EXCLUSIVE: Russia's Moon Rocket Program

by Erik Bergaust

missiles and rockets

INCLUDING MISSILE ELECTRONICS

THE MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

NOVEMBER 1957


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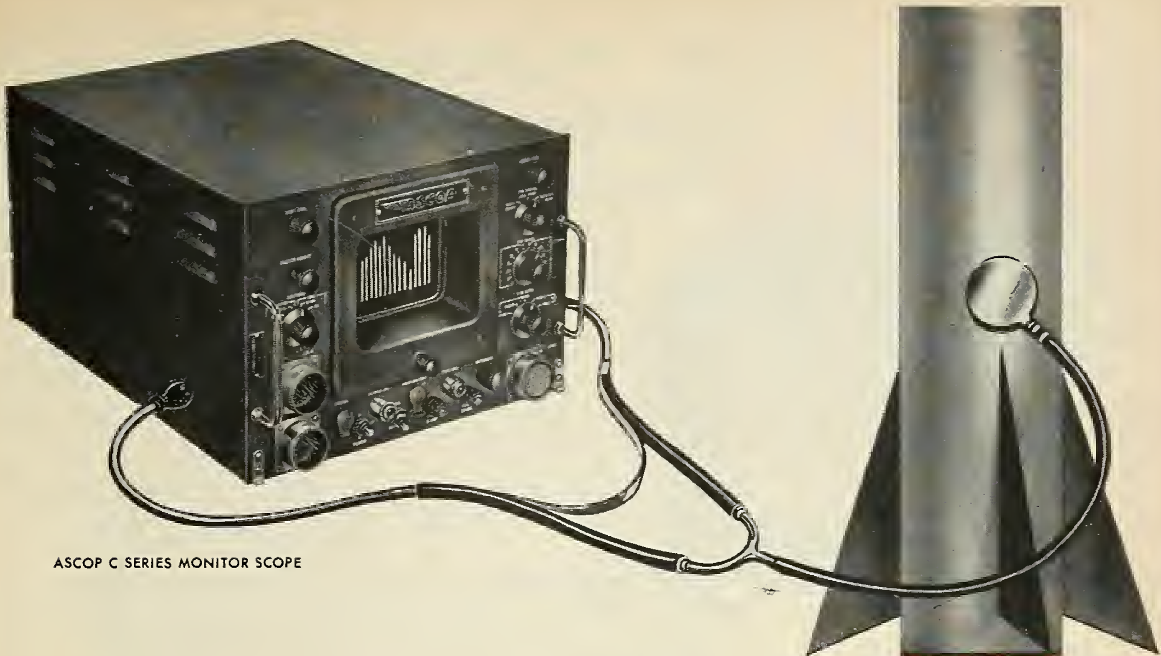

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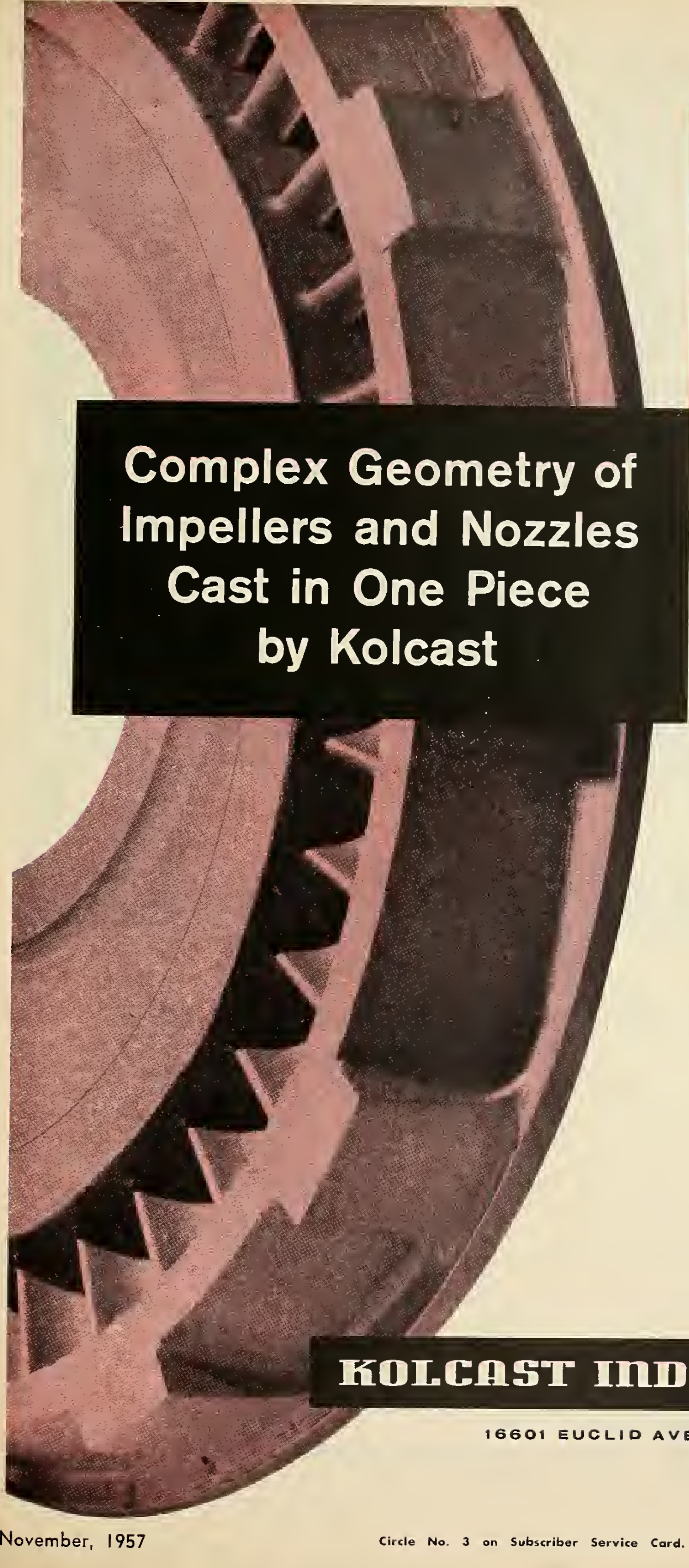

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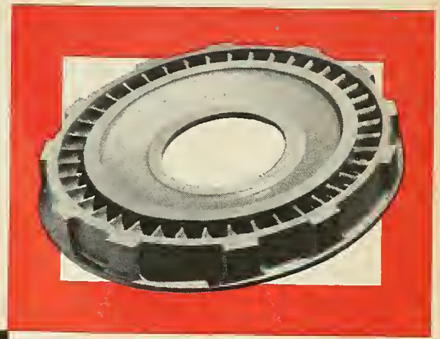

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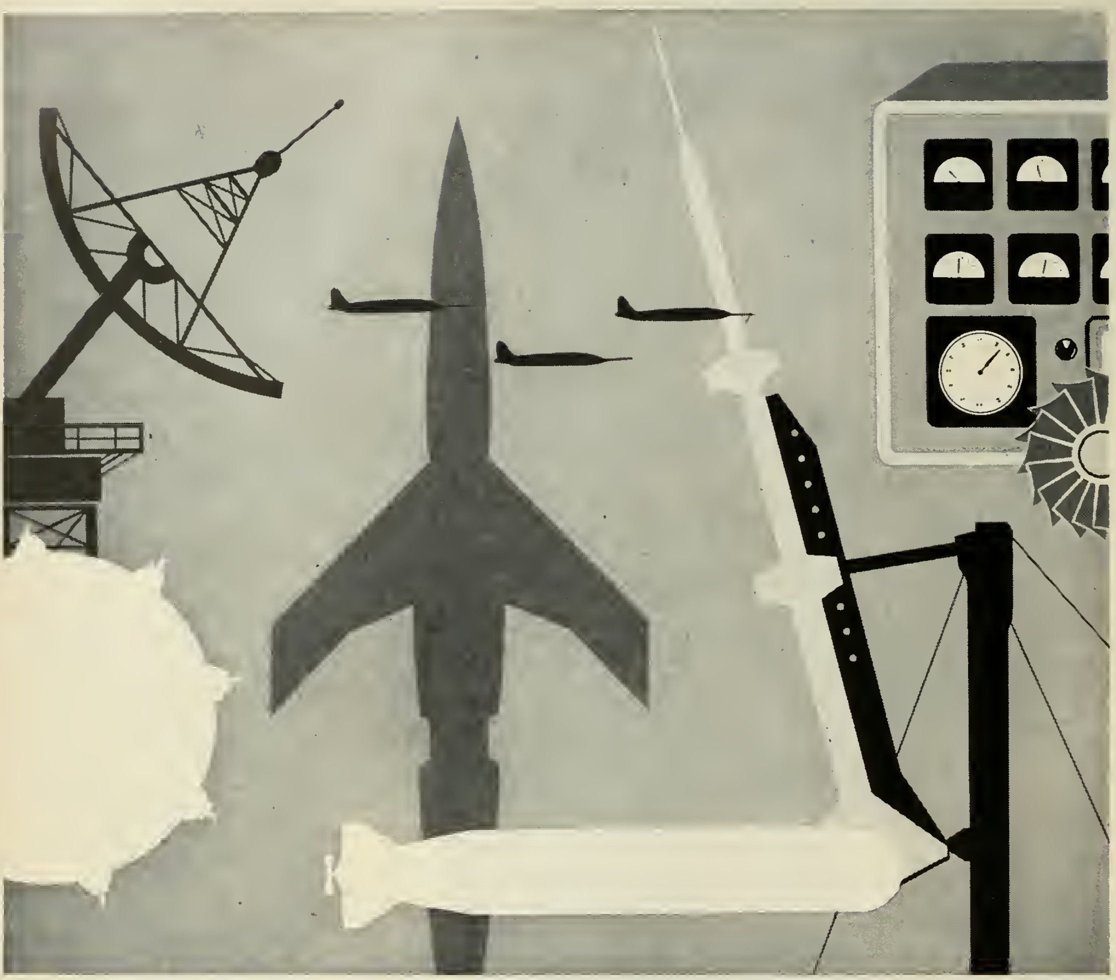

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missiles and rockets **vol. 2 no. 11**

news and trends

special features

rocketeer profile

missile age

next issue: Education, Training, Employment

cover picture:

The moon, as shown on our cover, has become vitally important. Man is just about to set foot on Luna. This is of such great concern as we have seldom known. With the race into space becoming more a matter of survival than just friendly competition, it is significant that we consider the most vital satellite of all—the moon. See the m/r *editorial on page 9 and our exclusive coverage of the Soviet moon rocket program, page 37.*

columns

departments

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missiles and rockets

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An Open Letter to President Dwight D. Eisenhower

Mr. President:

This is the age of science. This is the era of intellectual, uninhibited thinking. Tomorrow is here. And you, as the leader of the greatest nation on earth, must see to it that this nation will be out in front as mankind advances into the space age.

Until recently many of your top-level officials have considered space flight trivial and irrelevant. Space travel was something for science fiction writers and comic strip authors. Even within the Air Force, officials and officers were not to mention or discuss space flight. Our government's top policy makers refused to heed the scientists and engineers who predicted many years ago that tomorrow's war would be fought with space weapons, and that the nation which controlled space would control world peace and the destiny of mankind. These top officials, we hope, soon will begin to see the light. Mr. President, you must lead the way.

Overnight the American people have learned that in spite of their material wealth, in spite of wrap-around windshield automobiles and chrome-plated washing machines, in spite of superhighways and supermarkets and our high standard of living—the world is questioning our leadership of world power.

We have been shown that the current World War III is a battle of the minds. The nation that demonstrates its technical superiority effectively and dramatically to the rest of the world will profoundly influence the minds of men. The American public is beginning to understand this. The extent that our government policy makers understand it can determine our destiny.

In the eyes of some billion-and-a-half people, Russia now is becoming such a leader, and it will take an immense effort to overtake her. The mere stepping-up of our missile program and sorting-out of our inter-service missile rivalry problems won't do the trick. Pooling our scientific know-how with our allies won't do it either. The problem is more basic.

It begins with the materialistic attitude toward modern day living and our indifferent attitude toward science. Lack of scientists? Of course! Scientists are individualists, and individualism is on the wane in this country. Must we remain at the point where it takes an Admiral Rickover to get things done?

Many of this country's outstanding scientists were born in Europe. Many of them came here to become citizens of this great country because they thought they could accomplish more in an atmosphere where one supposedly has intellectual freedom and a greater understanding of mankind's progress and of things to come. How disappointed these scientists must be today!

More than ever, Mr. President, we now need leadership. We are looking to you for this. We need uninhibited thinking at Cabinet level. We need a scientist at Cabinet level, a Secretary of Science. We also need a space flight program. We must consolidate and pool our scientific talent, possibly through a National Advisory Committee for Astronautics or an Astronautics Commission, with a definite schedule and timetable for the conquest of space. We must take the initiative to become first in satellite science. We must put man into space; we must put man on the moon and on our two nearest planets. The United States must show the way. If she does not, Russia will.

We must do all this within 20 years or less and we must start the planning for such a program immediately, for two reasons: 1) Such a program will yield tremendous scientific victories which will benefit our entire human race in numerous ways. 2) Such a program will restore supremacy to the free world and in particular to the United States. This, Mr. President, will mean for us a total victory of democracy over slavery. Scientists and military planners must advance hand-in-hand to achieve this.

In order to accomplish this we must start at the basic research level. Instead of cutting funds for research and development, we must increase them. Research is the key to scientific and military achievement.

You now have the opportunity to reorganize our missile defense system and to start a space flight program. For the time being it is not so much a matter of granting more money for defense as a matter of organizing the expenditures and our scientific talent.

Obviously, we must spend more money in the future on a space flight program. John Q. Public understands the grave and alarming mess we are in, whether your Cabinet members do or not. He doesn't like to, but he will pay higher taxes if he can be assured that this nation will regain its Number One position in the world.

Actually, we have a lot of money in the bank for a space flight program. And we have the talent. *Jupiter* and *Thor* are duplicate programs initiated to perform duplicate functions. Seemingly one must go, but both have cost many millions of dollars; both have drawn heavily on available technical manpower.

The superficial solution is to decide that the full cost of one program and one missile team must inevitably be wasted—be lost to the country—a "necessary price" paid in the crash development of modern weapons.

This, Mr. President, is not so. There is a sound solution. If *Thor* proves to be the best weapon of the two IRBMs, do not cancel out the *Jupiter* team and money as a total loss, but shift the team and its hardware to America's inevitable space flight program. Special configurations of the *Jupiter*—or the *Thor*—are capable of putting up satellites of 1000 pounds weight. We could achieve this within months. Either missile represents a valuable piece of hardware for practically any preliminary space flight project. With this approach we can catch up with the Russians two to three years sooner —without slowing our military program—than if we repeat the approach we used in developing the *Vanguard* "me too" satellite.

The same technique can be used with our *Atlas* and *Titan* ICBMs. The missile not selected as a weapon must enter our future arsenal of space flight vehicles. So must the scientific team behind that missile.

Employing this approach, we will save the taxpayers millions, possibly billions, of dollars. The decision to pursue this goal and employ this technique must be made now.

Of course, we will have all kinds of investigations as soon as Congress convenes. And this is right. Senators and Congressmen need no urging to do something about our present confused situation; spontaneously they vow "something will be done about it" as soon as Congress convenes.

In all probability, Congress will throw some light on the confused background of our missile and satellite program. Incidentally, we hope Congress will also make public the names of the members of the nine-man committee that turned down the offer to use military hardware to launch the first U.S. satellite. It may be a waste of time to discuss at this time what we could have done and did not do. Nevertheless, for the record this is important. If nothing else, it will help sort out the incompetent from the capable, and it might give us a pointer as to where we will find the best-qualified scientists and leaders to conduct the kind of future space flight program this country so desperately needs.

We are not so sure that the U.S. is employing the best-qualified people at this stage of the game. Many missile industry people have questioned us about the capabilities of some of our current "space flight experts" (people who seem to have become space-minded overnight) and why we have not employed our true space flight scientists in the current IGY satellite program. We have no ready answer for them.

Yes, in the eyes of the world, the American satellite program now has become a "me too" project.

We urge you, Mr. President, to look at space flight as any other American institution, because sound, business-like competition would have put us out in front. The approach that has provided us with more washing machines and paved highways than the rest of the world also could have kept us the strongest nation in the world. No other approach will help us regain the ground that we have lost to Russia. No other approach will help us win the battle for the minds of men.

Those of us who talked with members of the Russian delegation at the space flight meeting in Barcelona recently heard these scientists all openly confirm the fact that Russia has a full-fledged space flight program. And you know, Mr. President, we don't have one!

The Russians have a definite timetable for their bigger satellites, for their different kinds of moon rockets and flights to the planets and manned, military space vehicles. In view of their technological advances in recent years—which they have proven beyond doubt—we can no longer afford to doubt any of their scientific claims.

Cost is of no importance to Russia. The Russian people might be starving; there may be a shortage of bread, soap, gasoline, clothing in the Soviet Union; but the world doesn't worry about this when the Russians send satellites and moon rockets aloft. Because this proves to the world that the Russians possess the ability to smash the Western World by missile bombardment.

Let us not fool ourselves, Mr. President; it takes more than power to put up a satellite. For years our missile engineers have tried to solve the structural problems created by high accelerations, tossing and stress in a missile, and for years they have tried to solve the guidance problems. Without solving these problems, you cannot launch a satellite. The Russians have solved them. We are still working feverishly to do so.

We must strip away this complacent feeling that we have held—that what the Russians can do, we can do better. This is probably true (for we undoubtedly have the better scientists). But in this race—and it is a race— the prize goes to the first achiever. The prize, of course, is world leadership.

The obvious lag in missile and satellite development could be fatal. It is not enough to say that for the present we have military superiority, which is doubtful anyway. We must demonstrate to the world our ability to exceed Russia in the scientific field and thus insure that free men will never become victims of communism through fear or default.

These potential new weapons are not toys. The nation that first controls space will control the world. The choice is democracy or slavery.

Let's get away from the attitude that the Russians "probably" haven't solved this problem or that problem. The launchings of their first *Sputniks* and space rockets are much, much more than "neat scientific tricks." You know it. The American people know it. And the American people expect you to do something about it.

You don't have to be a scientist, Mr. President, to solve this problem. You must be a leader.

ERIK BERGAUST

when and where

NOVEMBER

Second World Metallurgical Congress and 39th National Metal Exposition, International Amphitheater, Chicago, Ill., Nov. 2-8.

Institute on Electronics Management Meeting, Automatic Data Processing System, American University, Washington, D. C., Nov. 4-8.

Joint Military-Industry Guided Missile Reliability Symposium (security clearance required), Naval Air Missile Test Center, Pt. Mugu, Calif., Nov. 5-7.

IAS Weapons System Management Meeting, Statler-Hilton Hotel, Dallas, Texas, Nov. 7-8.

IRE, Instrumentation Conference and Exhibit, Atlanta, Georgia, Nov. 11-13.

Vickers Aircraft Hydraulics Conference, Park Shelton Hotel, Detroit, Mich., Nov. 12-13.

National Aviation Trades Assn., 18th Annual Convention Hotel Adolphus, Dallas, Nov. 13-15.

National Plastics 8th Exposition, International Amphitheatre, Chicago, Ill., Nov. 17-21.

International Air Transport Assn., Technical Conference, Miami, Fla., Nov. 18-29.

Aviation Distributors and Manufacturers Assn., 30th Meeting, Sheraton Cadillac Hotel. Detroit. Mich., Nov. 20-22.

DECEMBER

ASME Annual Meeting, Hotel Statler, New York, Dec. 1-6.

American Rocket Society Annual Meeting, Hotel Statler, New York, N. Y., Dec. 2-6.

High Temperature Strain Gauges, Symposium, Aeronautical Structure Laboratory, Naval Air Materiel Center, Philadelphia, Pa., Dec. 4-5.

ARS 1957 Eastern Regional Student Conference sponsored by the Polytechnic of Brooklyn Chapter, Hotel Statler, New York, N. Y., Dec. 6-7.

Gas Turbine Development Meeting, Speaker; Rear Adm. S. B. Spangler, USN, Air Development & Materiel Center, at Engineers Club, Philadelphia, Pa., Dec. 18.

JANUARY

IAS 26th Annual Meeting, Sheraton-Astor Hotel, New York City, N. Y., Jan. 27-31.

American Astronautical Society, Fourth Annual Meeting, New York City, N. Y., Jan. 29-31.

Seventh Annual Instrument Short Course, sponsored by Southern California Meter Association and Los Angeles Harbor Junior College, Wilmington, Calif., Jan. 30-31.

MARCH

Nuclear Congress, International Amphitheatre, Chicago, Ill., Mar. 16-22.

Aviation Division Conference, American Society of Mechanical Engineers, Statler-Hilton Hotel, Dallas, Tex., Mar. 17-21.

Atomic Industry Trade Show (in conjunction with the 1958 Nuclear Congress) International Amphitheatre, Chicago, Ill., Mar. 17-21.

U.S. ARMY PHOTOGRAPH

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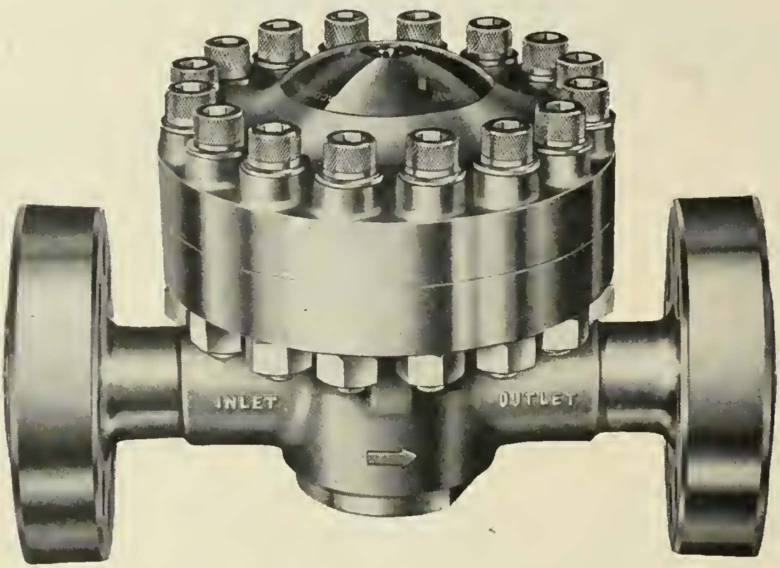

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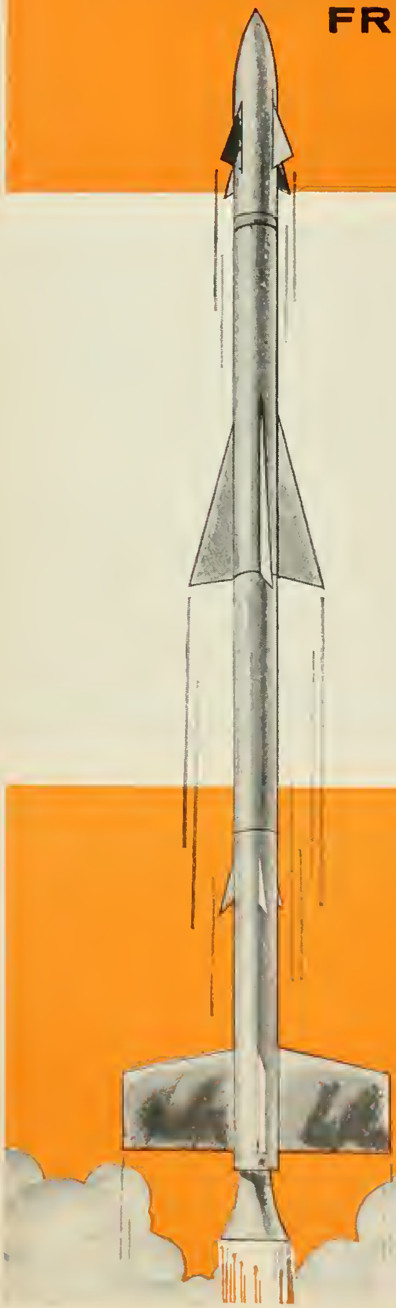

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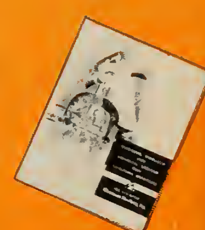

letters

Engineer Has Gripe

To the Editor:

May I pose a question to the rocket and missile industry: How can it be honestly stated that every effort is being bent to achieve the greatest progress in as short a time as possible?

Six years ago I contacted about 15 different companies in the airframe, engine and components fields about free radical applications for propulsion. The few replies I received fell into two basic catagories: 1) new idea, disclosure (giveaway), 2) completely uninterested.

In May 1957, I sent out a brochure to 35 companies comprising the major airframe engine and research companies, outlining my approach to free radicals in rocket propulsion. The even fewer replies were the same as in the first case.

In the time between my first and second attempts to broach the field, I have designed, built and tested actual systems which could be flown and which are in existence today. I am now developing a more advanced system, and will test it in the near future.

Dr. Goddard, the man who founded RMI, and myself have one thing in common—we all had to use "backyard" methods.

Rocketry was of minor consequence in Dr. Goddard's day. Today the picture is very different. However, a person with a good idea still must resort to "backyard" methods because industry doesn't have the desire, initiative or vision to make any moves progresswise unless the government foots the bill right from the start.

Right now I wonder if and when I will be faced with challenging some company or corporation because of proprietary rights. All this is not a very good picture for anyone coming up with a valuable idea. I haven't found one company in any of the fields attendant to rocketry who would give me the opportunity to work on free radical propulsion, or even detail my work in order that they may judge for themselves. This includes the company I now work for, a rocket and missile prime contractor.

From my own experience over the past six years, I claim real progress and basic new ideas are government furnished, governmentally used and paid for by the government.

Gregory D. Noyes
8405 Loch Raven Blvd.
Towson 4, Md.

German Eye View

To the Editor:

With reference to a letter by Mr. Russell H. Jones, Jr., "A New Road to Controlled Fusion" (September), may I suggest tuning the cavities of the rocket engine shown for resonance frequency, finding critical absolute size limit and then shaping the whole thing for proper focusing of the shock waves, as shown in the old Hertz-Wiesner patent of Bergmann Ultraschall, 1954.

Perhaps the Russians are already using this principle in the powerplant of their *Sputnik* vehicle, since Hertz was in Russia at one time. What a blow for America's "baby satellites!" I would suggest scrapping the little balls and asking the Ivans how to do a proper job of "satellite throwing."

If you are interested in resonance combustion for fusion reactions in open-space combustion chambers, my partner, Mr. Bernard Olcott, 952 Fifth Ave., New York City, can show you how to boost specific impulse by 100% over what you will ever be able to do with chemical fuels in rocket engines. And all this can be done without the humbug of "sophistication" that the Western World fiddles with so unsuccessfully.

The Ivans know how to simplify things while still decreasing weight. They also know that nothing is happening in the U.S. despite all that security nonsense. This does no good, and actually holds back any real research work and prevents the poor American expert from getting any information from behind the Iron Curtain. America, in turn, knows nothing at all about what the Russians are doing because the Russians keep their mouths shut. They do a job without much fuss about "super-hyper-zip fuels." They just use simple swing laws and cheap fuels, probably solids or "frozen liquids."

Joseph Reder
Heidelberg, Germany

Suggestion Box

To the Editor:

Your column "Glossarifery" in the October issue is entertaining and light, though lacking technical information. Please continue it. It's enjoyable.

However, I am a trained technical, but non-professional man in the missiles and rockets field. I read and profit from

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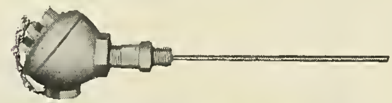

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your periodical. But—a lot of your jargon is above my head.

I offer here a sound suggestion: assist the technician in understanding the scientist.

How about setting aside a few pages each month for an honest to goodness glossary on missiles and rockets terminology. The real Noah Webster type.

I. G. Rooder

Convair Astronautics
San Diego, Calif.

Thank you for your suggestion which is under consideration.—Ed.

Asks Temperature Data

To the Editor:

In an early issue of MISSILES AND ROCKETS there appeared a chart of "Characteristics of the Earth's Atmosphere." One of the characteristics plotted is temperature, which shows a value of 1200°F beyond an altitude of 200 miles.

We are interested in learning how temperatures could be measured in such a rare atmosphere and what they really represent.

If you are unable to explain the method employed for measuring temperatures in outer space, perhaps you could give us the source of your information so that we could pursue this question further.

Erwin W. Tschudi

697 Thomas Ave.,
Baldwin, L. I., N. Y.

Temperature measurements have not been made at altitudes of 200 miles or above (pre-Sputnik). The values shown on the chart were obtained by extrapolation of known values at the lower altitudes.

One actual method of measuring temperatures at high altitude is by measuring the change in resistance in electric current through a wire.—Ed.

Wanted: "Angels" for Launching Bases

To the Editor:

This is a belated response to your proposal in "Missile Miscellany" in July that the American Rocket Society set up a missile launching base for "tomorrow's space-flight engineers, today's amateur missileer . . ." to "static test and fire their hardware."

I assume that this proposal was prompted by the letter from L. F. Megow, of the Rocket Research and Development Society, published in the same issue. Speaking as a member of an "amateur," nonprofessional society, may I suggest to the "manpower-hungry missile industry," that "would foot bill if ARS administered" that there is an organization that would probably jump at the chance. the American Astronautical Federation which has eight member societies.

So large and conservative an organization as that of the ARS must almost necessarily move slowly. Moreover, unless ARS attitude regarding amateurs has changed considerably from a few years ago, I feel rather pessimistic regarding any chance that the ARS would take up such a task in the near future.

The AAF was formed in 1954, five societies initially joining it. In three years membership expanded to eight societies, not including the Chicago Rocket Society which recently disbanded. These groups constitute almost an astronautic continuum in interests, experimental work, etc.

On the West Coast the Pacific Rocket Society and the Reaction Research Society have jointly purchased, and for over two-and-a-half years have operated, a testing area in the Mojave Desert. The two societies have developed new ideas and successfully launched what is believed to be the first hydrogen peroxide rocket constructed in the United States. There are active groups in Boise, Idaho: Salt Lake City, Utah; and State College. N. M. The Philadelphia Astronautical Society, to which I belong, has done work in liquid and solid propellants, although hampered by lack of adequate facilities. There is a student group at MIT. Cambridge, Mass. In addition, the rather widespread Society for the Advancement of Space Travel, also an AAF member. has headquarters in New Jersey.

I believe that from the framework provided by the member organizations and the national organization through the AAF constitution, a successful missile launching base could be set up, either through expanding existing facilities or establishing new ones. Furthermore, although the membership of each individual society is primarily nonprofessional and amateur, including many young members, professionals do belong.

If anyone is interested, may I advise that they contact the AAF President, Mr. Norris R. Peery of Intermountain Rocket Society, at 1425 Emerson Ave., Salt Lake City 5, Utah, or the AAF Secretary, Mr. Dale R. Smith of the Society for the Advancement of Space Travel, at 3001 Kyle Avenue, Minneapolis 22, Minn.

In ending, I must congratulate you for making such a proposal.

Leon M. S. Slawecki
Corresponding Secretary

Philadelphia Astronautical Society
3421 North Third Street
Philadelphia 40, Pa.

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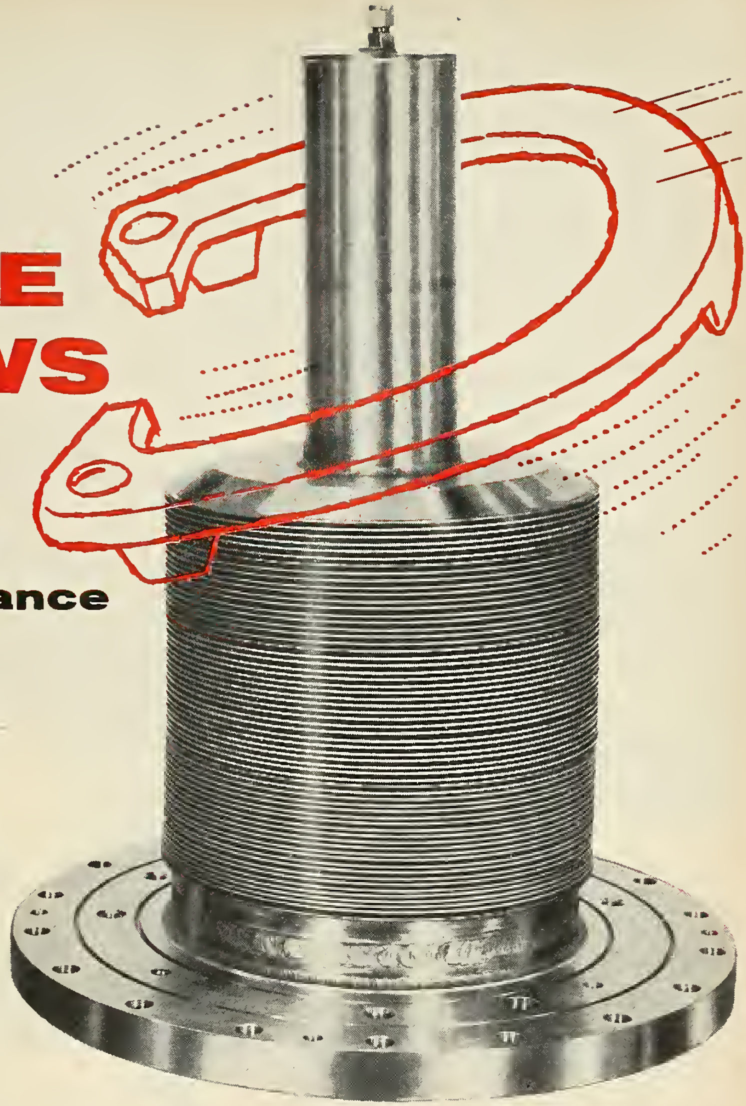

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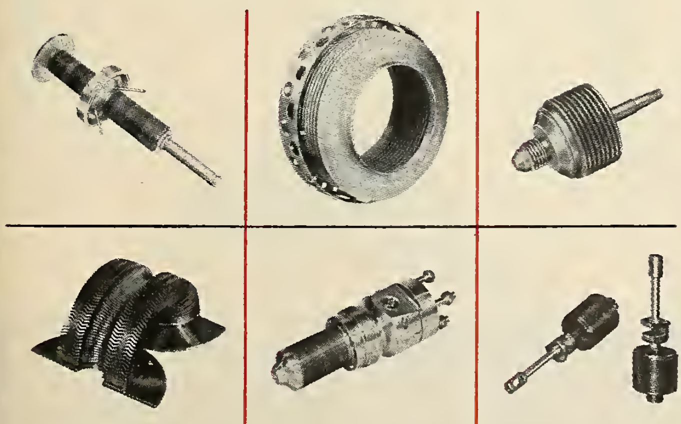

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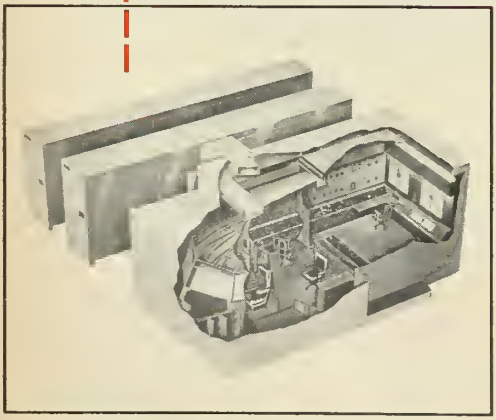

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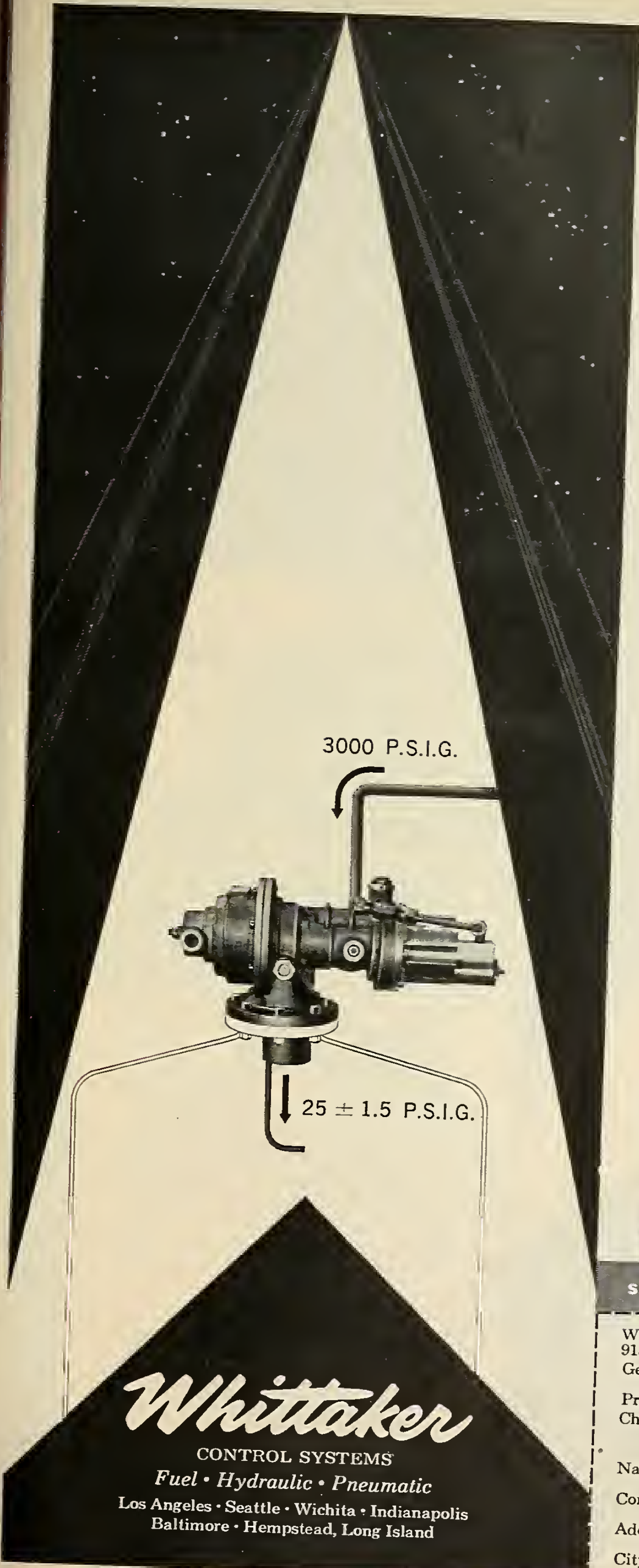

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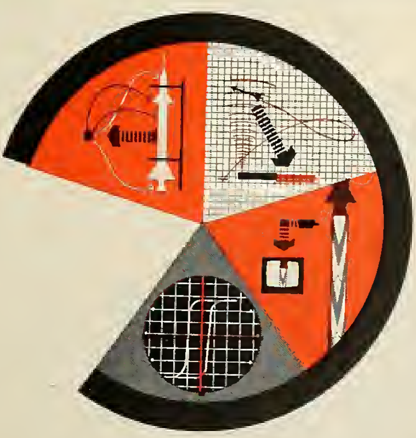


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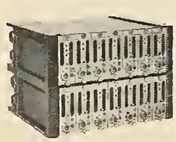

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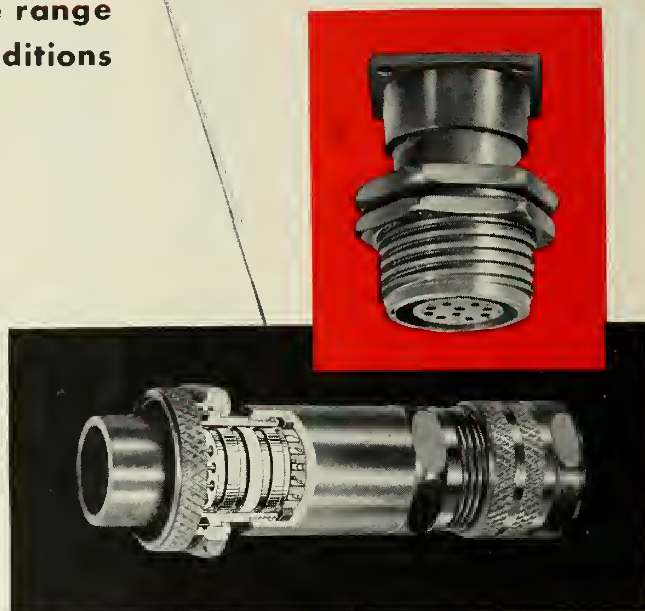

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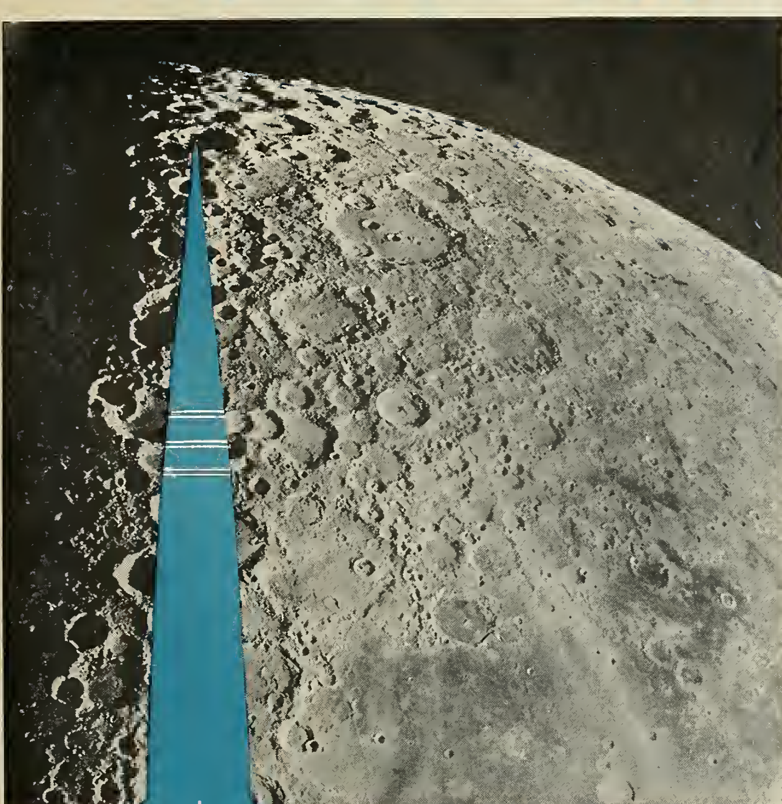

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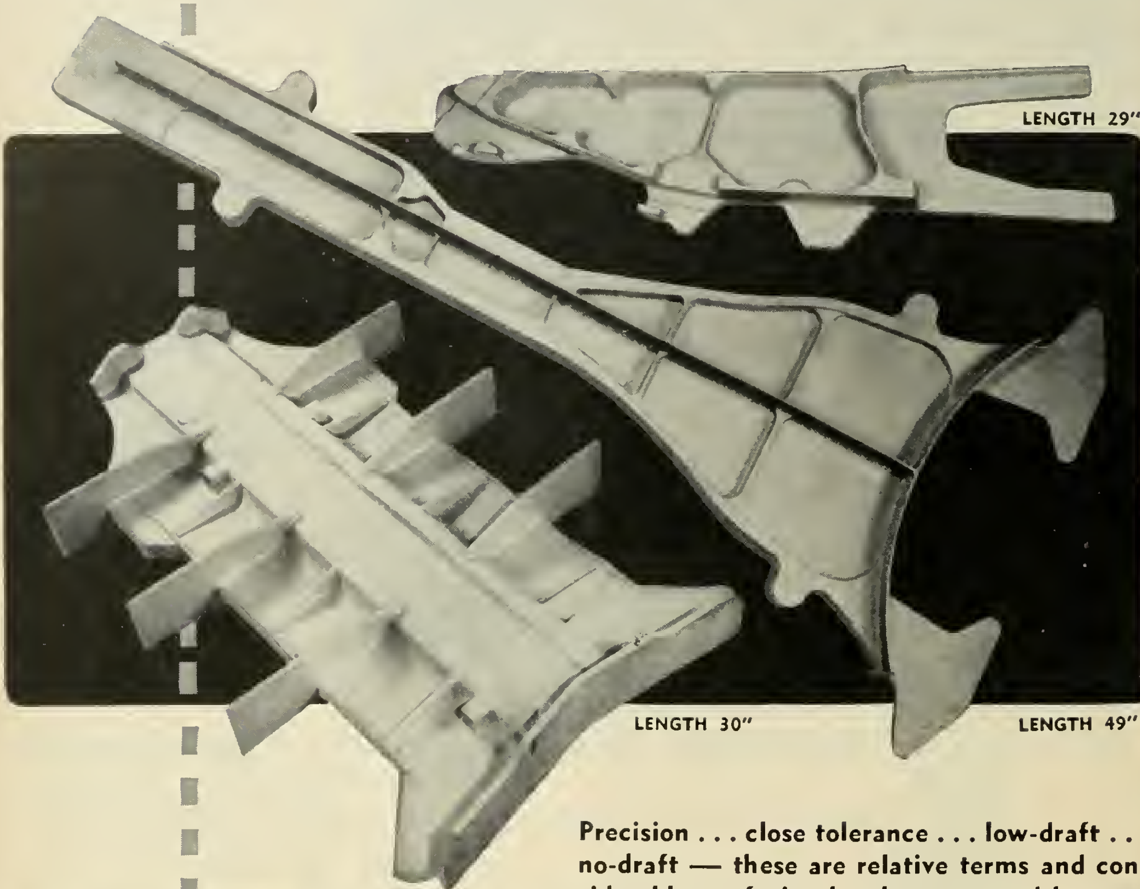

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Russia's Moon Rocket Program

Soviets Leap Ahead Again

Skip Bomber In Test Stage

By Erik Bergaust

BARCELONA—Details of Russia's moon rocket program were revealed to MISSILES & ROCKETS during the Eighth Congress of the International Astronautical Federation here. The expected news of Russia's technological victories in space flight science indicates the first lunar rocket may hit the moon before this issue of m/r goes to press. Furthermore, Dr. Leonid Sedov has confirmed to m/r that Russia's second satellite will carry a live passenger! A dog will be the first living creature to enter into an orbit around the earth. Dr. Sedov did not give a fixed date for this event but said it should occur about "the end of the month."*

The Moon is Next

This reporter learned exclusively from members of the Russian delegation to the IAF meeting that the moon comes next. When asked whether they have the hardware available or if they are building new launching equipment for any of their moon rockets, the Russians smiled and said Russia's satellite and moon rocket scientists are not concerned with this. "We just ask the military for the rockets—and they provide them. That's all." The Russian delegates were Academecian Leonid I. Sedov, chairman; Dr. Alla T. Massevich; Dr. Lydia Kurnasova; and A. Karpenko, secretary of the Commission on Astronautics, Academy of Sciences.

The immense significance of the above statement lies in the fact the Russians have an almost unlimited supply of workable, big liquid rockets available for space flight. Their T-4 engine, built for their manned skip-glide bomber vehicle which is now being test flown, yields a thrust of 820,000 pounds. When asked whether this engine will be used to propel their first moon rocket aloft, Dr. Sedov merely smiled and threw has arms out as if he couldn't care less what kind of engines would be used. (Dr. Sedov, at the seventh IAF congress in Rome last year, revealed exclusively to this reporter that Russia was working on several different kinds of atomic-powered rockets. The story appeared in m/r October, 1956.)

The race to the moon is on and Russia probably will win it. First comes the "direct hit approach"—with a little bit of luck, the Russians will do it.

Then, and this one is possibly more significant, comes the circumlunar vehicle. Eventually, this kind of rocket will carry cameras aboard.

Dr. Sedov—the great hero of the congress—also had some advice to Americans. He talked rather sarcastically about American interservice missile rivalry. When asked by an American delegate what he would have done after the first *Sputnik,* had he been an American, he said: "I would do something better and more significant." Of course, the American delegate agreed. But the sad fact remains—America is too far behind Russia to be able to match her in astronautics. So far behind, in fact, it is almost pathetic.

Moon Rocket Details

Dr. Sedov and his teammates were all smiles throughout the conference. They were joking and laughing happily, almost victoriously. And they most certainly had reason. Sedov told Dr. Fred Singer of Maryland University he would be happy to take one of the U.S. professor's cosmic ray counters aboard one of the next *Sputniks* since, apparently, Dr. S. F. Singer must wait a long time before he can have his equipment carried aloft in any American satellite..

The Russian delegation was approached by many newsmen asking

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*NOTE: *m/r went to press at the time Russia announced* Sputnik *II.*

questions about the Red missile program. But no comment was given by any of the Russians. As far as space flight is concerned, however, they were not afraid to talk.

From our conversations with the Red delegation, we can conclude the following facts about their moon rocket program:

1) The first Russian moon rocket will be launched just about the time this issue of *m/r* goes to press. If the attempt is successful, it will be advertised by the Russians as their big propaganda blow for the 40th anniversary of the Communist Revolution. If the rocket fails, the Reds will have some other stunt, such as flying their first atomic airplane, or a similar feat.

2) The first moon rocket may carry a payload of approximately 500 pounds and will be designed to either hit the moon or enter into an orbit around the moon. A radio transmitter will be aboard.

Reversed Thrust To Be Employed

3) The second type of lunar vehicle will be designed to retard its fall toward the moon by braking or reversed-thrust rockets and will plant itself and its transmitter intact on the moon's surface. The transmitter will send back to earth information on temperatures on the moon's surface.

4) The next type of moon rocket will carry television-type camera equipment that will relay back to earth close-ups of the moon's surface, possibly of the other side of the moon, never seen by man.

5) The fourth type might carry animals or even man—if the previous rockets have been successful and if the information gathered has been satisfactory enough to encourage manned trips into space. All this will happen within a few years.

The interesting point, of course, is that this sequence of approach has been discussed in this country and all over the world as the logical one for this kind of scientific-military adventure. The important thing is that the Russians are doing something about it and admit they are working hard to achieve these goals.

Man On the Moon in a Few Years

When this reporter asked Dr. Sedov whether he anticipated that man would establish an observation post on the moon in this century, he said: "Of course; at the rate we are progressing now, it shouldn't take too long." It's a sad thing to think about how Dr. Wernher von Braun outlined such projects for the U.S. government 10 years

Dr. Leonid I. Sedov, Soviet space satellite expert and well-known scientist, was the big hero at the Barcelona IAF meeting. Here he is trying to convince IAF president-elect Andy Haley the Russians will beat us to the moon.

And here he is being congratulated by the dean of aeronautics, Professor Theodore von Karman. The toasts to the Russians and their success were many. This one was in champagne. Sedov seemed to appreciate it.

During the technical sessions Sedov discussed scientific problems freely with delegates from many countries. Here he is offering Dr. S. Fred Singer of Maryland U. an explanation of some Soviet theory on cosmic rays.

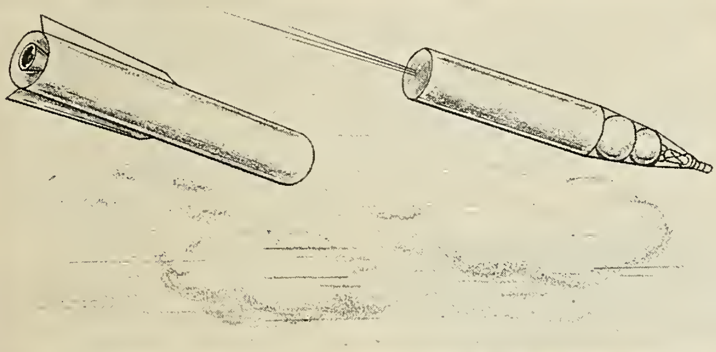
Sedov enjoyed the social affairs and was intrigued by the Spanish folk dance festival put on for the IAF delegates. He is seen with spacemen Rolf Engel, center, and Redstone's Dr. H. H. Koelle. They, too, had a good time.

ago—and was laughed at and was almost thrown out the door of the Pentagon conference room.

Dozens and Dozens of Satellites

Members of the Red delegation confirmed that Russia would launch "many" satellites during the IGY—and after the IGY. When asked how many would be sent aloft during the IGY, the answers ranged from "a handful" to "about a dozen," which means that the Russians will be launching satellites of various kinds at a rate of almost one every five weeks. (So far they have done considerably better than that.)

Sedov indicated that Russia's moon rockets and "other space vehicles" would be launched independently of their IGY satellites. He offered a remarkable comment in this connection: "One should not be so overwhelmed about these things; like America, we committed ourselves to launch a series of satellites during the International Geophysical Year. We're just doing what we said we would."



Russian drawing of rocket vehicle designed to land on the moon's surface, employing reversed thrust rocket in the nose for braking.

Inferior IAF Congress

IAF's new president, Washington, D. C. attorney and well-known space lawyer Andrew G. Haley, had some discussion with Sedov on the subject of space law and jurisdictional aspects of moon exploration, but Sedov did not commit himself in terms of whether the Russians would claim ownership of the moon once they've planted their flag there.

Had it not been for the launching of the first *Sputnik* and the presence of the four-man Russian delegation, the Eighth Congress of the International Astronautical Federation would have been a complete flop.

The meeting was almost completely disorganized. In spite of beautiful Spain and its hospitality, in spite of the Spanish host society's honest efforts, the meeting was amateurish from beginning to end. Americans dominated the technical session with some 25 papers (only a few of which were good), against two or three papers from any other country.

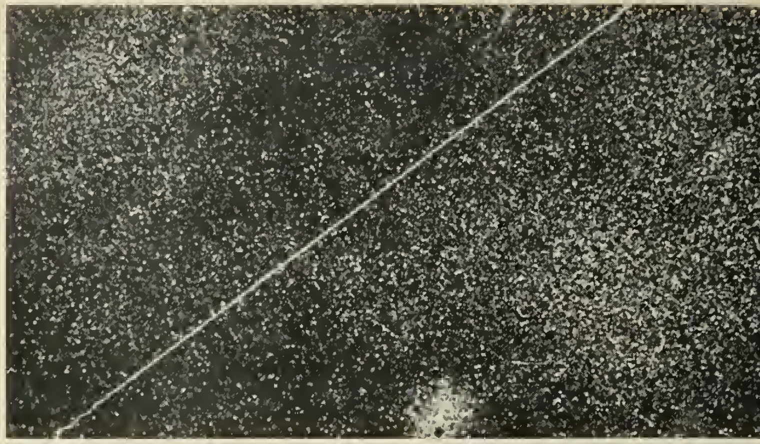
The press was disgusted, confused and frustrated over the complete lack of preprints of papers, press facilities, translations and liaison. Official press conferences were few and handled so poorly that many newsmen walked out in the middle of them. Furthermore, anyone who felt like giving a statement to the press arranged his own press conference. The Americans were great at this. Of course, the Russians did not hold any press conference. To quote Dr. Theodore von Karman: "The Americans are talkers; the Russians are doers." Dr. von Karman also criticized the quality of many of the American papers.

Durant Opposes U.S. Vice President

But there's hope for the IAF. Andy Haley was elected president for 1958, and he has promised a hectic, progressive year for the organization. Already he is busy at work planning the next congress, to be held in The Netherlands. The 1959 congress probably will be held in Moscow; 1960 in Stockholm, and 1961 in Washington, D.C.

Mr. Haley suggested current American Rocket Society President Robert C. Truax for IAF vice president for 1958, but Frederick C. Durant III apparently pursuaded Haley to reconsider. Haley withdrew his proposal. Thereafter the following astronauts were elected vice presidents: Acad. L. I. Sedov (USSR), Prof. Zarankiewicz (Poland), Dr. L. R. Shepherd (U.K.), Ing. A. Hjertstrand (Sweden), Dr. J. M. J. Kooy (Holland) and Prof. T. M. Tabanera (Argentina).

Asiatic flu took its toll during the Congress. Brig. Gen. Toftoy, Rolf Engel and an R.A.E. representative were each out for a few days with high fever. Sedov managed to carry through until Saturday before he, too, succumbed.



How Accurately Was *Sputnik* Launched?

To find out, the editors of m/r consulted Dr. S. Fred Singer, who made accuracy and lifetime calculations for Project *Mouse* in 1954. Here is what he said:

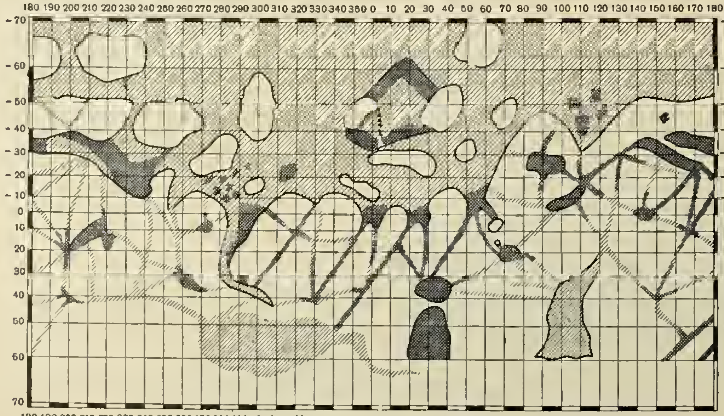
"We are not sure of the release altitude of the Russian satellite (burnout altitude of the last stage), but we can be sure that it was not less than 200 miles. For a lower release altitude any small error in release angle is fatal because of the dense lower atmosphere. Higher altitudes of release are desired, since they give more latitude against guidance errors.

"With *Sputnik*'s reported orbit, initial perigee and apogee 140 and 560 miles respectively, I get the following results:

Launch Altitude Miles	Velocity Error	Release Angle Error
375	−0.2%	2.8°
190	+1.8%	1.75°
140	+2.6%	0.0

"The release altitudes are chosen to bracket the probable value. The lower altitude is most unlikely due to reasons stated above. The angular error in these calculations is astonishingly large. It's sufficiently good enough for a satellite but not good enough for an ICBM.

"The answer must be that their ICBM guidance system is too heavy for the third stage of their satellite rocket. It is doubtful if they could hit the moon with this kind of guidance without a great deal of luck. Thus, *Sputnik* doesn't necessarily prove they have ICBM capabilities, only that they have a large rocket. On the other hand by itself it doesn't prove they don't have an ICBM either."



Recently released map of Mars published by Russian astronomers.

Super Control Center for Soviet Satellites

Moscow has a super control center for tracking of satellites. Permanent observation of the *sputniki* is conducted at various radio stations, such as the one shown in the above picture. The control center and the radio stations are operated by the Ministry of Communications of the U.S.S.R. near Moscow, under direct supervision of the Commission on Interplanetary Travel. The Soviets have informed us the engineer shown here is Ivan Pryzhkov—eagerly listening to the signals from *Sputnik* II.

Reds Build Huge "Brains" for Nuclear Calculations

The Soviets have built a machine that "multiplies 15-digit numbers at the rate of 500,000 actions per second, and adds such numbers at the rate of two million actions per second."

A problem in nuclear calculations which only a year ago would have required six months' work can now be done on the new computer in about one day.

The Soviet Academy of Sciences has a special computing center in Moscow, whose chief, Academician A. A. Dorodnitsyn, said recently that in one year his center's best computer did the work that would have required the efforts of 10,000 human calculators laboring not less than 20 years. This electronic computer takes less than 20 hours to solve problems "requiring 250 million actions in arithmetic." The computer is serviced by a team of only two engineers and one technician per shift.

Besides Moscow, main Soviet centers of electronic-computer improvement, production, functioning, and engineer training are Penza in east European Russia; Erevan, capital of Soviet Armenia; and Kiev, capital of the Soviet Ukraine.

The Kiev computing center is one of the most recently established in the Soviet Union. The giant computer, now being built for it, is already in partial operation. In one eight-hour working day it performs "the work that can hardly be completed by 100 experienced mathematicians laboring 10 years."

Red Star Reprints American Missile Map

Referring to it as "forced fear" the Soviet army newspaper *Red Star* recently reprinted a map originally used by U.S. News & World Report.

Showing the United States under a circle of Soviet ICBMs, the map is entitled "Russia Could Reach Target in the U.S." The map was cited as more evidence of American warmongering.

Moscow Shocked by Guided-Missile Toys

Under the banner headline, "Imperialism Breeds Murderers and Violators," the Moscow Komsomolskaya Pravda accuses the U.S. of deliberate encouragement of the sale of guided-missile toys.

"On the counters of American toy stores it is now hard to find the heroes of old fairy tales—those good-natured teddybears, those shy long-eared rabbits," the Red newspaper charges. Instead, U.S. customers have to buy all sorts of miniature weapons, particularly "atom bombs and guided missiles which fly, shoot, explode, destroy toy cities, and kill toy people."

The Russian article is accompanied by a picture showing an American boy, who, the Moscow editor explains, is a seven-year-old lad named Eddie, "full of happiness because he has an atom gun and a guided-missile installation which shoot and explode like the real thing."

Cushioning Cosmic Drop Attempted by Reds

Measures to protect a person "passing from airless space to the lower, solid layers of the atmosphere" are now being worked out by Soviet experts in cosmic medicine. This was announced at a recent Moscow meeting by Professor P. K. Isakov, a Stalin Prize winner and chairman of the Soviet State Committee on Cosmic Medicine.

Reds Reveal Scientific Plans

The Soviets now claim they have the world's largest installation "to capture and study broad lines of cosmic rays" as these particles of "ultra-high energies, messengers of cosmic spaces, penetrate the earth's atmosphere." According to *Komsomolskaya Pravda* the "unique machine," installed in the Lenin Hills of Moscow, has "five thousand registers."

Izvestia reveals that the Riga "Hydrometpribor," on Latvia's Baltic shore, is a leading Soviet factory producing precise instruments in the field of physics. Recently the Riga plant has made 100,000 of the instruments required for the Russian part of the International Geophysical Year. The scientists of the Moscow University are collaborating with the engineers and designers of the Riga plant in creating some of these instruments.

Russian LOZ Work Dates Back to '50

As early as 1950, the USSR had available pure, liquid ozone for research and limited development. Initial work on LOZ was begun around 1947 at several universities in the Moscow area, notably the University of Moscow and M. V. Lomonosov State University. By 1951 they had succeeded in stabilizing and producing enough LOZ so that it could be used by other personnel and for other basic work. For example, for some five years, the Russians have been using LOZ in an attempt to synthesize hydrogen superperoxide—H_2O_4. This latter compound, arrived at via LOZ and bombardment techniques, may in reality be a polymer of HO_2 (perhydroxyl). Key people in the Soviet super-oxidant projects are: A. P. Purmal, N. I. Kobozev, L. I. Nekarsov, and E. N. Eremin. Purmal's work is being carried out at the D. I. Mendelev Chemical Technology Institute at Moscow.

Soviets Build Bolometers At Academy of Sciences

The Institute of Physics at the Soviet Ukrainian Academy of Sciences announces that it has successfully tested and begun mass production of an extrasensitive bolometer "to measure the temperatures of revolving parts of machinery and to help in astronomical and allied researches." The apparatus is claimed to register such "minute changes in heat as one-millionth of a degree."

R

RAPID

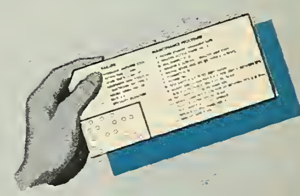
RACE* eliminates slow, time-consuming manual tests by electronically checking complete weapon system such as missile or aircraft. Operating on initial assumption that system is functioning properly, RACE speeds through primary test of over-all system or major sub-systems. If fault exists, RACE signals "no-go", then isolates fault through secondary tests. Complete job is done in only minutes.

1008 HOURS

A

AUTOMATIC

Advanced design eliminates chance of human error by use of standard computer techniques of programming, memory, digital and analog comparison. Signal generators include electrical, electronic, hydraulic and pneumatic signal sources, as required to actuate circuits or simulate system signals for comparison with standard reference signals.

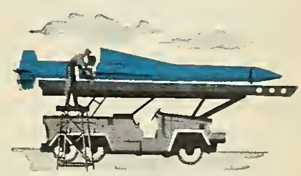


1009 HOURS

C

CHECKOUT

RACE not only pinpoints weapon defect —it also flashes on control console screen location, name of faulty unit, down-time involved, location of spare, type of technical work required, system power and arming conditions for safe repair. Simultaneously, punched maintenance card with complete, detailed instructions for repair is automatically ejected.



1025 HOURS

E

EQUIPMENT

Design flexibility adapts RACE for use at operational sites in pre-launch and pre-flight check-out, for in-flight testing, for maintenance areas and overhaul depots. Current and future applications include missile data reduction stations, shipborne and airborne radar, automatic navigation systems, aerial reconnaissance systems, ground fire control systems and missile guidance systems.

1030 HOURS

*T.M.

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There Wasn't a "Trick" to be Heard

World reaction to *Sputnik* II was like that to its predecessor but with these differences: nobody called it a "trick," and there were loud wails from dog lovers.

Renewed cries went up for a special session of Congress and a speedup of our missile program.

• Sen. Henry M. Jackson (D-Wash.) called for a missile "czar" and the launching of a "bold program" for increasing scientific and engineering training. "Moscow is now in the process of taking away America's historic trump card—its industrial and scientific supremacy," he said.

• Sen. Allen J. Ellender (D-La.) said it showed "the West has had its head in the sand too long," but that we are not trailing the Russians in the missile field. "They just beat us to the punch."

• In Japan, Masashi Miyaji, head of the Tokyo Astronomical Observatory, objected that the Russians did not announce the launching in advance.

• A group of scientists at Stanford University, Palo Alto, predicted that *Sputnik* II may continue to orbit for "100 years or more."

• Two reactions from top Defense people when asked if we would now speed up our missile program: Gen. Nathan F. Twining, chairman of the Joint Chief of Staffs, said, "What do you think?" Defense Secretary Neil H. McElroy said it would have no great effect. "We already are in a pressure program."

• Mrs. Irene Enzinger, founder of the Orphans of the Storm Animal Shelter, in Deerfield, Ill., spoke up for shocked canimaniacs all over the world, condemned such use of dogs as "disgraceful and cowardly," since the dogs "have no chance to speak up as to whether they want to be used in these experiments."

Excellent Progress at Martin Orlando

The first production *Lacrosse* missile manufactured at The Martin Company's new Orlando, Fla. facility, has been delivered to the Army less than 11 months since the start of construction on the plant.

This is indicative of the outstanding progress that is being made by The Martin Co. in placing their latest missile plant in full operation. The plant, being built in a pine forest nine miles southwest of downtown Orlando, will be completed this year. Installation of machinery was begun on Oct. 1. The first contingent of personnel will begin moving in Dec. 1.

The Martin Co. engineered a remarkable logistical operation in the rapid move of *Lacrosse* manufacturing from Baltimore to Orlando. A temporary building for *Lacrosse* manufacturing was leased in late October last year. A nucleus of manufacturing personnel was moved in that month. Machinery move was completed by February. One month later, the Army accepted the first *Lacrosse* missile produced in Orlando.

The company-owned plant will also produce the air-to-surface *Bull Pup* for the Air Force.

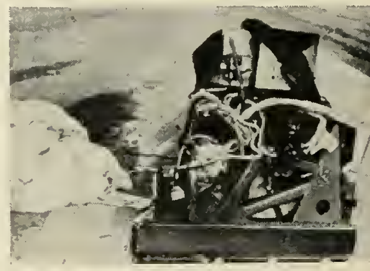
Outstanding rocket propulsion scientists Frau Irene Bredt-Sänger and husband Dr. Eugen Sänger who believe the Russians have been activating their skip-glide bomber project and that their T-4 engine is in production. The T-4 engine yields 820,000 pounds thrust and might have been used to launch SPUTNIK II.

Shooting Dogs into Space Old Hat to Russians

The Russian decision to use *Kudryavka (Curly)*, the dog, as the first warm-blooded space traveller was based on many years of successful experiments with dog "guinea pigs."

Several Russian animals, particularly dogs, have made high-altitude flights in rocket vehicles. A recent flight attained an altitude of 130 miles. The dogs were returned to earth by parachute and, according to Soviet scientists, survived the flights without mishap.

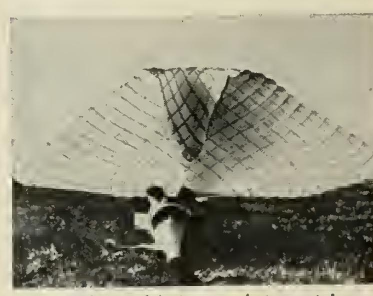
Apparently Russia was not prepared for the onslaught of world-wide denunciation of the experiment. Early



Russian space dog and rocket gear.

reports stated that *Kudryavka's* space cabin would be ejected from *Sputnik II* and would be returned to the earth by undisclosed means.

A. A. Blagonravav, top Soviet satellite scientist, has since disclosed that recovery of the capsule will not be possible. Another scientist has stated further that *Kudryavka* is not expected to live for more than 10 days. This may indicate that the dog's oxygen or water



Dog landing safely in parachute container.

supply will be depleted by that time.

Meanwhile, some U.S. officials involved in IRBM and ICBM nose cone development, have expressed the conviction that recovery of the capsule is possible if Russian developments in this field are on a par with U.S. developments.

The velocity of the satellite or capsule would have to be reduced at least 60 per cent before it reached the denser atmosphere below the 20-mile level.

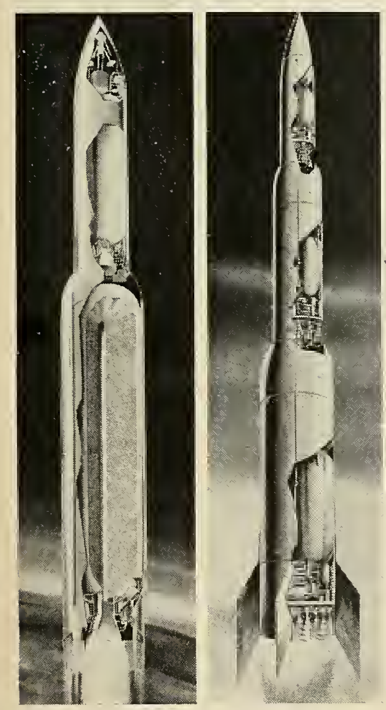
Research Rocket Flights Made off Cape Charles

ABOARD USS *LAUNCHER*—A series of research rocket flights are being made from the deck of this converted LCT (Landing Craft Tank). As part of a University of Maryland program under the direction of Dr. S. Fred Singer, eight high-altitude rocket flights are now in process with the object to obtain additional data about conditions in the ionosphere.

The program includes four flights by *Terrapin* (designed by the University of Maryland and manufactured by Republic Aviation) and four flights by *Oriole,* designed and manufactured at the University of Maryland. Experiments being conducted include the release of sodium vapor at 80-to-120-mile altitudes, the release of nitric oxide and the creation of artificial meteors. There will also be one shot of a flash bomb by the *Oriole,* in order to pinpoint its trajectory and thus, altitude.

The *Oriole* is a new "university research rocket," designed by Richard Bettinger, a graduate student at the University of Maryland. Using an Army *Loki* as a booster, *Oriole* is so simple that it's revolutionary. Depending on whether its "sting" is three-quarter inch or one-and-a-quarter inches in diameter, it will take a scientific payload to 80 or 120 miles altitude. Separating from the booster at the end of its 0.8-second burning time, the finless, unflared sting coasts to its peak altitude. With the *Loki*s provided free by the Army, the whole unit costs less than $300, less payload. It uses a standard *Loki* spin launcher adapted to the light-weight breakdown *Terrapin* launcher.

NAA Super Rockets for Mars and Venus



We don't lack ideas in this country when it comes to space flight. We just don't do much about realizing them. Here, for example, are a couple of North American artist's conceptions of solid-liquid and liquid (right) rocket vehicles designed for travel to Mars and Venus. The rockets are based upon available hardware. How about it, Mr. McElroy?

Jupiter is Accurate

The sixth *Jupiter* took off on a 1500 mile firing recently to fall within two and one-half miles of its ten mile target center.

Prince of Hannover

Andrew Haley, president, International Astronautical Federation, and Dr. Welf Henrich, Prince of Hannover and author of the first doctoral thesis on space law, are embarking on the first nationwide space law lecture series this month.

Their itinerary follows:

Nov.	Place	Sponsored by:
4	Princeton, N.J.	Princeton Univ. & ARS
	New York, N.Y.	Physician's Sci. Soc.
5	Detroit, Mich.	Univ. of Detroit
	Ann Arbor, Mich	Univ. of Mich. & ARS
6	Chicago, Ill.	Univ. of Chicogo
	Chicago, Ill.	Northwestern Univ. & ARS
7	Madison, Wis.	Univ. of Wisconsin
	Rochester, Minn.	Moyo Clinic
8	Minneapolis, Minn.	Univ. of Minnesota & ARS
10	Butte, Mont.	Civic Group
11	Missoula, Mont.	Montano Stote Univ.
12	Spokone, Wash.	Gonzago Univ. & County Bar Assn.
13	Seottle, Wosh.	Civic Group
	Seottle, Wash.	Univ. of Wosh. & ARS
14	Son Froncisco, Colif.	Univ. of Colif. & ARS
15	Los Angeles, Calif.	Univ. of Colif. & ARS
18	Solt Lake City, Utoh	Civic Group
19	Holloman AFB, N.M.	ARS
20	Denver, Colo.	Civic Group
22	St. Louis, Mo.	St. Louis Univ., Wash. Univ. & ARS
25	Cambridge, Moss.	Harvord Univ. & ARS
26	Washington, D.C.	George Wosh. Univ., Georgetown Univ. Americon Univ., Cotholic Univ., Univ. of Md. and ARS

Cryostat at Lockheed To Make Liquid Helium

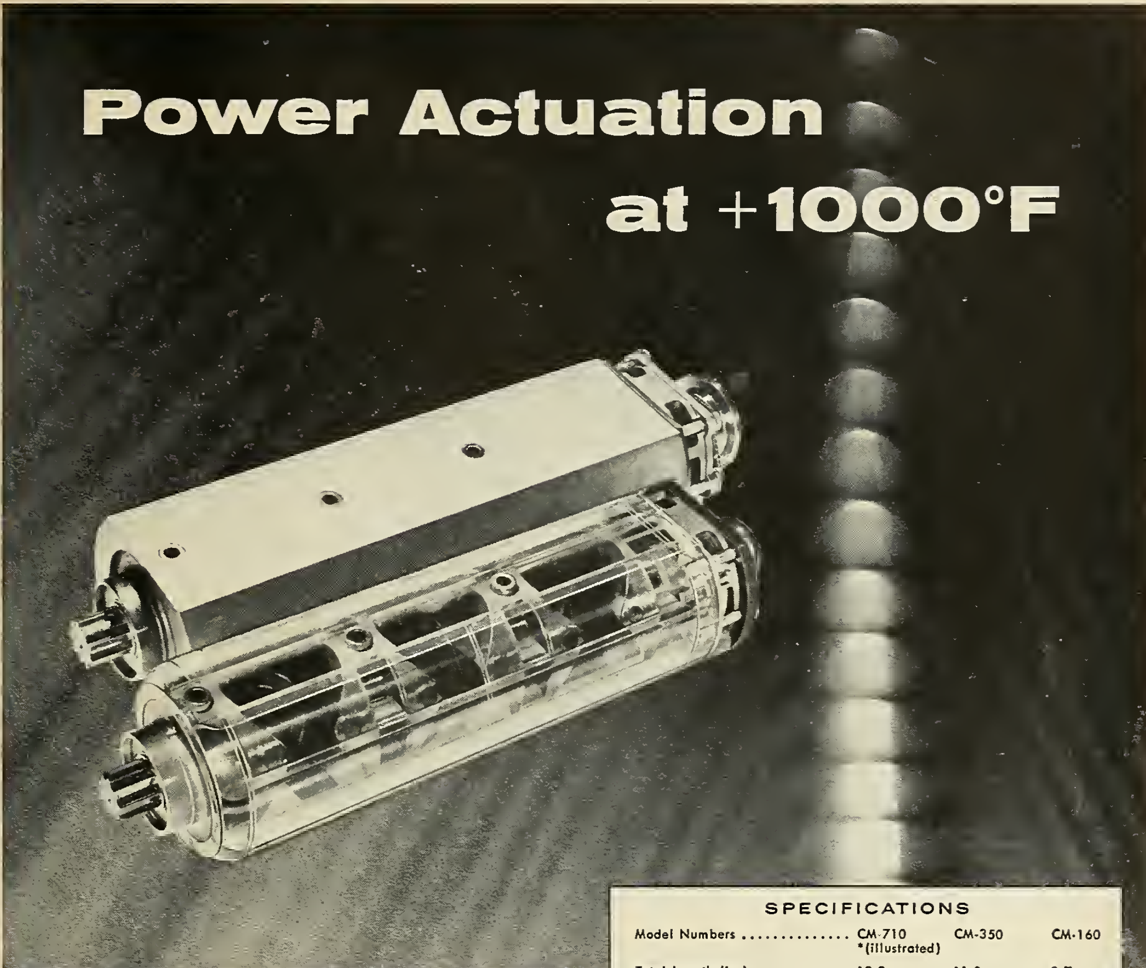
Lockheed is installing a cryostat for the production of liquid helium at the research laboratories of its missile systems division in Palo Alto. Prime purpose for the super-refrigerator that can produce temperatures cold enough to freeze moving molecules in their tracks, is Lockheed's own research, but it will also make the liquid helium commercially available to other scientific groups.

Eight San Francisco peninsula firms have already expressed a need for 400 liters per month. Capacity of the Lockheed cryostat will be about 1000 liters a month. Lockheed's missile division is studying the use of liquid helium as a low-temperature bath for electronic and other devices, and it also is conducting studies in certain unusual properties of the helium itself.

More Money for *Jupiter?*

HUNTSVILLE, Ala.—A supplemental appropriation, perhaps as much as $75 million, is believed to be wending its way through the Pentagon for the *Jupiter* program. Intended for accelerated development and testing of the IRBM, the money is presumably coming from Department of Defense funds to continue financing *Jupiter* when the current contingent fund of some $35 million runs out. This is accompanied

Power Actuation at +1000°F



SPECIFICATIONS			
Model Numbers	CM-710 *(illustrated)	CM-350	CM-160
Total Length (in.)	13.3	11.8	9.7
Min. Height (in.)	3.1	2.9	2.5
Max. Dia. Envelope (in.)	4.0	3.2	2.5
Weight (lb.)	22	15.5	7.5
Output at 200 psig supply pressure and 1200 rpm (hp)	18.5	9.1	4.2
Starting Torque at 200 psig supply pressure (inch-pounds)	1800	890	400

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by the withdrawal of an order eliminating overtime work at Redstone and ABMA.

Many personnel at Redstone feel that former Defense Secretary Wilson never chose to submit repeated requests for additional funds for *Jupiter* and *Vanguard* R&D to the White House. This is why President Eisenhower could publicly state that the missile agencies "got all the money they asked for," because, insofar as the White House knew, all fund requests had been granted.

200-Mile Limit Dead For Army

HUNTSVILLE, Ala.—Former Defense Secretary Wilson's controversial memo of last November 26th, which limited the Army to operational control of missiles with ranges of 200 miles and less, is expected to die an unmourned death before its first anniversary.

Informed sources at Redstone Arsenal and Army Ballistic Missile Agency here are unanimous in their belief that the Wilson memo was made obsolete by the launching of *Sputnik*. One top Army officer declared that even without *Sputnik* it would have lapsed, because of the repeated failures of both Air Force and Navy missiles in the over-200-mile range. He believes the limitation would have been scrapped in actual practice. Tests showed it to be illogical and unworkable because it imposed an arbitrary restriction on weapons whose precise range cannot always be estimated when they are in the research and development stage. It would have proved to be a needless obstacle to the detailed scientific inquiry indispensable to missile and rocket development.

Another informant here said the Wilson memo might never have been issued if the former Secretary had been allowed to retire, as he reportedly wished to do, on last January 1.

"Curley" and Koelle Confuse Missilemen

HUNTSVILLE, Ala.—As if there weren't already enough confusion in missile circles, people at Army Ballistic Missile Agency who telephone Dr. H. H. Koelle, chief of preliminary design, often wind up getting Dr. Wernher von Braun.

The reason lies in a nickname acquired by von Braun and the correct German pronunciation of Koelle's name. Von Braun is known to intimates as "Curley" because of his shock of blond hair. Koelle, in proper German, comes out "Curley" also.

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Sputnik Sparks Reaction at Redstone

SYMPTOMATIC of the mental chaos into which the Russian *Sputnik* plunged the Pentagon, two top U.S. missile experts recently were sharply criticized in official circles for their remarks at the Barcelona sessions of the International Astronautical Federation Congress in October. Redstone Arsenal's commander and deputy commander, Maj. Gen. H. N. Toftoy and Brig. Gen. J. A. Barclay, stated in prepared speeches that the U.S. could have had a successful satellite two years ago. Reaction from Washington was quick and acid. They were, in essence, told to shut up and sit down. The rub: the Pentagon itself had approved both talks prior to the *Sputnik*. But *Sputnik* led newsmen to draw inferences that the Pentagon had not anticipated.

THIOKOL Chemical Corp.'s Redstone Arsenal contract for solid propellants for the *Hawk* short-range missile was reportedly cancelled in late October because of a failure of the solid propellant fuel to bond properly with the metal shell of the firing chamber. Prime contractor for this project was Raytheon. The job was said to have been transferred to Aerojet-General's West Coast branch. Redstone comment questioned whether this was part of an interservice political maneuver to whittle away at the Army's huge missile center in Huntsville, Ala.

"THE THING" is what Redstone Arsenal missileers call the four-stage rocket to be launched in Project *Farside* from a balloon above Eniwetok Atoll in the Pacific within a few weeks in hopes of gaining an altitude of 4000 miles. The assembly is a four-stage rocket. The first two stages consist of five *Recruit* solid-propellant Thiokol engines. Four are in the first stage. Overall length of *The Thing* is 23 feet, weight 1900 pounds. The balloon that is expected to hoist it to 100,000 feet was produced by General Mills Corp.

NO REQUEST from the Navy has been received at Redstone Arsenal for help on the controversial *Vanguard* satellite project, despite repeated assertions by Army officials that the "hardware is available." However, it is learned that a *Polaris* engine is being worked on at Thiokol's plant here, indicating that Navy and Army are at least still talking to each other.

EMPLOYMENT at Redstone Arsenal, Army Ballistic Missile Agency and Ordnance Guided Missile School, all at Huntsville, Ala., now stands at 17,500, including persons working on a $24-million building program. This is up several thousand from last year. Payrolls amounted to $81 million as compared with the county's $60-billion gross income, putting the military in the forefront in this old Alabama area for the first time.

Missile Experts Differ On Crash Program

HUNTSVILLE, Ala.—Military and civilian experts on rockets and missiles at Redstone Arsenal and Army Ballistic Missile Agency here are sharply divided over a proposed super agency to control research, development and production of missile weapons systems.

The division of opinion follows the kind of clothing worn by the opiner: the military want a crash program; the civilians do not.

This difference is explained by impartial observers on the following basis: The military men are deeply conscious of immediate needs in the event of a sudden war and know the nation is ill-prepared in missile counterweapons. But the civilian scientists believe that potential enemies who might use missiles are actually in about the same state as the United States, in that they may have certain successful prototypes but are still far from full production of IRBM and ICBM weapons.

Another factor is the realization by members of the famous Wernher von Braun team here that one of their number would have little chance of being placed at the head of a superagency with a crash program mission. They are, after all, recently naturalized citizens and have many close relatives in both East and West Germany. They believe their best chance to achieve what they know to be possible in missile research and development would be to work under close and intimate supervision with a board of military and civilian experts who could arrive at well-considered evaluations of specific missile developments.

Kellogg Co. Alumni to Hold Reunion Dinner

Former personnel of the M. W. Kellogg Co. are planning to hold a reunion dinner during the week of the American Rocket Society Convention in New York this December. The dinner's organizers plan to hold it the evening of December 6, at Dido's Restaurant in Bayonne, New Jersey at 7:30 p.m. Reservations may be made with the restaurant at $3.75 per person.

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Similarly, a magnesium bar of equal rigidity to an aluminum bar will weigh only 75% as much as the aluminum bar. At equal weight, the magnesium bar will be over twice as stiff.

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LOX Plant Developed for Army Front

The Army Corps of Engineers and Air Products, Inc. have developed a million-dollar battlefront plant on wheels for the production of liquid oxygen from common air in sufficient quantity to help power *Redstone* and other missiles. The first of the plants was displayed by the Army at Fort Myer, Va., in late October.

The plant is mounted on four semitrailers and is designed to produce about 20 tons, or about 80 barrels, per 24-hour day of 99.5 per cent pure liquid oxygen when operated at normal atmospheric pressure in air of 50 per cent relative humidity. It will operate in outdoor temperatures ranging from 125°F to −25°F. The plant uses about 920 pounds of diesel fuel per hour and yields about two pounds of liquid oxygen for each pound of diesel fuel.

Two of the trailer units are identical. Each carries a 1200-horsepower diesel engine, and a rotary-type compressor which compresses air to 100-pounds per square inch. There is also an extended-surface heat-exchanger arrangement for cooling the engine and compressor and for a preliminary cooling of the compressed air as it leaves the unit. Each trailer measures 8 by 30 feet, is a little over 11 feet high and weighs about 50,000 pounds.

RMI Rides Out Govt. Economy Wave

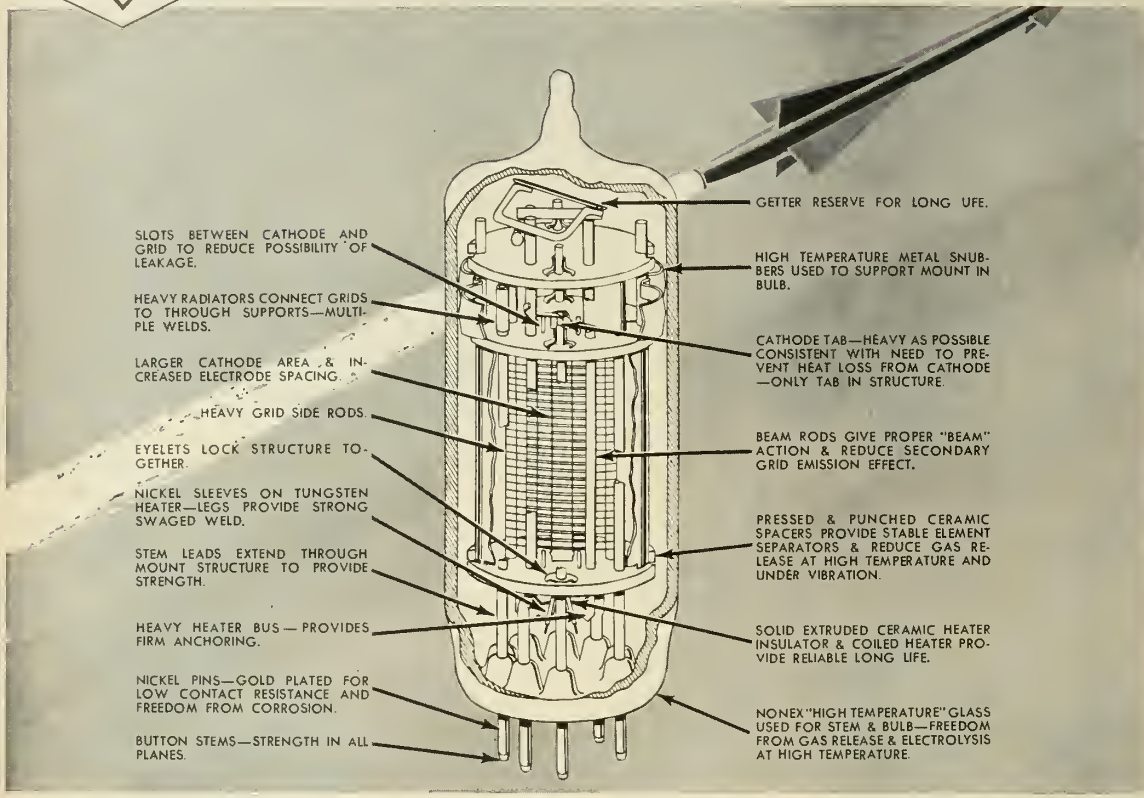
Reaction Motors, Inc. has undertaken a program to adjust the company's costs in light of the contract reductions and stretch-outs resulting from the government economy drive. The most immediate effect of the program was a reduction in the firm's work force, but company officials emphasized that no heavy layoff was contemplated at this time.

Even though no actual cancellations of RMI contracts have been received, the company said "certain adjustments are necessary if the company is to maintain its competitive position in the industry."

National-El Ray Co. Forms From Three Companies

A new electronic and electrical component manufacturing firm has been formed by three companies in North Hollywood, Calif. Known as the National-El Ray Co., the new firm is composed of El Ray Motor Co., Valco Engineering Co., and National Electronics Corp.

HY-G-300 ELECTRON TUBES FOR SURVIVAL



WHY BENDIX* HY-G-300 ELECTRON TUBES ARE BEST FOR EXTREME SHOCK, VIBRATION AND TEMPERATURES!

From the standpoint of design features (see above), these reliable hard glass tubes offer the superior quality needed to survive today's severe environmental demands.

Specifically, Bendix HY-G-300's are designed to withstand the following environmental conditions—bulb temperatures up to 300° C; vibration up to 20G's over the range of 5-2000 cycles; and shock of 200G's having 20-millisecond duration.

For full information about the HY-G-300 line . . . the surest answer to electron tube applications in jet aircraft, missiles and rockets . . . write RED BANK DIVISION, BENDIX AVIATION CORPORATION, EATONTOWN, NEW JERSEY. *TRADEMARK

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HY-G-300

TUBES ARE AVAILABLE FROM STOCK

Bulb Size	Dbl. Triodes Volt Amp.	R. F. Pentodes	Gate Pentodes	Rectifiers FullWave	Beam Power	Power Triodes Passing
T-12	—	—	—	—	—	6080WB 6082A
T-11	—	—	—	—	6384 6889	—
T-9	—	—	—	6853	—	—
T-6½	6851 6854 6900	6582A	6486A	6754	6094	6877 6900

Retma Type No.	Retrofit For	Generic Type	E_f	I_f	Bulb	Bendix Type No.
6080WB	6080 6080WA	6080	6.3	2.5	T-12	TE-46
6094	—	6AQ5-6005	6.3	0.6	T-6½	TE-18
6853	6106 5Y3	5Y3	5.0	1.7	T-9	TE-45
6384	6AR6 6098	6AR6	6.3	1.2	T-11	TE-27
6854	6385	2C51 5670	6.3	0.5	T-6½	TE-47
6486A	6486	6AS6	6.3	0.25	T-6½	TE-43
6582A	6582	6AK5	6.3	0.25	T-6½	TE-44
6754	412A	—	6.3	1.0	T-6½	TE-36
6851	5751	—	6.3	0.5	T-6½	TE-42
6877	—	Half of 6080	6.3	0.8	T-6½	TE-48
6900	5687	5687	6.3	0.9	T-6½	TE-54
6889	—	—	6.3	1.2	T-11	TE-52
6082A	6082	6082	26.5	0.6	T-12	TE-55

Red Bank Division

Bendix AVIATION CORPORATION

Circle No. 38 on Subscriber Service Card.

Scientists Study Spaceship Communication

Studies that might well pave the way for communication with manned spaceships of the future or for the remote guidance of unmanned spaceships is being conducted by Lockheed missile systems division scientists. More than 50 scientists, engineers, and electronic experts will explore the problems of sending and receiving space messages and identifying objects far from earth in a large, new space-communications laboratory.

Emanual A. Blasi, head of the missile division's antenna and propagation department and in charge of the laboratory operation, said areas to be covered include:

The effect of outer space cosmic rays on radar and radio signals.

The radar pattern presented by various space vehicle and missile shapes.

The effect of the ionosphere—the electrically charged space beyond the earth's atmosphere—on such signals.

The characteristics of various antennas when installed in missiles.

The three-story, 10,000-square-foot laboratory, Blasi said, can re-create space conditions as they exist many hundreds of miles above the earth. An anechoic chamber or "quiet room," measuring 20 by 70 feet, produces electronic conditions to be found 300 miles in space by eliminating all stray electronic signals.

Much of the advance research under way is in connection with the Navy's *Polaris* ballistic missile, on which Lockheed is the missile system manager.

An important part of the investigations covers antenna design and installation. Whether on a missile or spaceship, an antenna will send messages of varying strength depending on its angle to the receiving antenna. Space communication depends on how well the antenna transmits in different positions when installed in a vehicle.

To further these critical studies, the new Lockheed facility has four instrumented antenna and reflectivity ranges with four sets of tracks extending up to 500 feet. Small antennas installed in model missiles are mounted on nonreflecting pylons. Motorized carriages of the pylons, remotely handled from control rooms, carry the models to various distances along eight-foot tracks for the tests.

Because of the intense interest and research in space communications, the Lockheed facility will be made available to other scientific groups on a commercial basis.

Russian Public Watch Their *Sputniks*

Moscow moon watchers on the lookout for SPUTNIK I and II. Next: they will be looking toward the moon . . .

Narmco Facilities Increased by 20%

Narmco Mfg. Co.'s completion of plant No. 2 in La Mesa, Calif., adds 20% to the firm's manufacturing capacity. The one-story concrete block building houses expanded tooling, assembly, inspection and shipping facilities for the production of glass fiber laminates and sandwich-type structural components for aircraft and missiles. Narmco's backlog of orders of components and assemblies has increased 200% in the past 18 months.

R & D Program Begun By Synthetic Lithium

A joint program of research and development involving the Lithium Corp. of America and the Synthetic Mica Corp. has begun for the study of a new electronic tool—synthetic lithium flour-phlogopite mica. The new product is reportedly far superior to its potassium counterpart currently produced by Synthetic Mica Corp. Lithium Corp. will produce the lithium compounds necessary for production.

Lear Supplies *Bomarc* Guidance Parts

Lear, Inc., is producing airborne electronic intelligence components that control and direct the *Bomarc* interceptor missile to its target.

Although the Air Force does not identify specific components, Lear is known to be a producer of master references, stable platforms, computers, data links, and gyroscopic devices for automatic flight stabilization of guided missiles.

New Liquid Rocket Engine Design Shown

An integral, self-contained liquid propellant rocket engine package was shown publicly for the first time today by Reaction Motors, Inc. The powerplant as delivered includes the entire engine system, complete from propellants to thrust chamber. It is designed to be delivered ready to be fired upon installation in the airframe.

All propellant loading is done before the unit leaves the factory so that no propellant handling is required in the field. According to RMI spokesmen, the unit can be stored in a remote location for years, and installed at the time the airframe is to be launched. Its reliability is said to be extremely high.

RMI has plans for developing the unit in a wide range of sizes and performance specifications for use in most of our current and forthcoming missiles. Flexibility in operational characteristics—choice of propellants, duration of firing, thrust level—is one of the unit's main features.

GE Fuzing Army Missiles

The Army has disclosed that General Electric is working on multi-million-dollar projects to develop warhead arming and fuzing systems for five Army missiles.

GE's missile and ordnance systems department in Philadelphia is working on or has recently completed arming and fuzing system projects for the Army's *Honest John, Little John, Corporal* and *Lacrosse* surface-to-surface missiles and on the Army's *Nike-Hercules* surface-to-air missile.

It was previously known that GE had received Army contracts for guided missile arming and fuzing development, but the full extent of the work was not disclosed until recently.

New Monopropellant Licensed to Thompson

A new heterogeneous liquid monopropellant developed by Atlantic Research Corp. has been licensed to Thompson Products, Inc. The exclusive right to purchase, use, and sell the new propellant, called Arcogel, was conveyed to Thompson by a licensing agreement. The agreement includes a royalty to Atlantic Research on future sales of the gel propellant and burner systems. Thompson Products has also given a $30,000 contract to Atlantic Research to continue development of the propellant and associated burner systems.

Use of the new substance in both gas-generating and propulsive applications is being contemplated by Thompson. Refinement of manufacturing techniques, new formulations of the gel propellant for specific applications, and development of burning systems will concern Atlantic Research scientists, engineers and technicians.

Anti-Missile Office Opens at Redstone

HUNTSVILLE, Ala.—A new facet of missile activity will begin here shortly with the opening of the Redstone Anti-missile Missile Systems Office, marking the beginning of a concentrated effort to develop the so-called "ultimate weapon" to counter ICBMs.

The new office, already condensed to RAMMSO in official terminology, will be set up with a cadre of experienced scientists and technicians from Redstone Arsenal and Army Ballistic Missile Agency and is expected to be functioning by mid-November.

One of its first projects is reported to be a faster, more accurate version of the *Nike-Zeus* missile. This is regarded as a logical first step toward development of a program to offset Russia's presumed capacity to begin ICBM production within the near future.

Establishment of the RAMMSO office was hailed here as an indication that the work of Dr. Wernher von Braun and his Army missile team has gained recognition in the wake of the accelerated missile research and development programs authorized by the new Secretary of Defense, Neil H. McElroy.

No formal announcement of the RAMMSO office has been made here but informed sources said financial support has been guaranteed and a table or organization authorized.

The basic mission of the new office will be to coordinate all military and industrial activity required for the production of the anti-missile missile.

Technique Associates Move to New Quarters

Technique Associates, Inc., manufacturers of temperature measuring and indicating instruments, has moved its general offices and plant to larger quarters at 1413 N. Cornell Avenue, Indianapolis, Ind. Mailing address of the company is P.O. Box 91, Indianapolis, Ind.

Washington Trends

By Erik Bergaust

DEFENSE SPENDING WILL RISE SHARPLY IN THE NEAR FUTURE, with most emphasis on R&D phases of missiles. With almost all research fund cuts of recent months being restored after *Sputnik* I, the Capitol Hill fur will really fly soon after November 7, if the Soviet attempt at launching something spectacular is a success. The Reds are certain to try to mark their 40th anniversary "in a most fitting manner," as the pre-*Sputnik* statement said. If, as we believe, the Reds will try for a grandstand play on that date, they could not have better cooperation from the moon. It will be a full moon—with a full eclipse. With perfect timing and guidance, a flash bomb on the moon at this time would have a hundred times more effect than *Sputnik* I. And even though this is not considered likely, who (after *Sputnik* I) will stand up and say the Reds can't do it? The Naval Observatory here says the eclipse will be visible in the western half of North America and across the Pacific to Asia. An excellent audience.

DEFENSE CUTS HAVE LEFT THEIR MARK. Due to the slashing of defense expenditures, the top-secret Lincoln Laboratories in Lexington, Mass., has been forced to announce the dismissal, as of February 1, of 160 of its personnel, many of them scientists and engineers. The breaking up of such a team is much more damaging than the layoff of a much larger number of production workers.

EDUCATION MUST BE RECOGNIZED AS THE PRIME ASSET OF THIS COUNTRY. The President's Committee on Scientists and Engineers here has been told that the 14-year-old boys of today will be the designers of our rockets and satellites in just ten short years. Nevertheless, there is not a school in the country offering a curriculum in rocket design. The American Rocket Society accepts student members only when they are 17 years old. By this time, a boy is practically an engineering student and has not had the benefit of pre-college counsel in the rocketry field.

CODE NAME FOR ARMY'S SATELLITE IS "DEAL." IT HAS PENTAGON GO-AHEAD. The program will be taken in steps. *Jupiter-C* can orbit 18 lbs. It's based on *Redstone* first stage. By replacing *Redstone* with *Thor Jupiter* first stage and using *Sergeants* as second stage, it could conceivably place 1000 lbs. in an orbit within a few months. This program is in sharp contrast to an earlier Wilson order that Army would not work on satellites nor admit that Army interest in satellites existed. At one point, Assistant Defense Secretary McNeil dispached auditing teams to ABMA to ascertain that Army was obeying the order. This was BEFORE *Sputnik* I.

TESTS OF THE *RASCAL* WERE FROM MAXIMUM RANGE OF 100 MILES. Bell Aircraft confirms that the missile was fired from the limit.

THE AIR FORCE HAS A NEW WIND TUNNEL that duplicates "far-hypersonic" conditions, enabling scientists to study the high pressures, velocities and temperatures encountered by a missile re-entering the atmosphere. It can also duplicate the real gas effects of high-speed missiles operating in the atmosphere.

ONE OF ATOMIC ENERGY COMMISSION'S BIGGEST HEADACHES is the disposal of "hot nuclear garbage" which has been costing John Q. Taxpayer millions of dollars. It can't be disposed of, but must be stored in expensive stainless steel tanks and transferred to new tanks as it eats its way through the old ones. Rapid advance of rocket technology may provide the answer. Within 20 years, some experts estimate, it may be cheaper to load the stuff into rocket vehicles and impact it on the sun! The idea doesn't exactly intrigue us.

Soviet Affairs

by Dr. Albert Parry

It is with sad pride that this column takes credit for a major prediction come true: In my first column last July, I cited as worthwhile the conviction of an émigré source that the Reds would fire their artificial satellite into outer space on or about Sept. 17th, to celebrate the 100th anniversary of the birth of Constantin Tsiolkovsky, a Russian rocket pioneer. I referred to the forecast as an "educated guess." The Soviets fired their moon on Oct. 4th, making the prediction only two-and-a-half weeks off its mark.

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And now let me cite one more Russian prediction, this time not from émigré quarters but from a Red source, a prediction published in Leningrad nearly 30 years ago—that rockets and death rays will be used by the Soviets to defeat the United States in a future war between the two nations. This bold prophecy was made in a government publication. It was a book of science fiction, BOR'BA V EFIRE (STRUGGLE IN THE AIR), by Aleksandr Beliayev, issued in 1928 by the Communist Youth League publishing house with the approval and under the auspices of the Soviet state itself.

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That 1928 fantasy is startling and revealing, yet it is rare in the sense that the book came out in a small edition and, to my knowledge, has not been reprinted in Russian or translated into any other tongue. Its export from the Soviet Union was not encouraged by the Kremlin. In all my diligent, protracted search I have to date succeeded in locating only two copies of this book (in its Russian original) in this country.

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Why so scarce and obscure? The reason may be that the Soviets might have had second thoughts about the book soon after its publication. The frank story tipped the Red hand too early in the long-range timetable of America's destruction. At that time, in the latter 1920s, the Kremlin wanted American aid in Russian industrialization. It also wanted our recognition of the Soviet government. And so the daring book, although commissioned by the government, was practically "closeted" by the very same Red government.

•

Yet consider the time and the setting of that old Soviet prophecy. Three decades ago, while Red Russia was feeble and seemingly knew not which way to turn in order to survive, and while we were at the height of our Coolidge-era prosperity and power, the ruling class of the Soviet Union had this arrogant confidence that America and the rest of the West were doomed—that the "bloated capitalists" would perish through the coming Red might of rockets and rays to be delivered against New York and Washington by air, the weapons already then theorized by the little, aging provincial teacher of high school physics and mathematics, Constantin Tsiolkovsky of Kaluga, and his vigorous Soviet followers.

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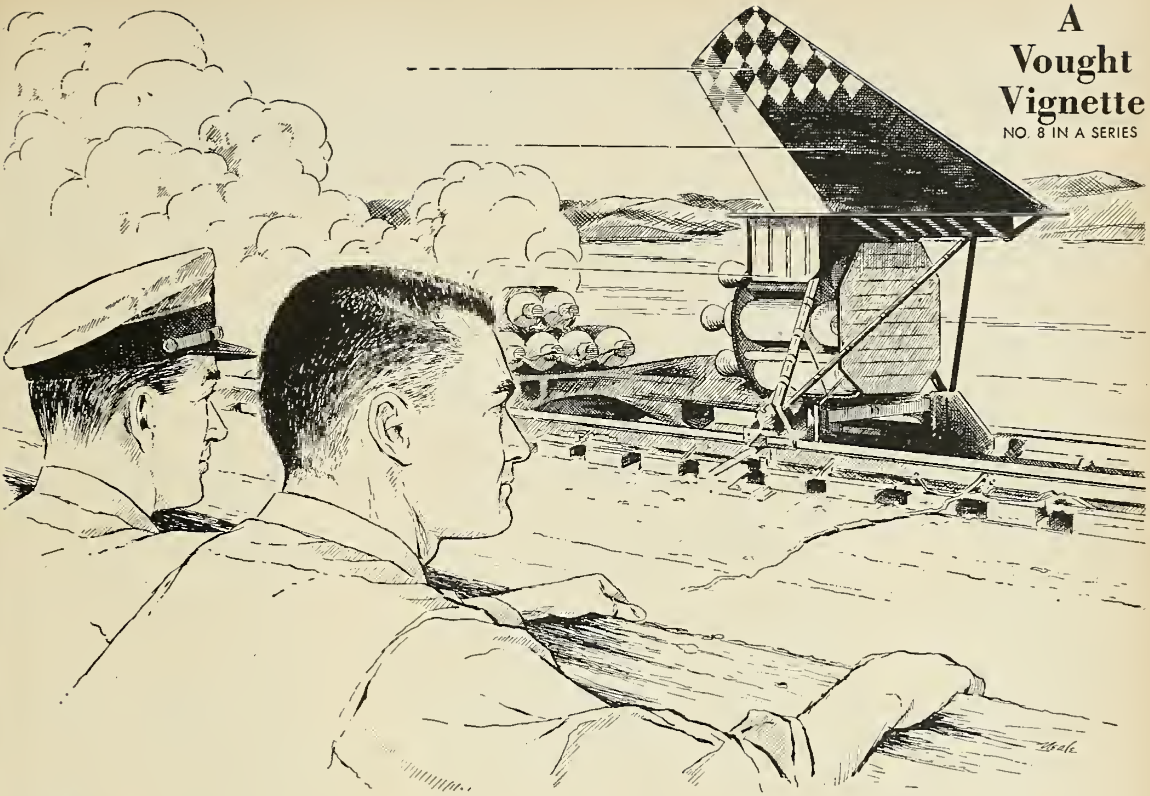
Truly no greater service toward awakening America from her complacency can be performed by some American publisher than through publishing this 1928 novel by Beliayev in English.



The structures engineer who found a fast detour

"Advise and assist on structural problems. Do what you can to keep the program moving . . ." With this outline of his liaison duties, Stress Analyst Ed Clay accompanied Vought's Regulus II missile to its desert test site.

On the desert, Ed found a dearth of structural problems. Regulus II reliability gave the flight test program tremendous momentum. In quick succession the missile notched 10 flights. When time came for a critical high-speed test, the program was three months ahead of schedule!

Then, the very fact that things had moved so fast threatened to rob the program of the time it had gained.

As Vought had planned, a wind tunnel flutter test had to precede the upcoming high-speed flight. But Vought's prearranged date at a government tunnel was over a month away. The facility was booked solidly up to the appointed day. And Vought's own Mach 5 tunnel was under construction.

Then Ed revealed the scope of his liaison. It had ranged to the rocket test track at nearby Edwards Air Force Base. There, with the help of a cooperative track project engineer, Ed had spotted a rusting rocket sled, left behind from a radome test. Now, if the sled could be rigged to carry that spare Regulus fin, Ed figured, they might get flutter data before the tunnel test.

That changed Ed's state of liaison. All Vought was suddenly at *his* service. Shopmen reworked the sled to mount the fin. Instrumentation technicians fitted the fin with gages and transducers. Vought's top flutter men double-checked, raised their eyebrows, then endorsed the whole thing.

At the track, moments before the rockets exploded, Ed had a twinge of doubt. His sled was a monster, indeed. Air loads would be terrific . . .

Then the sled shot off on the first of two successful trips that revealed all the data required.

At Chance Vought, there's liaison in spirit as well as in name. It allies engineers of many specialties and viewpoints against mutual problems. It builds channels instead of walls between diverse technical areas. It's another reason why top engineers are choosing Vought — *to keep abreast of all fields while advancing in one.*

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS

World Astronautics

By Frederick C. Durant III

A resolution to establish a Joint Committee on Earth Satellites and the Problems of Outer Space has been introduced by Rep. James G. Fulton (R-Pa.). This bill, currently referred to the Committee on Rules, has a great potential for bringing to the attention of Congress and the public the ramifications of extended satellite programs. The bill as it now reads calls for full and current briefing by the DOD on "all matters . . . relating to the fields of earth satellites and outer space." It goes on to state that, "any Government agency shall furnish any information requested by the Joint Committee with respect to such activities or responsibilities" and that, "all bills, resolutions or other matters relating primarily to the development, use or control of the earth satellites and outer space shall be referred to this Committee." Truly, this Committee would have great potential influence in the development of astronautics, particularly during the next few years.

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Original reports attributing the origin of the delightful "Geschutenwerkes Werdebuke" (m/r September, p. 54) to ABMA have not been verified. Two key technical members of the ABMA staff were delighted to obtain copies recently. Former German nationals, they commented privately that they had not seen it before. The author is probably a native born American. He deserves credit for a charming bit of whimsy and we would like to see him identified. Incidentally, a few copies of the complete list of translations of 43 terms are available on request to this column.

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The Associacion Argentina Interplanetaria (AIA) has expanded their rockets and satellites course. Ing. T. M. Tabanera, AIA president, has organized the course which is being held at the Sciences Faculty of the University of Buenos Aires in collaboration with the Institute of Scientific Research on Weapons. The course is in five parts: rocket motor design, energy sources, ballistics and guidance, electronics and hypersonic aerodynamics. The course runs three and one-half months.

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Preliminary meetings toward the forming of a Korean Astronautical Society have been held during the past few months in Seoul. Byung June Chang has attracted the support of local university professors and has requested registration by the Ministry of Education.

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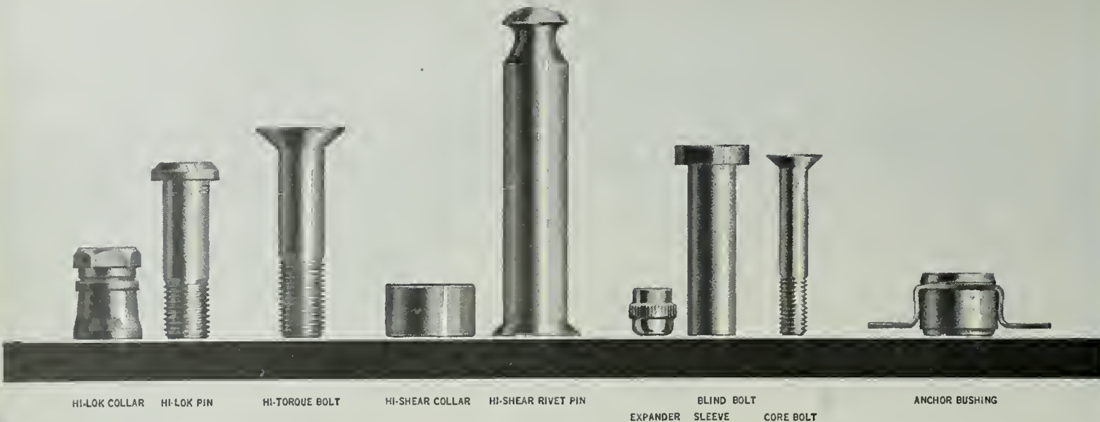
Niichi Nishiwaki, professor of mechanical engineering at the University of Tokyo, has completed a year as visiting professor at MIT. While in Cambridge he conducted basic research in combustion problems. He returns to Tokyo via Europe where he will visit a number of aviation and rocket propulsion establishments. Prof. Nishiwaki is active in both the Japanese Rocket Society and the Japanese Astronautical Society.

•

At the Annual Meeting of the Deutsche Arbeitsgemeinschaft für Raketentechnik (DAFRA) last month, President A. F. Staats announced the grant by the city of Bremen of DM5,000 to the Society for their experimental work. This significant sum is in addition to contributions by numerous industrial concerns. While there I saw motion pictures of the August firings of sounding rockets at Cuxhaven. Only a tantalizing glimpse was given of two larger two-staged prototypes which have yet to be tested.


HI-LOK COLLAR
HI-LOK PIN
HI-TORQUE BOLT
HI-SHEAR COLLAR
HI-SHEAR RIVET PIN
BLIND BOLT
EXPANDER
SLEEVE
CORE BOLT
ANCHOR BUSHING

VOL. 2 NO. 11

NOVEMBER, 1957

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

an m/r analysis:

Law Must Precede Man Into Space

By Andrew G. Haley

President, International Astronautical Society

NEVER BEFORE in the history of mankind has the necessity arisen so quickly to state legal parameters in connection with a vast new area of social change. The legal problems presented by the advent of space flight have been climacteric, and technology has far outstripped the formulation of the legal rules. The gap has widened to the point that the peace of the world is threatened.

The consent of all nations to the satellite program of the International Geophysical Year and the active cooperation of most nations have resulted under familiar and accepted principles of international law in giving full legal validity to the present IGY satellite program. But this is the one and only achievement. Space law still completely awaits development.

The most unfortunate development in connection with the orderly statement of space law has been the involvement of the problem in the proceedings of the United Nations Subcommittee on Disarmament in London. This involvement was inevitable because the question of control of objects entering outer space was bound to arise. The problems of space law found their first and most critical examination in the intense political atmosphere of the London Disarmament Conference. The statement of space law problems and the formulation of jurisdictional concepts and regulatory rules should long since have been undertaken by appropriate juridical bodies of the United Nations and of the International Civil Aviation Organization.

In arriving at a level-headed statement of the jurisdiction of space law, the lawyer must turn for help to the physicist to ascertain just where "air space" ends. We must ascertain the outer boundary of air space because hundreds of local laws of more than 90 nations and restrictions of a score of international treaties are bound tightly by the physical concept of air space.

Ironically enough the lawyer finds the main crackpots and nuisances among engineers and sociologists who assume the role of amateur lawyers and give vent to rather silly if harmless rhapsodies in a field wholly unfamiliar to them. To them the real problem of delimiting air space is wholly unnecessary. The sound scientist avoids legal interpretation, while at the same time making essential contributions by staying within his technical expertise, and keeping the lawyer well-advised on appropriate physical phenomena. Such has been the most helpful role of Dr. Theodore von Karman.

Dr. von Karman has suggested practical methods of formulating the jurisdiction of air space. Last spring he delivered a paper at the University of California entitled "Aerodynamic Heating—the Temperature Barrier in Aeronautics." In that paper he had occasion to use a diagram made by Masson and Gazley of The Rand Corporation showing the possible ranges for continuous flight in the velocity-altitude coordinate systems.

Pursuant to von Karman's suggestion I devised a diagram (Fig. 1) containing curves showing the high-altitude sounding rocket regime, the earth orbital satellite regime and tbe Kepler regime (earth escape velocity) and some supernumerary information. But most important is what we shall now call the Karman primary jurisdiction line.

To establish sound bases for demarcation of air and space jurisdiction, it is necessary to consider that the conditions for achieving aerial flight, that is to circle at constant altitude, are that weight equals aerodynamic lift plus centrifugal force.

The aerodynamic lift decreases with altitude because of the decreasing density of the air and in order to maintain continued flight beyond zero air lift, centrifugal force must take over. Consider the flight of Captain Ivan C. Kincheloe, in which he took the X-2 rocket plane to 126,000 feet altitude. His flight was strictly an aeronautical adventure and did not partake of space flight. At the altitude indicated, aerodynamic lift carries 98 per cent of the weight and only two per cent is centrifugal force, or "Kepler force." It will be noted that in the corridor of continuous flight when an object reaches approximately 275,000 feet and is traveling at 25,000 fcet per second, the Kepler force takes over and aerodynamic lift is gone. This is a critical jurisdictional boundary.

Fig. 1 is intended to be illustrative. The Karman line may eventually actually remain as shown in Fig. 1 or, after due consideration, tbe line may be significantly changed. In any event, this is the line at which "air space" terminates.

Any such definition should be finally promulgated through the United Nations and implemented by the International Civil Aviation Organization (ICAO). In determining the Karman line, the United Nations and ICAO will require the advice of a committee in stating the final definitions and in drafting detailed regulations. The basic statutes of ICAO will have to be broadened by international agreement and the name undoubtedly must be changed.

The first important action taken so far was the establishment in Barcelona by the International Astronautical Federation of the Cooper Committee, headed by world-renowned Professor John Cobb Cooper. It will consist of three lawyers and four physicists who will define air space and space jurisdiction.

It would be senseless to build a surface transatlantic steamship to perform the undersea functions of a submarine. The functions of the aircraft and the rocket ship are essentially even more disparate. In arriving at a reasonable Karman line, physicists and lawyers inevitably will reach agreement as to the point where the aeronautical vehicle no longer may perform efficiently and within reasonable physical and engineering parameters. It may be useful to examine, momentarily, some of these parameters:

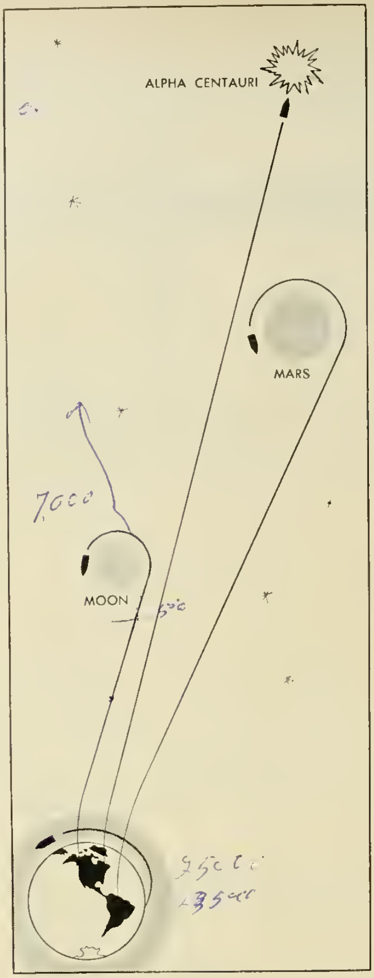
A. M. Mayo has pointed out that control of the pilot's immediate environment from the standpoint of pressure and composition would become increasingly difficult as a function both of the length of time of flight and of the pressure reduction and change of atmospheric composition.

He goes on to state that at altitudes below approximately 70,000 feet the problem of pressurization and composition is taken care of relatively easily by pressurizing outside air. At higher altitudes, pressurization of outside air becomes increasingly difficult both from the standpoint of the power required and from that of handling the very high temperatures resulting from extreme ratios.

Many other considerations will enter into the final determination of the Karman line. The danger of material collisions with the airframe, escape problems, the problems posed by combined stresses and multifold fundamental questions of the construction of aircraft, as such, will all enter into the final decision.

H. Strughold points out that with increasing altitudes, some of the biological effects creep in gradually, while others rise at sharply defined levels. On the whole, the road from the surface of the earth to free space displays characteristic ecological stages. These stages are determined by the functions which the atmosphere has for man and craft.

He points out that we must first consider the oxygen component in the chemical constitution of the air. In this respect, only the lower half of the troposphere can be designated as the physiological atmosphere or the ecosphere of the air. It is in this narrow zone that the stage for the drama of life on our planet is normally set. Only this layer deserves the name "atmosphere," which, from the Greek "atmos," means "breath."



The above sketch illustrates the four basic jurisdictional regimes: (1) the earth's shaded area shows the Karman primary jurisdictional line delimiting the air space; (2) the lunar orbit delimits the Keppler regime of earth; (3) the Martian orbit illustrates the solar Keppler regime which ends at a point beyond Pluto; (4) the Alpha Centauri trajectory is one illustration of the Sänger regime.

E. O. Hulbert states that the region of the atmosphere from 0 to 6.2 miles, where the temperature falls rapidly with increase of altitude, has long been called the troposphere. The region from 33,000 to 66,000 feet, where the temperature is approximately constant, is called the stratosphere.

The ionosphere has its own well-accepted nomenclature, the terms D, E, F_1 and F_2 designating the four ionized regions with maxima of ionization at about 43.5, 62.1, 124.3 and 186.4 miles respectively. Aside from these, there is no generally accepted terminology of upper atmospheric regions.

The terms upper and outer atmosphere are used with different meanings depending on the context, and it is best to keep their meanings fairly elastic. The region from about 12.4 to 21.7 miles, which embraces most of the ozone, has been called the ozone layer or ozonosphere. It has been proposed that the region from the top of the stratosphere, at about 12.4 miles, to the minimum of temperature, at about 43.5 miles, be called the mesosphere and the region of increasing temperature, somewhere above 62.1 miles, the thermosphere.

The exosphere has been used to refer to the outer fringe of the atmosphere, where the air particles execute long elliptical orbits bouncing outward from impacts with other particles and falling back under gravity. In general, Hulburt concludes, the physical properties of the various regions are not yet well enough known to permit their fixation by an accepted terminology.

In their most recent writings, Cooper and Meyer have sought to locate air space jurisdiction at a point in the ocean of air surrounding the earth where aerodynamic lift is gone. These authorities have avoided the mistakes of engineers and sociologists suddenly turned amateur lawyers, who are attempting to locate air space jurisdiction in such heterodox and altogether eclectic regions as the thermosphere, exosphere, mesosphere and ozonosphere, even the nomenclature of which is doubtful, and none of which has any reference whatsoever to the problem at hand.

Under certain conditions national jurisdiction will be *quite indirectly* but effectively maintained over what is called by Professor Cooper "contiguous space." In the near future the nations of the earth will be offered point-to-point rocket communications involving many services.

The trajectories of each of these routes will be different, and will involve different altitudes. Some of these rockets will describe a trajectory requiring heights of 300 miles or less, and others will probably require heights in excess of 1000 miles. National jurisdiction will be effectively maintained by the granting of launching and landing rights, and thus there will be indirect national control with respect to point-to-point earth rockets over contiguous space.

The international regulation of

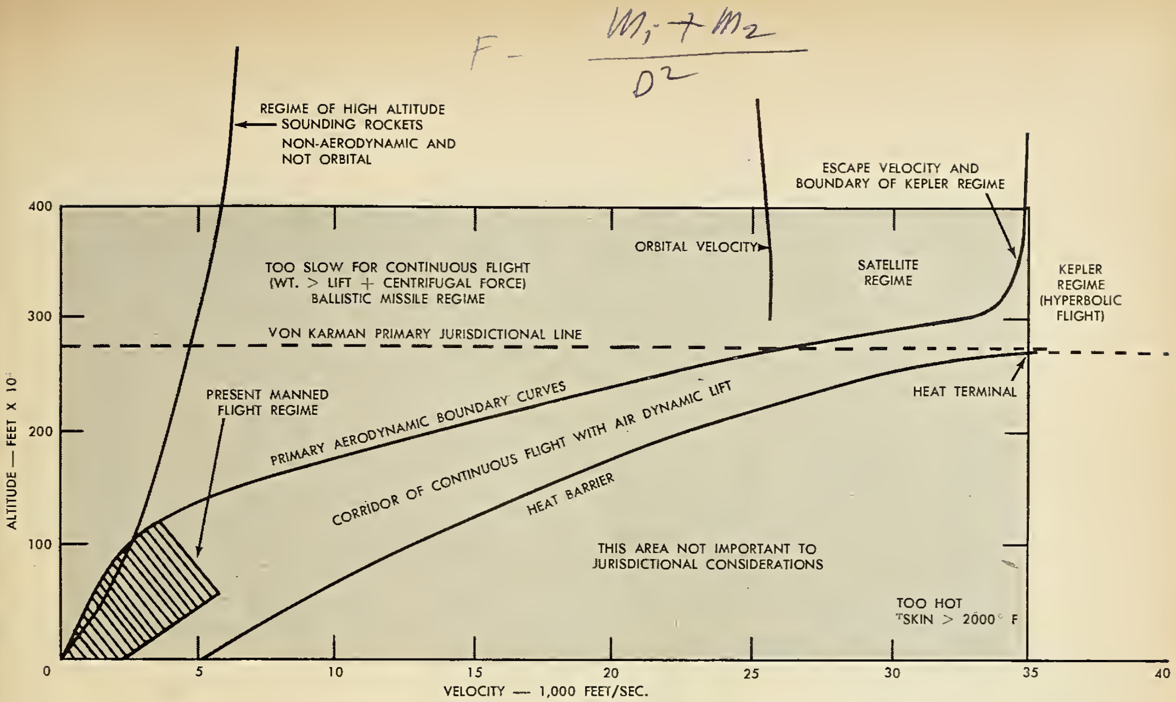


Diagram showing regimes of atmospheric and extra-atmospheric flight and depicting jurisdictional boundary lines.

point-to-point earth rocket vehicles will be under the jurisdiction of a successor international governmental organization to ICAO. The very problems of locating instrumentation along the manifold aerodynamic and nonaerodynamic routes, orbits and trajectories will require the highest degree of international cooperation and regulation for the operational efficiency and safety of all concerned.

The aircraft, the point-to-point earth rocket ship, and the spaceship capable of freely maneuvering in outer space when navigating around earth or landing on earth, will each need navigation aids, anticollision devices, secondary radar, communications systems, meteorological services and many other international aids and services. In every instance of movement to or from any point on earth, the national licenses and permits which are the essential prerequisites of national society will be needed.

Mankind must mature appreciably to create an international authority having sole and complete jurisdiction over space flight and such an achievement must wait the wise action of future generations.

No single nation has a paramount claim to outer space nor a monopoly on the scientific genius which will soon make its exploration and exploitation a reality. The field of astronautics will progress only as international cooperation in the field is achieved.

National sovereignty ends for all purposes with the Karman line. By way of analogy, the Stephen Decatur Doctrine demonstrated 150 years ago, that:

> The seas beyond reasonable coastal areas [space beyond the Karman line] are free and subject to control by no single despot or nation, and
>
> The sponsors of ships at sea [spaceships in space] must be responsible for the conduct of their vessels.

More than 50 nations are participating in the IGY. This involves very extensive utilization of governmental and nongovernmental facilities and personnel. Active participation in the program is required of each nation, of its army, navy, air force and coast guard personnel and facilities; of such governmental agencies as those concerned with standards, radar, radio, meteorology, weather, coast and geodetic surveys, geological surveys, and all types of official scientific and research organizations.

In addition, parallel, nonofficial institutions are involved, including universities and observatories in those few countries where such institutions are not controlled by the state. By agreeing to support actively the satellite program, the foregoing nations also agreed to the legal validity of the project.

On the basis of sound principles of international law, the nations of the world may not protest the flight of a nonmilitary artificial satellite over their territories when the purpose of such flight is the accumulation and dissemination of scientific data which shall be made available without restriction to all the nations of the world.

No single formal treaty emerged from the myriad agreements involved in the IGY. Nevertheless, a valid and binding world pact emerged from these acts of agreement and cooperation.

The international pact, in written form, may be abstracted from the thousands of documents and exchanges from which the living IGY has evolved. There is nothing about a single formal treaty which makes it sacrosanct or makes it even an essential source of international law.

In many instances the principles set forth in the treaty itself may have been established in international law long prior to the signing of the formal document itself. A rule of international law does not receive its validity from its enactment into a legal instrument, such as does an international law, which is valid although not enacted in such legal instruments. There are rules of international law which are not valid, although enacted in such instruments. Enactment, therefore, is no objective criterion for the alleged validity of a rule of international law.

The social scientist, just as clearly as the natural scientist, has the duty to acquire base-line data and then to implement such data in the dynamic evolution of society. The advent of the rocket motor, with its potential of unlimited access on the earth and in space, presents a great new mutation requiring the immediate and careful attention of the social and natural scientists. The base-line material of the lawyer has always been invested in the mores of mankind from which he must extrapolate principles of justice.

At this time we may postulate necessary rules of space exploration—namely, in any instance where there is reason to believe that intelligent life exists on a planet, no earth spaceship may land without having satisfactorily ascertained that 1) the landing and contact will injure neither the explorer nor the explored; and 2) it has been invited to land by the explored.

The regulation must be adhered to without exception, or we will project into space and perpetuate the bleak and devastating geocentric crimes of mankind. Further, we must conquer certain problems of semantics before we are worthy of space travel beyond our solar system.

This principle is just as old and simple as the basic idea of justice itself. It is a kind of compact not to harm or be harmed.

Metalaw was earlier defined as the law governing the rights of intelligent beings of different natures and existing in an indefinite number of different frameworks of natural law. An intelligent multidimensional creature would probably be so inferior as to require most considerate and sympathetic understanding and treatment by three-dimensional creatures existing in a three-dimensional universe, such as we conceive of mankind. The intelligent mankind concept runs into deep trouble *vis a vis* an intelligent two-dimensional creature existing in a three-dimensional continuum, and problems of metalaw become truly complicated when one considers a man's relationship with intelligent two- and one-dimensional creatures existing in a two- or one-dimentional universe.

With the assistance of Dr. Eugen Sänger and Dr. Irene Sänger-Bredt, the possible types of flight regimes, including those regimes which might philosophically spell the elimination of a dimension, were illustrated by a diagram (Fig. 2). Within this coordinate system are plotted the domains of aeronautics, the transition domain from aeronautics to astronautics and the domain of astronautics.

Proper aeronautics, characterized by air-breathing propulsion systems, reaches up to about 50 miles. It lies between the two well-known limiting curves—namely, the limit of aerodynamics lifting power and the heat barrier. This domain plot shows an onion-peel shape (attaching one onion peel to the next by increasing flight velocities and altitudes) when progressing from propeller reciprocating engines to turbojets and then to ramjets.

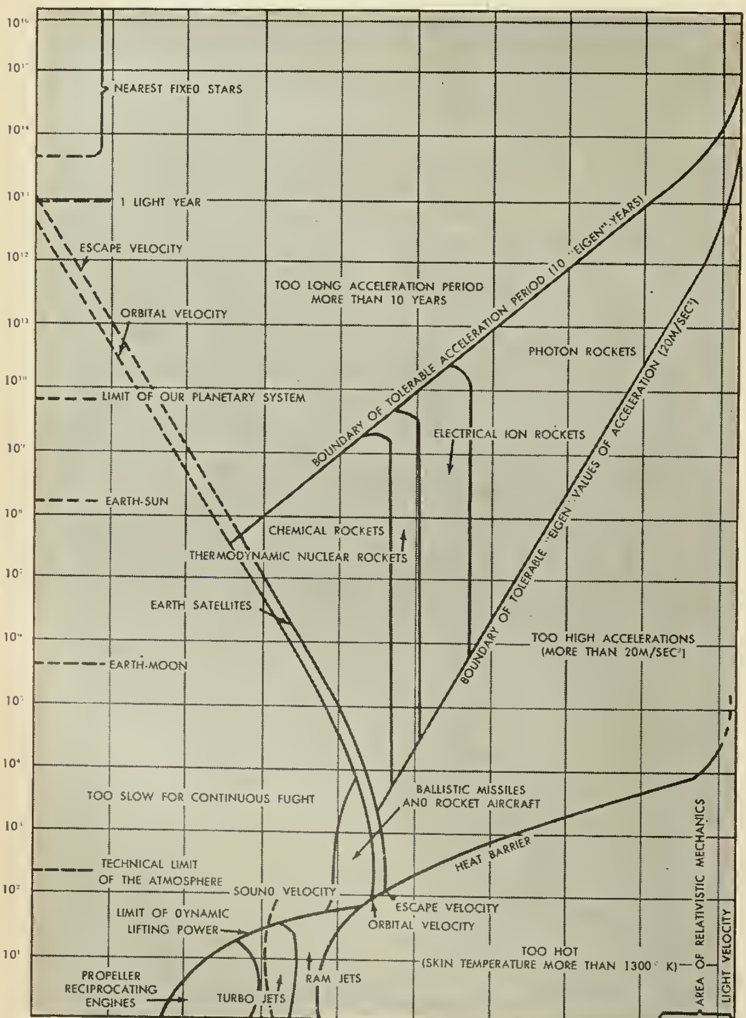
Though aerodynamic lifting power is gradually replaced by the centrifugal force from the trajectory curvature beyond a velocity of 62,000 miles per hour, the intersection of the curves of limit of aerodynamic lifting power and heat barrier is nevertheless physically real and constitutes as the utmost limit of the ramjet also the definite limit of aeronautics.

Contrary to this, ballistic rockets and rocket aircraft are not limited by the limit of aerodynamic lifting power due to their "non-airbreathing" propulsion systems and they can fully exploit the lifting support of the inertial forces due to the trajectory curvature from about 3730 miles per hour on, so that their possible altitudes of flight increased to several thousand miles and their flight velocities approach orbital velocity. The aerodynamic lifting power then is completely replaced by the inertial forces of the circular orbit about the earth.

These ballistic missiles and rocket aircraft form the transition domain from aeronautics to astronautics, which flows into the domain of pure astronautics with the reaching of the orbital velocity. Hence, only a small corridor connects aeronautics with astronautics.

Within the narrow band between orbital velocity and the constant $\sqrt{2}$-times larger escape velocity lie the artificial satellites on the earth. This band curves to decreasing flight velocities with increasing altitude due to the decrease of the gravitational acceleration by the square of the altitude over the earth.

Beyond this band there opens the immense vistas of interplanetary. interstellar and intergalactic space flight, in a structural shape surprisingly similar to that of aeronautics according to present concepts. ★



The Eugen Sänger schematic diagram illustrating all possible flight regimes. Verticle scale represents flight altitude in kilometers vs. earth velocity in km/hr (horizontal).

Manned Rocket Aircraft

By Frederick I. Ordway III

THE HISTORY of the rocket airplane can be compressed within a 30 year span, which, offhand, seems a rather considerable period for this almost novel device. Today, we are interested in the rocket airplane for two major reasons. First, the enormous power made available in a relatively small package allows very high velocities to be built up over short periods of time. Second, the rocket airplane offers an important research potential.

There is no particular difficulty in discussing the history and developments of the pure rocket airplane: it either does or does not have solely a rocket powerplant.

Little attention will be given to pure JATO applications of rocket power. A B-47 or an F-84 are completely operational without considering the fact that they may employ rocket-assisted take-off techniques. On the other hand, the XF-91 was as much built around its rocket engine as it was around its turbojet.

The world's first rocket airplane flight took place in Germany. Germany, too, put the first operational rocket fighter into the skies during World War II. Since then, the United States, France, Great Britain and Russia have made varying efforts in this pioneering field, and it seems that, in one form or another, rocket airplanes are with us permanently. The first manned spaceships may well be extrapolations of today's rocket-powered research aircraft.

For a brief rundown, Germany and Japan are largely identified with wartime efforts; the United States has led the world since then; France is assuredly Western Europe's greatest rocket plane promoter; Great Britain is moving ahead rapidly; and Russia represents somewhat of an unknown.

German Developments

Germany developed the first rocket plane in the 1920s. M. Valier conceived of a project wherein solid rockets would power a small airplane with an auxiliary piston engine for emergency.

On July 11, 1928, at Wasserkuppe, F. Stamer attempted a flight with a rocket-powered glider made available by the Rhon-Rossitten group. Slow-burning Sander's 25- and 30-pound-thrust solid rockets used initially failed to get the plane off the ground. On a third attempt, with two 40-pound-thrust units, take-off occurred, and a 4000-foot-long run of just over a minute was recorded. Later attempts were unsuccessful.

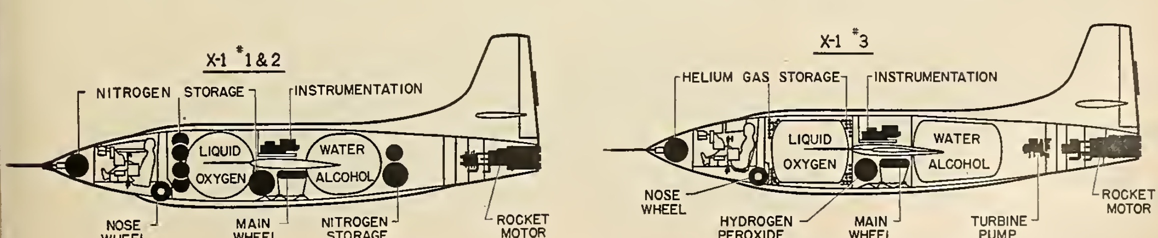
The Opel-Sander-Hatry (pilot-rockets-builder) rocket airplane, with Fritz von Opel as pilot, succeeded in flying on Sept. 30, 1929, at Rebstock (Frankfort) after two preliminary attempts. Power was provided by 16 powder rockets. The flight was nearly a mile long, lasting over a minute. Top speed was reported to be some 70 miles per hour. There was also a tailless *Espenlaub* plane with a 300-pound-thrust engine which could get off the ground very rapidly.

Several events led directly into Germany's wartime rocket airplane developments. Work began at Hellmuth Walter Kommanditgesellschaft in Kiel around 1935 on hydrogen peroxide engines, and thrust ratings went up from 650 pounds to over 2000 pounds in 1938. Turbopump systems gradually replaced pressurized gas feed systems, and bipropellant philosophy gradually replaced the monopropellant.

The first real rocket airplane appeared toward the end of 1938. The Heinkel He-176 reached about 550 miles per hour on a 1300-pound-thrust liquid Walter engine. Walter's engines were beginning to prove themselves and it was not long before other planes, such as the Messerschmidt Me-163 *Komet* mid-wing monoplane and the Bachemwerke *Natter* ram rocket, were using them.

The Me-163 took off and landed much like the modern *Baroudour* in that it jettisoned its take-off assembly and landed on skids. A short plane, the Me-163 was 20 feet long and had a wing span of 32 feet. It weighed up to 11,000 pounds and had a normal 52 pounds per square foot wing loading, which became 14 pounds per square foot when its propellants were exhausted. It featured sharp leading-edge sweepback.

Two major engines were used on different models of the plane: a "cold" engine operating only on T-stoff, while a "hot" engine used bipropellant C-stoff and T-stoff. With the latter combination the plane could reach nearly



Drawings illustrate the internal arrangement of the X-1 series of research rockets. Basic changes are noted in gas storage.

The X-1A, a modification of the "sound-barrier buster," reached a velocity of Mach 2.5.

Me 163B (General)

Contractor:	Messerschmidt
Years	1943-45
Powerplant mfg.	HWK liquid rocket
Powerplant type	109-509A
Powerplant weight, lbs.	365
Thrust, lbs.	3300 max.
Propellants	C-stoff, T-stoff
Specific impulse, lb.-lb./sec.	180-190
Firing time, min.	4½ (full thrust), 10-12 otherwise, and possibly to 20 min. by using intermittent glide techniques.
Airplane length, ft.	20
Airplane span, ft.	32
Airplane weight, lbs.	9000-11,000
Payload, lbs.	1500
Range, miles	22 (after climb at 495 mph)
Altitude, ft.	40,000
Speed, mph	450-620

600 miles per hour, but could fly only about 10 minutes.

At one time during the development program the Junkers firm took over the concept for improvement recommendations and came up with the Ju-248, a somewhat slimmer design. Messerschmidt got it back, however, and the Me-263 resulted, a plane that never was tested under powered flight.

The *Natter (Viper)* was the smallest rocket airplane concept to come out of war-time Germany, and it reached the flight test stage. Four solid diglycol 109-533 boosters made by Schmidding would lift *Natter* at a rapid rate of ascent. Subsequently a Walter C/T-stoff engine would take over.

Vertically launched, the all-wood *Natter* was cheap and could be built rather quickly. From 24 to 33 electrically-fired 7.3-cm *Fohn* air-to-air rockets were carried in the nose and fired simultaneously; once the attack had been made, the pilot would parachute to ground and the motor would jettison and likewise be parachute-recovered. With under 8000-pounds thrust, it had an acceleration of 2¼ g. The top speed was just over 600 miles per hour, and its ceiling was under 10 miles.

Natter weighed about two tons and incorporated an autopilot used until final closure, when the pilot was to take over. Some 20 pilotless tests were successful, but the one piloted attempt failed.

No discussion of World War II German rocket airplanes is complete without mention of the Sänger antipodal bomber. As far back as the early 1930s Euger Sänger was testing oxygen/fuel oil rocket engines in Vienna and he designed a plane looking much like the U.S. X-1. With Irene Bredt, he developed his wartime scheme of a rocket manned bomber that could hit targets on the other side of the globe.

The bomber would have an apogee of some 160 miles (top speed: four miles per second), which meant it would be well outside the effective atmosphere. Its re-descent path would be so calculated that the plane, upon reaching denser atmospheric layers where aerodynamic forces come into play, would ricochet back into space. By following such a "skip" path its range would be enormous.

In the words of Sänger and Bredt: "The launching and climb of the rocket bomber have the purpose of giving it, with a minimum of fuel consumption, the high velocity necessary to carry it through its long glide path; they are in the nature of an impulse which lasts only for a few minutes." They assumed the bomber would be catapult-launched along a rather long track; in effect it would have been a rocket-sled boost which would provide an initial 1000 miles per hour. This great idea remained in the project stage only, though rumors persist that the Russians have, since the war, developed the concept for their own use.

Sänger and Bredt wrote during World War II the following conception of an attack on New York by an antipodal bomber:

As an example of area attack with single propulsion and full turn, we use the attack on New York at a range of 6500 km. For c = 4000 m/sec, the bomb load is 6 tons, and the detailed attack runs as follows: the motor starts to work 36 seconds after the take-off at 12 km. distance from the take-off point, and consumes the total fuel supply of 84 tons in the next 336 sec. At the end of the climb process, the aircraft reaches a velocity of 6370 m/sec, an altitude of 91 km., a distance of 736 km. from the point of take-off, and a weight of 16 tons. Using only its store of potential and kinetic energy, the bomber flies on to the point of bomb release, 5550 km. from the take-off point and 950 km. in front of the target. At this point, which is reached 1150 sec. after take-off, the velocity has decreased to 6000 m/sec, and the stationary altitude to 50 km. After the bomb release the weight is 10 tons. Then the aircraft goes into a turn and in 330 sec. goes through a turn-spiral 1000 km. in diameter until it has reached the direction for the return flight to the home base. During turning, the altitude is greatly decreased in order to develop the aerodynamic forces necessary for the turn. At the end of the turn path, the velocity is still 3700 m/sec and the corresponding stationary altitude is 38 km. The supersonic glide path in the direction of the home base goes over 5450 km. in 2600 sec and ends 100 km. before the home base at an altitude of 20 km. and velocity of 300 m/sec. Subsonic glide and landing are completed in customary fashion. The whole flight lasts 4755 sec.

The Me-163 Rocket Fighter Program

Model	Velocity (max. mph)	Powered flight time (min.)	Rate of climb (ft./min.)	Engine No.
163A		3¼		R11-203
163BO	555	10	16,000	109-509A
163B1				109-509B1
163C	590	12	12,500	109-509A2

Rocket Engines Used During Me-163 Programs

Year	Me-163 model	Engine model	Thrust range (lbs.)	Engine weight (lbs.)
1941	A	R11-203	330-1650	165
1943	B0	109-509A (R11-211)	660-3300	369
1944	B1	109-509B1	220-4400	440
1945	B	109-509A1	220-3520	370
	C	109-509A2	440-3740	390

Japanese Rocket Airplanes

The story of Japanese rocket airplanes concerns essentially the *Baka*

Natter Models

Mark	Model	Engine	Powered flight time (min.)	Rate climb (ft./min.)	Velocity (mph)
1	BP-20B	109-509A1	2-4	37,400	620
2	BA-349A	109-559	2-4	.....	...
3	BA-349B	109-5090	2-4	37,300	620

Natter Engine Comparisons

Model	Thrust (lbs.)
109-509A1	220-3520
109-509D	880-4480
109-559	330-3750
(109-509A-2)	(possibly up to 4410)

piloted but powered bomb. They had their *Shusui* version of the Me-163, developed by the Navy, and other piloted bombs referred to *(Kikka, Toka,* etc.), but the *Baka (Marudai)* was their key development.

The *Baka* fired its rocket immediately after release from the mother airplane, and upon burnout glided to target, or it could initially glide and employ rocket power in terminal approach. The bomb generally was launched at altitudes up to 5000 feet and perhaps six or seven miles from the target. It could fly 60 miles if launched from 27,000 feet. The pilots would enter the *Baka* from a hatch in the bomber, much as they do today in entering X-1-type rocket airplanes.

Baka was attached by a mounting lug and a series of slings. Like the *Natter, Baka* was of wooden construction, with fabric-covered plywood surfaces. The guidance system, however, was unlike the *Natter*. First, there was no initial autopilot operation, and second, the human guidance system was considered expendable. Three solid-propellant rockets propelled *Baka,* though the idea of using additional wing-mounted rockets was considered in view of ground launch. The solid charge was a monoperforated double-base powder. If the weapon was launched at maximum altitude of 27,000 feet, it glided for 52 miles at about 230 miles per hour at a glide angle of 5° 35″. Then its rockets took over and during the last three miles speed went up to more than 530 miles per hour. If rockets were used during steeper glide angle, velocities increased to over 600 miles per hour.

Baka was clearly a desperation weapon and one that could be employed only by a nation that could accept the planned expendability of life without even a one per cent chance of survival. While there were many ingenious features to *Baka,* its maneuverability was poor, and except during its brief powered flight, it was susceptible to enemy countermeasures. It seems certain that *Baka* represented one facet of rocket power airplane philosophy that is destined not to reappear.

American Rocket Airplanes

There is a certain resemblance to early American rocket-plane progress in the case of Germany. The former, like the latter, started off by outfitting gliders with solid rockets which had no important effect. For example, back in 1933, 86 solid rockets were supposed to have powered an airplane called *Spirit of Night.*

Similarly, the first practical rocket plane in this country was a military interceptor type, and it was developed under the cloak of secrecy during World War II. It was the Northrup MX-324 flying-wing design, with a span of less than 30 feet. Like the Me-163, it used a liquid engine, in this case the Aerojet XCAL-200, which produced 200 pounds of thrust on red fuming nitric acid and monoethylaniline. The pilot operated the plane while in a prone position, allowing a thin airfoil and permitting him to withstand considerable g-forces. The first flight occurred in July 1944 in California. Some models took off and landed on skids.

Once the feasibility of a rocket airplane was established, the Army Air Force approached Bell Aircraft in 1944 to apply the principle to the problem of designing a research airplane that could explore the transonic and supersonic flight regimes. At the time they wanted 800 miles per hour at 35,000 feet for two to five minutes of flight.

Bell first looked at a turbojet-rocket combination, then decided to use rocket power alone.

AAF went to Reaction Motors for its 6000-pound-thrust liquid-propellant rocket engine being developed for Navy use. This four-chamber engine could provide thrust levels of 1500, 3000, 4500 and 6000 pounds. Weighing 210 pounds, it occupied a space four and one-half feet long, with an elliptical cross section having an 18-inch major axis and a 13½-inch minor axis. Thus Bell Aircraft Corp. and Reaction Motors started off on the X-1 series of rocket airplanes that have since broken altitude and speed records and have accumulated vast quantities of data on manned flight at the aeronautical frontiers.

The RMI 6000 rocket engine compared most favorably with the German Walter 509s in that it developed nearly twice the thrust, yet weighed a third less.

The X-1 program has been widely discussed, so that here we shall content ourselves with salient details only. The X-1 weighed 13,400 pounds and was 31 feet long. The thickness/chord ratio was 8 per cent, and it weighed 4890 pounds empty. In 1946 some 10 glide tests were made from B-29s in Florida, and on Dec. 9, 1946, the first powered flight took place. The program was designed to gather data on drag, heat, stability and pilot physiological strain at high speeds and altitudes. The airframe was stressed for +18g and −10g. The following summarizes highlights of the X-1 program.

Like the X-1, the later (1951) X-1A was generally air-launched from specially modified B-29s (later B-50s). This model had the same RMI 6000-pound-thrust engine, but it could carry

The X-1B was designed to test the effects of aerodynamic heat on aircraft structures.

twice the propellants and featured a turbopump assembly rather than a gas-pressurization feed system. It was somewhat longer than the X-1, fired for over four minutes, and glided in for a landing at 150 mph. It was delivered to Edwards Air Force Base for test in November 1953, and within a month had reached 76,000 feet and Mach 2.5.

A second X-1A, with 4 per cent thickness/chord ratio and aspect ratio of 4 (versus earlier 6) was ready in early 1955 but exploded and was jettisoned from the parent plane. Along with the X-1A were the X-1B, X-1D and the currently used X-1E, last of the series. All operate on alcohol-water liquid-oxygen propellants. Essential data on these planes are presented in chart form.

The X-1E was the last of the X-1 series. It investigates high speed heat problems.

The Douglas D-558-2 *Skyrocket* used the same 6000-pound-thrust engine as the Bell X-1 aircraft, and has the distinction of being the first plane in the world to reach Mach 2 in level flight. It was also the first plane to exceed 80,000 feet, its record being 83,235 feet (achieved by Bridgeman in 1953). It was outfitted with an air-conditioning system capable of maintaining cockpit temperature at 70°F during high-speed flight. Navy and NACA sponsored the research airplane.

In November 1947 the plane was ready and the first flight took place in February 1948, using only its Westinghouse jet-engine power. The rocket powerplant was still not ready. In February 1949 a combined rocket-jet flight was made. Later, air-launching techniques were employed, and in August 1953 an all rocket-powered flight was made which carried it to its record altitude. In November of the same year the record 1327-mph (Mach 2.01) flight was made.

Another Bell Aircraft development was the X-2, which was larger, heavier and faster than others of the X series. The history of the X-2 dates back to 1947. Delivery of the first unit was made during the summer of 1952. With small, swept, stainless-steel wings and a thick-walled nickel alloy fuselage, it was powered by a Curtiss-Wright XLR-25-1 variable thrust liquid-propellant rocket motor producing more than 15,000 pounds of thrust. The cabin was heat-insulated and all controls were power-boosted. The first of the X-2s exploded over Lake Ontario in May 1953, but the second went on to achieve aeronautical triumphs before it, too, was destroyed.

The X-2 used heat-resistant glass and heat-resistant alloys for all stressed parts. (At Mach 3, temperatures up to 350°C were expected.)

It made its first gliding flight in August 1954. Its first powered flight took place at Edwards AFB, California, in November 1955, and by July 1956 it had reached 1900 mph and an astounding altitude of 126,000 feet. Its record flight on September 27, 1956, brought it to Mach 3.1. On this flight, the "thermal barrier" research aircraft

German Rocket Airplanes

Airplane	Data	Comments
Antipodal bomber	Loaded weight: 220,500 lbs.; payload up to 672 lbs.; propellants: liquid oxygen/gas-oil; length: 91.8 ft.; thrust: 220,500 lb.	Project only; concelved in 1936, suspended in 1942; work performed at the Research Institute for Rocket Propulsion; designed to reach 93 miles altitude and 14,600 miles maximum distance from launch base.
Ar-234	With 45-second endurance, could reach 36,000 ft. in 3 minutes.	Made by Arado, with BMW turbojet and rocket.
DFS-194		High-speed interceptor investigated by A. Lippisch.
DSF-228	The 109-509A1 slated for this design.	A D5F-Siebel concept rocket reconnaissance craft. Prototype built and flown; was to have been operational up to 100,000 ft.
DSF-346	Two liquid rockets for Mach 2.6 speed.	Also DSF-Siebel design concept, scout bomber; initially a research type.
He-176	Walter liquid rocket on Heinkel airframe.	First flew in 1938; not operational.
Julia, P-1077	Thrust variable from 440 to 3750 lbs. over short periods; loaded weight: < 5000 lbs.; empty weight: 2000 lbs.; range: 40 miles; velocity: 500 mph.	Also a Heinkel development, it was a VTO type with four 2600-lb.-thrust, 10-sec. boosters plus a Walter liquid sustalner. Rate of climb about 40,000 ft/min.; skid landing. It was not built.
Ju-248	Approx. 26 ft. long; weight: 11,700 lbs.; range: approx. 100 miles; velocity: 620 mph; maximum thrust: 4430 lbs. Designed to reach 40,000 ft. in 3 minutes.	Used 109-509C1 liquid rocket engine; slimmer than the Me-163; a target defense plane. Only one was constructed.
Me-1638	See separate chart.	See separate chart.
Me-163C	Weight: more than 11,000 lbs.; designed for S90 mph, 52,000 ft. altitude. Endurance of 15 minutes at 500 mph.	A mid-wing monoplane, it evolved into the Me-262.
Me-262	Weight: 18,000 lbs.; thrust of liquid rocket: 2750 lbs.	8MW-718 rocket engine wlth BMW or Jumo jet engines; also designed to use one or two Walter rockets.
Me-263	Length: 25.9 ft.; span: 31.3 ft.; maximum thrust: 4430 lbs.; weight: less than 12,000 lbs.; velocity 620 mph (max.); rate of climb: 13,800 ft/min.	Used 109-509C1 engine; glide-tested only, however. Was a pure rocket fighter design. Development started by Junkers, turned it over to Messerschmidt. Ju-263 designation also seen.
Natter, 8P-208	Length: 18.75 ft.; span: 10.S ft.; climb rate: 35,000 ft/min.; 2.2 g acceleration; 12 mile radius of action; cruising speed: 496 mph (max. at 16,000 ft.: 620 mph).	Had four SR-34 solid boosters (109-533 diglycol) by Schmidding, and a liquid Walter rocket (recoverable). Pilot rode forward of wings. Largely wood construction.
P-1104	Rate of climb: 39,000 ft/min.	Messerschmidt design, pure rocket interceptor. Mk-108 armament visualized.
Ta-183		Focke-Wulf jet/rocket, twin-boom airplane.
Volksjaeger, He-162	Design endurance: 45 minutes.	Heinkel rocket fighter project.
Walli, EF-127, -128	Length: 26.4 ft.; span: 20.6 ft.; weight: < 6500 lbs.; range: 60 miles; speed 630 mph. Thrust was variable from 440 to 3750 lbs.	A target defense fighter, not built; rocket engine only, i.e., not jet auxiliary.
Zeppelin Ram Design		To have been used for ramming; solid-propelled, like the Japanese 8aka.

This variable-thrust rocket plane has reached the highest velocity and altitude to date.

Characteristics of Baka

Length (ft., in.)	19' 10"
Span (ft., in.)	16' 5"
Wing area (sq. ft.)	64.7
Wing loading (lbs./ft.^{2})	70
Weight (lbs.) (with 120 lb. pilot)	4535
Weight, warhead (lbs.)	2645 (with 1135 lb. explosive)
Weight, airframe	1000
Weight, propulsion unit (lbs.)	768
Length, propulsion unit (ft., in.)	6' 6"
Thrust (lbs.) (max.)	4500 (average: 1500)
Average firing time at 60° temperature (sec.)	~ 10
Velocities, considering maximum total horizontal range case (mph)	
1 rocket fired	350
2 rockets fired	455
3 rockets fired	535
(Note: Level flight speeds)	

crashed, due probably to loss of directional stability. Pilot Apt was killed.

The X-1E and the X-2 do not end the American rocket airplane research program. There are apparently at least two others. The first, the rumored Douglas X-12, is somewhat indefinite, but is supposed to be capable of reaching Mach 5, a range of 500 miles, and an altitude of 140 miles. It may be a Navy-DNR project. Details on the second, the North American X-15, are shaping up rather rapidly.

The X-15 is an Air Force-, Navy- and NACA-sponsored project and will be designed to probe two main unknowns: the effects on airplane and man of Mach 5-6 flight, and the effects on airplane and man of flight 100 miles or more above the earth's surface, including specifically heating, control, stability and re-entry.

What we are to see, in effect, is a manned spaceship, powered by a Reaction Motors 60,000-pound-thrust rocket engine and capable of operating in the void. An interesting fact about the airplane is that it is considered quite safe, despite the frontier regions in which it will fly. It has been thoroughly "human engineered," and aeromedical experts have labored on the project side by side with the aeronautical engineers. It will probably make its first test glide from the Edwards AFB flight test center in 1958.

The X-15 will have to be versatile to explore successfully a variety of speed regimes at a variety of altitudes. Top speeds will presumably be attempted at extreme altitudes—100 miles or so. Re-entry will be critical, and it is obvious that aerodynamic glide descent techniques will be employed. Results from X-15 flight testing are sure to be directly applicable to one of the most important facets of astronautics—descent onto planets with atmospheres.

Oddly enough, the United States has seemed to pay little attention to the rocket-powered military aircraft. Nevertheless, in the early 1950s, the development of an experimental rocket-turbojet interceptor airplane was sponsored by the Air Force. It was designated the XF-91 and was handled by Republic Aviation Corp.

It is noted mainly that it was the first U.S. rocket-powered combat-type fighter to exceed the speed of sound. This it did late in 1952 on a flight out of Edwards AFB. Test flights started in 1949, the first on May 9.

XF-91 had two powerplants, a GE J-47 developing 5200 pounds of thrust, and a Reaction Motors 6000-pound-thrust liquid rocket of the same type used on the Bell X-1 and Douglas D-558-2 research airplanes.

An interesting feature of the plane was the inverse taper on the swept-back wings, which reduced wingtip stalls due to lift loss. The wing also showed variable incidence, which allowed a high angle of attack for take-off and landing and low angle of attack for level operation. Pressurization and refrigeration were provided.

There are known to be other rocket airplane projects in the United States but details are not available. A rocket engine recently exploded during test at Reaction Motors, killing or injuring both RMI and Chance-Vought engineers. This set off new rumors about a suspected rocket airplane that may be under development by the two firms.

The Air Force has already predicted manned flight at Mach 10 within 10 years, which is double the speed assumed for the X-15. Rocket engines will gradually increase in power, and we may hear more of the turbo-rocket motor. Marquardt has one under development where the efflux of the rocket engine is passed through a turbine driving a compressor. Ram air is compressed and, by suitable ducting, is made to join the turbine exhaust, providing thrust. Aerojet-General has reported making studies of a 2000-mph commercial airliner which, it feels, could be available within 20 years.

This rocket-powered commercial airliner proposition was well publicized about a year ago in a series of articles by Dornberger. He visualized a two-stage rocket glider which would travel from 7000 to 11,000 mph at an altitude of between 25 and 35 miles. It would slow to 2700 mph for re-entry, and essentially would be automatically controlled.

French Rocket Airplanes

In the west France can be considered the European leader in the application of rocket power to airplanes, and is apparently the world leader when it comes to rocket combat-aircraft progress.

Her outstanding development at the moment is the *Trident* II SO.9050 airplane, which has been so successful that not only the French manufacturer, but German, Dutch and Belgium firms, have recommended that their governments adopt it as an interceptor.

The II model was preceded by the

Comparisons of U.S. Rocket Aircraft

Item	X-1	XF-91	D-558-2	X-1A	X-2	X-15	The Future
Velocity (Mach No.)	1.4	> 1	2.1	2.5	3.1	5-6 (design)	10
Altitude (ft.)	73,000	...	83,000	90,000	126,000	500,000 (design)	1,000,000
Thrust (lbs.)	6000	6000	6000	6000	15,000	60,000	100,000 or more
Length (ft.)	31	43' 3"	45	35' 7"	...	...	...
Span (ft.)	28	31' 3"	25	28	...	...	...

The Fairey DELTA I is the British entry in the rocket research airplane field. Craft utilizes a liquid rocket for assisted takeoff and a conventional turbojet for cruise.

U.S. Rocket Airplane Velocity Records

Plane	Velocity record
X-1	First to reach Mach 1
D-558-2	First to reach Mach 2
X-1A	First to reach Mach 2.5
X-2	First to reach Mach 3
X-15	Designed to reach Mach 5-6

experimental SO.9000 *Trident* I, which in May 1955 reached supersonic flight in climb. Its main powerplant was a three-chamber SEPR481 (earlier 25) liquid-rocket engine with MD-30 *Vipers* on the wingtips as auxiliary jet engines. Both I and II were conceived by French designer Servanty, and the first "jet only" *Trident* I flight was made on March 2, 1954 with Jacques Guignard at the controls. Charles Goujon took, it on its first rocket flight early in September of the same year. Though the rated thrust was about 9900, it actually built up 10,500 at sea level and 11,500 pounds at 40,000 feet.

The plane features short, thin, straight wings with no ailerons. It is light and fast, being designed for Mach 1.6 flight. Highly maneuverable, *Trident* I's rockets can be fired or turned off at will, both simultaneously or in sequence. The SEPR481 is believed to have undergone over 1000 ground tests and 125 flight tests during the development period. Specific impulse is 208-16 lb./sec. at high altitude.

SO.9050 *Trident* II is very much like *Trident* I. Apart from improved lift and aerodynamic considerations and a slightly shorter span, there is little to distinguish the two. *Trident* II uses two wingtip *Vipers*, but is shifting to Turbomeca *Gabizos* with afterburners at the present time. It has a two-chamber furfuryl alcohol-nitric acid SEPR631 rocket engine developing 6600 pounds of thrust. It makes use of honeycomb material and metal-to-metal bonding, is light, fast (has reached Mach 1.9 already and is designed for Mach 2 flight), and is operational at 50,000 feet. (It has attained 59,000 feet.) The plane is not area ruled.

This single-seat interceptor was first flown with jets only in July 1955 at Istres, near Marseilles, and in December Goujon took it on its maiden rocket flight. Since then more than 100 test flights have been made successfully. The plane is attractive to Europeans since it is simple, easily and cheaply produced, can be serviced rapidly, and can land on and take off from poorly prepared, small airstrips. (It needs about 1500 feet, and lands at 100 mph.)

It is a high-altitude interceptor that can patrol for a considerable time before making its supersonic close-in. It is reported capable of reaching 50,000 feet in two-and-one-half minutes. At the present time its ceiling is governed by pilot survival considerations only. The cabin is pressurized and has a canopy that can be jettisoned together with an ejector seat. Ten are on preproduction order by the Air Force. Production facilities are at Courbevoie.

Sud-Est's (now Sud) SE.212 *Durandal* may be dropped in favor of mass producing the *Trident* II. This mixed-engine interceptor first flew from Istres on April 20, 1956, with Pierre Maulandi at the controls. Like the *Trident*, delta-wing *Durandal* is a light, anti-bomber airplane that can make a sustained supersonic climb without even utilizing its rocket. More than 100 flights have been made.

Power is given by a SNECMA *Atar* 101-G-21 jet building up 9900 pounds of thrust and an SEPR rocket engine developing 3300 pounds. *Durandal* weighs about 12,000 pounds and has an announced speed in excess of Mach 1.5. Its armament consists of air-to-air homing missiles. A new, faster *Durandal* IV with an *Atar* 9 13,230-pound-thrust jet plus rocket is now being developed.

The *Espadon* SO.6025 (and 6026) jet-rocket airplane was used as a test bed for *Trident*'s rocket engine. At least 60 flights with the SEPR251 were successfully made, the first on June 10, 1952. Thrust was 3300 pounds, firing time 3.25 minutes. *Espadon* led directly into the current crop of French rocket airplanes, and was the first rocket plane developed in Europe since the war (Russia excluded).

Another mixed light interceptor is the *Griffon* 1500 (ex *Guepard*) of Nord-SFECMAS. This has an *Atar* 101-G with afterburner and two 2400-pound-thrust rocket chambers. It weighs 9000 pounds, has a Mach 1.3 velocity and first flew in September 1955. Nord's *Harpon* is a similar type. Dassault's MD-550 is a delta-wing airplane with *Viper* jets and an SEPR

X-1 History

1946	First powered flight (speed: Mach 0.795 at half throttle)
1947	Speed of sound exceeded in level flight (by Capt. C. F. Yaeger)
1948	Maximum speed of 967 mph attained
1949	Take-off from ground (2300-ft. run at full power; plane reached 23,000 ft. in 100 sec.)
1949	Maximum altitude attained (73,100 ft.)
1950	Retirement of X-1 to National Air Museum* in August

*Two other X-1s built, one of which had a turbopump assembly and exploded in November 1951.

The USAF-NACA-Bell X-1 Series

Plane	Remarks
X-1	See separate chart.
X-1A	Speed record set in Dec. 1953; altitude in June 1954. Air-launched at > 25,000 feet; duraluminum construction; ejection seat; tempered glass windshield.
X-1B	Like X-1A, weighs about 18,000 lbs; carries 1000 lbs. of special instrumentation; used from 1955 to determine effect of heat on structures.
X-1C	Cancelled.
X-1D	Destroyed in August 1951.
X-1E	Undergoing test. High speeds expected due to lighter airframe, less volume taken up by turbopump; heat studies being carried out.

SEPR Developments

Item/Number	25 (Guepe)	66 (also 661)	73	732	481	505	505-2	631
Type	auxiliary	sustainer & auxiliary	booster	booster	sustainer	booster	booster	sustainer
Propellants	f/na[1]	f/na	solid	solid	f/na	solid	solid	f/na
Thrust (lbs.)[2]	3300	3300	55,000	44,000	9900[3]	22,000	29,700	6600[4]
Firing time (sec.)	[5]	[5]	4	4.5	[5]	4.5	4.5	[5]
Total weight (lbs.)			1625			884	1030	
Engine weight (lbs.)	190	308		510				
Propellant weight (lbs.)			940				628	
Length (ft.)	4.92	9.2	8.8		turbopumps: 2.62 chambers: 5.91	7.9	8.8	
Width (ft.)	1.67	1.97	2.1		turbopumps: 1.90 chambers: 2.02		1.6	
Height (ft.)	1.43	0.98	2.1		turbopumps: 2.62 chambers: 2.02		1.6	
Typical application	Espadon	Mysteré IV, Mirage III	SAMs	SAMs	Trident I	SAMs	SAMs	Trident II

[1] furaline/nitric acid
[2] usually ±5%
[3] 3-chamber, at 3300, 6600, 9900 levels
[4] 2-chamber at 3300, 6600 levels
[5] variable

liquid-rocket installation. Capable of Mach +1 flight, it first flew in Bretigny in May 1955. Its armament consists of air-to-air missiles and 30-mm cannon. This plane is better known as the *Mirage* I.

Mirage II used two Turbomeca *Gabizos*, plus its two-chamber, 2400-pound-thrust SEPR rocket. *Mirage* III is today's version, having a SNECMA *Atar* 101-G with afterburner and the liquid SEPR rocket rated at 3300 pounds at sea level. Turbine cooling is achieved by using a methyl alcohol-water combination to cool generator gases.

Flight testing of this interceptor and tactical support craft began in November 1956. Area ruled, *Mirage* III is 35 feet long, has a 26-foot span, and weighs 11,000 pounds. Its armament can consist of 30-mm cannon, air-to-air rockets, bombs, napalm, and so forth. It has a long-range search and missile-control radar, can be zero-launched and land on skids, or it can operate conventionally from small, poorly prepared strips. It flies between Mach 1.5 and 1.7. *Mirage* IV will be outfitted with an *Atar* 9, and should operate in the Mach 2 region. The SEPR66 rocket engine powering the *Mirage* has seen very extensive ground and flight testing.

The French Air Force may order "hundreds" of the III model.

British Rocket Airplanes

Despite the seemingly obvious requirements for extremely rapid manned interceptors, Britain has not given as much attention to rocket airplanes as France. Back in 1950 the Ministry of Supply backed a Fairey VTO project which employed not only a two-chamber *Beta* 1800-pound-thrust liquid sustainer but two solid boosters developing a total of 1200 pounds thrust. The announced object of this program was to determine the practicality of vertically launching interceptors at low accelerations.

With a delta-wing configuration, it featured autopilot control, correcting the vehicle's path by deflecting the thrust line of the upper chamber. The VTO was presumed to be a test vehicle for an advanced FD-1 research airplane.

Other than this VTO project, the British are rumored to be considering a rocket bomber, though no details have been made public. The Avro.720 rocket-jet interceptor project was cancelled some time ago during an economy move. The major current development program involves the Saunders-Roe S-R.53 (a competitive design to Avro.720), about which a number of details are known.

Before going on to the S-R.53, however, it is well to stop long enough to mention briefly some of Britain's rocket engine developments. In discussing them, the question again arises: "When, exactly, do you have a *rocket airplane* and when do you merely have a *rocket-boosted airplane?*"

Generally, it is felt that if the engine is permanently installed and is used for purposes other than just help-

French Rocket Airplanes

Airplane	Designation	Manufacturer	Liquid rocket engine thrust (lbs.)	Velocity (Mach No.)	Remarks
Durandal	SE.212	Sud (ex-Sud-Est)	3300 x 2(?)	> 1	Delta-wing; bomber destroyer; supersonic in climb
Espadon	SO.6025 (6026)	Sud (ex-Sud-Oeust)	3300	> 1	Test airplane leading to Trident; post-war Europe's first rocket airplane; SEPR 25 then 251
Griffon	1500	Nord/SFECMAS	4800	1.3	Has Atar with afterburner; weighs 9000 lbs.
Harpon		Nord	4800	> 1	Similar to Griffon
Mirage I	MD-550	Dassault	3300	∧ 1	Delta-wing; first flew May 1955; armed with air-to-air missiles; has Viper jet.
Mirage II		Dassault	2400	> 1	Like I, with Gabizo jet.
Mirage III		Dassault	3300	1.7	Like I, with Atar 101-G jet with afterburner; area ruled; strong competitor to Trident II.
Mirage IV		Dassault		2	Like I, with Atar 9; not yet ready.
Trident I	SO.9000	Sud (ex-Sud-Oeust)	9900	> 1	SEPR 481 rocket & Viper wing tip jets; experimental
Trident II	SO.9050	Sud (ex-Sud-Oeust)	6600	1.9	In pre-production; like I, with shorter span; Gabizo jets; SEPR 631 rocket engine; may become standard NATO interceptor; reached 59,000 ft.

British Auxiliary Power Rocket Engines

	Screamer	Snarler
Designation	A.S. Sc. 1-2	A.S. Sn. 1
Developer	Armstrong Siddeley	Armstrong Siddeley
Weight (lbs.)	470	215
Chambers (No.)	1 (earlier, 2)	1
Thrust (lbs.)	800-9500	700-2000
Propellants	liquid oxygen/aviation gasoline/water	liquid oxygen/methyl alcohol/water
Specific impulse (lbs.-lbs./sec.)	208-217	200-200
Chamber pressure, psig	600	280
Remarks	First test, 3-54; first flight test, 12-55. More than 1300 firings have occurred. Program suspended in 1956.	Tested in 1950 on P-1072 interceptor. Can fire 3 minutes at full thrust; prototype flown, 11-47; over 650 firings. Program suspended in 19S2.

British Rocket Airplanes

Name	Manufacturer	Powerplant(s)	Remarks
Avro-720	Avro	Liquid rocket plus turbojet	Projected rocket-jet interceptor; cancelled.
Fairey VTO	Fairey	Liquid rocket plus solid boosters	VTO launch test vehicle; possibly for FD-1 research airplane.
S-R.53	Saunders-Roe	Viper jet plus Spectre rocket (liquid)	Now being flight tested; called a recoverable booster for air-to-air missiles.
S-R.177	Saunders-Roe	Liquid rocket	Project only.

ing take-off it should be thought of as an integral part of the airplane design, and not only an added feature.* The RAE *Alpha* rocket engine, for example, was the main engine for a Vickers transonic airplane model, while *Beta* I and II, later, were also used on the aerodynamic research vehicle. *Gamma, Scarab, Scorpion, Sprite* and *Super Sprite* engines are ATO units. The *Super Sprite,* incidentally, is the first British aircraft rocket engine to go into production.

Both the AS.1-2 *Screamer* and the AS.1 *Snarler* are primarily auxiliary powerplants providing surge speed for fighters, and can be stopped and started at any altitude. *Screamer* has been successfully used on the *Meteor* 8, and was considered the successor to the *Snarler* (which was flight tested in November 1950 in the Hawker P-1072). That *Screamer* was cancelled last year despite the fact that it reached the flight clearance stage indicates that the sponsoring Ministry of Supply decided to use peroxide rather than liquid oxygen for its rocket interceptors.

The delta-wing, mixed-power S-R.53 interceptor has been described as a "recoverable booster" for air-to-air missiles, as well as "the most important link in progress between the current orthodox fighter and the unmanned ground-to-air missile of the future." A Saunders-Roe development, its 1750-pound-thrust *Viper* jet engine is a product of Armstrong-Siddeley, and its *Spectre* rocket booster is from de Havilland.

The *Spectre* is presumably an outgrowth of the *Sprite* and *Super Sprite* programs, and has performed well in the S-R.53 application. It is interesting to note that the ratio of jet to rocket propellant can be varied according to the tactical situation.

The *Spectre* rocket engine is the main powerplant of the S-R.53, and not an auxiliary. It is apparently the first British airplane that can really be considered rocket powered.

Little additional information is available on the plane. Its rate of climb is rumored to be 40,000 feet per minute, and it has a large quantity of avionics for automatic control. The S-R.53 first flew at the Aeroplane and Armament Experimental Establishment, Boscombe Down, in May 1957, and can take off from, and land on, small runways.

Reports have it that the S-R.53 will evolve into the S-R.P-177, an advanced rocket interceptor, though there is apparently no official Royal Air Force support for the project. It, too, presumably will employ a *Spectre,* but a *Gyron Jr* jet engine is expected to be used (a scaled-down 15,000-pound-thrust *Gyron*).

It is also probable that the English P.1 will eventually be outfitted with a Napier *Scorpion* rocket engine, making it, too, a mixed fighter. *Scorpion,* as it now stands, has two chambers producing 2000 pounds of thrust each on kerosene or wide cut gasoline. At the present time it provides JATO power for the *Canberra* bomber.

** One could consider rocket-powered helicopters, such as Saro's* Skecter *to be rocket airplanes. This model has Napier HTP rockets in the blade tips, much like Reaction Motors' ROR (rocket on rotor) projects in the U.S.*

Russian Rocket Planes

Airplane	Velocity	Remarks
Yak-21	700 mph	21-ft. span, 12,000-lb. weight. Auxiliary rocket powerplant (liquid).
La-17	Mach 1	36-ft. span, 16,000-lb. weight. Auxiliary rocket powerplant (liquid).
I-1	1700 mph	Rocket interceptor-type research aircraft. Altitude: 100,000 ft.
I-2	< 800 mph	Liquid rocket VTOL interceptor, with less than 8 min. flight time. Armed with air-to-air missiles, 37-mm cannon.

Russian Rocket Airplanes

We know less about Russian rocket airplanes than we do about Russian missiles. Yet we are fairly certain that Russia has made considerable progress in applying rocketry to aircraft, and it seems likely that German wartime efforts provided the basis for this trend.

There are many indirect indications of Russian interest in rocket airplanes. As Dr. Albert Parry has indicated, the Russians are trying to find out more about "weightless airplane" research, and "non-weight aircraft." It was pointed out that reference was made to work on gravitation in the United States and the Canadian Avro "flying disc." There is also evidence of Russian research on the problems of manned re-entry into the atmosphere in rockets.

For years there have been persistent rumors that the Russians were adapting the Sänger antipodal bomber design to their uses. A T-4A designation has been mentioned, with a range of from 4000 to 10,000 miles. Its apogee has been guessed to be in the neighborhood of 120 miles. It would hold a single pilot, according to some reports, though others hold it would be pilotless.

The Russians have admitted they are thinking about manned intercontinental rockets. On Sept. 20, 1830 hours Huntsville time, the author picked up an interesting broadcast from Radio Moscow. Missile expert Sternfeld, speaking on the program SCIENCE AND ENGINEERING IN THE USSR, devoted 10 minutes to a three-stage Moscow-New York manned rocket with an apogee of 750 miles. Poor reception did not permit further details to be recorded, though cut-off altitudes were apparently mentioned.★

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Human Factors in Space Flight

By Arthur Kahn
Westinghouse Electric Corp.

SINCE THE END of World War II and the accelerated development of rockets and propellants, there has been a renascent interest in the engineering problems of space flight. This has been heightened by the ascent of *Sputnik.*

In the main, most of the effort has been concentrated on the ability to function in a weightless environment and on the effects of high levels of acceleration. Much of this effort has been to determine the limit of the human's endurance rather than his capacity to perform tasks in this environment.

Originally, scientific interest in space flight had been well formed prior to World War II. Oberth's book WEGE ZUR RAUMSCHIFFAHRT (THE WAY TO SPACE TRAVEL) took up many of the technical problems of space travel. Oberth incorporated many of his ideas into a spaceship that was used in a German movie of 1929-vintage entitled FRAU IN MOND (WOMAN IN THE MOON).

Until recently, Oberth's work was the most comprehensive source of space flight data. Much of this book and other material considered the engineering problems involved in constructing a spaceship and the propellants required for developing sufficient thrust to drive the vehicle beyond the earth's gravitational field. There is little mention of controlling the vehicle in flight, in landing on the moon and on the return trip to earth.

Despite this interest in manned space flight there has been little interest among engineers in providing solutions to the human factors problems. Oberth's most recent book, MAN INTO SPACE, devotes little space to the human factors problems other than to record the fact that these problems are being studied at the Department of Space Medicine, School of Aviation Medicine, at Randolph Field.

He indicates the crews for these vehicles must be selected in accordance with rigorous criteria which are not mentioned. With the present intensified interest in space flight, it is necessary to examine some of the problems in which the operator's requirements will determine engineering needs.

The problems involving the operator or operators of a manned vehicle traveling beyond the earth's atmosphere can be divided into four major categories: ecological, perceptual, personality and human engineering.

Physical Orientation

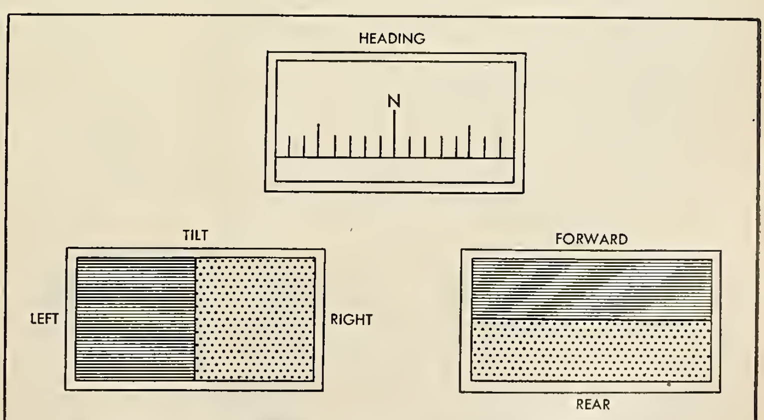
The ecological items are essentially aeromedical problems. Many of these problems now confront the equipment designer in high-altitude flight. The extent to which present operating conditions are akin to space have been indicated by Strughold in using the term "space equivalent" to denote those altitudes at which the human operator could be exposed to conditions within the earth's atmosphere that are similar to those in space. It is necessary to provide a full pressure regime beyond 50,000 feet. Blood "boils" at the vapor pressure that exists at 66,000 feet or 12 miles.

At nine-and-a-quarter miles, the amount of oxygen in the atmosphere is practically zero. At 15½ miles, it is impractical to pump air into the crew's quarters because the air is too thin. It also contains ozone, a poison. The environment must be controlled within reasonable limits by maintaining given pressure levels, humidity and temperatures as well as gaseous content.

A major problem is the removal of gaseous wastes of the respiratory process. In the earth's atmosphere, the CO_2 given off by humans is absorbed by plants which in turn give off the oxygen that man must have to survive.

Recent reports from the School of Aviation Medicine at Randolph Field suggest that such a closed system is feasible and can be incorporated into a space vehicle. If this closed system cannot be developed, oxygen must be either carried in the vehicle or somehow manufactured on board. Similarly, provision must be made for removing the CO_2. Protection also must be provided against cosmic radiation.

The problem of temperature and humidity control are related. Although man can withstand temperatures of over 100° for periods of time, he has an upper limit of 110°F. It will be necessary to maintain the temperature at a much lower level, in all probability about 80°F, if he is expected to perform tasks that require accurate computation and difficult decisions. Re-



Proposed tilt and heading indicator for ease of reading by crew.

search indicates that the optimum temperature will depend on the amount of clothing the operator wears, as well as upon the vapor pressure of the water vapor. It is obvious that it will be difficult to satisfy these requirements because at the beginning of space at about 500 miles from the earth, the temperature is about 900°K.

Psychological Orientation

The personality problems develop from factors in the individual's background. Such obvious problems as claustrophobia, inability to cope with fear of the unknown and social isolation must be considered.

At the present time the Air Force is sponsoring a study on these types of problems at Lockheed-Marietta. Beyer and Sells have discussed some of these problems in their article, "Selection and Training of Personnel for Space Flight." Clark and Graybiel have suggested that in some instances the feeling of detachment from earth may become a problem, particularly where the crew has little to do.

Many similar problems are being encountered in the selection of submarine crews and in the selection of men to man radar and weather stations in the DEW line. These problems emphasize the need for what has come to be known as small group research such as that conducted on combat assignments by the Air Force Personnel and Training Research Center.

Perceptual problems involve the capacity to "visualize" space as a kinematic environment with objects moving about the vehicle. The operator "builds up the space picture" from various sources of information that will be available to him. This is related to the problems of human engineering.

Human engineering factors should be considered in the construction of the various devices and displays that the crew will use to control the vehicle and its internal environment as well as the various equipment the crew may be required to wear.

The displays and controls for a spaceship can be divided into the following groups: (1) ecological systems (mechanisms for controlling the internal environment of the crew compartment), (2) navigation displays and control systems, (3) communication systems displays and controls, (4) displays for showing altitude of the vehicle and propellant conditions and controls for changing the altitude of the vehicle, and (5) the amount of propellant used.

The displays of the ecological system can be specified rather simply: pressure gauges and temperature and humidity gauges. The displays will also show the condition of the equipment maintaining the environment.

If the conventional pressure, temperature, humidity and rpm indicators are used, it would be quite an undertaking for the pilot and co-pilot to monitor all these displays in addition to performing some of the other tasks of navigation, communciation and vehicle control. Obviously, there is need for a display system that will present much of this information in such form that the operator will not be required to integrate various sources of information. The many problems of this one aspect of space flight must be attacked immediately if solutions are to be available when the instruments for these spacecraft are designed.

In developing the navigation displays, the methods used for navigation must be considered. Conley[1] suggests what he calls "V.S.A.—very simple astrogation." In this system, he requires the crew of a spaceship to make calculations of the flight time on a trip to the moon and position the moon at the end of the time of flight, making allowances for the sun's gravity drift.

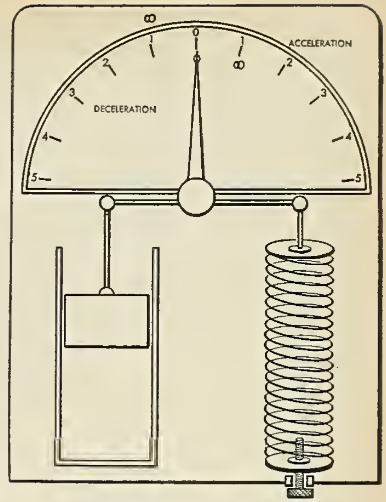
He then requires the pilot to aim the craft at this point. This procedure requires exact knowledge of the position of the craft and a representation of this position on an appropriate display. The design of such a display will require the scaling of the solar system's dimensions into meaningful displays within the aircraft's confines.

Since the available displays for navigation are somewhat unsatisfactory for high-speed high-altitude flight, much work will have to be done in order to develop displays that will be easily interpretable without the integration of information from other instruments. The ability and the ease with which the pilot will be able to "visualize" the space picture about him will depend on how much effort is put into the development of the display.

The problem of communication between the home base and the spaceship is one that must be considered. Clark in his book INTERPLANETARY FLIGHT indicates that it is possible to transmit speech to a spaceship 10 million kilometers away from earth with present-day equipment using a frequency of 3000 megacycles per second and an aerial of one square meter on the spaceship and 100 square meters at the earth's station.

The only problem would be the time lag due to the finite speed of the radio waves, since it takes 1.3 seconds for a signal to reach the moon from the earth. This problem might be circumvented by storing the complete message

[1] J. Space Flight, *Vol. 2, No. 2, 1950.*



Acceleration-deceleration meter.

before reading it out through a speaker system.

Other than the lag problem, the communication problems are no different than those that plague present voice communication systems. Increasing signal-to-noise ratio, cutting down interference and increasing the intelligibility of spoken messages are a few of the present-day problems that will be encountered in spacecraft communications unless solutions are obtained.

The foregoing paragraphs have not covered the problem of control of the space vehicle. Conley[2] has suggested an instrument that might be comparable to the combination of a gyro horizon and a heading indicator in conventional aircraft. Fig. 1 shows this instrument. It is aligned with the vertical axis of the vehicle. It is assumed that the pilot is seated on the same axis.

The instrument gives the angle of the ship to the vertical and to the horizontal as well as the direction of the spacecraft. He has also suggested a design for an acceleration-deceleration meter.[3] This instrument is shown in Fig. 2. He suggests that three of these instruments be mounted so that the sliding tube of the weight of one tube is aligned with each axis of the space vehicle.

The scale is so designed that on the earth's surface, gravity is unity or zero on the scale. If the spaceship were on the surface of the moon, the operator would require three meters to know what accelerations were acting on the ship and himself, plus additional meters for angular accelerations. This information is vital to his assuming a

[2] J. Space Flight, *Vol. 3, No. 3, 1951.*
[3] *Ibid.*

position that will minimize the effect of acceleration. He must have it in some form. With this projected system, he would be required to integrate this information—altitude, position and accelerations on the vehicle.

Conley's work indicates the difficulties that will face the pilot if the displays are attacked in piecemeal fashion. To get information about the performance of the vehicle, the pilot must read all three as well as the tilt meters. In order to control the vehicle, he must integrate all this information into some meaningful whole before he attempts some control action.

Since it is anticipated that the control of a space vehicle will be achieved by the use of rockets arranged about the vehicle, there will be non-continuous control of the vehicle. Current research indicates that with this kind of control, precise movement by a human operator is quite difficult. Research may be required to determine a method of integrating stepwise control so that it appears continuous or a method of obtaining continuous control of rockets through some kind of power control valve. This kind of control might necessitate a new approach to propellants.

While the ecological problems and physiological effects, including acceleration involved in space flight, are being studied, these problems related to the control and navigation of the space vehicle by a human operator have been neglected. Since requirements for the proper specifications for instrument design are so great, it would be desirable to have a continuous research project to obtain the necessary information.

This research should consider the problem of scaling the physical measurements and variables to the different methods by which the human operator can obtain information. Provision must be made for appropriate gain changing.

Consideration must be given to building computers that can be incorporated into the system with such read-out devices that the crew can achieve an optimum combination of information at any given time. Research should evolve the optimum combination. Provision must be made for automatic log keeping and read-out from this log.

This undertaking should provide the space crew with a set of displays that will minimize the problem of extracting all the information it needs. This information display should minimize control difficulties and the decisions the crew will have to make.

Without this effort, the information displays of the crew will be just "one more set of steam gauges." ★

New Air for Engineers

by **Joseph G. Logan, Jr.**

Cornell Aeronautical Laboratory, Inc.

IN THE PAST few years, the interest of aeronautical engineers has turned toward higher flight speeds and flight Mach numbers—up to 30,000 feet per second, about 30 times the speed of sound. In the regime between Mach numbers of six and 30, the "hypersonic" regime, the ideal gas concept of air must be abandoned. While this fact will be of principal import to the aeronautical engineer, its effects may extend even to the electronics engineer.

Air at room temperature is, of course, composed primarily of a mixture of oxygen and nitrogen molecules, about 21 per cent oxygen and 78 per cent nitrogen by volume. The remainder consists of small amounts of argon, water vapor, carbon dioxide, hydrogen, neon, krypton, and xenon. For the maximum temperatures encountered in the supersonic flight regime, engineers could regard the molecules of oxygen and nitrogen as rigid dumbbells. In this concept the molecular motions induced by collision were conflicted to translation and rotation. In the hypersonic regime the molecules of air have a much more complicated behavior (Fig. 1).

For example, the temperature behind a normal shock wave at a Mach number of six is about 1500°K (2240°F). As the temperature of the air gradually increases above this point, the molecules cease to behave as rigid dumbbells and begin to vibrate as a result of collisions. At Mach 10 flow the temperature behind a normal shock wave reaches 3000°K (4940°F) and the oxygen molecules begin to break up or dissociate. At these temperatures the molecules and atoms also begin to ionize and collisions between molecules result in the formation of nitric oxide. Similarly, at a flow Mach 17 temperatures reach about 6000°K (10,340°F) and nitrogen begins to dissociate.

The extent to which the composition of air varies with temperature is clarified in Fig. 2. It becomes apparent that, as a result of the breakdown of oxygen and nitrogen molecules at temperatures of about 6000°K, the air can contain as many as 10 different components. The introduction of these new components alters the thermodynamic properties of the air, and forces the aeronautical engineer to discard many of the rules he has lived by for so long.

Flow Phenomena Modified

Recently, calculations of the "new" thermodynamic state of the air at high temperatures, including the specific heat and the speed of sound, have been carried out at CAL. A large increase in specific heat occurs as a result of the new ways in which energy can be distributed in air at high temperatures (Fig. 3). The chart reveals that the specific heat at constant pressure can exceed the ideal gas value by factors of 12 at temperatures of 7000°K. In other words, it takes about 13 times as much energy to raise the temperature of a given mass of air one degree at 7000°K as at room temperatures. Engineers designing hypersonic shock facilities for operation in the 5500°K to 8000°K temperature range find this a real problem.

Another phenomenon observed is the decrease in the molecular weight of air as a result of the increase in the number of particles at high temperatures. The equation of state must therefore be modified to include the molecular weight as a parameter. Normal shock calculations must also be modified to reflect the altered relations between pressure, temperature and density. Accurate knowledge of the state of the air behind shock waves thus becomes indispensable to the engineer making aerodynamic flight calculations.

Effects of Real Gas Behavior

The changes in those properties of air referred to as real gas effects may considerably alter the equilibrium phenomena in the flow field outside the boundary layer. The first marked effect of the real gas behavior on aerodynamic phenomena is observed in the temperature obtained behind normal shock waves, as, for example, at the stagnation point on a blunt body. Since the amount of energy required to increase the temperature of air depends on the number of ways in which the energy can be distributed among the air components, the introduction of any new degree of freedom requires that more energy be supplied in order to achieve a given temperature rise.

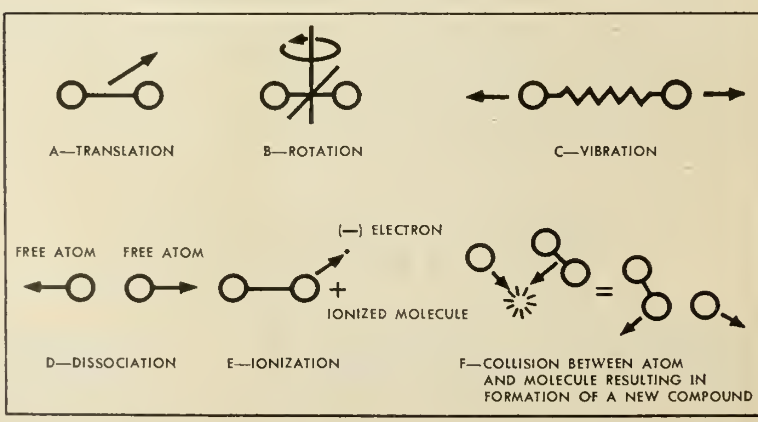


Fig. 1. The molecules of air in the hypersonic regime have a more complicated behavior.

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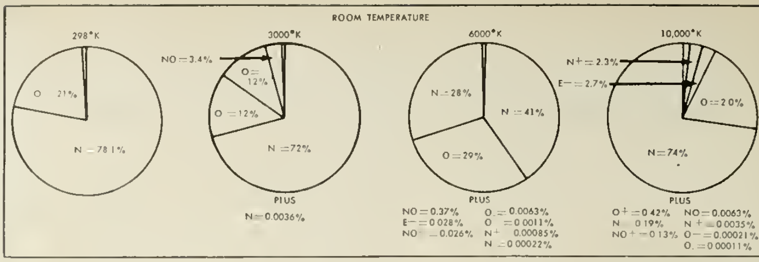


Fig. 2. Composition of high-temperature air (Density = one atmosphere).

Conversely, if there is a large number of ways in which the energy can be distributed, the gas temperature that can be obtained for a fixed amount of energy is always less in the real gas than in the ideal gas.

Consequently, the actual stagnation temperatures achieved behind normal shock waves is much lower than the temperature which would be calculated assuming that the air behaves as an ideal gas with a specific heat ratio of 1.4. The results shown are based on the assumption that thermodynamic equilibrium is achieved behind the normal shock waves; that is, that sufficient collisions have occurred so that subsequent collisions do not alter the thermodynamic state.

Another important difference between high temperature and low temperature flows at a given Mach number is in the shock angle on a wedge (Fig. 4). This is important because measurements of attached shock angles are commonly employed in determining Mach numbers in wind tunnels. At a given Mach number large differences in shock angle can result from the thermodynamic changes occurring in high temperature air. The difference is most striking for the wedge angle for which the oblique shock just detaches from a wedge. For real gas flows at high temperatures the oblique shock wave can remain attached for much greater wedge angles.

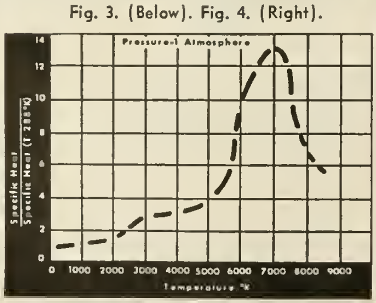
Lift and Drag Complications

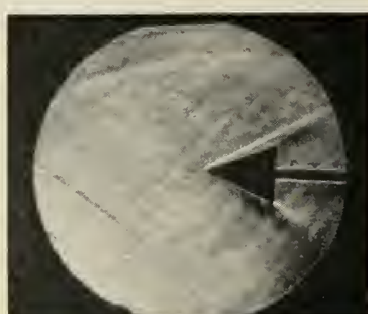
In two-dimensional steady flow expansions (known as Prandtl-Meyer flow), the actual flow Mach number increase across an expansion zone is smaller than would be calculated assuming ideal gas behavior. Fig. 5 shows that for supersonic flow expanding around a 20 degree corner the expansion zone is thinner, and the final Mach number is smaller than those obtained assuming ideal gas conditions. Since the pressure distribution over aerodynamic bodies is related to the flow Mach number, it can be expected that calculation based on ideal gas flow for pressure distributions over bodies will be inaccurate in high temperature flow fields.

As a final typical example, consider the effect of the real gas on the design of hypersonic test facilities. In the design of nozzles to obtain high flow Mach numbers, the nozzle ratio required in a real gas is much greater than the one calculated assuming an ideal gas.

The interpretation of data obtained in such facilities also is largely dependent on accurate calculation of tunnel flow conditions, since, as yet, the problem of measurement of temperatures and pressures in short-duration, high-temperature, low-density flows has not been entirely solved. However, before data obtained in these facilities can be reliably applied to full-scale bodies, it is necessary to learn much more about the air and its properties. One of the important problems being investigated at CAL deals with the actual state of the air in hypersonic shock tunnels. It has been assumed up to this point that the air in the high-

Fig. 3. (Below). Fig. 4. (Right).





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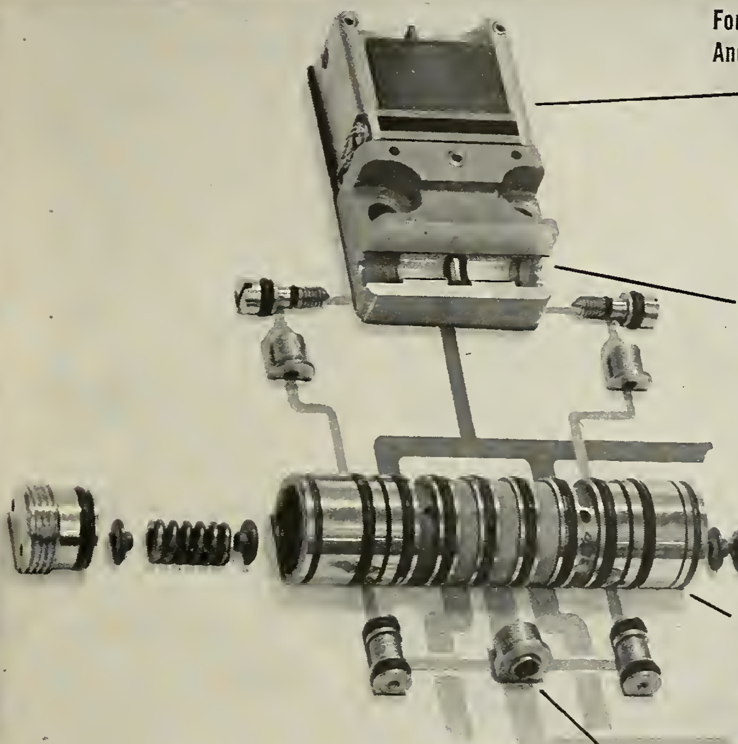

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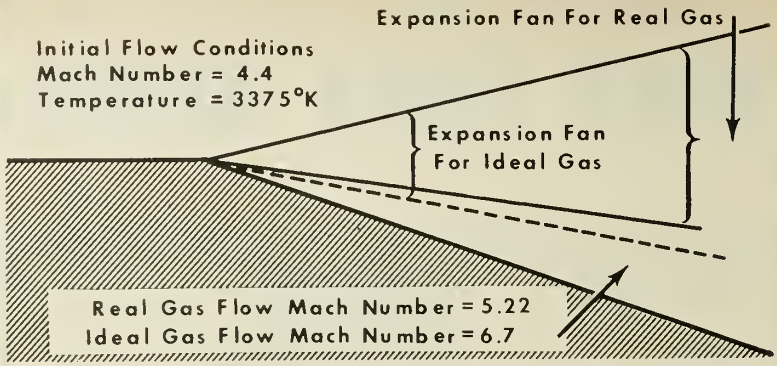


Fig. 5. Supersonic flow expanding around a 20 degree corner.

temperature region has attained the aforementioned state of thermodynamic equilibrium. Each of the forms of excitation shown in Fig. 1—translation, rotation, vibration, etc.—requires a certain number of collisions between air particles in order to reach the equilibrium state. A finite time, known as the characteristic relaxation time, is therefore required for equilibrium to be achieved.

Hypersonic nozzles must be designed so that temperature changes do not occur so rapidly that the thermodynamic state lacks sufficient time to adjust to the altered temperature conditions. Knowledge of the relaxations for the different processes are being carried out at CAL and other laboratories. Initial studies have indicated that it may be necessary to consider the relaxation time in the design of nozzles so as to insure that thermodynamic equilibrium is maintained in regions of rapid expansion.

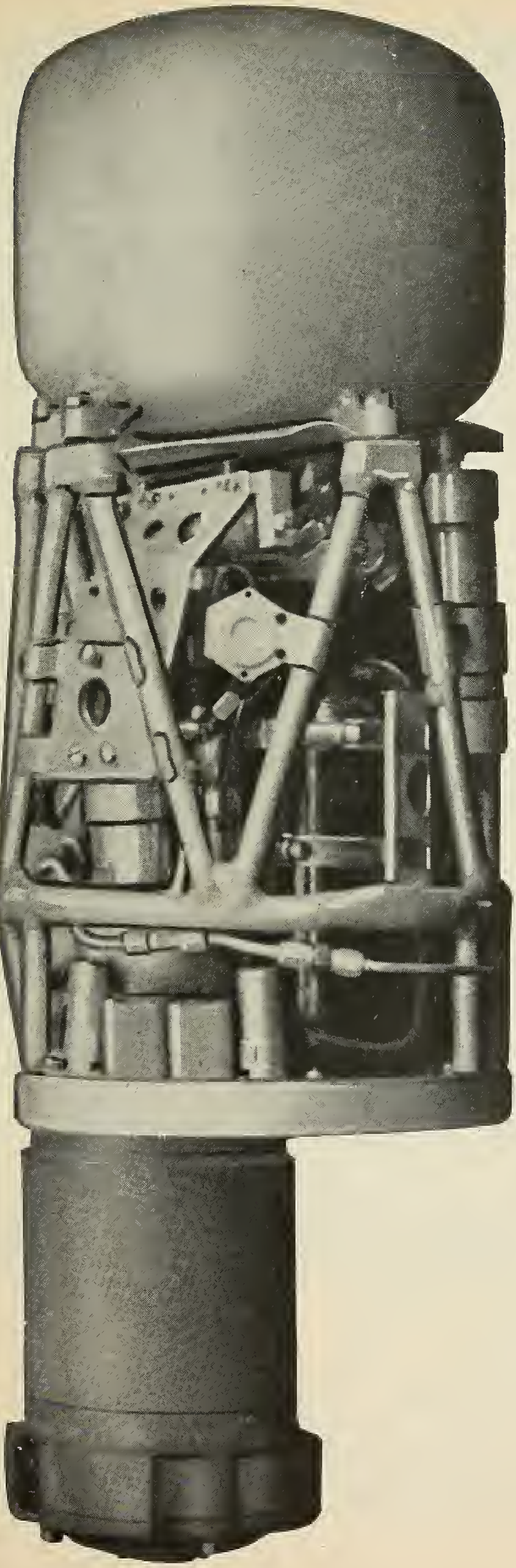
More Answers Needed

Interest in the problems introduced by the high temperature phenomena has triggered many new fields of research. As an example, this interest has led to studies of the kinetics of nitric oxide formation and has stimulated the development of a special shock tube for the study of chemical reactions at high temperatures.

Only a few of the many new problems introduced by the high temperature air phenomena have been discussed here. There are many others—for instance, the heating produced by radiation behind a shock wave may have important effects at high flight Mach numbers. Such problems are now being investigated in special shock tube facilities at CAL. There is also a sufficient number of free electrons present in air at temperatures above 3000°K (or above a Mach number of 10) so that the conductivity of the air is high. This high conductivity may pose serious communication problems. Further, it is to be expected that the real gas effects may modify the boundary layer and heat transfer phenomena. For example, above 3000°K the air contains many dissociated particles and if these particles diffuse across the streamlines and recombine at the wall, the surface heating may be increased above that obtained without diffusion.

Consequently, aeronautical engineers are on the threshold of designing aircraft and missiles to fly through an entirely different medium—a medium whose ramifications are just beginning to be recognized and whose characteristics have been only sketchily explored. We call this medium a new air for engineers.★

Fig. 6. Flow over a sphere in a hypersonic shock tunnel.



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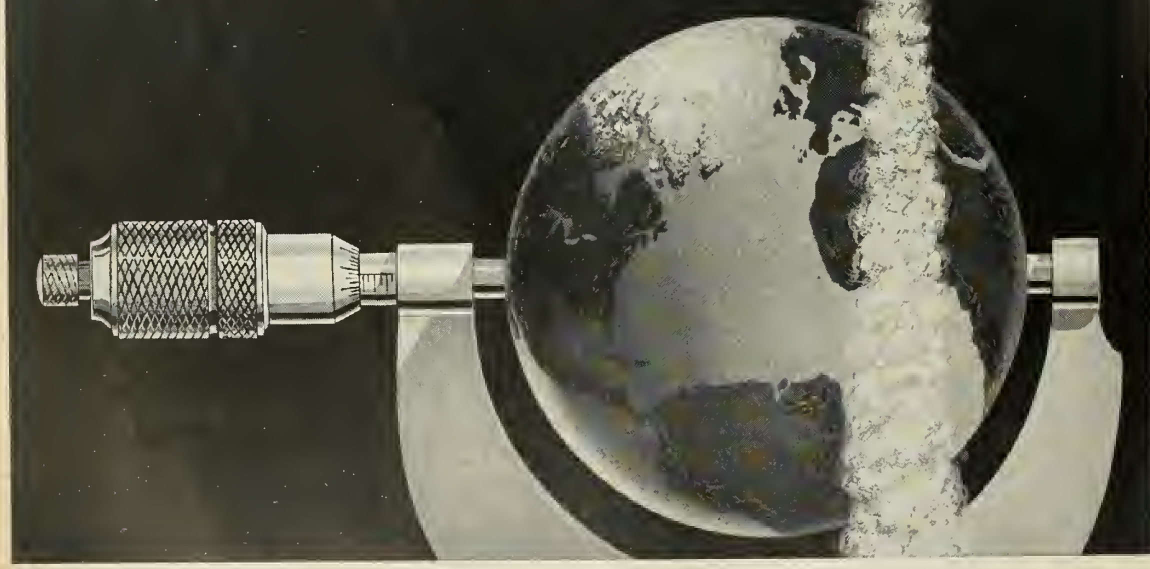


Human Engineering for Space Vehicles

New field of engineering for astronautics era

By Cmdr. George W. Hoover
Office of Naval Research

IN THE PAST human engineering has played the role of patcher-upper and ex-post-facto adviser—an aeronautical Mr. Anthony. Today it is playing a very definite part in the design of modern aircraft and spacecraft. Component manufacturers as well as airframe builders are retaining human engineers on their staff or in a consultant capacity. The human element is at last being taken into account in machine design.

Tomorrow, with the coming of the spaceship the human engineer must move up to take his place in the design team, because space flight cannot be achieved unless maximum integration is effected between man and machine. Effecting this integration is the human engineer's job.

Human engineering, however, cannot play its part in achieving space flight unless it is fully accepted by all members of the design team. Some engineers have refused to recognize this new field and in some cases have been well justified. Like every new science, human engineering has had and is still having "growing pains."

Common Language Needed

Perhaps the most important reason for this nonacceptance is due to a language problem. Most human engineers are psychologists by training and have had to draw from the vocabulary of that field to create new terminology to communicate the results of their findings. This was necessary because they were working in new areas where such things as "JND" (just noticeable difference) and "learning curve" (the rate of operational improvement in a given task) had no equivalent in engineering vocabulary.

This, however, certainly follows the pattern of other fields—the continuous misunderstanding between engineers and physicists, electrical engineers and electronic engineers, and even physicists and nuclear physicists. There is always a period when the language of a new art or science is being rephrased in terms of an old one.

But in the space flight problem, the language required is new to all engineers, physicists and human engineers alike, and so the members of the team must seek a common language in order to be able to interpret their mutual problems.

In the design of aircraft, until very recently, engineers as a rule could expect the pilot to meet the control requirements generated by the machine. At the present time these same engineers are facing much more complicated problems because the machine is forcing the pilot to extend his capabilities to the limit.

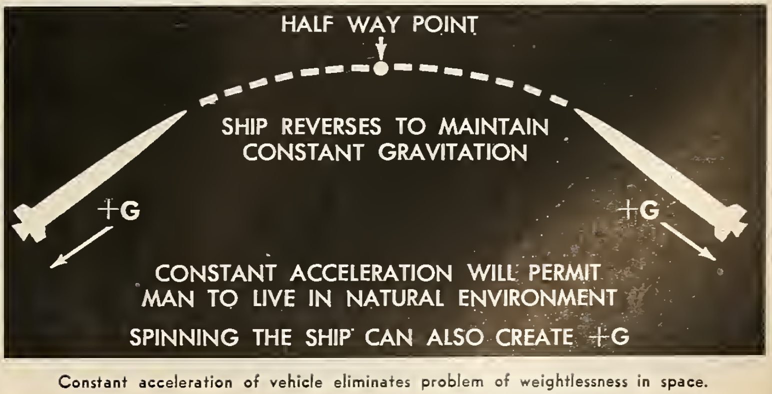
High altitude has forced the pilot to use oxygen equipment and pressure suits. High performance has brought about the need for anti-g suits. All of these require considerable training and demand that pilots be in extremely good physical condition. In the design of the spaceship the engineer will be forced to invite the aid of the human engineer because the machine's capabilities, by its very nature, will be far beyond the pilot's capability or physical limitation.

The spaceship will call for protection against extreme g loadings on the pilot due to the high thrusts which the ship may have to utilize. It will be necessary to protect against zero outside pressure in the event of loss of cabin pressure.

Because of the altitude the pilot must also be protected from cosmic and ultraviolet radiation, meteorite hits, intermittent weightlessness, and many other conditions abnormal to his ordinary pattern of living, all requiring definite procedures with no allowance for error. In space flight, just as in a submarine, there can be no mistakes, —but even more so, because the return to earth of a spaceship is more complicated than the return to the surface of the ocean by a submarine.

Man-Machine Interdependence

In space flight there must be as complete reliability as possible of both



Constant acceleration of vehicle eliminates problem of weightlessness in space.

man and machine. Both will be taxed to extreme limits.

If the spaceship is to operate successfully it cannot be designed by past conventional methods. Such methods might entail compromises of the total system which put an increased burden on either the man or the machine; and from past experience such burdens will undoubtedly be placed on the man.

In order to avoid any such compromise, the spaceship cannot be designed until a complete analysis of the problem is made and answers are found to such questions as these: What will man need to orient himself in space? How does man operate most efficiently under positive and negative g? What does man need to protect himself against extreme temperatures? Complete understanding is required of how man functions most effectively. Such an analysis can only be achieved by the joint efforts of engineers, physicists, human engineers and physiologists working as a team.

Human engineering is much more fundamental than experimental psychology and requires a thorough understanding of the way in which a man functions in order to determine his requirements when operating with a machine in a closed loop. Here the human engineer cannot accept what appears to be a reasonable answer, but must determine precisely what the man needs to operate efficiently and relay these requirements to the engineer.

Predesign Planning Vital

Generally, human engineers have been called into the design problem after the equipment has been designed and found to need improvement. They should be active in the establishment of the design requirements in order to insure compatability with the functions of the operator.

For example, the development of the space suit should have utilized the first signs of its need became apparent. services of human engineers when the Instead of this, the engineers were forced to design a suit to meet only the immediate problem with only partially adequate results.

The real task was to define the problem of how to create a proper environment to meet all conditions—not to attempt to solve it by designing a suit. A suit is only *one* way to create an environment, but unfortunately it does not meet total requirements, one of which is comfort.

Problems of space flight must be approached properly in order that mistakes which may prove fatal will not be made. Human engineers must be brought into the team at the beginning in order to insure that equipment will be designed to meet the crew's requirements.

Take the problem of weightlessness. A great deal has been written on this subject and many schemes have been devised to study means by which it would be possible for man to live in this environment. Many writers have pointed out the problems involved—eating and drinking, sleeping, working. They have pointed out the necessity for physiological as well as psychological studies to determine what will be required in the way of equipment and training for crews of spaceships.

Weightlessness comes about when the ship stops accelerating and coasts, or during extreme changes in thrust. There is no requirement for zero acceleration other than that based on present day rocket capability which, by no stretch of the imagination, will be sufficient to permit manned space flight.

Man's requirements necessitate his living in a gravity system. This calls for a vehicle which will be in a constant state of acceleration or deceleration, not one which will force man to live in an environment to which he is unaccustomed. The only problem will be during changes in amount or direction of thrust.

Is it better to accept a system

which creates an entire family of new problems, or to design a system which eliminates the problem? A man cannot be changed—the system can be.

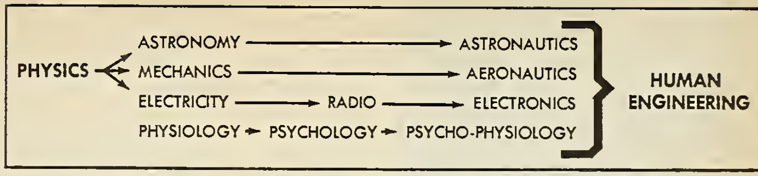
Engineers will state that even by extrapolating the state of the art to some future time, there is no foreseen propulsion method which can give constant acceleration during space flight. This will have to be found. Just as important as the requirement for temperature-resistant material for re-entry, just as important as the need for maximum thrust, is the fact that man cannot change his way of living. This is a man-machine system and the man is just as important as the machine.

Human engineering must be used and emphasized if manned space flight is to become a reality. With human engineering the focus changes—from how much radiation a man can take, to how protect him against any radiation; from how much sudden acceleration he can take, to how to propel the ship within the pilot's normal limits; from how much temperature a man can stand, to how to maintain a tolerable temperature.

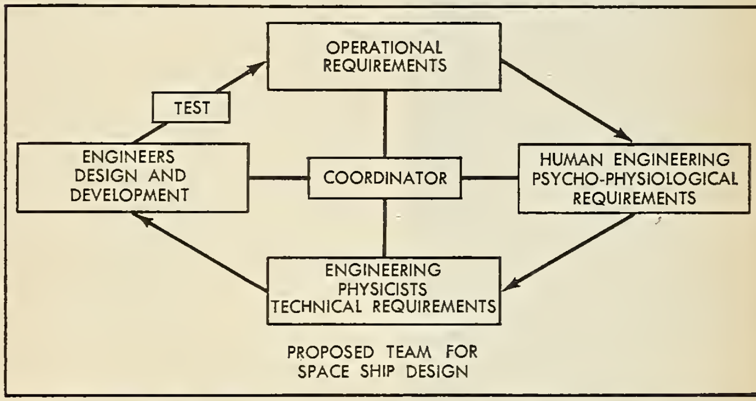
Up to now pilots and crews have had to be given special training and equipment and have had to adjust themselves to the deficiencies of inadequate machine design. In the spaceship this is not acceptable.

Space flight is not something mysterious or impossible. It is just another advanced step requiring an efficient man-machine system. It must be faced squarely, and this can only be done with human engineers working as a team with the design engineers.★

Opinions are those of the author. They do not necessarily reflect the views of the Navy Department.



"Family tree" of human engineering springs from many scientific fields.



Organizational chart shows the interdependence of all phases of design problems.

Rocket Sled Experiments

By Alfred Zaehringer

ROCKET SLED testing has become a vital part of our missile programs. Aerodynamics, propulsion, structures and even human factors are being evaluated in this economical, captive and recoverable method. There are now five major rocket tracks in the United States and four smaller facilities. The big tracks and lengths are:

1) SNORT, China Lake, 21,500 ft.
2) Baker 4, China Lake, 14,000 ft.
3) Edwards AFB, 10,000 ft., expansion to 20,000 ft.
4) Holloman AFB, expansion to 35,000 ft.
5) SMART, Hurricane Mesa, Utah, 12,000 ft.

Smaller tracks are located at Eglin AFB; Aberdeen Proving Ground, Aberdeen, Md.; Naval Proving Ground, Dahlgren, Va.; and Redstone Arsenal, Huntsville, Ala.

Tracks Busy

There is a great backlog of work stacked up for every track. Speed records for these tracks have constantly edged up to keep up with the ever increasing speed of aircraft and missiles. The Coleman track, for example, qualifies at Mach 2 (1500 mph at track elevations) but recently SMART had an 1800-mph run. This high-speed SMART run was made with a 9400-pound vehicle which went off the track, over the end of the 1500-foot high Hurricane Mesa, and some one and a half miles into the valley below.

The highest speed attained to date is believed to be the 2180 mph attained by SNORT on a single rail sled with recovery at the end of the run. In a two rail run on SNORT, 1705 mph was attained. Holloman engineers believe that when their 35,000-foot track is completed, it may have Mach 4 capabilities for aircraft and missile testing. Edwards will have its 20,000-foot track finished in about a year. It is designed for Mach 4.

Grading on the Edwards site has been completed and digging and pouring the concrete foundation should start soon. The distinguishing feature

Left—Hurricane Sam flails wildly during an ejection sequence. Sled has just entered water brake and is about to hit arresting gear. Below—Aerial view of SMART facility at Hurricane Mesa, Utah. Breech end is at top. Test specimen hurtles over 1,500 ft. cliff at lower left. Track is 12,000 ft. long.

of the Coleman track, the 1500-foot cliff at the "muzzle" end, will keep SMART in the business of testing human escape techniques, essential in high-speed jet and rocket aircraft.

Survival Tests

The escape problem for high-speed aircraft still remains critical. Above supersonic speeds, only 20 per cent of the pilots can expect to survive during an emergency ejection. With increasing speeds and altitudes, the trend appears to be heading toward pods or capsules which will insure safety at ultra-altitude operations. Capsules eliminate the effect of air blast and also obviate the need for special suits and survival gear.

An ever increasing track function, on the other hand, is to test nose cones of ballistic missiles. It has been said that the major function of the longer tracks is to simulate heating problems of full-scale, nuclear warheads for the IRBM and ICBM.

Hot Slippers

One of the major problems associated with the present slipper-type sleds is friction. These shoes have to clamp over the rails to keep the vehicle captive at all times. Since vehicle weights are not very high and since the fast speeds mean only transient contact, present rails suffer only small wear at speeds of 500 to 600 mph. However, vehicle weights have been going up: full-sized escape systems, then entire cockpit sections.

Missile nose cones and warheads have also grown. Therefore, hot slippers are becoming a problem. Stainless steel has been successful here but increasing attention is being paid to the ceramics, ceramets and ceramals. There is also the hydrodynamic approach, which would eliminate any solid contact surfaces.

Solid versus Liquid

The old question of rocket propulsion systems—solid versus liquid—again cropped up. It was agreed that for sled propulsion the following conditions have to be satisfied: (1) performance, (2) economy, and (3) reliability. At present, solids are widely used because of their high utility. Solid motors often give the highest thrust per given cross-sectional area. This is especially important in track work, and therefore solid motors have become workhorses at most tracks. Everybody, too, is likely to agree that solids are much more reliable than liquids. However, economy, especially for high thrusts and repeated operations at these high thrusts, may dictate going to liquids.

It would be more economical, for example, to couple 10 18,000-pound solid RATO motors for a few runs than to develop an 180,000-pound-thrust liquid motor (or two 90,000-pound engines). But, if you have a hundred or a thousand tests at 180,000 pounds, it may pay to develop a liquid engine. The Coleman track, because of its remote site, has heretofore operated exclusively on solids, but has just taken delivery on two Aerojet acid engines of about 50,000-pounds thrust.

As one track man put it, solid motors make nice modular units and allow great flexibility in arriving at almost any thrust level. Too, solid motors, having been loaded at the factory, are time and personnel savers, letting the track concentrate on the testing.

The SMART track has used six different solid units with great success. Coleman has a stockpile of now-obsolete *Loki* rockets for smaller vehicles. HVARs have also been used. Two of the most commonly used units are the 2.2KS-11,000 and 5KS-4500 RATOs. Two of the larger units are the T-50 booster and the 224-B made by Hercules Powder Co. ★

Propulsion Engineering

By Alfred J. Zaehringer

ROCKETS VERSUS BALLOONS. Performance of both vehicles is surprisingly similar, according to High Altitude Test Division at Holloman. The balloon has lifted 1300 pounds 76,000 feet high (98.7×10^6 ft/lb) while an *Aerobee* has lifted 154 pounds some 119 miles (97.0×10^6 ft/lb).

BURNING RATE OF NITRIC ACID PROPELLANTS has been studied at USNOTS, China Lake, Calif. With 2-nitropropane and 90-100% HNO_3, small changes in acid concentration (near 100%) cause large changes in consumption. This "low pressure step" is said to be related to the surface temperature of the burning liquid. Turbulent combustion is related to acid concentration and the number of carbon atoms in the fuel.

NEW PERCHLORATE. Nitrosyl perchlorate, $NOClO_4$, has been found to be quite stable in the anhydrous state. However, research in progress at the University of Amsterdam shows that the compound can be exploded by ultraviolet radiation.

BORON FUEL RESUMÉ. After 11 years of research, NACA finds that general combustion performance of the hydrides is good. Handling and storage are problems but not impossible to solve. Big problem is the formation of boric oxide on combustion. At 1000-2000°F B_2O_3 is a solid, but in the 2000-4000°F range it is a messy, syrupy liquid that clogs up hardware. This crudding is especially bad in turbojets, which may restrict it to special engines or to afterburners. However, NACA has successfully flown a pentaborane-powered ramjet. On the other hand, the Lewis Lab is disappointed in its results with metallic boron-jet fuel slurries: high combustion efficiencies could not be achieved at high-altitude conditions.

HOKO CONCENTRATED NITRIC ACID PROCESS is now being introduced to the United States. The Pintsch-Bamag process produces the 98-99% pure acid directly and can also produce nitrogen tetroxide, nitric oxide, RFNA or any concentration of nitric acid. Raw materials for 100 tons/day of 98-99% acid are 29 tons of anhydrous ammonia and 17 tons of oxygen.

LITHIUM DEUTERIDE may be under study as a fusion rocket propellant. Small amounts fed into a combustion temperature heated to 4000-7000°F would generate large amounts of heat which could be used to expand the helium gas exhaust product. Nine grams of LiD would liberate 4.3×10^{20} ergs. However, two of the big problems are diluting the stream to keep down temperatures and yet maintaining a self-sustaining reaction and adjustment of the proper feed rate.

METALS FOR ROCKETS. Satisfactory oxidation resistance for molybdenum still hasn't been attained. Tungsten might provide another 300-500°F increase but its oxidation resistance is also poor. Columbium may, however, provide another temperature increase.

Ultimate Weapon: The Mind of Man

By Tom Wilcox
Air Force Office of Scientific Research

THE SIZE, force and shock action of a military machine are formless, useless capabilities without the supreme motivation, guidance and intuitive genius of the mind of man. In the military affairs of our nation, as in all other endeavor, the study of science alone—without a clear understanding of the implications of its findings—can result in the enervation of man's progress. The finding of a principle or a thing is no more important than the recognition of its implications.

The Air Force Office of Scientific Research, Air Research and Development Command, provides a mechanism for daily translation of this philosophy from words into action. Scanning constantly all areas of industrial and scientific research, it seeks, finds and supports investigations which help to keep the Air Force in a position of technical and strategic superiority.

It has been said that the Air Force scientist is working the aviator out of a job; that research and development effort leads inevitably to only two possible conclusions: the removal of man from the aircraft and the development of the ultimate in destruction.

The first of these statements is neither inevitable nor desirable; the second is only partially correct. If it were true that science is taking the pilot out of the combat picture, we should view this as tragic and dangerous.

For science to serve the ultimate ends of the military mission, it must insure that the mind of man will, in some way, influence and control every weapon system we create.

To subordinate the intellect of a military commander to a synthetic complex of electronic gadgetry would be to deprive that commander of the imaginative and intuitive genius which has always led to victory in battle. Engineers and technicians can produce many types of computers which will rapidly calculate the most complex mathematical problems. They can provide them in many shapes and sizes. They can place them on the ground or fly them. With them, we can control speeds and altitudes. We can use them to navigate and to drop bombs or fire missiles and bullets.

But computers are unemotional. They cannot think. They do not reason. They need no food, or any stimulus other than the power which feeds their circuitry. They cannot be motivated to performance beyond that which has been punched into them, nor can they be trained to take advantage of an unforeseen circumstance or to change course in the light of unpredictable conditions. In short, they are nothing more than morons—and *wars are not won by morons.*

The history of warfare has been compared to a balance. The evolution, development and employment of new weapons tip the scale forcibly toward the side which has evolved the new concept. However, each new measure stimulates countermeasures which, if effective, balance the scale. To weight the balance to his own advantage the commander must do two things: first, he must employ his forces so imaginatively that, despite the equality and strength of his force and that of the counterforce, the imaginative commander quickly and successfully achieves his objective while the countermeasures result only in striking at phantoms.

The second factor for successful command is the ability to recognize and use the full capability of one's own resources. The creation of imaginative concepts of warfare and the recognition of our full capability are the mission of the Air Force Office of Scientific Research, and its unique contribution to the United States Air Force. Weapons which we are evolving today came from recognition of scientific discoveries of the more or less recent past.

Recognition of decades of exploratory research by inspired mathematicians and physicists led to our World War II Manhattan Project. This gave us the first use of atomic energy in war and, in turn, our present nuclear fission weapon systems and industry.

Germany's work on the V-2 rocket stemmed from military recognition of the early exploratory efforts of a small group of pioneer rocket experts.

The Air Force Office of Scientific Research role in support of basic research is unique. The Air Research and Development Command has 12 major activities concerned with developing and testing weapon systems and supporting research aimed at solving the problems of weapon development.

AFOSR builds no missiles, no rockets, no aircraft. Its program is concerned entirely with sponsoring the most basic exploratory work. The AFOSR program is designed to serve as a focal point within the Command for contact with university and industrial scientific research groups in all parts of the free world.

By communication and support of these scientists, AFOSR encourages them to bring to its attention entirely new concepts and capabilities. Some of these new concepts will eventually result in forming a basis for the development of new weapon systems and concepts for their employment.

AFOSR does no actual laboratory work within its own organization. It serves as a vantage point for scanning all scientific areas and supports by contractual means those which offer the greatest promise.

Some of its programs might seem far removed from military application. For example, AFOSR might investigate the magic substance chlorophyl, the chemical which, by photosynthesis, converts the carbon dioxide in the atmosphere to life-giving oxygen. This may have important future military application.

A future spaceship may depend on a closed environment to sustain life. With present techniques we would have to carry large quantities of oxygen and equipment in order to breathe. The quantities required, of course, would be governed by the time we kept the craft aloft. So it becomes obvious that an ability to regenerate our enclosed atmosphere would have a direct bearing on range and altitude. In aerial warfare these are essential factors of tactics and strategy and may actually determine whether we will be victorious or vanquished in some future war.

The Air Force search for scientific implications might be likened to a ground-force commander's study of terrain seeking to find the vantage points of high ground and maneuver area. AFOSR and its mechanism represent the Air Force's search for the high ground and maneuver areas in science. We must have this capability. Our potential enemy has it and backs it with resources far more extensively than we do.

Certain fields of investigation receive financial support which is no more than that required to buy two or three ordinary military trucks. The results of any one of these programs may save us millions in lives and dollars.

Research and development in the basic technical fields are among the most important investments being made to insure a safe, bright and prosperous future.

We cannot insure this future unless our support is sufficient for the task at hand—the job of searching, recognizing and supporting all scientific areas of military interest.

The need for resources is high. To exploit all areas properly, the support of exploratory research must be augmented.

A current need is for leaders of the financial and industrial world to join forces with the military in a strong partnership for support of scientific research aimed at providing the strongest, fastest, highest Air Force in the world.

We need to go higher and faster. There is a future requirement for a satellite or a platform in space. The pages of history are filled with the names of commanders who were beaten in battle by rocks, spears, arrows or shells hurled from heights they had considered impossible to scale. To scale the heights of science requires no less measure of courage, imagination and tenacity.

These two things we know: our fight for a dominant technological position must continue in full force; and we must not negate the judgment of man if we are to succeed.

We can send into space a platform for observation. We could instrument this platform to relay to us a great deal of information. But, no matter how fully we equipped it, we could still miss the basic ingredient of useful surveillance: the instant and meaningful interpretation of important data and the ability to initiate prompt action of a command nature.

Soon after man started to use the airplane as a combat observation post, someone tried to shoot it down. In short order, two men were aloft and shooting at each other. Thus evolved a completely new military dimension.

We are on the point of introducing another new military dimension as important and revolutionary as aerial warfare was a generation ago. Manned space flight and observations are within the foreseeable future, and it seems clear now that there will be uses far beyond observation. It also seems clear that, if we should put a device in a predictable orbit, it would be only a matter of time before someone tried to shoot it down. The optimum weapons system still must be guided by the unpredictable and random output of a man's imagination.

If we would insure technical victory in the present race for survival, we must mobilize all the human imagination and ingenuity in our entire storehouse of science. We must apply our findings to a complex of weapon systems in a manner which insures that they are only the useful servants of a commander, not his master. We must evolve weapons which can be employed in the unpredictable pattern of the human mind, rather than the cold, set logic of a machine. In the final analysis, it is the proper combination of man and weapons that wins wars—cold or hot.

By careful recognition and employment of our scientific input, we can insure that the order of battle will be the influence which directs the weapon. We must not build ourselves an arsenal which will direct or influence the order of battle. Much of our current effort is directed to the building of missiles. They currently deserve top priority. We must have the best possible as soon as we can.

It would be dangerous, however, to think of the missile as the ultimate end of weapon development. Countermeasures to stop missiles and means of detecting them will surely follow. We must accomplish two things: we must build missiles and missile countermeasures and, at the same time, strive for new concepts which will take their place when enemy countermeasures reduce their effectiveness.

We cannot safely assume that simply placing bigger bombs on predetermined targets will insure the final victory, or that a fixed or static defense machanism can stop the forces of an imaginative enemy. Such assumptions can well lose us a war, the nation, the American way of life.

The great strength of American arms has historically been augmented by the quick, imaginative flexibility of its manpower, from general to private. In the process of scanning our world of science, and developing and employing our arms, let us always remember a brief pasage by the contemporary author, John Steinbeck: "Our species is the only creative species, and it has only one creative instrument—the individual mind and spirit of a man. ★

The views expressed in this article are the author's and do not necessarily reflect those of the U.S. Air Force.

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Nutrition in Space Flight

By Dr. Carsbie C. Adams
National Research and Development Corp.

ONE OF THE BIGGEST problems of space flight is nutrition. How is the crew adequately fed over a long period with the extreme limitations of space? How is nutrition affected by pressure, zero gravity, radiation and the inevitable psychological reorientation?

Studies to date indicate that there are no serious obstacles to nutrition in space if the individual is in good health. Digestion should not be adversely affected if the ambient pressure is not so low as to produce a physical and nervous strain to the body generally.

The matter of spaceship cabin pressure raises the question as to how great a compromise can be made with sea level conditions for long-duration exposure.

There are reports that the feasibility of zero gravity has been established. This would seem to solve the major problems of orientation as related to nutrition.

Since the exact nature of cosmic rays' origin, density and composition have not been completely established, we can only speculate on certain close similarities to conventional atomic radioactivity. One is left with the supposition that a sufficiently strong cosmic flux will induce anemia and possible leukemia. The latter disease would be quite beyond the restorative powers of nutrition.

Pressure

There has been no direct evidence of a relation between nutrition and pressure except from the view of dietary results where food has apparently been consumed in normal ambient conditions and prior to flight. However, the WADC Report 55-353 reveals some potentially useful information: a high carbohydrate meal before ascent (15,-000-17,000 feet) increased both altitude tolerance (by 1000 feet) and psychomoter performance (by 2000 feet).

Adult male rats on a vitamin B_1-deficient diet for two months showed a greater resistance to lowered barometric pressure (34,000 feet) which was decreased to normal in one to three hours after supplemental thiamine feeding. However, a two-to-five month subminimal-thiamine diet seems to have no effect on man's altitude tolerance.

There is a more rapid loss of alcohol from the blood at 12,500 to 16,000 feet than at ground level. The most rapid loss of body water from adult rats at 15,000 feet occurs during the first eight hours of altitude exposure.

For the first 48 hours thyroid activity of unacclimatized rats is noticeably decreased at 11,500 feet and is accompanied by a sharp drop in rectal temperature for the first 12 hours of exposure. Thiouracil (anti-thyroid substance) taken for from four to 35 days does not affect the altitude tolerance of man at 32,500 feet.

Daily three-hour exposures to a simulated 12,000-foot altitude produced no significant change in appetite, gastrointestinal absorption, adrenal cortical function, sodium and chloride balance, urine volume or ketosteroid excretion.

The respiratory rate of an experienced pilot in action is directly related to the complexity of a given task.

Cabin pressure in a spaceship may not be equivalent to that in terrestrial craft. A typical airline cabin is set for 8000 feet pressure equivalent, just below the altitude for physiological effects.

Experience may reveal that tolerable pressure drop is an inverse function of duration.

Appetite may be influenced by mood. It has been demonstrated that eight hours at 10,000 feet induces "boredom, incoordination and headache."

Elimination at tolerable pressure reductions would either be unaffected or slightly aided. The body as a whole will eventually assume the pressure of the environment and thereafter the effect of pressure on elimination one way or another is negligible or zero.

Ingestion should not be adversely affected at any pressure which the unprotected body can endure. The pressure at which water would erupt (boil) at ambient temperature would kill the body by explosive decompression.

Susceptibility to anoxia (17,000 feet for two hours) may be reduced by a high-carbohydrate diet prior to ascent. Administration of glucose did not alter the susceptibility of rats to the acute effects of anoxic anoxia (4.5-5.6 per cent O_2). Glucose ingestion 30-50 minutes before flight prolongs consciousness time with high-altitude anoxia (27,000-30,000 feet).

The ingestion of 50 grams of glucose one half hour prior to altitude (12,700-17,200 feet) ascent decreased the intensity thresholds for vision at those altitudes. This is attributed to the elevated blood sugar. Cortico-retinal function (peripheral vision) and psychomotor function (block placement) tests indicate that significant gains in altitude tolerance (15,000-17,000 feet) can be achieved by ingesting high-carbohydrate foods before and during flight. With partial inanition, there is also an increased hypoxia tolerance due to lowered oxygen requirements.

Nicotinic acid increased the minimum survival altitude for rats by 4525 feet. Vitamin C does not affect consciousness duration in man at 27,-000 to 30,000 feet. Oral vitamin E increases anoxic anoxia survival time in adult rats; mitigation occurs if the diet contains more than 12 per cent fat. Vitamin E similarly affects the rabbit. Iron supplementation in rats does not increase hypoxia tolerance at 20,-000 feet.

No direct connection between appetite and oxygen has been found. Any deviation from normal sea level oxygen content in space would tend to be in the direction of hypoxia. Use of 100 per cent oxygen, except in case of emergency, would be an extravagance. The reduction of body temperature, associated with hypoxia, may demand or create the imaginary requirement for additional food, disregarding the influence of the lesser exertions of free-fall, if present. It may be expected that a modeate hypoxia of sufficient duration could be psychologically depressing and would adversely affect the appetite.

No connection between oxygen content of the cabin breathing mixture and the processes of ingestion, digestion, and elimination have been encountered in current literature.

Zero Gravity

Work is now in progress on the relationship between nutrition and zero gravity. One aviation magazine confirmed that "experiments related to the space travel regime have established the feasibility of eating and drinking during a condition of weightlessness. The studies, conducted by the School of Aviation Medicine, Randolph AFB, Texas, employed a Lockheed F-940 following a parabolic flight path that afforded interludes of weightlessness as high as 45 seconds."

Earlier reports which considered the possibilities of adverse effects due to disorientation were pessimistic. It was thought that vertigo, induced by disorientation, would create a situation making digestion all but impossible.

The element of appetite in this respect would seem to be related to individual adaptability to the situation. Flights in the X-1 and X-2 airplanes suggest that vertigo would not appear if the pilot kept his eyes open and thus maintained the visual element of the orientation trial. Compensation presumably kept the orientation from collapsing altogether.

Ingestion would not present serious problems insofar as valve action of the body is concerned. Food placed in the mouth would be retained by the confining action of closed lips. The main problem apparently is preingestion status of the nutritive material. Solids may be confined by their structural nature (as in sandwiches) or by continers, and liquids introduced either as part of the solid material or administered by squeeze-type bottles.

Liquids and solids, reduced to a paste-like consistency, may require some help from the tongue to move them into the esophagus. This skill should be acquired with a minimum of practice.

Digestion, including the later-phase process of assimilation, runs into the problem of digestive fluids dispersing into foam, and may, according to Buettner, tend to isolate the food material to be processed from the peristaltic agencies of the alimentary tract.

The solution here appears to be the inclusion with the food of a defoaming agent which is compatible both with the food and the organs of the body performing the various digestive processes. No data has yet appeared on these, but no serious problem is evident at present.

The only problem in elimination is disposal. Special toilet installations, or some such local device as centrifugation, might solve this.

Radiation

Two types of radiation hazards must be considered as cumulative in their effects. No impediment to appetite, ingestion, digestion, assimilation or elimination is known in the sense of immediate effect.

One major source of radiation likely in space is bombardment by cosmic ray particles.

Cosmic radiation may manifest itself in two ways—action on food and action on the body. Buettner says categorically that "radiation hazards to food may be safely excluded since cosmic radiation in this respect is completely harmless." This is not surprising on reflection, as radiation using atomic energy is currently contemplated. The scientists seem to be very confident of the general feasibility of the idea and are worried mainly about such groups of food as dairy products, which stubbornly resist irradiation processing for preservation.

The effect of cosmic radiation on human beings is another matter, because the impact of particles on cellular components, notably nuclei, is thought to be quite capable of pathological effects. The difference of opinion on the matter is somewhat curious. The only thesis the optimists can defend is that the radiation intensity has been greatly overrated.

If there is division of professional opinion on so basic an aspect of cosmic radiation, there is not much hope for a concise description of general cosmic radiation and its specific effects on humans. To treat it as analogous to atomic radiation, with certain obvious exceptions, seems logical, but not more than this can be said at the present time. Cosmic ray biologists are still determining the best type of specimen to send aloft.

One is left with the cautious supposition that cosmic ray sickness will manifest the same symptoms as atomic radiation sickness, and thus have the same effects on the alimentary processes. Human tolerance to gamma rays is about 0.5 roentgen.

Overirradiation produces vomiting, then fever, diarrhea, weakness and progressive anemia. Hemorrhages result from impairment of blood-clotting mechanisms. The reduced white blood count would handicap the victim in event of exposure to disease. Space flight may be harmless, hazardous or suicidal, depending on the flux density.

Careful Selection

It is assumed that the crew has been carefully screened for emotional stability and general good health, using the same high standards as in the selection of jet fighter pilots. It is further assumed that sanitation and toxicological hazards have been taken into account in the design of the ship.

Nutritional substance must be adequate in quantity, well balanced, palatable and provide adequate body energy. Adequacy of quantity requires extreme compactness. Some improvement along this line has been noted in conventional food merchandising, notably in frozen foods, dehydrated products and sometimes in the techniques of meat cutting. This is not enough for the logistics of space flight.

Some effort has been devoted to tabletized and other forms of concentrated nourishment. There are two opposing schools of thought on whether or not the body can safely survive with bulkless food. One school maintains a certain minimum is required to maintain conventional gastrointestinal peristalis. The other school points to the fact that the body accumulates and voids itself of waste long after the last food ingested has been eliminated. However, there is no record of an experiment where subjects attempted to subsist completely on superconcentrated foods and water alone. Meanwhile, it would be folly to assume that bulkless, tabletized foods can be trusted for long sojourns into space.

Another aspect of the nutrition problem is preservation, which often requires refrigeration and always asepsis. Food kept outside the vehicle and in shadow will be adequately refrigerated, and space is certainly sterile. A food product or concentrate which required neither would be very convenient.

Algae has been advanced as a food substance and is presumably fairly rich in carbohydrates. The present state of the art indicates a good start, but algae is not yet at the point where it is a very serious contender to other forms of food except insofar as it does regenerate itself. The Arthur D. Little Co. has in operation a pilot which measures 600 square feet in area and with 1200 gallons of culture produces somewhat over 0.75 pounds of dried algae per day. The quantity of useful food substance from this has not been determined, but is surely not 100 per cent. Even if it were, this is hardly enough to provide adequate nutrition for human beings even with a zero margin for error. If the vehicle is sufficiently large, it might help in providing part of the daily requirements.

Palatability complicates the nutrition problem and algae does not stand out in this respect. It does not whet the appetite nor encourage ingestion in the average person. Artificial preparations have an advantage here, as palatable additives enhance the overall acceptability.

What remains is a synthetic food concentrate, which is light, compact, balanced, palatable and requires little or no refrigeration or post-packaging asepsis. Concepts on nutritional adequacy will have to be altered to fit the needs of space flight. ★

The F-94C aircraft used in parabolic flight to obtain reduced gravity states.

Progress in Space Medicine

By Maj. Gen. Otis O. Benson, Jr.
Commandant, School of Aviation Medicine

THE LARGER portion of the atmosphere, from the standpoint of human flight, is not unlike interplanetary space, if we ignore some conditions caused by the presence of the solid body of the earth itself. This knowledge makes us realize that space operations in the form of space equivalent flights are here and are of immediate interest to the Air Force.

In the *preliminary* phases of space operations most of the medical problems are encountered as they most probably exist in the *more advanced* and *final* phases of space operations, such as in interplanetary space travel. The main difference is the duration of the flight.

One of the most important medical considerations is engineering of the cabin of a space vehicle from the standpoint of human factors. This must be a development of close cooperation between the engineer and the biomedical scientist.

The cabin, of course, must be completely sealed. It is interesting to note that such a space cabin is required at altitudes as low as 70,000 to 80,000 ft. This cabin is not pressurized by the use of outside air, but rather must be pressurized from within—a self-sustaining system. It is the task of Space Medicine to provide the crew with the best possible artificial atmosphere providing adequate barometric and oxygen pressures. Removal of carbon dioxide produced by the crew in respiration is of special importance.

Other problems include humidity control, temperature control and odor removal. The magnitude and complexity of these technicophysiological problems require careful experimental studies in the laboratory.

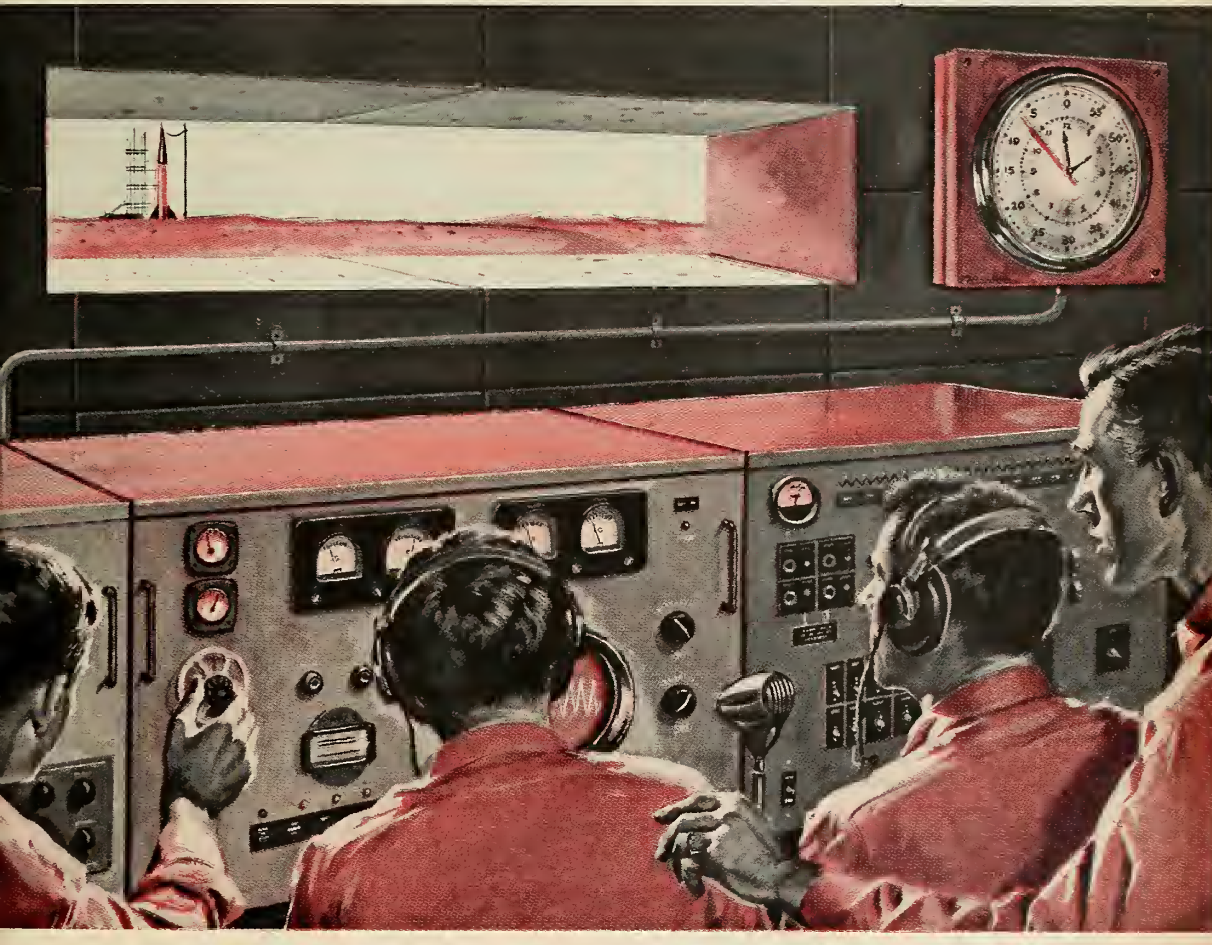
On the vertical frontier opened by the rocket, human factors will play an important or even a decisive role. The medical problems involved in rocket or space operations are the subject matter of Space Medicine, a branch or an extension of Aviation Medicine. During the nine years that Space Medicine has existed as an organized entity, considerable progress has been made in both theoretical and experimental considerations. Here, briefly, is an updating.

Such studies are possible in experimental hermetically sealed cabins, such as the so-called space cabin simulator at the School of Aviation Medicine. This experimental device is different from altitude chambers where body reactions under decreased air pressure are studied. In contrast, task of the space cabin simulator is to *take care* of its occupants. Considerable progress has been made in this research field.

A Lesson From Plants

Experiments have been carried out for periods up to 24 hours under normal barometric conditions, and for a number of hours under reduced pressure corresponding to an altitude of 24,000 ft. Similar studies have been done in sealed gondolas for high altitude balloon flight at the Aero Medical Field Laboratory at Holloman AFB.

In space operations of longer durations, the scope of the problems will increase. New methods for the regeneration of cabin air may become necessary from the standpoint of economy. One means to accomplish this is the production of oxygen and removal of



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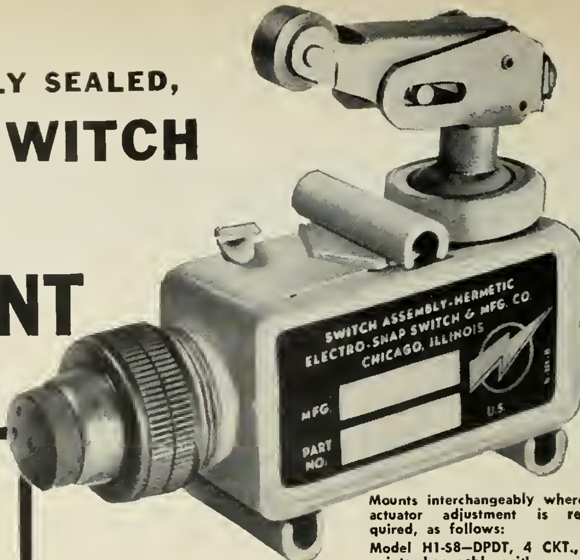

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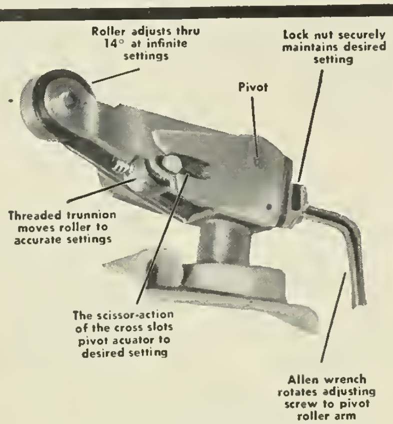

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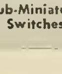

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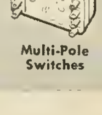

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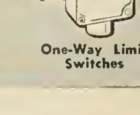

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carbon dioxide with the aid of photosynthesis as it occurs naturally in plants.

In experimental studies sponsored by the School of Aviation Medicine and carried out by Dr. Jack Myers, head of the Department of Algal Physiology, University of Texas, it has been found that five pounds of a species of alga are sufficient to supply the respiratory requirements of one man. These studies are being pursued and more data are being obtained.

Maj. Gen. Otis O. Benson, Jr.
Commandant, School of Aviation Medicine

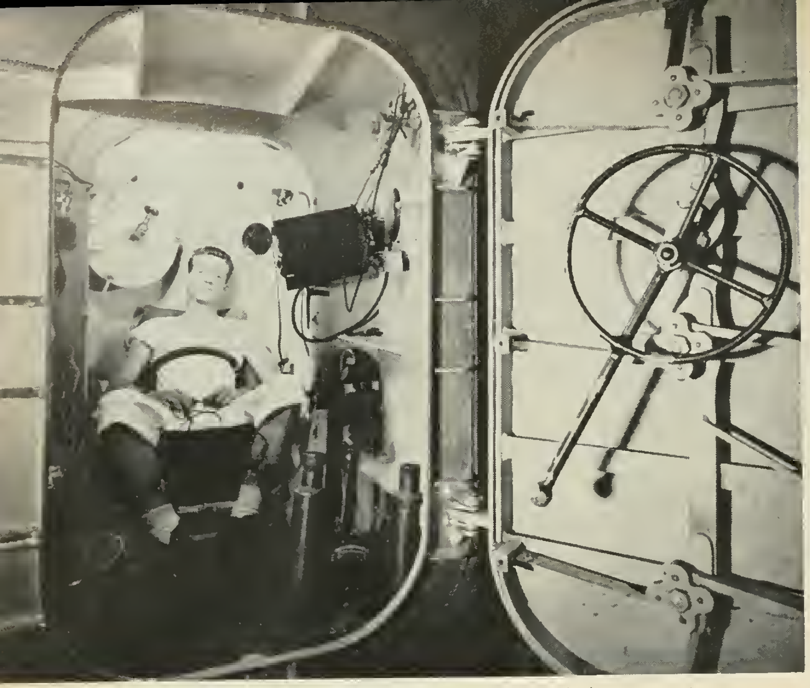
Of course, in space equivalent flights and space operations of short duration, we will never resort to such a photosynthetic gas exchanger because of the weight and volume of such a device. For space operations of long duration it might be a different story; and under such conditions, the elimination and reutilization of waste products may become necessary. Developmental studies in this direction will make the scope of the physiological problems involved in a closed ecological system complete.

Problems of another nature, such as the psychological behavior in closed systems, will also enter the picture. Such studies are under way.

External Protection

A space cabin also must be equipped to protect the crew against external factors, such as meteorites and cosmic ray particles. Here is a fruitful field for close cooperation between the astronomer, astrophysicist, engineer and the bioscientist.

Insofar as cosmic rays are concerned, we are much better informed today as a result of theoretical calcula-



Space cabin simulator used at Randolph AFB to study human reactions.

tions and experimental observations from high altitude balloons. For short-time exposure at altitudes where the primary cosmic rays are encountered, the situation is less dramatic than was thought some five years ago. With regard to flights of long duration, however, the question of health hazards from exposure to cosmic rays remains unanswered.

In the experimental sealed cabin we can simulate a number of space flight situations; but one condition that can hardly be produced in the laboratory is that of the state of weightlessness. Comparative studies have been made in a swimming pool, in which some of the features of weightlessness are achieved.

For a more complete understanding of zero-gravity and its biological effects during actual flight we must produce the "real thing"—namely, weightlessness in flight.

The method of producing weightlessness in parabolic flight maneuvers in jet planes is now pretty well understood. Control systems have been developed and a significant number of experiments have been carried out at the Aero Medical Laboratory, Wright-Patterson AFB, Ohio, and at the Aero Medical Field Laboratory, Holloman AFB, N. M., as well as at the School of Aviation Medicine.

These studies are designed to determine the performance of man under a state of reduced gravity to the point of weightlessness and to assess his tolerance to this strange situation. From current data, inference is drawn that man adapts very well to fractional gravity states of short duration.

Tests To Date

The experiments of Dr. S. J. Gerathewohl of the School of Aviation Medicine have shown that about 25% of the subjects became moderately nauseated during maneuvers associated with parabolic flight, 25% were relatively indifferent, and the majority of human subjects enjoyed the experience. These and other studies, extremely important to engineers and bioscientists, must be extended over longer periods of weightlessness before final conclusions can be drawn. Our preliminary observations may have a bearing upon the ultimate selection and training of aircrews for space operations.

This is only a very brief survey of the problems and interests of Space Medicine and its progress. From the fueling of a rocket vehicle through its launching and flight, its re-entry into the atmosphere and ultimate descent, the bioscientists are attempting to identify the problems and obtain solutions.

Toxicity of propellants, forces of acceleration during launching, and deceleration forces upon re-entry are under study in terms of their effects upon the personnel.

The elements of discrimination, decision and judgment still dictate that man is superior to the "black box" in innumerable situations and that he hasn't been ruled out for space flight operations. Our interests always are in the man who flies—from ground level to infinity. ★

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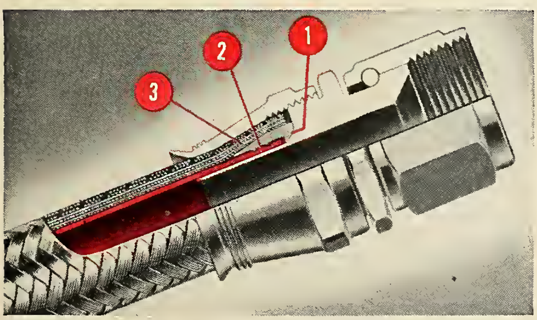

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*DuPont trade name for its tetrafluoroethylene resin.
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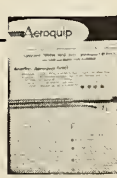

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rocketeer profile

Pied Piper Bob Truax

By Erica Cromley

. . . a glimpse behind the braid of the man who spurred the Navy's rocket program

CMDR. ROBERT C. TRUAX is said to be the only man ever to fire a rocket in the engine room of a U.S. naval vessel. Let us hope so. A man who has earned many honors for his "firsts" in Navy rocketry, Bob Truax feels this is one tribute he can do without. He claims innocence.

The Navy's rocket expert does admit, however, that he rigged up a rocket engine test stand aboard the USS *Enterprise* in 1940 and continued the rocket experiments he had begun as a teenage Naval Academy midshipman in the late 1930s. Although the shipboard project was encouraged by the skipper, Navy sources say there was an audible sigh of relief when the young rocket enthusiast was assigned to the Bureau of Aeronautics. Bob Truax, now 39, has lived rockets since his boyhood days when he did his rocket tinkering in the basement. While a midshipman at the Naval Academy he badgered everybody and anybody for bits, parts and pieces from which to make a rocket engine. The U.S. Naval Engineering Experiment Station near Annapolis helped him build a test stand.

He was unable to evoke a single explosion, but six years later in 1945, after he had graduated and was back at the test station, he effected what he describes as a "doozie." It shattered bulletproof glass. The device—a nitromethane engine.

In August 1946, he was ordered to BuAer in charge of rocket powerplant development, having, in effect, sole responsibility for BuAer's progress in this field—a $6-million-a-year project.

Among the projects he mothered were development and test of the powerplants for the D558-2, the *Viking* and the earth satellite vehicle (1946-1948).

Says the rocketeer in recollection, "At this time I completed a study of a long-range [1100-mile] ballistic missile for fleet use and succeeded in getting BuAer endorsement on a program to develop this missile. The program was rejected by the Chief of Naval Operations. This engine is slated for use in the NAA X-15 airplane."

Four years later, with a master's degree in nuclear engineering, he was assigned to head the BuAer surface-launched branch of the guided missile division. Here he supervised the *Rigel, Lark, Regulus* I and II projects.

He says of this stint: "My duties also included proposing new projects. I vigorously advocated initiation of a ballistic missile program and an anti-ASW missile of original concept."

In the fall of 1954, he was borrowed by the Office of Naval Research to study the problem of fleet air defense. His report, submitted six months later, resulted in sweeping changes in the missile radar control equipment and shipbuilding programs. He still has the letter of commendation from the Chief of Naval Research for this work.

Bob Truax, perhaps more than anyone else, was responsible for getting the Navy started on its rocket program. However, the Navy apparently didn't move fast enough for him and it wasn't long before the Air Force requested that he be assigned to its ballistic missile program.

Currently the naval rocket pioneer channels his talents into the Ballistic Missile Division Headquarters, Air Research & Development Command. Title: Deputy Director, USAF Ballistic Missile Division.

Since he joined Maj. Gen. Bernard Schriever's staff, Bob Truax has been working on the Air Force' reconnaissance satellite project, frequently referred to as Project *Big Brother*. The project's name, however, is *Pied Piper*.

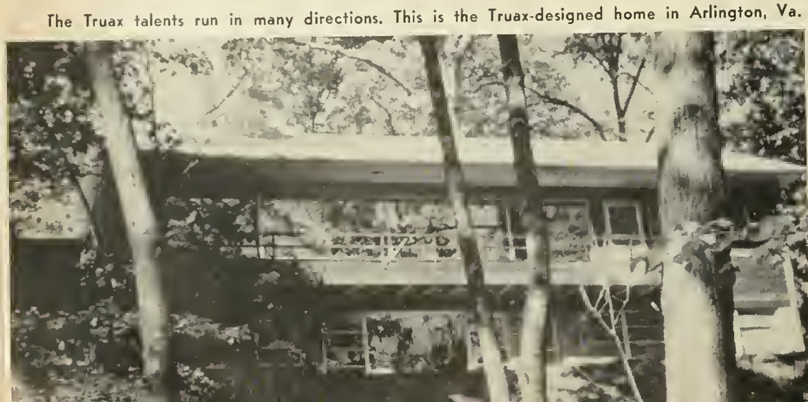
This satellite, which was originally part of President Eisenhower's open-skies plan, started out as nothing but a study project. Today the project has come to life, more money has been granted for it, and Bob Truax is expected to be stuck with it for some time to come.

Only a few of the Truax achievements in rocketry are recorded here. He has received awards from various scientific associations for his work, has published many papers and reports of inestimable value to other rocketeers and holds seven patents for aero-rocket devices. He was a director of the American Rocket Society from 1947 to 1950 and is about to step down as its president next month.

In tribute to his work, the Navy has a couple of honors in the works: the Legion of Merit Award "for his continuous outstanding service in the field of rockets and missiles," and a promotion to captain.

Considering his achievements, a portrait would emerge of an intensely

The Truax talents run in many directions. This is the Truax-designed home in Arlington, Va.



Junior and Senior Truax sea-shelling on family weekend trip.

Posing for dad. Ann, 15; Kathleen, 13; Steven, 11; Gary, 6.

dedicated, senior, introverted science type, with no time for anything but his life's work. Not so.

Bob Truax takes his work seriously; himself, not. He has a tremendous zest for living which is immediately apparent on meeting him. He resembles nothing so much as an exuberant undergraduate (crew-cut included) who has just received a bigger check from home than he expected.

The 39-year-old rocket whiz has been termed by his friends as magnetic and dynamic, with boundless energy and countless friends. Said one, "I have never heard him say an unkind thing about anyone." His co-workers all use identical phrases when they describe him: extremely dedicated, gets along well with everybody, farsighted, extremely modest and not aware of his greatness.

He has a flair for expressing himself well which puts him in great demand as a toastmaster. Though modest about his rocket achievements, the Truax pride is vocal where his family is concerned. There are four junior Truaxes ranging in age from six to 15. None of them are basement rocket tinkerers. Six-year-old Gary is more interested in making airplanes, collecting bones and skulls. He also likes to draw spaceships. "Watch today's kids," says father Bob. "What they draw today may well turn out to be the designs of tomorrow."

Steven, 11, who just became a boy scout, gets his kicks on the baseball diamond as a Little Leaguer. Kathleen, 13, is taking art lessons, and 15-year-old Ann, who wants to be a nurse, has her head buried in first-aid books.

Indirectly, rockets were responsible for Rosalind and Bob Truax getting together. In 1938 during a search for a refractory material for a nozzle, he met Carl Schroeder, a metallurgical engineer from New Jersey. At the invitation of mutual friends, Schroeder and Truax met to talk over nozzle problems. The friends also invited Schroeder's daughter, Rosalind. This led to an invitation to the hop at Mem Hall, a three-year courtship and a trip to the altar in July 1941.

They set up housekeeping in Annapolis. Here Bob Truax started on the JATO development project at the Experiment Station a few months before Pearl Harbor. They have moved 22 times in the 16 years since.

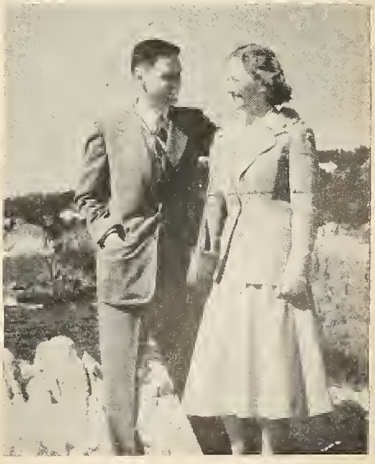
The commander describes his current home as a "typical California tract house, what you call a rambler though this one doesn't ramble far." They're renting. Home is in Arlington, Va., a Truax-designed house complete with work-saver cabinets. "A showplace," he says in a rare burst of immodesty.

The Truaxes are outdoorsy types. There are family hiking and camping weekend trips. A recent such excursion took the family on a canoe trip down the Colorado River.

He looks forward to spending time with his family but admits it is not nearly as much as he would like. The experiments still go on in the basement where he concocts electronic devices using the "cookbook" method. And like many a cook, chef Truax's concoctions do not always turn out as planned. Once he started out to make a Geiger counter and wound up with a computer. He expects to track *Sputnik* with a six-inch reflecting telescope of his own making.

Bob Truax is a nonsmoker, nondrinker and easy to please in the food department. Preferences run to hash, and macaroni and cheese. This may be more than a matter of choice. In addition to six Truaxes, the Navy rocketeer supports two cats, one black cocker and a horse. Dog is named Jet. Horse is named Rocket. Of course.★

Below—Hometown father and son game in Rolling Hills, Calif., with Father Bob at bat.
Right—The Truaxes at Monterey, Calif. They have moved 22 times in the past 16 years.



MISSILE AGE

By Norman L. Baker

Lockheed Offers Satellite and Moon Rockets

The Missile Systems Division of Lockheed has proposed a practical, realistic approach to the task of gathering upper-atmosphere data desperately needed in our ICBM, anti-ICBM, satellite and missile programs. The beauty of the Lockheed proposal is the use of a family of research rockets evolving from the successful X-17 re-entry test vehicle that will reach altitudes ranging from 200 to 8000 miles up and out. Most advanced models could reach orbiting and escape velocities.

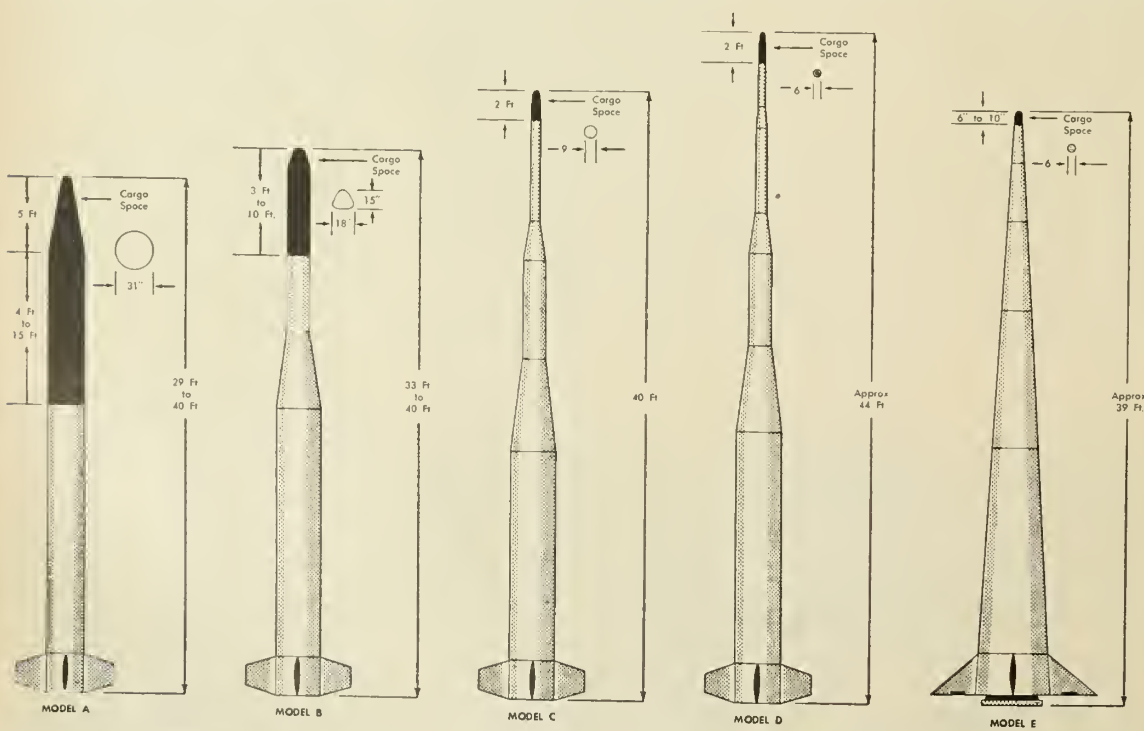
Designated *Explorer,* the series consists of five models ranging from one to five stages. The vehicles combine a wide range of payload and altitude capabilities with reliability, safety, simplicity and easy portability. Rocket motors are "off the shelf" solid propellants, developed by the Thiokol Chemical Corp., that have been thoroughly flight-tested in previous operations. The staged vehicles use a combination of *Sergeant* and *Recruit* rockets. The *Recruit* is the same rocket that is used in the four-stage *Far Side* vehicle.

The performance characteristics of the *Explorer* models make them acceptable for geophysical and communications data gathering. The high g accelerations (100 g) expected with this type of vehicle make them unsatisfactory for the evaluation of components or equipment sensitive to rolling or high g forces. A vehicle incorporating roll stabilization and guidance is now under study and will meet the requirements needed for evaluating highly sensitive components in the ICBM and AICBM programs.

It became obvious during the X-17 program that a vehicle of similar capabilities could be utilized to investigate the problems beyond those of immediate concern to the ICBM re-entry phase. A re-evaluation of the X-17 vehicle resulted in the *Explorer* series. The *Explorer* would embody the same dependability and portability as the X-17, but with a much wider range of capabilities.

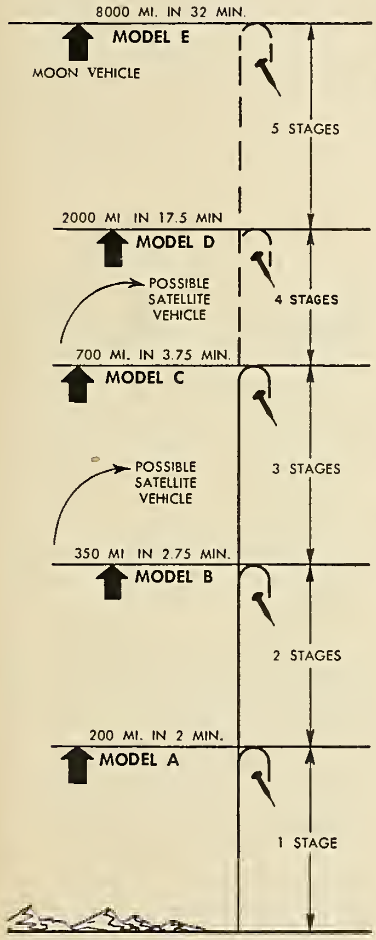
Model A

This is a single-stage vehicle utilizing the Army XM-20 *Sergeant* sur-



MODEL A: XM-20 SERGEANT, gross weight 9000 lbs., thrust 50,000 lbs., MODEL B: gross weight 10,000 lbs., thrust (first stage) 50,000 lbs., (second stage) 104,000 lbs., MODEL C: X-17 research re-entry vehicle, gross weight 10,400 lbs., thrust (first stage) 50,000 lbs., (second stage) 104,000 lbs., (third stage) 34,000 lbs., MODEL D: gross weight 10,459 lbs., thrust (first stage) 50,000 lbs., (second stage) 104,000 lbs., (third stage) 34,000 lbs., (fourth stage) 1680 lbs., MODEL E: gross weight 19,000 lbs., thrust (first stage) 62,000 lbs., (second stage) 115,000 lbs., (third stage) 37,300 lbs., (fourth stage) 8100 lbs., (fifth stage) 1800 lbs.

face-to-surface missile powerplant. The cargo compartment, 31 inches in diameter and four to 15 feet long, could carry from 100 to 500 pounds of instrumentation. Its ability to remain at peak altitude of 200 miles for as long as two minutes makes it suitable for collecting geophysical data. As a testing range instrumentation vehicle, with a payload of 100 pounds, it would have a range of 400 miles and an apogee of 50 miles.



Model B

This two-stage model would use a *Sergeant* first stage and three *Recruit* rockets for the second stage. The aerodynamic design has already been proved in flight. Instrumentation payload could weigh from 80 to 500 pounds. It would be capable of remaining near peak altitude of 350 miles for almost three minutes.

Model C

Identical to the X-17, this three-stage model has a *Sergeant* motor for the first stage, three *Recruits* for second stage and a single *Recruit* for the last stage. With a 50-pound payload it has a peak altitude of 700 miles or 350 miles with a 250-pound payload. The payload space is nine inches in diameter and two feet long.

Model D

This four-stage rocket, and the Model E, would require further development in order to achieve the desired ranges of altitude and payload capabilities. Requiring only a mimimum of development, the Model D could be made by adding a fourth stage rocket, similar to the *Arrow*, to the Model C. It would carry a 10-pound payload to an altitude of 2000 miles. It would place its payload near peak altitude for almost 18 minutes.

Model E

Lockheed states that this version is based on a proven and reliable design concept with capabilities of extending measurements into the region from 2000 to 8000 miles above the surface of the earth. Using currently available solid propellants, it is expected to exceed satellite orbital velocities. Escape velocities are possible with recent propellant improvements. This rocket vehicle could, with adequate guidance, transport a payload to the surface of the moon. Preliminary design results indicate that a cargo space six inches in diameter and six to 10 inches in length will be available for a payload of 10 pounds.

In addition to the basic vehicle, Lockheed could make available all the necessary equipment and organizational capabilities for use with the *Explorer* flights. The equipment includes the launcher, umbilical stand, mobile crane, handling slings, mobile scaffolding, forklift, and tractor and lift-trailer combination for towing and erecting the missile.

The original Lockheed proposal for the *Explorer* research vehicles was made at the beginning of the IGY. It was well received by the National Committee for Rocketry and Meteorology, but due to lack of funds for further programing the *Explorer* project is still in the planning stage.

Lockheed's approach to the missile and space research program is indicative of the realistic thinking of some of the top planners in our research programs. A recent example of this approach was the *Far Side* project.

Few companies holding large defense contracts are willing to become involved in a low cost, small quantity production item like the *Explorer*, especially when the major components of the vehicle are manufactured by another company.

Litton Chamber Probes Space Conditions

An inhabited high-vacuum laboratory has simulated the pressure conditions that prevail 95 miles above the earth.

The laboratory is an invaluable research tool in performing fundamental studies needed for the development of outer space weapon systems.

Niels Jensen, a scientist from Litton Industries, Inc., Beverly Hills, Calif., has been working inside the 15-foot long, eight-foot diameter "high-vacuum" chamber with only a special pressure suit to protect him against the simulated conditions that exist in the thin atmosphere.

Protected by the unique pressure suit with its external system of oxygen supply and heat removal, an operator can inhabit the vacuum of the chamber and perform intricate research.

The laboratory will be used to facilitate the advancement of knowledge about the behavior of physical phenomena, equipment and instrumentation under conditions of extremely low pressure and density.

Also to be explored by the new laboratory is the chamber's applicability to electron-tube research.

Grand Central Builds Rocket Fire Fighter

The U.S. Forestry Equipment and Development Center at Arcadia, Calif., is evaluating the *Little Vanguard* solid-rocket-propelled forest fire extinguisher. Developed for Grand Central's own protection on its 8000-acre

mountain-walled test site, it first attracted national attention when a mass firing was demonstrated publicly.

It is a solid-propellant-powered missile slightly over 54 inches in length and is launched from a simple wooden trough. Payload is 8.5 gallons of borate or 76 pounds of other material. On impact it covers a splatter area of 700 square feet. Range is 410 yards with one rocket motor or 1200 yards with two motors.

Aeronutronic Plans for Advanced Missiles

Aeronutronic Systems, Inc., Ford Motor Co.'s West Coast subsidiary, has leased 100 acres and optioned a like amount as a site for its new multi-million-dollar research and development center near Newport Beach in Southern California.

Construction will begin immediately on the first unit, a series of aerothermochemical laboratories to explore problems associated with the design of advanced missile systems. These include anti-missile systems, reconnaissance systems and upper atmosphere vehicles. April 1958 is the targeted completion date for the first phase.

Propeller Company Turns to Rockets

For many years a byword in the propeller manufacturing field, Hamilton Standard is offsetting the problems of reduced defense appropriations and declining volume of business by greatly expanding their missile efforts.

Hamilton's latest expansion, a 410,000-square-foot building, will move them still more firmly into the jet propulsion era. It is probably the largest facility built solely for the development, testing and production of controls for turbine, atomic and rocket engines.

Hamilton Standard currently is producing air conditioning systems, turbine starters, hydraulic pumps and pneumatic valves as well as fuel controls, and is developing still newer products for the turbine and missile fields.

American Rocket Co. Plans Lithium Production

American Rocket Co. announces that it has been working on lithium rocket propellants for about a year. The high-energy propellants are based on lithium perchlorate, nitrate and other chemicals. Both solid and liquid propellants have been formulated and are being evaluated.

Aerojet-General Awarded $55-Million *Titan* Contract

Aerojet-General was recently awarded a $55-million AF contract for *Titan* engine units. Fabrication and testing of the engines has been under way for several weeks at Aerojet's Sacramento plant.

Manufacture of the large engine components at AF Plant 70 is proceeding on schedule. *Titan* is a two-stage ICBM under development by The Martin Co. of Denver. First-stage engine thrust has been reported at 300,000 lbs., with second-stage thrust at 60,000 lbs. First flights of the *Titan* are expected shortly before January 1st.

Goodrich Increases Rocket Research Facilities

B. F. Goodrich Aviation Products has purchased land and buildings at Rialto, Calif., for expansion of their rocket research program. Goodrich, engaged in rocket propellant research since 1953, will continue research and development in this field in the Rialto location.

Vitro Labs Awarded *Terrier* Systems Contract

Vitro Laboratories, a division of Vitro Corp. of America, has been awarded a contract with the Bureau of Ordnance for systems engineering of *Terrier* guided-missile installations on new carriers of the *Forrestal* class.

The work covers installations on new attack carriers and a nuclear-propelled carrier which has been authorized for construction.

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The new B & H TAKCAL incorporates a refinement of the frequency meter principle. It operates in the low (0 to 1000 cps) range, reading the frequency of the tachometer generator on a scale calibrated in percent RPM corresponding to the engine's RPM. It reads engine speed while the engine is running with a guaranteed accuracy of ±0.1% in the range of 0 to 110% RPM. Additionally, the TAKCAL circuit can be used to trouble-shoot and isolate errors in the aircraft tachometer system, with the circuit and tachometer paralleled to obtain simultaneous reading.

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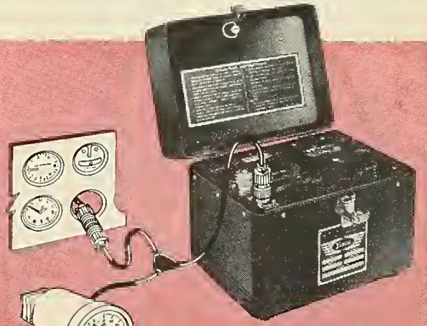

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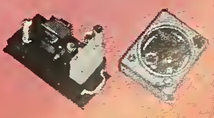

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Circle No. 74 on Subscriber Service Card.

West Coast Industry

By Fred S. Hunter

Have you heard of "Frescanar?" This is nomenclature for a frequency scanning radar technique Hughes Aircraft Co. has had under wraps since it was first conceived in 1948. First application is in the Hughes-developed AN/SPS-26 shipborne radar system recently installed by the Navy in a guided missile cruiser for sea tests and shipboard evaluation. Reports indicate that AN/SPS-26—an integrated electronic system for accumulating three-dimensional data on all airborne targets—has revolutionary capabilities. Tests on the first model of the surface pulse search system before delivery to the Navy are said to have been highly pleasing to the Hughes ground systems division which developed the antennas and circuits for the Frescanar technique. These tests included many hours of on-the-air operation at high power. The radar system also incorporates some new tube developments, notably a traveling wave tube designed by the Hughes microwave laboratory.

•

Aerojet-General will be back on schedule on solid-rocket production December 1 at Sacramento, where $500,000 worth of fire damage was incurred in two explosions about a week apart. Included in the repair is redesign of the No. 3 line to incorporate production improvements. Aerojet also has a brand new No. 5 line of the latest type going in at the Sacramento solid plant plus a new propellant chemical laboratory. When you mention a line at a plant like Aerojet's, incidentally, you aren't referring to a production line in the ordinary sense. You mean a group of five, six or seven buildings spaced apart and protected by revetments between one another.

•

Boeing now has its YIM-99 logistic depot in operation at Seattle for storage and distribution of spares for the service-test (Y) *Bomarc* interceptor missile, together with maintenance, repair, modification and supply of components. It will serve, in effect, as a "prototype" depot as the Air Force prepares to fit the *Bomarc* weapon into the continental defense. The first *Bomarcs* are scheduled to become operational within the next fiscal year, beginning July 1, 1958. Initial launching of the *Bomarc* prototype took place just five years ago this fall. A ramjet, the *Bomarc's* mission is to intercept fast bombers, but in Seattle recently Lt. Gen. C. S. Irvine, deputy chief of staff, materiel, said the Air Force might look at an advanced version for an anti-missile missile.

•

To keep pressurizing gas from mixing with liquid oxygen used as an oxidizer in liquid-propellant rocket engines, Rocketdyne has come up with a perforated inlet tube to slow down the nitrogen as it is diffused into the LOX system. Instead of mixing with the LOX, the nitrogen is forced to the top of the LOX tank before starting its pressurizing cycle. From 10 to 20 times less dilution of the LOX takes place with the new inlet tube, and this may increase performance up to 30 per cent for a long-range missile.

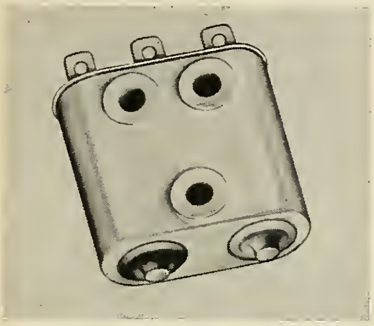
•

Lockheed picked Starline Way as the name for a street to be cut through the Sunnyvale missile plant site because it suggests the company's long line of star-named aircraft, now followed by the *Polaris* missile . . . Transistor business now about $30 million a year, is expected to reach $150 million a year in the next couple of years.

NEW MISSILE PRODUCTS

PRECISION SWITCH

Haydon Switch, Inc. has developed a unique type of miniature precision switch which is hermetically sealed, yet unaffected by high ambient pressures. The company claims that the actuation force remains constant even under atmospheric pressures as high as 180 psi. The switch is said to work equally well in a vacuum.



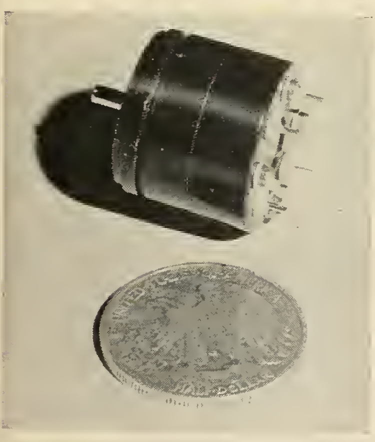
The design is applicable to miniature and subminiature switches of various electrical ratings. The company can also furnish the switch with a seal impervious to the deteriorating effects of immersion in corrosive liquids.

Circle No. 203 on Subscriber Service Card.

MICROSYN

Lear, Inc., is manufacturing a self-contained microsyn of approximately 1" diameter and 1" length, with a sensitivity of 500 millivolts per degree and with a threshold of 0.01 degree at 20V excitation. Linearity is within 0.5% to seven degrees. The subminiature microsyn weighs less than 1.2 oz.

Intended for use wherever there is need for accurate translation of angular displacement into electrical signals, the miniature units may be used in such



applications as position-indication of gyros, control follow-up devices, computation, motion and torque amplification, etc.

The company produces the microsyns with pigtail connectors or with color-coded teflon-insulated terminals. Excitation may be 20V, 400 cps or 25V 800 cos. The units use standard BuOrd mounting and have demonstrated resistance to the most severe environmental conditions.

Circle No. 214 on Subscriber Service Card.

ALUMINUM CASTINGS

New investment casting techniques in aluminum developed by Arwood Precision Casting Corp. are claimed to give higher guarantees of strength and ductility than have ever been possible in aluminum investment castings.

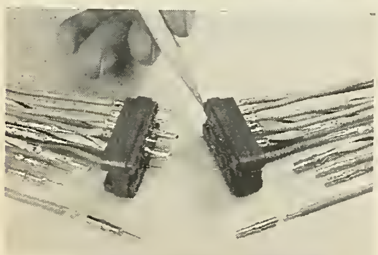
Castings produced by the "suparcast" method can be used wherever aircraft-quality castings are called for, and the user receives minimum guarantees of tensile strength, yield strength and elongation.

In high-stress areas of the casting, Arwood guarantees minimum tensile strength of 38,000 psi, minimum yield strength of 27,000 psi and elongation of 5%.

Circle No. 209 on Subscriber Service Card.

SOLDERLESS CONNECTOR

Solderless multi-lead plug-and-receptacle connectors designed to speed the wiring of electronic harnesses and achieve



greater dependability and versatility have been introduced by Burndy Corp.

Called the "Hyfen" the connector has two mating units, a plug and a receptacle. Instead of being soldered, pins and sockets are crimped to wire ends by single-stroke manual or high-speed automatic tools.

This method is said to be not only faster than soldering but also to make more reliable, more easily checked connections. Elimination of solder fluxes and dissimilar metals improves resistance to corrosion. A minimum number of contact points also reduces reliability problems.

Circle No. 202 on Subscriber Service Card.

SILICONE RUBBER

A new room-temperature vulcanizing silicone rubber has been introduced by Dow Corning Corp. Identified as Silastic RTV 501, it is intended for encapsulating electric and electronic parts and for general potting, sealing and caulking applications.

The material has a long shelf life in the unvulcanized state, is easy to handle and blend and retains its rubber-like properties over a temperature span of from −70 to as high as 500°F.

Silastic RTV 501 may be mechanically or manually mixed as long as three hours before application, in the proportion of 25 parts to one part Silastic Catalyst A by weight. Both ingredients have a viscosity of about 60,000 centistokes, or the consistency of a heavy fluid.

Vulcanization takes place within 24 hours at room temperature. The compound is completely stabilized after 48 to 72 hours. Moderate heating (up to 200°F) will accelerate curing in most cases.

Circle No. 204 on Subscriber Service Card.

ALL-PLASTIC GATE VALVE

The Vanton Pump & Equipment Corp. is making an all-plastic gate valve specifically designed to meet the problems of conveying corrosive and abrasive liquids in lines that cannot be chemically contaminated.

The product, called the "Flex-Plug" gate valve, combines both the straight-through flow, non-pressure drop characteristic of a gate valve and the throttling, flow-control feature of a globe valve, allowing for wide versatility of application. The valve is available in 1" and 2" sizes with screwed ends.

One of the design features of the valve is the resilient synthetic cap which can be removed quickly and replaced easily without removing from the line.

Wear of the resilient cap is at a minimum since the cap is flexible and seated on a swivel that is free to turn. It never reseats at the same place. In addition, because of the flexibility of the cap, the valve can handle slurries despite their abrasive action.

The new Vanton Flex-Plug gate valve has a back-seating feature created by the pressure exerted by the seating of the flexible cap on the bottom face of the bonnet when the valve is fully open, thus relieving pressure of the packing.

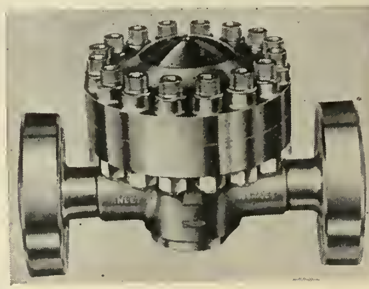
The Flex-Plug gate valve is rated for 200 lbs. working pressure. The valve performs excellently under vacuum service. Research and field tests conducted by Vanton show that seating with a resilient surface against rigid plastic materials will hold a vacuum more efficiently than a metal-to-metal seal.

Circle No. 208 on Subscriber Service Card.

PRESSURE REGULATOR

A servo-dome pressure regulator has been introduced by Accessory Products Corp. which features exceptional accuracy in flow and/or pressure control.

Performance features include identical line and orifice sizes from ¼" to 3"; inlet pressures from 0 to 6000 psi; outlet



pressures from 0 to 5500 psi; zero leakage through positive shut-off; precision control accuracy and instantaneous response; and direct action which eliminates pilot control.

The valve handles a wide range of fluid media—air, gasses and liquids; a temperature range of −65°F to 250°F; internal or downstream sensing control; external or self-contained dome loading; burst pressure is four times rated pressure. Available in stainless steel, aluminum, alloy steel and bronze.

Circle No. 201 on Subscriber Service Card.

FLOWMETER

A new line of lightweight, turbine-type flowmeters with an accuracy of ½% has been developed by the commercial research division of the George L. Nankervis Co. The new flowmeters handle chemicals and other liquids over a wide range of temperature and pressure conditions.

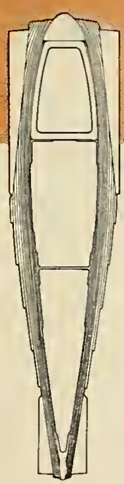
Pressures up to 5000 psi are easily accommodated at temperatures ranging from −80° to 1000°F, viscosity permitting. Designated as the Cox Type 20, the new instruments are available in stainless steel or aluminum.

Accuracy of the new flowmeters is guaranteed to be ±½% of any reading over the 10:1 range of the instrument. Repeatability is ±.1 of 1%.

The flowmeter consists of a stainless steel (or aluminum) housing, a precision turbine wheel suspended in the housing, two flow straightening assemblies and a magnetic pickup coil. It can be calibrated either in gallons per minute or pounds per hour.

A significant feature of the new instruments is the fact that they can be easily disassembled for cleaning and servicing and reassembled without affecting

The Bell XH-40 turbine-powered 'copter . . . the Army's frontline workhorse of tomorrow



Cutaway cross-section of inboard half of the XH-40 rotor blade showing how the extrusions, machined ports, and contoured aluminum sheets are bonded with Narmco Metlbond 4021.

DISTINGUISHED PERFORMANCE . . . PLUS ECONOMY!

In designing rotor blades for the XH-40, the Army's most advanced utility helicopter, Bell Helicopter engineers were seeking a structural design that would combine outstanding performance with bedrock fabrication economy.

The solution? A uniquely different kind of rotor blade laminated of multiple layers of thin-gage, contoured aluminum sheets, bonded into an homogeneous structure with a high performance, high peel strength structural adhesive. This structure offers a host of performance and fabrication advantages . . . outstanding aerodynamic smoothness, low maintenance, excellent sealing qualities, high corrosion resistance, plus complete absence of assembly distortion. Furthermore, by completely eliminating stress concentrations, the bonded structure takes full advantage of the optimum fatigue life of the blade configuration.

Best of all, the bonded blade design has resulted in a dollar savings of 40 percent as compared with a conventional tapered forging design.

The adhesive used to accomplish the unusually large area bonding required in the fabrication of these laminated blades? A Narmco product, naturally . . . high peel strength, high fatigue resistant Metlbond 4021®. . . one of a great family of sandwich and metal-to-metal adhesives designed specifically to accomplish the toughest jobs in aircraft and missile design.

NEW FROM NARMCO
Narmtape® 108
the first structural sandwich adhesive with built-in filleting action! Complete technical data available upon request.

Write today for specific performance and fabrication data on NARMCO structural adhesives. Narmco technical field representatives throughout the United States and Canada can assist in solving your structural design problems quickly, efficiently, economically.

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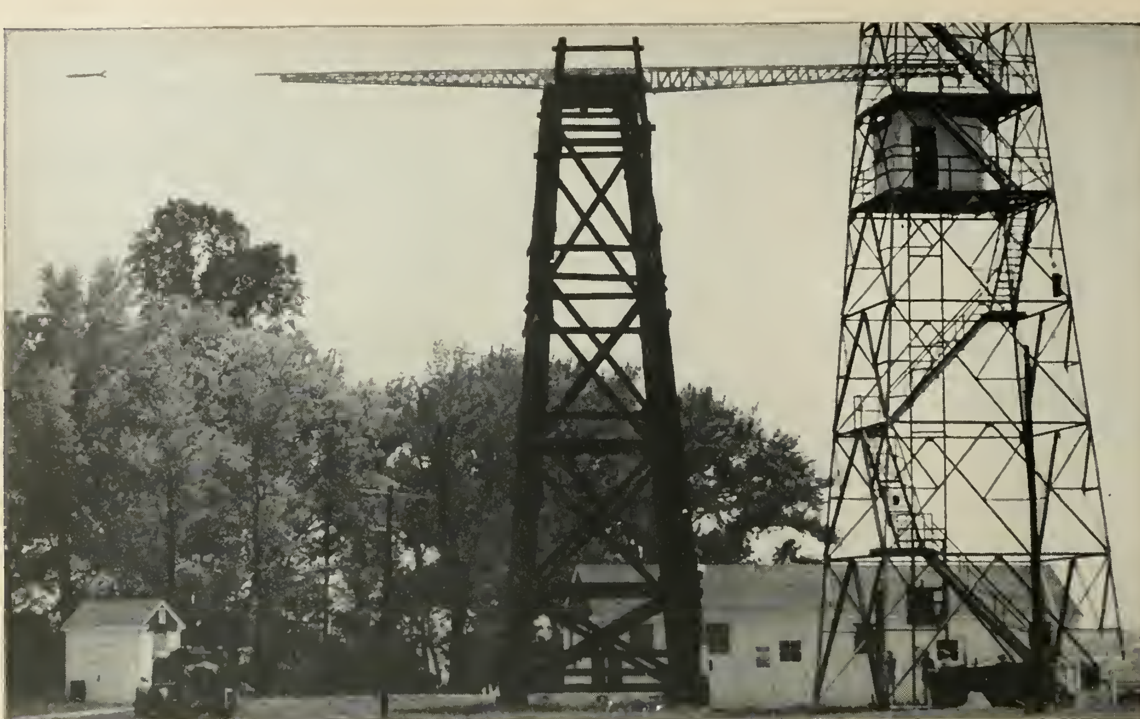

U. S. Army Photo

Experimental rocket being launched from tower at DOFL's Maryland test facility.

ELECTRONIC AMMUNITION THAT "THINKS" IS DEVELOPED AT ARMY'S DIAMOND ORDNANCE FUZE LABORATORIES

Since 1940, scientists and engineers at Diamond Ordnance Fuze Laboratories, with their industrial contractor counterparts, have made important contributions to electronic ordnance. These include the proximity fuze, greatly improved fuzes for antitank and other special ammunition, and, more recently, fuzing systems for guided missiles. Other basic results of DOFL's research and development teams are new electronic systems which increase the accuracy of measurement of distance, velocity and direction, new electronic and mechanical control systems, and new and radical components and materials. DOFL's main laboratory is in Washington, D. C., and it maintains an extensive test facility at Blossom Point, Maryland. Over 1400 scientists, engineers, technicians, and supporting personnel work in these centers.

Electronic ordnance was born in World War II. Ammunition of this type, a DOFL specialty, senses the presence, distance, and direction of a target and causes the warhead to function at the instant when it will inflict the most damage. Electronic control can be compared to having a sharpshooter in every piece of ammunition. The accurate effect is devastating.

Many advances in ruggedness and miniaturization, pioneered by DOFL, are contributing significantly to peacetime technology. Typical industrial products which sprang from ordnance programs are printed electronic circuits, tough and tiny electronic tubes, and rigid mounting of components in solid plastic blocks. These valuable by-products have contributed heavily to the ability of DOFL's industrial teammates to design safer, smaller, and better components.

This is one of a series of ads on the technical activities of the Department of Defense.

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DIVISION OF SPERRY RAND CORPORATION

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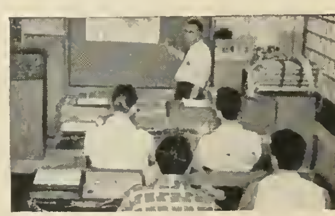

Class of technicians at Ford Instrument is instructed on techniques to be employed in assembling equipment for Army Ordnance project.

ENGINEERS of unusual abilities can find a future at FORD INSTRUMENT CO. Write for information.

linearity. Twelve sizes of flowmeters, with capacities ranging from .25 to 125 gallons per minute, are available.

Circle No. 212 on Subscriber Service Card.

FREQUENCY CONVERTER

Designed for application with guidance systems and in telemetering functions, a new transistorized frequency converter is being marketed by the Aeronautical Division of Robertshaw-Fulton Controls Co.

A substantial size-weight reduction is said to have been achieved over previously available rotary electro-mechanical frequency converters. Use of transistorized circuitry has reduced weight and overall size by approximately 60 per cent, and brought about minimum maintenance conditions.

Circle No. 215 on Subscriber Service Card.

HYDRAULIC PUMP

A large capacity variable delivery hydraulic pump has been developed by the Stratopower Division of The New York Air Brake Co. The pump, designated as the STRATOPOWER 64W1000, is claimed to have several design advantages over existing pumps on the market, including high horsepower per lb. ratio (2.8 hp/lb.), a light, compact package delivering over 50 hydraulic horsepower in an envelope 9⅛ x 6¼ inches weighing approximately 19 pounds, and exceptional control stability.

Other features include high overall efficiency of 90 per cent or more, low inlet pressurization of under 50 psi at full speed, self-aligning rotating members and exceptionally low pulsation and oversurge characteristics.

Circle No. 205 on Subscriber Service Card.

MAGNETIC HEAD

A 7-channel magnetic tape recording head developed by Data Storage Devices Co. can be directly connected to thermocouples to record without the use of amplifiers, using only 20 microwatts. The complete system is carried aboard a missile and the head has been designed to withstand high shock and vibration forces as well as high temperature and thermal shock.

Other features of the small, lightweight, aluminum head include gap alignment scatter under 1/10 MIL, mounting base machined to within 90° ±15 seconds of the gap line and tape guides integral with the head.

Circle No. 216 on Subscriber Service Card.

TAPERED ORIFICE VALVE

A valve expected to replace needle valves in nearly all applications has been introduced by General-American Valve Co. The tapered orifice valve features a new concept of flow control and will pass foreign particles up to twenty times larger than comparable needle valves.

By moving a plug with a tapered slot into an out of the circular valve opening, the flow of fluid or gas is controlled by the area of the tapered slot at the head of the opening. A circular sealing ring eliminates by-pass.

Principal advantages of the new type valve are its high accuracy in flow control, infinitely variable control, non-clog-

Circle No. 110 on Subscriber Service Card.

Circle No. 78 on Subscriber Service Card.

ging, non-freezing, abrasion-resistance and an excellent coefficient of flow at all settings with very low turbulence.

The company says the valve has been thoroughly field tested and is available in many sizes, pressure ranges and connections.

Circle No. 207 on Subscriber Service Card.

LIQUID SPRINGS

A miniature spring using liquid compressibility has been developed by Taylor Devices Inc.

The ½" diameter, self-contained liquid spring developes 800 lbs. force at ¼" stroke with an 80 lb. preload and is only 2" long plus ⅜" mounting stud. By the use of an internal hydraulic levering principle, the liquid spring produces up to 20 times the force of a standard coil spring of the same diameter and length. Liquid springs and Spring Shoks up to 50,000 lbs. force are available from the company.

Taylor's liquid springs, with standard ⅜-24 mounting thread, are preloaded and completely self-contained, eliminating stripper bolts, washers and mechanical springs.

Circle No. 200 on Subscriber Service Card.

PRINTED CIRCUIT CONNECTOR

A printed circuit connector with patented polarizing screwlocks has been developed by the electronic sales division of DeJur-Amsco Corp. The right-angle construction precision connectors are designed for printed board or printed cable applications, and withstand vibration and high altitude. Contact spacing is based on .100 grid and the connectors are available in 11 or 33 contacts.

Circle No. 210 on Subscriber Service Card.

STRETCH FORMING MACHINE

A two-way stretch forming machine for use in forming integrally stiffened missile skins is being introduced by The Hufford Corp. Described as a bi-axial stretch-forming machine, the unit handles wider and heavier sheets in which the stiffening ribs have been extruded, and holds tolerances not possible on other types of forming equipment.

Circle No. 211 on Subscriber Service Card.

CRYSTAL OSCILLATORS

Reeves-Hoffman crystal-controlled oscillators, available over a frequency range of 4 kc to 250 kc, are transistorized for compactness. Length (seated) is 5½"; diameter 1⅜". The oscillators are capable of surviving shock of 100 g's and withstanding vibration of from 5 to 55 cycles at 0.030-in. total excursion. Output power is 600 microwatts. Frequency stability is ±0.015 per cent over an ambient temperature range from −40°C to +60°C. Over the same range of operating temperature, out-put level stability is ±2 decibels from the 25°C level. The oscillators are mounted in a plug-in octal base.

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"Old Faithful"

Rocket motors powered by Phillips solid propellants have set new standards of confidence in programmed performance. Scheduled firings are made on schedule . . . to the second! The reliability of Phillips solid propellants in jet-assist take-off applications is extremely high.

Such outstanding uniformity and dependability are due to the design simplicity of Phillips solid propellant systems. Because they require no pumps, valves, or internal controls, the possibility of mechanical failure in Phillips solid propellant rockets has been substantially eliminated. Process and quality controls assure in advance that each production unit has the desired ballistic characteristics.

Recent technical breakthroughs achieved by Phillips extend the limits of solid rocket thrust and duration with less weight and greater efficiency. Furthermore, Phillips solid propellants are easy and safe to handle or store . . . and the cost advantage is considerable.

Check with Phillips for latest developments in this field before your designs are committed.

We invite you to write and discuss your technical and production problems with us. Or call one of our regional representatives: Washington, D. C.—E. L. Klein, EXecutive 3-3050; Los Angeles—R. O. Gose, GRanite 2-0218; Dayton, Ohio—C. W. Strayer, YOrktown 3263.

Address all inquiries to:
Rocket Fuels Division
Bartlesville, Oklahoma

Phillips 66

PHILLIPS PETROLEUM COMPANY

Bartlesville, Oklahoma

Circle No. 80 on Subscriber Service Card.

K-FACTOR TESTER

Specific thermal conductivity of materials is measured with a K-factor tester developed by Tatnall Measuring Systems Co. The device consists of a portable hot plate unit, a cold bath and a relay rack. The hot plate unit is a seven-layer sandwich of plates held together by spring-loaded bolts. The unit and electrical connections are enclosed in a bag of thin plastic. The two outside plates are metal coolant plates and the three central members form the heating part of the apparatus. Specimens up to 1.25" thick are held between the coolant plates and the heating section. Special models operating at temperatures up to 600°F are available. The cold bath comes in three models which operate from room temperature down to −100°F. Various models use water, water and glycol, or alcohol and solid CO_2 for coolant, depending on the operating temperature required. Measurements take from two to six hours, depending on specimens, and readings may be taken from the recorder on the relay rack or from a potentiometer.

Circle No. 208 on Subscriber Service Card.

ROCKET IGNITER TESTER

Model 101-5A igniter circuit tester has been approved by the Army Field Services Division and the Safety Engineer at the Office of Chief of Ordnance. Featuring very low output for maximum safety, the 101-5A is used for preflight testing or for routine quality control igniter inspection.

Unit has .005 amp. output and this is achieved at net loss in accuracy which is —.01 ohm in the 0 to 5 ohm range, and —.02 ohm in the 5 to 30 ohm range. Instrument is suited for field use because of its portability, fast operation, weatherproof construction, one-year battery life, and 4-place digital readout.

The tester is manufactured by Allegany Instrument Co., Inc.

Circle No. 258 on Subscriber Service Card.

CO-POLYMER SEALING COMPOUND

Stillman Rubber Co. has developed a compound said to have exceptional oil and fuel resistance at extreme temperatures for use in bonding and sealing operations. Designated SR 251-70, the compound is available for prototype and small production orders.

The compound may be bonded to aluminum and many other metals, making it suitable for poppet applications at temperatures as low as −65°F. For dynamic sealing, minimum recommended temperatures range from 400° to 500°F, depending on duration of heating. The material is suitable for both dynamic and static sealing.

Circle No. 209 on Subscriber Service Card.

CHECK VALVE

High pressure valve operating at 5000 psi (7500 psi proof, 12,500 burst) and from −320°F to 450°F in fuming nitric acid, LOX, liquid nitrogen, propyl-nitrate, anhydrous ammonia, helium, hydraulic fluids and other liquids and gases. Construction is of Carpenter #20 steel with body poppet and stops, Hayne's alloy #25 steel spring, entrapped Teflon seat; available from ¼" to 1". Cracking pressure is ¼ psi and a variety of port sizes are available.

Circle No. 217 on Subscriber Service Card.

LIQUID DENSITY MEASUREMENT

Precision Thermometer and Instrument Co. has developed a precision device for measuring liquid density of continuously flowing process liquid. The device has zero-set and temperature adjustments for original calibration under working conditions and to provide temperature-corrected specific gravity readings. Readings can be made directly without reference to charts or graphs. The instrument is for use at temperatures to 220°C, and is available in ranges from .01 to .50 specific gravity. It can be used at pressures up to 125 psi., and is equipped with standard connections.

Circle No. 221 on Subscriber Service Card.

PRECISION AIR GAGE

Precision air gages to check gimbal alignment and concentricity are being produced by Federal Products Corp. The three readings, gimbal alignment with each pivot with the centerline of the gimbal and concentricity of one pivot with the other, are indicated simultaneously on dials of a triple-unit air gage. Dials are graduated to 20 millionths of an inch.

The company says that gages have been developed to handle gimbals up to two feet or more in diameter, and the techniques can also be applied to the accurate positioning of parts when machining to tight tolerances.

Circle No. 222 on Subscriber Service Card.

RADOME CERAMICS

Kearfott Co. has announced the availability of high-purity, aluminum oxide ceramics for use in radome construction. The material is said to have unique dielectric properties in the microwave region. At 50kMc its loss factor is only 0.000093; X-band and Ku-band loss factors vary from 0.0017 at room temperature to 0.00017 at 1000°F. Most significantly, its dielectric constant of 9.38 ± 1% remains stable over the entire temperature range up to 1000°F. The material has a frequency loss at high temperatures 50 times smaller, and at 10kMc the loss is 20 times smaller, than commercial high alumina materials.

Circle No. 223 on Subscriber Service Card.

BALANCED MIXER

A series of millimeter wave balanced mixers (Series MA-1026) has been developed by Microwave Associates, Inc. The series is designed for use with RG-96/U waveguide transmission systems and when used with matched pairs of 1N53 or 1N53A coaxial mixer crystals, the units provide high local oscillator noise suppression in Ka-band radar receivers over the 34-36 KMC/s range. The VSWR is 1.3 maximum, balance is ½ db, cross talk is 20 db minimum, and output capacity is 3 uuf, nominal.

Circle No. 224 on Subscriber Service Card.

PRESSURE REGULATOR

A hand-adjustable pressure regulator and relief valve for accurately controlling gases such as helium, nitrogen and compressed air, under pressures up to 3000 psi has been developed by Futurecraft Corp. The regulator, termed the Hi/Lo handloader, is of the zero-bleed internal venting type with hand-adjustments of the control knob regulating pressure and providing pressure-relief over the entire 0-3000 psi range.

Circle No. 225 on Subscriber Service Card.

missile miscellany

It's spelled S-P-U-T-N-I-K; pronounced SPOOTNIK; means "fellow traveler." It also means that we, as a nation, have goofed badly. We insisted Vanguard had no military or political significance—wrong on both counts. We separated Project Vanguard from all other (military) projects—and isolated it from all other knowhow and proposals. We stubbornly refused to consider at least two other vehicles which could have placed a satellite (of much political and some scientific significance) in an orbit—the X-17, 18 months ago; Jupiter-C, at least a year ago. Either could have and still can get an 18-to-20-pound beeper up there. Army not only has Jupiter-C's ready to go but satellites as well.

And just in case you missed them, here are some of the bitter quips that ran through Washington in the immediate P.S. (post-Sputnik) days: A suggested sign over Vanguard Chief Hagen's door: "Washington slipped here." Sputnik decoded #1: "I like Ike. I like Ike. I like Ike. I . . ." And as it goes over Washington #2: "Beep, beep, beep—ha ha—beep, beep, beep—ha ha—." Real name for Vanguard—Rearguard; or Offguard . . .

There's renewed talk in Washington of a preventive war (by the same old spielers) should Russia conclusively demonstrate she's too far ahead of us technologically. And a counter-fear that Russia, or more specifically Khrushchev, might try the same just to keep himself in power. Everybody loses either way.

Chess-playing Russia aimed to sputnik on September 17 in honor of space flight pioneer Tsiolkovsky and missed by a mere 17 days. Then before the Reds had lost their advantage, Sputnik became Sputniki. This is pawn position. Next the knights, castles and bishops will move out onto the board, and finally the queen—man into space. Placing half a ton of satellite into an orbit means Russia has the rockets to do this now. Recovery of the dog alive will mean the Reds also have the other necessary knowhow. The West faces a grave and deepening danger.

After the recent AF press conference announcing the results of Project Far Side, the correspondent for one of the nation's leading newspapers remarked bitterly, "My paper detests liars." So does this page. So it aims to put the record straight: Before Sputnik, there were two official attempts to kill Far Side—once last spring when ARDC tried to shift it over to its Cambridge research division or have it eliminated, and once this summer when Asst. Secretary of AF Horner tried to kill it, saying, "AF has no business going to the moon." In both instances Air Force Office of Scientific Research fought hard and won. Second try though (when AF gave in), it categorically refused to grant more money. Thus, taxpayer paid $750,000; Aeronutronics Systems, Inc., put up $400,000 of its own funds. With Sputnik, however, top AF types hailed this as greatest thing ever; now claim full credit for dreaming it up, pushing it through and being so well prepared to hold up our country's honor. And put such pressure on Eniwetok launching teams to hurry up that three shots launched in marginal weather were failures. Credit where credit is due: To Dr. Morton Alperin, Col. Wm. O. Davis, Thomas Wilcox, Dr. S. Fred Singer, Dr. Harold Wooster, Mel White and the men of Aeronutronics and to the Army for having low-cost off-the-shelf rockets available. In August this page wrote: "This page figures the future's for those who stick to the facts; that for those who would cite fact and fiction as one, tomorrow will be rough; end early. And speaking of facts, like dates, those who have reason to fear the first shake should beware the Ides of October."

It's still true after Sputnik as well as before . . . Let's cut the politics; let's quit trying to cover up; let's use the past solely as a classroom; and get on with the job—before the Russians atomize or Siberianize us.

Reports of Soviet 820,000-pound-thrust rocket motor may mean they're well along with T-4, their boost-glide skip bomber . . . Reds also claim to have solved manned re-entry problems with parachutes . . . Feat of atomic-powered Nautilus submarine going 1000 miles under arctic ice pack could have connection with U.S. Navy claims that fleet ballistic missiles can be fired from under arctic ice—by first melting a hole in it.

Chicago University astronomer G. P. Kuiper, using self-designed infrared spectrometer, has decided Saturn's rings are made of snow; there's CO_2 in Martian atmosphere; some of Jupiter's moons also have snow . . . Temple University Research Institute is static-testing liquid rocket engines using 100% pure liquid ozone; also firing LOX with cyanogen to achieve 4800°K combustion temperatures . . . Ultrapure titanium, zirconium, chromium, hafnium, columbium, and vanadium can be made by aluminum reduction of their oxides . . . Gold-bonded transistors show improved alpha cut-off frequencies . . . AF has run up against a stone wall in trying to find name for radar-jammer-jammer.

Anent Pentagon flip-face on giving out missile firing information, this page was warned: They can tell just as little of the truth with a flood of claims and statements as they can by keeping mum. Step's for the good, though.

There's a vernier solid-propellant engine now under development for Jupiter at ABMA-Redstone. It mounts behind nose cone with a break-away nozzle and has some connection with improved terminal guidance, hiked range or both.

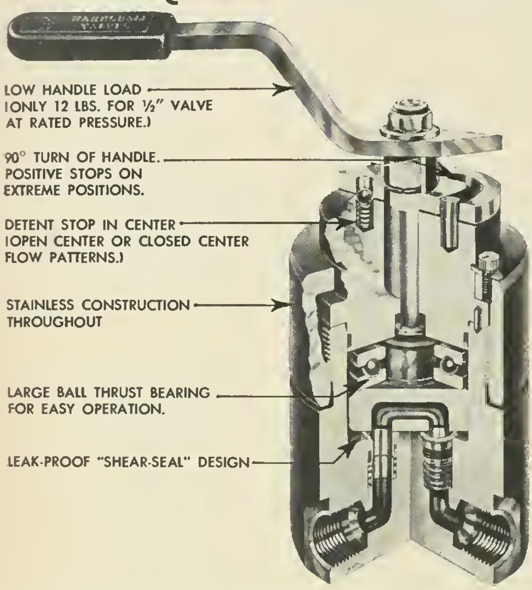
The other night this page listened with respect to a dedicated space flight man who claimed our only hope of getting really ahead of Russia in the current technological race was to cut through—to go directly to the step after next and to work toward putting man into space for 48 hours and safely recovering him. There are some people in qualified positions who think that, with the right management, we could do that within 30 months, and it need not cost many billions of dollars —maybe under $200 million, in fact.

Also a suggestion that the U.S. would do well to establish something outside the military services roughly equivalent to Russia's very active Commission on Interplanetary Travel. And a hope from the people in this country who are worried that Sputnik may have been like an . . .

10,000 P.S.I.

4 WAY VALVE

FOR LIQUIDS OR GASES



This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

This highly successful principle of extreme pressure control is fully described in "Shear-Seal" bulletin BVM-2.

BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

Circle No. 84 on Subscriber Service Card.

SCIENTISTS AND ENGINEERS:

Lockheed Missile Systems offers staff positions at Palo Alto and Sunnyvale, California

(Both facilities are within 38 miles of San Francisco)

Weapon systems management programs at Lockheed Missile Systems call for achievement of a high order in these fields. Assignments are on the Polaris Intermediate Range Ballistic Missile program and other extremely important activities.

Aerodynamics

Theoretical and experimental investigations of the aerodynamic characteristics of missiles at Mach numbers through the hypersonic range; optimization of controlled missile performance; specification and supervision of experimental aerodynamic investigations required to verify and improve missile and weapon system design; analysis and interpretation of aerodynamic flight test data.

Flight Dynamics

Analysis of missile dynamic motion and establishment of stability and control systems criteria for trajectories with 3 or more degrees of freedom; development of techniques for the analysis and interpretation of flight dynamics test data at hypersonic speeds; study of special dynamics problems arising during preliminary design and development of missile systems.

Thermodynamics

Boundary layer and heat transfer analysis in hypersonic flow fields such as pressure gradient- and real-gas effects; analysis of thermodynamic performance of missiles in continuum flow, slip flow and free-molecular flow; calculation of transient structural and equipment temperatures resulting from aerodynamic heating and radiation; specification of ground tests and flight tests required to verify and improve thermodynamic design of missile and weapon systems; analysis and interpretation of thermodynamic ground test and flight test data.

Engineers and scientists are invited to address inquiries to: Research and Development Staff, Palo Alto 7, Calif.

Lockheed

MISSILE SYSTEMS

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

Palo Alto · Sunnyvale · Van Nuys California

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Missile Business

By Seabrook Hull

THE ADMINISTRATION CAN DO NOTHING of a major nature for weeks, maybe months, to try and counteract *Sputniki*. A combination of the statutory national debt limit plus the expenditure accounting system now employed mean that there is neither money nor obligational authority for moving quickly. The Administration is hog-tied until either Congress raises the debt limit, the expenditure accounting system is dropped or tax revenues as a result of 1957 earnings start coming in. This last will result in an easing of the situation by about mid-January, 1958.

WATCH CONGRESS FOR THE TIP-OFF on the how's and when's of a major reorganization of our missile effort. Almost to a man, the House and Senate are stung (a) by Russia's technological surge ahead and (b) the Administration's efforts to laugh it off. There has been a basic loss of confidence by the American people which Congress feels probably more than the White House.

Any precise forecast of just what the next 12 months hold for our missile, rocket and space flight effort obviously isn't possible. However, you can get a pretty good idea by running down the list of probables, based on public statements by the Congressmen and on private conversations by m/r editors. Two basic things are certain: The final result will be a major reorientation of our whole space flight and missile program. And, it will mean more missile money for you—or less.

HERE'S HOW CAPITOL HILL THINKING IS GOING—a list of the actions that will be considered, some of which you can count on being adopted:

A NATIONAL ADVISORY COMMITTEE FOR ASTRONAUTICS—a wholly independent, nonmilitary agency drawing on the best from all sources to make U.S. space flight effort a No. 1 priority project, like Russia's Commission for Interplanetary Travel. Russian *Sputniki* are Russian—not Army, Navy or Air Force—satellites.

A JOINT CONGRESSIONAL COMMITTEE FOR ASTRONAUTICS, similar to that now in being for atomic energy, to keep constant watch on our progress in space fight.

A DEPARTMENT OF SCIENCE with a scientist in the Cabinet—to assure optimum efficiency in fighting Russia in the technological struggle.

A COMPLETE SERIES OF INVESTIGATIONS by several major Congressional committees, such as Appropriations, Armed Services, Government Operations and Atomic Energy. These will be aimed not so much at fixing the blame for our current lagging position as they will be aimed at finding out why and what can be done now to remedy the situation. In these hearings Congress will rely heavily on people in Government.

NO CUTBACK NOW ON MANNED AIRCRAFT until new weapons are really available, but maybe a major effort to jump way ahead with such projects as boost-glide skip bombers, manned satellites, a true space force, man on the moon, etc. This means a budget increase and a major reshuffling of current emphasis.

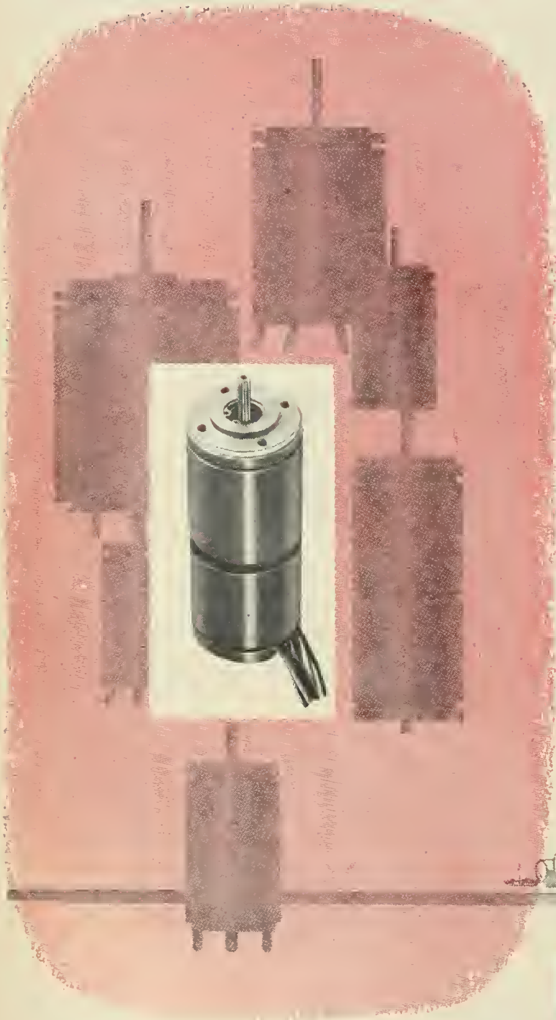
OPENING THE FLOODGATES OF MONEY is definitely not in the cards. Selectivity is a must. Congress will insist on it, being pretty much convinced the fault was not how much money but how it was spent.

A MAJOR LOOK AT EDUCATION is also certain. In this instance, *Sputnik* may provide the incentive to really do something about increasing teachers' pay and bringing school capacity up to population. Also, there will will be a real effort to revamp what is taught, when and how. This means more emphasis on mathematics and the physical sciences in grade and high schools. It may also mean a Federally supported system of scholarships to assure that those young people with promise get the chance to go to college.

MORE PAY AND RECOGNITION FOR GOVERNMENT SCIENTISTS is a good bet. Also, Congress may suggest that industry develop some means of rewarding its technological manpower other than by promoting them into administrative jobs.

EDISON MINIATURE -- HI-TEMP

servo systems and components



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TYPE OF MOTOR	TWO PHASE SERVO MOTOR-DAMPING GENERATOR
NO LOAD SPEED (MIN. RPM)	5800
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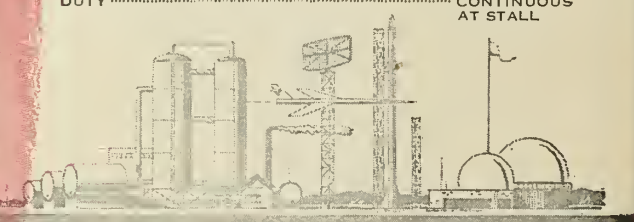
POWER INPUT TO MOTOR AT STALL (NOM. WATTS/PHASE)	3.5
SPEED AT MAX. POWER OUTPUT (RPM)	3300
TORQUE AT MAX. POWER OUTPUT (OZ. IN.)	.31
THEORETICAL ACCELERATION AT STALL	34,800 RADIANS/SEC.[2]
TIME CONSTANT	.019 SEC.
POWER INPUT TO GENERATOR AT STALL (NOM. WATTS)	3.5
OUTPUT VOLTS AT 0 RPM (MAX. RMS)	.019
OUTPUT VOLTS PER 1000 RPM (MIN.)	.5
PHASE SHIFT (MAX.)	10 DEGREES
DUTY	CONTINUOUS AT STALL



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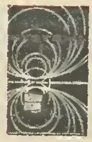

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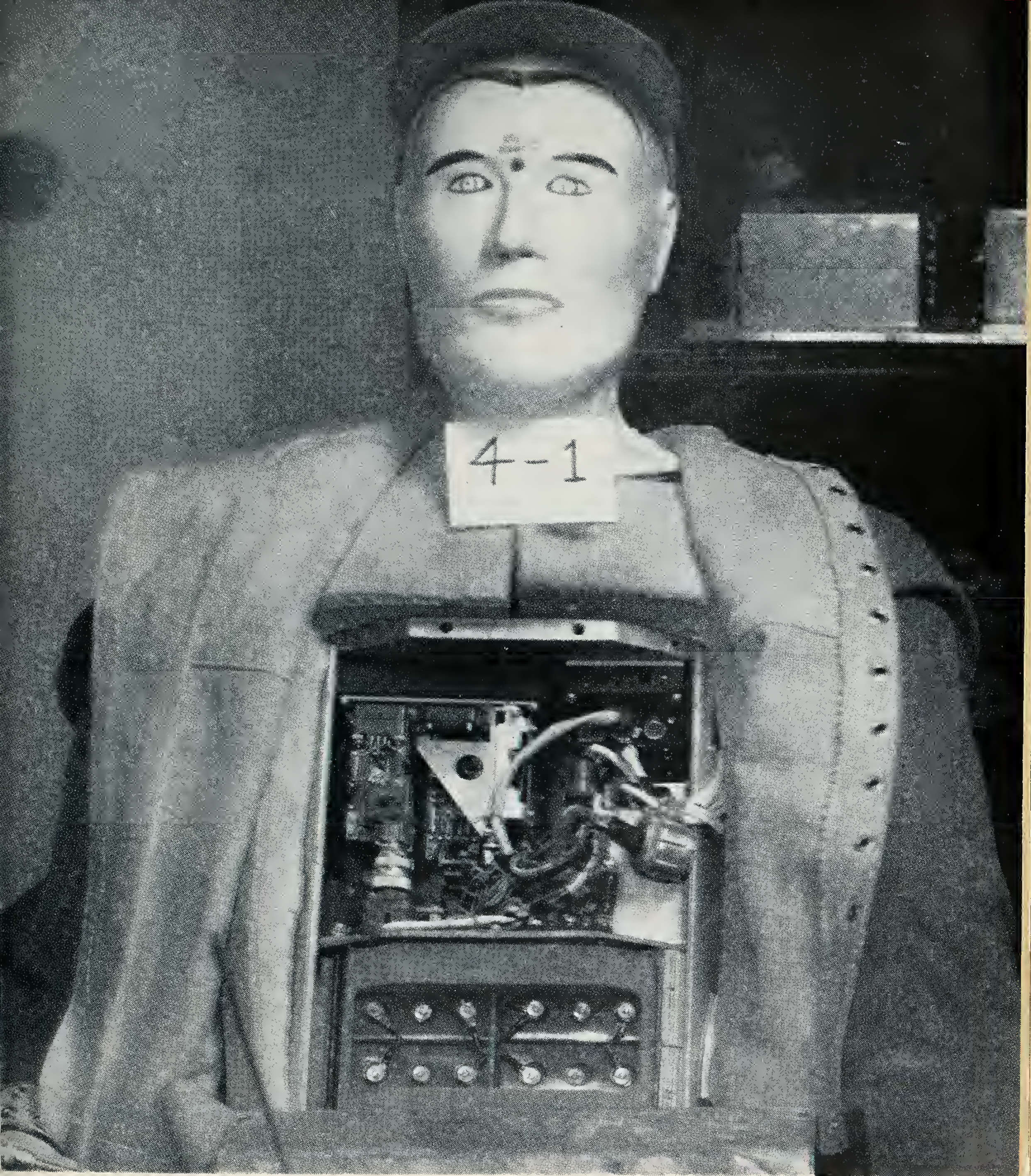

missile electronics

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		Input Voltage (400~)	Input Current (Amps.)	Input Power (Watts)	Output Voltage (Volts)	Sensitivity (MV/deg.)	Phase Shift (deg. lead)	Input Voltage (400~)	Input Current (Amps.)	Input Power (Watts)	Output Voltage (Volts)	Sensitivity (MV/deg.)	Phase Shift (deg. lead)	Rotor (Ohms)	Stator (Ohms)	Zro (Ohms)	Zso (Ohms)	Zrss (Ohms)		
Torque Transmitter	CGC-8-A-7	26	.100	.5	11.8	206	8°	—	—	—	—	—	—	37	12	54 + j260	12 + j45	80 + j20	30	7
Control Transmitter	CTC-8-A-1	—	—	—	—	—	—	11.8	.090	2	23 5	410	9°	150	24	212 + j684	22 + j115	246 + j60	30	7
Control Transformer	CTC-8-A 4	—	—	—	—	—	—	11 8	.029	.08	22.5	390	8°	389	64	560 + j1860	90 + j340	640 + j190	30	7
Torque Receiver	CRC-8-A-1	26	100	.5	11.8	206	8	—	—	—	—	—	—	37	12	54 + j260	12 + j45	80 + j20	30	30 sp.
Electrical Resolver	CSC-8-A 1	26	.038	42	10.8	190	20	11 8	.078	26	23.2	400	11°	230	27	286 + j620	45 + j148	350 + j75	30	7
Electrical Resolver	CSC-8-A-4	26	.038	42	26	454	20	26	.030	.23	21 5	375	12°	230	170	286 + j620	250 + j830	350 + j75	30	7
Control Differential	CDC-8-A-1	—	—	—	—	—	—	11 8	.085	.21	11 8	206	9°	36	25	38 + j122	27 + j120	48 + j14	30	7
Vector Resolver	CVC-8-A-1	26	.057	.34	11.8	206	10.2	—	—	—	—	—	—	78	27	103 + j440	8 + j30		30	7

LOOK TO CPPC FOR SYNCHRO PROGRESS

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missile electronics vol. 1, no. 2

contents

missile electronics news

special features

Will commercial TV networks interfere with missile technology?

Limited space in the radio spectrum allocated for radio telemetry is creating a serious bottleneck in missile performance data-gathering. AAP Electronics Editor Henry Steier discusses the importance of telemetry in the transition to unmanned flight (page 149).

What are the applications of electronic components miniaturization in the missile system?

In missile evaluation the Micromation (miniaturization) concept is being applied to computing, controlling and indicating functions of complex missile systems. Sidney Herman of Waldorf Instrument Co. introduces typical applications of the Micromation system (page 154).

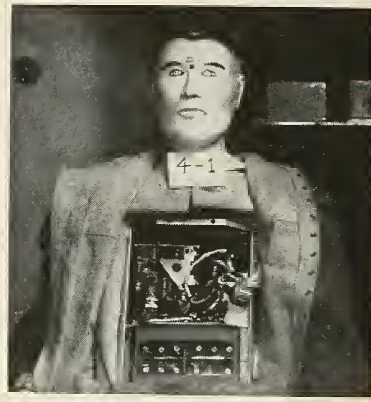
Is it necessary for specialized precision instrumentation to be confronted with continuing obsolescence?

Walter H. East, Vice President of Electro Instruments, Inc., presents one solution to the problem of obsolescence. An integrated modular instrument design is capable of combining and integrating with other instruments to form complete data-handling and automation systems (page 160).

How can missile training costs be reduced?

Expenses have been greatly reduced in the training of guided missile operators by use of electronic devices instead of actual missiles. An m/e editor, Frank McGuire, describes the system produced by Giravions Dorand, a French firm (page 166).

cover picture:



Hurricane Sam, an anthropomorphic dummy, is the star performer at the SMART test track located at Hurricane Mesa, Utah. Base cost of Sam is $3000 and when fully instrumented costs $10,000. Tests with Sam have been conducted to investigate the F-94C ejection seat at a speed of 600 mph. The dummy was ejected about 11,000 feet down the track from the breech end. However, Sam did not separate from his seat and, as a consequence, became a battered dummy on the mesa slope below the muzzle end of the track. Sam's instrumentation was designed to withstand the tremendous accelerations and impacts encountered.

departments

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washington briefs

BATTELLE MEMORIAL INSTITUTE in Washington says it is studying the effects of radiation damage to semiconductors under an ARDC contract. Details of the mechanism of radiation damage will aid in selecting semiconductor materials for use where radiation is a potential hazard.

NATIONAL BUREAU OF STANDARDS here is conducting research on the chemical and electrical properties of solid wax electrolyte batteries. A new field of battery research, the investigation is expected to help in understanding the phenomena that takes place in wax electrolytes subjected to electrical fields. It may also show better methods of fabricating such batteries.

TWO NEW ELECTRONIC STANDARDS for the electronics industry have been published by EIA in Washington. They concern fixed film resistors (high stability) and power filter inductors for electronic equipment.

ATOMIC ENERGY COMMISSION is asking for bids from qualified companies for preliminary studies on a compact nuclear reactor system for military use. The Department of Defense wants a mobile powerplant with moderate power rating (up to 2000 kilowatts net electric output), extreme compactness and low weight.

AIR MATERIEL COMMAND'S Brigadier General Ben I. Funk has told the West Coast Electronics Manufacturers Association that almost every subsystem of the ballistic missile is almost totally dependent on the successful application of some type of electronic hardware. In view of this, he added, "it becomes apparent that we not only want your participation in our program, but that we need it badly."

RELIABILITY AND QUALITY CONTROL SYMPOSIUM will be held in Washington from January 6 to 8, at the Statler. Papers will be presented by more than 40 industry authors and those from the military, government and research institutions. Open panel discussion on reliability definitions will be moderated by C. M. Ryerson of RCA.

RADIO ASTRONOMY has given rise to a new method of using solid-state amplifiers which give 20- to 30-db improvement over noise problems. The technique is applicable from 1500 mc to the infrared portions of the spectrum.

WESTINGHOUSE RESEARCH LABORATORY has developed a magnetic steel which allows magnetism to turn around corners, and which promises to improve the performance and simplify the construction of electrical apparatus. Named Cubex Steel, the material is a major scientific breakthrough for the electrical industry and is technically known as "cube-oriented silicon-iron." Crucial characteristic of the steel is its unusual ability to be magnetized easily in four directions, eliminating the need for piecing a magnetic core together.

TESTERS FOR ELECTRONIC TESTERS have been developed for ARDC to calibrate and adjust AF electronic equipment for maximum accuracy.

USAF IS HAVING A HARD TIME finding a term for the device to jam radar jammers. As in the anti-anti-missile-missile-missile (one that destroys anti-missile missiles), they are afraid it will be the start of a chain—such as counter-countermeasure device . . . and here we go again.

HOW BIG IS *SPUTNIK* I? Electronics experts are wondering. Andrew Ledwith, Smithsonian Astrophysical Observatory technician, figures that it is either 16.7, 33.4 or 66.8 inches in diameter. He bases his figures on the size of the antenna and the frequency it broadcasts on.

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missile electronics news

Raytheon Occupies New Facilities

Raytheon Manufacturing Co.'s missile systems division headquarters will move into a new 40,000-square-foot office and laboratory building in November. Completely air-conditioned, the building will be located on a tract of slightly more than four acres.

Raytheon is prime contractor with complete systems responsibility for both the Army *Hawk* and the Navy *Sparrow* III missiles. The division has plants or laboratories in Bedford, Lowell and Andover, Mass., and Bristol, Tenn. It also maintains flight test facilities at Oxnard, Calif., adjacent to the Naval Air Missile Test Center, Point Mugu, Calif., and at the Army's White Sands Proving Ground, N. M.

The division employs more than 6800 employees and occupies about one-third the total manufacturing space of the company.

Army Tracks Satellite With Direction Finder

The Army's newest high-power direction finder has been brought to bear on *Sputnik*, assisting in tracking its orbit as far as half way around the globe.

The high-precision radio sentinel at the U.S. Army Signal Engineering Laboratories, Fort Monmouth, N.J., is one of the more recent additions to the military electronics arsenal and is capable of pinpointing signals in any part of the earth, and far out into space.

Alerted shortly after the satellite's launching, the direction finder has sighted and followed the sphere by radio almost every time it circled the earth.

The high-precision equipment, designed to pinpoint enemy radios in combat, is in operation 24 hours a day scanning the skies for the satellite's faint radio beep. On contact, a propeller-like pattern flashes on the electronic viewing screen to give operators a direct and continuous angular bearing on the sphere.

At the same time the Army Signal Corps' latest high-power combat receivers were in operation and picked up the satellite's signal during 50 consecutive revolutions, intercepting it both directly and via the long path around the world, spanning a distance up to 24,000 miles.

Electronic Engineering Co. Leaves Canaveral

The Electronic Engineering Company of California has closed its Florida division offices and transferred the research and development operations at Cape Canaveral Missile Test Center to the company's main laboratory in Santa Ana, Calif.

Electronic Engineering designed and developed missile-range instrumentation equipment for the base, including the timing system, several digital data-transmission systems, radar installations, plotting-board instrumentation and other special work. Total cost of the work was in excess of $4 million.

The company first established a Florida division during the early development of Cape Canaveral as a test base in 1950.

Transfer of operations resulted from the reduction in field engineering needed to integrate new equipment into the instrumentation system as the field office at Patrick Air Force Base is no longer required. Operation of the test range is under the joint management of RCA and Pan American Airways.

Hallamore to Produce TV For Remote Operations

Contracts totaling nearly $300,000 for closed-circuit TV systems to monitor rocket engine and missile testing have been awarded the Hallamore Electronics Co.

The systems, two of the largest ever developed for this purpose, are being installed for the Army's guided missile center in Huntsville, Ala., and The Martin Co.'s *Titan* ICBM program in Denver.

Under the two orders, Hallamore will provide a total of 46 systems, each consisting of a receiver, a single multiwire connecting cable, and a camera capable of withstanding the white-hot exhaust blast of rockets. Each system affords intercommunication between receiver and camera locations as well as remote control of camera lens position and pan and tilt action.

Scheduled for completion early in 1958, the 24-system installation for The Martin Co. was described as one of the largest in the nation. The Army Ballistic Missile Agency installation consists of 22 systems.

Tele-dynamics Completes Philadelphia Plant

Tele-dynamics, Inc., manufacturer of telemetry systems, has completed occupation of a new plant in Philadelphia, Penna. The plant contains advanced facilities for research, development engineering and production of electronics equipment. It occupies about 100,000 sq. feet.

Aircraft Firms Pay for Missiles

Aircraft companies working on ballistic missiles are contributing a large part of the cost of the programs, according to Orval R. Cook, president of Aircraft Industries Association. In making the statement, Cook cited figures furnished by Brig. Gen. Ben I. Funk, ballistic missiles manager for AMC.

From the time that acceleration of the ICBM and IRBM programs was ordered in 1954 until July 1957, the government invested nearly $200 million in new facilities to build the weapons, according to Funk. During the same period, the contractors on on the *Atlas, Titan* and *Thor* programs provided about $100 million of their own funds for the same purpose.

Bendix Computer Division Opens Office in New York

Bendix Aviation Corp.'s computer division has opened a new district office to handle sales, service and applications of its general-purpose electronic computer and accessories in the New York area.

The company pointed out that Bendix computer division now ranks fourth in size among electronic computer manufacturers.

Largest Analog Computer Installed at Convair

The largest direct analog computer ever built is now being installed in facilities of the Convair Division of General Dynamics Corp., Fort Worth, Texas. The $700,000 machine was designed and built by Computer Engineering Associates, Inc., Pasadena, Calif. When assembled, the computer will have a total length of 91 feet.

The unit will be used for the flexible modeling of missile and aircraft systems. The computer makes use of the analogy which exists between electrical circuit networks and physical systems. Such physical systems as mechanical, elastic, thermal, hydraulic, fluid flow, and even nuclear systems are describable mathematically by equations identical in form to those which describe electrical system networks that are either predominantly or entirely made up of passive elements—resistors, capacitors and transformers.

The capacity of the direct analog computer to represent complex systems exceeds that of conventional electronic analog computer installations. The value of the direct analogy is particularly evident in observing the effect of changes of system parameters on system behavior.

Radiation Effects on Electronics Studied

Boeing physicists have initiated a series of studies to determine the effects of nuclear energy on transistors used in the IM-99 *Bomarc* missile. From the tests, the physicists hope to establish the vulnerability of the missile's electronics system to radiation from an atomic bomb explosion.

The tests have been conducted near atomic pile sites at Arco, Idaho and Los Alamos, N.M. Transistors, operating in an electronic circuit, are exposed to nuclear radiations in these tests. Oscilloscopes show how the transistors are functioning and what changes are caused by the radiation.

Experience has shown that three things can happen to a missile in the vicinity of an atomic explosion: first, a sudden overpressure which is powerful enough to rip off wings if the missile is too close to the center of the explosion; second, a searing blast of heat that could burn up the missile; third, the effect of nuclear radiation.

Because damage from nuclear radiation has a longer range than does damage either from overpressure or from blast heat, *Bomarc* physicists are working to solve that problem as it affects transistors.

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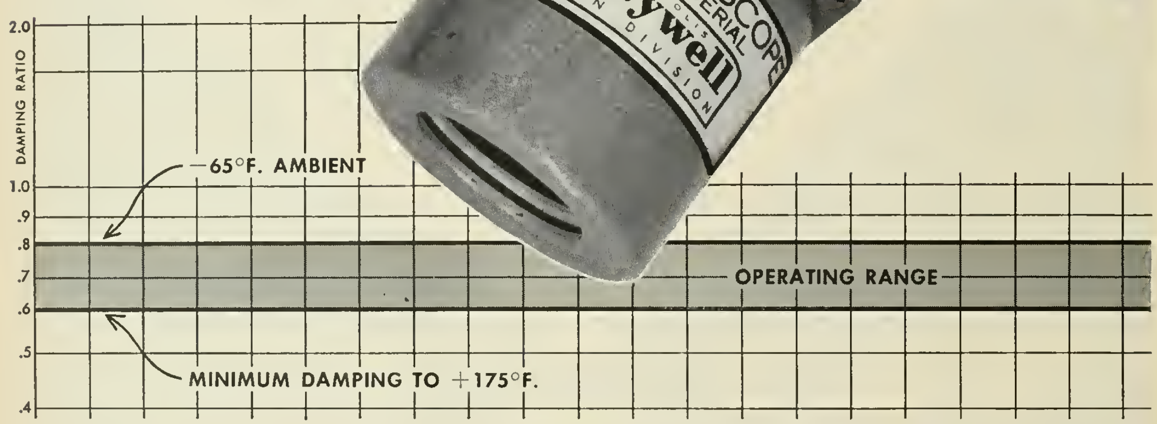

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astrionics

By Henry P. Steier

TRUE STORY OF RUSSIAN SCIENTIST A. A. Blagonravov's visit to Naval Research Laboratory's Minitrack I test facility at Blossom Point, Md. In Washington for the International Conference on Rockets and Satellites as part of the IGY, Blagonravov accepted an invitation to hear first U.S. recordings of Sputnik's signals. Listening for a while, he then remarked, "Da, I recognize the voice."

SPUTNIK (or more correctly Spootneck, which means "fellow-traveler") is causing more than anxious thoughts on the state of U.S. missile science. It's delaying to some extent development of gyros and accelerometers for our missiles. Word comes from Minneapolis-Honeywell Co. Aero division engineers that every few hours Sputnik's 20.004-megacycle signal raises havoc with some of their precision gyro measurements. Basic timing standard used by M-H engineers is Bureau of Standard's 20.000-mc transmission from station WWV. Difference between it and Sputnik's signal is only four kilocycles. This causes beats between the two. Engineers wonder how long they'll have to live with the interference.

WHOPPING LONG ANTENNAS are trailing along with Sputnik. Two antennas are used to handle the 20- and 40-mc transmissions. There are four antenna elements. Two are nine feet, six inches long; two are seven feet, 10½ inches long. Rather than mounted around the hemisphere of the satellite ball, they are mounted on one side and appear to be designed to act as trailing elements.

ALL THIS TALK ABOUT "EXACT" KNOWLEDGE of the Sputnik's orbit based on our calculations should be taken with a grain of salt. Some good data has come from optical measurements. However, considering the available optics, poor weather and the radio tracking limitations, the orbit calculations leave much unknown.

CAUGHT UNAWARES WITH ITS MINITRACK I and II stations tuned for our 108-mc frequency, the engineers at NRL have been operating under full steam to convert quickly. Main reason for choice of 108 mc was low ionospheric refraction of radio beam at that frequency. Refraction is 6¼ times worse at Sputnik's frequencies.

AT 108 MC, A TRACKING ANTENNA giving good angle resolution and non-ambiguity can be built on a 500-foot base line. Much more space is needed for lower frequencies. So we are still handicapped by the real estate thus far acquired and although our engineers are converting Minitrack I and some of the simpler type II stations to track the 40-mc frequency, the angle resolution will be limited. Higher frequency was chosen as best of the 20-40-mc evils. Refraction goes down as the square of the frequency.

DESPITE THE SUPERB PERFORMANCE of Army's *Jupiter* flights with high accuracy (Astrionics column, September), it appears the Air Force has a good argument for its use of floated gyroscopes instead of air-bearing types in the ICBM's control system. Top floated-gyro engineers say that producibility and performance repeatability problems plague air-bearing gyro producers. AF arguments for its missiles always hinge on producibility of the whole weapon system.

IS SPUTNIK'S SIGNAL CODED or not? Engineers who have watched the signal on oscilloscopes say it definitely appears to go from unmodulated to modulated wave forms. The regularity indicates it's strictly a matter of periodic switching and not atmospheric problems. A separate group of government researchers are tackling the decoding aspect but don't hold much hope for results.

NO GETTING AWAY FROM IT!

Here's the Army's answer to a major problem in U. S. defense. Hawk, recently-revealed missile, hunts and destroys invading aircraft *even at tree-top altitudes!*

Raytheon radars of unique design give Hawk its amazing low-level ability in the blind zone of conventional radars.

This aptly named 16-foot missile is launched from fixed installations for the defense of U. S. cities. Highly mobile, Hawk can also travel with fast-moving land forces, or be carried by helicopter or plane.

Raytheon, with more than a decade of pioneering in guided missiles, is prime contractor for the complete Hawk weapon system.

RAYTHEON *Excellence in Electronics*

RAYTHEON MANUFACTURING COMPANY, WALTHAM 54, MASS.

telemetry for tomorrow:

TV allocations and split responsibility hamper rapid missile progress

By Henry P. Steier

IS U.S. TELEVISION broadcasting hamstringing our missile technology? One official of a key astrionics company thinks so. Many informed observers in the industry have implied it at professional gatherings.

MISSILES AND ROCKETS has learned that limited allocation of frequency space for telemetry and divided responsibility for data handling pose grave bottlenecks in achieving U.S. missile supremacy. This, from a company which has done an outstanding job getting the results of missile tests to prime- and subcontractors.

The company is Radiation, Inc., Melbourne, Fla., which since 1950 has played a significant role in that part of missile technology which might be termed "the silent service." It designs, builds and uses astrionics gear which tells missile engineers how their brain children are performing.

The business is the quiet part of an industry of ear-splitting rocket exhausts. One word, *speed,* probably keynotes a major part of Radiation's work. From the start the company dedicated itself to finding ways and means of quickly getting, and reducing to the language of computers, the data that comes from a myriad of wavy oscillographic records on flights of manned and unmanned vehicles.

Starting out as an engineering group which designed systems for acquiring data from manned aircraft, the company now finds an increasingly bigger job for itself during the transitional period from aircraft to missiles.

New, giant ICBM tracking antenna designed by Radiation, Inc. Unique feed system at center of the reflector gives conical scan. Antenna automatically homes on telemetered signals from the missile. Rate-memory circuit continues tracking during fadeout or noise period.

Conrad H. Hoeppner (left), technical advisor, and George S. Shaw, vice president for engineering, Radiation, Inc., which is equipping Air Force test range from Cape Canaveral, Fla., to Ascension Island with ICBM tracking telemetry antennas.

This is because, with man eliminated, engineers are forced to collect far more data through telemetry. As the distance over which the vehicles operate has increased, data reception problems have multiplied.

Today, Radiation is the prime contractor for the world's largest automatic tracking telemetry antennas. They were specifically designed for our ICBM program. From these antennas will come the first indication that the U.S. has a workable ICBM.

Four of the 60-foot diameter, 1000-mile range, supersensitive antennas are being built. One is already in place on the island of Antigua, BWI. The others will be installed at Cape Canaveral, Fla.; Fernando de Noronha, Brazilian penal colony island; and Ascension Island, 5080 miles from the start of the range. One will be a spare.

The extremely long range of Radiation's TLM-18 antenna system will also make it useful for satellite and interplanetary rocket programs. It has a high gain of 28 decibels and the 1000-mile range is achieved when missile-borne transmitters use 30 watts power.

Located at the focal point of the 60-foot reflector is a rotating-lens system made up of 60 metallic disks. The feed to the lens system is off center and rotated at 10 cycles per second to produce a conical scan pattern.

The lens disks are rotated together at 600 cps in front of a wave-guide feed and form an artificial lens. Result is illumination of the target area at 10 cps and an overall beam pattern about five degrees wide. The lens is covered with a fiberglass dome.

The tracking system includes a rate memory device so that during momentary signal fadeouts the antenna will continue automatically to track the target. Tracking will continue up to 20 seconds after a fadeout.

Radiation's vice president of engineering, George S. Shaw, has expressed alarm at the lack of attention which data collection and processing have been given in U.S. missile efforts.

"There is no shortage in American industrial capability to put the hunks of sewer pipe together and fly the things," he said. "It's not like putting together a complicated airframe structure such as the B-58 where we know millions of man-hours and chronological steps are needed so you cannot shortcut."

With a missile, Shaw explained, even though the full vehicle development is incomplete, you can fire it and get information. But, he contended, this is not doing the good it should.

One of the gravest bottlenecks in getting data back to engineers on missile performance, Shaw said, is the limited space in the radio spectrum allocated for radio telemetry. Legally radio telemetry has been allocated a 20-megacycle wide-band split between the 220- to 235-mc region. The myriad telemetry users must all share the same 20 mc, often on a time-shared basis, which delays tests. Some bootlegging is allowed on a noninterference basis from 235 to 265 mc.

"Now with so much of our national defense depending on these missiles and aircraft," Shaw said, "telemetry has to be used for missiles, aircraft and atom bomb tests. Every form of data collection, tied together by radio, uses the narrow assigned bands.

"This is essentially the band width that we use for three or four television stations, and almost every city of 100,000 to 200,000 has that much band width allocated to it for television for pleasure. Thus we have allocated TV bands from about 500 mc to 1000 mc, or 500 full megacycles, which we have only used on a scattered basis."

And he added, "It is completely incongruous situations like this that are degrading our technical outlook." Arguing for better government control of our band space resources, Shaw said, "Let them squander a little of this (TV) band on radio telemetry in the same way we squander gasoline and tires on Sunday afternoon.

"Certainly the Soviets have no TV-channel interference problems. If they did, they'd put them off the air. They've put the problem at a higher level of importance than we have. Let's hope we can be as dynamic in changing our ways as Russia was after 1945.

"We sort of hamstring ourselves in the way we work things out. Telemetry is especially important during this transition to unmanned flight. The cycle will reverse, however, at some point and may occur sooner than you think. Probably it will occur on the Soviet side first because of their difference in philosophy on the value of human life. The cycle will reverse back to the manned vehicle." This will not eliminate the telemetry need, but will ease the problem and enable use of man to read data.

In the 2000-mc band there are 100 mc available to telemetry users. However, use of the space is surrounded by problems. Interference with certain radars occurs. Transmitting equipment for a given efficiency gets much larger because of the microwave plumbing needed.

At 200 mc, an input of 200 watts gives an output of perhaps 100 watts. To get the same power at the higher frequency, 600 watts input would be needed. This is a big handicap when batteries or solar cells are used as in a weight-sensitive satellite or missile.

To get the same antenna gain at the higher frequency as the low, the antenna aperture must be the same. But the beam angle goes down. In the case of Radiation's 200-mc ICBM tracking antenna, the beam angle is about five degrees. If the frequency were 2000 mc, the angle would go down to one-half degree. This would seriously affect ability to track the missile and raises the probability of its loss if its trajectory becomes erratic.

Shaw said very little money has been spent on R&D for 2000-mc telemetry. The advent of further developments in the use of the MASER (magnetic amplification by stimulated emission of radiation) might aid the efficiency-weight problem. But such developments are in the multimillion dollar bracket.

Another advantage predicted by Shaw if low-weight MASERs are built is increased missile accuracy. Net effect of using the ultra-high frequency stability of the MASER might be to increase ICBM accuracy within five miles, he believes.

Radiation together with other companies is doing whatever is possible to shorten the time lag brought about by data reduction. At this time the company uses FM/FM pulse-width modulation equipment for data transmission. On the ground this is converted to pulse-code modulation for input to the computer.

Every one of the IRBM and ICBM programs have been aided by Radiation's work either in the form of components or systems. Data-processing equipment supplied for the B-58 program was a recent contribution to the aircraft field.

The equipment assembled by Radiation is not necessarily made by the company. Most of it is purchased and modified to suit the needs of a specific system.

Shaw said, "Certainly we are not needed from the standpoint of production. We have never produced large quantities of equipment and don't intend to build a large production outfit. The nation has that capacity. What we do need is the capability to engineer specific hardware required in a small quantity. There is where Radiation fits in."

When a missile contractor is given a job to produce a missile, he does not develop new means of instrumentation. It is specifically written that he use available test-equipment facilities. He does not have R&D money for improved instruments. All he can do is repackage what is available to suit his vehicle.

"The telemetry industry has not and dares not, for economic reasons, to proceed developing lines of needed equipment. Quite frankly, there are few new instrumentation techniques that go beyond merely repackaging, stabilizing a transmitter a little better or improving the gain of a receiver.

"Beyond this, you get into millions of dollars investment, and dollar sales have not warranted that the electronic giants spend the money on R&D. So the prime sources of R&D have failed to provide new telemetry and dynamic instrumentation at the rate needed for the satellite, ICBM and moon vehicle problems," Shaw explained.

Another serious bottleneck is that radio telemetry in the United States has been a split responsibility.

First, the vehicleborne equipment is the responsibility of the prime contractor. But the missile test centers have responsibility for the data-collection equipment, and some data-reduction equipment. Some of the data-reduction job goes back to the prime contractor.

This split responsibility wastes time and missiles. This is because of hours, days and even months spent in reducing the data or transferring it to different interests, since some of the reduction is done by the prime contractor, who might be thousands of miles away.

If the contractor gets the information on magnetic tapes in oscillographic form, it must reduce the records to numbers before calculations can be made and decisions reached on a vehicle or subsystem's performance.

"The thing that gets so important here is that with our missile production capability we can fire test missiles at a fantastic rate on a weekly or monthly basis. The only thing is that with our data handling techniques it might well be three or four months before the data is fully available for modification of how the next test should take place," Shaw told m/r.

And he added, "We probably partially waste two vehicles. We fire simply because we don't know enough about the first flight to go right ahead and do something immediately."

An example of how time is wasted because of limited data-processing capability is the procedure by which a missile contractor might reduce the data supplied to him on a magnetic tape.

Some companies use lines of girls who read the paper oscillographic tapes manually and put the information in digital form on a consolidated record. Punched cards are made from these, and then run through a computer.

This is not altogether necessary with today's advances in data acquisition and automatic reduction. One of Radiation's major efforts is to design and fit together systems to telemeter, process and reduce data to digital form on magnetic tapes. In this form it is compatible with high-speed input capability of digital computers.

Some companies such as AC Spark Plug and General Electric have recently built advanced data-reduction systems to shorten the time lag. Building systems for other companies to do fast data reduction is a primary job of Radiation's data systems division.

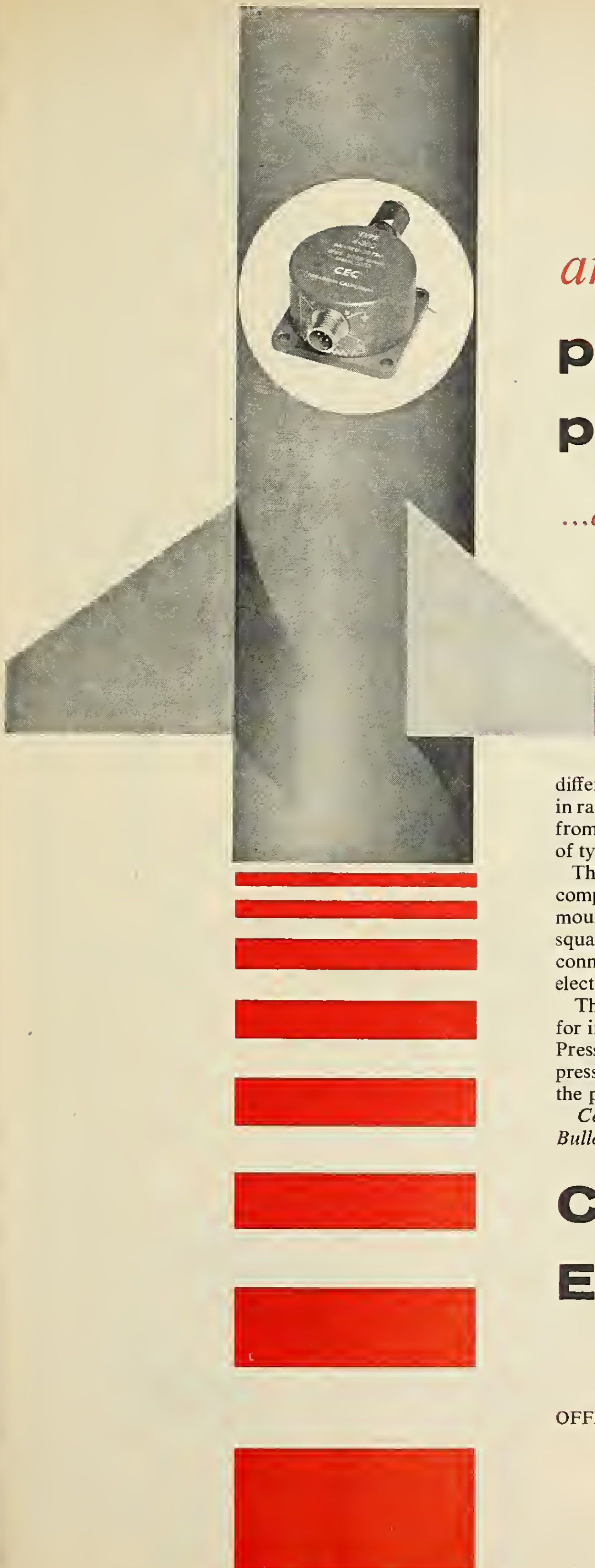
Needed badly is some form of more accurate acquisition in the vehicle. Some form of pulse-code modulation equipment in the vehicle would speed up data reduction. Next step after that would be to pick up the information in digital form.

If this were done, the digital data could be telemetered directly into a computer and the test results would be available almost immediately for assimilation by engineers.

The field for development of digital transducers is wide open, but lack of money for the R&D presents a pessimistic picture for any early big gains in this field. Radiation has entered the field of developing digital transducers because of the tremendous potential.

The company was started by its president, Homer R. Denius, and Shaw with a capital outlay of $25,000. Preliminary estimate of 1957 sales is $7 million. There are five operating divisions: research, data systems, RF, instrumentation and product. The company also has facilities at Orlando, Fla., as well as a nationwide organization.

A systems research group was recently added to the company to study potential fields of endeavor. It includes Lloyd Everyingham, James Brantley, John Doolittle, Armand Tanguay and Don Rhodes, all formerly with Cornell Aeronautical Laboratory. L. W. Sieck, formerly with AF Development and Planning Board, is also with the new group. ★



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OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

micromation for system miniaturization

Missile applications have supplied the catalyst for coordinated miniaturization

By Sidney Herman
Waldorf Instrument Co.

RECENT efforts in missile instrumentation have concentrated on independent element miniaturization. Solving the problem of miniaturizing the overall system required more than mere selection of miniaturized elements and components. The functional unit had to be considered as an entity, and each designed with respect to the other parts in the functional system. The design process is a closed-loop in which the basis for selecting any one component depends upon feedback from other elements in the loop.

Application of this design philosophy to coordinated system miniaturization is Micromation.

The Micromation concept has been applied in missile evaluation to typical computing, controlling and indicating functions which are parts of more complex systems. The systems include ground test equipment, preliminary firing, checkout units, and analog converters used in missile guidance. It is possible for the design engineer to proceed directly from his system block diagram to procurement of functional modules after specifying inputs and outputs. The intermediate stage-by-stage design is eliminated.

A common instrumentation problem is that of servoing data. Input data may be received from any one of a number of transducers: synchro, potentiometer, strain gauge, thermocouple, etc. The desired output is a shaft rotation equal to a function of the input value, linear or otherwise.

In the normal design process, this functional block would be broken down into subunits as shown in Fig. 1. Requirements for each unit would be analyzed and performance specifications established. Some requirements would be compromised to permit use of available components.

As a result of the Micromation process, a proof-tested combination of miniaturized subunits is available and is assembled into a functional module. This module performs the desired servo repeater operation with matched subunits, in minimum size and weight, without sacrificing power, reliability or ease of maintenance.

As a further result of the Micromation process, the burden of subsystem engineering is shifted from the system designer to specialists. The functional module incorporates the latest proven techniques of miniaturization and subsystem design.

One of the first examples of a Micromation product is a completely self-contained synchro-type servo-repeater module presently in production at Waldorf. The unit, Model No. W1801, is two inches in diameter and four inches long. It contains a transistorized servo amplifier, size eight servo motor and control transformer, power supply, and gear head. One of the preliminary models is shown in Fig. 2. Each component is also constructed as a miniature modular assembly thus maintaining a simplicity of maintenance. Fig. 3 shows each of the components that, when assembled, comprise the repeater.

The complete repeater unit weighs 13 oz. and is installed in the same manner as a motor or synchro component.

Production units have been tested under varying conditions of temperature and supply frequency. Results are shown in Figs. 4 and 7.

There is an evergrowing trend toward the use of digital computing

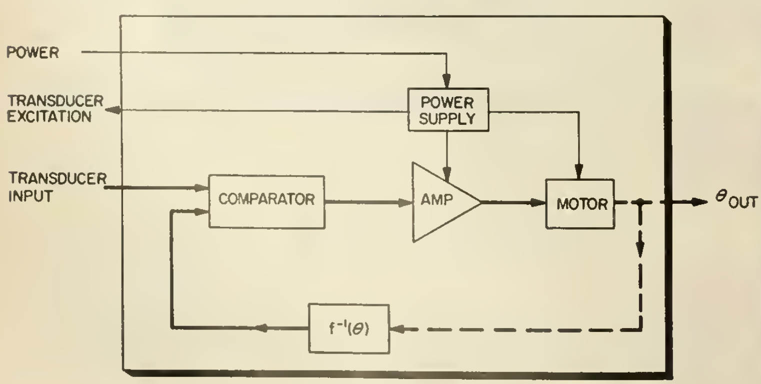

Fig. 1. A normal functional servo block would be broken down into subunits as shown.

Fig. 2. Synchro-type servo-repeater module.

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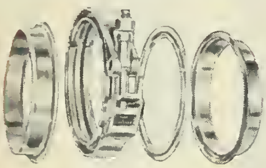

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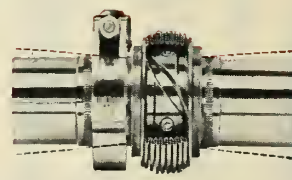

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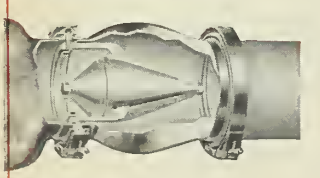

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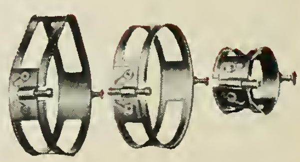

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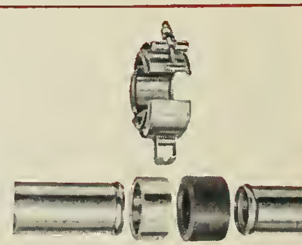

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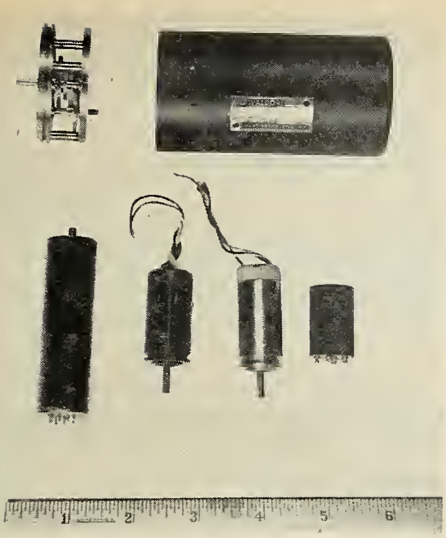


Fig. 3. Components of Model No. W1801 servo unit.

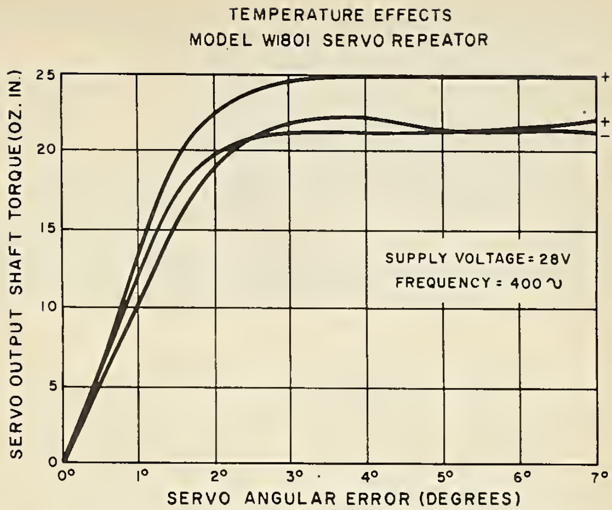


Fig. 4. Results of tests of unit of motor torque vs. input voltage.

techniques in instruments.

A common problem encountered, however, is that of converting the input analog voltages received from transducers into digitized outputs equal to a desired function of the input valve, linear or otherwise.

The treatment of the servo repeater prohlem, modified by addition of a digitizer as shown in Fig. 5, may he applied. For example, to convert synchro input linearly, a unit such as the Model W1801 Synchro Servo Repeater with the addition of a digitizer on its output shaft may be packaged as a completely self-contained module, each component constructed as a miniature modular assembly. The resultant Micromation package would be a "black box" with provisions of a synchro-transmitted input and a digitized electrical output.

The servo amplifier and motor requirements are satisfied by the same proof-tested components used in the repeater (Fig. 5). A servo amplifier Model W1803, presently heing produced, is another result of applying the Micromation concept.

The unit, a transistorized module

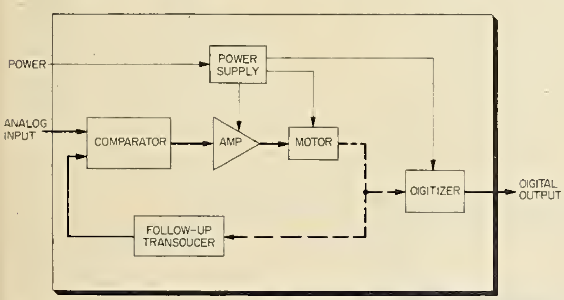


Fig. 5. Vector quantity resolved into perpendicular components.

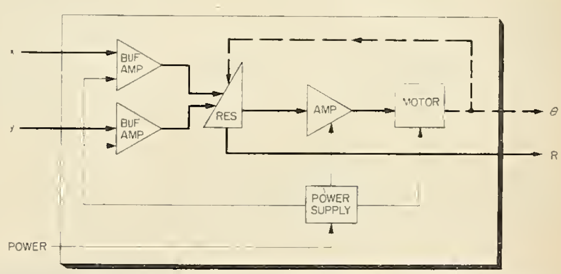


Fig. 6. W1801 amplifier tests of temperature on torque vs. voltage.

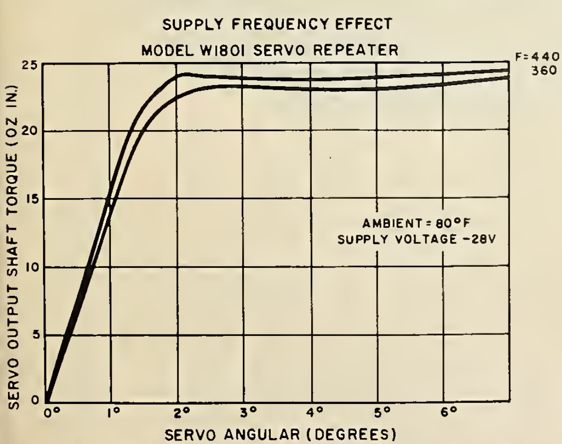


Fig. 7. Repeater tests of frequency on torque vs. servo angular.

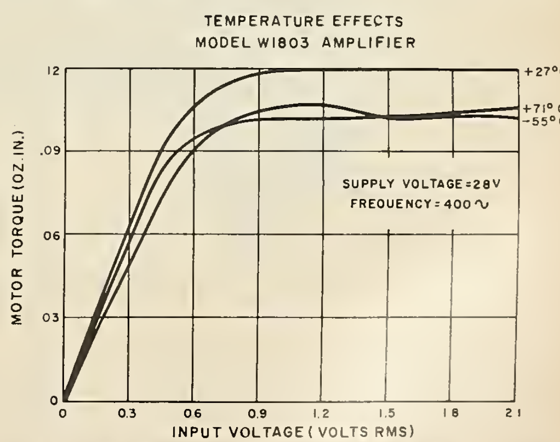


Fig. 8. W1803 amplifier tests of temperature on torque vs. voltage.

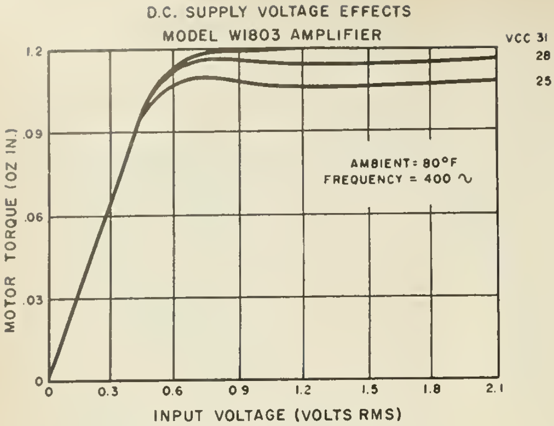


Fig. 9. W1803 amplifier tests of dc voltage on torque vs. input.

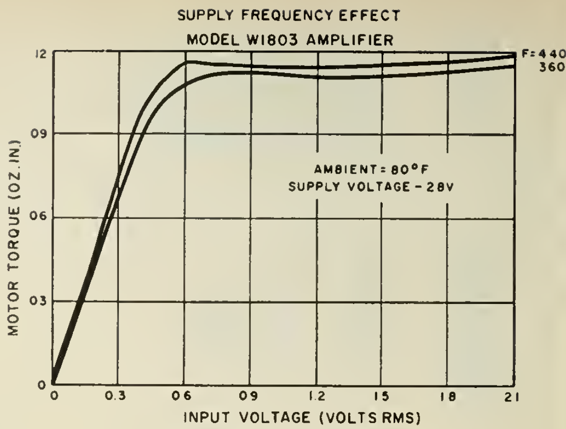


Fig. 10. W1803 amplifier tests of frequency on torque vs. input.

13/16″ in diameter and 2¾″ long, weighing 2 ounces, is designed for use with 26-volt, 400-cycle, size 8 or 10 servo motors. Capable of being mounted in any position and requiring only a 28-volt, dc power supply (at 125 milliamperes), the 90° phase shaft required for two-phase induction-type servo motors is obtained directly. Therefore, no external capacitors are required.

Production units have been tested under varying conditions of temperature, supply voltage, and frequency. The primary consideration during all these tests was the amplifier's function in the system. As a servo amplifier it is basically required to drive the motor to produce an output torque proportional to the error signal input. Thus, the motor output torque rather than output voltage was the measured characteristic of merit. Results are shown in Figs. 8, 9, and 10.

Right Triangle Solver

A problem continuously arising in analog computations is that of resolving a vector quantity into mutually perpendicular components, or, its converse, obtaining the vector quantity from its components, Fig. 6 illustrates the manner in which a Micromation module would solve the latter in a self-contained subsystem package.

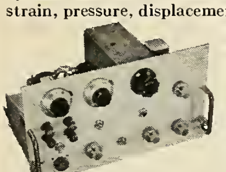
The same off-the-shelf, modular servo amplifier package (Model W1803) and motor previously described, are used. The other elements within the system unit are treated in an identical manner.★

TECHNIQUES and DEVELOPMENTS in oscillographic recording

FROM SANBORN

CIRCUIT DESIGN AND TYPICAL USES OF THE "150" CARRIER PREAMPLIFIER

One of the most frequently used plug-in front ends for Sanborn 150 Series oscillographic recording systems is the Model 150-1100 Carrier Preamplifier, since with it a "150" system can record such variables as force, temperature, strain, pressure, displacement, velocity, flow, acceleration — or any variable which can be expressed as a suitable input signal by a transducer. The "1100 Carrier" will operate with a variety of different transducers and bridge circuits, which will be mentioned later on.



In the block diagram (Fig. 1),

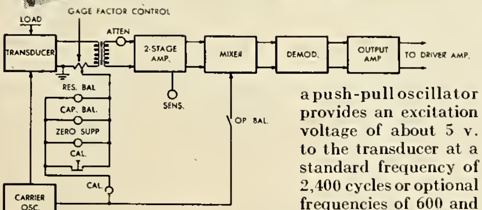


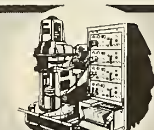
FIG. 1

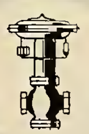
a push-pull oscillator provides an excitation voltage of about 5 v. to the transducer at a standard frequency of 2,400 cycles or optional frequencies of 600 and 1,200 cycles, using plug-in components. This excitation voltage also feeds the Balancing, Calibration and Zero Suppression circuits. (The Balancing controls allow correction of resistive and reactive signal leakage from the transducer, so that at zero load the net signal to the Preamplifier is zero. The Zero Suppression feature permits bucking out a large static load so that a small part of the load can be expanded over the full recording chart. The Gage Factor control allows the zero suppression range to be made equivalent to some convenient transducer load, or the full load rating of the transducer, and also causes the calibration signal to represent 2% of that load.) Transducer output is fed to the transformer through the Gage Factor potentiometer, across which the Balancing-Calibration-Zero Suppression circuits develop a voltage effectively in series with the transducer output. The mixer receives a suppressed carrier AM signal and re-inserts a carrier component, to make its output a conventional AM signal whose modulation represents the transducer load. The modulation signal (whose amplitude and polarity represent magnitude and direction of transducer output) is recovered by the demodulator and fed to the output amplifier, which in turn excites the Driver Amplifier and recording galvanometer of a "150" system.

Transducers which may be used with the Carrier Preamplifier include strain gage half-bridges or full-bridges, commercial resistance or reactance bridges, differential transformers and resistance thermometer bridges. The transducer chosen should provide at least 18.0 microvolts per volt of excitation at the minimum load to be recorded, for a one cm. deflection; impedance should be 100 to 1000 ohms. With strain gages, normal operation provides sensitivities of 50, 20 or 10 micro-inches per inch for each cm. on the recording, depending on the number of active gages. With resistance thermometers, if 1°C. or 2°F. per cm. stylus deflection is sufficient sensitivity, the user can construct his own resistance thermometer by including a 3 ohm coil of copper wire in one arm of an equal arm 100 ohm bridge.

Helpful information about the use of transducers with the 150-1100 Preamplifier is contained in the following Sanborn RIGHT ANGLE articles (reprints on request): Coupling Differential Transformers, Aug. and Nov. 1956; Filter Networks for use with Force Dynomometers, Nov. 1956; Calibration with 1-, 2- or 4-arm Strain Gage Bridges, Aug. 1955; Theoretical and Actual Applications of Bridge Circuits, May and Aug. 1954.

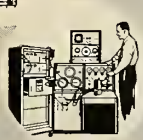
Wing flutter recording to infrared research . . . with the versatile "1100 Carrier"





Today, Carrier Preamp-equipped Sanborn "150" systems are being used for frequency response tests of process control system components; to record shaft deflections of fluid mixing equipment; in infrared research . . . vehicular traffic studies . . . submarine hull vibration measurements. Applications are limited only by the transducers available.

These are applications of only one "150" front-end; eleven more interchangeable, plug-in Preamplifiers increase the scope of Sanborn oscillographic recording systems to meet an almost infinite variety of research, production and field testing requirements. All Sanborn "150" direct writing systems record inkless traces in true rectangular coordinates; all provide 1% linearity; Basic Assemblies — equipped with your *choice* of Preamps — are available from one- to eight-channels, packaged in vertical cabinets, portable cases, or specially modified housings.



Technical data and help with your oscillographic recording problem are always available from Sanborn.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman St., Waltham 54, Mass.

modules for digital instrumentation

By Walter H. East, Vice President
Electro Instruments, Inc.

DUE TO THE DYNAMIC character of current expansion in the electronics industry, the specialized precision instrumentation field is more than ever confronted with the problem of equipment obsolescence. Such obsolescence is usually caused by changes in problem requirements but it is frequently occasioned by inflexibility or incompatibility in the design of the instruments themselves.

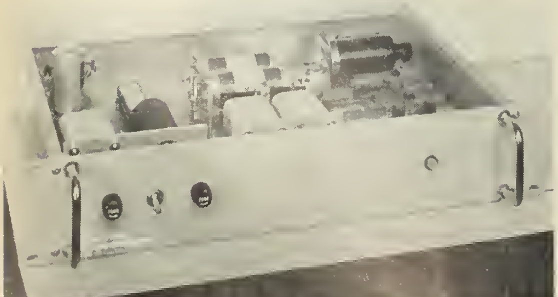
One solution to this problem is an integrated, modular instrument design. The basic modules should be capable of combining to form precision instruments as well as integrating with other instruments and machines to construct complete data handling and automation systems. Also, the development of new instruments should extend the usefulness of the instrument line and maintain a current position rather than cause obsolescence or complete loss.

There is also the obvious advantage of easy maintenance—no small problem in complicated electronic packages. With modular instruments it is a simple matter to substitute an interchangeable module and keep the system in operation.

Electro Instruments, Inc. has been manufacturing a complete line of precision digital instruments for automatic measurement of DC and AC voltages, resistance, DC and AC ratios. These basic instruments can also be modified for operating with machine read-out equipment or for integration into systems. However, each change or modification entails new engineering and since customers cannot always predict future needs for their instruments, modifications at a later date are always difficult. Then, too, there are inevitable minor changes required for specific

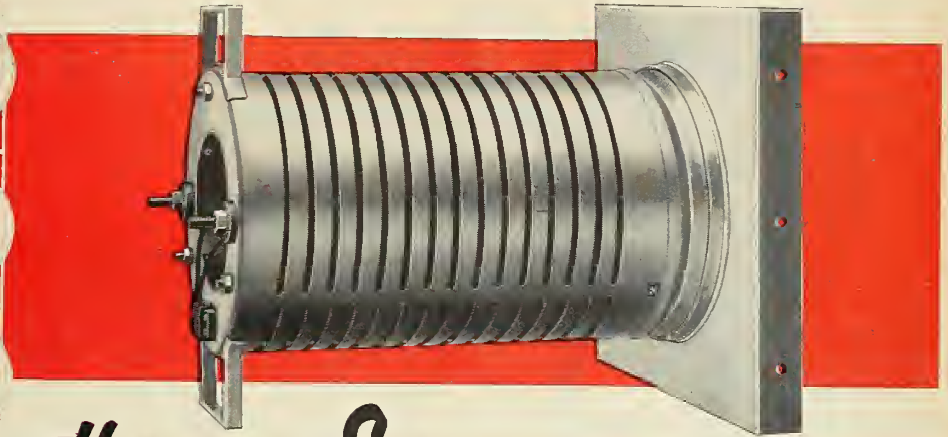
Five-digit digital voltmeter module.

Four-digit digital voltmeter module.



Power module for power and reference voltages and flexowriter module for sensing meter balances and operating typewriters.

MORE VERSATILE THAN EVER . . .



the new Sun . . .

ELECTRIC POWER ABSORBER

Newly designed—to meet critical space and weight requirements. Front panel makes possible cantilever mounting of several units horizontally or stacked in tiers.

Mounting panel is only 13 inches square. Overall length is 18 inches—weight approximately 18¼ pounds depending upon capacity.

Amazing efficiency! 10 to 15 KW power absorption per unit—up to 2350 BTU's of heat dissipation per pound of weight. No other type of power absorber, air or water-cooled, can begin to match this performance.

Exceptionally well suited to aircraft and guided missile testing and service equipment, this unit has many commercial and industrial applications, too.

You'll want to investigate this versatile unit for your own power absorption requirements. Write today for full details and specifications.

SUN ELECTRIC CORPORATION

CHICAGO AERONAUTICAL DIVISION: 6325 Avondale Ave., Chicago 31, Illinois
LOS ANGELES AERONAUTICAL DIVISION: 6703 Sepulveda Blvd., Los Angeles, California

applications. The complete instrument design common in specialized instrumentation does not readily lend itself to engineering changes.

After due consideration of these problems and others learned from extensive field experience of over 1000 instruments, the new E-I modules were designed to meet the majority of the needs for digital instruments and instrumentation systems.

Each module solves a specific measurement problem and all may be combined and recombined into a variety of instruments. Auxiliary modules are available for complex systems when automatic programming and recording of test data is required. All types of printed forms, punched cards or tape may be obtained for automatic data production.

Basic Module Design

In addition to designing for maximum application flexibility, each module has been transistorized. This advanced circuit design has many advantages besides the obvious reduction in size, power consumption and heat dissipation. It also provides both new and improved specifications plus improvements in reliability and ruggedness.

The basic modules consist of a power module, four and five digit DC and resistance switch modules, AC converter and DC pre-amplified modules. Each unit is packaged in three ½" x 19" x 12" standard rack cabinets. Combinations of instruments are constructed by merely changing interconnecting cables.

The heart of this system of modular units is the switch section unit. These modules enable the user to measure DC voltages from 0.1 mv to 999.99 volts and resistance from 10 milliohms to 10 megohms with an accuracy of 0.01 per cent. Either the voltmeter switch section or the ohmmeter switch section may be obtained in four or five digit models. The switch section modules are very compact and may be installed in the operating position of a control console, eliminating the necessity of a remote read-out.

The movement of the stepping switches is controlled by a new logic program which takes a minimum number of steps and reaches the final reading with a minimum of wear. The mechanical design of the switch section provides a new ease of servicing.

The power unit contains the necessary power supply, the null detecting amplifier, and reference voltage supplies for the other modular units in the system. The use of transistors in this unit has greatly reduced heating effects. The use of temperature controlled Zener

At Moog:
Production Valves
Quality Tested

One reason Moog makes so many servo valves so well is just what you see here—a superbly-equipped test room where every valve is put through its paces. All test apparatus was designed and built by Moog especially to test production valves for performance criteria including flow rate, frequency response, resolution, linearity, and hysteresis. This attention to quality in quantity is your assurance of reliable servo valves for your production requirements.

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MOOG VALVE CO., INC. PRONER AIRPORT, EAST AURORA, NEW YORK

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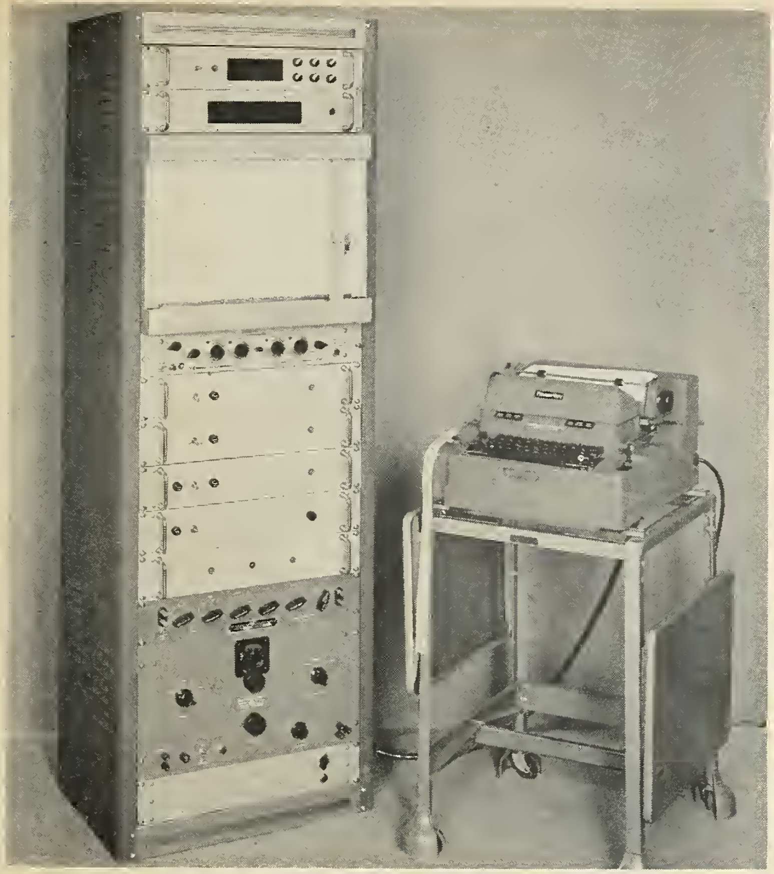


Typical automation system constructed of standard E-1 modules. The system automatically scans and measures 400 channels of AC and DC voltages with typewriter readout.

diodes as a source of reference voltage has eliminated any dependence on a mechanically fragile standard cell. By using a transistorized stepping switch drive system, a low voltage controlled flow of power to the stepping switches reduces mechanical wear in the switch with a consequent increase in switch life. Where possible, JAN approved components are used throughout this unit for utmost reliability.

The AC converter and DC preamplifier modules enable the user to extend the use of this instrument for precision measurement of AC voltage from 30 cycles to 10,000 cycles to an accuracy of 0.1% and DC voltages from 10 microvolts to 0.1 mv with an accuracy of 0.02%.

Module System Integration

Automatic checkout systems may be easily constructed by adding scanner and print-out modules to the measurement units described above. The input scanning equipment consists of a master scanner module which contains the visual read-out and print-out facilities for automatically scanning up to 10,000 input test points. The master unit also contains a switching circuit with gold contacts for the first 100 points. To this master unit may be added up to three slave units, each of which contains 300 additional input signal circuits all having gold contacts. If desired, the user may also connect these slave units to function as parallel switch circuits to provide four-wire scanning, thereby minimizing effect of lead resistance when using a digital ohmmeter.

Readings taken automatically by the combination of the input scanning and measurement modules may be recorded in any variety of digital forms by the use of one of the print-out control modules. The printer control unit is designed to operate the Clary adding machine type of printer. Electrical typewriter controls are available for either the Underwood Servotyper or the IBM typewriter. If further automatic data reduction is required, the information may be recorded on punched tape by the use of Flexowriter units. The IBM control units enable the user to record data on punched cards for processing by computing equipment.★

visual trainer for AT missiles

By Frank G. McGuire

REALISTIC TRAINING for realistic cost has been provided for the SS.10 and similar antitank missiles by Giravions Dorand, a French firm. The model DX-40, a cine-simulator, uses motion pictures, a computer and remote control units to provide troop training in wire-guided missiles.

The device enables operators to direct missiles onto a moving target under realistic field conditions while an instructor observes the exercise. The cost of the entire unit is about $57,000, showing a marked economy over usual training methods.

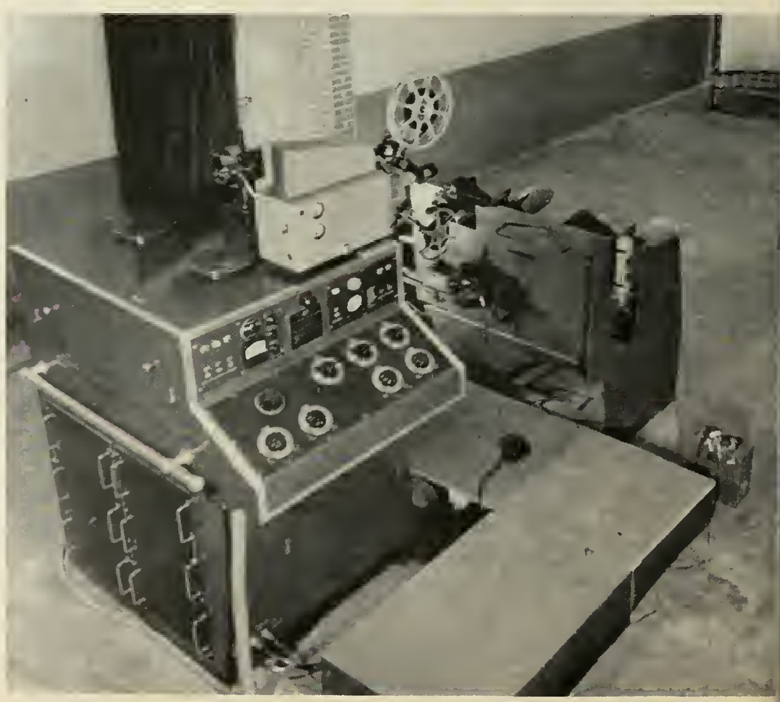
A moving target is displayed on a panoramic screen by the projector. A luminous spot also projected upon the screen represents the missile as seen by the operator. The luminous spot is remotely controlled by the student and corresponds exactly to the position of the missile at all times.

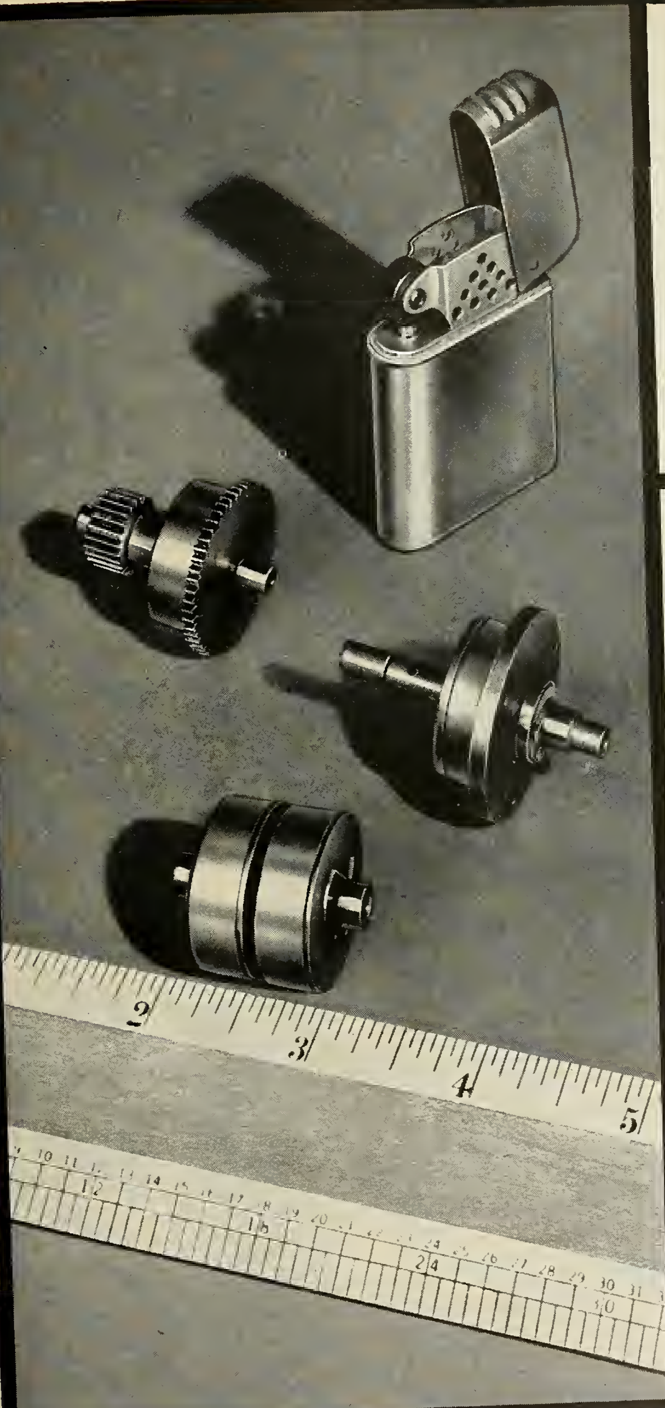
An optical cam system continuously determines the distance between the operator and target, and simultaneously computes the distance between the operator and missile. When these two distances become equal, a special device stops the simulator, freezing the target and missile images. This allows assessment of the exercise—target hit or missed, depending on spot coincidence with target image.

The system allows the instructor to follow and usefully instruct the student during the exercise. He may freeze the action at any time in order to point out particular faults, make corrections, then continue the action.

The device is composed of several units: the main cabinet, housing the

Visual trainer supplants much more expensive method of using actual missiles.





How Much Torque Capacity Can Be Handled In An Inch?

The largest Formsprag clutch shown at left measures less than two inches—weighs about the same as your cigaret lighter—yet delivers more torque per cubic inch than any other available today.

Good news for aircraft, missile and rocket engineers whose job it is to pack more and more power into less and less space. For example, here's how two aircraft component manufacturers have taken advantage of Formsprag's unique clutch design . . .

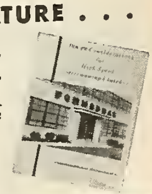
A landing gear manufacturer has employed Formsprag clutches to over-run the primary hydraulic system so that in case of emergency the pilot can actuate the landing gear mechanically.

An accessory gas turbine manufacturer uses a Formsprag clutch as a disengaging device on a starting mechanism.

If you would like to know more about how Formsprag clutches may be of help in solving your design problems, why not have a talk with a Formsprag engineering consultant?

SEND FOR LITERATURE . . .

ask for new paper entitled "Design Considerations for High Speed Over-Running Clutches."



Over-Running, Indexing and Backstopping Clutches for aircraft, automotive and various industrial applications.

FORMSPRAG COMPANY

23585 HOOVER ROAD, WARREN (DETROIT), MICHIGAN

World's largest exclusive manufacturer of over-running clutches.

58-G

Circle No. 25 on Subscriber Service Card.

computer, on top of which is mounted the target projector and the missile projector. The front face of this main unit carries the starter and control panel as well as the setting-up console.

A separate cabinet houses the electronic equipment of the simulator, and the panoramic screen is placed about six to 11 feet in front of the student, who holds the remote control box.

The first of these units, the main cabinet and the electronic cabinet, are ruggedly constructed for disassembly and transport by rail, road, sea or air. Special packing cases are provided with the machine.

A Debrie projector is used with a mercury-vapor lamp. The projector is equipped with an instantaneous stopping device, allowing a still picture to be seen, and a reverse-running control. CinemaScope projection is obtained by use of an adjustable hypergonar projection lens.

The missile-tracer projector, controlled by the computer, produces a light spot whose size and intensity diminish automatically with increasing "distance" from the operator.

Installation of the DX-40 requires a minimum floor space of five by nine yards, and installation in a trailer is possible. Maximum power required for operation is four kva at 220 volts, ac, single-phase. Unpacked weight of the simulator is about 2400 lbs. ★

Instructor can monitor the exercise, stop the equipment and point out student mistakes.

calendar

NOVEMBER

Fourtb Institute on Electronics Management, Automatic Data Processing System, American University, Washington, D. C., Nov. 4-8.

Joint Military-Industry Guided Missile Reliability Symposium (limited to those with Secret security clearance), Pt. Mugu, Calif., Nov. 5-7.

Aeronautical Communications, Third Annual Symposium, Hotel Utica, Utica, N. Y., Nov. 6-8.

Plastics for Airborne Electronics, Regional Technical Conference, Society of Plastic Engineers, Los Angeles, Calif., Nov. 11.

IRE Third Instrumentation Conference, Atlanta Biltmore Hotel, Atlanta, Georgia, Nov. 11-13.

EIA, IRE, Radio Fall Meeting, King Edward Hotel, Toronto, Canada, Nov. 11-13.

IRE, Mid-America Electronics Convention, Municipal Audit., Kansas City, Nov. 13-14.

National Aviation Trades Assn. Annual Convention, meetings with National Air Taxi Conference, Maintenance Council and Aerial Applicators, Hotel Adolphus, Dallas, Texas, Nov. 13-15.

TWE Fifth Annual Convention, Hotel Statler, New York City, N. Y., Nov. 13-15.

IRE, New England Radio and Electronics Meeting, Mechanics Hall, Boston, Mass., Nov. 15-16.

AIEE Magnetism and Magnetic Materials Conference, Sheraton-Park Hotel, Washington, D. C., Nov. 18-21.

Aviation Distributors and Manufacturers Assn., 30th Meeting, Sheraton Cadillac Hotel, Detroit, Mich., Nov. 21-22.

DECEMBER

American Society of Mechanical Engineers, Annual Meeting, New York, Dec. 2-5.

IRE (Philadelphia Section and the Professional Group on Military Electronics) and the Human Factors Society of America on "Human Factors in Systems Engineering," Penn-Sherwood Hotel, Philadelphia, Pa., Dec. 3-4.

IRE, AIEE, ACM, Eastern Joint Computer Conference, Sheraton-Park Hotel, Washington, D. C., Dec. 8-11.

1957 Eastern Joint Computer Conference and Exhibit, Sheraton-Park Hotel, Washington, D. C., Dec. 9-13.

JANUARY

Electronics Reliability and Quality Control, Fourth National Symposium, Hotel Statler, Washington, D. C., Jan. 6-8.

APRIL

ASME Div. of Instruments and Regulators Conference, University of Delaware, Newark, Delaware, Apr. 1-3.

ASME, Maintenance and Plant Engineering Conference, Penn Sheraton Hotel, Pittsburgh, Pa., Apr. 14-15.

people

John F. Hicks has been appointed assistant to the general manager of Fairchild's guided missiles division. He will be in charge of public relations and will edit the division house organ, MISSILE NEWS.

C. Hart Miller has been elected executive vice president, general manager and a director of Sierracin Corp. of Burbank. He resigned as vice president, administration of Northrop Aircraft's Northrop division to accept the new position.

Robert E. Honer has been appointed chief electronics engineer at Convair San Diego.

Dr. Edward Lilley is leaving the Naval Research Laboratory to serve as assistant professor of radio and rocket astronomy at Yale University. This marks the first time that Yale has offered courses in these subjects.

Roy A. Long, research engineer at Stanford Research Institute, was elected a fellow in the Audio Engineering Society in recognition of his work in communication systems.

David Eaton has been named to the newly created post of vice president of marketing at Reaction Motors, Inc.

Arch Wallen, appointed factory manager at Northrop Aircraft's Northrop Division, will direct production of the *Snark* SM-62.

T. F. Dixon, chief engineer at North American Aviation's Rocketdyne division, has been named to a special committee on propulsion to provide technical information to the Department of Defense.

Ramo-Wooldridge has elected three new vice presidents. They are **Dr. Ruben F. Mettler,** associate director of the company's guided missile research division and director of the *Thor* IRBM program; **Dr. Burton F. Miller,** director of the communications division; and **Milton E. Mohr,** group director of the control systems and Boston divisions.

Ralph J. Leppla has been appointed supervisor, and **Thomas A. Peterson,** design engineer of Leland Electric Co. Division of American Machine and Foundry Co. The appointments are in the newly created static regulator and control design department.

Gen. Ira C. Eaker has been named director of Eastern offices of the Douglas Aircraft Co. He has been vice president of Hughes Tool Co. for the past ten years.

Datran Electronics has appointed **Allen J. Edwards** as director of customer relations. He was formerly with Coleman Engineering Co.

Robert P. Crago has been named director of engineering for IBM's military products division. He has been replaced as general manager of the division's Kingston, N. Y. plant by **Richard J. Whalen.**

P. R. Perino has joined the staff of Allegany Instrument Co. as project engineer. He formerly was with Aerojet-General, Phillips Petroleum's rocket fuels division and at Redstone Arsenal as instrumentation engineer.

Henry S. Forrest has been appointed director of government service engineering and manager of the eastern office of Control Data Corp.

William H. Starbuck has been named sales manager of Elgin National Watch Co.'s micronics division.

Stanley Waxman has been appointed assistant vice president of operations at Grand Central Rocket Co. Other appoint-

ments at the company are **H. L. Thackwell**, vice president, and **Angus M. Scott**, assistant director of projects.

Wilson W. Petty has joined Titanium Fabricators, Inc. as chief engineer. He was previously with North American Aviation.

J. Vance Holdam, Jr. has been appointed vice president in charge of operations at Laboratory for Electronics, Inc.

Thomas F. Watson has joined the Arnoux Corp. as a senior field engineer. Prior to joining Arnoux, he was chief of instrumentation at the USAF rocket test facility, Edwards AFB.

Luther C. Ringer has been named production manager at Narmco Mfg. Co.

Dr. Robert B. Costello has been appointed assistant manager of the materials department at Aerophysics Development Corp.

Directing Exide's new missile applications department will be **Rear Adm. W. H. Ashford** (USN, Ret.) and **G. S. Hartman.** Missile engineering manager will be **H. A. Fuggiti,** while **J. J. Sullivan** continues as missile production manager.

John R. Townsend was appointed special assistant to the Assistant Secretary of Defense for Research and Engineering. He will also serve as the director of the Office of Fuels, Materials and Ordnance.

Joseph O'Reilly is the new general manager of the Ferroxcube Corp. of America.

Fischer & Porter Co. has announced the appointment of **Edward H. Muhlelsen** as manager, aircraft and missile industry division.

International Business Machines Corp. has appointed **Horace W. Thue** director of manufacturing planning. He was formerly manager of the missile and commercial aircraft division at Douglas Aircraft Co.

Everett M. Patterson has been elected president of the Bulova Research and Development Laboratories, Inc. He was also elected to the board of directors.

Philco Corp. has appointed the following scientists to manage various phases of its government and industrial division: **J. Forrest Bigelow,** radar and radio systems; **F. J. Bingley,** audio-video data systems; **C. P. Woodward,** missiles and advanced tactical systems; and **Ralph Deutsch**, fundamental techniques.

John T. Gorham, formerly with the Secret Service and agent in charge of the White House detail, has been named manager of the industrial security department for Bell Aircraft Corp.

Robert G. Clark has been appointed vice president and treasurer of Epasco Inc., manufacturers of electronic data control equipment and systems.

RCA's electron tube division has appointed **C. J. Hollatz** manager of commercial operations.

Douglas C. Vest has been named director of research and development for Redel Inc. He was formerly in charge of applied interior ballistic research, Aberdeen Proving Ground, Maryland.

Robert A. Lebman has been appointed executive vice president, general manager and a member of the board of American Electronics, Inc.

Robert W. Olson has been named vice president, research and engineering, of Texas Instruments Inc. and **E. O. Vetter** as general manager of TI's industrial instrumentation division.

John T. Castles has been appointed

sales manager for the silicone products department of the General Electric Co. Formerly manager of rubber market development, Mr. Castles succeeds **Jerome T. Coe** who has become the department's marketing manager.

Robert M. Fritz has been appointed marketing manager for the General Electric Co.'s missile and ordnance systems department.

Chance Vought Aircraft, Inc. has promoted **Kelly G. Smith** to quality control manager and **George Gasper** to chief tool engineer.

Laurence E. Russell has been appointed director of marketing for the organic chemicals division, Olin Mathieson Chemical Corp.

M. B. Jobe has been appointed manager of customer relations of Goodyear Aircraft Corp. where he will supervise all customer relations division heads.

Richard D. Evans has been appointed as government sales manager for the Special Tube Operations of Sylvania Electric Products, Inc., where he had been special sales representative for the company's semiconductor division.

Edwin S. Hoffman has joined Stavid Engineering, Inc., as contract representative in the firm's Washington, D.C. office.

STATEMENT REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946 (Title 39, United States Code, Section 233) SHOWING THE OWNERSHIP, MANAGEMENT, AND CIRCULATION OF

MISSILES AND ROCKETS, published monthly at Harrisburg, Pennsylvania, for November, 1957.

1. The names and addresses of the publisher, editor, executive editor, and business manager are: Publisher, Wayne W. Parrish, Washington, D. C.; Editor, Wayne W. Parrish, Washington, D. C.; Executive Editor, Erik R. Bergaust, Washington, D. C.; Business Manager, Leonard Eiserer, Washington, D. C.

2. The owner is: American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington 5, D. C.; Wayne W. Parrish, President, Washington, D. C.; Albert H. Stackpole, Vice-President, Harrisburg, Penna.; E. J. Stackpole, Director, Harrisburg, Penna.; Leonard Eiserer, Exec. Vice-President and Secretary-Treasurer, Washington, D. C.; Eric Bramley, Vice-President, Washington, D. C.; Robert R. Parrish, Vice-President, Chicago, Ill.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: None.

4. Paragraphs 2 and 3 include, in cases where the stockholders or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees hold stock and securities in a capacity other than that of a bona fide owner.

5. The average number of copies of each issue of this publication sold or distributed through the mails or otherwise to paid subscribers during the 12 months preceding the date shown above was: 11,872

LEONARD EISERER,
(Signature of business manager)

Sworn to and subscribed before me this 11th day of October, 1957.

HELEN M. DES PREZ,
Notary Public.
(My commission expires November 30, 1961)

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RANSPORTER. Liquid oxygen and nirogen transporter featuring a new ype of undercarriage. The unit is being uilt in sizes up to 2500-gallon capacity. Hofman Laboratories.
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ircle No. 251 on Subscriber Service Card.

EMPERATURE ACCELERATION INDIATOR. Device warns of excessive temerature rise in rotating machinery. Lyoming Div., Avco Mfg. Corp.
rcle No. 252 on Subscriber Service Card

AUGE PROTECTOR. An adjustable uge protector designed to limit maxium pressure on air or oil gauges has en developed. The protector autoatically cuts off flow to the gauge henever system pressure exceeds the ring setting of the device. It reopens itomatically when pressure drops below e cutout point. Superior Hydraulics.
rcle No. 253 on Subscriber Service Card.

ABLE SPLICER. New method of splicg single and multi-conductor shielded bles uses standard, inexpensive parts make compact, flexible, high-conducity splices with electrical and physical operties comparable to those of the ble. Burndy Corp.
cle No. 254 on Subscriber Service Card.

OLDERING AIDS. Designed for nted circuits, these miniaturized solring aids have straight or angled tips. ey are useful in connecting or disnnecting soldered joints; reaming der from lug holes; probing, scrapg and cleaning; positioning wires, conts and parts. CBS Tube Division.
cle No. 255 on Subscriber Service Card.

ANSISTOR TESTER. An instrument rapid evaluation and testing of NPN d PNP power transistors at their rmal operating power has been deoped by Strand Engineering Co.
cle No. 256 on Subscriber Service Card.

RIABLE SPEED DRIVE. Designed for in process controls or mechanical vo units, this device has infinitely iable speed control in either manual automatic operation. Humphrey, Inc.
cle No. 260 on Subscriber Service Card.

DUPLEXER TUBE. Microwave Associates has developed a 500-kilowatt dual TR tube (bandpass) intended for use with short-slot hybrid couplers. Termed the MA-306B, the new duplexer tube incorporates special design features to sharply reduce arc loss which is 0.6 db at 40 KW peak power.
Circle No. 263 on Subscriber Service Card.

DIP-SOLDERING PRINTED CIRCUITS. Automatic dip-soldering of printed circuit boards is now practical through the use of ceramic dip-soldering fixtures. The product is suitable for temperatures up to 1065°C, will not warp, and molten solders will not adere to it. Technion Design & Mfg. Co.
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POROUS TEFLON FILTERS. Molded porous teflon filter cups 12" high, 5½" O.D. and 5" I.D. have been produced, with porosity limited to the lower 7" of the product. The filter is rated to remove from suspension essentially all particles over three microns in size. Porous Plastic Filter Co.
Circle No. 265 on Subscriber Service Card.

INERTIA SWITCH. An automatic device actuated by thrusts, impacts or excessive vibrations has been developed by Micro Switch division of Minneapolis-Honeywell.
Circle No. 262 on Subscriber Service Card.

SLM INDICATOR. Both fast and slow transient differential pressures at any two points in a pneumatic or hydraulic system, as well as on an aerodynamic model, can be measured with the SLM differential pressure indicator (Model DPI-114) manufactured by the Kistler Instrument Corp.
Circle No. 261 on Subscriber Service Card.

INFRARED MENISCUS LENSES. Designed to give optimum performance under certain conditions where achromatic imagery is not required, these single-element lenses are designed to have minimum spherical aberration when imaging an object at infinity at a dominant wavelength of 3½ microns. Servo Corp. of America.
Circle No. 257 on Subscriber Service Card.

THERMAL RIBBON. Providing a means of electrically detecting temperatures of the surface to which it is connected, this ribbon is very flexible and has negligible thermal lag. It is less than .020" thick and may be cemented to flat, cylindrical or irregular surfaces. Minco Products, Inc.
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MISSILES AND ROCKETS
NOVEMBER, 1957
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76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100
101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126

• • **Missile Literature**

150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175

• • **New Missile Products**

200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224
225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249
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