines mare readily, and resists carrasian better than its metal caunterparts.

Westinghouse Aerospace Proposal

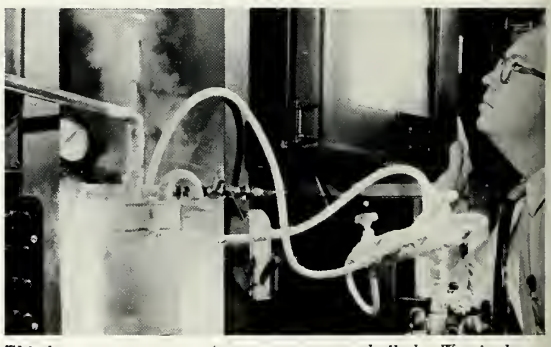
CRYOGENICS INSIGHT... MATERIALS TESTING AT −452°F

Westinghouse is interested in the low-temperature properties of structural materials. Our behavior studies range from fundamental research . . . through applied research and development . . . to collection of actual engineering data. Results of these investigations have been applied to normal—as well as high-temperature problems. We'd like to share some of these findings with you.

Although it is not too generally recognized, low-temperature mechanical testing is quite useful in development of new metals and alloys for many applications. In addition to malleable molybdenum, Westinghouse has advanced some of the rare-earth metals to promising potential with cryogenic studies.

In working with niobium, for example, low-temperature testing showed that small variations in gaseous impurities could cause marked differences in flow and fracture characteristics. Vacuum annealing treatment of test specimens helped identify the responsible impurities, providing invaluable data for developing this metal and its alloys. Low-temperature mechanical testing has proved to be a key tool in the study of strength of materials for exacting uses.

These facilities are available on a developmental contract basis.



This low-temperature testing apparatus was built by Westinghouse for strength and ductility studies of metals. The device attains temperatures as low as −452°F (4.2K) through use of liquid helium.

JI 92509

CLIP COUPON FOR FAST FOLLOW-UP ON YOUR MATERIALS PROBLEMS

Westinghouse

Westinghouse Electric Corporation
P. O. Box 868, Pittsburgh 30, Pennsylvania

Yes, I'm interested in your Aerospace Materials Capability.

☐ Please have Westinghouse Sales Engineer stop by to discuss my component requirements.

My major interest is in ☐ Calorobics ☐ Cryogenics.

Please send me data for these applications:

REFRACTORY METALS AND ALLOYS FOR:	TEMPERATURE RANGE	OPERATING ENVIRONMENT	OPERATING TIME
☐ Rocket Motor Components			
☐ Skin Materials for Mach 3 and Higher Speed Vehicles			
☐ Space Vehicle Components			
☐ Nuclear Power			
☐ Thermoelectric Devices			
☐ Thermionic Conversion			
☐ Magnetohydrodynamics			
☐ Closed-Cycle Gas Turbines			
☐ Semi-Conductor Devices			
☐ Electronic Components			
☐ Magneto-Mechanical Devices			

REINFORCED PLASTICS	TEMPERATURE RANGE	OPERATING ENVIRONMENT	OPERATING TIME
☐ Rocket Nozzles			
☐ Ablative Heat Shields			
☐ Housing for Jet Engine Compressors			
☐ Aerodynamic Foils			
☐ Air Frame Components			
CERAMICS			
☐ Leading Edges of Hypersonic Craft			
☐ Fuselage-Outer Wall Panel			
☐ Rocket Nozzles			
☐ Radar Windows			
☐ Thermal Insulators			
☐ Wearing Parts in High Temp. Areas			
☐ Jet Vane Control			
☐ Flame Holders			
☐ Ramjets			

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Ceramics Pose Greatest Challenge

- **Huge potential blocked by brittle characteristics**
- **Reliance on empirical preparation methods**
- **Higher purity one tack in current investigations**

by Frank Halden
Senior Ceramic Technologist
Stanford Research Institute

PERHAPS NO CLASS of materials has greater potential for meeting present and future missile needs than ceramics—the oxides with their low density, great stability and strength at elevated temperatures, the carbides with their extreme melting temperatures and hardness, and graphite with its excellent thermal shock resistance.

Yet, ceramics have been the least utilized and in some respects the most disappointing. Why? What must be done and what is being done to take advantage of these materials?

There are two major limiting factors in working with ceramics—their brittleness and the difficulty in controlling their fabrication processes.

As a class, ceramics are perhaps the most difficult materials to study and utilize. Their stability and refractory characteristics limit purification possibilities. Since they are primarily ionic compounds, their ductility is considerably less than that obtained in metals. Stoichiometries often are not sharply defined but may vary with considerable changes in properties.

Problems such as these have forced a heavy reliance on empirical procedures for preparation and handling. Only recently, with the development of modern heating techniques and chemical tools, have we been able to examine these materials in some detail.

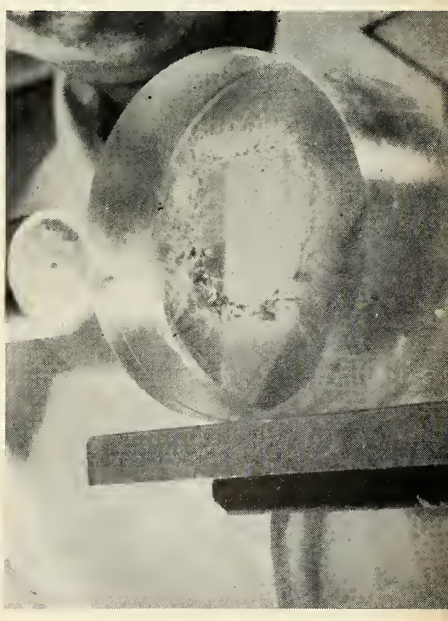
To decrease brittleness we must obtain much higher purities, gain an understanding of failure mechanisms, and control grain size, porosity, and surface condition. Combinations of ceramics with metals and plastics are being studied in hopes of taking advantage of the desirable properties without being handicapped by their limitations.

To improve ceramic fabrication, industry must explore entirely new techniques and gain a better understanding of operable mechanisms. We must develop testing procedures suited to this type of materials, not just borrow available techniques which have been developed for metals.

• **A bird in hand**—It is probably fairly safe to say that no new wonder materials will be discovered which will combine extreme melting point, high stability, high strength at elevated temperatures, ductility, and good thermal shock resistance. Rather, the greatest progress probably will come as we learn to handle and control the materials now available. This will require at least as much scientific effort as has been devoted to metals—in view of the additional problems, probably considerably more.

Stanford Research Institute, together with a number of other research facilities, is attempting to provide some of this advancement. Programs in progress deal with development of improved coating techniques for ceramics on metal and metals on ceramics, growth and study of single crystals of refractory compounds, development of improved testing techniques, examination of residual stress distributions, investigation of the influence of surfaces on physical properties, and the study of the influence of deviations in stoichiometry on physical properties.

From such bits and pieces will come the clues leading to development of superior materials for missiles and space craft. As research continues, we can expect an increasing rate of improvement in the properties of high-temperature materials. ⌘



Radiation Effects

SHORT PULSES of Gamma radiation equal to that of an atomic explosion are produced by a linear accelerator at Hughes Aircraft. Nozzle appears on the left of the lucite target.

300,000 psi Case Yield Strength Ma

- *Prediction based on experimental results and a realization that current metals are being used at a fraction of potential*
- *High-yield steel must start with maker's recognition and control of new factors*
- *Steel will remain the dominant materia until filament winding is perfected*
- *Need still exists for correlation betwee various specimen tests and the perform ance of the pressure vessels*

THE ENTIRE SOLID-PROPELLANT missile industry is working to solve the many problems associated with materials for rocket motors—spurred by the need for reliability and increased system efficiency.

This efficiency drive is channeled either toward raising propellant specific impulse or increasing the mass ratio.

The terminal velocity of the vehicle is a function of these two values: it varies directly with specific impulse and exponentially with mass ratio. Hence, important increases in terminal velocity, or system efficiency, can result from relatively small decreases in weight of inert parts.

The search for lightweight components has led to general use of ultra-high-strength steel for rocket motor cases. Glass filament-wrapped cases may eventually displace steel for many rocket motor applications, but until this material is developed further and tested in use, steel will remain dominant.

Raising usable strength level of steel with high reliability is now very important to industry. Steel will remain the primary material for many applications where glass filament will not meet design and operational requirements. Steels, when produced and fabricated by current state-of-the-art techniques, appear to be limited to a useful strength level of about 240,000 psi yield strength. Above this point, brittle behavior becomes more likely and burst strength of pressure vessels becomes erratic and falls off rapidly.

• **Ultimate in sight**—Industry effort has been applied toward pushing this limit upward. Experimental studies at Solar give some promise that the much-sought-after goal of 300,000 psi yield strength may be possible and practical.

It is well known that iron whiskers have an ultimate tensile strength of over 1,000,000 psi. The actual atomic force holding the material together is therefore many times greater than anything realized in practice today. Today's materials are used at a small percentage of their theoretical capability: a number of small pressure vessels have been burst tested at Solar, exhibiting burst strengths up to 361,000 psi. Other investigators have experienced similar results, indicating that this performance level is definitely within the capabilities of the material.

Therefore, the problem is one of identifying and controlling those variables which enable one vessel to sustain over 300,000 psi stress while another apparently identical vessel may burst at half that value.

The test methods used in evaluating materials have an important influence on results and conclusions. Tensile properties, as determined in a uniaxial test, are not sufficient as criteria of a material's usefulness in a motor case. Brittle behavior, or lack of resistance to crack propagation under the system of stresses imposed in a pressure vessel, results in erratic burst strengths.

Various tests have been devised to indicate the tendency of a material toward brittle failure, but there is still need for correlation between these tests and the performance of pressure vessels made of the material. Solar has relied largely on the use of small pressure bottles as being the most reliable test of a material. These tests are supplemented by metallography, hardness, X-ray diffraction and X-ray fluorescent analysis.

Fabrication and joining processes are under investigation to identify and control brittle behavior variables.

Fundamental metallurgical research includes studies on the mechanism o brittle fracture; influence of chemistr on weldability; influence of such factor as grain size, segregates, decarburiza tion and inclusions on notch sensitivity influence of ausforming, strain aging and special heat treatments on mechan ical properties; and test methods fo evaluating materials.

Several of the newer treatment depend on deformations at some tim during the processing cycle for produc ing ultra-high strength. Ausforming an strain aging both have the effect of re ducing the spread between ultimate an yield strength, pushing the yiel strength up to well above 300,000 psi

Surface decarburization already ha been recognized broadly as one of th steps necessary to reach the 300,000 ps yield strength goal. It has the effect o softening the surface layers and reduc ing notch sensitivity with only mino loss of total section strength. Solar is evaluating various decarburized condi tions to determine the controlling fac tors in the process.

• **Manufacturing methods**—If the ductile-brittle boundary is the first impediment in the way of the 300,000 psi case, defects introduced by the steel manufacturing process of product fabrication processes are the second. The defects may be cracks, inclusions, segregate areas, porosity, or other non-homogeneous structural features capable of creating a stress concentration. Solar's work on the mechanism of brittle fracture has led to the conclusion that closer control of the steel structure is essential to increase the toughness of the steel.

Control over the steel composition was also found to influence weldability. The effects of nickel and phosphorous combined were much more deleterious

le Practical

by A. T. Letsinger
Senior Project Engineer
Solar Aircraft Co.

to the properties of H-11 steel than phosphorous alone, indicating that the ratio of these elements may be critical in high-strength weldments.

Similarly the degree of banding in this steel was found to affect material properties in the heat affected zones adjacent to welds. These discoveries clearly point out that 300,000 psi steel must start with recognition of new factors and unprecedented control over them by both the steel maker and the fabricator.

For the 300,000 psi case, it is highly desirable to keep joints to a minimum. Hence, shear forming or deep drawing is recommended as the preferred forming method. However, there are instances where joints are unavoidable; the Solar studies have included optimizing welds in steels with 300,000 psi potential.

It has been found that weld reliability is controlled by the solidification pattern, banding in the parent metal, composition of the steel, and other factors. Solar has been able to control the welding process so that welds with almost identical properties to those of the parent metal have been obtained. From this work Solar believes that 100% weld reliability is quite possible without any weld reinforcement at strengths up to 320,000 psi U.T.S. If these welds are confined to relatively low-stressed girth welds, welding will not impose a limitation on reaching the 300,000 psi yield strength goal.

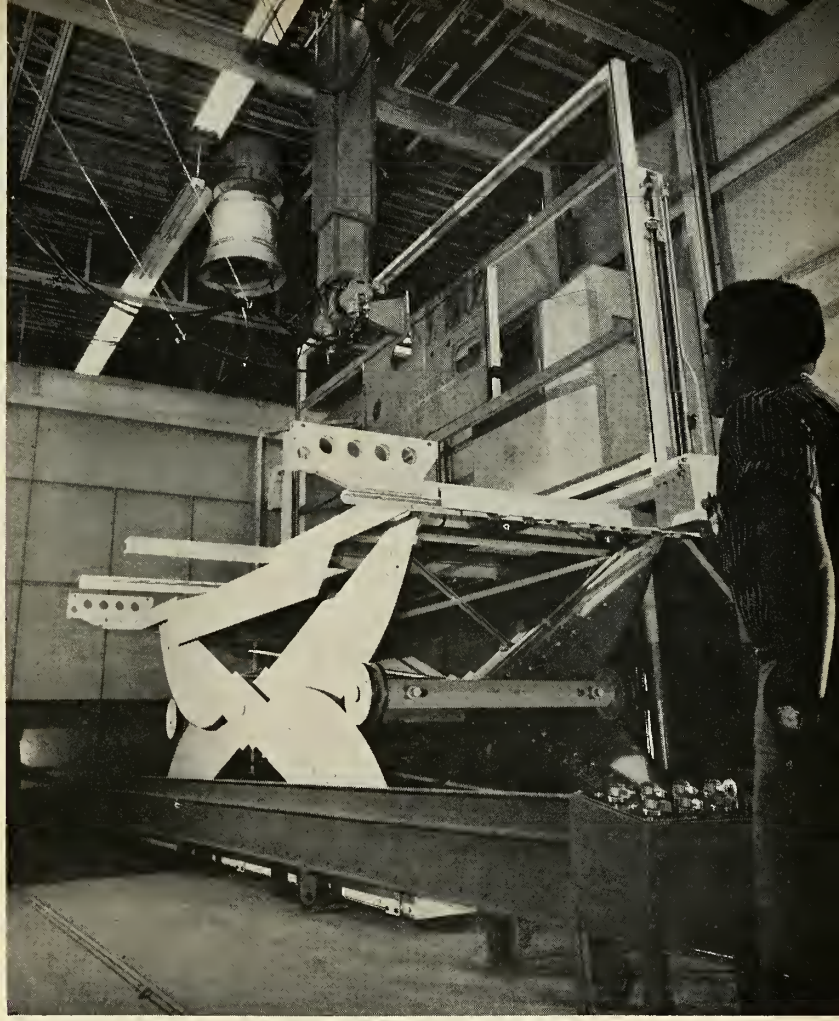
Other characteristics requiring sophisticated control are weld bead geometry, internal defects, and weld distortion. A number of special processes have been developed at Solar to meet these needs. Oscillation TIG welding is applied mechanically to produce flat, regular welds on both sides of the metal, free of stress concentrators. Hydraulic pressure sizing is used to correct weld distortions. Multiple-pass welding is sometimes used for grain refinement. Seam forging of welds to minimize weld defects is another useful technique, and has been used in the shear spinning of roll and welded cylinders.

In view of these developments, Solar Aircraft believes that the 300,000 psi yield strength case is imminent. With the successful completion of the studies, the time is not far distant when such cases can be offered to industry as an important advancement in the search for lighter weight solid rocket motor hardware.

• **Exhaust effects**—New propellants with higher specific impulse have introduced a host of nozzle material problems. Nozzle materials technology has not kept up with advancements in propellant temperature, erosive characteristic, and duration of burning; consequently, current nozzles are seriously overweight.

Development objectives are to decrease this weight and at the same time increase the operating temperature and erosion resistance capability. Among the more important materials used in the development are tungsten in the nozzle throat backed up by a ceramic. This combination is successful uncooled up to 6000°F. For higher temperatures, which are predicted up to 8000°F, cooled nozzles will be mandatory, since tungsten, with the highest melting point of any metal, melts at 6170°F.

The main problem in the materials development are in forming and joining of tungsten. While major strides have been made in solution of these problems, further development needs to be done before these techniques will be available for general use. ⌗



Internal Medicine—B-70 Style

PINHOLES IN HONEYCOMB panels for the B-70 can be detected with this mammoth X-ray unit. North American developed the rig for production line quality control.

Basics Stressed

Republic Takes Analytic Road

- *Potential of high-energy sources not yet achieved in spectroscopy and allied methods*
- *Gas chromotography being applied to describe high-temperature processes and effects*
- *Metal fatigue and brittle fracture under attack through solid-state theory*

by Dr. Samuel Korman
and
Dr. Robert Bastian
Republic Aviation Corp.

ADVANCES IN PHYSICS, chemistry and metallurgy at Republic Aviation Corp. are expected to provide new insight into materials development.

The Research and Development Center is actively promoting the application of specialized concepts to the evolution of new analytical techniques and composition control programs.

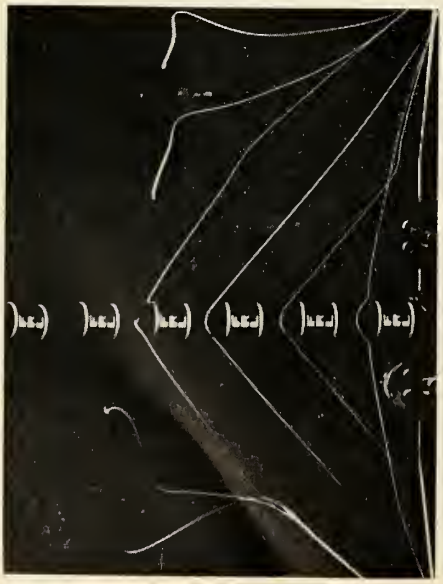
One illustration is the work being pursued in the estimation of trace impurities in high-temperature metal, alloys, and ceramic materials. This project is based on the belief that the key to better materials is more fundamental knowledge relating composition and properties.

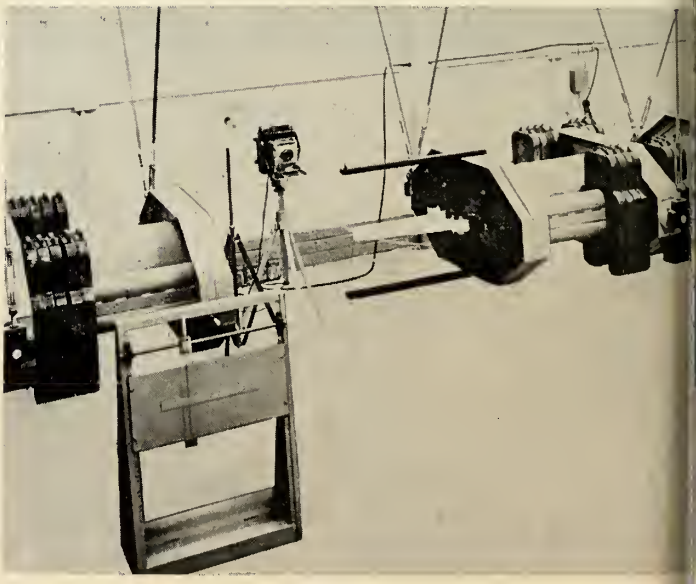
In this connection, radically new concepts are being explored involving spectroscopy with high-energy discharges and similar sources that produce complete, rather than merely selective, vaporization of samples.

A factor here is the extension and modification of spectroscopic equipment and associated analytical tools. The applicability of these new techniques depends on whether instrumentation is available which can generate and analyze abnormally low signal-to-noise flame sources and photographic images.

• **Analytical methods**—There is strong feeling that the potential of high-energy sources in spectroscopy has not been fully appreciated. Unlocking this door will lead to greater precision in analysis of critical impurities. The concepts of high-intensity discharges and differential microphotometry are coupled together to yield more accurate data on materials composition.

These results will furnish better





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understanding of fabrication and service properties in connection with the refractories. Ultimately, Republic hopes to evolve analytical specifications to aid in specific materials designs and selection.

Another area of the laboratory's analytical efforts involves the application of gas chromatography to the description of high-temperature processes and effects upon materials. Working in close coordination with the advanced fluids laboratory, researchers use gas chromatograph equipment to segregate the components of service-tested fluid samples.

The chromatograph is a device which utilizes the physical chemical properties of specially prepared absorptive columns to sort out the components of the sample. These are then displaced sequentially through a recording device which produces characteristic curves related to the composition of the displaced component.

Running such analyses to identify the components of a sample makes it possible to describe the thermal degradation process in detail. Correlation with initial composition of the fluid, as well as the elimination of deleterious impurities, such as moisture, dissolved gases, extraneous chemicals and catalytic agents, can lead to improvement in service life, ceiling temperature, and other desirable characteristics.

Ultimately it is planned to extend the features of gas chromatography to the study of vacuum and radiation effects upon materials, such as plastics, which are sensitive to such space environmental factors.

• **Solid state involved**—Another important activity of the program lies in the area of the physics of materials. Solid-state theory is being applied to metal fatigue and brittle fracture phenomena. Under contract with AFSWC, advanced theories are being formulated on the role of dislocations in solids and the kinetics of the interactions to produce experimentally hypotheses of crack propagation and fracture that are verifiable. Also under investigation is the behavior of dislocations in the generation of microcracks within metals and alloys of specific composition.

These studies are intended to yield a better understanding of those characteristics of various metallic compositions which may influence crack formation and propagation so that fatigue and brittle fracture may be controlled or inhibited. Another objective is to learn in more detail how to utilize brittle materials such as refractory ceramics for structural applications.

The program in emissivity of materials is extending to the rational development design, and selection of materials with specified emissivity, absorptivity and reflectivity properties. More sophisticated equipment has been designed for these studies; it will include measurement of these properties over selected wavelength ranges, temperatures, and other environmental parameters.

In metallurgy, investigations are underway to evaluate tungsten alloy systems and protective coatings for refractory metal structures. Using the approaches dictated by controlled composition and advanced processes, comparisons are made of electron beam melted alloys with the vacuum arc products for properties at temperatures up to 4000°F.

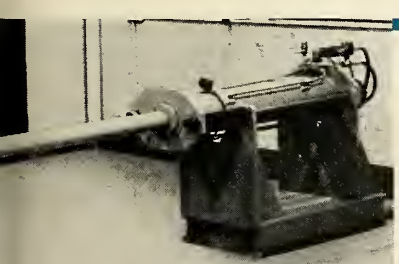
Associated with this effort, considerable attention is being given to critical appraisal of refractory coatings compositions and modes of application, with a view toward establishing a reliable base for manufacturing development and for service specification in hot structures.

There is further emphasis on the evaluation of metals and ceramics by support in areas of metallography, X-ray analysis, and electron microscopy. Experts in these fields are devising new techniques for analysis of substructural changes in refractory metals and high strength steels. These changes are correlated with fabrication or service, with the purpose of understanding the changes in the metals brought about by such factors. Experience gained is used to improve materials selection and specifications.

The utilization of ultrasonic energy is still another phase in Republic's program. In this area, such phenomena as control of nucleation and grain size, and materials aspects of ultrasonic joining are of interest.

In the field of plastics and composites, the materials laboratory is concentrating upon evolution of improved ablation systems and radomes.

Republic looks to its materials development laboratory, and to the use of modern concepts and equipment of metallurgy physics and chemistry, to provide the materials information needed to insure successful design and manufacture of aerospace system of the future. ⁂



Re-entry Drag Studied With Cannon

A helium-activated gas gun at Fabric Research Laboratories fires a 75 mm projectile at pendulum supported specimens. Tests simulate the impact strains drag devices undergo when deployed from a fast-moving vehicle. A second weighted pendulum stops the projectile and aids in precise velocity determinations.

Selective Electroplating Save

- *Dalic Process permits on-the-job plating without need for immersion.*
- *Costly over-machined or worn missile components are now being reclaimed by manufacturers using technique.*
- *Standard or precious-metal deposits of high purity and excellent quality are controlled to within 0.0001 inch.*
- *Harmful electrical shock is avoided; plating solutions are non-toxic.*

FUEL INJECTION nozzle for turbine after-burner receives 0.0004 to 0.0006-in. plating of nickel on inner diameter and chamfer.

by Charles D. LaFond

A PROCESS OF SELECTIVE plating without the need for immersion is being used by many missile component manufacturers today to save time and money.

It is not used solely for protective plating. The technique has been employed regularly to reclaim intricate and costly parts that are worn or have been tragically over-machined during manufacture.

Called the Dalic Process, it was developed by J. J. Georges Icxi of Laboratories Dalic, Paris, France. Sifco Metachemical, Inc., of Cleveland, is the sole U.S. licensee for its manufacture and distribution here.

The only equipment needed is special hand-stylus plating tools, a power pack, and kit of Dalic plating solutions. The equipment may easily be carried to the job, and it is adaptable for mechanized production.

Most significant attribute of the Dalic Process is that it can be used to deposit metals quickly in places where conventional plating might be extremely difficult or even impossible. Because the process is suitable for selective plating, components need not be disassembled.

Solutions used are non-toxic and harmful electrical shock to the user is impossible.

• **Plating by painting**—Prior to actual plating, the surface must be prepared with electro-cleaning and/or etching solutions. These are applied with a stylus and an electrode. The surface is then water rinsed.

To plate an area—large or small—an anode pad is saturated with the desired metal-plating solution and rubbed over the applicable surface. The surface itself is made cathodic.

This simple procedure is followed until the desired plate thickness is attained. The power pack includes a finely graduated ampere-hour meter which indicates deposit thickness. Thickness, according to Sifco, can be controlled to within 0.0001 inch.

Very rapid deposition is achieved by the unusually high current densities used—that is, compared with conventional bath plating.

The completed plating job resulting from this process is a deposit that is fine grained, possesses excellent adhesion, has low stress, and is free from porosity, Sifco asserts.

Deposits reportedly are of consistently high purity and are harder than those achieved in conventional plating (except for chromium). In addition, the company maintains that hydrogen entrapment which might cause embrittlement does not occur.

• **Varied missile use**—To find out just how the Dalic Process has been used in the missile industry, M/R called on several manufacturers of key components. These are some of the responses and applications for which the technique has been used successfully:

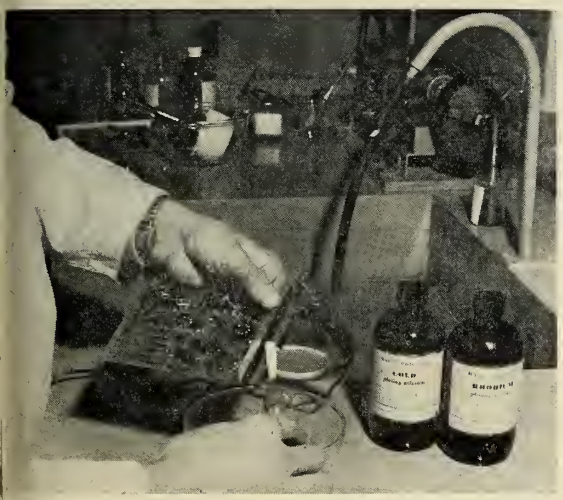
The missile launching valves used in the compressed air system aboard the submarine USS George Washington are a good example of how this technique cut normal lead times and solved problems in the *Polaris* program.

Exposed to a hostile sea water environment, these missile launching valves nevertheless must be capable of instantaneous action even after prolonged periods of inactivity, as might occur when the submarine cruises on-station for periods of several months.

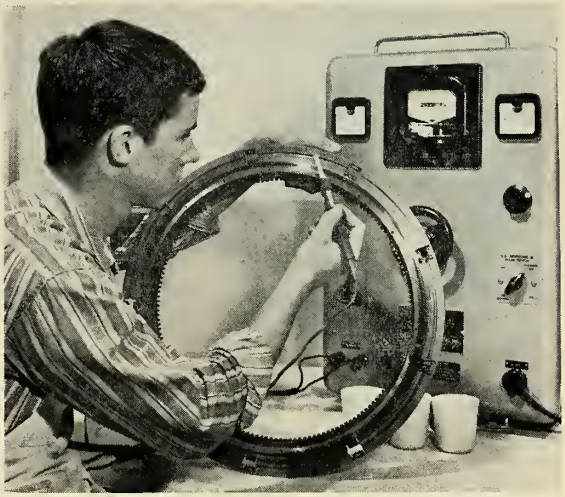
A protective plating was decided upon to keep the valve body interiors, face plates and O-ring seal areas free from corrosion. This protective plating could have been applied by conventional electroplating, using tank immersion methods. But this would have required sending the launching valves to a special plating shop, with resulting time losses. Instead, the Navy decided to undertake the protective plating job right at dockside, using the Dalic electroplating process.

In applying the specified 0.003-inch protective plating, the Dalic stylus, wrapped with a cotton swab (anode), was dipped in a special indium-tin alloy plating solution and then rubbed over the exposed valve sur-

ime and Dollars



PREVIOUSLY ASSEMBLED printed circuit board is given a 0.000050-in. plating of gold on all of its contact tabs.



DALIC PROCESS is used at Custom Tool & Mfg. Co. to "paint" thin groove on missile guidance gear with 0.0003-in. copper plate.

face (cathode) to be protected.

Despite the comparative ease and dispatch with which this valve plating job was accomplished, the resulting indium-tin alloy coating reportedly is both dense and highly wear resistant. In fact so much so that, according to naval engineers, the plating procedure is expected to prevent indefinitely any valve deterioration from sea water exposure. If touch-up plating is ever required, the process used for the original job can be employed again.

The Navy reports the Dalic plating job on the launching valves saved an estimated 800 hours over conventional methods in preparing the components for service.

Dalic selective plating has been used for many years as a special tool at Lycoming Division of Avco Corporation, Stratford, Conn.

Aircraft engine gears of all types and sizes have been selectively touched-up by Dalic copper as a stop-off prior to nitriding or carburizing. These salvage operations, according to Lycoming, have saved time and money and are a continuing operation.

Currently, Lycoming's missile programs (including production of re-entry vehicles for the *Atlas, Titan* and *Minuteman* missiles) have emphasized the need for special plating techniques. Missile assemblies and components are now being processed by Dalic plating, not on a salvage or repair basis only, but as an initial manufacturing process.

A re-entry vehicle flare assembly, after proper preparation of the aluminum from which it is fabricated, requires an initial nickel plate, followed by a flash of gold and finally a silver plate of 0.0002 inch.

The interior of the nose cone backup structure is first zinc-chromated; then selective areas are plated. In a bath-applied plate these operations would have required extensive masking and plating procedures on large parts.

The unique advantages of the Dalic process eliminate the difficulties presented by orthodox procedures, and make it possible to confine masking and plating operations to only the limited areas involved.

Re-entry vehicle shelf and canister components undergo the usual involved preparations for plating on aluminum prior to a zincate, low pH copper plate, and final cadmium plate. Subsequent operations on these components frequently remove or destroy the plate in given areas.

The ability to "spot" plate exactly where it is needed has enabled Lycoming to re-cadmium plate the selective areas without difficulty or undue expense, says its engineers.

Future applications such as Dalic tin plate on stainless steel followed by fluxing and soldering are contemplated by the division.

Custom Tool & Manufacturing Co., Minneapolis, had a particular problem with the gear ring used in a large guidance system. Made from 4140 steel, a 0.0003-inch plating of copper was needed in a circular groove (see accompanying photo).

Because of the extremely tight tolerance (±0.0005 inch), plating by conventional methods would have been nearly impossible. To avoid the heat problems, intricate masking requirements, and the inherent danger of hydrogen embrittlement, the Dalic method was used successfully by the company.

Goodyear Aircraft Corp. in Akron, Ohio, employed the process to plate nickel on mis-machined internal threads of missile valve components. Plating was continued on each piece until an accurate fit was accomplished.

The company said it has used the process to salvage over 200 costly missile components which were out of tolerance.

Others who are successfully using this unusual technique in their missile work include Boeing-Seattle Div., Lockheed Aircraft Corp., American Bosch Arma, etc. The National Aeronautics and Space Administration at Langley has been using the process to plate precious metals on portions of satellites and space vehicle hardware. ⌗

Every breakthrough in military electronic equipment design creates new, complex and urgent problems in installation, modification, testin maintenance and personnel training. Hallicrafters radical new "Blue Streak" project—utilizing quick-reaction techniques—*offers experienced Hallicrafters support teams to assist key military personnel . . .* pinpoints problems in advance . . . solves them on the spot with new levels of speed and economy.

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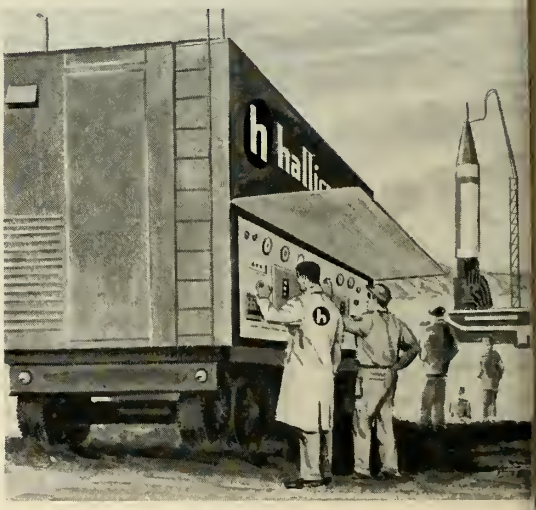

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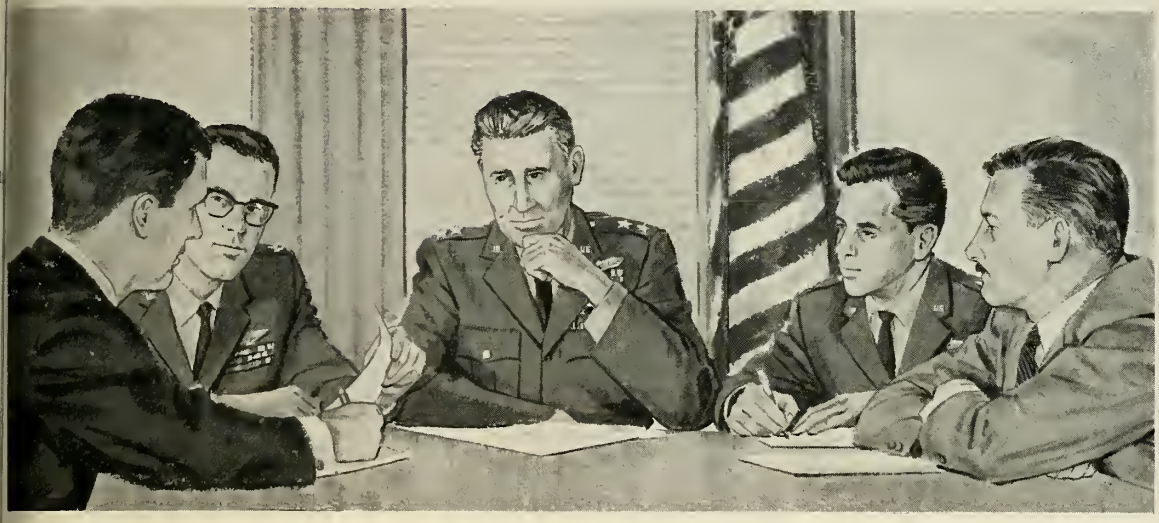

TEAMWORK IN MODIFICATION: Modernization of RF transmission systems completed in 30% less time through "BLUE STREAK" team assistance to base maintenance groups.

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Re-entry Drag Devices Studied

- *Decelerators expected to reduce the weight penalties suffered in thermal protection of returning vehicles.*
- *Ideal material is still being sought, and its fabrication into a deployable structure will present additional problems. List of potentials is growing.*

by Myron J. Coplan
Assistant Director
Fabric Research Laboratories, Inc.
Dedham, Massachusetts

SUCCESSFUL PERFORMANCE of space vehicles will depend as much on safe recovery as on flawless launching.

This is conspicuously true for manned space flights, where both moderated deceleration and soft landing are mandatory.

Examples of the latter situation include even lift-surface vehicles (e.g., *Dyna-Soar*), which will probably require a last-stage decelerator much like the now traditional drag 'chute for jet planes. Non-lift orbiters (e.g., *Mercury* capsule, *Discoverer* nose cone) obviously call for last-stage parachute descent even though re-entry may occur without the aid of auxiliary decelerating equipment.

Landing or final descent maneuvers involve much lower levels of thermal stress on the decelerator than would occur at hypersonic speeds. More or less conventional parachute materials seem capable of serving the purpose. This is simply because the bulk of the vehicle's kinetic energy would already have been converted to heat and dissipated by processes of radiation, or transpiration, at speeds and altitudes much higher than those involved in terminal deceleration.

But it may not be desirable for the vehicle itself to provide all of the drag. The lower the drag-to-weight ratio, the denser the atmosphere at which deceleration occurs, and the more severe the heat stress. Consequently, considerable weight penalties may be suffered to protect the vehicle with heat shields, ablative surfaces, transpiration cooling systems, etc. The alternative would be to spread out the aerodynamic drag forces over longer times, at higher altitudes, by means of a deployable, expandable drag device. This allows more favorable overall drag-to-weight ratio in the hypersonic flight regime. An ideal device would also function in terminal deceleration and escape in the vent of abortive launch.

A number of expandable decelerator concepts are under consideration and at various stages of development. It appears axiomatic, in view of their intended use, that these must be built to sustain stagnation temperatures of some magnitude. A peak temperature of about 1500-2000°F must be endured for times in the order of seconds to minutes.

Survival of the decelerator also depends on resistance to oxidation at the temperatures involved. Not only is O_2 present but also possibly atomic oxygen and ozone, and even oxygen dissociated in the shock.

• **Functioning structure**—At first glance 15-minute durability in an oxidative environment at 2000°F may not appear too formidable to a materials engineer. But when the requirements "deployable" and "expandable" are imposed, the situation acquires some intriguing complexities.

It will be appreciated that the drag device weight and bulk must be minimized prior to deployment. It must present a high drag surface in operation. The achievement of appropriate deformability and elastic recoverability calls for a low-rigidity material capable of being compacted without permanent set or damage. But thermally durable materials are generally characterized by high modulus and low yield or rupture extension.

One fortunate situation arises when peak deceleration is dictated by the tolerance levels of humans: the stress capabilities demanded of the decelerator are not inordinately high. For example, to exert a maximum deceleration of 10 g (near human threshold) on a two-ton vehicle requires a total force of 40,000 lbs. Distributed uniformly and tangentially on the perimeter of a 30-ft.-diameter hemisphere, this force results in a stress of on 40 lbs. per inch width.

Thus a foil only 1 mil thick cou sustain the peak load if it had a tensi strength of 40,000 p.s.i. at peak hea Since it happens that peak stress ar peak heat generally do not occur at th same point in time, there is a safe factor built into the calculation.

The drag device must have a hig emissivity. Essentially all the heat flov ing into the canopy, balloon, or un brella must be lost by radiation. Th light weight and low bulk of the dra device is such that heat-dissipativ tactics are difficult if not impossible.

It was inferred in the sample ca culation for stress that foil structure might be useful. Actually, design con siderations indicate that more nearl textile-like materials are desirable. Thes require fibers for their fabrication. Th range of potentially useful materia available in fiber form may be arb trarily classified as metallic, ceramic or carbonaceous.

Wire cloths of semi-conventiona type but composed of high temperatur alloy wires are being investigated a canopy fabrics for inflatable structures and as the membrane on a folding-stru umbrella system. All of these requir a flexible heat-durable coating to con trol or eliminate porosity.

The coated wire-cloth materials ar by no means ideally compactable an recoverable. The principal drawback i the limitation on the diameter of con ventionally wire-drawn filaments. Th ultimate structural unit would be bundle of wires, each wire being in the order of ¼ to ½ mil in diameter Strength, flexibility and recovery ca be achieved if the wire diameters ar fine and large enough bundles ar assembled.

Ceramic fibers, particularly con tinuous filament fused quartz, are avail

(Continued on page 63)

SPRINGBOARD FOR SPACE: LUNA

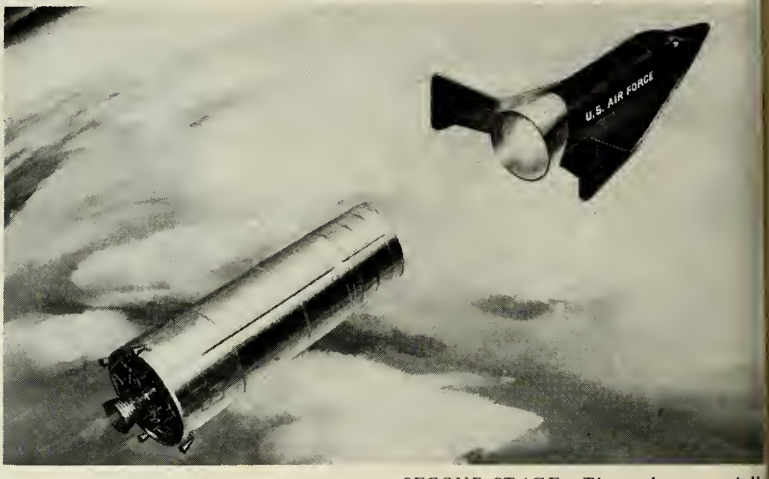
The moon is a ready-made space station for interplanetary exploration; space vehicles could be built, fueled, and launched there; lunar elements could be used to give man independence from earth. To help make this concept a reality, NAA's Missile Division has integrated the ideas of scientists in many fields and is studying how to reach the moon... how to live in its alien climate... how to process lunar matter. One example: a study of processes to obtain water from materials likely to be found on the moon.

THE MISSILE DIVISION OF NORTH AMERICAN AVIATION, INC.

Downey, California

Dyna-Soar Demands Exotic Materials

- *Performance requirements force designers into superalloys and refractory metals*
- *Ceramics confined to non-structural areas*
- *Detail components exert considerable influence*
- *Materials must match aircraft standards*



SECOND-STAGE Titan booster falls away in artists conception, leaving Dyna-Soar in piloted, near-orbital flight.

by M. A. Nelson

Chief, Dyna-Soar Structures Technology
Aero-Space Division
Boeing Airplane Company

THE EXTENT TO which construction materials can withstand widely varying thermal environments must obviously be a major controlling factor in the re-entry performance of space vehicles.

This is equally true for pure ballistic, pure glide, or combinations of these. An intense, short-term thermal environment is characteristic of ballistic re-entry; glider-type vehicles experience relatively long heating periods of lesser intensity.

Space missiles of several varieties have demonstrated the capability of materials systems to survive a single ballistic re-entry, but re-entry vehicles based on the glide concept are in the early stages of development. The *X-15* program is providing an initial step in the exploration of the fringes of manned glide re-entry. The *Dyna-Soar* program will continue and extend this exploration.

The thermal environment associated with a space vehicle such as *Dyna-Soar* is the paramount reason why materials engineers and designers are being forced to turn to materials and methods of construction which are new to aircraft applications.

• **Other effects**—But we must also recognize the numerous attendant effects of hypervelocity flights within and outside of the earth's atmosphere. Oxidation and erosion of materials used for the external surface of the vehicle is accelerated by high-velocity air, high structural temperatures, micrometeorite abrasion, and ionized and dissociated gases. The near-vacuum conditions encountered in orbit affect the properties of many materials, causing certain metals to become stronger and less ductile, conventional lubricants to evaporate, and thermal insulations to improve in efficiency. For orbits beyond a few hundred miles, the degradation of effects of cosmic radiation on organic materials must be considered.

Secondary radiation from certain materials, resulting from impingement of cosmic radiation, can be deleterious to humans and equipment. The combined effects of these and other pertinent operational environments must be given attention before the final selection of materials of construction for re-entry devices.

Before the Space Age, the aircraft designer had access to a large selection of thoroughly tested materials for structural applications. Here the principal considerations were strength, weight, reliability and economy.

• **Exotic materials common**—The demands for increased performance from re-entry vehicle materials have focused the designer's attention on such nonconventional aircraft structural materials as the superalloys, refractory metals, cermets, ceramics and various composites.

The high nickel- and cobalt-base superalloys retain usable strength up to 2000°F. These alloys suffer rapid surface oxidation above 1300°F, with certain alloys tending toward intergranular oxidation. The surface oxidation can be adherent, however, with a tendency to prevent further oxidation while also providing a desirably high-emissivity surface. Intergranular oxidation, on the other hand, adversely affects both the strength and ductility of the metal.

With the exception of Inconel X structure such as that used on the *X-15*, fabrication of aircraft-type hardware from superalloys has been accomplished only on an experimental basis. In fusion welding of superalloys, considerable attention is being directed toward attaining the filler wire selection, welding control and heat-treatment processing necessary to produce ductile welds of aircraft quality.

Industry experience in the production of superalloy materials has likewise been limited, and using contractors therefore find problems in obtaining material in production quantities which possess consistent mechanical properties. This is notably true for sheet gages less than 0.020 inches and

(Continued on page 54)

FORECAST

Major space age role for fluorine rocket fuel oxidizers

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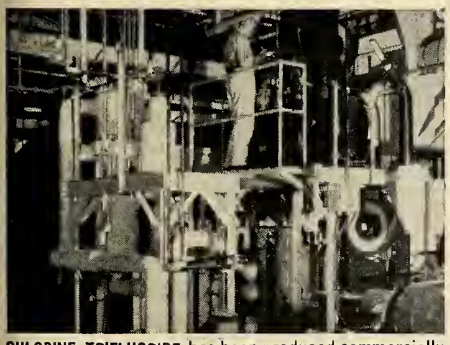
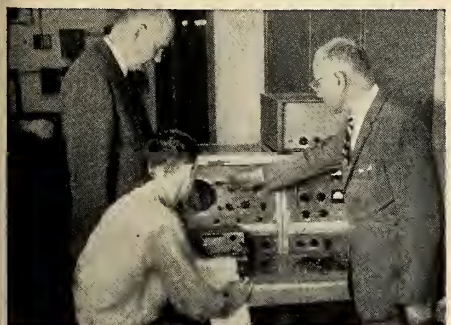


CHLORINE TRIFLUORIDE has been produced commercially by General Chemical for the past 10 years. Reactors like this one, located at General's Baton Rouge Works, have a capacity of more than 100 tons of CTF per year.



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If you would like technical data, we will be glad to send you our free bulletins, "Fluorine" and "Chlorine Trifluoride." Simply request them on company letterhead.

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Prime Contractor: Boeing Aircraft Co. Booster Contractor: Thiokol.

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Rocket Operations Center: Ogden, Utah
Bomarc B motors produced at the Utah Division

Materials Gap Gets Worse

(Continued from page 27)

be the key to important technological advances leading to improved defense systems. Basic knowledge of what makes materials strong, ductile and brittle in crystalline, foamed, filament- and particle-reinforced and laminated structures concerns the solid state mechanics of matter.

Individual experiences with metals, ceramics and plastics have served to re-emphasize the importance of a materials-science approach. Basic understanding of the fundamental behavior of materials has benefited when the two fields have shared knowledge.

• **Molecular understanding**—In the final analysis each materials discipline must concern itself with the aggregation of atoms and their growth into a structure, identification of what constitutes and determines a perfect and what an imperfect structure, and ho a bulk solid is thereby constructed.

The physical metallurgist is famili with nucleation and growth, crys structure, impurities and imperfectio and microstructure, because these search subjects have occupied h interest in understanding basic me and alloy behavior. A similar approa to ceramics and plastics has clear shown the long-term value of bas materials research in solving o engineering materials problems.

In summary, knowledgeable app cation and development of materia for current engineering problems c best be achieved through the establis ment of a materials technology who precepts are well founded on a fund mental understanding of matter.

Re-entry Taxes Structures

(Continued from page 50)

for standard shapes and parts as fasteners, angles and tubing.

Above 2000°F the refractory alloys such as columbium and molybdenum are the only metals which are currently available and suitable for airframe applications. Alloys of both these materials require oxidation-resistant coatings. These coating processes are generally involved and difficult to apply to complex structural components. For the time being, therefore, the designer is limited to relatively small, simple components if his coating application is to be reliable in all respects.

Coating processes which require diffusion of a dissimilar material into the surface of the refractory metal may embrittle and reduce the strength of the refractory base metal. If the refractory base is welded, embrittlement may also occur, due to recrystallization in the heat-affected zone or absorption of gases into the weld. Truly reliable coating and welding of refractory alloys will emerge when adequate process controls are developed.

• **Ceramic potentials**—For the extreme temperature areas of re-entry vehicles (such as at the stagnation regions), the high-temperature ceramics, cermets and composite metal-ceramic structures display better survival characteristics. The inherent lack of ductility, sensitivity to thermal shock and low strength exhibited by most of these materials has forced the designer to re-orient his thinking away from conventional design practices.

In general, it has been found desirable to restrict the use of these materials to applications which are no structural in nature.

Detail components essential to t fabrication of the structure—such bearings, mechanical fasteners, lubr cants, seals, insulations and transpa ents—can exert considerable influen on the structural concept, arrangemer and fabrication of the total vehicl Blind fasteners are not now availab in the high-strength superalloys or r fractory alloys. Ordinary windshie materials common to present-day ai craft will not meet re-entry vehic design requirements for optical m terial. A shift to higher temperatur capability materials such as pure quar is necessary.

Continued development is require for seals, sealants and insulations wit varied thermal capabilities, from nea room temperature in crew and equi ment compartments to the extern high-surface temperatures for aer dynamic sealing.

• **Triple threat design**—The cha lenge to re-entry vehicle structural d sign and construction is essential threefold. The structural designer mu learn to arrange new materials of co struction into concepts and arrang ments which are foreign to conve tional aircraft structures. The metho of producing these materials in nece sary shapes, forms and sizes must b further developed in order to atta accepted aircraft quality standard Finally, the processes for fabricatir these materials into reliable structur components must be continuously in proved and refined.

1. RCA IMAGE ENHANCEMENT SYSTEM produced this high-quality 1000 TV line resolution image from an original aerial photograph.

2. ELECTRONIC DIFFERENTIATION OF ORIGINAL PHOTO gives a three-dimensional appearance useful in synoptic observations.

RCA Image Enhancement Techniques

Give New Dimension To Visual Data

3. ELECTRONIC SLICING CONTRAST STRETCH in the intermediate level is an enhancement technique useful in object recognition.

◀ RCA Imagery Simulator and Enhancement Console

Image Enhancement, a new approach to photo interpretation developed by RCA Astro-Electronics Division, brings out hidden information from visual data. The RCA Image Enhancement Console quickly makes visible a wealth of information the unaided eye might not discern, by electronically emphasizing and/or de-emphasizing selected qualities inherent in any pictorial presentation.

Here are some of the ways the RCA Image Enhancement techniques aid image interpretation and information extraction:

- **SLICING**—Contrast "stretch" or video slicing provides increased contrast in a desired portion of the gray-scale transfer characteristics. It gives new vividness to selected details.
- **OUTLINING**—This produces an outline or contour of constant intensity, and of either polarity, along the loci of a selected video gray level. It emphasizes lines or areas of equal brightness quickly and is especially useful in delineating nebulous objects such as cloud formations.
- **DIFFERENTIATION**—This technique extracts interesting bas-relief effects and three dimensional light and shadow effects from pictorial information. It facilitates synoptic observations.

Image enhancement techniques are currently in experimental use. Applications in meteorology may include aid in interpretation of cloud cover photographs such as were taken by Tiros I. Enhancement techniques can aid in interpretation of all photographs taken during aerial and space reconnaissance missions. Unique image sensing methods such as radar, infrared and ultra-violet may benefit by enhancement. Medical and industrial x-ray analysts are extremely interested in the advantages which image enhancement may offer. Astronomers feel that these techniques will aid in their interpretation of photographs of the heavens. New applications are constantly being considered.

If you would like to fully explore the unique capabilities of the RCA Image Enhancement techniques, RCA's Space Center will welcome the opportunity to discuss them with you. Contact the Marketing Manager, RCA Astro-Electronics Division, Princeton, New Jersey.

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General Electric Silicone Rubber finds dozens of uses in missile systems. How many more will prove vital?

General Electric silicone rubber has the "thermal toughness" to stand up under the searing heat of rocket blast-off or possible atomic attack. Add very good electrical properties and excellent resistance to aging, weathering, moisture, flame, ozone and corona and you can easily see why silicone rubber is now being used in virtually every U.S. missile and space vehicle.

Since both space technology and silicone rubber are relatively new, General Electric believes there are many more areas not yet explored where silicone rubbers can help keep a missile functionally reliable and combat-ready. To help designers in their evaluation work, we list here the principal properties and applications of G-E silicone rubber.

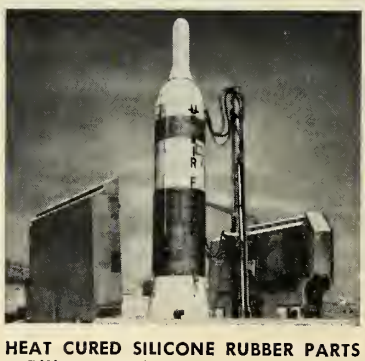
RTV LIQUID SILICONE RUBBER — One of the most versatile materials developed in recent years, RTV is a liquid rubber that cures at room temperatures. Like all silicone rubber, it remains flexible over a wide temperature range and is virtually ageless. Since it comes in a wide range of viscosities, it can be poured, sprayed, dipped, painted or applied with a pressure gun or spatula. It bonds tightly to metal when a primer is used. When not primed, you can readily remove RTV and then reapply more. You can impregnate tightly wound coils with RTV or form sections several inches thick.

You can control cure time from two minutes to 24 hours. These are RTV's typical properties:

Viscasity	from 120 poises (very pourable) to 12,000 poises (paste)
Specific Gravity	1.2 to 1.5
Solids Content	100%
Shrinkage	0.2%
Heat Resistance	from —90°F to 600°F, and as thermal insulation, in 5500°F flame for minutes
Ozone Resistance	Comparable to Mica
Electrical Properties	See last table

Applications—RTV is used as a high temperature structural sealant in missiles, satellites and space vehicles. It is used to pot and encapsulate electronic components and assemblies for electrical and heat insulation and for protecting delicate components from physical damage. It is commonly used as an impregnating insulation in transformer coils, to pot and hold cable in raceways and to pot cable breakouts. You can make flexible molds with RTV and hence make accurate, duplicate castings from originals.

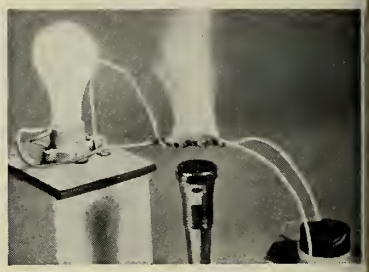
RTV is an excellent thermal barrier and as such is applied on and around missile nozzles. Tests show RTV's resistance to flame temperatures as high as 5500°F for several minutes. RTV also functions as a flexible ablative material and is used around probe holes, along raceways, and between stages and structural joints on the missile skin.



HEAT CURED SILICONE RUBBER PARTS —Silicone rubber gaskets, port seals, O-rings, shock mounts and other mechanical parts are not only used on missiles but have wide application in ground support equipment. For instance, missile silo doors use silicone rubber seals that will stand up to outside weathering, ozone and abuse for years and which will also resist the heat of missile launching and nuclear attack. Silicone rubber also resists brief exposure to cryogenic materials.

Silicone rubber has long-lasting temperature resistance from —150°F to 600°F, with excellent electrical, weathering, ozone, corona, radiation and non-aging properties at these temperatures. High tensile strength and low compression set are also within its range of desirable properties:

Tensile Strength, psi	800—1500
Elongation, %	100—600
Hardness Durometer (Shore A)	25—80
Compression Set, %	10—80
Tear Resistance lb/in	40—200
Radiation Resistance	1×10^8 roentgens
Electrical Properties	See table below



WIRE AND CABLE INSULATION — The long term reliability of silicone rubber when operating in high ambient temperatures and when current over-loads cause the conductor to approach 500°F is an important feature of silicone insulation. In an 1800°F flame, specially constructed silicone rubber insulated cables will continue to insulate for hours, forming a non-conductive ash that gives off no toxic fumes. And short term reliability is obtained even when silicone rubber is exposed momentarily to a direct flame of 5500°F.

Because of this excellent heat resistance, more current can be carried than in conventional cable (or smaller cable can be used). Other features: best compression set of all elastomers at temperature extremes, so that silicone rubber wire and cable does not deform under clamps; high ozone, corona, radiation and weather resistance, low moisture absorption, flexibility down to —100°C. These are the typical properties:

Volume Resistivity	10^{15}—10^{16}
Dielectric Strength, volts/mil	600—650
Dielectric Constant, 60 cps	3.0
Power Factor	.0010—.0050
Radiation Resistance	1×10^8 roentgens
Physical properties	Similar to table above.

Applications—Wiring harness made of silicone rubber insulation is often found throughout missiles. Cable offers added reliability for use in various places throughout the launch complex below ground from power plant to silos. All combat vessels built for the U.S. Navy during the last ten years, including fleet ballistic missile submarines and the new nuclear-powered cruiser and aircraft carrier, have silicone rubber insulated cable installations in all fixed wireways. In every case, silicone rubber is chosen because it is virtually non-aging, stands up to intense heat better than any other flexible insulating material, and continues to operate even when subjected to fire.

●

There are many more places where G-E silicone rubbers' inherent properties can be vital in missiles, satellites and space vehicles. For further data, call your nearest G-E sales office or write Section 01133, **Silicone Products Department, General Electric Company, Waterford, New York.**

Progress Is Our Most Important Product

GENERAL ELECTRIC

Tiros II Will Bring Weather Satellite Speedup

Success of Nov. 23 launch causes NASA to reconsider present plans; Soviets bid for 'joint project'

BROADENING AND SPEEDING of the U.S. weather satellite program is in prospect as a result of the success of *Tiros II*. Meanwhile, the Soviets are trying to promote a cooperative international weather satellite program.

Dr. Morris Tepper, chief of meteorological satellites for the National Aeronautics and Space Administration, said after the Nov. 23 launch that plans for one more *Tiros* in 1961 and a series of four *Nimbus* satellites beginning in 1962 were "as of before 6:13 this morning" and will be reconsidered.

Tepper did not elaborate on how the program could be speeded. He conceded that lead time built into the procurement schedule will make it difficult to accelerate the *Nimbus* launch. NASA will request bids on a *Nimbus* prime contract in the next week or so, he said, and will need three or four months to get a contractor aboard.

The NASA weather chief said he has no objection to a system of international sponsorship and control apparently sought by the Soviets and added, "It would be a wonderful thing for meteorology."

• **Russian Proposal**—In a paper issued by the Soviet Embassy on the same day as the *Tiros* launch, Prof. G. Pokrovsky, a Soviet space scientist, proposed a worldwide system of weather satellites as "a joint project for all countries."

Dr. Francis W. Reichelderfer, Chief of the U.S. Weather Bureau, reported that Soviet meteorologists had shown great interest in *Tiros I* data when he showed it to them at a meeting of the World Meteorological Organization in Geneva last summer. Reichelderfer said he gained the impression that the Soviet space program did not include meteorological satellites at present.

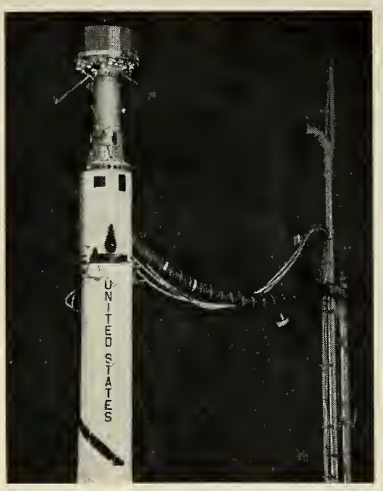
• **Tiros Changes**—First information from the instruments aboard *Tiros II* was that all were working well with the possible exception of the wide-angle television camera. Quality of the first wide-angle pictures was not as good as those from *Tiros I*.

Tiros II differs from the first weather satellite, launched April 1, in two major respects. The new 280-lb. satellite, 10 lbs. heavier than the original *Tiros*, carries infrared observation to measure the amount of solar heat absorbed and reflected by the earth, to provide a new tool for understanding the weather.

A second difference is a wide program to test and evaluate cloud cover maps as an aid to operational military and civilian forecasting. The program is still an experiment, but it is an experiment in the practical use of the cloud data.

The infrared equipment consists of two experiments. The first, which scans by a combination of the satellite's rotation and motion of the satellite in its orbit, consists of five sensors. These measure earth albedo at 0.2-5 microns, radiation of earth and atmosphere together in the 7-30+ micron range, earth radiation in the 8-12 micron "window," 6.3 micron water vapor radiation from 25-30,000 ft. altitude and a 0.5-0.7 micron visual channel.

The second IR experiment has two sensors, one white and one black,



TIROS II weather satellite awaits launch from Thor-Delta at the Cape.

which measure the total heat balance of the area viewed by the wide-angle TV camera. The TV cameras, one covering an area 100 miles wide and one covering 800 to 1000 miles, are similar to those on *Tiros I*.

To provide a calibration of the IR data, identical IR experiments were launched by a balloon from

Sioux Falls, S.D., a few hours before *Tiros II*. The balloon, which apparently became caught in the jetstream, caused a rash of UFO reports throughout the Midwest.

• **Not a missile spotter**—The IR equipment aboard *Tiros II* would be of no value for detecting missile launchings, NASA's John W. Townsend declared, because its resolution of five degrees means that any individual signal covers an area of 900 square miles. Even the largest rocket would not radiate enough heat to be detected against the background level from such an area, he pointed out. And, as they said at the time of *Tiros I*, NASA spokesmen repeated that the resolution of the TV cameras would be no help toward military surveillance. Resolution of the narrow-angle camera is 0.2 mile per TV line.

The Weather Bureau is using its National High Altitude Facsimile Network to transmit the so-called Neph Analyses—maps of cloud cover superimposed on regular weather maps. Production of the Neph analyses was to begin within three or four days after launch, after exact information on the satellite's attitude, spin rate and orbital elements were obtained.

Military weather services will also make widespread use of the maps.

Another new item aboard *Tiros II* is a magnetic orientation control. After some time in orbit, the satellite precesses *Tiros II* carries some loops of wire for setting up magnetic fields that can be activated by ground command to interact with the earth's magnetic field and return the space-craft to the desired orientation.

The satellite, shaped like a pillbox, measures 42 in. in diameter and 19 in. high, and is covered with more than 9000 solar cells to power five transmitters and other equipment. The initial orbit, with apogee of 431 statute miles and perigee of 406 miles, was the most nearly circular orbit ever achieved. Period is 98.2 minutes, and inclination is 48.3°.

Astro-Electronics Division, RCA, designed and constructed *Tiros I* and *II*, and was responsible for special ground equipment, Barnes Engineering Co. provided the IR detectors. Douglas Aircraft Co. manufactured both stages of the *Thor-Delta* launch vehicle, with Rocketdyne first-stage engine, Aerojet-General second-stage and Bell Laboratories command guidance, using a Remington Rand Univac computer.

The Army Signal Corps Research and Development Laboratory, Ft. Monmouth, N.J., and the Navy's Pacific Missile Range at San Nicolas Island, Calif., operated the two ground stations. RCA has a backup ground station at Princeton, N.J. ⁂

—contracts—

NASA

Westinghouse Electric Corp., Pittsburgh, for supplying a high-energy arc heater to be used in a wind tunnel at Moffett Field. Amount not disclosed.

$270,850—Controls for Radiation, Inc., Cambridge, Mass., for operational services at Plum Brook Nuclear Reactor Facility near Sandusky, O.

NAVY

General Electric Co., Lynn, Mass., for conducting studies on the use of a lightweight gas servo system for thrust vector control for the *Polaris*. Amount not disclosed.

$26,000,000—Bendix Corp., Bendix System Div., Ann Arbor, Mich., for continued development and evaluation of the *Eagle* missile.

$8,000,000—Vitro Laboratories, Silver Spring, Md., for continued coordination and testing of *Polaris* weapon systems on nuclear-powered submarines.

$885,000—Vitro Electronics Div. of Vitro Corp. of America, for a portion of the systems engineering and instrumentation of two Victory ships being demothballed for tracking duty with the PMR fleet.

$194,177—University of Southern Calif., Los Angeles for design and production of a high-altitude environmental test chamber.

AIR FORCE

$2,300,000—Westinghouse Electric Corp., Pittsburgh, for continued development of molecular electronics systems.

$1,150,853—Goodyear Aircraft Corp., Akron, O., for additional contractor maintenance work and supplies for the TM76A *Mace* missile program.

$1,000,000—Magnavox Co., Ft. Wayne, Ind., for components of AN/ARC-34 radio sets plus spare parts and ground support equipment.

$666,000—The Twin Coach Co., Buffalo, for electronic consoles for the *Hawk* system. Subcontract from Raytheon Co.

$400,000—American Brake Shoe Co., Kellogg Div., Oxnard, Calif., for hydraulic pumps for the GAM 77 *Hound Dog*. Subcontract from North American Aviation's Missile Division.

$151,000—Minneapolis-Honeywell Regulator Co.'s Special System Div., for development and production of guidance compartment cooling systems for the *Minuteman*. Subcontract from North American Aviation, Inc.

ARMY

$5,375,000—Goodyear Aircraft Corp., Akron, O., for continued *Nike-Zeus* research and development.

$4,947,000—Food Machinery and Chemical Corp.'s Ordnance Div., San Jose, Calif., for design and development of the *Mauler's* vehicle and pod assembly.

$4,920,002—Thiokol Chemical Corp., Bristol, Pa., for continued production of rocket motors.

$3,267,396—Raytheon Co., Waltham, Mass., for engineering services on the *Hawk* missile system. (Two contracts).

$1,995,000—RCA's Defense Electronics Products Div., Moorestown, N.J., for fabricating the new missile tracking equipment for a missile tracking and measurement vessel.

$1,118,934—Intercontinental Manufacturing Co., Garland, Tex., for manufacturing metal parts for rocket motors.

$330,000—Raytheon Co., Waltham, for *Blue Streak* emergency replenishment repair parts, *Hawk* missile system.

MISCELLANEOUS

$1,643,000—Grumman Aircraft Engineering Corp., for modification of the SA-16 *Albatross* for use as an antisubmarine warfare aircraft.

products and processes

Epoxy Hermetic-Seal Bushings

Designed for solder-in installation into hermetically sealed metal equipment enclosures, Model M-1003 Hermetic-Seal Feed-Through Bushings constructed of solid cast-epoxy resin, are available from Components For Research Inc. Having no internal voids to be filled with oil, they can be mounted in any position.

Model M-1003 is capable of corona-free operation at 40 kv and ha a peak pulse operating level of greate than 70 kv for air-to-oil, or 140 k oil-to-oil, operation. Flashover is 6 kv positive DC.

Epoxy construction also contribute a thermal-shock resistance range fror −60 to +175°F, the small over-a length of 5 in., and the low weigh of 16 oz.

Circle No. 225 on Subscriber Service Card.

Air Conditioning Unit

A compact, high-capacity air conditioning unit, designed for integral mounting in electronic racks, is available from Ellis and Watts Products, Inc.

The Model RBM100 cooler provides automatic removal of condensate, requiring no drain line. All motors operate continuously to eliminate voltage fluctuations. Supply air temperature is controlled with an adjustable, hot-gas by-pass regulating valve. Provision is made for either vertical or horizontal supply air discharge—changeable in the field.

Circle No. 226 on Subscriber Service Card.

Valve Operation Analyzer

An automatic device for the exact measurement of time intervals in sequential operations of solenoid or relay-actuated components or systems has been introduced by Consolidated Avionics Corp. The unit also provides "position-versus-time" plots for such operations as linear or non-linear valve motion.

Known as a Valve Operation Analyzer the unit measures time interval as short as 0.1 millisecond and pre sents the readings visually. As many a 12 sequential events occurring within three-second time span can be auto matically timed.

Circle No. 227 on Subscriber Service Card.

Rotary Indexing Table

The "Milichex" rotary indexin table Model M2X-900 for fractions o angles is available from Michigan Too

Co. A double-table arrangement allows setting angles to quarter degrees with accuracy of ¼ second of arc. Useful for either inspection or machining, the table eliminates gage blocks and permits unskilled operator to quickly set and reproduce any angle in increments of 15 minutes.

Circle No. 228 on Subscriber Service Card.

Solid-State Commutator

A solid-state switching device, available from Electronic Systems Development Corp., samples data from multiple sources on a time-sharing basis. Output can be applied to a single input of recording equipment, indicating equipment or data transmitting link such as a single telemetry sub-carrier channel.

The "Series ES/35" unit is supplied in standard scan rates of up to 25 KC, and different models can accommodate from 2 to 100 channels. Linearity is within ±0.1% deviation from straight line; contact resistance 25 ohms max.

Circle No. 229 on Subscriber Service Card.

RF Frequency Voltmeter

An RF millivoltmeter which measures RF voltages from 1 millivolt to 10 volts at frequencies up to 1,000 MC is available from Hewlett-Packard Co. Readings are virtually free from the temperature effects normally associated with sensitive RF meters. Model 411A is compact and includes two linear voltage scales in a 1:3 ratio.

Circle No. 230 on Subscriber Service Card.

Printed Circuit Connectors

The Electronics Division of DeJur-Amsco Corp. has available a series of printed circuit continental connectors with beryllium copper contacts.

Designated Series 600-120, these

units have dual terminations and bifurcated "Bellowform" contacts for 1/16 in. printed circuit board or tape cable. They are available in 6, 10, 15, 18, 22, 28, 43, 48, 58 and 105 dual contact sizes (or an equivalent of 12 through 210 terminals), and a choice of three mounting styles.

Circle No. 231 on Subscriber Service Card.

Numerical Control

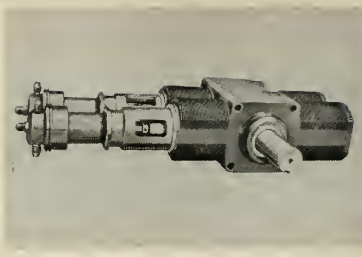
General Electric is marketing a numerical control system for metal-working machines which will make punched-tape programming as simple and economical for contouring operations as for standard positioning.

Modular, compact design of the control will simplify both installation and maintenance. All electrical circuits incorporate printed circuit boards in plug-in modules, instantaneously removable for easier maintenance.

Circle No. 232 on Subscriber Service Card.

Lightweight LOX Pump

A high-pressure pump for low boiling point liquefied gases, such as argon, oxygen, nitrogen and liquid hydrogen is available from Paul Chemical Co. Tipping the scales at 30 lbs., the pump provides the same standards of performance and reliability as high-pressure pumps designed for equivalent work loads, but weighing up to 900 lbs. The need for external support equipment such as lubrication pump, filter and reservoir, cooler, fan, etc., has been eliminated.



Circle No. 233 on Subscriber Service Card.

Strain Gage with Readout

Statham Instruments, Inc. has introduced a resistance strain gage, Model SG2, with a complementing portable bridge control readout, Model BCR1-O.

The Model SG-2 resistance strain gage is designed for repetitive measurement of strain or unit elongation. It incorporates the Statham zero-length unbonded strain gage, and has strain or elongation sensed between two fixed knife edges and one movable knife edge.

Circle No. 234 on Subscriber Service Card.

new literature

T & P CONTROLLERS—A 6-page Catalog J-C describes the pneumatic pressure and temperature controllers available from OPW-Jordan. The brochure describes features and accessories, and gives dimensions, specifications, materials of construction and complete engineering information.

Circle No. 200 on Subscriber Service Card.

UNITIZED CHECK WEIGHING SYSTEMS—A bulletin on check-weighing systems has been published by Weighing & Controls, Inc. The systems covered in the bulletin can be applied to all types of dry or liquid, single- or multi-unit containers to provide a continuous check on the filling accuracy of packaging equipment.

Circle No. 201 on Subscriber Service Card.

METAL PROCESSING—Phoenixspun Powerspinning, a new development in metal processing is described in a bulletin published by the Metal Spinning Division of Phoenix Products Co. The Phoenixspun method makes possible the economical and highly accurate spinning of even the toughest alloys . . . chrome-moly steels, the stainless steel alloys, titanium, high-strength aluminum alloys, etc., in thicknesses up to 2 in. and diameters of 170 in.

Circle No. 202 on Subscriber Service Card.

BROACHING MACHINES—A 6-page brochure issued by the Foote-Burt Co. describes their line of continuous horizontal surface broaching and vertical surface-broaching machines. The bulletin illustrates a number of typical parts produced more rapidly and economically by broaching than by any other method.

Circle No. 203 on Subscriber Service Card.

DATA DIGEST—Laboratory for Electronics, Inc., has published a new Technical Data Digest describing the company's capabilities in airborne doppler navigation systems. The eight-page, illustrated brochure details specifications of these equipments, including system philosophy, operational capabilities and performance, and various models of the Doppler Navigators produced.

Circle No. 204 on Subscriber Service Card.

STEEL CASTINGS — Lebanon Steel Foundry has published a bulletin on precision steel castings, produced in ceramic molds. The bulletin describes the relative advantages of process and illustrates examples and applications.

Circle No. 205 on Subscriber Service Card.

Re-entry Drag Devices

(Continued from page 48)

able as yarns suitable for the flexibility requirements. However, low rupture elongation and sensitivity to abrasive damage make this material difficult to fabricate and may well interfere with compactibility. Graphite cloths, leached glass cloths, non-woven and woven staple fibers of a variety of oxides are also available. But these also tend to suffer from friability, and low flex and abrasion resistance.

The list of potentially useful materials is growing. Many of the new alloys, fiberized ceramic materials or graphitic fibers could be the ideal material, provided suitable structural designs and fabrication techniques are developed. "Whiskers" seem to be naturally adaptable for the job, but quantity production represents a considerable problem.

Research is continuing but is still some distance from developing the ideal material for expandable drag devices. The additional problems of fabricating the material into a structure (joints, seams, hinges, etc.) has also to be tackled. Intensive effort is required in both areas. ⁂

—when and where—

DECEMBER

IRE Professional Group on Vehicular Communications, Sheraton Hotel, Philadelphia, Dec. 1-2.

American Institute of Chemical Engineers, Statler Hotel, Washington, D.C., Dec. 4-7.

Electronics Industries Association, Third Conference on Maintainability of Electronic Equipment, Hilton Hotel, San Antonio, Tex., Dec. 5-7.

ARS Annual Meeting and Astronautical Exposition, Shoreham Hotel, Washington, D.C., Dec. 5-8.

National Conference on the Application of Electrical Insulation, Conrad Hilton Hotel, Chicago, Dec. 5-8.

American Nuclear Society, Mark Hopkins Hotel, San Francisco, Dec. 11-14.

International Scientific Radio Union (URSI), IRE Fall Meeting, NBS Boulder Labs, Boulder, Colo., Dec. 12-14.

Industrial Building Exposition and Congress, Coliseum, New York City, Dec. 12-15.

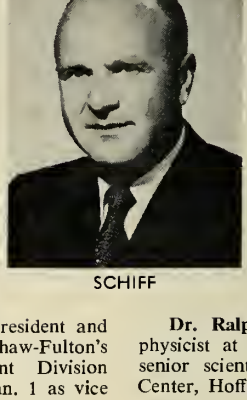
Annual Eastern Joint Computer Conference, Hotel New Yorker and Manhattan Center, New York City, Dec. 13-15.

Atomic Industrial Forum, Annual Conference, Fairmont Hotel, San Francisco, Dec. 14-16.

Institute of the Aeronautical Sciences, Wright Brothers Lecture, Smithsonian Institution, Washington, D.C., Dec. 17.

names in the news

WEHRLI



SCHIFF

STONE

Robert L. Wehrli: Vice president and general manager of Robertshaw-Fulton's Aeronautical and Instrument Division moves to Richmond about Jan. 1 as vice president and assistant to the president. **Raymond H. Heller,** director of field engineering and sales, moves up as general manager of the Aeronautical and Instrument Div., effective immediately.

Dr. George K. Chacko: Former operations research analyst for Atlas Powder Co., appointed manager of operations research for the Semi-conductor Division of Hughes Aircraft Co.

Donald E. Sweet: Senior engineer at the Electronic Engineering Co. of California, named staff engineer. Prior to joining the firm in 1956, he was an instructor in *Nike* computer operations at the Army's Redstone Arsenal.

Harry L. Stamm: Selected as manager of applications engineering section for the Trimpot Division of Bourns, Inc. Stamm and his staff of six application engineers will be responsible for technical liaison with sales engineers and customers.

Robert Poet: Appointed general sales manager of Telecomputing Corp.'s Narmco Industries' Materials Division, in charge of sales and marketing activities.

Hans M. Schiff: Joins Packard Bell Electronics Corp. as general manager of the Technical Products Division, succeeding **Richard B. Leng,** who earlier this year was named group vice president of the Defense and Industrial Group. Schiff was formerly operations manager of Ryan Aeronautical Co.'s electronics division.

Robert L. Eichberg: Former assistant to the president of Avco Corp.'s Research and Advanced Development Corp., joins Stromberg-Carlson's Electronics Div. as system program manager.

James C. Smith, Jr.: Elected director of Chrysler Corp.'s Advanced Projects Organization. He joined the company in 1956 as chief engineer of Marine Missile Systems and in 1957 was named Missile Division's chief project engineer in charge of engineering program management of the *Redstone* and *Jupiter* missile systems.

Dr. Ralph P. Ruth: Former projec physicist at the Bendix Corp., appointe senior scientist at the Hoffman Scienc Center, Hoffman Electronics Corp.

Richard L. Stone: Named manager sales for the General Electric Special Pro grams Section in Radnor, Pa. Was for merly an advanced program plannin specialist for the section and prior to tha project engineer with the company's Mis sile and Space Vehicle Dept. assigned t ICBM and IRBM nose cone development

Jackson Dies in Crash

Col. Nelson P. (Pete) Jackson (USAF-ret.), President and one of the founders of the National Rocket Club, was killed on Nov. 13, when the light plane he was piloting crashed into Spruce Knob, southeast of Elkins, W Va.

Mr. Jackson, who was manager of Joy Manufacturing Co.'s Washington office, was on his way to the firm's New Philadelphia, Ohio, plant. Prior to joining Joy, he handled nuclear activities in Washington for the General Electric Co. A West Point graduate, he commanded the 64th Fighter Wing during World War II, and was awarded 19 decorations.

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ADVERTISERS' INDEX

EMPLOYMENT

Meetings in Europe Affect U.S. Defense

STRANGELY ENOUGH, many of the events which will greatly affect and help to shape U.S. foreign and military policies for the next four years of the Kennedy Administration are now being worked out in Europe.

Directly or indirectly, these events will have a strong bearing on American spending abroad, for arms and other commodities. They will affect our Congressional attitude on sharing nuclear secrets, and even affect any revision of the Atomic Energy Law. They concern our association with NATO and other European international organizations.

Last week Secretary of Treasury Robert B. Anderson and Under Secretary of State Douglas Dillon visited Bonn to confer with Chancellor Adenauer. Object: to persuade Adenauer to increase Germany's contribution to joint defense—and thus decrease ours.

The old Organization for European Economic Cooperation, which has quietly occupied the Chateau Muette on the edge of the Bois de Boulogne in Paris since the advent of the Marshall Plan, is being changed to the Organization for Economic Cooperation and Development.

The U.S. was an associate member of the OEEC. We will be a full member of the new OECD (17 European members, Iceland, Canada and the U.S.). Object: to cooperate on general economic and business policies, expand aid to undeveloped countries and expand trade generally.

One of the men sent to see Adenauer—Douglas Dillon—is also the father of OEDC. He is being mentioned for a post in the Kennedy government, possibly as Secretary of Treasury.

On December 5, France, West Germany, Italy, Belgium, the Netherlands and Luxembourg will meet in Paris for a "little summit." Object: to consider establishing their own mutual defense grouping outside NATO.

These are the six nations associated in the Common Market. De Gaulle advocates establishing national forces on an integrated plan as opposed to integrated forces under NATO. Adenauer opposes. The U.S., although not participating, will watch it closely—because if the De Gaulle sentiment carries it could seriously undermine or destroy NATO.

On November 26, a group from the Joint Senate-House Committee on Atomic Energy was to leave for an inspection tour of U.S. military installations in Europe. Object: to determine if the present handling of nuclear weapons abroad is within the spirit and intent of the Atomic Energy Law. Their findings will inevitably affect their attitude toward any request to amend the measure if there is a move to provide nuclear arms to NATO.

Vice President-elect Lyndon B. Johnson headed up a Congressional group which went to Paris for a NATO Parliamentarians Conference opening last week. In the Johnson party was William Fulbright, the Democratic Senator from Arkansas who has been prominently mentioned to fill the post of Secretary of State. While this Conference has no concrete authority, it obviously has tremendous influence.

And, on December 16, the Foreign and Defense Ministers of NATO will meet in Paris. Object: to conduct the annual review of NATO and to consider a proposed 10-year plan and such opposing matters as nuclear arms for NATO, adoption of the *Polaris* (or some other missile) and—world arms reduction.

THERE HAS BEEN a great deal of early consultation between officials of the old Administration and liaison appointees of the new. It is obvious, however, that the Eisenhower representatives will be able to commit the new administration to few if any important decisions. Nor would the other nations accept such interregnum answers as binding.

Nevertheless, these events in Europe, now and for the next few weeks, cannot help but have a great influence on the decisions facing the Kennedy Administration. They will affect the U.S. citizen in such odd and varied ways as: Will the service wife accompany her military husband overseas? Where will *Polaris* submarines be based? How greatly should the defense and space program be accelerated? They could even determine the size of the draft and U.S. industrial employment.

They are interesting events to watch.

Clarke Newlon

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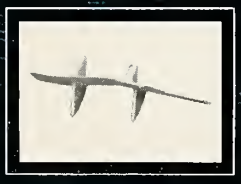

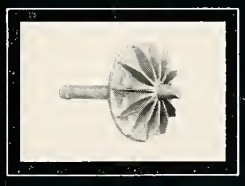

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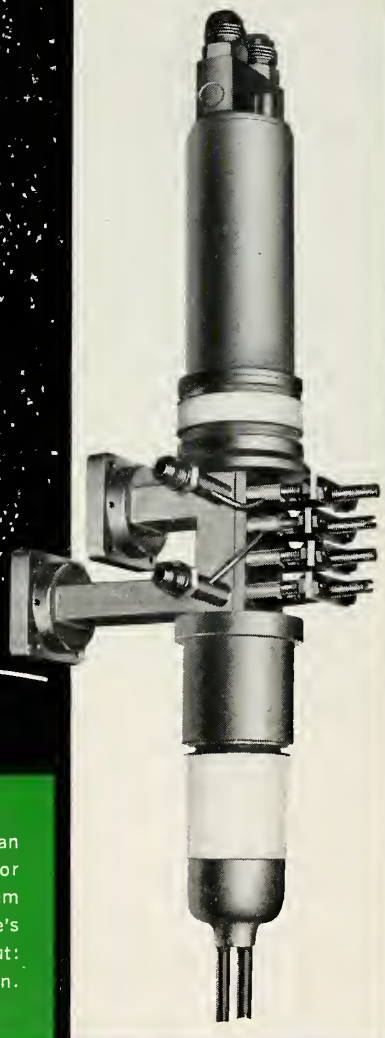

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