"Missile Away!"

THE NEW MEXICO-WEST TEXAS SECTION OF THE AMERICAN ROCKET SOCIETY

Vol. IV, No. 2
SUMMER
1956
35c

THE NEW MEXICO-WEST TEXAS SECTION
OF
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"MISSILE AWAY!"

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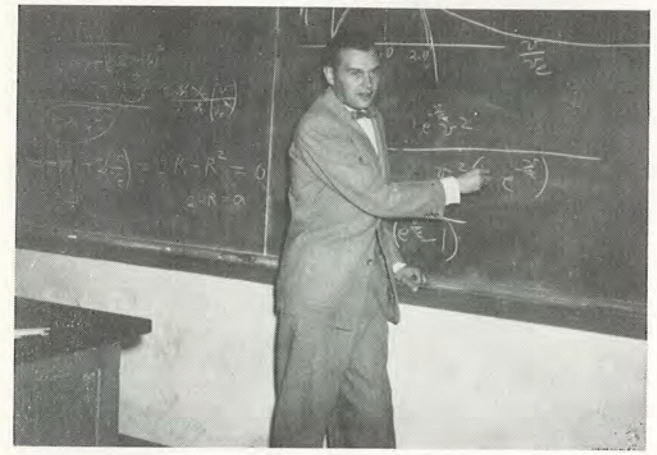
SPECIAL SUPPLEMENT:
"Reference Data for Guided Missiles"
Booklet courtesy Fairchild Guided Missiles Division, Fairchild Engine and Airplane Corp. (ARS Members only).

STATEMENT OF EDITORIAL POLICY

The purpose of this magazine is to bring to scientist, engineer, specialist, technician, and layman a better understanding of the rocket and guided missile field with its present and future uses in war and peace. To this end, it is dedicated to publish material of common interest written in terms which are readily understood and illustrated with the finest efforts of the photographers and artists associated with this field.

TECHNOLOGY and TEACHERS

editorial



IN the preceding issue of "MISSILE AWAY!" the editorial discussed the critical shortage of scientific and technical personnel. The conclusion was that something must be done; otherwise scientific progress will come to a "shuttering halt".

There are many factors which could affect the output of persons having the technical training and interest required to fill the shortage mentioned above. One of the most important of these is the educational system which supplies the colleges, our elementary and secondary schools.

It is my contention that our schools are involved in a feedback system which will cause the quality of the student to become progressively worse. The feed-back to which I refer is that often the least qualified of each class becomes the teacher of the younger group.

I believe there are three primary reasons that this trend exists: 1) salaries, 2) social status of the teacher, and 3) the absurd regulations of the individual state specifying the requirements of a qualified teacher.

Very little needs to be said regarding the salaries of the elementary and high school teachers. When school teachers are required to spend their summers working at supplemental tasks to meet their financial obligations, rather than spending their time improving their teaching skills, then we should conclude they are being grossly underpaid. New Mexico, having a reputation for paying teachers high slaries, has an upper limit in the vicinity of $5000; starting salaries may approach $4200. Industry, in many cases, will buy this starting school teacher at $6000 or better. Unless some personal conviction compels this person to teach, is it any wonder he changes his allegiance to the highest bidder.

In each community, the teaching staff is more or less directed by the particular whims of the community. To site an example, I personally was instructed by a county superintendent not to attend church in the community in which I was contemplating teaching. It seems there were only two churches and the church members of one did not think kindly toward a teacher who attended the other. And to quote a school board member of another small communiity, "I have very little use for teachers myself; they lack the initiative to go into a business for themselves". Granted, these incidents are not too common, but how many teachers leave the profession over incidents of this type?

The third and final item which I consider a major cause to having an inadequate teaching staff are the incompetent regulations governing the qualifications of a school teacher. In the state of New Mexico a regulation requires that a person have 12 hours in the field and 4 hours in the subject, and a teaching certificate indicating completion of 15 hours of educational courses. Four hours of college algebra or business arithmetic makes a math teacher? This is the law, so it must be; but the same regulation rules that nearly all college instructors in the nation are not qualified to teach in high school.

The results are that in many cases our schools are staffed with teachers having inadequate training to bring out a student's potential talent. They lack an understanding of science and consequently cannot develop the student's interest, nor give the student the necessary background to be prepared for college. The results—a low starting number and a high mortality rate of science majors on the college level.

—K. H.

BOOK REVIEW

THE EXPLORATION OF MARS, by Willy Ley and Wernher von Braun, paintings by Chesley Bonstell, Viking Press, New York, 1956, 176 pages, 16 paintings in color, 5 paintings in black and white, $4.95.

HERE we have the third book of what might be termed a grand trilogy covering the early years of space flight and covering a period of time from now until 2000 A. D. The first two books in this series ("Across The Space Frontier" and "The Conquest of the Moon") were expanded versions of serial articles appearing in **Collier's**. "The Exploration of Mars", however, is brand-new, not having seen serial magazine publication elsewhere. Many of the paintings have appeared recently as magazine covers, and part of the book is a re-write of von Braun's "The Mars Project", published some two years ago.

While the Bonestell paintings alone make the book worthwhile, there is a plethora of information on Mars in the book, written in the complete—if somewhat too-complete—style of Willy Ley. Ley goes back to cover the planet Mars from the early Chaldeans through today, then more or less turns the works over to von Braun who tells us how we might get there in the fifty years. It is difficult to tell where one writer leaves off and another begins insofar as style goes, a real credit to Ley and von Braun.

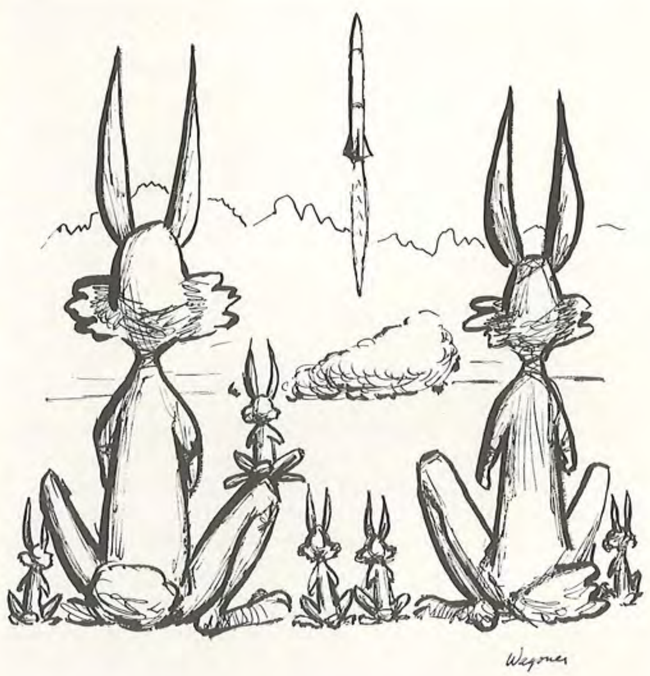
Ley's coverage of the astronomical history of Mars is as complete as could possibly be expected, making this book a fine bit of source material. Mars, he points out, has always been one of the more important night sky objects in human history. In ancient times—up to 1700—the regular two-year appearance of the red planet in the sky was always a supernatural sign of impending war. Later, observations by Tycho Brahe and Kepler led to Kepler's formulation of the laws of planetary motion: the planets move in eliptical paths about the sun. Had Kepler chosen Venus instead of Mars, he probably would not have developed this law, since Venus' orbit is very circular while that of Mars is highly eccentric.

Ley covers the discovery of the **canali** by Schaparelli in fine detail, and goes on to cover the various theories brought forth up to the present day to explain these curious markings. When it comes to the discussion of life on Mars, he tacitly remarks that soon the arguments will be over because the human race will go to Mars to have a first-hand look.

Von Braun takes over here and explains that with present-day knowledge and theory, it would be possible to design ships for a voyage to Mars. He is careful to point out that his project is based on what we know at present, and that he has not taken into account possible developments in nuclear power plants or other types of deep-space propulsion. The expedition outlined in this book is not as extensive as that propounded in "The Mars Project"; it has been cut to two ships—one to orbit about Mars and the other to land on the surface. An appendix of considerable length gives the specifications of the ships and the trajectories.

If you are an amateur astronomer, interested in Mars, or have the other two books, we would highly recommend "The Exploration of Mars." Although there are several parts of the book which may be controversial, one is reminded of the old saying that "you gotta sell **something**!" And if this book, like its two predecessors, helps sell the idea that it **is** possible for mankind to journey to the planets and learn something worthwhile, it will have done its job.

—G. H. S.



"People sure think up some crazy ways to amuse themselves, don't they, Maw?"

"MISSILE AWAY!"

THRUST!

by

RUSSELL K. SHERBURNE

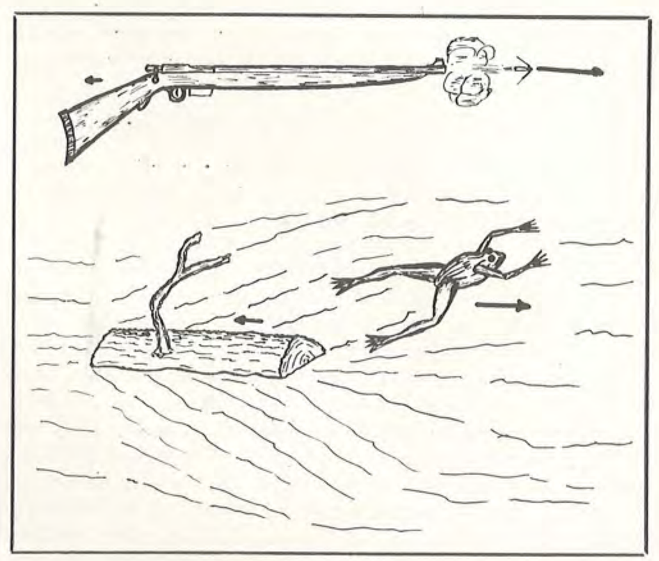
Although this magazine is not devoted solely to propulsion, the principles and theories behind the operation of the simplest of all heat engines, the rocket, are of interest to all because the rocket is the prime mover for many missiles. Beginning here, we present the first in a series of articles to be written by Dr. Sherburne for this magazine covering the basic principles of rocket propulsion.

TO many people rockets are propelled in a mysterious fashion. Yet, just as for all other objects, a force must act on a rocket in order to accelerate it. How is it that rocket propulsion can simultaneously be the same and different from other forms of propulsion?

Let us first see how a rocket appears to operate differently from other vehicles, such as automobiles, trains, boats and airplanes. All of the common vehicles seem to push on or be pushed by something: e.g. wheels push on the ground or on rails, propellors push on water or air, and in the case of a sailboat, the wind pushes on the sail. A rocket on the other hand seems to have nothing against which it can push (nor for that matter has it any wheels, propellors, oars, or anything else that it can use to do any pushing).

But a rocket does push against something. A rocket pushes against part of itself—the emerging jet gas in the exhaust nozzle.

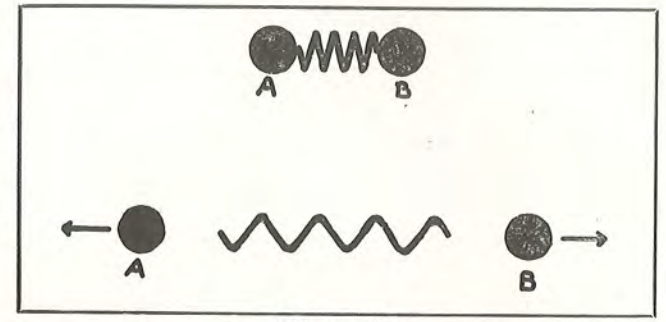
Common examples of behavior similar to that of a rocket are shown in Figure 1. The frog and log move in opposite directions as the frog leaps from the end, and a rifle moves backward with its "kick" as the bullet leaves the barrel.



(Figure 1)

Let us use another simple illustration to elaborate on rocket thrust.

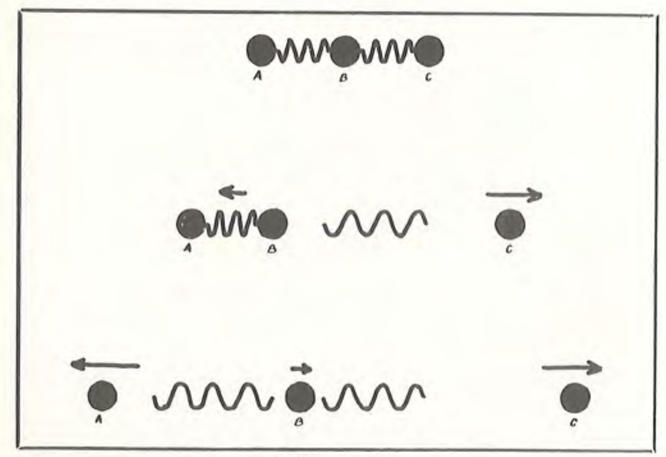
Use two heavy balls separated by a coil spring as shown in figure 2.



(Figure 2)

If the balls are pushed together, compressing the spring, and set on a smooth surface—and then released—the spring will expand and both balls will move away from their original positions. They will both leave their respective starting points with the same speeds if they are equal in weight.

Now let us do nearly the same thing with the more complicated system shown in figure 3.



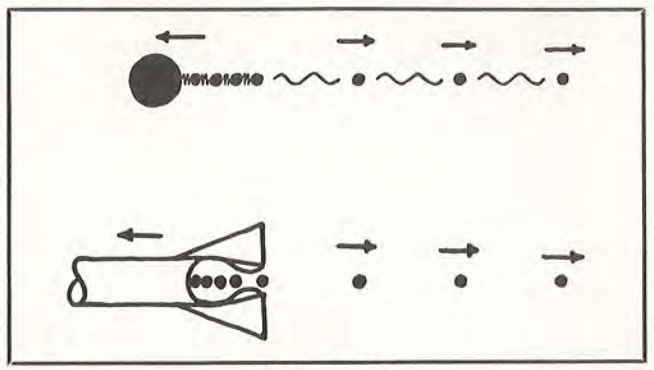
(Figure 3)

(next page, please)

THRUST! (Continued)

Here we have three balls separated by two springs. Proceeding as before, we compress the spring and place the balls on the smooth surface. We do not release both springs at the same time, but first allow the spring between A and B to expand. This will move ball C to the right, and balls A and B with the compressed spring between them, will move at a slower speed to the left. If we now release the spring between A and B, the speed of B to the **left** will be reduced, perhaps enough so that it reverses its direction and starts to the right, following ball C. At the same time A is given an additional impulse by the second spring and its speed to the left is increased.

In figure 4, a large ball A and a small ball B are shown.



(Figure 4)

If these are released in the way described above, ball B will move to the right at a much higher speed than ball A will move to the left, **but both balls will move.** If we choose, we can use many small balls and one large ball, releasing the springs between them in the sequence from right to left. Each time one of the springs is released, an additional speed is given to all of the balls which remain to the left as shown in the diagram. If we use a very large number of small ball-and-spring combinations, we can increase the speed of the large ball to nearly any amount that we desire.

Of course these balls and springs do not look very much like a rocket propulsion system. But the correspondence is quite straightforward. The bottom part of figure 4 depicts the correspondence to a rocket. The small balls are the particles of the jet gas, and the large ball is the rocket structure. The balls which have already received their impetus from the expansion of the springs are particles of jet gas which have left the rocket. The rocket and particles within the combustion chamber correspond to the ball-and-spring combinations which are still compressed. The intermediate stage in which the springs are in the process of expanding would correspond to the gas molecules spreading apart in the rocket expansion nozzle.

This description of a rocket propulsion system is qualitative, yet there are several important things that we can note from the analogy. First of all, just as the balls pushed against each other by means of the springs between them, the rocket and its exhaust jet push against each other. There is nothing else involved—**no outside** medium to push against as in the case of the automobile, the airplane, or the boat. This fact permits rocket propulsion system to operate nearly independently of the things that may exist around it.

A second fact to note is that since the rocket does not push against an **outside** medium, it has to carry its medium with it—propellants to generate jet gases.

Next, the rocket system is continually decreasing in mass as gas is expelled. Since the rocket system has a limited amount of mass, the thrust operation can continue for only a limited amount of time, i.e. until all of the propellant material has been used.

Finally, the more material a rocket ejects as jet mass, compared to the remaining mass of the rocket, the faster the final speed of the rocket will be.

From these qualitative observations, we can proceed to a more quantitative description of the rocket thrust.

Referring to figure 2 again, we note that since balls A and B have the same mass, they will move at the same speed as the spring expands. If B has a larger mass than A the speed of A will be greater than that of B after the expansion. Carrying the analogy over to the rocket, and thinking of A as the rocket mass which remains after the expulsion of the jet mass, B, we conclude that the more mass ejected from the rocket per second, the faster the rocket will move at the end of that second—or in other words, the larger the force that will be exerted on the rocket.

We have an alternate approach. As yet, we have said nothing about the stiffness of the springs. It should be clear that the stiffer the spring we use, the faster the "jet mass" will move, and also the faster the "rocket" will move. Putting this in terms of force acting on the rocket, we conclude that the faster the jet mass moves away from the rocket, the larger the force that acts on the rocket.

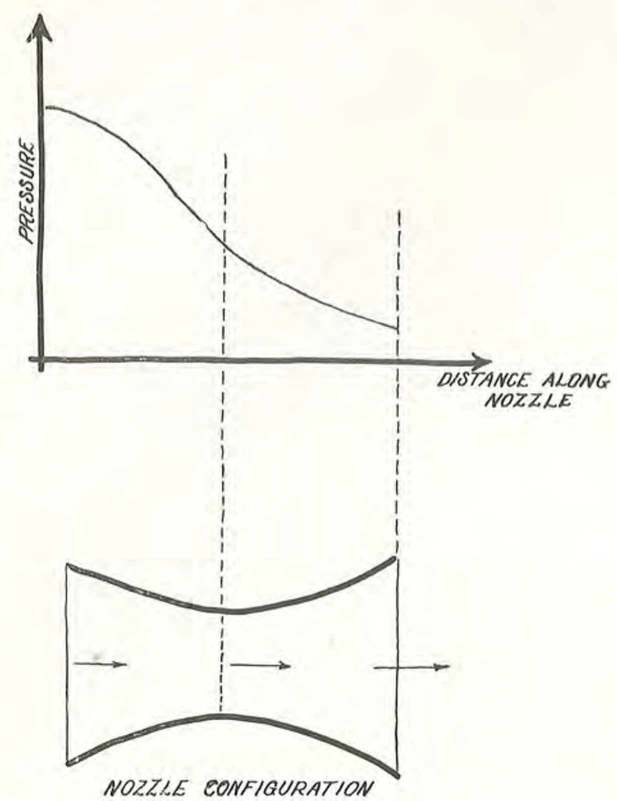
Combining these two conclusions, we have what is usually referred to as the "thrust equation". The thrust is equal to the amount of material ejected per second multiplied by the speed at which the material is moved. In a more technical way this is stated as

Thrust = Mass Flow Rate x Exit Speed.

Rocket engineers are frequently interested in obtaining the largest thrusts possible. We have seen that there are two ways this can be done.

Either mass flow rate can be increased, or the exit speed can be increased. A serious difficulty in increasing the mass flow rate is that the faster we use the material, the shorter the time of thrust operation. On the other hand, increasing the exit speed does not have this disadvantage. For this reason missile designers are very much interested in achieving high exit speeds. As we saw in the earlier description, the exit speed for our ball-spring combination depended on the expansion of the spring. In terms of the rocket system, it is the temperature of the gas in the combustion chamber which, to a large extent, determines the exit velocity.

It was stated earlier that rocket thrust is nearly independent of the surrounding medium. The product of mass flow rate times exit speed is usually referred to as momentum thrust since it results from the momentum per unit time (relative to the rocket) given to the jet gases. The exit speed depends slightly on the pressure of the medium (usually air) outside of the rocket. But aside from this slight dependence, the momentum thrust is independent of the outside.



PRESSURE DECREASE IN NOZZLE

MOZER

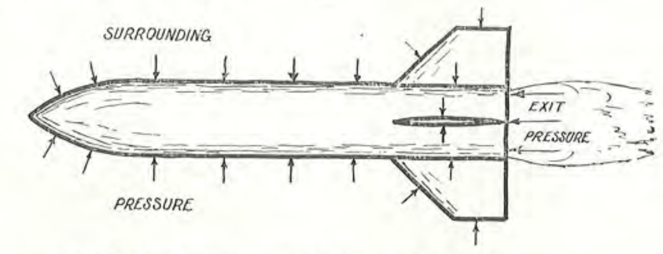
There is another contribution in addition to the momentum thrust that is usually included in the total thrust. As the jet gas expands through the motor nozzle, its pressure continually decreases. The pressure of the gas as it leaves the nozzle is determined by the combustion chamber pressure and the nozzle shape and not by the pressure of the outside medium. Thus it is not only possible but usual that the jet gas exit pressure and the pressure of the outside medium are different. Summing the static pressure forces over the entire rocket surface, and considering the nozzle exit plane as the outside surface at the rear of the rocket (nozzle and combustion chamber are hence considered to be inside the rocket), a net force results which is equal to the nozzle exit area multiplied by the difference between the two pressures, jet exit pressure and outside pressure. This contribution to the thrust is called the pressure thrust. The thrust equation now is

Thrust = momentum thrust plus pressure thrust
or
Thrust = mass flow rate x exit speed
plus
nozzle exit area x pressure difference.

The pressure thrust can be either positive or negative. It the jet exit pressure is greater than the outside pressure the net force is in the forward direction and the total thrust is increased. If the reverse situation exists naturally, the overall thrust is decreased.

Usually the pressure thrust is quite small compared to momentum thrust but this is not always true. For example one of the modern high altitude rockets expands the jet gases to approximately 3 atmospheres (42 lbs.-in.) at the nozzle exit. At sea level this would make the pressure difference 2 atmospheres. Since outside pressure decreases with altitude this difference would become larger as the rocket climbs. The nozzle exit area is in the neighborhood of 100 square inches so that the pressure thrust would be at least 2,800 lbs. and increasing with altitude.

Total thrust for the rocket is approximately 25,000 lbs. so that pressure thrust in this case is more than 10 percent of the total.



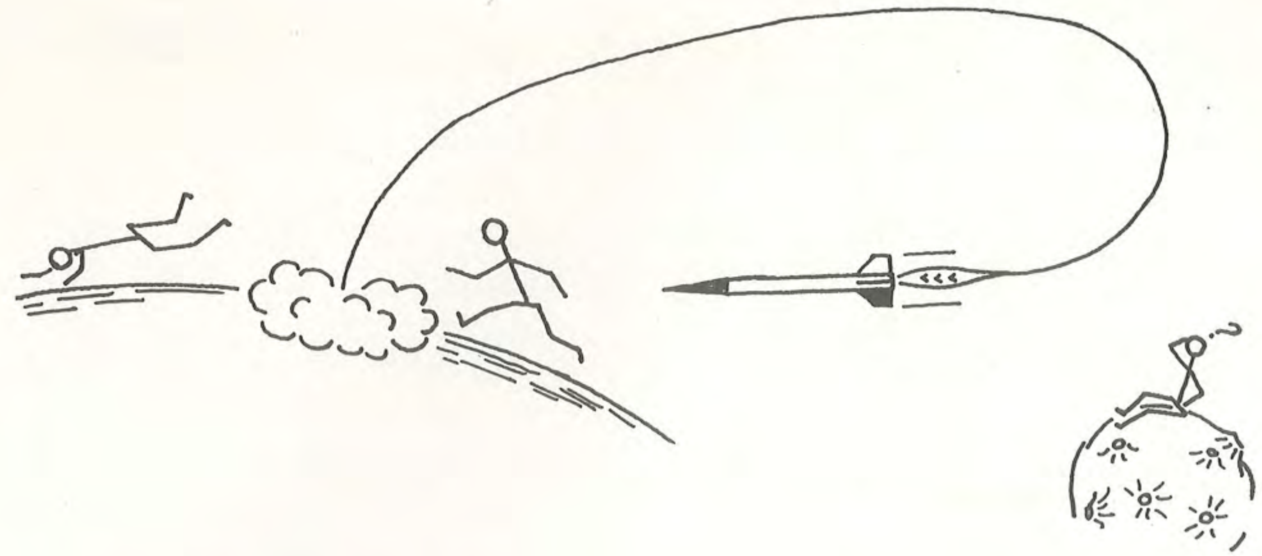
PRESSURE OVER ROCKET SURFACE

MOZER

For a rocket operating in space, outside of an atmosphere, the outside pressure is necessarily zero. This does not mean that pressure thrust is zero but simply that pressure difference is equal to the exit pressure of the jet gases.

It might appear from the above discussion of pressure thrust that it would be desirable to have a high value of jet exit pressure and thus increase total thrust by increasing pressure thrust. This is not possible since jet exit speed (and hence momentum thrust) also depend upon exit pressure. A more detailed analysis shows that the two contributions, momentum thrust and pressure thrust, are interrelated in such a way that total thrust is a maximum when the pressure thrust is zero. When this condition exists the nozzle is matched to the surroundings.

An understanding of rocket thrust and how it depends on mass flow rate and exit speed is very important to the rocket designer. But this is by no means the complete story. The energy available for propulsion and how efficiently this energy is used will determine rocket performance to a large extent. This subject will be considered in the next article of this series. • • •



FORCES
resulting from co-ordinate conversion

by

HAROLD A. DAW

New Mexico College of A.&M.A.

LONG range missiles have created renewed interest not only in the principles of classical mechanics, but also an interest in methods and techniques by which these principles may be applied to make real missiles go real places. The formalistic mechanics needed for today's problems were pioneered in times past. It makes a field far too complicated and extensive to be adequately touched upon in a single article. Rather than consider missile motion, this discussion will be restricted to the motion of a mass point and an attempt will be made to describe some rather interesting facets of single particle motion.

The behavior of mass point motion can be determined by the application of Newton's three laws. These laws may be stated as follows:

1. A particle remains unaccelerated unless an unbalanced force acts upon it.
2. The product of the mass and the acceleration is equal to the unbalanced force.
3. To every action there is an equal and opposite reaction.

To study the motion of a particle by means of these laws, we first need a coordinate system. But it is readily observed that not all coordinate systems are equally useful. Consider the truck in Fig. 1. The x coordinate system is fixed relative to the stars. In this coordinate system, one finds that Newton's laws hold. But if one considers the motion of the truck in the x′ coordinate system, fixed in the truck, one finds that Newton's laws do not hold. In fact, in this later system regardless of the forces applied to the truck, the truck remains at rest. A coordinate system in which Newton's laws hold is called an "inertial system". Systems of coordinates anchored in the fixed stars closely approximate such a system. For most laboratory work, the earth also closely approximates an inertial system. However, when one is thinking of large distances and high speeds, the earth can no longer be approximated by such system.

Let us take a closer look at the coordinate system in

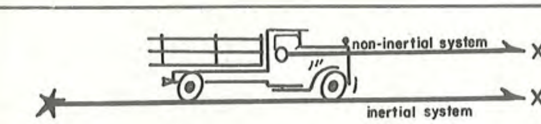


FIG. I

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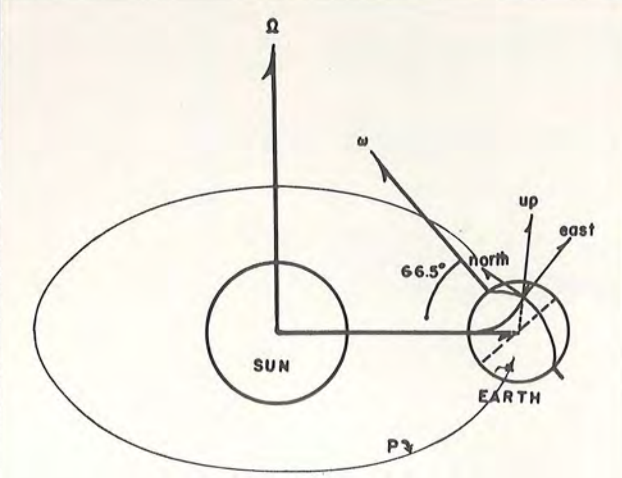

FIG. 2

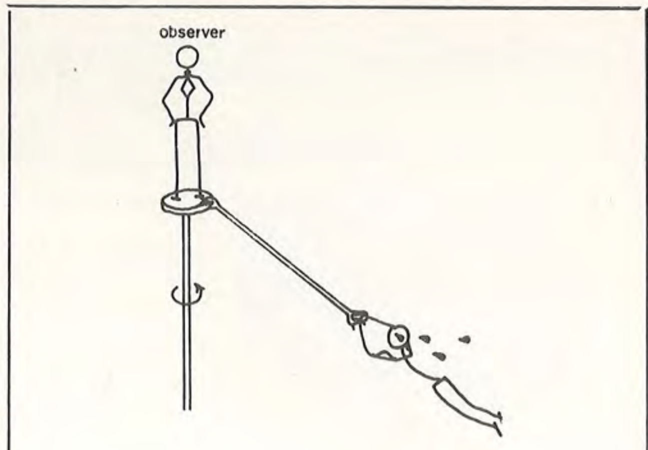

FIG. 4

which we live. It is represented by the drawing in Fig. 2. Commonly used directions in a coordinate system fixed relative to the surface of the earth are up (and down), east (and west), and north (and south). The earth moves about the sun in a plane called "the plane of the ecliptic". The earth is a sphere eight thousand miles in diameter located about ninety-one million miles from the sun. The earth makes one traverse of the path P every year. The symbol Ω represents the rotation of the earth about the sun. The earth also rotates on its own axis, making one revolution every twenty-four hours. This rotation is represented by the symbol ω It must be obvious that motions will be a little difficult to describe in such a system since this system is both translating and rotating relative to an inertial system, i.e. a system anchored in the fixed stars.

We will consider the general problem of describing motion relative to the surface of the earth only in its elemental parts. For this purpose, use will be made of some simple examples. Consider the two figures, Fig. 3 and Fig. 4. Fig 3 shows a man clinging desperately to a spining cord. If the observer examines the tension in the cord and the pull of gravity on the spinning man, he will find an unbalanced force acting on the man, pulling him toward the center. This is what is to be expected; since by observation the man is accelerated in a circular path, Newton's second law requires an unbalanced force. In Fig. 4, the observer sees the man stationary at the end of the cord, but from the bulging muscles and the sweat on the brow of this stationary man, the observer can tell that some force must be pulling the man from the rope. Further, from Newton's laws, the observer would conclude that the man was being pulled out just as hard as the man was pulling in. In the first figure, the unbalanced force is referred to as the "centripetal force" since it is directed toward the center. In the second figure, the force pulling the man out is called the "centrifugal force" and is often referred to as a fictitious force. It is real enough to the observer in Fig. 4, but it arises from the coordinate system the observer chose to observe from.

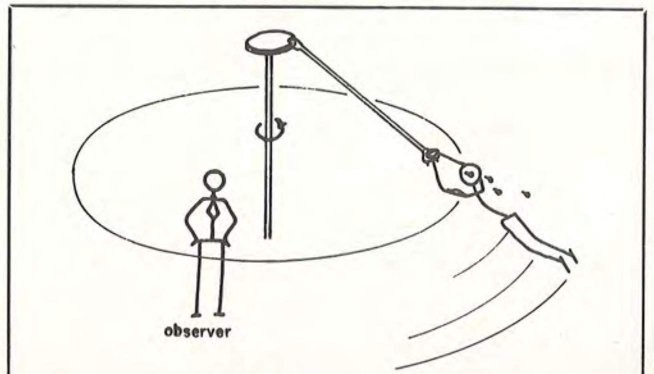

FIG. 3

One of the major problems in visualizing such a "fictitious" force is finding a proper way of placing oneself into the chosen coordinate system. In the problem just discussed a convenient way of accomplishing this is to let a man (or ball) swing rapidly on the end of a string. If the swinging object is illuminated with a stroboscope at the proper frequency, the object will appear to be stationary and the effect of the centrifugal force will be clearly apparent.

Further insight into the problem of motion relative to the earths surface can be obtained by writing Newton's second law in vector form, and transforming from an inertial system xyz into a coordinate system x′y′z′, rotating with a constant angular velocity. The details will be omitted, but it is easily shown that in the primed system the mass times the acceleration equals the sum of the forces observed in the inertial system plus a centrifugal force plus a Coriolis force. The centrifugal force we have discussed. It arises from the position of a particle relative to the axis of rotation. The Coriolis force is named after the Frenchman who first investigated it. This force is proportional to the velocity of the particle and is also perpendicular to the velocity. This force exists only when motion is considered relative to a rotating coordinate system and the particle being observed has a velocity relative to this system. Since the force is perpendicular to the velocity, it can not alter the speed of the particle but causes the particle to move in a circle

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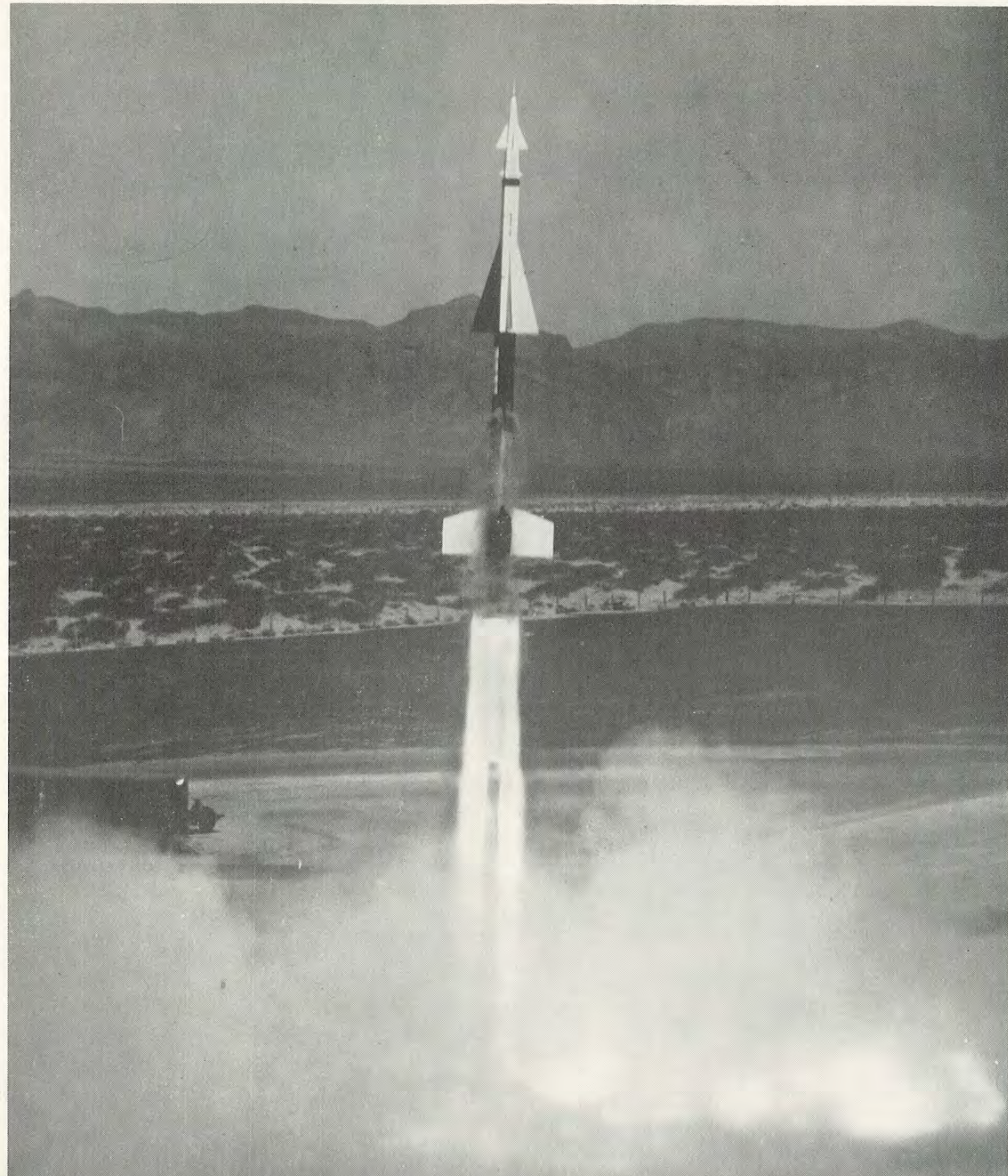
winged victory . . .

Nike takes off amid fire and fury. (U. S. Army photo)



with constant speed. A method of observing this force independently was suggested by an article in the American Journal of Physics[1]. A parabaloid of revolution can be constructed by spinning a plaster of paris mixture in a pan atop a phonograph turntable. Since the plaster of paris is free to flow at first, it assumes such a shape that no net force is exerted on the plaster particles at the surface. When the plaster has hardened, a small ball can be placed on the surface. The ball will be in static equilibrium at any point on the surface if it is not moving relative to the surface. This is due to the fact that the gravitational and centrifugal force add to leave only a force normal to the parabaloid surface. If only one could now stand in this system and cause the ball to move, they should see the ball move under the influence of Coriolis force alone. Standing on a rotating turntable may cause one to get dizzy as well as break up a friendship with one's Hi-Fi friend; however, if one rotates an erecting prism about the axis of the rotating turntable, the turntable can be made to appear to stand still. One can now observe the action of the Coriolis force only. Fig. 5 and Fig. 6 show the behavior of particles in this system.

Some of the effects of these so called fictitious forces present in our daily life should be mentioned. Fig. 7 indicates that a plumb bob does not point toward the center of the earth, but due to centrifugal force is pulled slightly to the south in the northern hemisphere.

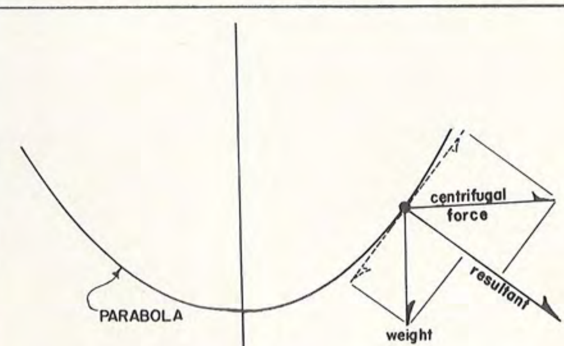


FIG. 5

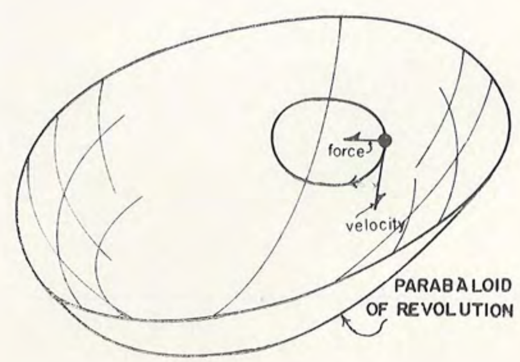


FIG. 6

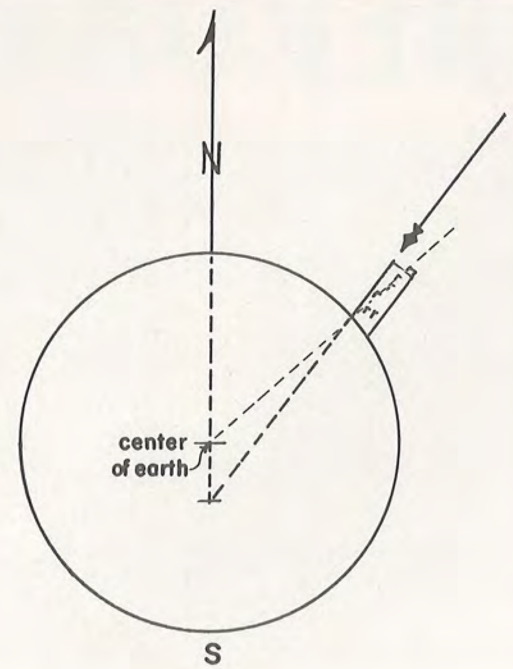


FIG. 7

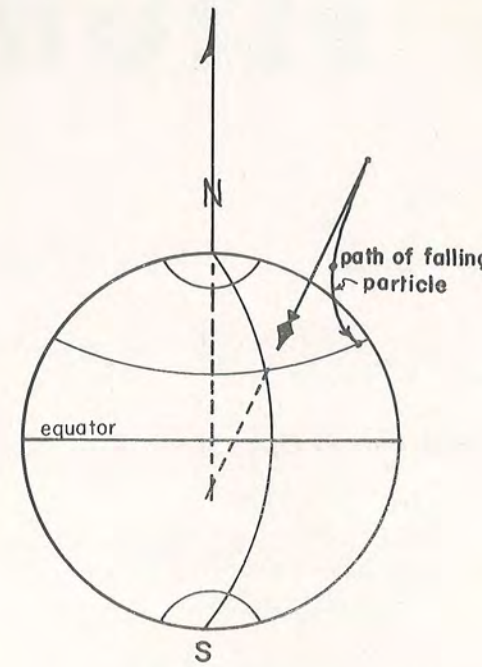


FIG. 8

This figure also indicates, with slight exaggeration, that one builds one's house in conformity with the centrifugal force. That a ball does not fall along a plumb bob string when released from the top of the plumb bob is illustrated in Fig. 8. The Coriolis force is responsible for the ball being carried to the east. Fig. 9 shows how the winds on the earth are deflected to the right in the northern hemisphere and to the left in the southern hemisphere due to the action of the same Coriolis force.

When one wishes to foretell the motion of a missile, these forces must be taken into account. At the latitude of Las Cruces, a missile will fall approximately two and one half miles to the west if fired one hundred miles vertically, approximately seven and one half miles to the west if fired two hundred miles vertically, due to the action of Coriolis force alone. As longer range missiles are built, greater and more exact corrections will be needed. Without proper forethought it is possible to fire a missile well away only to find it returning to the starting position. That a physicist might argue the missile did not turn around, but the earth rotated under it would bring little satisfaction to the widows of scientists upon whom the missle fell. Lest any reader become confused by this article, let me point out that a plumb bob five feet long would hang only about .05 inches from the vertical, hence in part, a mountain has been made of a mole hill. Let us hope that missiles never make moles of men. • • •

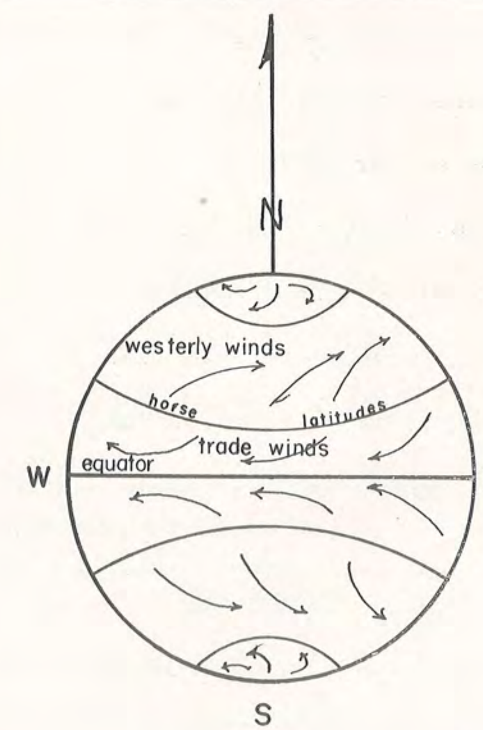


FIG. 9

[1] A. A. Klebba and H. Strommel, Am. J. Phys. 19, 247 (1951).

FLIGHT REPORT... Aerobee-Hi NRL-50

Rocket Data—

Model: RV-N-13a

Length: 279 Inches

Diameter: 15 Inches

Fuel: Aniline—Furfuryl Alcohol Mixture

Oxidizer: Red Fuming Nitric Acid with 6% excess oxides.

Rocket Dry Weight: 257 Lbs.

Instrumentation Weight: 135.6 Lbs.

Oxidizer Weight: 711 Lbs.

Fuel Weight: 309 Lbs.

Helium Weight: 6.5 Lbs.

Take-off Weight: 1479.1 Lbs.

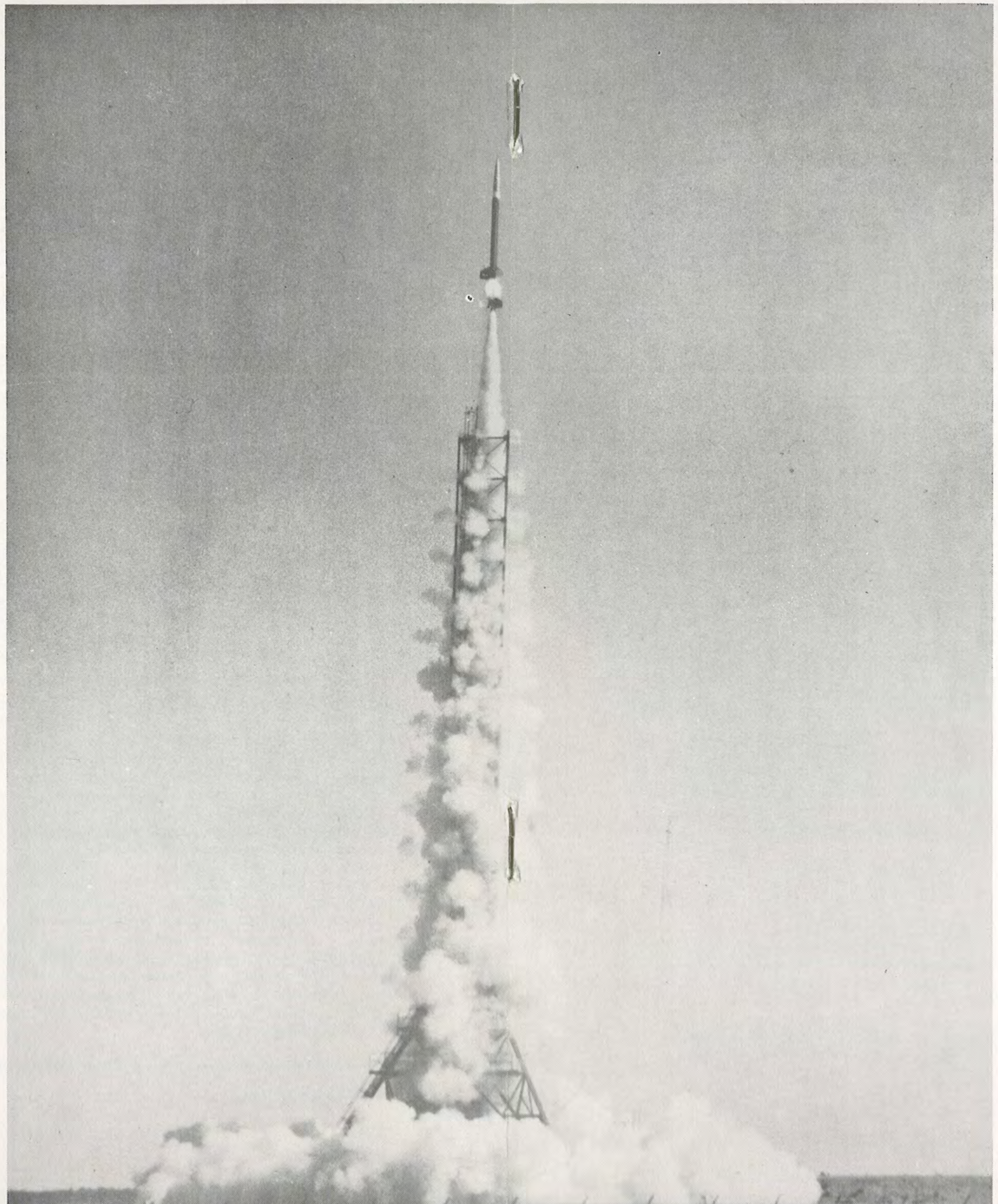
Thrust of Sustainer: 4000 Lbs.

Thrust of Booster: 18,000 Lbs.

Experiment: Electron Density and Absorption of the Ionosphere, Magnetic Field, Height of F_2—Layer.

Manufacturer: Aerojet General Corp.

User: Naval Research Laboratory, Rocket Sonde Branch.



Performance—

Firing Date: 29 June 1956

Firing Time: 1206 M.S.T.

Booster Burnout: 2.2 Sec.

Rocket Burnout: 52.0 Sec.

Burnout Altitude: 136,000 Ft.

Burnout Velocity: 6600 Ft. Per Sec.

Peak Altitude: 163 Miles

Peak Time: 275 Sec.

– Records Broken –

Viking 11, 158 Miles

V-2 (TF-1), 132.6 Miles

Aerobee-Hi (Air Force), 123 Miles

"Missile Away!" salutes this heretofore insignificant rocket, the little Aerobee, and the men of the U. S. Navy who fired her.—

THE ANTENNA PROGRAM AT PSL

Satellite telemetering antenna

by
R. H. DUNCAN
and
H. W. HAAS

IT often seems to the antenna engineer that he is the last man to be consulted in the design of a missile. After the aerodynamicist has conjured up a suitable body configuration, the propulsion engineers have commandeered ninety per cent of the available space, armaments engineers have taken ten per cent, controls and dynamics have taken up five per cent (the required space on a rocket always adds up to 105% of that available), the antenna engineer is then asked to get aboard with several antennas.

These are always to be flush mounted, not more than three inches long and not exceeding two ounces in weight. In addition, the range safety cut-off antenna should have an isotropic radiation pattern in violation of Maxwell's celebrated equations. Antennas for telemetering and other purposes are invariably required to radiate a uniform hemispherical pattern either broadside or off the tail depending on the aspect of the missile when certain vital information is to be delivered to the ground.

All this is as it should be. The primary duty of a rocket is to deliver payload to some point in space, either a warhead or instruments for upper atmosphere research. It becomes the antenna engineer to be as effective and unobtrusive as possible under the circumstances. It is the purpose of this article to outline some of the developments in missile antennas carried out by the Physical Science Laboratory, developments which have made the missile antenna an almost aerodynamically non-existent addition to the missile structure.

In a very real sense, there is no such thing as a missile antenna. The antennas of simple theory always radiate into free space, or they are associated with an infinite ground plane and radiate into half space. If one mounts a dipole on a missile, the resulting radiation pattern is that of a dipole in the vicinity of a cylinder, and it approaches that of the dipole-infinte plane combination only in the limit of zero wave length, or high frequency. In the telemetering band, about 1.5 meters, a missile is very definitely finite and cylindrical as far as the antenna is concerned, additional complication being introduced by the fin structure and tapered nose section. Conceptually, then, one recovers by imagining the missile itself to be the antenna. The job of the antenna engineer is to provide some type of discontinuity to or gap in the structure to act as an exciter. Unfortunately, this shift in concept and terminology doesn't make the job much easier. However, it does provide a very convenient bit of pedantry for confusing specialists in other fields.

One of the first antennas developed by the Physical Science Laboratory was the fin notch antenna for Aerobee-Lo. According to our records this type of exciter was conceived at the Applied Physics Laboratory of the Johns Hopkins University and developed by PSL under a contract with the U. S. Navy in 1949. Since that time the fin notch has been used in several missiles, at 54.5 mc/s, 225 mc/s and 580 mc/s. The notch casting is fitted into the fin with the notch parallel to the missile axis. **Impedance of the exciter can be controlled by varying the position of the feed point in the notch. Some pattern control is provided by varying the notch position, with the most uniform coverage.** However, the ideal location is nearly always compromised by the stress analyst. Choosing the position of a fin notch to acquire the best radiation pattern always involves considerable hassling between the antenna designer, missile manufacturer, and the agency flying the missile.

The fin notch antenna also provides an excellent example of how engineering effort can lead to basic research. Early notches failed at high altitudes because of ionization of atmospheric gases in the notch. The cure is simple: a teflon slab fitted into the notch prevents breakdown from occurring. However, the physics of such discharges is interesting for its own sake. After the initial investigation related to antennas, a group was formed in the Physical Science Laboratory to continue theoretical and experimental studies of gaseous discharges. Their work, in progress for the past five years, has provided a fund of information on these phenomena. In addition to doing basic research, the group provides consulting service on all missile antenna designs performed at the laboratory.

The best aerodynamic antenna design achieved at

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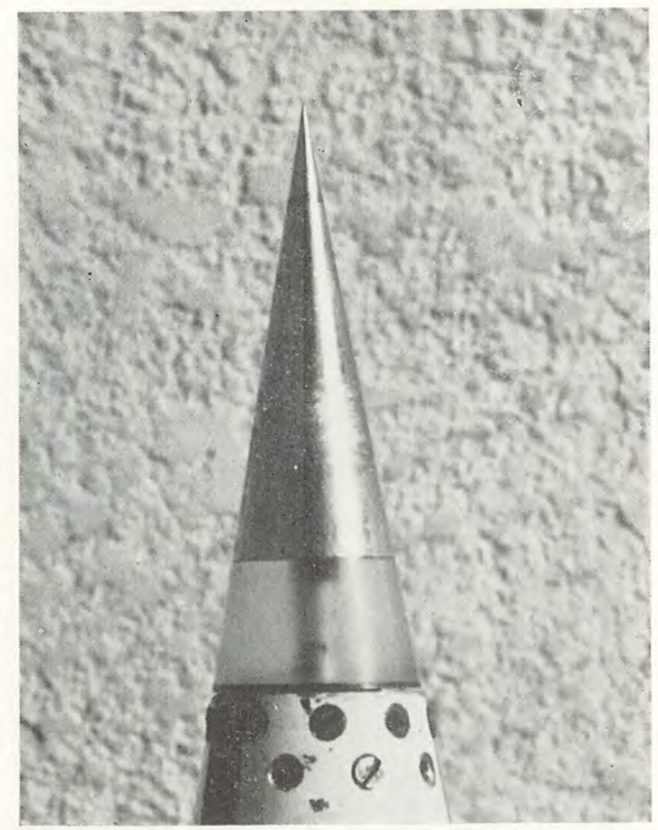


The nose-cone antenna developed by PSL as it was installed on an early Aerobee rocket. Note the insulating ring of plastic.

ANTENNAS—(cont.)

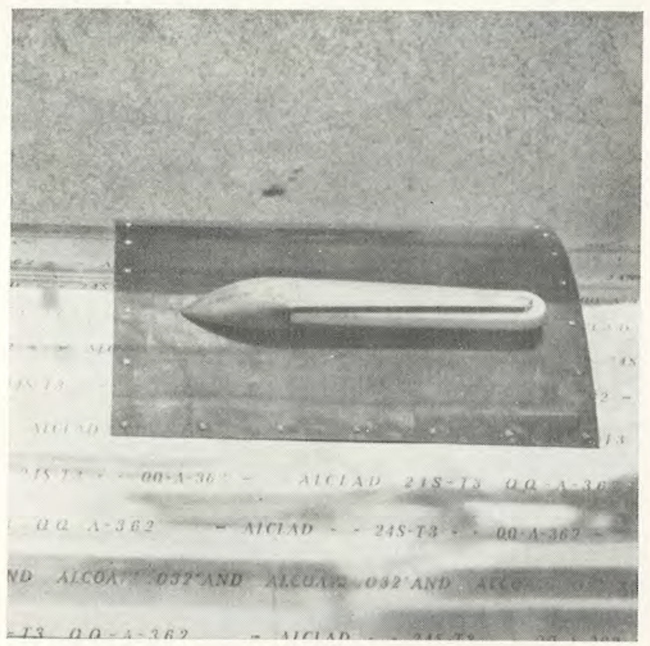
the Physical Science Laboratory is the nose cone antenna. So far it has been used only on Aerobee missiles. The nose cone antenna replaces the nose tip of the rocket and is insulated from the rocket itself by teflon. The entire assembly is fitted to the original contour and it weighs very little more than the material it replaces. This would seem to be ideal, and it would be except for the fact that the radiation pattern exhibits a null directly aft of the missile. (This is to be expected, since the design type and method of excitation is that of a long wire antenna fed near one end). Consequently, some attention must be paid to the location of ground receivers when this antenna is used.

In spite of their obvious aerodynamic advantages the fin notch and nose cone antennas can not always be used. For one thing, there are usually more channels of communication to a missile than there are fins. For another, every last iota of space in the nose may be allotted to upper atmosphere research instruments. The answer to this situation is provided by the quadraloop antenna. This antenna is basically a streamlined protuberance at the side of the missile, the gap being teflon filled to prevent gaseous breakdown. Sufficient data is now available to permit easy and rapid design of this antenna. The radiation patterns are almost independent of missile diameter, so that when a design has been achieved for a particular frequency, it can be applied to several different missiles without extensive additional work.

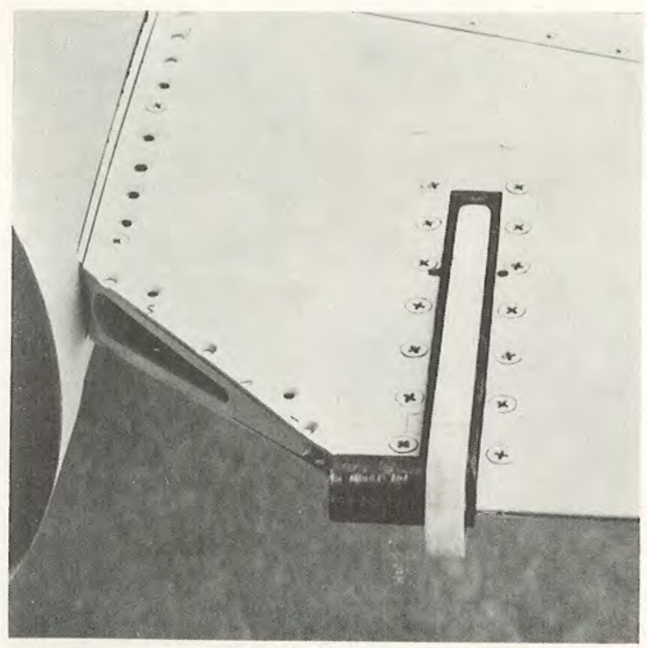
Not all of the antenna development at the Physical Science Laboratory is concerned with missile borne antennas. Several antennas have been provided for ground use. The most recent of these is a three element helix array for the Vanguard project and is an outgrowth of considerable experience with single helix units, several of which are in service at WSPG. Work of this nature is in the area of competent design rather than research and development. However, there is an apparent need for development of unconventional helix antennas with varying pitch and diameter to provide further control of pattern and gain characteristics.

The antennas described here are only a partial list of those in the Physical Science Laboratory repertoire. Several other types are in service and several concepts are available for study and development. A recent achievement is a "split missile" design which differs from others of its type in that it permits cabling across the dividing insulator without shorting the missile sections together at radio frequency. An antenna and transmitter to provide signals for ocean recovery of a rocket nose is in the last stages of development. This system will be used in a project for photographing hurricanes. Experience with it may lead to contributions to other recovery systems.

In closing, the authors would like to express their appreciation to their predecessors, colleagues, and assistants who have contributed in many ways to a successful program.



The quadraloop antenna mounted on the skin of a dummy missile prior to running field strength surveys on it.



The fin notch antenna design by PSL which is presently mounted on Aerobee rockets as shown here.

MISSILE FLIGHT SAFETY CONSIDERATIONS AT WSPG

by
George L. Meredith
and
Donald I. Thompson

Presented at the Semi-Annual ARS meeting in Los Angeles, September 1955

The term Flight Safety and what it implies is becoming a major topic for consideration by the officials of the various Proving Grounds. As the research in the field of rocketry produces higher, faster and longer range missiles the majority of the Proving Grounds are becoming too small to contain the flight of these rockets without some method of "shutting off" the missile in the event that it becomes dangerous. This problem was recognized at WSPG in 1947. Since this paper will deal with the activities at WSPG, it might be well to discuss the history and development of the group to its present status.

In May 1947 the first incident occurred which indicated the need for a system, operating as a separate unit, to provide a means of terminating the flight of unsafe rockets. A rocket which was supposed to fly North flew South instead and landed in Juarez, Mexico. Fortunately there were no casualties. Later the same year another rocket wandered off to the East and landed near Alamogordo, New Mexico. These two incidents, either of which could have resulted in many casualties, brought about the organization of a Flight Termination group, or Radio Cutoff, as it was known in the early days. A contract was let to New Mexico A & M College to provide and operate a system to perform the necessary functions to prevent a rocket from violating range boundaries. Since the idea was new and experience was limited, the first system and techniques, though workable, were rather crude if judged by present standards.

In 1950 it was decided to make this service a function of the Proving Ground. A Missile Safety Branch was organized as a function of the Technical Services Division, and assigned the task of development of criteria, selection and development of equipment and the installation and operation of the system. This group, in taking over the job, had the experience and part of the personnel of New Mexico A & M as a background in carrying out the policies of the Proving Ground.

This organization has grown into what is now the Missile Flight Surveillance Office, one of the staff functions of WSPG. The duties and responsibilities have grown with the organization. At present any project wishing to use the WSPG range must satisfy the requirements for safety set up by MFSO. If the missile has the capability of violating the range boundaries, a shut-off system must be provided. This may be a part of the missile system, in which case the circuitry used must pass inspection; or if the missile has no provision for emergency shut-off, the WSPG radio link is used. This radio link will be discussed in more detail later.

Before any system could be put into operation a set of rules and standards were necessary.

The broad requirement as set up the WSPG Command can be expressed in a few words "no rocket is to be allowed to leave the WSPG range." This sounds easy if you say it quick. But it really isn't easy at all. There are many types of missiles tested at WSPG all of which must be handled differently. In order to set up the safety requirements for a particular missile it is necessary to know practically everything about the missile and its performance. Propulsion data, including thrust and burning time; predicted trajectory; guidance capabilities, both during and after thrust; and drag characteristics are the more important factors to be considered in setting up the criteria for that particular missile.

In order to be cognizant of when a missile is going sour, a study of its capabilities has to be made and presented in a manner which enables the Flight Safety Officer to predict impact within calculated tolerances.

The simplest type of safety criteria is that used for fail-safe missiles. The capability of such missiles upon initiation of the fail-safe mechanism is a limited range, a certain number of yards, practically independent of altitude. Thus safety consists of a line drawn parallel to the range boundary at a fixed distance from it, determined by the characteristic of the burst missile and delay time in the fail-safe circuit.

The only other types known are those used in ballistic missiles where only thrust is terminated and missile break up does not take place. For each of these missiles an impact range capability graph is constructed for each program. (Figure 1). By program is meant the angle from some reference plane or line at which the missile is inclined at motor burn-out. The graph will contain two curves. One: Range to burn-out versus time. Two: Range from burn-out to impact versus burn-out time.

A criteria for radar plotting board grids can then be constructed for each missile from these graphs. The criteria will consist of a family of curves centered round the launcher and which determine the limiting azimuths at any point in space. (Figure 2).

Trajectory computations are done either by electronic computers for the project or by office type calculating

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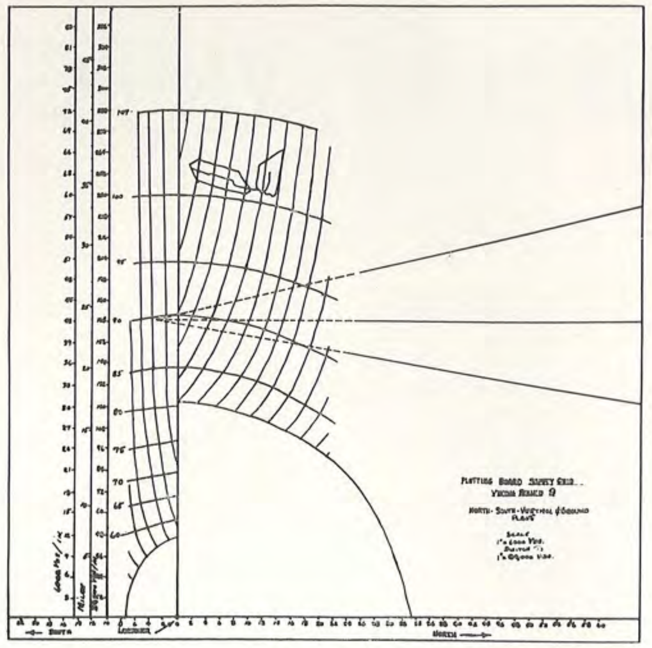
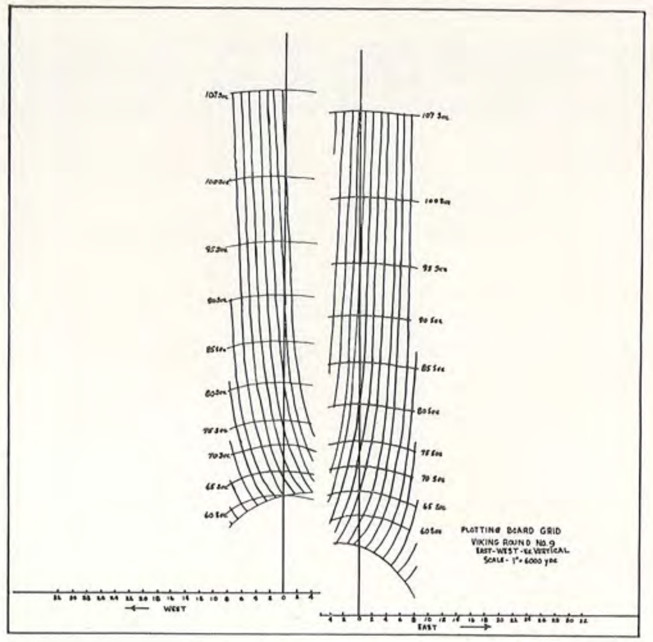


(Figure 1)



(Figure 2)

FLIGHT SAFETY—(cont.)

machines. The 1103 is now used especially for MFSO to compute performance for high altitude research vehicles. A system of equations has been devised to account for effects of coreolis accelerations on impact point. This method is simple and straight-forward, there being two steps in each time interval used, one to approximate the next value based on previous conditions and the second to adjust these values by averaging the 1st step and previous interval values. The definition of the coordinate system used in these computations may be stated as follows:

1. A cartesian coordinate system with origin at center of the Earth.
2. Vertical axis with positive direction upward from origin through launch point.
3. East-West axis parallel to equatorial plane or to rotational vector.
4. North-South axis defined as perpendicular to first and second axes.

The equations used for these computations will not be given here but are available to anyone who is interested.

Now that the mathematicians and theorists have decided what the rules and standards are to be and have developed a method of applying these standards, it becomes the job of the engineers to provide the equipment and the techniques to implement the system. First I think it would be advisable to define the requirements and then search for a means of meeting the requirements.

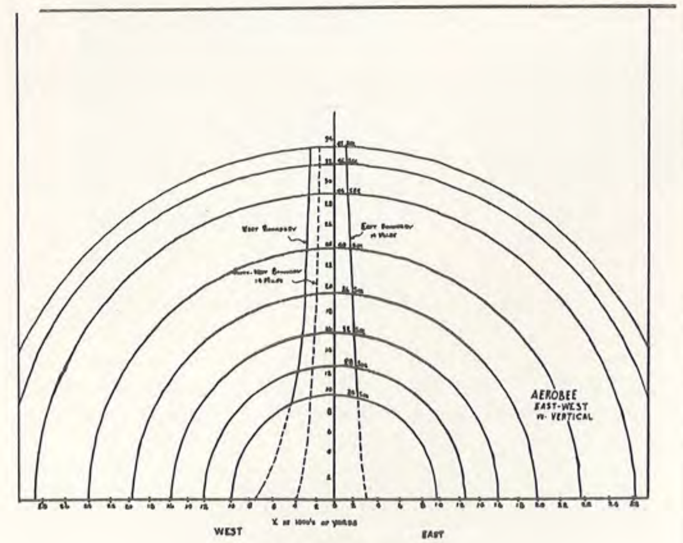
1. The position of the missile must be known and presented during flight.

This sounds easy. Radar was developed during World War II for the purpose of spotting and tracking aircraft. This function was performed quite successfully. Why not use radar in this application? We can, but not as easily as it might appear. There are major differences in the two applications which increase the difficulties in the use of radar. Missiles are smaller, with a correspondingly smaller echo or return signal. Missiles are faster, which would require a faster tracking rate. There is the problem of "jet attenuation" during the burning period (the most important part of the flight as far as safety is concerned). These are a few of the problems which confronted the White Sands Signal Corps Agency in building a radar system for missile work. The system is not perfect but the problems have been solved in an acceptable manner. New equipment and new techniques are being developed to improve the present system. Beacons or radar transponders have been developed and are being flown in missiles to increase tracking reliability.

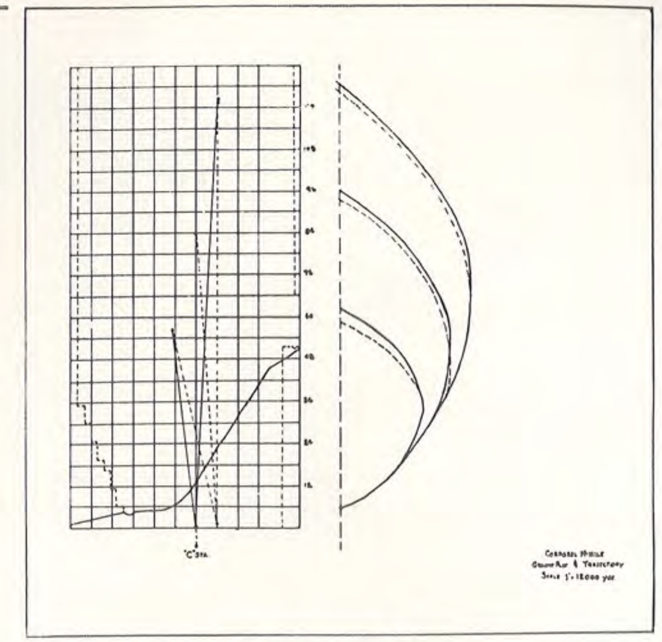
We may now assume that the tracking requirement has been met and that the radars can follow the missile. But radar data as presented on the dials and scopes is in polar coordinate form. This is not usable for flight safety purposes unless you can find a man who has a computer in his head that can take constantly changing range, azimuth and elevation data and picture it as a position in space in relation to a plot of land, in this case White Sands Proving Ground. Since these people are very rare, a REAC computer is used to change the data to the form necessary for presentation on a plotting board.

2. A means of relating missile position and performance to the WSPG range.

There are two major means for meeting this requirement. The most commonly used and most trustworthy method is by the use of plotting board grids (Figures



(Figure 3)



(Figure 4)

FLIGHT SAFETY—(cont.)

3 and 4) set up on the basis of specific missile performance and showing maximum deviation from the normal which is allowable. The data plotted on these grids is present position data taken from radars.

(a) Another presentation of great value to the Flight Safety people is from the impact predictor. (Figure 5). There are two of these in operation at WSPG. One uses radar data, the other takes data from optical trackers. The trace drawn on the grids by the pens is a prediction of the impact point of the missile if thrust was terminated at that instant. (Assuming a ballistic path to impact from termination point.) This data is of more value on the high altitude research type mission than the flatter trajectory usually found with the short and medium range weapons. But in any application it is a valuable tool in the WSPG flight safety program.

3. A reliable means of terminating the flight of a missile.

A great deal of discussion has centered around this requirement. A number of system and equipments have been proposed. Most of these have been eliminated for various reasons. The principal reason being reliability. In this business a piece of equipment is not acceptable if it works most of the time. It must work every time. This may sound unreasonable but it can be done and has been done. In the past five (5) years the MFS group at WSPG have instrumented 275 missiles with no failures of electronic equipment and only one suspected failure of associated equipment. This failure was due to skin heating which set off an explosive device used to sever a fuel line. The explosion occurred after burnout but severed the telemetering antenna cable and caused a loss of data. Steps have been taken to prevent the recurrence of this incident.

The present system in use at WSPG is a low frequency (6 meter) F.M. radio link. Each ground station consists of two transmitters with a fast switching method of changing over in case of trouble. The primary transmitter in the permanent ground station is a 1 KW Collins 732A (modified). The standby transmitter was designed and built by the engineers of MFSO.

The receivers are the best that have been found. Two types are used. The AN/DRW-4 is a modification of the ARW-37 which was designed as an aircraft control receiver. It is a single-conversion, superhetrodyne, narrow band FM receiver using a crystal controlled local oscillator. The modifications have been made with the purpose of increasing reliability and minimizing the possibility of failure due to vibration. The receiver has five control channels. Average sensitivity for single channel control is 5 microvolts on the antenna.

The other receiver used in the AN/DRW-3(XE-2). (Figure 8). Developed by the Signal Corps and built by Link Radio, this receiver has the same general RF characteristics but greater sensitivity (approximately 1 microvolts). It is smaller and lighter but has only one control channel. This restricts the use to a great extent, since many operations require two or more functions.

The receivers just described control the operation of various safety devices in the missile. These devices perform such functions as closing valves, cutting fuel lines, or causing missile break up by the use of explosives.

There are two types of operation of these receivers, command and fail-safe. The terms are almost self-explanatory. The command system requires a positive command to perform a function. A failure of any type would negate its value as a safety device. The fail-safe system is used with a command "on". To initiate any action the command is turned off. Also any failure in the system either in the missile or the ground station would cause the action to take place.

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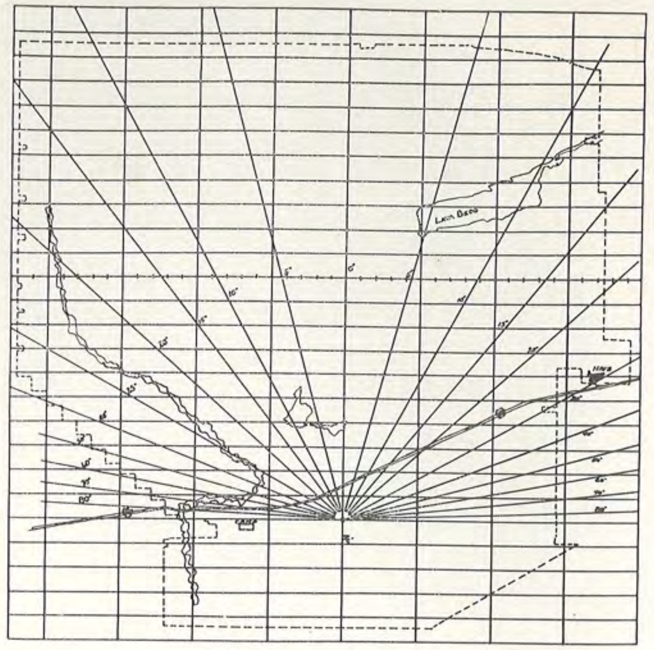


(Figure 5)

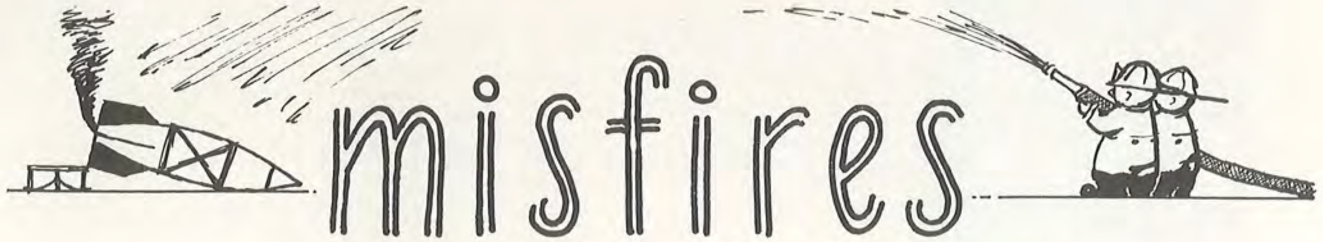
FLIGHT SAFETY—(cont.)

Both systems have been used at WSPG. The choice is a joint decision of the project and the flight safety group, with the type of test involved being the major consideration.

There is another system in the development stage which may supplant the low-frequency radio link. Radar beacons are an invaluable aid in tracking a missile. If a command channel can be perfected to operate a cut-off strip and the reliability can be increased to the point where it will be acceptable to the MFSO, there is a good possibility that this system will be put into operation. But this is in the future and will have to be proven.

Now we have a system complete from philosophy and theory to hardware and operations. It is not perfect but it is the best that can be had at present. We hope that it can be improved. But one very important factor has been left out. What of the men who have developed, built and who operate this system? They have a difficult job and a great responsibility. They can easily become the target for attack from all sides. What makes them tick? The operating personnel are electronic engineers chosen for their ability to work under pressure, and their personal integrity. There can be no compromise. Everything must be right. This includes everyone from the Division Chief to the field engineer and the lab technicians. It is a close-knit organization trained to work as a team, and to trust each other.

We of the MFSO feel that we have created something worthwhile. We believe in what we are doing. Our record is good and we are proud of it. We may not go to the moon but we will keep the rockets on the range until you are ready to send one out.



COMICFIDENTIAL

Goon Project Flight Test Report

Goon S/N 25 was successfully launched at 1014 on April 28, 1956, using the new Mk. 6 (RS-2) rubber sling catapult. The purpose of this firing was to further evaluate the roll stabilization under conditions of 056-degree relative wind, 80% humidity, 76-degree F. temperature, and 29.86 barometric pressure. Elevators were set at 50-degrees up with tabs at 2½ degrees. Rudders were wing and wing. The new Brownie Mk. I aspect camera was installed in a spring-mounted, lead-covered, cork-lined box of rubber. Telemetering of the mirror type was installed.

Booster ignition occurred prematurely at X-minus 4 minutes, 36 seconds, when the guard on the Main Gate inadvertently tuned his table radio to a frequency of 1332 kilocycles. It is believed that spurious radiation from the set's local oscillator precipitated premature ignition of the igniter squib. Steps are being taken to silence all electromagnetic radiation within a radius of ten miles from the launcher during the time the igniter is installed.

Following the premature ignition, the missile quivvered in place for 5.64 seconds, moved ahead 2.89 feet, spun twice clockwise, then roared down the launcher rail at an angle of attack of 45-degrees, reaching a speed of 62.67 feet per second on leaving the rail. The Corn L-type 74 roman candle booster separated cleanly after hanging by No. 6 shackle for 7.6 seconds. The missile then rolled slowly to the left for 520 degrees while going into a 12-g 47-degree turn to the right. Upon reaching the end of boost phase, guidance capture was effected and the missile programmed upward at an angle of 76 degrees. Self-destruct failed to arm, and as the missile approached the west boundary of the range, the Cessna L-19 chase plane was ordered to shoot it down. The crash occurred 86½ yards north and 67½ yards west of the launching site.

The Recovery Section combed the area, and at the present time 18,269 pieces have been recovered and completely examined. The aspect camera was recovered although it was rolled into a ball the size of a walnut. The film was scorched, exposed, and broken into approximately 300 pieces. Results are being compiled at the present time and a report should be forthcoming early in 1958.

It is now believed that the excessive roll rate as well as the out-of-tolerance yaw was caused by a 0.0016″ shear pin in the counter-reversing link of the hydraulic regulator of the steering intelligence system being shaken loose when the launching officer suffered a spasm of coughing while performing final checkouts. Steps are being taken to fabricate new shear pins of 0.0017 diameter.

No photographs were available showing the launch phase of Goon S-N 25. However, an alert, attentive project photographer was on hand to cover the impact area. Shown at the last rites are the project engineers who are now in the employ of the Ajax Fireworks Company.

Poet's Corner

ODE TO I. G. Y.

When it's springtime in Fort Churchill,
And it's forty-five below,
And the Eskimos go barefoot
In thirty feet of snow,
And the polar bears get sunburned,
And the seals make love all day;
When it's springtime in Fort Churchill,
I'll wish I was far away!

— Anonymous

"Some GI traded it last week for a '53 Ford. Take a look . . . new paint, good tires . . ."

ENGINEERING TYPES

— by Wagoner —

EINSTEIN'S THEORYS WERE ALLRIGHT.... HE JUST DIDN'T GO FAR ENOUGH.

Rare Birds of the American Southwest

Compiled by

R. K. AUDOBURNE

DOUGLAS' SPOONBILL: Ianus Honestus

Field Marks: 21 feet nose to tail with a 30 inch body Uniform color; white, dark grey or brown, or brilliant orange. Four nearly right triangular tail surfaces spaced symmetrically around the rear body. Nose is larger in diameter than main body.

Similar Species: Square Tailed Swift ("Missile Away!" Winter 1954) is similar but is smaller in size, has square tail surfaces, and lacks the bulbous nose.

Range: Originally seen in southern New Mexico but has spread over nearly the entire United States in the last few years. Germany and Japan have also been inhabited by this bird.

Comments: This bird must decide where its going before leaving the ground. It launches itself by a device which points it in the right direction to reach its destination. The launcher is portable and can be used in a wide variety of locations. The bird needs to be warm at takeoff and wraps itself in a blanket for a considerable time before attempting a flight.

Immediately after leaving the launcher the Spoonbill exhibits the peculiar habit of spinning around an axis through the length of its body. This spinning helps to keep it on the proper course to its destination.

Other Names: Hercules Spoonbill, Desert Destructer, and Honest John.

post shoot conference

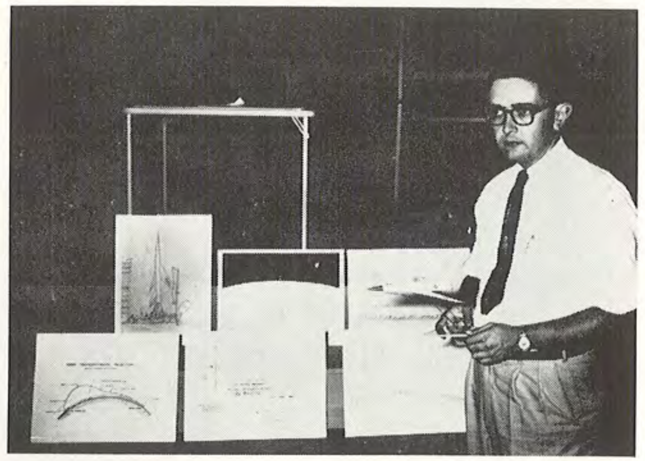
President Russ Sherburne, being past president as well as president, received a letter from Dr. R. W. Porter regarding nominations for national officers for 1957. Russ took this up with the Section Board of Directors, and the Board made the nominations as follows: for president, CDR. Robert Truax, USN; for vice president, George P. Sutton and Howard Seifert; for Board of Directors, Frank L. Koen, Jr., Darrell C. Romick, R. Gilbert Moore, and Russell K. Sherburne.

Three new members have been appointed to the Section Board of Directors. President Sherburne, utilizing his powers to appoint to fill Board vacancies, picked Bill Fickes and Chuck Johnson of WSSCA, and Chuck Mozer of the Physical Science Lab, N. M. A & M. A. Thus far, these boys have been pitching in with great fervor.

The newest vacancy on the Board was due to the leaving of Bill Hancock. Bill took a position with General Electric at Malta, N. Y. In the past, Bill has always been one of our most loyal and hard-working Section members. The Space Ball for 1956 was under his control, and the soire turned out to be the success that it was mostly because of his efforts. We're going to miss you, Bill.

On the satellite scene, Dr. Fred L. Whipple of Harvard has instituted a Visual Satellite Observation Program—Project Moonwatch—which will be undertaken by amateur astronomical societies throughout the country. Plans are also afoot to get the amateur radio hams into the act, too, by having them get set up on the telemetering frequencies. We all know that the ARS had a great part in getting the whole satellite program started in the first place; isn't there something the ARS can do to help now, Dr. Whipple?

The Section offered to send this magazine to every member of the American Rocket Society, the National Headquarters to pay for it on a basis of cost—printing, binding, and mailing. The matter was to have been taken up in the National Board of Directors in June, but thus far we have heard no word one way or the other.



Two Section members are in the process of preparing papers for the Annual ARS meeting in New York in November. Russ Sherburne has just submitted his paper covering a much more detailed analysis of the rocket performance parameters on which he spoke at the April meeting. Harry Stine has submitted a paper on a long range manned rocket research vehicle and gave a sneak preview to the Section at the June Meeting on 28 June 1956. We hope this will constitute a precedent for other Section members and act as a prod to get them busy on papers for national meetings, too. After all, you don't have to go into it cold, boys; you can try it out on your long-suffering friends in the Section first!

Go back and look at the center spread of this issue. That isn't just anordinary Aerobee rocket blasting out of the launching tower. That's Aerobee NRL-50, the Aerobee-Hi. Yes, we finally got one to work! Many of your fellow Section members had a hand in helping the rocket toward that record. 163 miles up is a long way for a little rocket like the Aerobee to go, but it wasn't sent there easily.

(page 36, please)

POST SHOOT (Continued)

Just shortly before our Spring issue went to the readers with the Post Shoot Conference item about Ed Francisco's illness, Ed showed up at White Sands looking hale and hearty. He is now on the road to recovery and living in Albuquerque . . . and has taken up his membership in this Section again! Ed was present at the April 26th meeting where Russ Sherburne was the featured speaker on the subject of rocket performance parameters.

The May meeting of the Section was held at the Town and Country Restaurant in Las Cruces and featured a motion picture from White Sands Proving Ground entitled "Eyes of the Range." A good time was had by all, but we are beginning to wonder if our banquet there had anything to do with the restaurant going out of business completely some two days later!

For some two years now, readers have been seeing little black rocket and guided missile silouettes in the pages of "Missile Away!" The Section Board of Directors has just completed arrangements to use these silouettes along with other information to help the financial situation of the Section. An agreement has been made with the Arthur Price Associates of New York City wherein the Section will supply unclassified rocket and missile silouettes and fact sheets to that agency. Arthur Price, a past vice-president of Sears, is going to do all the necessary promotional work to put this missile data in the form of give-aways, cutouts on cerial boxes, and perhaps plastic models. The idea was started some two years ago by Frank Koen. We don't know yet just how much this will net the Section, but the preliminary estimates by Price indicate some slightly fantastic sums. We may have our own clubhouse before we get through!

You fellow Section members will be happy, no doubt, to receive the special supplement that goes along with this issue. The Fairchild Guided Missiles Division set them to us after we wrote them about the books. When the books came, there was no letter, no nothing . . . so we don't know who to thank for his work. But we certainly do appreciate it!

A recent communication from the editor of the SoCal Section "Newsletter" thanked us for the "plug" we gave them in the Spring issue, pointed out that they had no intention of going into competition with us, and reported that they would continue their publication as a strict newsletter. Well, thanks, fellows; we didn't mean to imply that you were competition or that we disliked the idea. We don't feel that there can be any real competition between ARS publications, since each came into being to satisfy a definte need within the Society. As you requested, we'll send you some news items. How about some articles from your boys . . . and from people in the others sections, too?

Gil Moore, inveterate jokester, cartoonist, and ulcerated rocket engineer, clipped the following item from the El Paso **Times** on the 19th of June. It had tickled the editor of that publication, and it tickled us, too;

"In view of the recent interservice clash on missiles, I thought you might be interested in knowing that due to a recent reclassification of security information, it can now be revealed that 'Talos' was not named after anything in particular, but was derived from the words, 'TRY AND LAUNCH ON SCHEDULE.'

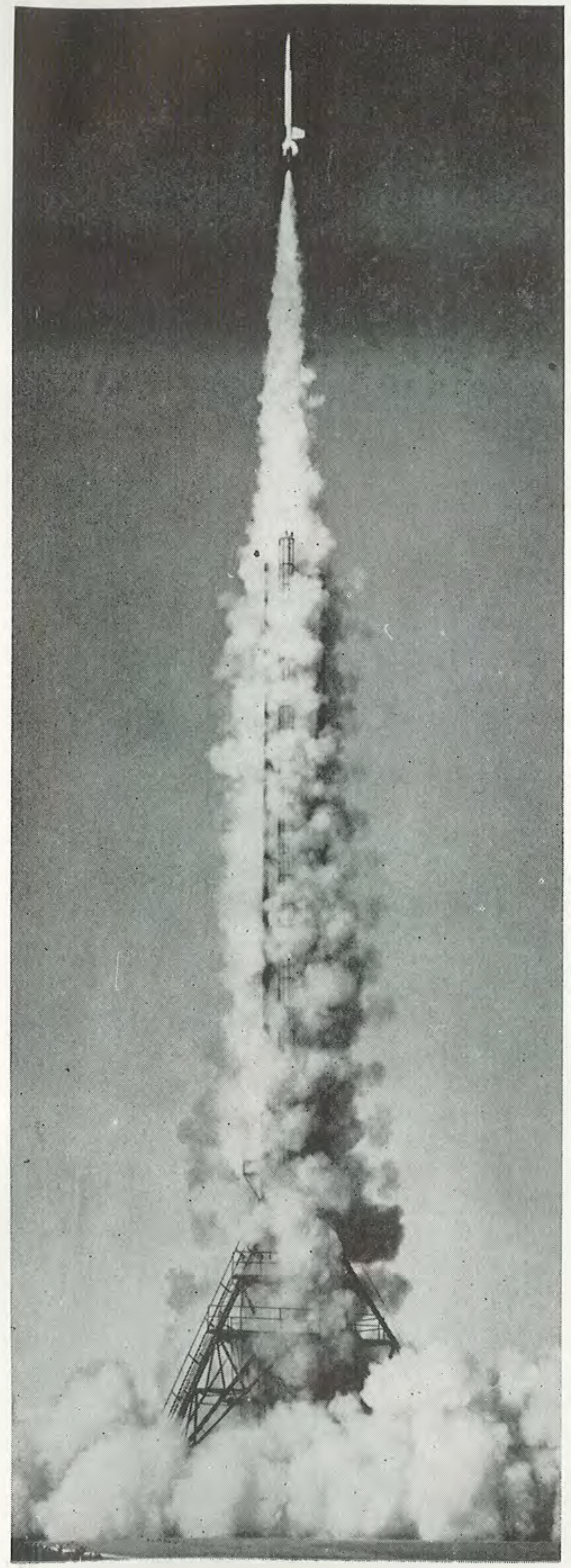
"Signed: Anti-Aircraft Artillery Officer.

P. S. I am sure you realize why I prefer to appear anonymous.

"As an afterthought:

"Advice to politicians—Engage brain before putting mouth into gear."

The originator of "Try And Launch On Schedule" was, of course, Gil Moore . . . and we have documentary evidence to prove it. Of course, we also have documentary evidence to point out that Talos was the ancient defender of the Isle of Crete; born of fire, he also destroyed by fire. We just want the facts, m'am; just the facts!

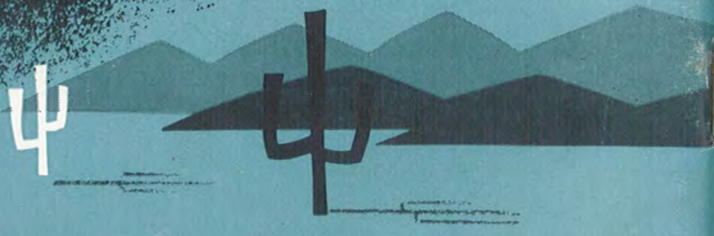


Keeping pace with the rapid growth of the electronics industry in the West, Neely Enterprises has opened a new office — THEIR SEVENTH — in Las Cruces, New Mexico.

The mark of Neely Enterprises is known and respected throughout the West. For over 20 years, this brand has stood for the finest — most complete — service in electronic instrumentation.

The primary aim of the Neely Engineer who calls on you is to save your time — increase the efficiency of your operation — with the application of the latest electronic equipment.

Time spent with a Neely Engineer pays you dividends.



NEELY ENTERPRISES

electronic manufacturer's representatives

LAS CRUCES OFFICE
126 South Water St.
JAckson 6-2486

LOS ANGELES OFFICE
3939 Lankershim Blvd.
Phone: STanley 7-0721

SAN FRANCISCO OFFICE
2830 Geary Boulevard
Phone: WA 1-2361

SACRAMENTO OFFICE
1317 Fifteenth Street
Phone: GI 2-8901

SAN DIEGO OFFICE
1029 Rosecrans Street
Phone: AC 3-8106

ALBUQUERQUE OFFICE
107 Washington Street, S.E.
Phone: 5-5586

PHOENIX OFFICE
641 E. Missouri Avenue
Phone: CR 4-5431