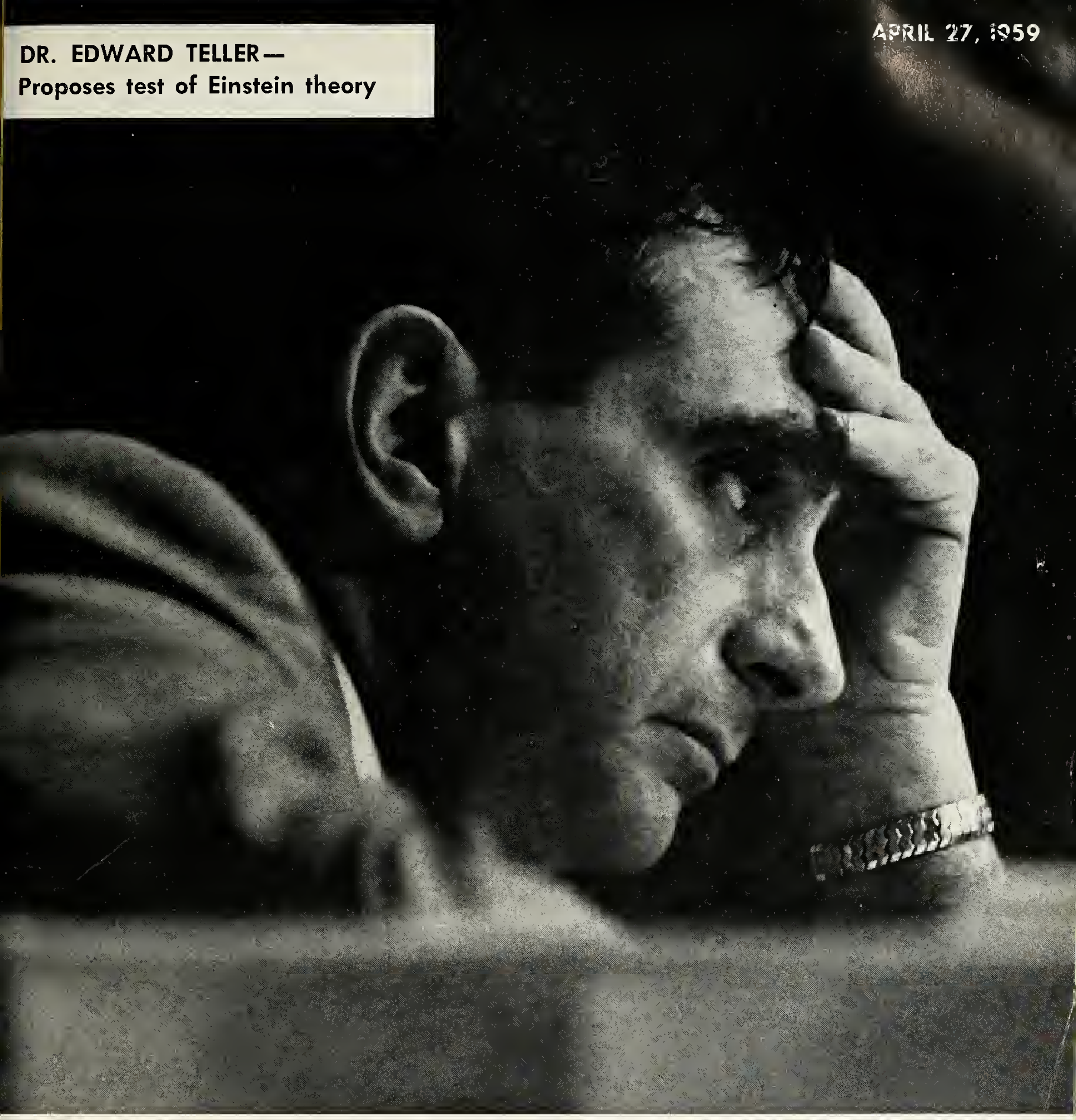
DR. EDWARD TELLER—
Proposes test of Einstein theory

APRIL 27, 1959



missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

APRIL 27 HEADLINES

SPECIAL SECTION

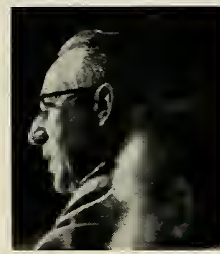
MISSILE SUPPORT EQUIPMENT

ASTRONAUTICS ENGINEERING

MISSILE ELECTRONICS

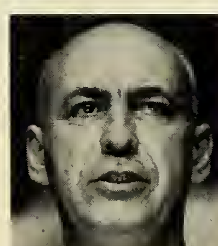
DEPARTMENTS

COVER: At World Flight Congress Dr. Edward Teller proposed test of Einstein theory. . .

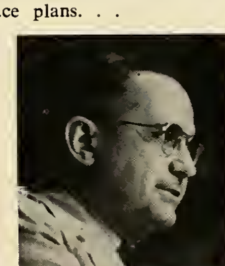


ARPA's John E. Clark stressed close tie-in of military and civil space projects. . .

AFA Pres. Peter J. Schenck presided over Missile Management Conference. . .



NASA's Robert Gilruth outlined *Mercury* project and civilian space plans. . .



SPACE Age conference was chaired by ARS President John P. Stapp (See pages 34-41)

Let's Consider the Optik

At the beginning of a press conference following a recent space launching by NASA, one front-row correspondent opened the questioning thusly:

"Would it be asking too much to stick to one term of measurement in this exercise? Last week we had feet per second. The week before it was miles per minute and before that we had knots. What are we having this time, something different?" (They were.)

The reporter's plea is only a faint echo of the space scientist, who can work with and convert all the terms mentioned above but finds that none of them is really appropriate in the space exploration field.

In this week's M/R a guest author makes an honest appeal to the scientific community for standardization of velocity terms and units. He suggests that feet-per-second, miles-per-hour and the metric system fail miserably in the space environment. He observes that the missile and space industry is now at a critical time when serious consideration must be given to changing units of measurement—particularly as related to high velocity—and that a change later will cost us far more in the long run than the cost of changing now.

He paraphrases a comment by Dr. Hubertus Strughold, a contributing editor of this magazine, in which Dr. Strughold commented:

"We should bestir ourselves now, while on the threshold of the space age, to systematize our units of measure to avoid further loss of manpower and efficiency from this source."

The author of this week's article, Maj. William C. Mannix, formerly with ARDC and now with Headquarters, USAF, has a suggested solution for the problem which he offers for use or for comment. He suggests that the velocity of light, which is constant and measurable, be used; he has divided this velocity of light into units and for the unit he has provided a name—Optik. He admits this may not be the best word and would be happy to see a better one. The spelling is for non-English-speaking users of the word. He thinks "einstein" or "roemer" which have been suggested before might also be considered.

Major Mannix convincingly states that as new scientific frontiers are established we find that some of our familiar terms are no longer clear and must be redefined. For example, "hyper-velocity" means a great many things to a great many people, but with no general agreement.

New barriers are being broken and new distances are being conquered with almost bewildering rapidity these days. It follows naturally that in the hustle of collecting new data we are less concerned with how we report new findings than with the fact that we have enlightening results to report.

The scientific community, as Major Mannix points out, is the final jury in the matter and any idea proposed must make a significant contribution to even be considered. But it is natural for the scientific community to follow the path of least resistance and to continue using the old familiar terms and units, even when they are clumsy and inappropriate.

With different investigators using different terms and units in different projects, confusion is inevitable. Worse, as we continue to use the outmoded terms, they will become imbedded in our thinking and in our records. The longer we wait the more difficult and the more expensive any change will be.

Major Mannix believes the scientific community should make a serious effort to standardize logical and convenient terms which will reflect the advances in the relatively new scientific art of astronautics as soon as possible. He cautions, however, that this must be done and done finally only when the state of this art has advanced far enough to outline its boundaries and encompass the territories within.

We believe that there can be no better time than right now to instigate the beginning of such a project. Delay, in the hope that confusion in terms and units will somehow straighten itself out, is pure wishful thinking. World standardization is necessary and even critically necessary.

To that effect, we would like to recommend that one of the international astronautics organizations, such as IAF, take up the project of standardization of velocity terms. It is worthwhile and should have been started some time ago. The goal should be a uniform standard of measurement. Whether it is the Optik or something else is relatively unimportant.

Clarke Newlon

Y.C. Lee

His full name is Yuan Chu'en Lee, but to most of us at Aerojet, he's known as "Y.C." As Director of Corporate Research, Y.C. is in charge of our astronautical, other-planetary endeavors.

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washington countdown

IN THE PENTAGON

Defense officials warn that the hardening of ICBM bases will not make them invulnerable forever. They say the day will come when mapping and missile guidance will be so accurate that no amount of hardening will protect ICBM's from being destroyed by multi-megaton warheads.

• • •

Production of U.S. missiles by Western European manufacturers still appears to be a long way ahead. This is true not only of the much-talked-about NATO IRBM but of such smaller tactical missiles as the *Sidewinder* and *Hawk*. One hitch of many is the treaty ban on Western Germany. The ban prohibits the Germans from making missiles without special permission. It could be relaxed by the treaty signers—all members of NATO. But some are reluctant.

• • •

The Defense Department—at least for the present—has met head-on the growing drive in Congress to add hundreds of millions of dollars to the defense budget for ICBM programs—particularly for more *Atlases*. Top defense officials say that if Congress votes the extra money it won't be spent. However, the department is privately reviewing proposals to pump more funds into the ICBM programs after all.

• • •

The Pentagon is taking a ho-hum attitude toward an advance deal made by the seven astronauts to share whatever publication profits they may garner from taking part in the man-in-space program. A Washington lawyer thought up the deal and drew up the contract for the seven airmen. He says his role is strictly non-profit.

ON CAPITOL HILL

The House Armed Services Investigating Subcommittee's inquiry into the weapons system concept of procurement may run longer than expected. Originally the subcommittee expected to end its investigation by late July. Now after two weeks of hearings it looks as if the investigation won't be completed until at least the end of the year. The next two firms at bat: Boeing and Convair.

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A new Special House Space Subcommittee on International Cooperation and Security is considering some on-the-spot inquiries overseas. It may study space activities in Russia, Italy, Great Britain and Japan.

• • •

A number of Congressmen are frowning over a recent turn in NASA's public information policy. Despite vigorous protests from Rep. James G. Fulton (R-Pa.), NASA officials refused to make public at a House Space Committee hearing a complete list of planned unclassified space programs with a tentative calendar. They said they declined as a matter of "public policy" because the information might help the Russians—and they conceded it might prove embarrassing later on, too.

AT NASA

Here is the current lineup of launchings in the Venus probe program: *Thor-Able III* next month into a 150-30,000 mile orbit; *Thor-Able IV* early in June; *Atlas-Able* to Venus; *Atlas-Able IV* shortly afterward also to Venus.

• • •

Thor-Able IV will carry a 78-pound payload. *Atlas-Able IV* will carry a 325-pound payload. However, the whole program may be postponed if the solar battery paddle wheels on *Thor-Able III* fail. The paddle wheel power plant is needed for communications in the Venus probe.

AROUND TOWN

U.S. space experts and many Congressional officials are pressing for early negotiations to either rent or buy the British-owned Christmas Island as an equatorial launch site for satellites.

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A two-day symposium on space research will open at the National Academy of Sciences April 29—not June 29 as previously reported in *M/R*. The symposium—to be attended by top U.S. space experts—will follow the academy's annual meeting.

industry countdown

STRUCTURES

ARPA wants $50 million in 1960 FY for *Saturn*—the ABMA space probe which will use cluster of eight *Jupiter* rockets as a 1.3 million pound thrust booster. Rocketdyne is furnishing engines for four *Saturns* and 12 more are programmed. Static firing is scheduled this Fall with first launching attempt a year later. In-house ARPA study is directed at feasibility of recovering the booster cluster for re-use. *Saturn* second stage will be an as-yet undetermined ICBM; third stage a *Centaur,* and possibly there will be a fourth stage.

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Douglas Aircraft reportedly is working on a "hot" new missile. Project is so hot North American projects have to wait whenever Douglas uses its skin millers.

• • •

Look for major changes in ARDC when Maj. Gen. Bernard A. Schriever takes over next month. Insiders feel he will scrap some marginal programs to put more money in others considered critical. Schriever is expected to strive for a more balanced organization with research directed toward advancing a mixed aircraft-missile force.

• • •

Effective May 1: A 3% raise for about 100,000 hourly-paid missile and aircraft employes of Douglas, North American and Lockheed. Raise was included in contracts negotiated last year with AFL-CIO United Auto Workers and Machinists Unions.

• • •

Lt. Gen. Clarence Irvine, retiring April 30 as boss of Air Force procurement, will probably go to work shortly for either North American, Hughes or AVRO—in that order of likelihood. He would like to be on the West Coast.

PROPULSION

NASA plans several more orders of the new *Vanguard* third stage which is produced at the Allegany Ballistic Laboratory—a Navy R&D center run by Hercules Powder Co. Though only two more *Vanguard* shots are scheduled, the ABL engine will be used for the top two stages of *Scout,* and for the top stage of *Atlas-Able* and *Thor-Able.* It may also be put on top of *Pioneer* series and *Centaur* and *Vega.*

• • •

Last 15 minutes of *Thor* countdown is now automatic. Once system locks in at T-15, countdown progresses to firing without possibility for human error. Shut-off comes automatically if something goes wrong. Effort now is to cut the time still further.

• • •

Sweden's Svenska Flygmeter has aircraft rocket booster using jet fuel and hydrogen peroxide. The VR-3 engine developing 5700 pounds of thrust at 65,000 feet has one control lever for stopping, starting and throttling.

ELECTRONICS

"Q" ball is the name of Nortronics attitude sensor to indicate angle of attack and side slip during atmosphere exit and re-entry of the *X-15.* Device is hydraulically actuated sphere which always points directly into relative wind. Pilot gets a visual readout on instrument panel.

• • •

Advanced inertial guidance systems in time are expected to permit "name the crater" accuracy of lunar impact. Dr. J. F. Shea of A. C. Spark Plug predicts the next five years will see inertial systems reduced to one-tenth present size and weight; reliability will improve and they will be able to handle any navigational problem with "hi-fi" or combinatorial systems incorporating stellar-inertial, doppler-inertial and radio inertial.

• • •

Managing NATO's new antisubmarine warfare laboratory at La Spezia, Italy, will be Raytheon Mfg. Co. The lab opening May 2 at the Italian navy base will be directed by Dr. Eugene T. Booth, ASW expert on leave from Columbia University.

ASTROPHYSICS

Measurement of micrometeorite erosion damage to satellite down to 1/100,000 inch may be possible with new technique developed by physicist R. C. Goettelman of Stanford Research Institute. He proposes placing radioactive source inside the satellite, focusing beta rays at the metal skin. A beta ray counter of the backscatter would measure any erosion of metal.

• • •

Rain on the moon? Russian IGY scientific writer F. Zigel predicts that within a century man will succeed with the aid of huge atomic power plants in surrounding the moon with an artificial atmosphere, using chemical elements of the lunar crust to generate nitrogen, oxygen and other gases. Then, says Zigel, "he will create artificial clouds and cause the first rains to fall on its barren surface, and life will flourish."

More about the Missile Week on page 16.

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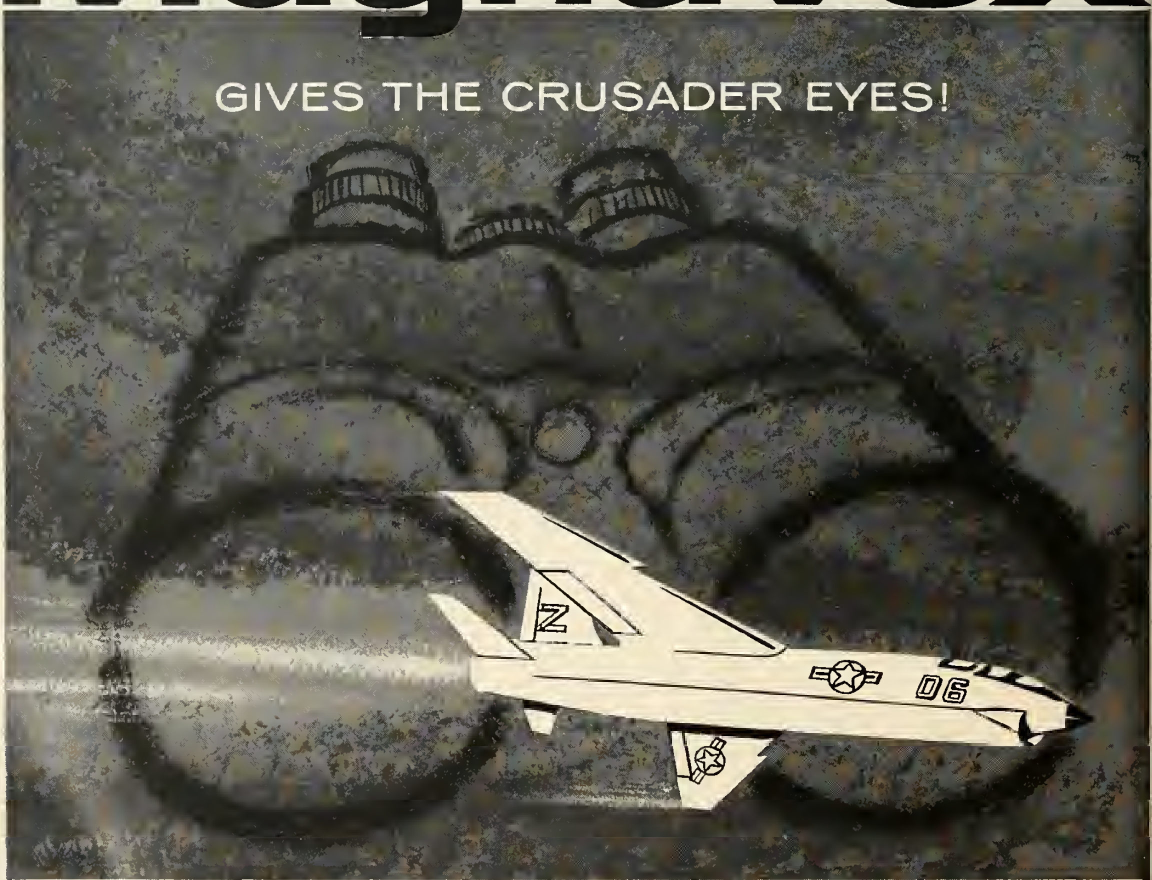

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missiles and rockets

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G.I.'s work on *Redstone* in Germany.

NATO Missile Build-Up at Stake

Outcome of East-West conference over Russia's May 27 Berlin ultimatum will effect $1 billion in U.S. missile aid

by James Baar

WASHINGTON—The growing missile power of NATO is certain to be at the heart of forthcoming East-West conferences over Russia's May 27 Berlin ultimatum. Hanging on the outcome are plans of U.S. industry to provide at least $1 billion worth of missiles to NATO forces.

This is the bright blue chip that a number of high-placed Western diplomats want to toss on the negotiating table at Geneva next month.

Few things could make the Russians happier.

Today NATO has less than 22 divisions standing between the Red Army's hordes and the Atlantic. Fail to arm fully all NATO forces with missiles capable of delivering nuclear warheads and their strength compared to the Red Army becomes all but laughable.

Still, when British officials—and some other Western European and American officials as well—talk of possible East-West disengagement in Central Europe or a freezing of the status of forces, it is this missile power that is at stake.

• **The result**—Freezing the status of forces would mean an end to the missile build-up of NATO.

Disengagement would mean making a neutral zone out of Central Europe. It would result in ending the big missile build-up in Western Germany including German cash purchases of missiles in the United States.

Diplomats favoring such plans would seek in return Soviet agreement on some system of East-West inspection and control.

The boost in NATO missile power began only within the last 10 months. Until then only the more than five U.S. divisions in Western Europe, along with U.S. Air Force and Navy units attached to NATO, had so-called advanced weapons—missiles with nuclear warheads.

In all, U.S. Army and Air Force units in Europe last summer had between 20 and 30 missile battalions—all tactical. By now some 10 missile battalions are being put into the hands of non-American NATO forces. By the end of the year non-American NATO forces are scheduled to have more than 35 missile battalions—tactical and strategic.

This means that Gen. Lauris Norstad, NATO commander, will have nearly two-thirds of the 100 missile battalions of all types that he seeks to have by 1963.

• **Breakdown**—Missiles now in the hands of U.S. forces in Europe include:

• Two battalions of 250-mile-range Chrysler *Redstones* in Germany and a third battalion on the way this month.

• Six battalions of 35-mile-range Western Electric *Nike-Ajaxes* (eight launchers to a battalion) in Germany.

• A classified number of 75-mile-range Firestone *Corporals* and 20-mile-range Douglas-Emerson Electric *Honest Johns* in Germany and Italy.

• Three groups of 700-mile-range Martin *Matadors* in Germany. (They are being rapidly replaced with the improved longer-range Martin *Mace*.)

U.S. missiles now in the hands of other NATO forces or scheduled to be by the end of the year include:

• Two to four squadrons of 1500-mile-range Douglas *Thors* in Great Britain.

• Two to possibly four squadrons of 500-mile-range Chrysler *Jupiters* in Italy.

• One group of *Matadors*.

• Nine battalions of *Nike-Ajaxes*.

• Two battalions of *Corporals*.

• Twenty-one battalions of *Honest Johns*.

The tactical-range missiles will be distributed among nine NATO nations: Great Britain, Italy, France, Norway, Denmark, the Netherlands, West Germany, Greece and Turkey.

And much more is on the way.

The United States is trying to complete arrangements with Turkey for installation of IRBM bases there on Russia's exposed southern flank. The IRBM's, which would be manned by the Turks, would be capable of hitting most of European Russia and striking deep into Russia's industrialized Asiatic heartland.

Moreover, the Administration has made clear that present plans call for arming NATO forces with missiles at a continuously accelerated pace.

The Military Assistance Program in the FY 1960 budget alone proposes spending $302 million on missiles for America's allies—mostly NATO nations. Also, $421 million worth of previously authorized missiles are still to be delivered. And hundreds of millions of dollars more are expected to be spent in the next few years.

Besides the missile types already listed, new MAP funds would be spent on 20-mile Martin *Lacrosses*, 20-mile Raytheon *Hawks*, 20-mile Convair *Terriers* and *Tartars*, 7-mile Philco-General Electric *Sidewinders*, guided drones and others.

• **Cash and production**—Nor are all the missiles to be bought with U.S. money. Western Germany—America's best cash missile customer—wants to buy many more missiles of various types including the best of the most advanced. France has been interested in purchasing 1000-mile-range Chance Vought *Reguluses*.

And, finally, a long-range program for developing Western European ability to manufacture missiles is underway.

The first ones would be tactical—such as *Hawks* and *Sidewinders*. But the eventual goal would be production of a second generation NATO IRBM.

Thus, the overall pattern of power in Europe on the eve of the May 27 ultimatum and a probable new Summit Conference is plain.

NATO has less than 22 divisions at combat readiness and about 80 reserve divisions. It has about 5000 planes operating from some 150 airfields. It has more than 1000 combat vessels. The NATO forces are armed with about 40 missile battalions.

But within six months to a year the NATO forces will have more than 60 missile battalions and will ring European Russia with some 100 IRBM's.

Russia has 175 full and partly-full divisions and 20,000 planes that could be used for a lunge across Western Europe. It has more than 400 submarines. Its troops are armed with tactical and medium-range missiles.

However, Norstad has said that he is unimpressed with the size of the Russian forces if his troops can be rapidly armed with missiles carrying nuclear warheads.

This, he said only recently, is his "greatest want."

And he added pointedly: The NATO forces "are not conventional. All of them depend on an atomic capability either within the units themselves or in an atomic weapons system."

Small ALBM May Go on F-105

Republic's Mach 2 fighter may be built in Europe under NATO nations' share plan

by Clarke Newlon

LAS VEGAS—It is more than probable that several member nations will propose to the NATO Council in Paris that the atomic/missile-capable Republic F-105 all-weather fighter be built in Europe jointly under a "share" plan.

This was revealed during the World Congress of Flight here following remarks by Deputy Assistant Secretary of Defense (Military Assistance Programs) Charles H. Shuff. Speaking at a missile management symposium, Shuff said:

"The ever-diminishing amount of funds available for U.S. assistance and the ever-increasing requirement for U.S. military products necessitates the search for new ways and means to meet these requirements. The military assistance trend is downward. The U.S. cannot afford $2 million per copy for aircraft for her European allies. We can, however, partly pay the cost and we are sure the allies will do their best to share the cost."

Shuff did not allude directly to the F-105 but his cost figure fits the big offensive fighter. His talk also followed closely remarks made in Washington recently by NATO Commander Gen. Lauris Norstad, who said that NATO's greatest need was for modern armament.

The F-105 is a Mach 2 fighter with a combat radius of almost 1000 miles. It can navigate to its target, fire either missiles, cannon or nuclear bombs and return without the pilot ever seeing the ground. While it might be equipped with the *Hound Dog*, it is more likely to carry a smaller version of the *ALBM* now being developed. Such an air-launched missile for the F-105 probably would have a range of some 500 miles, be nuclear-armed and be carried in the bomb bay.

SMALL version of ALBM could be carried in bomb bay of F-105 Thunderchief.

It has been officially announced that the F-105 will soon go to the NATO-committed U.S. units stationed in England, France and Germany. And the European NATO nations now realize that the big fighter fulfills their defensive requirements.

It is understood here that the first requests to the NATO council will come either jointly or severally from Germany, the Netherlands, Belgium and Italy. England and France are aware of the plan but are uncommitted. Both have their own all-weather fighters under consideration, the French Mirage IV and the British TSR-2 (British Tactical Strike Recon), but these are years away from production and would cost as much as the F-105, it was pointed out.

• **How to share**—Under the "share" plan one of the NATO nations would be named as assembly and test manager. Another—Germany for instance—could produce the guidance, another the wings or air frame, and so forth. Britain, which has three engines suitable for the F-105, doubtless would produce the powerplant. These engines are the Rolls Royce Conway, the Bristol Olympus and the de Havilland Gyron. The present F-105 carries the P&W J-75 engine.

It is conceded that under the proposed plan certain parts of the plane, possibly the heavy forgings, would have to be made in this country. These would be handled by Republic and might constitute as much as 25% of the cost—the U.S. contribution to the plan. Republic would also gain by providing technical assistance throughout the life of the aircraft.

Each of the several countries teaming in such a production "share" plan would contribute a portion of the cost and draw planes from the final line in proportion to that contribution. While the sharing of cost is a big item, the fact that it would provide work for aircraft plants of the countries involved is another large factor in the plan. None of the countries who would participate has been able to operate its plants at anything remotely approaching capacity.

Getting a Contract . . .

WASHINGTON—The complexities of contractual relations between customers and the Armed Services sometimes defy description. Occasionally they drive some to distraction, producing bursts of temper or sardonic humor.

In the latter category is the following anonymous document which purports to be a management proposal submitted to the Air Force as part of the routine established for getting a contract. It may be easy for you to identify the company, so M/R has deleted the names. Who knows, you may even work there.

• **General experience**—A detailed reference to the large number of programs which we have mismanaged would be beyond the scope of this proposal (see report 789-2, AF Board of Inquiry; see also report of Congressional Investigating Committee, 1209-A). We feel, however, that the experience gained from these miserable failures puts us in a strong competitive position since it is unlikely that these mistakes will be repeated.

Our competitors may have a greater number of failures, but we would like to point out that our errors were made on larger and more important projects. Furthermore, we have absolutely no experience in the specialty areas required for this design and will therefore approach the problem without prejudice.

• **Organization**—We have reviewed this question carefully and find that we are unable to determine the precise instant of time at which the customer desires to see the organizational structure, and are therefore at a loss as to how to present it. We have investigated the use of high-speed movie cameras and recorders as means of presenting a changing organization, but feel these do not meet the requirements.

We therefore request that the customer specify the moment desired. We suggest that a time during the interval from 0200 to 0700 on a Sunday would be best as experience has shown that the rate of change is at a minimum during this period.

We have found on recent proposals that our key personnel received offers from one of our competitors a few days after the submission of a list of personnel. Since there seems to be evidence of a security leak in the customer's organization, we request that a need-to-know be established before this information is supplied.

• **Technical approach**—Our plan for this project is to hire engineers from the companies which lose the competition. Our technical approach will therefore be determined by these people and can be obtained from our competitors' proposals. We do have a few guiding principles. We have found that on a project of this nature, about 12-18 months are required to catch up with the art. This time is spent in visiting other companies, universities, and test sites and in reading classified reports and *Missiles and Rockets.*

This period is followed by a six-month study phase. At the end of this time it is usually desirable to start traveling again because of the extremely rapid changes that take place in the state-of-the-art.

• **Schedule**—In order to improve the appearance of our proposal the art department has made up a seven-color schedule using stereoscopic plexiglass overlays. The dates in this schedule represent a weighted average between the estimates of the Research and Sales divisions (they are the Sales division figures). In any event, company practice is to terminate a project when the personnel are needed on a new and more profitable contract.

• **Subcontracts**—It is a firm company policy to never let a dollar get out of the house.

• **Cost information**—We do not plan to spend much in engineering. We have found that engineers make changes, and this reduces profits.

Facilities will be a large item. We view this contract as an excellent opportunity to build up our plant.

No charge has been put in since we do not plan to test. In the past, test programs have shown up faults and caused cancellation of contracts years before the mistakes would have been discovered in the field.

The entertainment item was inadvertently omitted from the request for proposal. We have added it.

• **Contract forms and profits**—An exhaustive study will be made during the first six months of the contract to consider these factors. All of the modern techniques of operational analysis, game theory, and high-speed comput-

Do You Follow This Routine?

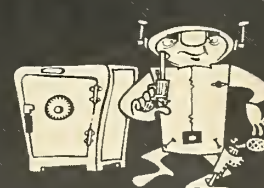
Great Capabilities

We have no experience, so will research the problems without prejudice . . .

Great Organization

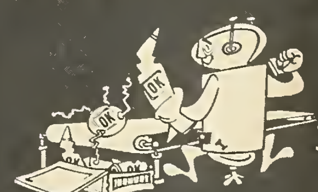
Our key personnel are still with us despite offers from our competitors . . .

Chance For Subs



It is a firm policy to never let a dollar get out of the house . . .

Great Reliability



No testing — tests show faults and cause cancellations years before mistakes would be discovered in the field.

ing will be applied to the problem of profit optimization.

Key points in this study will be legal loopholes, tax dodges, and evasively written clauses. It is expected that several nationally known consultants will be retained for this work due to the overiding importance of the problem.

• **Physical resources**—An excellent survey of our physical facilities is contained in the Receiver's Report prepared during our most recent bankruptcy proceedings. A copy of that report is appended.

• **Additional facilities**—It is our belief that an important project such as this should not be carried out in our shabby plant. We plan to use government-furnished facilities exclusively. We would like to point out that several directors of the company have excellent property which they would be willing to sell to the government for the erection of these facilities.

About the Cover

At the Space Age Conference in Las Vegas, Dr. Edward Teller, famed physicist who directs the University of California's Radiation Laboratory, tossed a mild bomb burst by suggesting a test of Einstein's theory of relativity. It was not his idea alone, Dr. Teller said. He proposed, in briefed-down Tellerese:

"We'll send out, maybe, all kinds of conditions permitting, one of the nice vehicles of ARPA and NASA and put a little nuclear explosive on it, and let it go out a big healthy distance, like, let's say, hundred million miles and then look sharp.

"This thing will explode and send out the whole electromagnetic spectrum from an X-ray through visible to infrared through radar. These will be emitted in a very sharply defined time instant to an accuracy better than a microsecond. Let's see whether all these signals will arrive at precisely the same time. Physics relativity tells us that no matter whether it's X-rays or visible or radar—light velocity is light velocity and we mean it and there is no deviation in vacuum, no deviation of the light velocity whatsoever.

"We'll have the means to check this statement (the theory of relativity) more than a thousand times better than anybody has checked it before."

Others thought all waves would arrive together, if not science will continue to look behind the time differentials.

more about the missile week

Tank-launched *Shillelagh*, lightweight surface-to-surface guided missile designed for close-in troop support, will be developed under $23 million Army contract with Aeronutronic Systems Inc. Raytheon Mfg. Co. will develop the missile's electronic computer fire-control system at its Santa Barbara, Calif., plant.

Polaris test vehicle went more than 300 miles in April 20 firing. Shot was the first considered partially successful after five earlier attempts failed to approach programmed 500-mile objective.

Full-scale mockup of Bell Aircraft *Dyna-Soar* proposal is being examined at Martin Co.'s Baltimore plant by an Air Force evaluation team. Martin and Boeing Airplane head the competitors for design of the man-carrying, boost-glide vehicle. A decision on the winning configuration is expected within a few weeks.

Support for an increase in the Administration's missile budget is gathering in the Senate. Chairman Dennis Chavez (D-N.M.) of the Senate Military Appropriations Subcommittee predicts the funding will be upped, probably in line with the $700 million to $1 billion increase the House is expected to recommend. Chavez' subcommittee begins hearings May 4 on the President's $40.9 billion defense program.

Also on May 4, hearings will be conducted by the Labor Department to determine minimum wage rates in the electron tubes and related products industry. The hearings have no bearing on the pending decision whether the electronics industry is part of the aircraft/missile industry under provisions of the Walsh-Healy public contracts act.

New names: Induction Motors Corp., having moved into large-scale manufacture of electro-mechanical components, is switching its name to IMC Magnetics Corp. The company has just acquired Gray & Kuhn Inc. of Roslyn Heights, L.I. To also make its name more descriptive of what it does, Moog Valve is changing to Moog Servocontrols Inc.

NASA is getting new talent for its Langley Research Center. About 25 scientists and engineers of Canada's Avro Ltd., which recently had its Avro CF-105 interceptor program cancelled, are expected to be hired at Langley.

Inspector General Joseph Kammhuber, chief of the West German Air Force, and a group of Luftwaffe officers, visited Republic's Farmingdale plant last week for a complete demonstration of the F-105 tactical fighter. West Germany would like to acquire the plane under a build-in-Europe "share" plan.

Add silicon carbide foam to list of insulating materials available for missiles and rockets and other uses. Developed by the Carborundum Co.'s R&D division, SCF is self-bonded open cellular structure. A cubic foot of low density weighs 16-18 pounds; high density 30-35 pounds. It provides corrosion-resistant thermal insulation up to 4000°F.

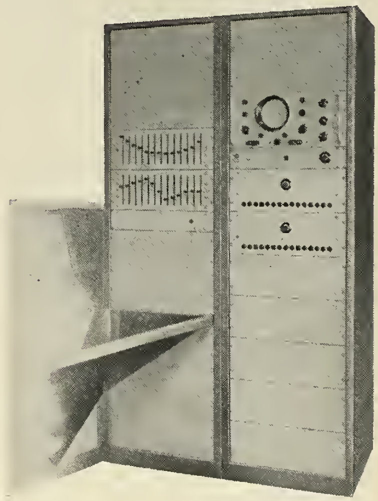
For greater space/missile and petroleum geophysical research, Texas Instruments has formed a new Geo-Sciences and Instrumentation division headed by Fred J. Agnich.

Expansions: CBS-Hytron, which is changing its name to CBS Electronics, on July 1, plans a $5 million, 160,000-square-foot semiconductor plant at Lowell, Mass. Having proved-out pilot production of ammonium perchlorate, Pacific Engineering & Production Co. is expanding its Henderson, Nev., facility to a rated 5 million pound-per-year capacity. Brush Beryllium Co. is adding to its Cleveland Plant and is establishing a fabrication facility and sales office in the San Francisco area. Newport Beach, Calif., location of Aeronutronic Systems Inc., a Ford Motor Co. subsidiary, is being enlarged by 540,000 square feet of new plant space, including more room for the company's Space Technology Division.

Competition for *Titan* all-inertial guidance system has been won by AC Spark Plug Division of General Motors. Based on MIT research, system will utilize liquid bearing gyros. It is reported to be much smaller than the *Thor* system. Work will be done in Milwaukee, with about 50% subcontracted. Arma, which is being replaced in the *Titan* program by AC Spark Plug, has *Atlas* guidance system.

Vibration Testing of New Missiles Saves Money and Time

Trend is toward more accurate reproduction of effects of dynamic forces, using such equipment as Ling's spectral density analyzer system



by Cameron G. Pierce*

CULVER CITY, CALIF.—The final test of missile reliability is in the mission. If it takes off, follows its prescribed flight path or trajectory, survives all the environmental hazards, and hits the target area, it is a reliable vehicle.

The entry into space of men and machines presents a host of complex new problems. Advanced techniques such as vibration testing provide opportunities for investigating and solving many of them under controlled conditions during the development period rather than the flight test phase. In both money cost and time cost, such "preflight testing" is most desirable.

Preflight test programs have been instituted with the prime purpose of insuring high missile performance. This is accomplished in part by subjecting it to simulated environments and determining its idiosyncracies with regard to particular flight conditions and factors. Once the missile's sensitivity to these parameters has been determined, effort may be expended in redesign or modification to remove or reduce all adverse reactions.

Shortcomings in the telemetering systems of today leave much to be desired in the way of performance information. Thus, it is of vital importance that as many simulated "flight tests" as possible be performed on the ground before the missile is launched to assure the maximum of reliability. This philosophy dictates the preflight test concept of missiles today.

• **Vibration**—One particular area of environmental factors which is receiving increasing attention is that of vibration. This is concerned with the effect of dynamic forces on the missile elements—forces having amplitudes that vary with time as opposed to static forces which remain essentially constant with time. These dynamic forces may vary from the low-frequency sloshing in fuel and oxidizer tanks, to the high-frequency phenomena associated with engine pulsing and aerodynamic turbulence.

The nature of vibration forces is such that each physical system can exhibit particular sensitivity to certain characteristics of the force. The resulting effect on the system is much more severe than had a force of equal amplitude been applied statically.

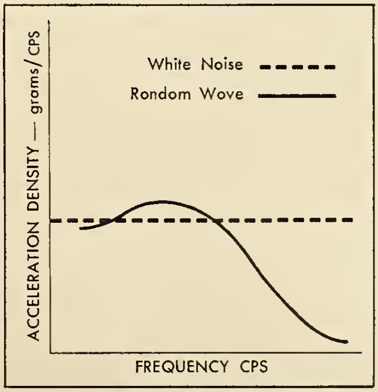


FIG. 1—Power Spectral Density curve.

Vibration testing programs are applied to determine the extent and nature of the system's sensitivity to dynamic forces of various forms. These programs must investigate the effects of all aspects of the force including the amplitude, frequency, time duration, and the various combinations of these parameters. Also, they must subject the missile and its components to forces that are representative of those encountered in operation and provide accurate indication of the system's response to the loading conditions.

• **Dynamic force effects**—No portion of the missile system is exempt from the effects of dynamic forces. Whether these effects result in malfunctioning of the element depends on the degree of sensitivity of the element and the intensity of the force characteristic causing the adverse response.

Structural elements of the missile (and wherever possible, the entire missile) are tested to determine the basic vibration modes of the structure. This data permits the calculation of the dynamic characteristic of the structure and its susceptibility to damage from forces induced by major propulsive and aerodynamics factors. In addition to the effects of these higher-amplitude forces, the missile structure must be tested for

*President, Ling Electronics, Inc.

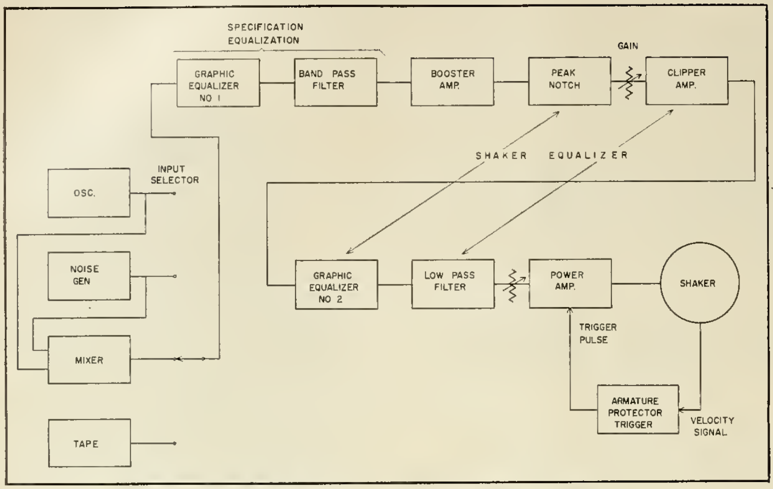


FIG. 2—A functional block diagram of a typical vibration system.

the fatiguing and damaging effects of lower amplitude but multi-frequency forces characteristic of aerodynamic turbulence and powerplant fluctuations.

Closely coupled to the dynamic characteristics of the missile structure are the frequency response characteristics of the missile's control system. Structural oscillations can be picked up by the various dynamic sensors used in the control system. These are often of the proper frequency and phase to result in system instability and destruction of the missile.

Vibration tests applied to the structure-control system combination can insure that the placement of sensors will avoid dangerous pickup of structural vibration. In the case that such placement is not possible, test results can be used to determine the necessary filter characteristics to stabilize the control system in the sensitive range.

Particularly affected by the higher-frequency components of dynamic forces are the fragile elements of the electronic components in the missile system. These components have high natural frequencies which make them very susceptible to the rapidly fluctuating forces. Not only are electronic components subject to actual physical damage, but the forces can cause extraneous and erroneous signals to be generated by the components with drastic results to the missile guidance and control systems.

• **Testing techniques**—Early dynamic force investigations were concentrated on determining the effects of shock loads on structures and components. These studies were begun when it was determined that a suddenly applied force could cause considerably more damage than the same force applied gradually.

In the course of these studies it was discovered that the dynamic characteristics of the structure or component not only determined the nature of the response to these transient forces, but also determined the response to repetitive forces associated with machinery having rotating and reciprocating elements.

These discoveries opened the era of sinusoidal testing wherein the responses of structures, components, and entire systems were determined as functions of the frequency of the applied sinusoidal forces. In most cases linearity was assumed and the effects of complex wave-form were predicted on the basis of a frequency-by-frequency analysis.

Sine wave testing serves its major function in the analysis of the frequency response of control systems and the determination of the vibration modes of the structure. In addition, it is useful in establishing system response to any particular force with a distinct frequency.

Missile studies have revealed the seriousness of dynamic forces with random frequency and amplitude characteristics. These forces were present previously, but were in most cases negligible compared to the effects of shock and sinusoidal loads. Their presence now is more troublesome since they defy the use of linear analysis. The nature of their reaction on missile systems is still cloudy.

One thing is certain: random vibrations arising from multi-frequency aerodynamic turbulence and propulsion system fluctuations are major threats to missile performance and reliability.

• **Random waves**—The prime source of difficulty in the handling of random vibration problems is, of course, the very "randomness" of the forces. Random wave vibrations may be considered as having a finite bandwidth but amplitudes which exhibit statistically random characteristics as a function of time.

As a result, it is impossible to postively describe the amplitude of any of the frequency components at any one time. Rather, statistical analysis is employed to describe the characteristics on a probability basis—that is, the probability that any one amplitude can exist at any one specific instant.

Random wave vibrations can be plotted as a function of frequency by employing the Power Spectral Density curve. This is a plot of amplitude versus frequency, where the amplitude characteristics have been determined statistically. The amplitudes for each frequency are examined and their root-mean-square (rms) value is determined. This is used to determine the acceleration density defined by the following equation:

$$A = \lim_{F \rightarrow 0} [a^2/F]$$

where:

- a is the root-mean-square value of the force,
- F is the bandwidth of the force, and
- A is the acceleration density in g^2/cps.

The density function plotted versus the frequency spectrum of the loadings is the Power Spectral Density curve. Typical of random wave characteristics is the plot shown in Fig. 1. White noise which has the special characteristic of equal acceleration density at each frequency has the flat curve shown in the figure.

Describing random wave vibration requires that the frequency spectrum and the shape of the Power Spectral Density curve be given. In addition, the total rms vibration level of the spectrum may be determined by the formula:

$$A_{rms} = \sqrt{\sum_{f_1}^{f_2} [A \, \Delta f]}$$

• **Random wave testing**—Requirements for random wave testing have dictated the development of high-performance equipment capable of duplicating the vibration environment with extreme fidelity. This is of the utmost importance because not only must each frequency component be reproduced accurately, but the exact relationships between the components must be maintained.

To accomplish these tasks, provisions must be made in the equipment to compensate for any and all resonances which might influence the final value of force as applied to the system under test. This equalization of the test equipment insures that the system under test is loaded in accordance with the applicable Power Spectral Density curve.

There are certain limitations to the amplitude of loading possible. A Gaussian distribution implies some probability that amplitudes of unlimited value exist. However, the standard working procedure is to provide the system with the capability of furnishing amplitudes equal to three times the rms. This factor is defined as the Crest Factor. A value of three is used since statistically 99.7% of the time the actual forces would have been below three times the rms value.

Since the requirements for random wave testing are far more rigid than those for sine wave testing, test equipment developed for random wave studies is quite adequate for sine wave testing.

Typical Test System

Fig. 2 is a functional block diagram of a typical vibration system incorporating both random wave and sine wave capabilities. Noise generators, sinusoidal signal generators, and magnetic tape reproduction equipment can be the source of the vibration signals.

In a great many instances the vibration environment is composed of sinusoidal forces superimposed on a white noise spectrum. To duplicate this condition an electronic mixer is employed to mix the chosen sinusoidal signal with the output of the noise generator. To insure that the correct relationship is maintained between the two signals, a servo system using feedback signals from the shaker is used to monitor and adjust the amplitude of the sine wave signal generator.

• **Noise output**—The first graphic equalizer and the band pass filter are used to shape the output of the noise generator to the Power Spectral Density specified. This first shaping does not take into consideration any of the effects of the shaker or other elements of the testing system. Development of these graphic equalizers has greatly improved control of spectrum shaping and has reduced the time required in equalizing the system for testing. The equalizers provide amplitude control of the spectrum between 2 and 8000 cps. Each one of a series of attenuators controls the level of a small band of frequencies. Adjusting the positions of the attenuators produces a frequency response curve similar to the physical positions of the attenuators.

A booster amplifier placed after the specifications equalization raises the equalized signal to the level required for further shaping. This is necessary because equalization will have reduced the system gain.

Once the output of the noise generator has been equalized to the test specifications, compensation for the electronic and mechanical characteristics of the test equipment must be provided to produce the desired amplitude characteristics at the shaker table. This compensation cancels the effects of mechanical resonances and loadings in the shaker and the test fixtures.

To accomplish this system equalization, a combination of graphic equalizers, low pass filters, and peak and notch filters are used. Fig. 3 shows the steps in the equalization process from the output of the noise generator to the required Power Spectral Density characteristics at the shaker.

Peak and notch filters provide vibration test engineers with the capability of placing peaks and notches anywhere in the frequency band from 2 to 5000 cps. These may be characterized by "Q" values of from 0 to 1000 and maintain adjustable heights and depths to 40 db, independent of the "Q" chosen.

The equalization equipment also provides certain safety checks. The clipper amplifier placed after the gain control insures that no signals with amplitudes above a safe range for the shaker are transmitted to the power amplifier. The power amplifier itself is provided with an armature protector which short-circuits and dynamically brakes the armature in the event of instantaneous overcurrent or overtravel.

To insure that the desired acceleration distribution is maintained, a new spectral density analyzer system (developed by Ling Electronics, Inc.), can be used in conjunction with a spectral density equalizer which can be operated with the existing peak-notch filter. Signals from the test specimen instrumentation are fed to a filter analyzer which has a set of narrow-band filters that matches those of the equalizer. Each of the filters has a band pass characteristic identical to the corresponding filter in the equalizer.

The outputs of the analyzer filters are separately and continuously detected and averaged so that the outputs of all the filters may be available simultaneously. An electronic switch samples the "averaged" analyzer outputs and the result is continuously displayed on an oscilloscope as spectral density versus frequency. The presentation is in the form of a series of dots having a vertical position proportional to the average g^2/cps in each incremented band of frequency. Corrections in energy distributions can be made immediately by simple adjustments of the spectral density equalizer attenuators.

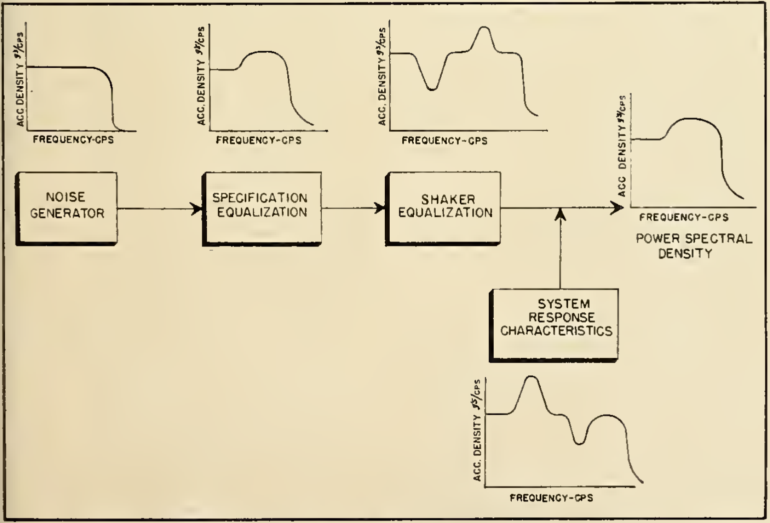


FIG. 3—Steps in shaping required Power Spectral Density characteristics.

High power requirements are necessary to duplicate the vibration environments to which today's missile systems are subjected. Power amplifiers for some vibration tests require 350 kilovolt-amperes to provide peak shaker forces of 70,000 pounds. When missile size and weight factors are prohibitive, portions and individual components of the missile can be shaken.

• **Shaker limitations**—Up to this point in the vibration test system, the elements of the system have all been electronic. However, the shakers themselves are usually electrodynamic, and they present the principal limitation in a vibration test system. Electrodynamic shakers operate on the same principles as do loud speakers. Electronic signals applied to the armature set up magnetic fields about the armature coil which react with the magnetic fields about the field coils. The result is a force tending to move the armature. The armature is connected to the shaker table so that the force applied to the armature is transmitted directly to the table.

The main limitation in shaker performance arises from its physical nature—that is, the shaker must ultimately move a mass. The power required to provide this motion increases both with the mass and the frequency of the signal. However, electrodynamic shakers do provide the most successful means of interpreting electronic signals into mechanical motion with any degree of fidelity and power.

Rugged accelerometers and velocity-sensitive devices are used to monitor the motion of the article being tested, and the shaker table itself. These are usually of the crystal variety which combines sensitivity and good frequency response with a minimum of weight to influence the test. In addition, some instrumentation has been designed to measure displacements by optical means.

Future Developments

As environmental conditions become more severe and missile systems more complex, the trend in vibration testing is toward more accurate reproduction of the conditions the missile will encounter. The reaction of a large and complex missile system to vibration forces can be considerably different from that of any of its parts.

As a result, it will be necessary to increase the test equipment capabilties with regard to the frequency range and the force available at the output. Ideally, each missile system will be tested in a simulated environment duplicating vibration, temperature, pressure, humidity, and other conditions.

Foremost in the efforts to increase test equipment capabilities are developments leading to more efficient and better performing shakers which can withstand other environments such as temperature and altitude. At the same time development work is being directed at new concepts in shaker design and construction.

One new area of endeavor is the use of acoustical testing techniques. In these tests the missile will be vibrated by sound waves generated by high-intensity loud speakers.

This area of testing is becoming increasingly important as the sound levels of rocket engines and aerodynamic turbulence increase to the point that they can physically damage missile structures and components.

Electronic systems currently produced to drive shakers can be readily used to drive these high-intensity sound systems.

Explorer V Will Carry Highly Complex Payload

by Paul Means

WASHINGTON—The payload of *Explorer V*, to be launched sometime this summer, will conduct more scientific experiments in space than any U.S. satellite to date.

The payload will be carried aloft by the Army's *Juno* vehicle, marking the sixth time this vehicle has attempted or put a satellite into orbit and the first time under NASA direction.

Basic purpose of the experiment is to obtain more information about radiation and charged particles in the inosphere in addition to experiments designed to measure micrometeorite density, and the performance of solar cells without micrometeorite shields. NASA project officer is H. E. La Gow of the Beltsville Space Center group.

The vehicle will be sent into a 50-degree inclination low elliptical orbit so that it passes through the inner Van Allen belt.

The top-like design of *Explorer V* aided the fabrication of solar cells into it, and will also help obtain maximum gyro-stabilization with little or no precession. Release of the 20mc antenna spool will retard the vehicle's spin.

The elements of the payload, and their missions, are:

• **Cosmic ray detector**—This instrument consists of two tiny Geiger-Mueller tubes which measure charged particles. One tube is not shielded, and will map both hard and soft components. The shielded tube will detect hard particles only.

• **Lyman Alpha detector**—Photosensitive ion chambers designed to detect Lyman Alpha solar ultra-violet rays at 1216 angstroms.

• **X-Ray detector**—An ionization chamber filled with Argon gas which has a beryllium window and is sensitive to radiation from 15 to 3 angstroms.

• **Heavy nuclei chamber**—An ionization chamber which divides hard particles into three classes: those with masses equal to or greater than the atomic number three, equal to or greater than the atomic number six, and equal to or greater than the atomic number nine. The mass of the particles is measured by the amount of ionization of the Argon gas produced per unit path length in the chamber.

• **Radiation and heat balance experiment**—This will measure the direct radiation of the sun; the fraction which is diffusely reflected by the earth, clouds, and atmosphere; and the fraction which is converted into heat by the earth and reflected back into space in the far infrared portion of the spectrum. Each of the satellite's six sensors are made up of a thermister housed in a hemiphere, two of which are painted black, two white, and two with a special coating which absorbs short wave radiation only.

• **Micro-meteorite density**—A cadmium sulphide evaporated photo conductor that counts the number of times micrometeorites in the order of ten microns and larger hit the sensitive area. The impact makes an opening in the optical opaque film covering allowing sunlight to enter the cell whose resistance is proportional to the area of the opening.

The power supply will be solar cells charging nickel cadmium batteries.

The satellite has no recorder, and ground stations record information only when the satellite passes over.

Quick Photo Service For NASA Satellite

WASHINGTON—Ground equipment monitoring the television cameras in the National Aeronautics and Space Administration's upcoming meteorological satellite experiment will be able to make photographs from the television signals minutes after reception. The ground station receives signals from a miniature magnetic tape recorder in the satellite and immediately re-records the signal on magnetic tape.

NEEDED:

New Velocity Measurement Unit for Space

Is the Optik—based on speed of light—the answer for the confusion in scientific terms?

by Maj. William C. Mannix, USAF*

WASHINGTON—Voltaire stated the proper dictum of the scientist and philosopher: "If you would converse with me, define your terms." With our sudden, serious interest in space operations expanding tremendously, it is paramount that we select and standardize logical and convenient terms and units as soon as practicable.

One goal for standardization is very high-velocity phenomena in space, especially between masses at extreme velocities. Here is an area of fast-moving scientific front lines, temporarily relying on uncertain and clumsy "holdover" terms and units for expression.

We are not only reporting data in a hodgepodge of units. but we have failed thus far to define "hypervelocity," the word most commonly used to describe this area.

The term "hypervelocity" out of context means different things to different people, depending on background. To ordnance experts, something above artillery or machine gun muzzle velocity is implied, possibly 4000 feet per second or greater.

Others in the ballistic missile field think of the word as implying an order of magnitude higher velocity. Finally, still others whose concern is collision with solid debris in space visualize a still higher order of magnitude of velocity. This is a wide range of impact phenomena, probably with several important discontinuities in behavior, to cover with the single term, "hypervelocity."

• **Brackets**—At first glance it looks like a simple matter to put our house in order by subdividing velocities into convenient brackets, and labeling with descriptive terms. We even have a precedent from aerodynamics, as follows:

Subsonic—referring to speeds in air up to Mach .95.

Transonic—Mach .95 to 1.05.

Supersonic—Mach 1.05 to about 5.0.

Hypersonic—Mach 5.0 to 50.

Since this terminology applies to the special case of a body moving relative to a compressible fluid, we can use the root word "velocity" rather than "-sonic" if we wish to show that we refer to the more general case of one body relative to another with gas nonexistent or irrelevant. We should keep in mind that the terms we develop for relative velocity may be used by space trajectorists as well as impact scientists.

It should be noted in passing that "velocity" is a vector term, including both speed and direction, whereas "speed" is a scalar term and the more general of the two. However, general scientific usage seems to favor "velocity," especially when used as a root word. This may be for phonetic reasons, or more likely because it is difficult to dissociate speed from direction in practice. In the terminology proposed later in this article, "speed" can be substituted for "velocity" to fit those cases where a rigorous distinction is needed.

Suppose we were to set up convenient velocity brackets (following the aerodynamic precedent), and label them hypervelocity, supervelocity and so on. For convenience, order-of-magnitude subdivisions are preferable. But we immediately run into a disturbing problem: which units among the several in common use shall we subdivide? We are struck with the lack of consistency that has already developed in the short life of this subscience; it is readily evident, as mentioned earlier, that this stems from the diversity of disciplines represented in this new area.

There is the usual disparity between engineers and physicists on foot-pound-second versus centimeter-gram-second systems, and worse: data on high velocity impact is being gathered and reported in miles/second, kilometers/second, meters/second, and feet/-second; in miles/hour and nautical miles/hour (knots); even in millimeters per micro/second. The very existence of such a mixture of units tempts us to brush them all aside and start afresh. Yet, if we take that step, we must be sure we have chosen an un-

"OPTIK" SYSTEM
Relationship to Other Units of Measurement

VELOCITY RANGE				GUN VELOCITY (1-10 Optiks)	HYPER-VELOCITY (10-100 Optiks)	ULTRA VELOCITY (100 Optik-1 Kiloptic)	COSMIC VELOCITY (10 Kiloptic-1-Megoptik)			
	1 millop-tik	10 millop-tiks	100 millop-tiks	1 optik	10 optiks	100 optiks	1 kilop-tik	10 kilop-tiks	100 kilop-tiks	1 megoptik
METERS/SEC.	0.3	3	30	$3x10^2$	$3x10^3$	$3x10^4$	$3x10^5$	$3x10^6$	$3x10^7$	$3x10^8$ #
FEET/SEC.	0.9843			984.3			984,300			984. $3x10^6$
KILOMETERS/HR. ..	1.080			1080			$108x10^4$			$108x10^7$
MACH (SEA LEVEL)	$81x10^{-5}$			0.81			810			
EINSTEIN (ROEMER)	10^{-9}			10^{-6}			10^{-3}			1

Approximately the speed of light. Exact value is $2.9979x10^8$ meters per second. Note that earth's escape velocity is 37.27 Optiks.

**The author—with an extensive background in weapons research in ARDC, is now with the Assistant for Foreign Developments, under the Deputy Chief for Development, Headquarters, USAF.*

deniably superior set of units, lest we only add to the confusion.

• **The test**—What is a good system of units and measure? There are several tests which can be applied:

a. Natural significance: Is the basic unit directly related to some constant and measurable fact of nature? (This gives us more feel for the significance of measurement and provides a standard for calibration).

b. Numerical convenience: Does the unit system subdivide readily, i.e., progress in orders of tens or twelves? The decimal system of numbers is not nearly so useful as a duodecimal or "dozenal" system would be, based on 12 instead of 10. The unfortunate choice of 10 no doubt resulted from the number of digits on human hands, a fact important to the thinking of primitive man but unimportant today. The logic of 12 is based on its whole number divisibility by five out of the six lowest numbers, contrasted with three out of the six lowest numbers in the case of 10. This logic is shown by the persistence of 12 as a factor in so many measurements of length, time, circular measure, counting, and so on, in spite of conflict with the decimal system of numbers.

c. Basic unit size: Is the basic (or the working) unit chosen so that we will usually work with reasonably small numbers?

• **Good units**—Based on these tests, some reasonably good systems of units are as follows: Time units are based on the period of rotation of the earth, and are fairly convenient arithmetically. The meter was related to the earth's circumference (one ten-millionth the distance from equator to pole, now more specifically defined as the length of a particular platinum-iridium bar). The length is convenient, and with decimal divisions and multiples, it provides a system which is as convenient as we can get with the decimal system of numbers.

The gram of mass, as the mass of a cubic centimeter of a readily available and measurable substance (water), and the gram of force, as the pull of the earth on a mass so defined, is the basis for a good system. On the other hand, the foot-pound-second system is a poor one because the basic units lack both natural significance and numerical consistency or convenience.

Regarding velocity units, it follows from the above that feet-per-second and statute miles-per-hour fail the tests suggested. The knot, based on the length of one minute of arc on the earth's surface, has terrestrial significance but none in space. It does not convert readily to either of the most common systems now in use, feet-per-second or meters-per-second. If we must standardize on one of the velocity systems now in use, either meters-per-second of kilometers-per-hour satisfies most of the tests for mundane use. Both possess terrestrial significance, numerical convenience, and magnitude of the working unit which is convenient for everyday use.

• **All fail**—But what of velocity in space? Unfortunately, all of the unit systems mentioned above fail the tests of significance and magnitude when considered for space usage. Thus, it seems worthwhile to seek a more significant basis for velocity measurement, especially if one can be found which converts readily to at least one of the established systems.

Following a discussion by the author on this subject at the Second Symposium on Hypervelocity Impact Effects in 1957 (jointly sponsored by NRL and ARDC), Messrs. A. Hurlich of Convair and E. B. Bell of the Air Force independently suggested that the velocity of light, expressed in meters-per-second and appropriately subdivided, would provide a good velocity system for space use.

The author concurs wholeheartedly. The velocity of light is constant and measurable; it certainly has natural significance in a grand sense. Through great coincidence (since there is no natural relationship between the size of the earth and the velocity of light) it approximates very closely a round figure in metric linear measure: 3×10^8 meters-per-second. Hence a subdivision of the velocity of light, chosen of convenient magnitude, and expressed in meters-per-second, is proposed as the basis for an improved velocity unit system.

• **The name?**—What should such a unit be called? The concept of velocity, whether expressed by $c = mc^2$ or by $KE = \frac{1}{2}mv^2$, will be more simply and powerfully expressed by a single word without any per-unit-time tag. (Precedents exist in the terms ampere, knot, watt, and other time-dependent units which stand alone.) The "optik" is suggested as a name for the basic working unit, spelled with a "k" to avoid the English-pronunciation ambiguity of the letter "c". The proposed velocity system is outlined in the accompanying chart, giving the relationship of the Optik to various other units.

The exact value of the velocity of light is now considered to be 2.99796×10^8 m/s, instead of 3.00×10^8. However, the difference is only about one-fifteenth of one percent, which is only a slightly larger error than calling π equal to 3.14 instead of 3.1416, and smaller error than calling the force of gravity 32.2 instead of 32.174.

There is already limited usage of the term "einstein" for the constant "c," the velocity of light; and it has been suggested that the term "roemer" (in honor of the man who first accurately measured this velocity) be used in the same way. In either case, the word "megoptik" clearly signifies that the practical and not the rigorous value is intended.

• **What to discard?**—A practical question is, "What units can we discard if we adopt the Optik as the working unit in high velocity?" Statute miles per hour is already on the way out, insofar as flight technology is concerned, and should be completely deleted from missile or space travel work.

An intermediate step (which would be an important step forward whether the Optik is adopted or not) is conversion of all high-velocity work to m/s or km/sec as soon as possible.

If this is done, the rest is easy—for the Optik is two things at once: It is a grouping of meters-per-second in "lumps" of 300, for convenience at high velocities, and it is also a simple fraction of the speed of light.

The problem of logical, convenient and universally accepted units is as old as science itself, never completely solved, but nonetheless subject to periodic improvement and enlargement to encompass new horizons. All scientists are aware of the problem, constantly reminded by the inefficient coexistance of cgs and fps systems. As Dr. Hubertus Strughold recently pointed out (M/R, Jan., 1958), "we should bestir ourselves now, while on the threshold of the space age, to systematize our units of measure to avoid further loss of manpower and efficiency from this source."

We are now at a critical point in time such as faced the Ford Motor Company and/or the Society of Automotive Engineers around 50 years ago, when either organization could have led the auto industry (and possibly all U.S. industry) to adopt the metric system. One thing is certain: either changing later or not changing at all to a better system of measure will cost us far more in the long run than the cost of changing now.

Regarding the specific proposals above, the purpose here is to propose some system of velocity units and terms, with both physical significance and numerical convenience, to as wide an audience as practical—for criticism, improvement, or acceptance.

The final jury is the scientific community. Comments on the above proposals, addressed to *Missiles and Rockets* magazine, will be greatly appreciated by the author.

Throttleable Engine Prolongs Aircraft Life

Rocketdyne's AR series with up to 6000-lb. thrust is ready for use although Navy has cancelled program

by Frank G. McGuire

CANOGA PARK, CALIF.—A super-performance, liquid-propellant rocket engine designed to add three years or more to the useful life of fighter/interceptor aircraft has been developed by the Rocketdyne Division of North American Aviation, Inc. The powerplant, designed to be as safe as an automobile engine, uses 90% hydrogen peroxide and JP-4 or JP-5 for its operation.

Rocketdyne has built four versions of the engine: AR-1, AR-2, AR-2-1 and AR-2-2. Only the first is not throttleable, and all have aerial start/stop/-restart capability. The Navy awarded the company a contract in 1955 for development of the series, and only recently cancelled the program because it had dropped the mixed aircraft powerplant concept. However, millions of dollars were spent on the program, and the engine is now ready for use, after qualification.

Originally, the AR series was to be used in various fighter/interceptor aircraft to attain super-performance when needed. A number of FJ-4 Fury jet aircraft were converted to the dual powerplant concept, and 103 flights were made using the engine.

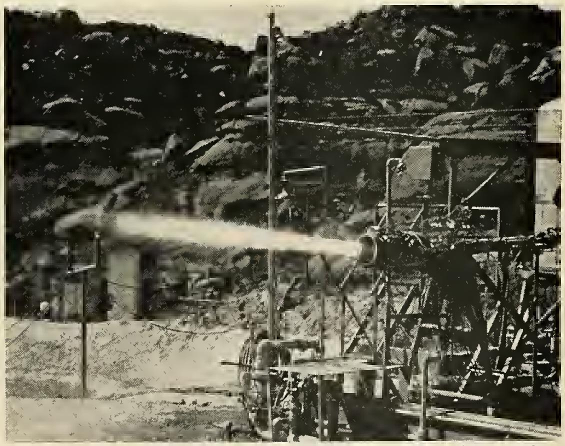
• **Progression**—The first in the series, the AR-1, is a fixed-thrust unit developing 5400 pounds thrust (all thrust ratings given are for the design altitude of 35,000 feet). Some 92 flights were made with the engine in an FJ-4 aircraft, and it was soon decided to modify the engine to provide throttle capability. The fixed-thrust characteristic did not allow the pilot to vary the power as needed, although the AR-1 did have start/stop/restart capability.

Throttle capability was built into the next engine in the series, the AR-2, enabling the pilot to vary thrust from 3000 to 6000 pounds. Operation time of the AR-1 and AR-2 is three minutes, and the AR-2-1 model is operable for seven minutes. Operation time is limited only by the oxidizer capacity of the aircraft. From the first in the series, the AR-1, to the latest, the AR-2-2, Rocketdyne succeeded in eliminating about 12 components, such as the start tank and other items.

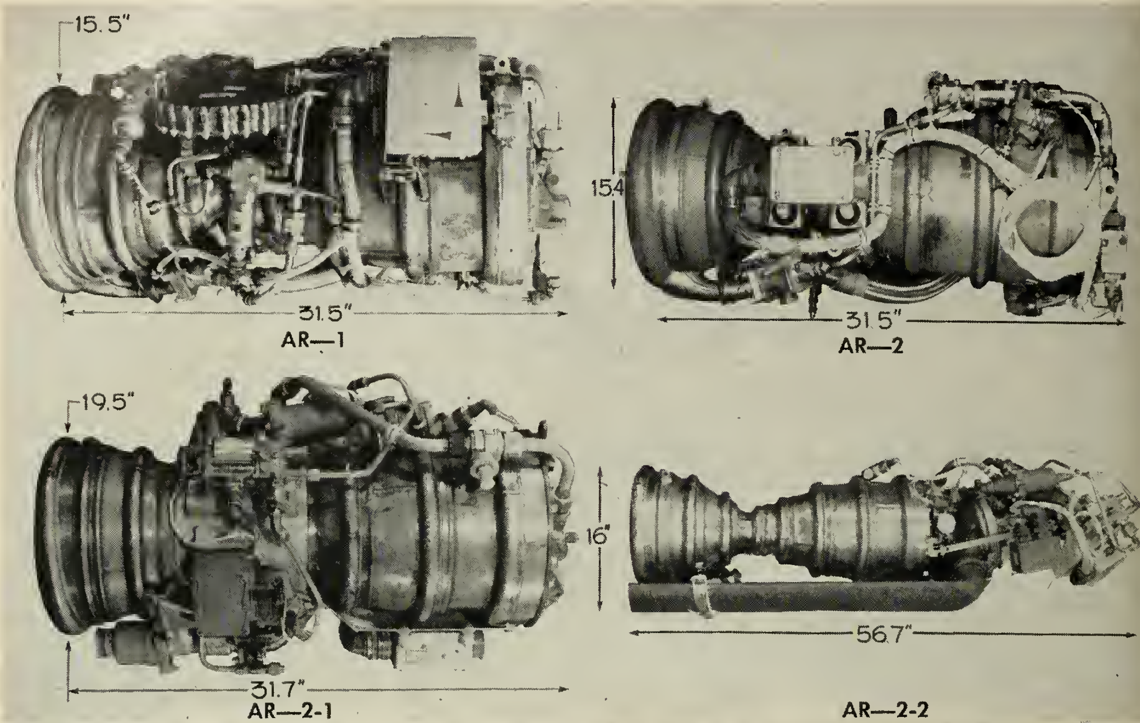
Basic differences in the four models are as follows: The AR-1 has the major drawback of being non-throttleable; the three succeeding models are throttleable and differ mostly in the arrangement of components and mounting equipment. Various sub-units, such as turbopumps, are either grouped around the engine for accommodation in a short space or strung out behind it, for a longer, thinner space.

No structural changes are required in the aircraft, despite greatly improved performance. In the FJ-4 Fury, the climb rate was doubled, the turning radius was decreased, and the speed moved into the supersonic range from a normal subsonic limit. No pitch or yaw effects were encountered when

SHORT but powerful AR-2 liquid engines which were tested on FJ-4F are assembled at Rocketdyne.



USING hydrogen peroxide and JP-series fuel, AR engines undergo static firing.



GOOD EXAMPLE of compact engineering design is this sequence of AR series engines developed by Rocketdyne.

air starts were made. According to Rocketdyne engineers: "There is no comparison between the cost of this AR conversion and the cost of a new Century-Series jet fighter."

• **Test results**—Tests of the engine series showed a very high safety factor. In the AR-1 and AR-2, the running time is three minutes, and preliminary flight rating test (PFRT) required a continuous operation at 35 times the normal length of operation. The AR-1 and AR-2 therefore had to operate for 105 minutes without malfunction. Not one engine failed the test. The AR-2-1 model, with a seven-minute operation time, was tested for 140 minutes continuously, and never failed.

Other tests for the series included 52 malfunction runs, where deliberate malfunctions were provoked to check on damage to the engine. If damage resulted, the offending part was redesigned. Vibration tests were run over a great range of frequencies, with nine hours of operation at 163 cps. Passing the PFRT allows Rocketdyne to install AR series engines in manned test vehicles. Before full production can begin and make the engine a standard item, however, there is a qualification test calling for 300 minutes continuous operation.

The AR-1 engine weighs 240 pounds, and the AR-2 weight has been reduced to 229 pounds. Further reductions are anticipated with the new tubular-wall, stainless-steel thrust chamber expected to reduce overall weight by 50 pounds.

• **Operation details**—Oxidizer capacity for the AR engine in the FJ-4 aircraft was obtained by removing a fuel cell from behind the pilot and replacing it with a bladder-type, kidney-shaped, plastic tank holding three hundred gallons of H_2O_2 suspended from the structural members of the aircraft. The AR engine, burning 100 gallons per minute, was thus limited to three minutes operation in the FJ-4.

The fuel pump which supplies JP-4 or JP-5 to the aircraft turbojet also supplies fuel to the AR engine. The pilot has a switch for the booster pumps, which operate at 25 psi, and can start the rocket engine at any thrust level which he pre-sets with the throttle. The throttle is a rheostat type, sending a signal to a thrust control unit. This signal is matched with one emanating from a thrust-control transducer, which determines chamber pressure and translates it to an electric signal.

If the chamber pressure is too low for the thrust level desired, a signal is transmitted to the gas generator, which produces more output to drive the turbopumps, which in turn provide more fuel and oxidizer to the engine. When chamber pressure rises so that the throttle signal and the thrust-control transducer-signal match, that thrust level is maintained until changed by the pilot.

The gas generator operates with a 16-mesh silver-plated screen to act as a catalyst on the hydrogen peroxide. The H_2O_2 decomposes into superheated steam at 1400°F, when passing through the 2½" diameter screen.

Catalyst screen packs are constructed with alternating silver-plated and stainless steel screen layers so that the steel screen acts to prevent the decomposition temperature of the H_2O_2 from melting the silver and fusing the screen layers together or closing the holes in the mesh. The life span of the screen pack is limited to five operating hours by the silver plating, which must be of a special type for the operation.

Valves are operated under line pressure, not electricity, to provide a higher safety factor. The only electrical connection is a cutoff device preventing the pilot from turning the engine on if a valve is partially open.

• **Oxidizer-cooled** — The double-walled chamber is cooled by the H_2O_2 flow, making it the only Rocketdyne engine cooled by the oxidizer instead of the fuel. Operation of the AR series is on a 7:1 oxidizer/fuel ratio. Since H_2O_2 decomposes at 1400°F and the flash point of JP-4 and JP-5 is about 700°F, there is automatic ignition when the two meet.

H_2O_2 is pumped into the thrust chamber, where it passes through a nine-inch-diameter screen pack similar to that in the gas generator; then the superheated steam is mixed with the fuel coming through the injector head. Combustion is at 5000°F. Large rings encircling the engine are expansion joints in the outer wall to allow it to match the thermal expansion of the inner wall. Chamber pressure is about 500 to 600 psi, depending on the thrust level set by the pilot.

Servicing time on the AR engine series is very short to fit the 28 minute airplane service time. Hydrogen peroxide was chosen for the engine because of safety and handling ease. The multi-million dollar Navy program called for conversion of fleet aircraft carriers in order that they might carry a large H_2O_2 tank to service carrier-based aircraft with AR engines.

With the new tubular-walled stainless-steel thrust chamber now under development, Rocketdyne expects to boost thrust to 12,000 pounds. The new thrust chamber will also greatly simplify manufacturing methods. The development, however, is not expected to change the Navy's decision to cancel the project.

The decision was apparently made for budgetary reasons, considering the cost of modifying aircraft carriers to handle H_2O_2, and increased emphasis on missile capability, such as in the *Eagle* program, rather than on aircraft. *Eagle* concept calls for slower aircraft.

Bell to Build $20 Million Laboratory

HOLMDEL, N.J.—Bell Telephone Laboratories will build a $20-million modern laboratory here on a 430-acre site for R&D on advanced communications. Occupancy of the first portion of the building will be in late 1961.

Bell has owned the property since 1929 and present buildings provide working space for about 150 scientists, engineers and staff studying high frequency radio and electronics.

AF Team Seeks Safer Missile Flights

GMB group is handicapped by sparse data but hopes to develop a central report procedure

by Richard van Osten

LOS ANGELES—Future design and operation of Air Force missiles may be influenced by a small, unpublicized group at Norton AFB, San Bernardino.

Bearing the weighty title of Guided Missiles Branch, Investigation and Field Operations Division, Directorate of Flight Safety Research, Office of the Inspector General, USAF, the 2½-year-old section is tackling the task of missile flight safety. Plans are being made for the day of a full AF missile inventory.

GMB activity is not accurately defined by title. The term "missile" includes all phases of missiles, rockets and drones if a flight endangers life or property, military or civil. At present, GMB is not directly concerned with such AAM's as *Falcon* and *Sidewinder*. These are treated as an integral part of aircraft armament. Nor is there any direct safety responsibility for R&D weapons, although data is being gathered for future use.

Until actual launch, missile safety rests with Ground Safety—a broad activity administered by Deputy Chief of Staff, Personnel. When the button is pushed, GMB interest takes over.

As in most interagency programs, GMB responsibilities are surrounded by a thin line. There is considerable data feedback and interchange from all AF missile and rocket activities.

Organization is patterned after aircraft safety programs pursued by DFSR, whose accident reporting system originally offered little missile application.

After studying how the system could apply to missiles, GMB obtained a revision of AF Regulation 62-14 to cover missile accidents.

In discussing the group's mission with M/R, Lt. Col. Paul E. Cool, GMB chief, pointed out the program's broad scope and provided a good example of the thin responsibility line.

• **Some problems**—Some difficulty (later corrected) was encountered with early fire control systems. It was possible to inadvertantly fire a missile from an on-ramp aircraft—it had happened. GMB was concerned because it could occur in the air. The revised regulation covers such incidents.

Collection of incident reports remains a problem. The branch reviews daily launching reports from missile test centers for implications of safety problems. Formal reports have been gathered on about 26 missile and mine aircraft-missile mishaps.

This is sparse data, but each report must be dredged as a vital part of future programming so the proper machinery will be ready when needed. A numerical coding system has been devised to pinpoint failure areas and can be applied to longhand forms or coded cards for electronic processing.

Lt. Col. Cool . . . Statistics now—Safety later.

There are two basic report classifications: major mishaps—personnel injury, property damage, or off-range impact—are considered accidents; missile failures in operational units are "incidents." No formal reports are required from R&D units, although GMB would like more than they have received. Additional data inputs are planned in the form of staff reports from other activities.

It is GMB's hope to develop a single report procedure for all agencies. At present, missile units may be required to file as many as five different reports on a single mishap.

• **Overlapping admitted**—Reaction to the program has often prompted the question "Aren't you getting into missile reliability and operational effectiveness?" The answer is "yes," according to Lt. Col. Cool, but only as necessary to build an effective accident prevention program.

When sufficient evaluated data is available, it will become an additional input for missile requirements and perhaps a strong influence in overall planning.

To date, GMB projects have not involved much engineering detail. In a typical example, four Q2 drones impacted off-range in nine months. Many other off-range impacts were prevented only by flight termination through command signals. The resulting investigation recommended study and revision of the center's Q2 operational procedure. In the year since this was accomplished, the center has had no off-range impacts.

The *Matador* was the subject of a similar program when guidance problems appeared in early models. GMB notes, however, that most such weapon difficulties are countered by system improvements almost before the cause can be determined from the scattered reports available.

Limited firings have produced a scarcity of IRBM and ICBM operational data. GMB advocates a system safety review prior to first R&D launch of a production model. This has been conducted on the *Thor*, but there is much effort to make the review a system requirement.

Data concerning missiles powered by engines with AF aircraft histories are coordinated with applicable activities. This area was highlighted when a fuel system modification, badly needed when the engine was used in planes, went unattended in the missile application until it was pointed out that the weapon's operational efficiency (and safety) had been impaired.

• **Only a beginning**—Missile safety training is both necessary and desirable, but GMB has not yet determined program needs. As a starter, DFSR's subject-of-the-month safety program for 1959 includes "Missile Safety" as its target for December.

There is some unofficial thought that to maintain top crew readiness, it may eventually be necessary to launch missiles from sites in metropolitan areas. This could only come after an increase in practice missile allocations. Statistics on crew proficiency are being carefully monitored. Additional firings will mean added production and costs, and it may prove cheaper to fund additional vehicles than risk unskilled launch procedures when they are most needed.

Data is GMB's number one problem. It would like to see improved telemetry systems to better inform operational units. Another problem area is that too few missile activities are aware of GMB and its functions. As a guide to commanders, the group has prepared a "Missile Range Safety Guide" available to all missile activities. The booklet serves also as a door-opener for GMB.

• **Hopeful outlook**—The picture is not too black: in a 10-year period, ARDC has launched 3,685 missiles of various types with one fatality and three serious injuries; ADC, TAC and SAC have good safety records because of serious-minded safety organizations and policies.

The 1958 Worldwide Flying Safety Officer's meeting marked the initial inclusion of GMB in safety problems. High-ranking personnel from most AF commands with missile units presented their views. As a result, the following recommendations were drawn up by GMB. (They are intended as *recommendations only* and do not reflect present or future policy of DFSR or GMB):

1. Direct missile safety efforts, including factory-to-target sequence, from a single staff agency at AF level.
2. Establish Missile Safety Officers in pure missile and staff units. The officers should be a combination of present ground and flying safety officers—specialized and trained in weapon system to which assigned.
3. Authorize missile safety AFSC's (job codes) for identification of training and assignment of personnel. Establish detailed breakdown of various specialities in missile safety and career fields.
4. Develop through AF staff a single mishap format for all staff agencies.
5. Establish training courses for air-launched and ground-launched missile safety; major air commands to determine quantitative requirements; QP-RI personnel to propose curriculum requirements.
6. Make certain revisions in AFR 62-14 for clear delineation between flight safety and ground safety responsibilities.
7. Rewrite AFR 62-14 to separate missile and aircraft requirements.
8. Have major air commands place a requirement on ARDC for safety review of missile going into operational use prior to first R&D launch of production model.
9. Have Deputy Chief of Staff, Development, investigate development and standardization of safety equipment and instrumentation on integrated ranges.
10. Have Deputy Chief of Staff, Development, investigate feasibility of providing simplified data recorder and telemetry system for operational ranges.
11. Have DFSR investigate MATS problem in carrying hazardous missile items.
12. Have DFSR propose to ARDC that safety information be included in missile T.Os.
13. Have major air commands distribute nuclear safety studies to appropriate squadron level.
14. Have major air commands review missile safety check lists for adequacy of safety measures.
15. Have DFSR provide bibliography of material necessary for safety problems on missiles.

Dahlgren Develops Computer

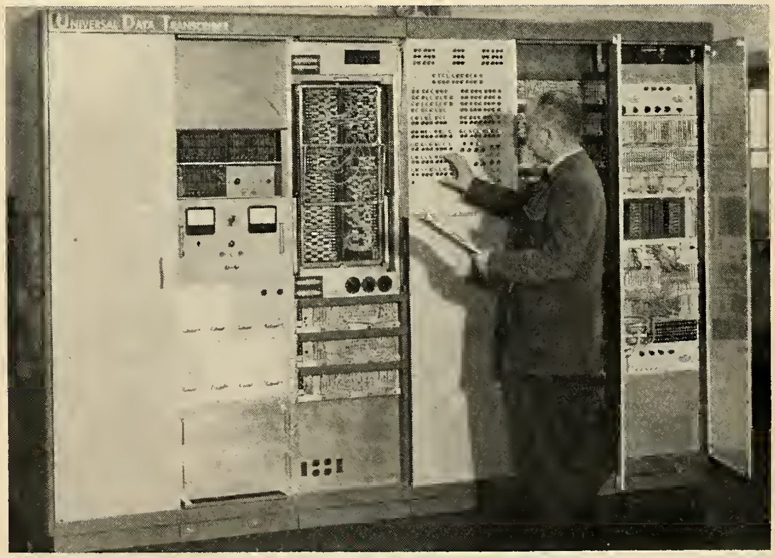
Used for Polaris, machine will handle half-million bits of information each second

Washington—A model of the Navy's latest contribution to computer technology—the Universal Data Transcriber (UDT)—will be shown for the first time at Andrews AFB on Armed Forces Day. Completed less than a month ago, the UDT is already playing an important part in processing world-wide aiming data for the *Polaris* program.

The transcriber was developed by Dahlgren Naval Proving Ground Computation Center to provide flexible conversion of data between systems previously incompatible because of different formats. Any source of digital data—cards, punched or magnetic tape, etc.—can be converted to any format desired and printed out on tapes, cards, printers, plotters, or other form of digital output. The machine will handle up to a half-million bits of information each second.

Although designed primarily for use with the NORC computer at Dahlgren, the UDT can be used to transcribe data for use with any digital computation equipment. According to Navy engineers, the use of the system will allow the utilization of much data previously "lost" because it could not be economically and quickly translated to fit other systems.

Navy's NORC, said to be the world's leading digital computer, is reportedly three to five times faster than comparable commercial machines.



FIRST DISPLAY of computer will be made at Andrews AFB.

Department of Science: Still 'Iffy'

Hoover-type commission recommended in Congressional hearings to decide how to centralize scattered efforts in science

by Erica M. Karr

WASHINGTON—The Senate Government Operations Committee has wound up the first of two sets of hearings on the question: Should the United States establish a Department of Science. Consensus of most witnesses during the two-day hearings was that something should be done to coordinate the labyrinth of government's scientific efforts starting with a Hoover-type commission to decide what, when and how much.

Most of those favoring a super science agency also suggested that a committee of experts—to include scientists from government and industry—recommend exactly which U.S. scientific functions should be blanketed under the department.

The bill setting up such a Federal agency, to be headed by a Secretary of Science, was introduced jointly by Sens. Hubert H. Humphrey (D-Minn.) and John L. McClellan (D-Ark.).

The measure would coordinate and centralize under one administrative head civilian science functions now scattered in various agencies. A similar though less sweeping measure has been introduced by Sen. Estes Kefauver (D-Tenn.).

Although the Science Department proposal got short Congressional shrift last year, supporters feel the move is inevitable eventually. Said one: "It's coming. It might not be this year, but you can bet your life on it: The United States will have a Department of Science before too long."

• **How it would work**—The Humphrey bill would put under one administrative roof the following: the Atomic Energy Commission, the National Aeronautics and Space Administration, the National Science Foundation, the Bureau of Standards and research functions of the Smithsonian Institution.

All strictly military agencies, such as ARPA, would stay in the Defense Department although there would be liaison with the new civilian department. The status of such Executive Office groups as the Science Advisory Committee would be left to the discretion of the President.

The Commerce Department's Office of Technical Services would be transferred to the department to (1) develop a comprehensive science information program, (2) act as a central clearing house for foreign scientific literature, (3) collate, abstract, translate and disseminate domestic and foreign scientific information, (4) consolidate and coordinate scientific functions of other agencies with the department, (5) supplement and support civilian sources of scientific information.

• **Congressional groups**—In addition to streamlining the government scientific structure, Congress would remodel its own house. The Humphrey bill also calls for a super science committee on each side of Congress to cover astronautics, basic and applied science, atomic energy, and the new Department of Science, with subcommittees for each specific area.

• **More research**—The bill would establish National Institutes of Scientific Research in answer to the "urgent need for a greatly expanded program of scientific research in the United States."

The advantages to industry of a civilian scientific super agency are obvious. There would be one central source for scientific information, letting of contracts and decision-making. One agency would not be able to tie up funds for the project of another agency and leave the contractor caught in the middle, as has happened in the past.

• **Scientific opposition**—Despite the clear benefits to science, some scientists strongly oppose the Science Department idea on two grounds: they fear they would be dictated to by "politicians"—told what was wanted and how to do it—and that a new department, no matter what its scope, would come out on the short end of things moneywise.

Supporters of the new measure say that a Secretary of Science would be one political appointee who could go to bat for scientists more effectively. As for money, it is pointed out Congress has never been so science-minded and—if it follows in its own footsteps of last year—it will try to add to rather than subtract from budget requests.

• **Other questions**—Some of the problems to be considered in creation of a Science Department in addition to which scientific functions now within existing agencies should be blanketed are:

What degree of control or coordination should the new agency exercise in the scientific work of other departments or agencies?

Should it be a purely civilian agency or should it also take on civilian research on military projects?

• **Administration foes** — Although Science Department boosters are riding high on the tide of the times, there is some strong administration opposition. The new Federal Council for Science and Technology created by Presidential order on March 13th was seen as an attempt by Science Advisor Dr. James R. Killian to stall creation of such a department.

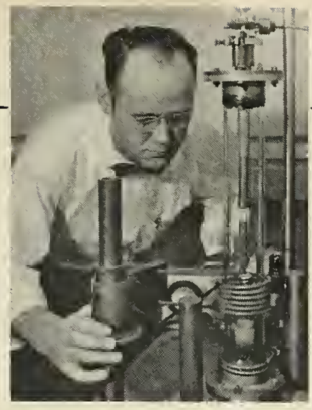
Further, it is pointed out, a good argument can be made that the new scientific organizations have not yet had a chance to prove themselves.

Although there is always resistance to creating another government agency, it is not expected to be strong in this case. Whether enough support can be garnered to push a measure through this year will depend to a large extent on the public support it gets.

One encouraging sign to Science Department pushers: One of the Humphrey bill's four co-sponsors is the junior senator from Texas, Ralph W. Yarborough. Said one legislative expert: "Yarborough is hardly likely to put his name to a measure that he wasn't sure would have the support of Lyndon Johnson (Senate Leader from Texas), and if it's got that, it's in."

"In" in the Senate would still leave a few hurdles.

Sam Rayburn, Speaker of the House, will not commit himself "until I have a chance to study the bill." And biggest question mark of all would be the President, who despite strong opposition from some in his Cabinet, has not yet made his own views known.



Furnace used at the National Bureau of Standards to grow crystals by the Kyropolos technique. The coil surrounding the vacuum chamber provides a temperature sufficient to keep the metal in the small cup molten. As a seed crystal is removed very slowly from the melt, the metal adhering to it reaches the melting point and starts to solidify, forming a large single crystal.

How NBS Researches Semiconductors

Studies include crystal growth, electrical and optical measurements, carrier lifetime, nuclear magnetic resonance, and theory

By Charles D. LaFond

WASHINGTON—With the missile and space industries demanding new electronic solid-state devices, the National Bureau of Standards is carrying out a continuous semiconductor research program to provide more data on the basic properties of materials.

Seven related projects now in progress at the Bureau include research in crystal growth and purification, electrical property measurements, optical measurements, carrier lifetime studies, mechanical and electro-mechanical studies, nuclear magnetic resonance, and development of theory.

Since the discovery of the first transistor—the solid-state triode—in 1948 by Bell Telephone Labs' Bardeen and Brattain, NBS has had a semiconductor research program.

Sponsored in part by the Department of Defense, the NBS solid-state research is aimed toward interpretation of physical properties of matter in terms of microscopic behavior of electrons, nuclei, and lattice vibrations.

During the 1930's the groundwork was laid by Wilson and Sommerfeld for a quantum mechanical theory of electrons in crystals. Born's work on crystal dynamics and Peierls' introduction of the phonon (quantized lattice vibration) concept provided the basis for understanding lattice properties. Toward 1940, solid state physics came into its own.

The materials first investigated on the basis of electron and lattice theories were germanium and silicon. The Bureau became involved in the general effort to arrive at an understanding of semiconducting solids in 1949, when work on the properties of rutile (TiO_2 in one of its crystalline forms) was initiated. These studies eventually resulted in the development of the titanium-dioxide rectifier.

• **Imperfection studies**—Studies of imperfections such as vacancies, interstitials, and dislocations during the last 10 years have made it possible to increase the strength of materials, especially metals. With the growing need for materials to withstand very high and very low temperatures, the results of such studies have found immediate technological application.

In 1952, NBS attention was turned to a new class of materials, the III-V compounds—binaries formed between elements of the III-B and V-B columns of the periodic table. The Bureau is believed to have been the first to undertake research on this group of semiconductors. During the following two years many crystals of aluminum antimonide, gallium antimonide, and indium antimonide were prepared and their electrical and optical properties investigated.

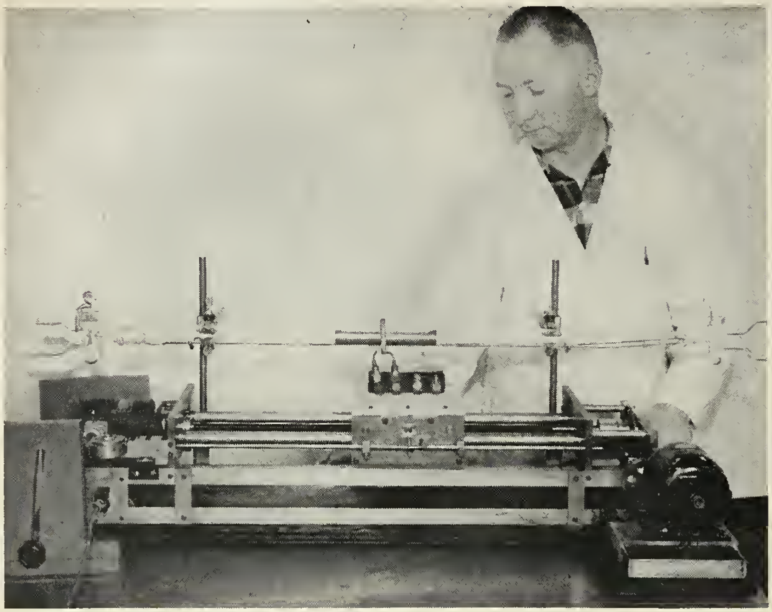
Later on, this research was extended to include studies of mechanical and magnetic behavior. InSb (indium antimonide) was shown to be an extremely interesting material for both basic research and for application to infrared photodetectors and galvanomagnetic devices. Consequently, appreciable effort it still devoted to this material.

Other materials studied during the last five years are magesium-tin and semiconducting gray tin. Recently attention has again been focused on TiO_2 as a result of heightened interest in thermoelectric devices, which has stimulated the study of oxide semiconductors, and especially oxides of the transition metals. Titanium dioxide was chosen as a prototype of this class and also as an example of a high-temperature semiconductor.

Increased activity in solid state research at very low temperatures has more recently produced devices like the maser and the cryotron, a superconductive computer component.

The scope of the NBS program of semiconductor research can be appreciated more readily through the following seven related projects (with some of the results) now in progress at the Bureau:

• **Crystal growth**—Since solid state materials are evaluated on the basis of electron and lattice theories, they must be studied in their crystalline form. Crystal growth and purification have been a vital part of the Bureau's program. Crystals of the III-V compounds are prepared by the Kyropoulos technique. A seed crystal is immersed in a melt and then is slowly removed, forming a large crystal. During the last four years, NBS has grown over 100 crystals of InSb, mostly monocrystal-



AUTOMATIC zone melter is used at the Bureau of Standards to obtain extremely high purity in semiconducting materials. Center: Water-cooled radio-frequency work coil used to melt the solid material to be purified. The coil surrounds a carbon boat which holds the bar of material. The driving motor and the return motor are on the right and left, respectively.

line, by this technique.

To obtain structural information, it is often necessary to have very pure materials or materials with known contamination or doping. Therefore, before the final crystal growth, the crystal-forming substance is purified by the zone melting technique. In the NBS zone melter, the solid material to be purified is placed in a fused silica or carbon boat within a vycor tube. A water-cooled induction coil, concentric with the vycor tube, is then made to pass slowly along the length of the solid material.

The resultant heating effect produces a small molten zone in the bar of material. This moves along the length of the bar with the coil, causing a continuous separation of impurities at the zone boundaries. The separation occurs in such a manner that after the material has been melted a number of times the impurities tend to concentrate at one end of the bar.

Indium antimonide with impurities of only 1 to 10 parts in 10^8 has been obtained with this method. It is also possible to blend evenly a specific amount of another metal to obtain a desired alloy.

• **Electrical measurements** — The first measurements made on each new conducting crystal are of an electrical nature. Conductivity is of primary interest and is determined from the potential drop along a sample of rectangular shape. Additional information is then obtained by studying the Hall effect.

(In 1897, E. H. Hall observed that when a current-carrying conductor is placed in a magnetic field, perpendicular to the current direction, a voltage is developed in a direction perpendicular to both the magnetic field and the conductor current. The Hall coefficient is the constant of proportionality between the voltage produced and the product of the current and field strength. The sign of the Hall coefficient distinguishes between n- and p-type semiconductors.)

A third property investigated is the thermoelectric effect—the voltage between two ends of a specimen kept at different temperatures.

From the variation of these quantities with temperature, information is obtained necessary for an understanding of the mechanism of conduction in the crystal and for evaluating the material for practical electronic use. Measurements of the conductivity, Hall effect, and thermoelectric power are made down to liquid helium temperatures, as are most of the other property measurements on semiconductors. Conductivity and thermoelectric power have been determined up to 1000°C.

Conductivity and Hall effect measurements made at the Bureau on the III-V compounds have shown widely differing properties for this group of materials. Energy gaps range from 3.0 ev to 0.16 ev, and mobilities from 10^2 cm^2/volt-sec to 10^5 cm^2/volt-sec. For some applications, this class of compounds should be very important.

• **Optical measurements—The** employment of semiconductors as infrared photo-detectors requires a better understanding of the principles of the photoconductive process and information on new materials. To provide these data, essential for extending the application and reliability of detectors, the Bureau measures absorption spectra and photoconductivity.

These investigations are carried out as a function of temperature, and interest is focused mainly on the infrared region. Gallium antimonide, cadmium antimonide, indium antimonide and magnesium-tin (having intrinsic absorption edges in the 1 to 7 micron range) have been studied.

Recently an investigation of the photoconductive response of copper-doped InSb showed that fairly large photosignals can be obtained at liquid helium temperatures in the far infrared range up to 35 microns. Interesting quenching effects were found in n-type InSb containing a slight amount of copper impurity.

• **Carrier lifetime**—Carrier lifetime (ζ) is one of the major parameters governing the conduction process in solids. It is defined as the length of time an electron (or hole) takes part in the conduction process before recombining with a hole (or electron) in the valence (or conduction) band.

Its numerical value is therefore of great importance in evaluating materials for application as rectifiers, transistors, and photodetectors. The Bureau has been studying carrier lifetime not only to provide critical values, but to provide a means of investigating the recombination and trapping processes in crystals.

These lifetime values are derived from photoconductivity measurements and the photoelectromagnetic effect. The latter is a kind of Hall effect in which the charge carriers are produced by incident light and deflected in the sample by a magnetic field. The current, perpendicular to both the incident radiation and the field, is proportional to $\nu\,\zeta$, while the photoconductive signal is proportional to ζ. Hence the value of the lifetime is obtained directly from the ratio of the two signals.

• **Mechanical and electromechanical**—The basic nature of semiconductors also is studied by obtaining data on the mechanical properties of crystals. This information is essential for effective material application. This mechanical behavior has been studied by means of several different experiments. Some provide information about the state of the lattice and others indicate the electron assembly. An example of the former is a determination of elastic constants.

These have been measured on single crystals of indium antimonide and the results were correlated with optical and thermal data. So far, it appears that the values of the elastic constants are indicative of the partly ionic character of this compound.

Other experiments depend on the interaction of the lattice structure and the outer electrons. A recent measurement of the resistivity of n- and p-type InSb, under the influence of tensile stress, has confirmed the energy band structure of this material.

The study of internal friction is very well suited to investigations of imperfections. The temperature or frequency dependence of the mechanical damping often reveals relaxation peaks and attenuations, which can be related to dislocations, vacancies, interstitials, chemical impurities, and other irregularities.

Measurements of this kind have been made on InSb up to the melting point (523°C). The experimental method used was the composite oscillator technique in which the sample is driven by a quartz transducer. Similar measurements in TiO_2 are currently in progress.

• **Nuclear magnetic resonance**—Since its discovery 13 years ago, nuclear magnetic resonance has proved to be a very useful technique for studying solids, according to NBS. It has been used to investigate defects and impurities in semiconducting materials. The solid being studied is contained in the coil of a resonant circuit between the poles of an electromagnet.

As the circuit is tuned through its resonant frequency, the nuclei in the sample material move from one orientation to another with a net absorption of energy. The relaxation time—the time nuclei remain in the higher energy state—is measured by pulse equipment.

Initiated in 1956, the technique resulted in the determination of the temperature dependence of the spin-lattice relaxation time in sodium chloride. During the past year, emphasis has been placed on the spin-lattice interaction in aluminum antimonide as deduced from the resonance of the aluminum nuclear spin.

• **Development of theory**—Designed to cover a wide area of physical measurements, the various avenues of experimental work at NBS form a network of closely connected approaches to understanding the electronic and lattice structure of particular solids. At the same time these data are complemented by the formulation of new theories. For example, experimental studies have resulted in a theory for transport phenomena in a strong magnetic field and in a better understanding of the electronic energy-band scheme of TiO_2, containing vacancies or impurities.

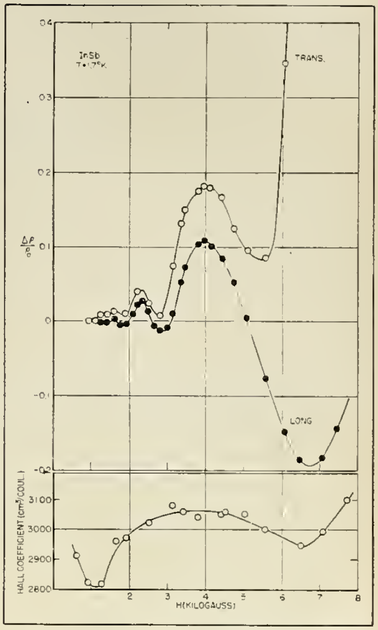
Future NBS research in solid state physics will continue to concentrate on a few materials to provide more complete data and adequate theories to describe observed phenomena. During the coming year the Bureau believes that TiO_2 will receive particular emphasis.

It is hoped that electrical, optical, and magnetic investigations of this material will provide valuable information concerning the role of impurities in the conduction mechanism. By the broad study of a few specific materials, the Bureau intends to continue fulfilling its basic function of supplying materials data and providing a basis for the development of new devices and better engineering materials.

In its electrical property investigations, several phenomena of fundamental importance have been discovered by the NBS researchers. A typical example resulted from a study of InSb. During a measurement of its magneto-resistance as a function of magnetic field H at liquid helium temperature, it was observed that the behavior of InSb was not quadratic in H as expected from classical considerations, but showed several oscillations instead.

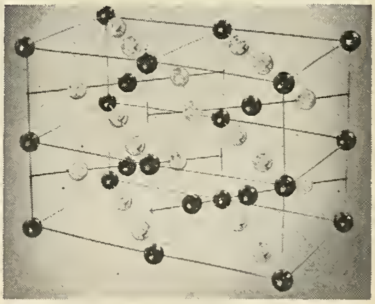
These oscillations later were proved to be periodic in 1/H. According to an NBS spokesman, this phenomenon is closely associated with the oscillatory behavior of susceptibility, which has been observed in several metals. Known as the deHaas-Van Alphen effect, it occurs when the electron mean free path becomes a circular orbit.

Then, quantization of the electron orbits must be taken into account; the electronic energy states becomes discrete and produce oscillations in the diamagnetic and transport properties.



UNUSUALLY high magnetoresistance $\Delta P/P_0$ and the Hall coefficient determined by NBS for n-type indium-antimonide at 1.7°K are shown.

SOME TYPICAL crystals studied at the NBS. Left: A crystal of bismuth-telluride; right: three crystals of indium-antimonide.



MODEL is shown of TiO_2 in the crystalline form of rutile. By the addition of foreign ions or the loss of oxygen (light balls), material becomes a semiconductor.

Space Age Pictorial Review

WORLD CONGRESS OF FLIGHT

Famous Photographer Cornell Capa traps spirit of Space Age Conference exclusively for Missiles & Rockets

The first World Congress of Flight was held in Las Vegas where the greatest figures of the entertainment world can be seen and heard for a $3 minimum and where the call of the croupier is never stilled. The Flight Congress ran with clock-like precision and efficiency for distinguished visitors, delegates and newsmen; provided one of the greatest air shows ever seen in this country, and a wealth of technical discussions, and was judged eminently successful—despite pre-convention apprehensions and fears of disapproval from another Congress in Washington.

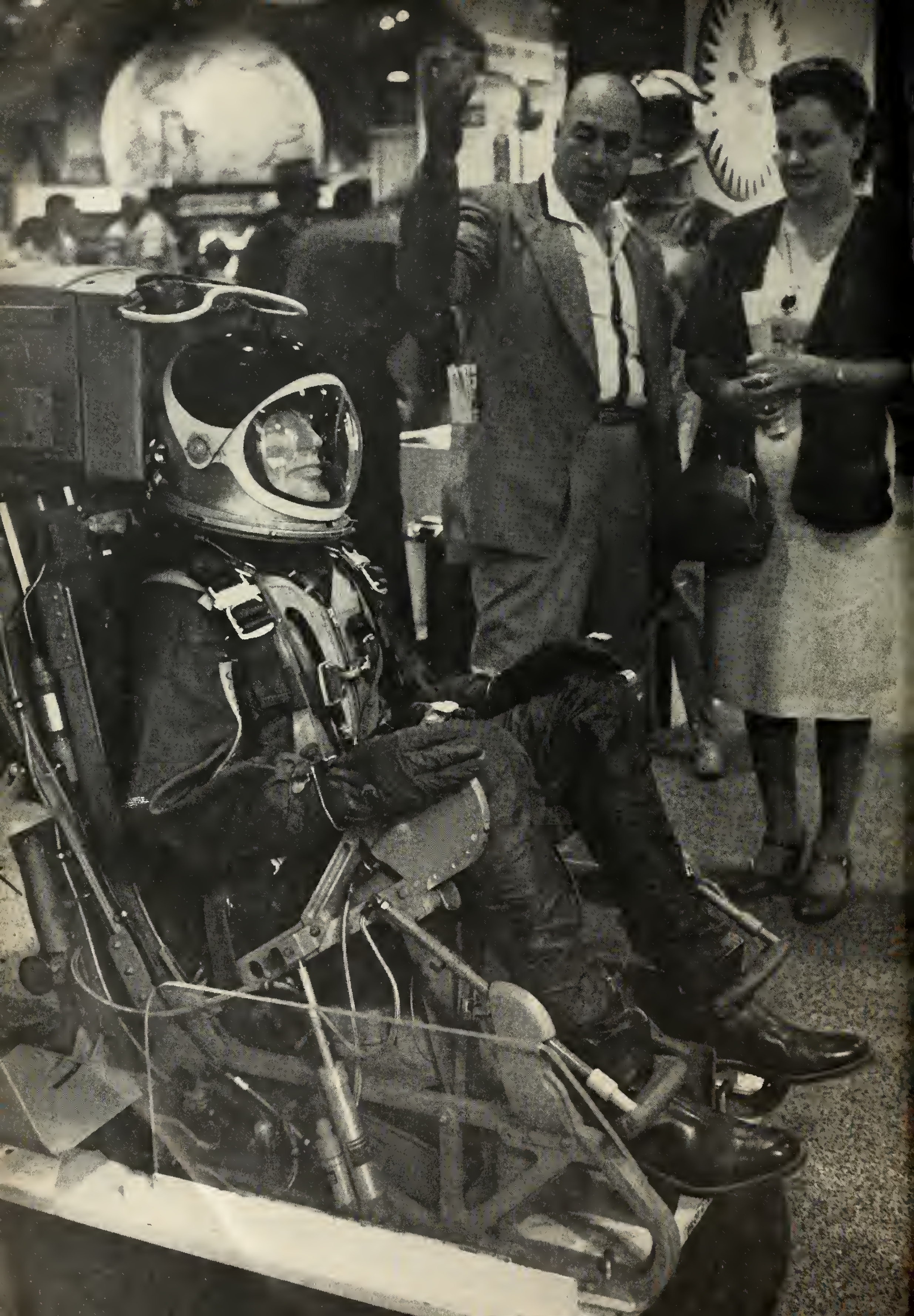
To cover this Space Age symposium, *Missiles and Rockets* engaged a world-famous photographer—Cornell Capa, brother of the late and equally famous Bob Capa—and presents his pictures on the following pages. Cornell is a member of the international Magnum group. He is best known for his work in Life Magazine and his chief interest, he says, is MAN in his various surroundings. In recent months, Cornell has been devoting his time to stories of the Space Age, of which *M/R* will carry more in the future.

WORLD CONGRESS OF FLIGHT was held in the Las Vegas Convention Center, so newly completed that the carpenters were still hammering when the doors opened on the first visitors. Closely grouped on the 100,000 square feet of floor space, delegates saw exhibits ranging from computers to jet engines like the one being inspected above by a member of the Las Vegas western-garbed police.

IN THESE UPTURNED faces Photographer Capa has caught the spirit of the jet age air show. These spectators saw five aerobatic teams, Chinese, Italian, Dutch, U.S., Air Force and Navy, plus a fire power demonstration and fly-bys. The show was held at Indian Springs AFB, some 45 miles from Las Vegas. Local officials solved a transportation problem by declaring a school holiday so 1000 teachers could haul guests in their own automobiles.

AN RED DEVILS, at left, normally flew a four-man team with a . Here the soloist joins the team to roll by the stands.

THREE GIRLS in Las Vegas costumes pose pistols-drawn before a mock-up of NASA's *Mercury* vehicle, designed to place the first American in space.



SHELTERED BY AN overhanging canopy, the $6-million Convention Center cut to a minimum the normal crowd discomforts, probably will be copied elsewhere.

T OF THE X-15 will be dressed as this dummy (left) appears to
convention delegates inspecting model of the rocket craft's seat.

FAMOUS CIGAR in hand, General Curtis LeMay, Air Force vice chief of staff, chats with other visitors in front of the General Electric exhibit.

GLASS IN HAND, Prince Bernhard of the Netherlands chats with Sen. Clair Engle of California (back to camera) at Northrup party on Thunderbird hotel roof.

TWO DIFFERENT HAZARDS to mankind: above, "les girls" of El Rancho's Nouvelle Eve show, below, the Douglas *Genie,* nuclear-packing air-to-air missile.

BACKSTOP PILOT for the *X-15*, North American's Al White in his space suit stands under the profoundly awed gaze of a young admirer while older onlookers show almost equal interest. Note space helmet in White's mittened hand.

people

Dr. L. B. Valdes will head Rheem Semiconductor Corp.'s new division for research, development and production of diodes, transistors and other semiconductor devices. The new organization will employ 200 persons by the end of this year and will be housed in a plant soon to be built. Dr. Valdes, who developed one of the first point-contact transistors, has assisted in constructing the first silicon junction transistor and has contributed to the development of various techniques used in the fabrication of semiconductor diodes and transistors.

Four members of the Army's missile-space team have been invited to membership in the new Research Advisory Committee being set up by the National Aeronautics and Space Administration. They are: **Dr. Ernst D. Geissler,** Committee on Missile and Spacecraft Aerodynamics; **Dr. Walter Maeussermann,** Committee on Control, Guidance & Navigation; **Dr. Russell D. Shelton,** Committee on Nuclear Energy Processes, and **Hans Paul,** Committee on Mechanical Power Plant Systems.

Physicist **Dr. Ervin H. Bramhall** has been named chief of weapon systems analysis at Solar Aircraft Co. He previously was systems analyst with the Institute for Defense Analysis. Other posts held by Dr. Bramhall include professor of physics, University of Alaska; physicist-in-charge at the Alaska Geophysical Observatory; operations analyst with the Army Air Force in the Pacific; professor of physics at the University of Hawaii; deputy chief for the Scientific Research Division of the U.S. High Commissioner to Germany, and chief of the physical sciences section of the Research and Development Division, Army Ordnance.

Two new executive assignments at Bell Aircraft Corp. are **Dr. Walter R. Dornberger,** director of engineering of the Niagara Frontier Division, and Vice President **Julius J. Domonkos,** vice president-Manufacturing in Bell's corporate office. Domonkos, formerly manager of the Aircraft Division, will coordinate and direct manufacturing operations in the subsidiaries and operating divisions of Bell Aircraft. Dornberger, who has been technical assistant to the president, will direct all missile, space flight, aircraft and rocket engineering efforts in Bell's Buffalo-Niagara Falls operations.

A. John Gale, vice president and director, applied physics, High Voltage Engineering Corp., will serve on the Research Advisory Committee on Electrical Power Plant Systems of the National Aeronautics and Space Administration. Gale, a recognized authority on ion thrust and other exotic methods for space propulsion, has been associated with HVEC since 1950, first as chief, development division and, since 1956, as director, applied physics. He was appointed vice president in 1958.

An Australian wind tunnel expert, **Dr. Heinz A. Gorges,** has joined the Army

Ballistic Missile Agency under a one-year consultant contract, and will work in the Aeroballistics Laboratory, which operates the missile agency's two wind tunnels. In Australia, Dr. Gorges was principal officer of the Wind Tunnel Group at the Weapons Research Establishment, the base station to Woomera Rocket Range, which is operated jointly by the Australian and British governments. At Huntsville, as in Australia, Dr. Gorges will concentrate on high-speed airflow and its influence on missile design and development.

Frank G. Denison, Aeronautic Systems, Inc.'s new vehicle technology manager, will be responsible for classified military programs underway in the fields of aerodynamics and structures, propulsion research, vehicle components and materials. He will be located in the Aeronutronic Research Center now building in Newport Beach, Calif. For more than 15 years Denison has worked in engineering management programs in the guided missile and related fields.

Rear Adm. John C. Parham, U.S. Navy (Ret.), now heads Motorola's Military Division's Washington office. Adm. Parham joined Motorola in January after retiring as Inspector General of the Bureau of Ordnance. Earlier, he commanded the U.S. Naval Missile Test Facility at White Sands, N.M. Between 1954 and 1956, the Admiral served as Guided Missile Systems Director at the Bureau of Ordnance. His Naval duties also included command of the guided missile testing ship USS Norton.

Waste King Corp. has promoted **Boyd T. Marshall** from vice-president-engineering program development to vice-president-general manager of the Technical Products Division. Other Technical Products Division promotions include those of **Frank J. Gallagher** from plant superintendent to chief manufacturing engineer; **Robert Potter** from project engineer to manager-manufacturing services; and **Arthur R. Schneider** to chief engineer. Completing key management positions are **Henry B. Coates,** general plant superintendent, and **Gardner Mason,** manager of quality control.

The appointment of **Charles N. Hood II** as director of engineering for the Airborne Accessories Corp., manufacturers of electro-mechanical equipment for aircraft and missiles, has been announced. Hood was formerly with the General Electric Co.'s Defense Electronics Division.

Hugh Mease, Jr. has been appointed manager, market research and product planning subsection of the General Electric Co.'s Heavy Military Electronics Department.

Lear, Inc. has announced election of **James L. Anast** as president, and **K. Robert Hahn** as executive vice president. **Andrew F. Haiduck** was named to the new post of group vice president.

missile business

by William E. Howard

"Looking more like the automobile business all the time." This is a Washington commentary on today's missile industry trend toward consolidation into relatively few major companies. Creating pressure for more mergers are government weapons system procurement policies which demand greater amounts of cash and more diversified facilities on the part of contractors.

So heavy are the requirements for eligibility that DOD allows small business firms to bid on an average of about 20% of all its "hard goods" prime contracts. In the first half of the 1959 FY, small business actually obtained under 60% of what it could bid on, the Pentagon reports.

The situation is more striking in the award of prime missile and electronic contracts. In the six months ended Dec. 31, DOD says small business—firms with less than 500 employes—won just .9% of $1.8 billion in missile awards and 7.7% of $891 million in electronics contracts. The percentages are almost exactly what they were for the first six months of the 1958 FY, although the dollar volume of awards in the first half of the current fiscal year was *double* what it was for the first six months last year.

Several mergers are in the works. One of the big ones in the talking stage would bring together Central Public Utility Corp.—a holding company with a strong cash position—and Philips Industries Inc., Consolidated Electronics Corp. and Philips Electronics Inc. Texas Instruments Inc. has just combined with Metals & Controls Corp., Attleboro, Mass., reputed to be the nation's largest privately-owned nuclear fuel manufacturer. Negotiations toward a possible merger are being conducted by Thiokol Chemical and Marquardt Aircraft—two leaders in the propulsion field.

Pressure to merge also comes from within the industry—the need to keep abreast of booming technological developments just to stay in business. This requires reinvestment in new plant, research and test facilities at a ravenous rate.

To meet this demand, says Donald W. Douglas, Jr., president of Douglas Aircraft, industry since World War II "has spent more than $2 billion . . . and quite likely will have to invest another billion dollars or more within the next five years." He notes that current costs for building and equipping new plants are running about $36 per sq. ft. against $12 per sq. ft. for World War II plants.

Douglas says: "Add to these factors the reduction in progress payments, increased tightening of procurement regulations, the effects of renegotiation, the increased costs of R&D—including even the preparation of proposals—and the financial problem confronting the industry assumes major proportions."

The younger Douglas was speaking from first-hand acquaintance with the accounting ledgers. His company reported a net loss of $4.2 million for the first quarter of the fiscal year which ended Feb. 28. This compares with net income of $8.5 million for the like period of 1958. Heavy write-offs for its DC-8 jet transport were attributed to the loss.

Douglas doesn't expect a profit for the company's entire fiscal year. The company, incidentally, at its recent stockholder meeting revealed that it generally makes 2% to 3% on military work, while its profit on commercial production can range from a loss to as high as 20% to 30%.

Another stockholder meeting yields the information that Beech Aircraft Corp. is moving into the space field. Beech, principally engaged in private airplane production along with some military work, has landed a $1 million Air Force contract for a "transient heat" laboratory. To be located at Boulder, Colo., the new installation is for ground testing the thermal effects of space flight on prototype rocket and space vehicle propellant systems. Temperatures simulating space conditions will be generated by a system of electric heaters.

contract awards

NASA

WASHINGTON—The National Aeronautics and Space Administration announced award of a $945,000 contract to Chance Vought Aircraft, Inc., for construction of the frame and launcher for the Project *Scout* vehicle.

The Dallas firm will also integrate *Scout's* four solid-rocket stages and send a crew to the Langley Research Center to assemble the rocket for its test flights, scheduled for mid-1960.

Earlier, NASA announced the following awards were made in March:

$4,120,000—General Electric Co., for the second-stage, liquid-propelled rocket engine to be mounted on an *Atlas* as Project *Vega*.

$3,000,000—Jet Propulsion Laboratory, for *Vega* integration, payloads and technical project supervision.

$1,070,000—Bell Aircraft Corp., for feasibility study of a high-energy fluorine-liquid hydrogen rocket engine, including paperwork and hardware.

$930,000—North American Aviation, Inc., for destruct system and design of transport vehicles and launcher in Project *Mercury*.

$540,000—U.S. Army Signal Corps, for infrared radiation and heat-balance experiment in Project *Tiros*, a classified meteorological satellite experiment transferred from DOD to NASA.

$260,000—Naval Research Laboratory, for test equipment for telemetry stations.

$150,000—U.S. Weather Bureau, for meteorological analysis in various experiments.

$120,000—Electro Mechanical Research, Inc., for two telemetry systems to build a prototype for use in Project *Mercury*.

$100,000—Naval Ordnance Test Station, for R&D on advanced television cameras for advanced space vehicles.

$100,000—Army Ordnance Missile Command, for reimbursement for special technical studies and activities.

$80,000—Cook Electric Co., for five free-channel miniature airborne tape recorders for use in various projects.

$60,000—Thiokol Chemical Corp., for *Recruit* rocket motors and high-energy work at Lewis Research Center, Cleveland.

$60,000—Radioplane Div., Northrop Corp., for landing and recovery system for Project *Mercury* capsule.

$50,000—Herrick L. Johnson, Inc., for 3600-gal. liquid hydrogen trailer to be used in support of high-energy rocket work at Lewis.

$20,000—U.S. Army Ordnance and Cooper Development Co., for 10 two-stage *Nike-Asp* sounding rockets.

ARMY

$13,266,720—California Institute of Technology, for R&D work at the Jet Propulsion Laboratory.

$5,912,018—Mattich and Sundt, Vandenberg AFB, for construction of missile launching complex at Vandenberg.

$3,750,000—Collins Radio Co., for fabrication and installation of one primary and two secondary satellite tracking stations (primary station at existing U.S. base in Spain; secondary stations at Far East sites still to be chosen).

$3,000,000—Aeronutronic Systems, Inc., subsidiary of Ford Motor Co., for development of surface-to-surface *Shillelagh* guided missile. (The figure is for spending on the program in FY 1959; contract eventually is expected to run to $23,000,000.)

$1,842,084—Douglas Aircraft Co., Inc., for *Nike-Hercules* adaption kits, rocket frame components and *Nike* repair parts (three contracts).

$1,500,000—Freuhauf Trailer Co., for a flat bed transporter.

$1,139,569—The Martin Co., Orlando, for work on the *Pershing* system.

$685,970—Consolidated Western Steel, Los Angeles, for design, development, fabrication and testing of *Little John* missile motor case assembly.

$554,704—Chrysler Corp., for *Redstone* components.

$532,450—Leslie Miller, Inc., Forth Worth, Tex., for construction of *Atlas* facilities at Warren AFB, Wyo.

...contracts

$528,501—**Victoreen Instrument Co.**, Cleveland, for vacuum electron tubes (fixed-price contract with price redetermination).

$236,625—**Federal Div., ITT**, Clifton, N.J., for manuscript and illustration for technical manuals on the trailer-mounted guided missile target simulator equipment 1502.

$195,679—**The Firestone Tire & Rubber Co.**, for classified work and for repair and modification of *Corporal* equipment (two contracts).

$187,483—**Autonetics Div., North American Aviation, Inc.**, for design, development and fabrication of a digital analog computer.

$144,050—**Potter Aeronautical Corp.**, Union, N.J., for turbine type flow-meters.

$128,275—**Resdel Engineering Corp.**, Pasadena, for R&D on converter systems.

$101,850—**Indenco Engineers, Inc.**, San Leandro, Calif., for final design of the *Bomarc* facility at Travis AFB.

$78,000—**Rocketdyne Div., North American Aviation, Inc.**, for classified work.

$45,958—**Telemetering Corp. of America**, Sepulveda, Calif., for R&D on a telemetry system.

AIR FORCE

$19,910,782—**International Business Machine Corp.**, for on-site installation, maintenance and logistic support services of SAGE computer systems at various Air Defense Sector Sites for FY 1959.

$2,250,000—**American Car and Foundry Div., ACF Industries, Inc.**, for continued production of mobile launchers for *Snark* ICBM's.

$1,000,000—**Beech Aircraft Corp.**, for construction of a "transient heat" laboratory at Boulder, Colo., for ground testing effect of high temperature on prototype rocket and space vehicle propellant systems.

$1,000,000—**National Company, Inc.**, Malden, Mass., for Atomichron stable frequency standards for ICBM's.

$750,000—**Military Field Services Div., Burroughs Corp.**, for technical non-personal services for on-site maintenance and instruction for the AN/FST-2 coordinate data transmitter.

$664,849—**Gilfillan Bros.**, for moving target reflector sets.

(The **Siegler Corp.**, Los Angeles, announced receipt of a contract totaling almost one-half million dollars from the **Hallamore Electronics Division** for modification of special mobile test trailers for the *Atlas* program.)

$167,452—**Defense Electronics Div., General Electric Co.**, for telemetric data monitors, demultiplexer groups and multiplexer groups.

$124,020—**Litton Industries of Md., Inc.**, College Park, Md., for antennas.

$99,065—**Philco Corp.**, for research on monocrystalline semiconductor films.

$70,000—**RCA Laboratories, David Sarnoff Research Center**, Princeton, N.J., for research on unipolar control devices.

$64,500—**Intercontinental Electronics Corp.**, Mineola, N.Y., for TI-440 radar-to-television scan conversion system.

$50,000—**Western Reserve University**, Cleveland, for continuation of research on orbital electron capture by nuclei.

$49,950—**Horizons, Inc.**, Cleveland, for research directed toward investigations of ferroelectric memory devices and systems.

$40,018—**Ball Bros. Research Corp.**, Boulder, Colo., for research toward development, test and fabrication of sun-azimuth pointing platform.

NAVY

$216,990—**Montrose Div., Bendix Aviation Corp.**, for synchros.

$82,897—**Globe Industries, Inc.**, Dayton, Ohio, for timers.

$55,500—**S. S. Hunter, Inc.**, Syosset, N.Y., for pneumatic guided missile test sets.

$52,990—**American Construction Co., Ltd.**, Honolulu, for guided missile support facility at U.S. Marine Corps Air Station, Kaneohe, Oahu, T.H.

$43,815—**Nems-Clarke Co.**, Silver Spring, Md., division of Vitro Corp. of America, for range operation equipment, receiving radio, spectrum display unit, etc.

READY

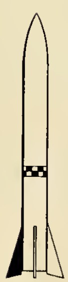
ONLY LEAR ELECTRIC SERVOS ARE MAINTENANCE-FREE AND *ALWAYS* ON THE ALERT

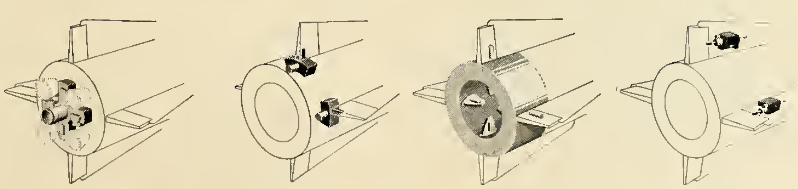
To help keep the peace, today's missiles must be instantly ready to fire as the Sheriff's six shooter of old. Delay or failure is fatal. Lear Electric Servos—even after "standing by" for three to five years—give this sure fire readiness to the nation's missile arsenal.

Lear Electric Servos provide more fire power per dollar by eliminating constant, high-cost maintenance required by other types of missile actuators. Lear's servo actuators save manpower, equipment and money. They are field tested and stand ready to "take over" instantly in missile jet vane, air vane or elevon actuation.

This proven action performance plus economy, both in-flight and "on the ready," has won enthusiastic Army and Air Force acceptance for surface-to-surface and air-to-ground missile applications, and Lear electric servos can be designed to be an integral part of any known missile.

Select your servo from this field tested line.





LEAR

GRAND RAPIDS DIVISION

110 IONIA AVENUE N.W., GRAND RAPIDS 2, MICHIGAN

G-4

propulsion engineering

Ammonium nitrate as a rocket engine oxidizer decomposes differently than AN as a molten laboratory liquid. Aerojet-General chemists indicate this may change many old views of how this oxidizer operates. They point out that many studies have been made of how ammonium nitrate is decomposed by heat. However, these studies have been made on the molten salt and show that water and N_2O are the primary products. However, AN heated at a solid surface produces primarily nitric acid (vapor) and ammonia. This, they emphasize, is the reaction that takes place as the result of rapid heating, such as burning in an engine. Further, their studies indicate that the rate-controlling process of AN thermal decomposition takes place at the surface layer only. The work was done in Aerojet's Chemical Division at Azusa for Wright Air Development Command.

Fluorine is not yet a practical oxidizer, NASA propellant bosses say. They point out that fluorine can be handled fairly easily as a gas, thanks to recent developments. However, NASA needs it as a liquid, and this cannot be handled routinely. Fluorcarbon plastics are suitable for use as seals and gaskets in systems handling the gas. These plastics also are compatible with the liquid under laboratory conditions, NASA says. But they rapidly break down when operating conditions such as friction and pressure are introduced.

Titanium's corrosion resistance is markedly increased by the addition of trace amounts of palladium and other noble metals. Union Carbide Metals reports that 0.1% of palladium increases titanium's ability to ward off corrosion by 98%. Up to as much as 0.2% palladium will not affect titanium's characteristics, except for increased corrosion resistance. Union Carbide Metals says the Ti-Pd alloys will be reasonably cheap—it costs only 28 cents to add the right amount of palladium to a pound of titanium. The most effective alloy with a noble metal, the company says, is titanium-tantalum. However, this almost absolutely-corrosion-resistant combination will be too expensive for general use. UCM says it will license its Ti-noble metal alloying process to present titanium producers.

Ethers will lubricate nuclear engines and turbojets before very long. W. C. Hammann, Monsanto Chemical, and E. R. Barnum, Shell Development, say polyphenyl ethers are the answer to lubricating problems around 400°F. Actually, decomposition of many of the ethers takes place around 850°F, they say. Some polyphenyl ethers have useful lives of 20-80 hours at 900°F. Also, they told a national meeting of the American Chemical Society, these ethers are two to five times more resistant to breakdown under nuclear radiation than present lubes. But, there is a catch: Many of the engines that can take advantage of these lubricants still are on the drawing boards.

Nuclear engine research soon will center on NASA's two new experimental heat transfer loops. Work so far has been limited to sodium, potassium, sodium hydroxide, and NaK (sodium-potassium) loops. NASA's two new loops will use rubidium and cesium, operate at 1200-1500° F.

Hypergolic propellants don't interest one top NASA propulsion expert. These fuel-oxidant combinations that ignite automatically when mixed have been billed as solving high-altitude ignition problems. However, a NASA propellant authority says he feels ignition system troubles are on the way to being solved, and hypergolics may not be needed.

Premixed ozone and combustible gases can be burned in pure ozone, Army research indicates. Hydrogen, cyanogen and methane can be mixed with ozone without explosion, the Army reports.

APRIL

Aero Medical Association, 13th Annual Meeting, Statler Hilton Hotel, Los Angeles, Apr. 27-29.

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

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

MAY

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

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

Instrument Society of America, 5th National Instrumentation Flight Test Symposium, Olympic Hotel, Seattle, May 4-8.

International Scientific Radio Union, Spring Meeting, Willard Hotel, Washington, D.C., May 5-7.

1959 Electronic Components Conference, Benjamin Franklin Hotel, Philadelphia, May 6-8.

Institute of Radio Engineers, Seventh Regional Conference and Trade Show, University of New Mexico, Albuquerque, May 6-8.

Armed Forces Day, Observances scheduled throughout week of May 9-17.

Aviation Writers Association, 21st Annual Meeting and News Conference, Washington and Willard Hotels, Washington, D.C., May 10-16.

The Atomic Energy Commission, Technical Information Meeting on Test Reactors, National Reactor Testing Station, Idaho Falls, Idaho, May 13-15.

Society of Aircraft Materials and Processing Engineering-Eastern Div., Spring Meeting, Hotel Statler, New York City, May 15.

Space Medicine Electronics Symposium, Franklin Institute, Philadelphia, May 18.

Society of Aeronautical Weight Engineers, 18th Annual National Conference, Hotel Henry Grady, Atlanta, May 18-24.

The Society for Experimental Stress Analysis, 1959 National Spring Meeting, Sheraton Park Hotel, Washington, D.C., May 20-22.

Instrument Society of America, 1959 Ohio Valley Instrument and Automation Exhibit and Symposium, Cincinnati Section, Music Hall, Cincinnati, May 21-22.

Institute of Electrical Engineers, The Radio and Telecommunication Section, International Transistor Exhibition and Convention, Earl's Court, London, May 21-27.

American Rocket Society, Institute of the Aeronautical Sciences, American Institute of Electrical Engineers and the Instrument Society of America, "Investigation of Space" Conference, Brown Palace and Cosmopolitan Hotel, Denver, May 25-27.

American Society of Mechanical Engineers, Design Engineering Show and Conference, Convention Hall, Philadelphia, May 25-28.

The Institute of the Aeronautical Sciences, San Diego Section, Regional Meeting on Supersonic Transports, San Diego, May 26-28.

Federation Aeronautique Internationale, Annual Conference, Moscow, May 28-31.

JUNE

Institute of Radio Engineers' Professional Group on Microwave Theory & Techniques, National Symposium, Harvard University, Cambridge, Mass., June 1-3.

Institute of Radio Engineers' Professional Group on Production Techniques, Third National Conference, Villa Hotel, San Mateo, Calif., June 4-5.

The Pennsylvania State University's Missiles Systems Engineering Seminar, University Park, Pa., June 7-13.

Aero Club of Michigan, Industry Missile and Space Conference, Sheraton-Cadillac Hotel, Detroit, June 8-9.

American Rocket Society, Semiannual Meeting, El Cortez Hotel, San Diego, June 8-11.

United Nations Educational, Scientific and Cultural Organization, Paris, June 15-20.

Cornell University Industry Engineering Seminars, Cornell University, Ithaca, N.Y., June 16-19.

Institute for Practical Research on Operations, Chief of Research and Development, U.S. Army, The University of Connecticut, Storrs, June 21-July 3.

American Institute of Electrical Engineers, Air Transportation Conference, Olympic Hotel, Seattle, June 21-26.

JULY

Tenth Annual Basic Statistical Quality Institute, Chief of Research and Development, U.S. Army, University of Connecticut, Storrs, July 12-24.

Second Annual Institute on Missile Technology, Chief of Research and Development, U.S. Army, University of Connecticut, Storrs, July 26-Aug. 7.

AUGUST

Institute of Investigation of Biological Sciences, Sponsors: Air Force Office of Scientific Research, Aeromedical Div., World Health Organization and United Nations Educational, Scientific and Cultural Organization. Montevideo, Uruguay, Aug. 2-7.

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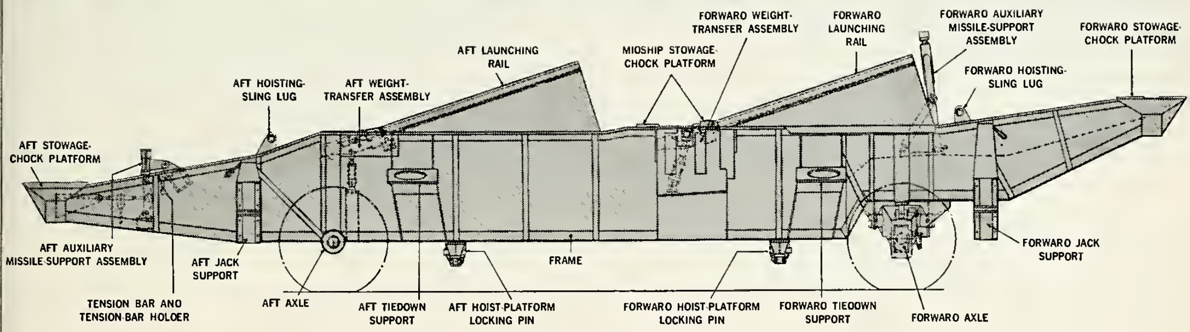

Another Loewy missile handling achievement— "Dolly Launcher" for guided missiles on Navy cruisers

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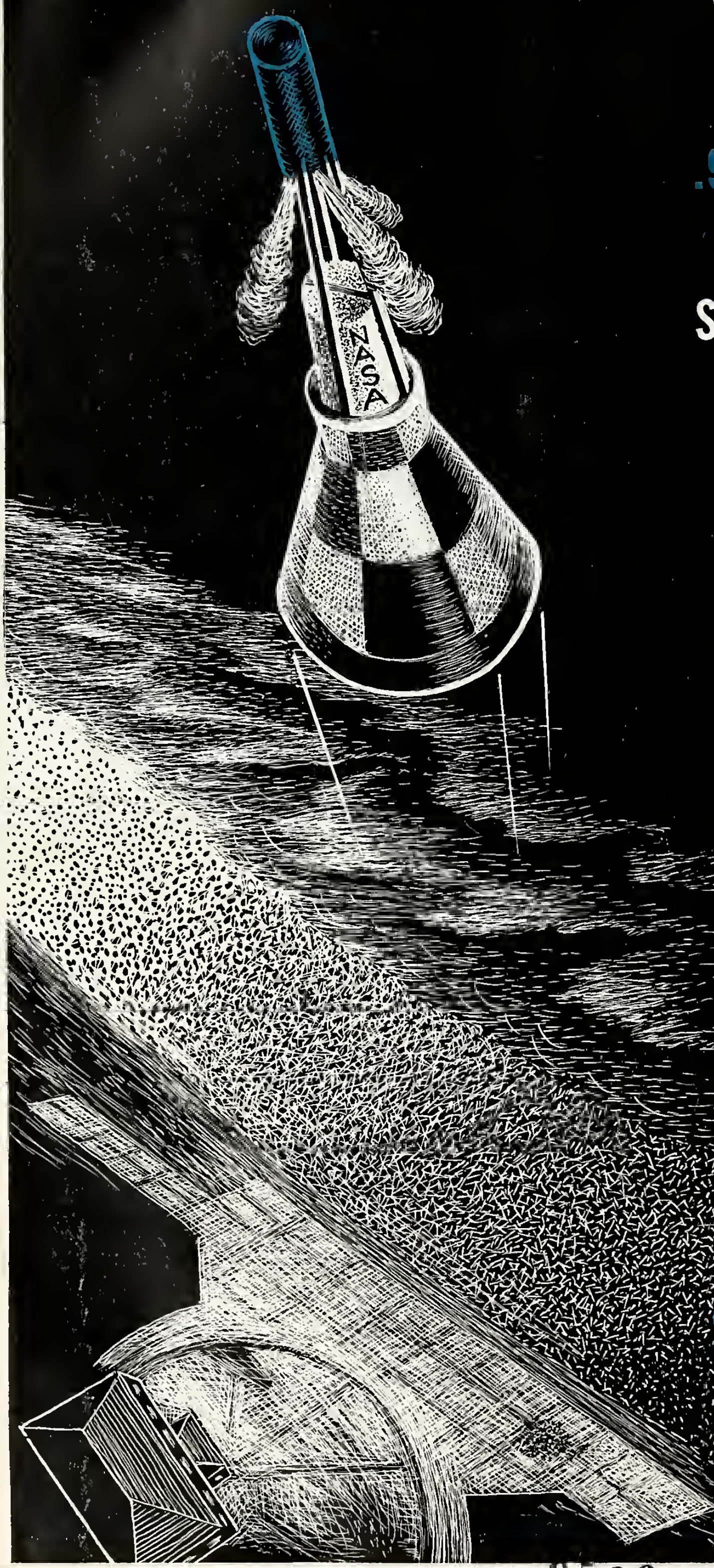

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