Vol. III, No. 2
SUMMER
1955
35c

"Missile Away!"

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

10th. Anniversary
WHITE SANDS PROVING GROUND

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"MISSILE AWAY!"

Vol. III, No. 2
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Editorial: "about basic research"

> This editorial is not intended as a critical review of or refutation of the article "The Strange State of American Research" by Eric Hodgins appearing in the April, 1955 issue of FORTUNE magazine. The article is quoted frequently in this editorial because it expresses so well much of the thinking of many Americans who think about the subject at all. The editors of MISSILE AWAY! agree with much that appeared in FORTUNE's article. They do not intend to imply, through silence either agreement or disagreement with any part of that article not directly quoted.

There is in this country a rapidly growing and well-merited concern over the relatively small expenditure of effort and thought on basic or fundamental research, in comparison with the vast amount of money, energy, and brain-power spent on applied research.

It would be well to attempt to define "basic research" before discussing it. There are actually at least three differing and not entirely compatible definitions.

FORTUNE magazine, in its article "The Strange State of American Research" by Eric Hodgins in the April, 1955 issue, implies one definition when it says that certain expressions of genius are:

". . . more apt to thrive in an atmosphere of lonely reflection and austerity where little equipment is needed beyond pads of memorandum paper and a batch of well-sharpened pencils."

This implication that "pure thought" and "pure research" are research; but it is important, for example, to anyone who hopes to establish a satellite space station. To do so, he must first expand the frontier of man's knowledge. This research, however, is neither uncommitted nor disinterested. It has as one very selfish purpose the object of giving the occupant of such an artificial satellite the chance of staying alive.

The FORTUNE article quoted above further says that there is a temptation, as basic research lags, to appropriate more money to it, and adds that lack of money is not the root trouble. On the following page, however, it appears to imply agreement with the idea of what it calls "many administrators of science" that "Whereever funds are to be divided between basic and applied research, 10 per cent is the **minimum** share that should be allocated to basic." Since the article also appears to feel danger in the concept of permitting research to be conducted by means of the average man, implying further that basic research belongs in the hands of genius, a curious design develops—that of the "cost plus fixed fee" genius. Must basic research be tied digidly either to genius or to any fixed percentile of technological advance?

Is there no room for the "hack researcher"? Not all of us are of the pure-bred genius strain. Are we therefore barred from attempting to add to man's knowledge? Or, if we attempt, are our efforts foredoomed to failure?

Genius is certainly needed in the conduct of fundamental research. To operate effectively, however, even if he uses nothing more than pencil and paper, genius demands information. The flaw in Aristotle's theory was not in lack of genius, but in lack of experimentation. The areas in which such experimentation may be conducted cheaply and easily are rapidly diminishing. Galileo needed only stones and an elevated location in order to prove Aristotle wrong, but most of the easily acquired information about our environment has already been gathered, even though by no means all of it has been transformed into knowledge.

The information about which the genius is expected to ponder is becoming more expensive and more difficult to get as time goes on. For example, in order to carry a few relatively inexpensive basic research instruments into the environment they were designed to study, and to get readings from these instruments, millions of dollars have been spent on Viking rockets and their associated equipment. Not all of the men involved in the Viking program, incidentally, need be of the pure bred genius strain in order for their efforts to be of value in adding to man's fundamental knowledge.

Unfortunately, as information becomes more difficult to acquire it becomes more easy to conceal. Security measures, otherwise well justified, can be dangerous if they conceal information from those men of genius who can best make use of it.

Since it is generally agreed that America's scientific strength is in applied research and technology, and that we need more basic research—more fundamental knowledge on which to work—this leads to the possibility of a new treatment of security as it applies to the scientific genius or supposed genius. All available knowledge should be made available to these men without consideration of "need to know". Such men as these should not need or be interested in information as to the **application** of this knowledge, except insofar as technological development makes possible the acquisition of further needed information.

The means of communication of these men of genius should be practically unrestricted, so that they can share knowledge with others of their kind, abroad as well as at home. There should be no attempt at control of the direction of their thinking.

Any results of their thinking, of course, should be examined carefully by other scientists. The results achieved by one of these men should be obtained, not from 'final reports' but from continuing reports of 'kibitzers' who look continuously over the shoulders of the genius, while disturbing him as little as possible. These reports should reach a second and larger group of scientists, who should devise and conduct experiments to attempt to prove or disprove the ideas of the first group of basic researchers, and to discover practical uses for this knowledge and to hint at directions where further research would be of value. This information should flow back to the first group of researchers without restriction. Security limitations on the outward and downward flow of this information should be as liberal as possible.

The genius required in this second class of researcher may vary greatly, and may often be no less than that required of the first group. In some cases they may be combined in one man.

The third group of researchers should be primarily administrators. They should examine new knowledge as it applies to problems of applied research, hunting always for ways to apply new ideas. Here, at this level, security restrictions should begin to weigh heavily.

The fourth level, of applied researchers and hardware builders, should have the tightest possible security restrictions, since it is here that America's strength is greatest. Since such secrets as appear here are ephemeral, and since the basic knowledge of the first and second one and the same—that scientific philosophy and fundamental research can be equated, or almost equated—coincides closely with the Greek ideal. It is important, but does not cover the whole field of fundamental research, since the lonely reflector must have facts about which to reflect, and the memoranda produced by his well-sharpened pencils must be tested against reality.

Aristotle noticed, perhaps, that stones fall faster than leaves and that leaves fall faster than feathers. He therefore jotted down the thought that the rate at which a body falls is a function of its weight. As a product of lonely genius, it influenced man's thinking for more than a thousand years. Unfortunately, it was not true.

A second definition of fundamental research may be found in the same FORTUNE article, more explicitly stated. Fundamental research is " 'uncommitted' thinking or experimentation, 'prompted by disinterested curiosity and aimed primarily at the extension of the boundaries of human knowledge.' " This definition, in a footnote, is credited to "Sponsored Research Policy of Colleges and Universities: A report of the Committee on Institutional Research Policy; American Council on Education; 1954." The definition appears good, except that it seems to require a knowledge of the state of mind and the objectives of the research before the products of his research can be classified as being basic or otherwise.

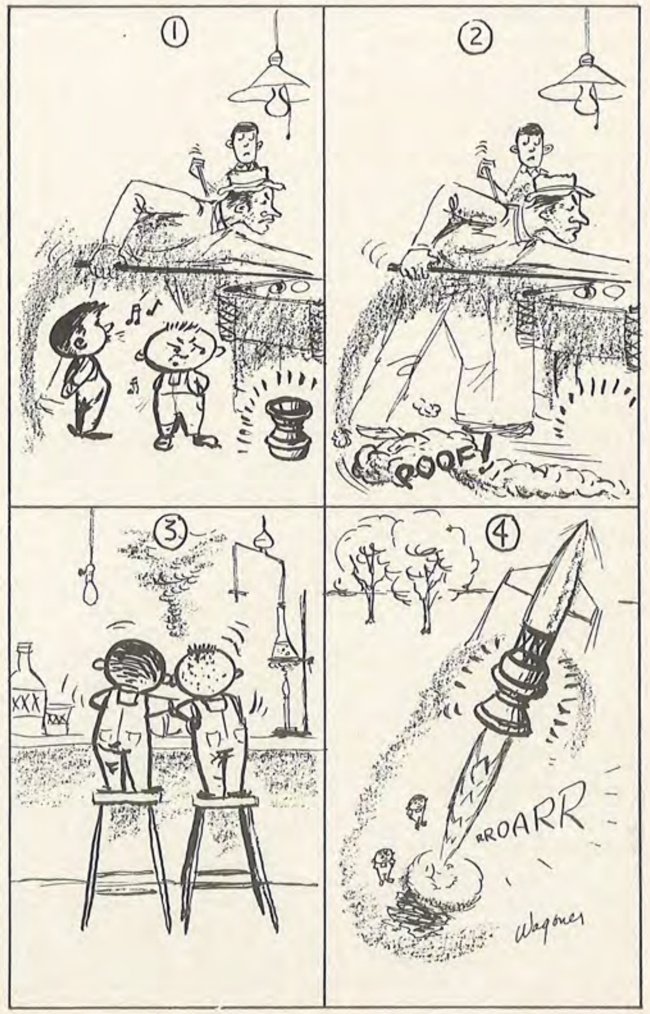
A third definition, then, might describe basic research as that which discovers or attemps to discover new facts, or to provide new understanding, of man's environment. This definition may not help much; it certainly clouds the borderline between fundamental and applied types of researchers would necessarily be almost as available to foreign scientists as to our own, a dynamic situation develops. Our technology engages in a Red Queen's race—it must run as fast as possible in order to hold its own. Since this is true whether or not basic knowledge is concealed or widely disseminated, it is not an unhealthy condition.

The dangers of attempted concealment of basic knowledge are very great: that we will find it simpler to keep needed information from our own actual and potential men of genius than to keep such information out of the hands of our enemies.

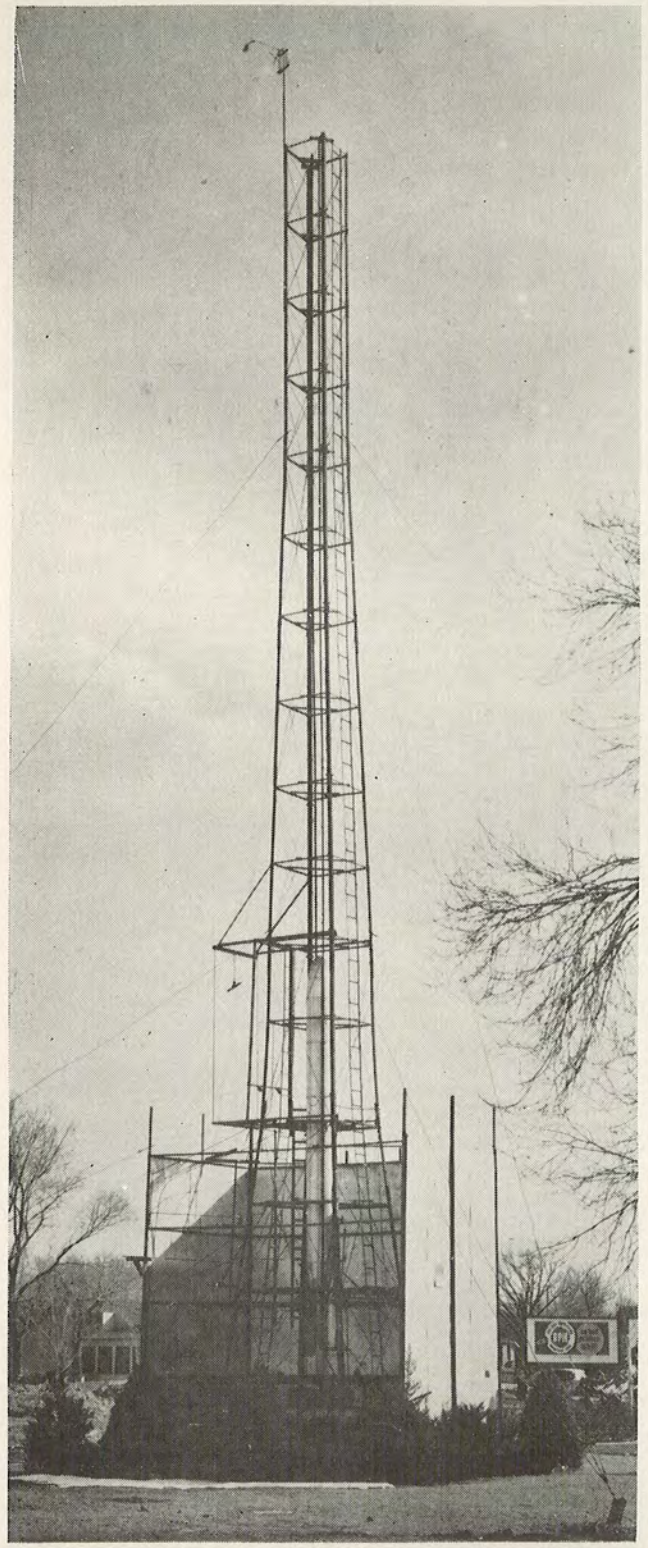
It would be ironic if we were to be destroyed by technical advances stemming from basic knowledge first acquired by Americans, concealed from those Americans who could have made best use of that knowledge, but pirated and used by our enemies.

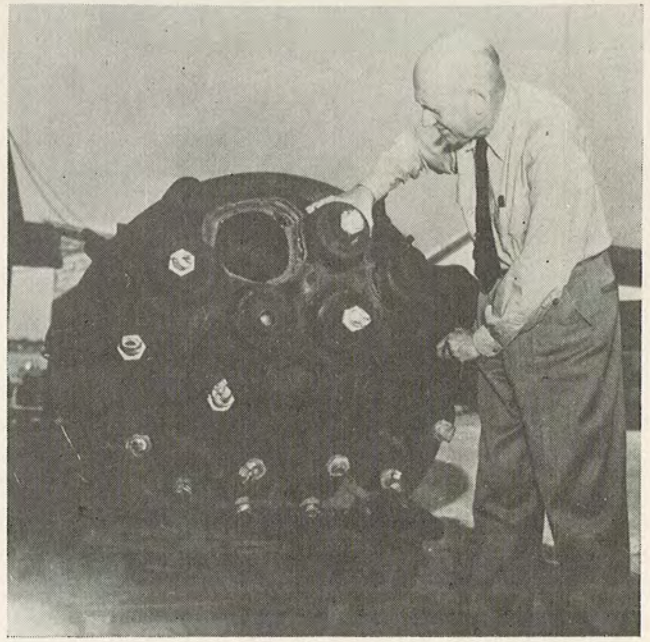
Basic research, then, may turn out to be expensive. In some cases it may intertwine inextricably with applied research. It is, however, essential. The greatest concern is not that there may be too much experiment to the amount of thought; it is not, to quote FORTUNE, that "defenders of things as they are" can say that we are able "to conduct research by means of the average man." The great danger is that our great technology will be working with second-rate ideas because the results of the experiments, the output in counting and measuring and cataloging of the ideas of "average" scientist and the ideas of genius alike, will not be readily and freely available to those who inspired thoughts and experiments could produce the first-rate ideas which our tecnology needs to keep us supreme.

—L. J. S.



DR. ROBERT H. GODDARD... *pioneer*





Almost coinciding with the opening of White Sands Proving Ground ten years ago was the untimely death of the dean of American rocket pioneers, Dr. Robert H. Goddard.

We feel it is only fitting to publish, in this historical issue of "Missile Away!", some of the photos of Dr. Goddard's pioneer work in the hope that, as we watch the Corporals, the Nikes, the Vikings, and the Aerobees thunder aloft in 1955, we may gain some appreciation of Dr. Gcddard's work of twenty years ago.

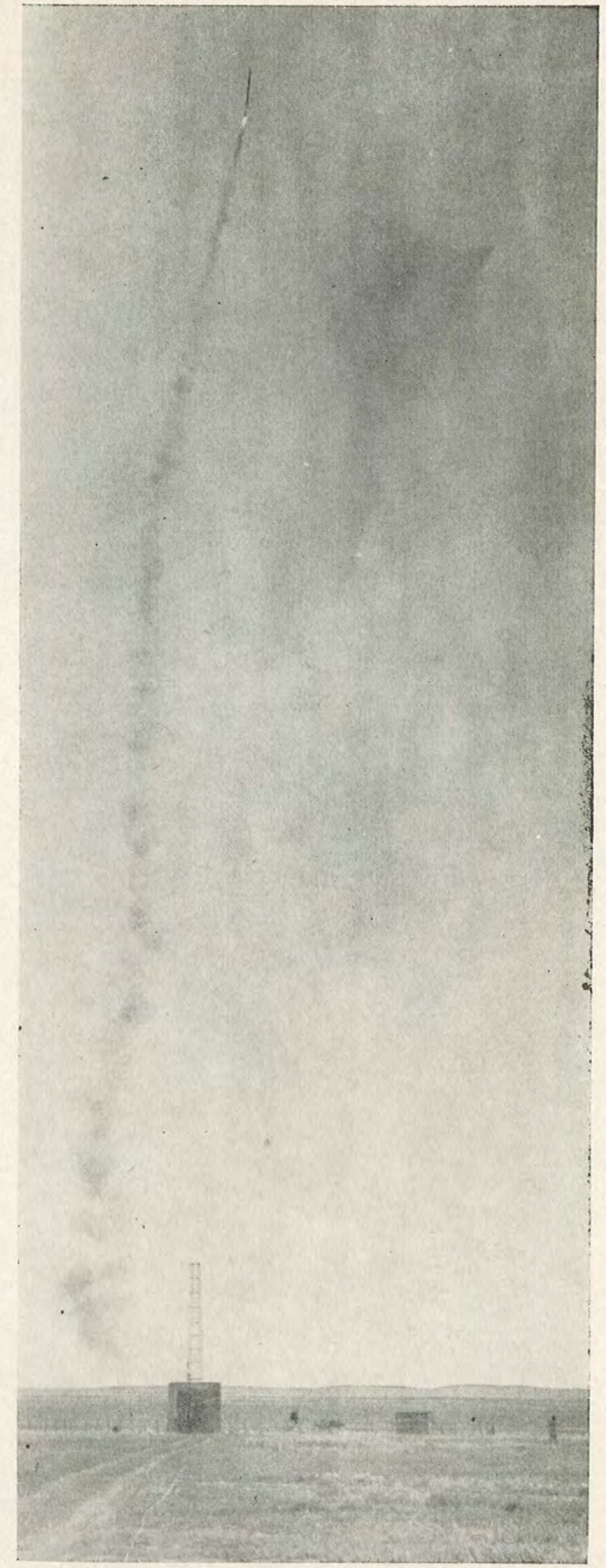
Included in these photos is one of particular historical interest: a rare picture of Dr. Goddard, made a few months before he died, inspecting the remains of one of the first V-2 rockets shipped over from England in the closing days of WWII. The photograph was made at the U. S. Naval Rocket Test Station, Annapolis, Md., where Dr. Goddard spent the war years developing liquid-propellant JATO's. The photo was obtained from Robert Gilpin.

All the other photographs were graciously made available to "Missile Away!" by Mrs. Robert H. Goddard.

Above: 16 March 1926

Right: 1934

Below: May 1926



IRM-WSPG

(Integrated Range Mission — White Sands Proving.Ground)

by
LT. COL. B. R. LUCZAK, Chief, IRM

Early History—Sabers, Shells, and Bombs in the Sand Dunes

The area North of El Paso between the San Andres Mountains and the Sacramento Mountains is known as the Tularosa Basin. It figures prominently in the military life of the nation. The sand dues and "boondocks" were familiar sights to the cavalry men of the last century operating out of Fort Bliss. The clear, moisture-free atmosphere, the highly ideal climate was conducive to the training of antiaircraft artillerymen. Thus, during World War II the horse was replaced by the jeep and the cavalry was replaced by the antiaircraft as far as Fort Bliss was concerned. Camps were established near Beasley's Ranch, near Oro Grande, at Hueco, and throughout the area.

Also, during World War II, the-then Army Air Corps conducted bomber training on the Alamogordo Bombing Range, which was roughly the portion of Tularosa Basin North of Alamogordo, out of what is now the Holloman Air Development Center. At its peak, the area was a beehive of activity. Toward the end of World War II the training in this area dropped to low ebb for the part of both the Antiaircraft and the Air Corps.

Missiles Over the Mesquite

Early in 1945, the Atomic Energy Commission had little difficulty obtaining an area of land shown on the map as X, for the purposes of detonating the world's first nuclear device. Therefore, in July 1945, Trinity Site made its noisy debut into history heralding a new era. About the same time the Army was looking for a place in which to fire the V-2 missiles and early U. S.rockets. A number of German scientists from the Guided Missile Research Center at Peenemunde, headed by Professor Werner Von Braun, had ben brought to this country and were established at Fort Bliss at the old William Beaumont Hospital Annex. Along with this group came over a hundred German V-2 rockets and many more component parts.

The original mission of this particular group was to acquaint American science and industry with the know-how that Germany had acquired in some ten years of rocket and guided missile research, and to do so in a hurry. Permission to use this little used area was readily obtained by the Army since the Government already had various lease holds on a large portion of it.

The U. S. Navy, Bureau of Ordnance, had a need for a missile testing range of approximately the size and characteristics of White Sands Proving Ground. Thus, in 1946, the Naval Ordnance Missile Test Facility (known by the unpronounceable short title of NOMTF) became a tenant organization within White Sands.

The "Hot" Cold War Phase

Shortly after the conclusion of World War II this country entered into the cold war. As the cold war became hotter, the activity on the part of the Air Forces at Alamogordo Air Base and on the part of the antiaircraft out of Fort Bliss also increased.

The phenomental increase and growth in the guided missile program also caused the White Sands-Holloman area to be the scene of intense activity. As time went on, the situation developed wherein the Army out of White Sands instrumented approximately 80 miles North for V-2 and other firing, while the Air Force out of Holloman instrumented for various bomb drops and for the Air Force guided missile projects transferred from Wendover Field, Utah, and additional Air Force guided missile projects assigned to Holloman for test.

Accompanying the instrumentation of this overlapping range were the various roadnets and vital communication facilities. Also, in the White Sands area and south of it the antiaircraft expanded its firing ranges and its training activities.

Once It Was Easy

At first, coordination on firings was not difficult. Where each service conducted very limited firings, such as one V-2 from White Sands or one V-1 per week from Holloman, there were few problems; but, gradually, all this changed.

Initially there was the frequency coordination problem, and then, as the programs mushroomed, range time, scheduling, and time signals became more and more difficult. The Secretary of Defense took cognizance of this situation, for in August of 1952 he declared White Sands Proving Ground and Integrated Range operated on an equitable basis for the three services—

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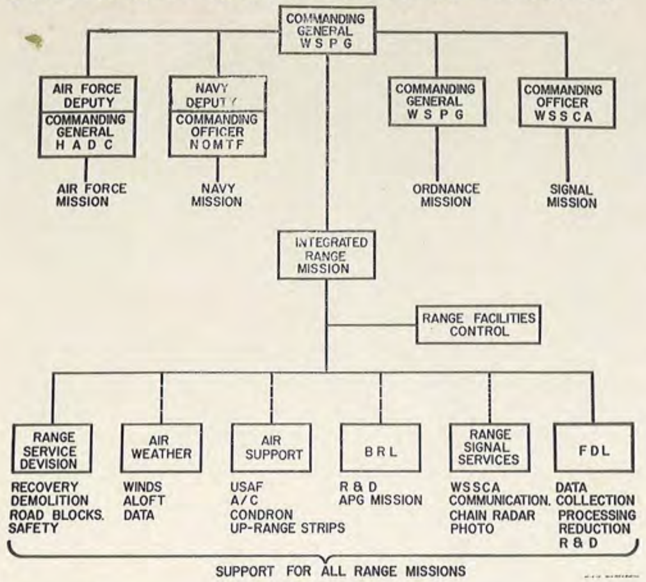
← Topographical Relief Map—WSPG

INTEGRATED RANGE MISSION—W.S.P.G.



Army Navy, and Air Force.

In the letter establishing the Integrated Range, he prescribed that it be operated by the Department of the Army, through the Chief of Ordnance, through the Commanding General, White Sands Proving Ground. He provided that the Commanding General, White Sands Proving Ground, would have on his staff the Commander, Holloman Air Development Center, as Deputy for Air Force, and the Commanding Officer, NOMTF, as Deputy for Navy.

The Commanding General, White Sands Proving Ground, was delegated two separate and distinct jobs. One is to pursue the Department of Army Guided Missile Program, by testing and firing Ordnance Missiles. The organization that fulfills this function has the appropriate title of "Ordnance Mission." The other job is to operate the White Sands Proving Ground Integrated Range for the Navy, Air Force, and the Army (the Commanding General, White Sands Proving Ground, wearing his Ordnance Mission hat). The organization that carries out this responsibility is the Integrated Range Mission.

The Integrated Range Mission Organization

In the Secretary of Defense's letter, he specified that both the Air Force and Navy Deputies would have an appeal channel directly to their Service Secretaries on decisions of the Commanding General, White Sands Proving Ground. This device provided a powerful motivating force for impartial operations of the Range.

The Range Facilities control office operates the range on an hour to hour, day to day basis. With some 4,000 square miles of real estate, 12,000 miles of communication wire, 1,000 miles of road, 370 instrumentation stations and some 300 missions per month to complete, life is indeed complicated for the one man who has to run it. For experience has shown that the absolute control must center in one individual, the Range Facilities Controller. Regardless of how many experts are made available to advise and reinforce him, he alone is charged with the responsibility, and he alone makes the decision.

Each mission has individual needs of particular instrumentation, specific frequency silences, road blocks, recovery of the missiles and many other requirements. With the multitude of changes caused by weather, project difficulties, instrumentation troubles, and road block times—to name a few—the Range Facilities Controller lives in an atmosphere of decision-making; in less polite jargon, he has "an ulcer racket".

Other organizations under the Integrated Range are the Range Service Division which is primarily an Army Military Organization. Their's is the job of recovery, demolition, and roadblocks. To help them carry out this mission they employ some 10 army aircraft and 2 helicopters.

Missile flight information is supplied by the 24th Air Weather Detachment of the 4th Weather Group which is a Air Force organization staffed by Air Force military personnel, and constitutes part of the Air Force's contribution in this Integrated Range. Air Support is another major Air Force manned contribution to Integrated Range. This includes the operation of various drone activities. The war-weary B-17's or the faster, snappier P-80's are flown up and down the range remotely and used to test out the weapons system.

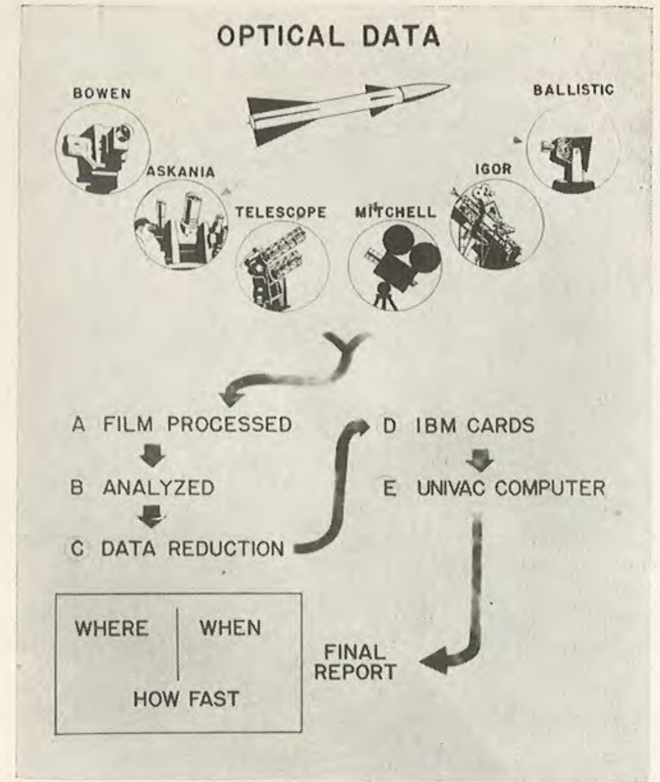
BRL as shown on the chart stands for the Ballistic Research Laboratory Annex of Aberdeen Proving Ground. Aberdeen Proving Ground is the "longhair" organization of the Office Chief of Ordnance insofar as research and development is concerned and is staffed by competent Civil Service employees. They maintain what amounts to a Field Engineering Office here at White Sands to check out their various developments and to gather instrumentation development data that is available only on a range of this type.

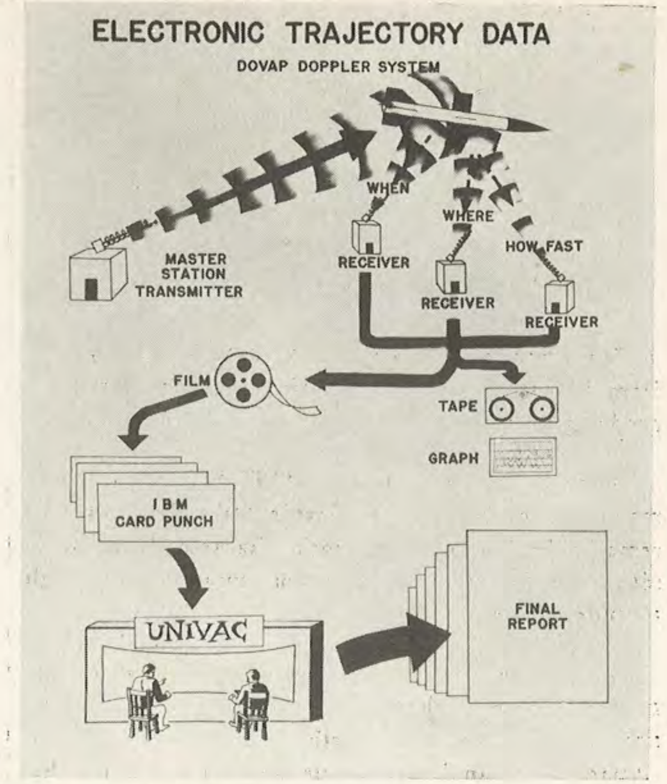
Range Signal Services is one of the organizational units whose parent is the Commanding Officer of White Sands Signal Corps Agency, shown under Chart No. 2, as having the signal mission. There is an agreement that the Signal Corps wil furnish all the radar and communication services needed on the White Sands Proving Ground Integrated Range. Range Signal Services operated by Signal Corps and Civil Service personnel is that portion of the White Sands Signal Corps Agency's mission that carries out this important function under the operational control of the Integrated Range Mission.

The Flight Determination Laboratory, known as FDL, is the largest division on the Proving Ground. It has over 1,000 personnel, consisting of a wide variety of groups including Army military, Air Force military, Civil Service personnel, Wage Board personnel, employees of several commercial contractors, and even students from New Mexico A & M College. The mission of this organization is data collection, data processing, data reduction, and research and development of range instrumentation.

Where, When, How Fast and What:

One of the reasons this area of the United States was chosen for a guided missile range was the fact that the atmosphere was conducive to obtaining data at long distances and to a very high degree of accuracy. Optical event instrumentation is used to obtain **event data** which simply tells what the missile is doing at any particular time with no reference to its space position or data. **Position data** gives the position of the missile in space at any particular time and also lists important elements of its velocity and acceleration. Position data requires at least three instruments simultaneously photographing or sighting on the missile. By a triangulation based on a highly accurate time resolution system, the position of the missile is fixed in space and its velocity and acceleration is computed.





The principle optical instruments used on the White Sands Proving Ground Range are: the Mitchell High Speed Camera, the Fastax, and the Bowen as event and position cameras. These particular instruments remain at a fixed position and do not track the missile. They are used primarily in the launch and impact areas and are capable of a high degree of accuracy. The Askania Cinetheodolites are German-made missile tracking cameras which give primarily position information on each film frame beside the missile image listing its exact azimuth and elevation along with precise timing reference marks. All this information is photographed on each 35mm frame including fiducial marks which enable tracking errors to be later reduced out of the film.

The Tracking Telescope is primarily an event instrument and is capable of photographing missiles at extremely long distances with sufficient clarity to disclose what the missile is doing. Tracking and photographing a missile at a 100-mile altitude is not uncommon for these instruments. The IGOR, which means Intercept Ground Optical Recorder, is used primarily for intercept information on surface to air missiles such as the NIKE or other Antiaircraft Missiles, while the Ballistic camera is capable of furnishing the most accurate position information available.

To exploit the full capabilities of the Ballistic Camera, a technique is used of inserting carefully timed flashing lights on the missile and firing it at night. These lights register on the Ballistic film's emulsion enabling experts to determine missile position from known star locations.

By employing these astronomical techniques a not-uncommon space position can be obtained with an accuracy of plus or minus 10 feet in 60 miles. The film from these optical data instruments is processed within the Flight Determination Laboratory and analyzed. The information from usable films is then reduced, punched on IBM cards or paper tape, and goes through the UNIVAC, Remington Rand's electronic brain, into a final report.

Where the requirements for accuracy are not so stringent, electronic trajectory measurement has many advantages to the missile project. Several systems of electronic data trajectory information are available on the Integrated Range. The MIRAN, a RADAR triangulation system, was developed by the Air Force while the DOVAP Doppler System was developed into its present degree of accuracy by the Ballistic Research Laboratory of Aberdeen Proving Ground. It utilizes the well-known Doppler principle apparent to anyone who ever stood along the railway tracks while a fast-moving train was pounding its whistle. As the train approached, the whistle would apear to increase in pitch, and then it would gradually decrease as the train

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passed. But at all times the pitch would actually remain constant. The fact that the source of sound moved resulted in the different frequency of vibration to the listener.

In DOVAP Doppler, the master station transmitter operates the pitch signal. This is received within the missile, is retransmitted and received by at least three receiving stations. These stations record the information on tape, graph, or film which is tied into the overall timing standards. This information is analyzed and reduced to trajectory information for the final position report.

Both of the above systems gather information on what's happening to the missile from exterior sources. Telemetry data monitors the inside of a missile transmitting this information to the ground. The technique consists of having sensing devices and transmitters within the missile which transmits the variations in the sensing devices down to a data receiving station. Here the information is recorded on high speed tapes, on graphs, and on film. The film is annotated, and when necessary calculations are needed, it is put on IBM punch cards, sent to UNIVAC, and is put into the final report.

Timing Signals

All the instrumentation efforts on the Range are tied together by an elaborate system of timing signals. These are distributed by hard wire, by microwave, and even by radio. They are received at permanent type structures and portable rigs. These timing signals are absolutely necessary to obtain position information about the missiles and to tie-in event data from various sources and various fragments of information. Timing signals are even used to activate the opening and closing of shutters on the cameras.

In order to obtain positive position information through three or more instrumentation stations, cameras, whether they be "clicked"four times per second or a hundred times per second, must be "clicked" at the same time regardless of their location. The requirements for positioning are too precise to be left to human efforts. Therefore, use is made of timing signals to open and close camera shutters simultaneously. Here the criterion is milliseconds.

Pass Me The Missile

Another device of literally "chaining" the Integrated Range together is the chain radar system. With its four primary stations, one at the south end of the range, one at the north end of the range, and two in between, this system provides effective radar coverage for the users of the Range. The system operates as follows: A missile of the Corporal type which is a long range ballistic missile is launched from the south toward the north end of the range. The missile would be initially tracked by the radars at C Station on the south, and this information would be put on a common communication or "bus-line" system. As the Corporal goes higher and higher and further north the information from C Station radar is being sent to the other three main

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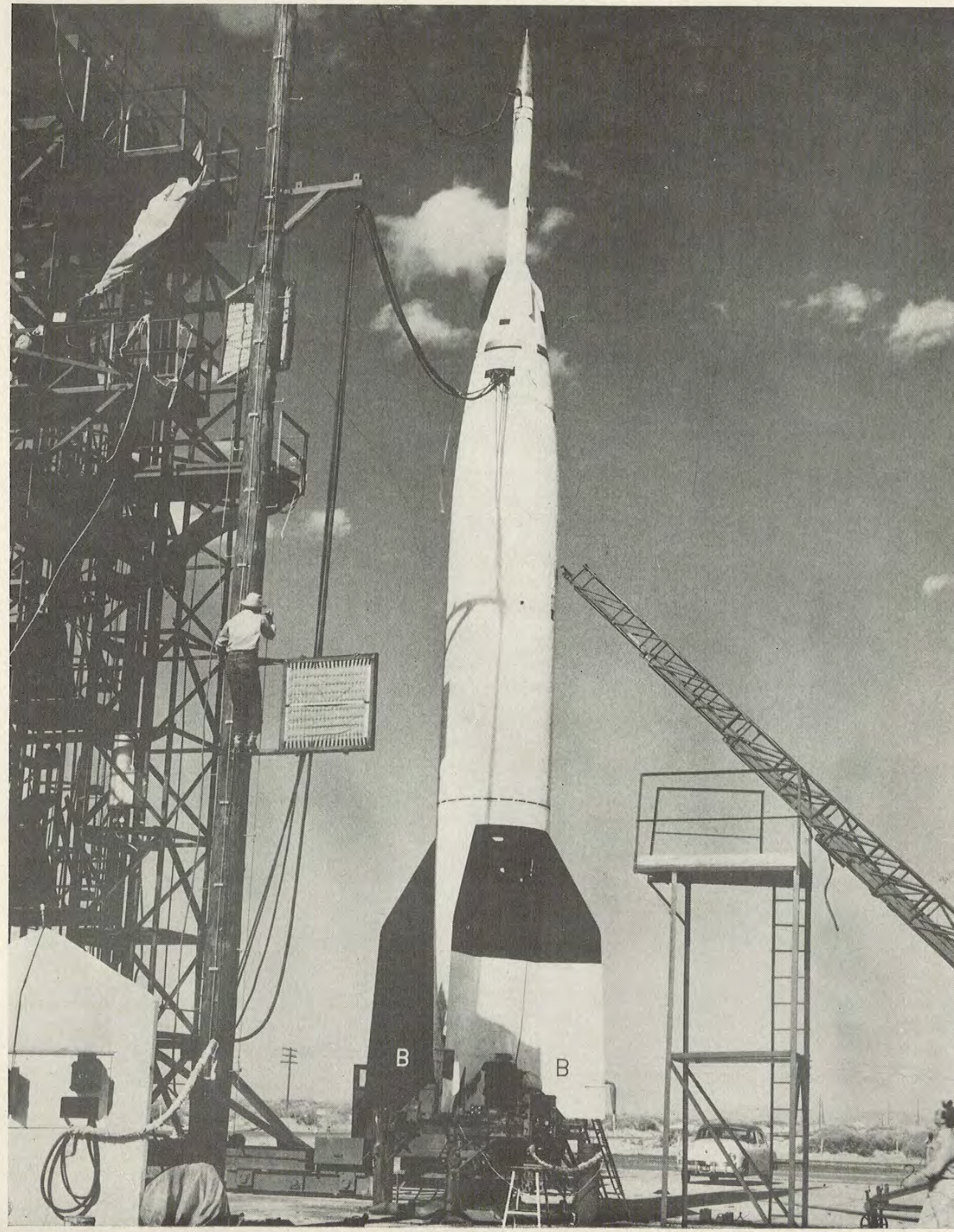
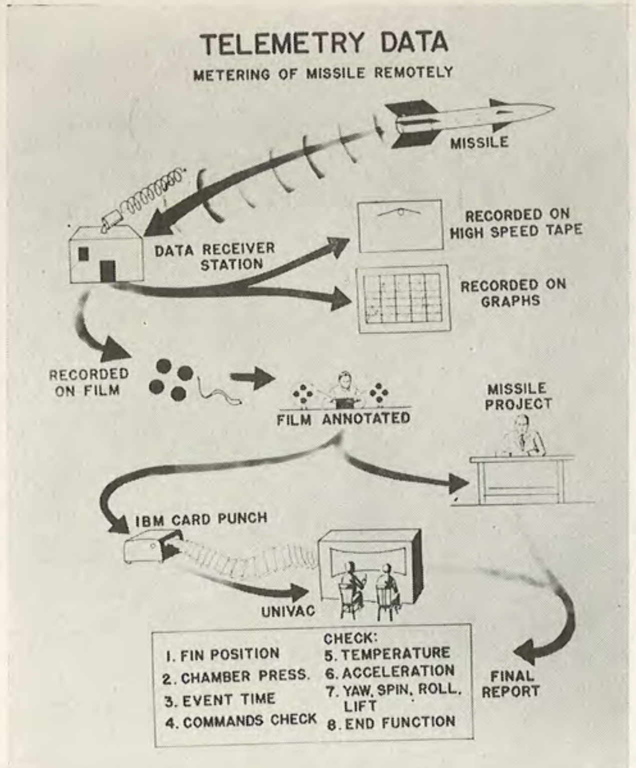
prelude to the IBM . . .

V-2/WAC "Bumper"—250 miles up . . . into space.





INTEGRATED RANGE MISSION—W.S.P.G.

radar stations. About now the radar at King I, located at Holloman Air Development Center, would begin to get a very strong signal from the Corporal, while the radar at C Station is getting weaker. The controller at C Station would then, at the opportune time, switch the main trackings from the C Station radar to the King I radar. The King I radar, therefore, would be feeding the "bus" system and providing information which would position the antennas of the other radar stations. The radars would literally pass the missile from one radar to another.

This Radar system has several purposes, the primary ones being that of safety, acquisition, and drone control. Every missile that is fired on the Integrated Range must incorporate within it a device that will insure its ability to be destroyed by a ground monitor in case the missile should go astray and threaten to leave the range.

The chain Radar system provides a flight plot of the missile by using an automatic pin device which evolves a horizontal and vertical trajectory plot. This path is intensly watched by the Missile Flight Safety Officer who operates a grid or fan. When it appears that the missile has gone outside the normal safety boundaries, the Officer will press a destruct button which either shuts off the power, blows off a fin, or in some other manner insures that the missile falls within the Range boundary.

In addition the radar information of the missile path is used to position the many cameras that are up and down the range. As an example, a camera on the north end of the range, hampered by curvature of earth or land mass, cannot see the launch of the Corporal missile. It would be difficult for an observer purely by visual means to acquire this missile visually at its greater speed and height. In order to "put him on target" the radar information is fed into a highspeed computer which "informs" a camera operator by reflections on the camera dial. By zeroing-out these reflections his visual tracking view is placed on the missile. Then, as he visually acquires the missile, he disregards the radar information and tracks optically.

Operating the Drones

Another use of chain radar is in drone operations. A typical drone operation begins when a B-17 which has previously been flown by a crew and completely checked out stands on the runway at Holloman Air Development Center with all four engines roaring. On the ground are two crews with remote radio gear, one looking down the runway while the others station themselves to the side about mid-way down the runway and at some distance. When the signal is received for take-off the motors are remotely advanced to full power, the brakes are released, and the huge form begins its lumbering race down the runway. The ground crew checks its deflection and speed, and when the plane appears to have enough momentum for take-off, the other crew begins to apply its up-elevator.

Overhead are two "mother" B-17's already waiting for their "baby". With the offspring airborne the upwheel signal is given, cruise power is applied, and the plane is in the air. One of the "mothers" comes down on a level with "baby" and, on signal, controls pass from the ground crew to the mother ship.

For a mission from C Station this entourage proceeds down range acquiring altitude all the while. In the meantime the C Station's chain radars search for the flight. The drone is most easily picked up since it has a beacon. Then the two "mother" ships are picked up and tracked by separate radar. These tracks are recorded on ink type plotting boards in the C Station control room. Sitting in a comfortable chair overlooking these plots is a rated pilot. He has a small box beside him which contains remote controls necessary to "fly-the-drone". By now all three ships are well acquired by radar and the plots are being correctly received, the ground pilot at C Station cals for drone control, and, on signal, the control of the drone is passed over to him while the two "mother" ships head for safety outside the range boundaries. The ground-bound drone pilot flies the drone through the prescribed maneuvers. It would not be possible for the "mother" drones to position or control a drone with the required accuracy.

Far above the drone and off to one side is a fighter, fully armed. He has the enviable job of shooting down the drone in case control is lost and it becomes a menace to the surrounding communities.

While they don't often get a chance, it is with great relish that these pilots look forward to the opportunity of swooping down on a B-17 that won't shoot back with all their guns blazing. The mother ships' function is to fly in and survey the drone or evaluate damage when a hit is suspected and call the fighter to quickly dispatch it if ground control is lost.

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Waves-Radio, Radar UHF-VHF

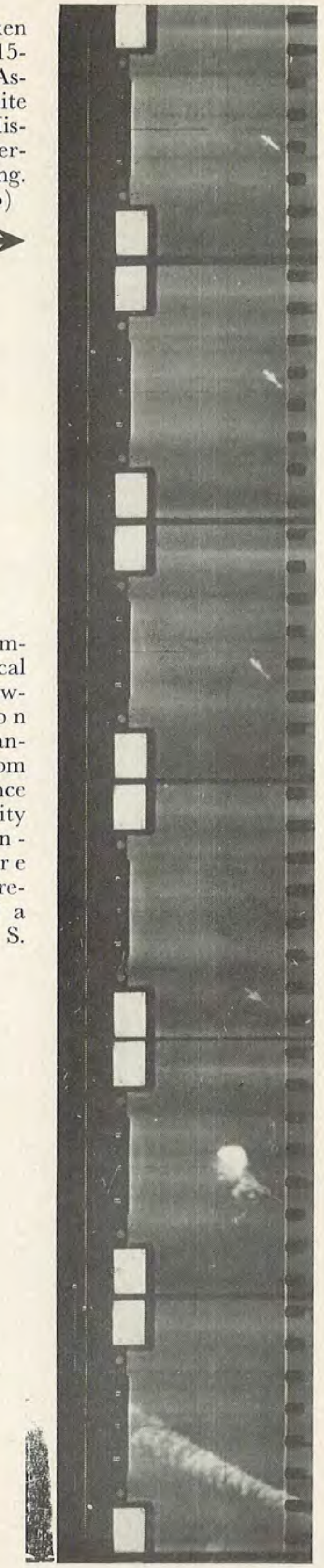
One of the biggest problems of the Integrated Range is frequency interference. There is probably no area in the world that has the variety or the intensity of frequency interference that the White Sands Proving Ground area has. The Area Frequency Coordinator for the State of New Mexico having jurisdiction the State and U. S. territory over an aaea of 150 miles fhom White Sands Proving Ground is located here. However, the problem is much larger than assigning frequencies or trying to control power. It involves the day-to-day, hour-to-hour, and even minute-to-minute use or denial of certain frequencies.

There are instances reported where a taxi cab in an Alabama city whose VHF radio range should have been 10 miles or less so completely interfered with some of the instrumentation on the Proving Ground that a mission had to be cancelled. Another instance occurred when two ships in the Pacific interfered with the controls of a drone.

Integration, not Co-existence

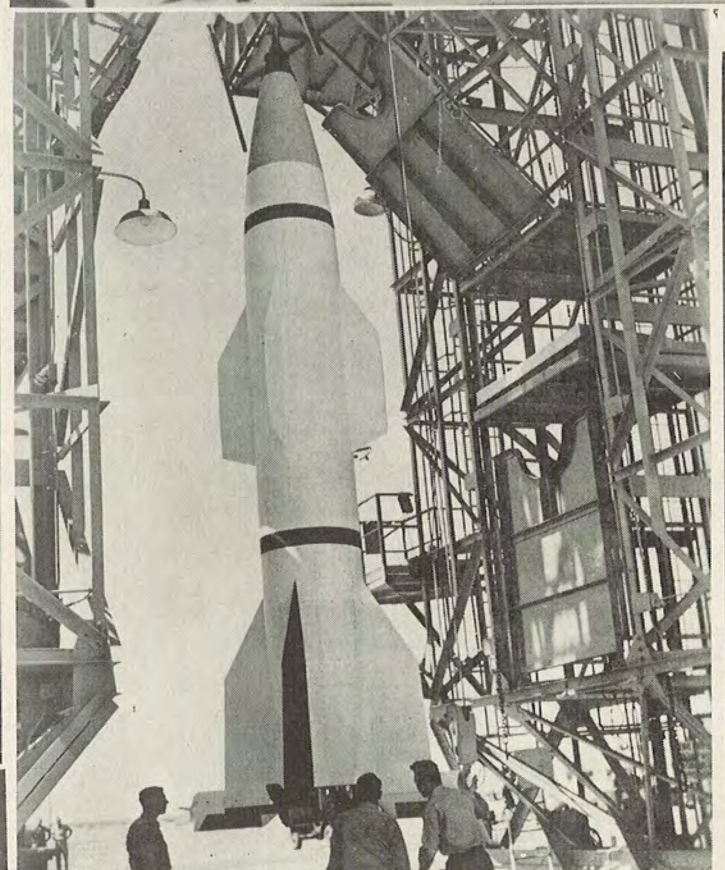
White Sands Proving Ground is a splendid monument to the faith that the three Services can work together in harmony. Here at White Sands, integration is a fact and not implied co-existence. In addition to the Deputies for Air Force and Navy, representatives from the three Services operate within the various top echelon committees, such as the Program Review Board which permits or denies entry of programs to the Range. The Range Schedule Planning Committee is also a three-service affair. This committee schedules the range for a week at a time. A Master Planning Board is another example of three-service representation in determination of what will be built and where. The result has been that White Sands Proving Ground has become what is reputed to be the best instrumented Guided Missile Range in the world and certainly the one with the biggest workload. • • •

Contact prints taken from a long-focus (15-foot Cassegrain) Askania Cinetheodolite showing the Nike Missile approaching intercept and detonating. (U. S. Army photo)

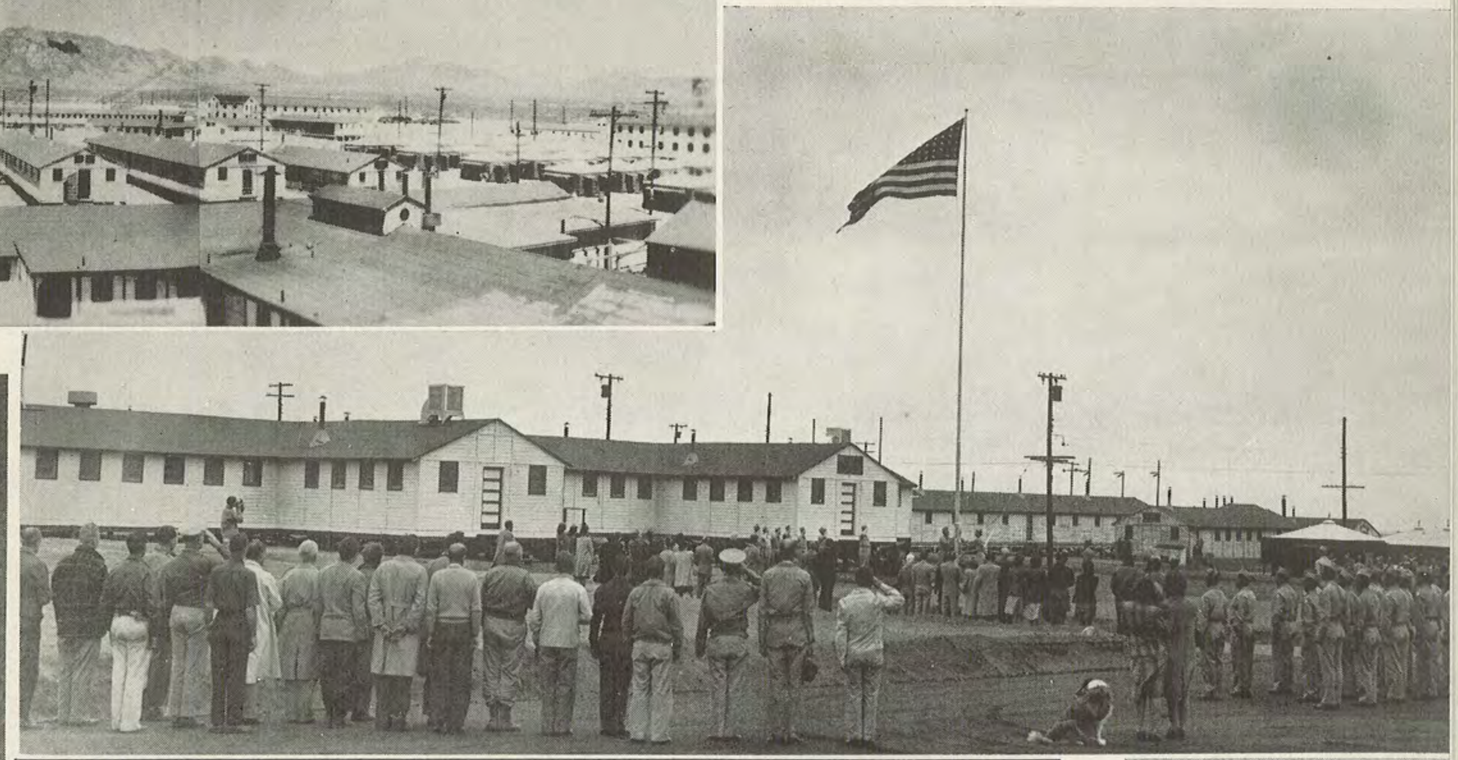


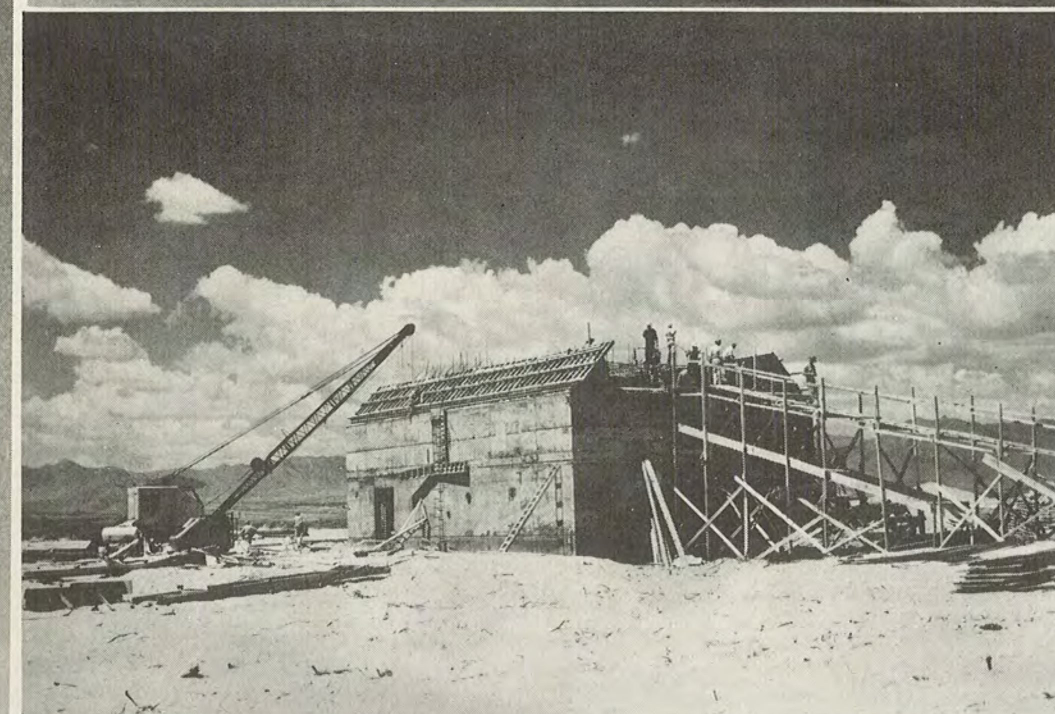
One of the more important WSPG optical instruments, the Bowen-Knapp ribbon frame camera, is manned by a sailor from the Naval Ordnance Missile Test Facility at WSPG. Bowen-Knapp cameras are used to record a preselected portion of a rocket's flight. (U. S. Army photo)

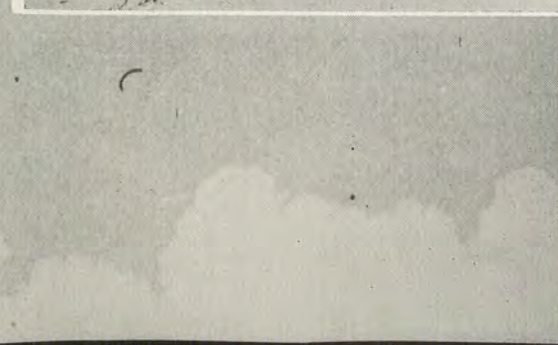
Miracle in the DESERT — *The Beginning* —



Up l: V-2 No. 16; **top:** panorama, 1946; **above:** **Hermes; left:** early shoot at C Station; **right:** early Nike.







Up r.: 1st Official flag-raising, 29 Nov. 1945; **right:** WAC Corporal take-off; **above:** building the Army blockhouse.

The Origin and Development of the Tracking Telescope

by

CLYDE W. TOMBAUGH

Flight Determination Laboratory, W.S.P.G.

The optical instrumentation of rockets has used the three major types of investigation employed in astronomy, namely: spatial coordinates, large-scale resolution of detail, and spectral analysis. Their equivalents are also found in electronic instrumentation. Spatial coordinates define a trajectory or an orbit. The first derivatives yield velocities, the second derivatives yield accelerations, just as in astronomy. Spectral analysis in astronomy yields radial velocity (in the line of sight) of any celestial body by the Doppler displacement of the spectral lines and chemical composition by the identification of the spectral lines. Very little could be known about incandescent stars without the aid of spectral analysis. In electronic instrumentation, the Doppler effect is used in the Dovap method to yield the most precise measurements of velocity. With several stations it can also furnish excellent coordinate data. Radio astronomy is a new science which provides spectral analysis in the electro-magnetic spectrum of wave lengths much longer than could be obtained by any other means, and some curious features of the Galaxy have been revealed. Radar has several advantageous features, but its resolving power of detail to reveal shape and attitude is terribly low and inferior to modest optical equipment because of the relationship of aperture and wave length.

The application of long focal-length optics to render large-scale photographs of rockets in flight at great distances and high velocities had its inception just ten years ago. A tracking telescope is essentially a planetary telescope confronted with high and variable angular tracking rates. The project was initiated by Dr. James B. Edson when he was with the Ballistic Research Laboratories at Aberdeen Proving Ground. Here he worked during the last years of the war and a few years afterward. Dr. Edson was a planetary astronomer at the Lowell Observatory, Flagstaff, Arizona during the latter years of the 1930. The photographic recording of delicate surface markings on the disks of the planets had become a routine technique three decades earlier following successful attempts to photograph the exceedingly delicate canals of Mars in 1905. Many other astronomers with more powerful telescopes have tried and failed because they did not learn and understand the nature and influence of conflicting factors that came into play. Both Dr. Edson and the author learned the optical and photographic "tricks of the trade" from the Lowell masters. They were dedicated to the task of photographing at least the stronger canals in an effort to convince a doubting world that the canals are realities and not figments of the imagination. The Lowell astronomers spared no pains, and they developed a very fine technique. Only within the last decade have their results been equaled by anyone else. Within the last twenty years, photographic emulsions have been improved considerably with greater sensitivity and contrast and less graininess, which has made the problem easier and also made it possible to record still finer planetary detail. As yet, no photographs can quite equal what the eye can glimpse during the most superb moments of seeing. It presents an ever continuing challenge to skill and technique.

At Flagstaff, they used a large refracting telescope of 24 inches aperture with a focal length of 32 feet, an F 16, which was set up in operation in 1896. All achromatic telescopes suffer from some chromatic aberration, which is the failure of such instruments to unite the rays of all colors into one focus. The larger the refractor, the worse is this failure. Since the visual method was supreme in delineating fine planetary detail, it was natural to design the telescope so that the yellow and green rays were brought to the most perfect focus. The sensitivity of the eye is greatest in the yellow-green region of the spectrum. The peak of the solar energy curve is also in the yellow-green region. There is good evidence that the sun has been a yellow-type star for hundreds of millions of years. It is, therefore, not surprising that Nature has taken advantage of this fact in adapting the vision of her animals accordingly.

Both planets and rockets are illuminated by sunlight, which is strongest in yellow-green, fair in orange-red and blue, and poor in indigo and violet light. Together with the selective sensitivity of the eye, the smearing caused by the out-of-focus indigo and violet light is not too serious. But when photography is applied to refractors, it is another matter. Nearly all photographic films and plates are notoriously sensitive to the short wave lengths of light. The use of yellow color filters becomes imperative. This was fine for studying the markings on the solid surface of Mars. In order to better understand the behavior of these markings, which seemed best explained by the seasonal growth of vegetation of some sort, it was realized that a more intensive study would have to be made of the Martian atmosphere. Some whitish areas of semi-transparent appearance were seen to form and change rapidly on the planet's disk. Their ephemeral character suggested that they were in the Martian atmosphere and not on the ground. If photographs could be taken in blue light, these particular whitish areas could be more effectively recorded, and perhaps reveal other weaker ones which were invisible to visual observations.

With an acromatic refractor corrected for the yellow wave lengths of light, the taking of blue photographs is not so simply done by inserting a blue color filter ahead of a blue-sensitive plate. The dispersion in focal depth among the blue, indigo, and violet wave lengths alone was too great to permit good images. To by-pass this difficulty by narrowing the spectral band still further would have necessitated prolonging the exposure to a prohibitive amount.

By this time, the reader is probably wondering what all of this has to do with large-scale optical instrumentation of missiles at White Sands and other proving grounds. Plenty, if you will read a little further, please.

Returning of the problem at the Lowell Observatory, the dilemma could be resolved in either of two ways: (1) to use a reflecting telescope, which by its nature converges all of the wave lengths of color into one focus; or (2) to design and build a special "blue corrector" lens to unite the family of short wave lengths into one focus, but at the expense of the longer wave lengths in the visual spectrum.

Reflecting telescopes (which use curved mirrors to converge the rays of light to a focus) did not enjoy a

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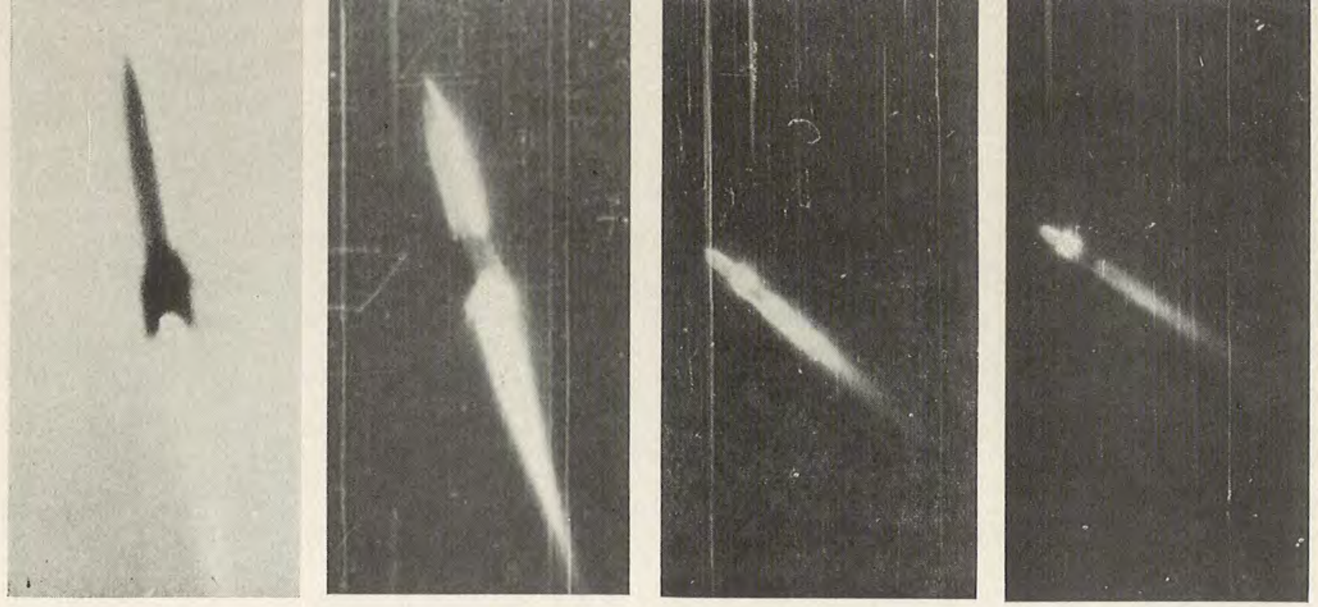

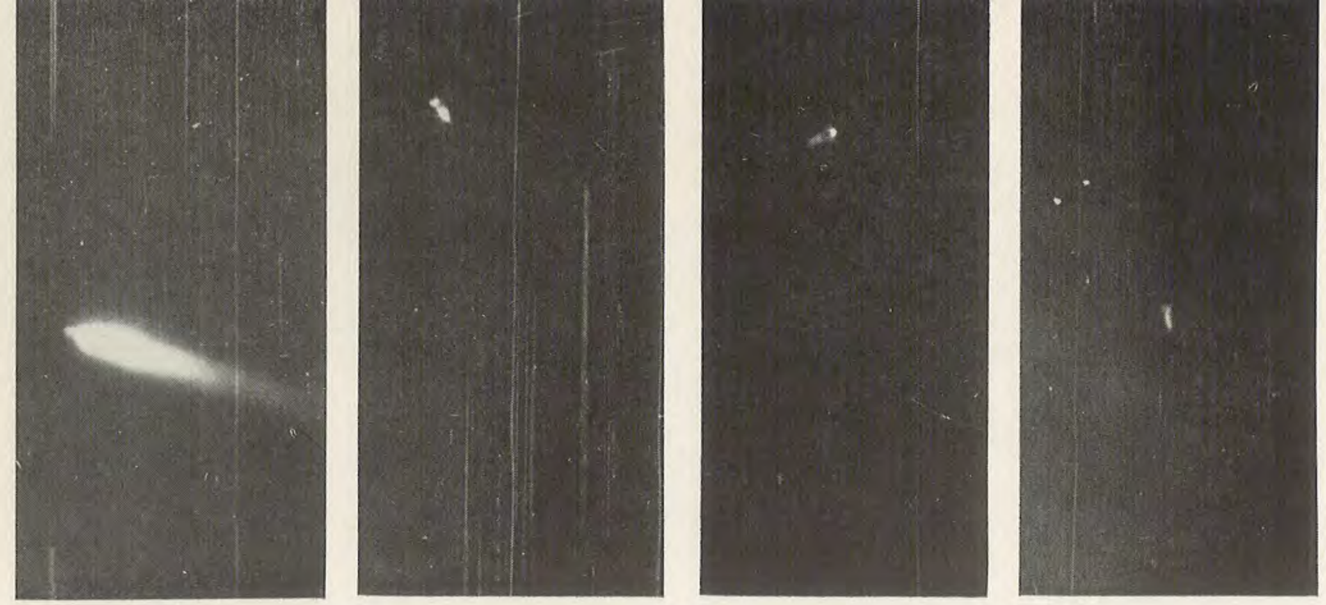

These historic photographs are the first successful films made with "Bright Eyes", the first rocket tracking telescope. The rocket is V-2 No. 16, fired 5 December 1946. At right, it is just off the ground. As it rises, the foreshortening becomes more apparent as the camera peers up the tail-pipe. At this point, it is 1.1 miles up and at a slant distance of 7.0 miles. As the rocket ascends into the rarefied upper atmosphere, changes in the jet pattern may be seen. At the moment of Brennschluss or fuel exhaustion, there is a radical change in the flame appearance. Post burn-out actions of the rocket can be clearly seen as it tumbles and precesses through the ionosphere. The last photograph was made when the rocket was 55 miles high and at a slant distance of 60 miles. Note the film scratches—referred to in the article. These pictures are a far cry from those possible today, but are of rare historic value. (U. S. Army photo)

favorable reputation for rendering fine planetary detail, because they had not produced the most successful results. Their curves are particularly sensitive to distortion by temperature changes in the glass. Diffraction effects, produced from the occultation of the secondary mirror in the middle of the tube and its supporting spider, disturbs the constrast-resolution relationship to an appreciable extent. The silver reflecting coats tarnish, and the mirrors must be resilvered every few months.

The blue-corrector was a lens approximately 5 inches in diameter and was placed about five feet ahead of the focus. In going from blue-photography to the yellow and red, the blue camera had to be taken off the telescope, and then the blue corrector carefully removed from inside the great telescope tube. Although no special corrector was as badly needed for the red photographs, nevertheless, the "yellow-red" camera had to be re-focused after photographs in yellow had been taken. At least one and generally several sets of such photographs were taken each possible night. The change-overs were most cumbersome. I could not see the performance of this kind of practice in the field work at White Sands. Besides, refracotrs have to have long primary focal ratios to be efficient; and for rapid manual tracking of rockets, long tubes for larger sizes was equally objectionable. The work at White Sands required even greater versatility in the use of color filters. These were the decisive factors in adopting reflector optics at White Sands.

Another vicious problems in tracking telescopes is the very small angular field of view which inevitably accompanys large scale images. In planetary photography, it is very important that the exposures be as short as possible in order to complete an image or frame before turbulence ("boiling of the image") kicks up again. The planetary observer looks through a powerful 12-inch aperture guide telescope which is attached to the larger one. When the turbulence suddenly and momentarily subsides, he presses the bulb for the exposure.

In the early days of planetary photography, they did not have high sensitivity fine-grained plates such as we have today. All finer-grained plates are slower in speed. At that time, they chose to enlarge the scale of images and record them on coarse-grained fast plates. The effective focal length of the telescope was increased from 32 feet to 175 feet by the use of a negative amplifier, which yielded an image of Mars ¼-inch in diameter. The large scale diluted the intensity or brightness of the image so that the exposures could not be less than one second of time. The best strategy was to underexpose at the telescope and force the plate in the developer. This same principle was profitably used later at White Sands on the tracking telescope films.

Dr. Edson was the first to see the potentialities of large scale photography of missiles in flight. The Germans never had anything like it in their war time testing of the A4 (more generally known as the V-2) rocket. They had their own theoretical ideas on how a rocket behaved along its high and long trajectory, but no one had ever taken a movie film record when the rocket was above 20 miles or so on sufficient scale to show the "attitude" (direction of the longitudinal axis). It is my understanding that the longest focal length used at Peenemunde was the 100-cm. Askania Cine-Theodolite. Such an instrument could photograph the V-2 as a dot image under very favorable conditions to a height of 40 miles.

The first tracking telescope was fabricated in the Ballistic Research Laboratories at Aberdeen Proving Ground. Two refracting telescopes of 4⅛ and 4¾ inch apertures were borrowed and mounted on a modified M 45 Machine Gun Multiple. An Eyemo 35mm movie camera was mounted on the larger one, and a riding seat attached behind the smaller one for a visual observer to note what happened and record his description phonographically. The idea of the riding visual observer was for the purpose of noting the more delicate details which, as in planetary observing, cannot be photographed.

Dr. Edson brought this first tracking telescope to White Sands in the early summer of 1946 to test its potentialities on V-2's in flight. He located it on a hill north-west of Fox Askania station, known as "F Star". The instrument was nicknamed "Little Bright Eyes".

Dr. Edson had other commitments and was not in a position to remain at White Sands and see the tracking telescope through to success. Much difficult experimentation was ahead. He was fearful that it might fall by the wayside unless someone acquainted with the nature of the problem could be interested in working with it. One weekend he made a trip over to my home in Flagstaff to sell me on it. The driving rates required to track rockets seemed too high to attain the fine detail; and besides I had just signed a two year contract to teach at the University of New Mexico in Albuquerque. I consented to come to White Sands to see a V-2 shoot scheduled about the last of July of 1946.

I came to Las Cruces, and then out to the White Sands Proving Ground, as planned. Reaching the top of St. Augustine Pass, I spied the new, small rocket base. Little did I realize that I would spend at least the next nine years of my life there. On the morning of the firing, I rode out of F-Star in a jeep (my first jeep ride) with Edson. That road to F-Star was a classic for tortuous meandering. The firing was scheduled for eleven o'clock, and strangely enough as I recall it was fired about that time. Edson plunked me into the visual observer's chair. Mr. Ralph Konegan, then a G.I., was the tracker. Then came the count-down and the rocket took off. The turbulence was fierce, but I could see the shock nodes in the V-2 flame and soon they disappeared. The lighting was badly against us and the rocket could not be tracked much beyond burn-out.

Upon returning to the base, we had to wait until evening to develop the film because of the temperature. The film was badly scratched. The images were poor. The film was some low contrast coarse-grained

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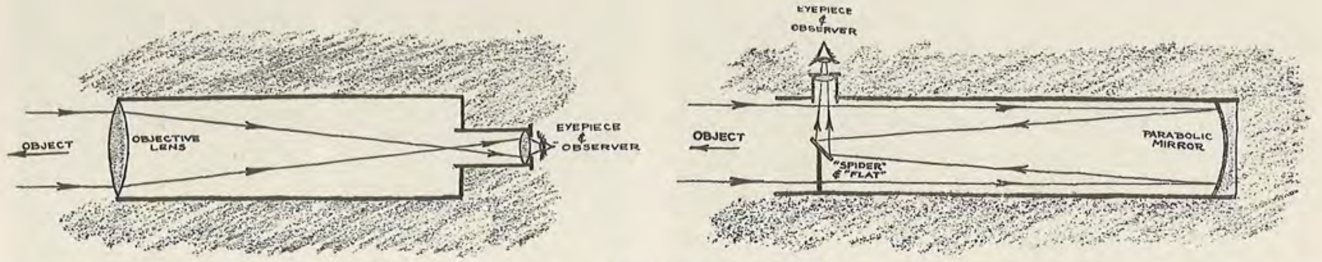

Diagrams of the two main types of telescopes. On the left is the refractor type with its large objective lens which brings the light to a focus, and its eyepiece which further enlarges the image for the observer. Refracting telescopes are limited in use because of the chromatic abberation of the objective lens and the size of the lens. On the right, the Newtonian type of reflecting telescope utilizes a parabolic mirror to focus the light which is thence reflected to the eyepiece and observer by means of a small optical flat supported by a spider in the center of the tube.

THE TRACKING TELESCOPE (Cont.)

variety. The results were most discouraging.

Dr. Dirk and Mr. Henry Cobb were down from Aberdeen, attending to matters of the BRL Annex. They were anxious to get additional scientific personnel. The University officials kindly released me from the Albuguerque contract, and so in the middle of August I joined the Civil Service at White Sands.

To make the tracking telescope work more successfully was my primary problem for the next several months. The scale of the magnification was much too high. It was not possible for the tracker to keep the rocket image within the frame more than a fraction of the time, which detracted from the value of the record. Also, the image was too diluted in intensity, and only a light yellow color filter could be used. It was necessary to boost the contrast between missile and sky background. Since the sky is blue, the missile should be painted another color. Then the sky background can be subdued by a color filter which absorbs the blue and transmits the color of the missile. The color of the sky partially follows the Raleigh Scattering Law. Of the visible spectrum the sky is weakest in the deep red, and this would have been ideal if the loss of light energy in the yellow could be afforded by the optics. In the case of the much shorter focal ratio Askania Cine-Theodolites, deep red filters were being used from the start. The Germans had designed them to do so. But the peak of solar illumination is in the yellow-green region of the spectrum. Photographic emulsions are not as sensitive in the deep red. There is also a fair amount of green light in the sky, so a compromise was struck between these conflicting factors by adopting a deep yellow filter. The original focal length of the tracking telescope was too ambitious. By moving the position of the amplifying lens I lowered the equivalent focal length to 20 feet, which increased the brightness of the missile image sufficient by to afford throwing away the green light. This subdued the sky background quite appreciably and improved the contrast between missile and sky background. With a larger angular field, the tracker was able to keep the missile within the frame most of the time. Although this resulted in some improvement, it still was not good enough.

Mr. Richard Dietz, a mechanical engineer, came to White Sands from Aberdeen. I appointed him crew chief of "Bright Eyes". Mr. Ralph Konegan was the first tracker. He was a G.I. at the time and later joined the Civil Service. We had plenty of mechanical troubles, as is generally the case with any prototype piece of equipment having moving parts. I struggled with the optical and photographic problems. The tracking telescope was on trial for its life. I wondered how long our failures would be tolerated. I worried about it because this new prospective means of rocket instrumentation was dear to Edson's heart, and also some others had quite a stake in it. Our operation reports on post rocket-shoot "critiques" were pretty unimpressive, and I fear we acquired the reputation of being the "hard-luck" boys.

Focussing was a problem because there was little to focus on in daytime. One could not focus on stars at night because thermal expansion of the tube the next day would spoil it. "Conjugate foci" relationship prevented us from focussing on nearby mountains. The images on distant mountains were too soft because of turbulence and haze. The planet Venus is easily picked up in daytime, and we used it to determine the position of infinity-focus. Since the chromatic dispersion of the refractor was now largely eliminated by the use of a deep yellow filter, the only serious remaining source of soft images was turbulence in our own atmosphere. Turbulence or "boiling" is exceedingly bad for several hours during the middle of the day.

The rocket firings were nearly always scheduled for eleven o'clock in the forenoon. We didn't have a chance unless the firings could be scheduled for late afternoons. We pleaded in vain. Not only was the turbulence near maximum at eleven o'clock, but the lighting of the missile was the worst possible. From F-Star the rocket passed almost in front of the sun, and we could see only the shadow side of the rocket. So we abandoned F-Star site and moved near the site now occupied by Nan Igor. Signal Corps had laboriously just built a little pole line up that rocky hill of F-Star from Fox Askania. A new ground wire connection had to be run from Nan Askania to our new site, and several people were pretty unhappy. The change in site brought considerable improvement in our results.

We still could not get sufficient contrast to photo-

graph a V-2 anywhere near the peak of its trajectory. Edson had been able to get the paint pattern on the rocket changed from the old German black checkerboard to flat white color excepting some black on the fins to identify roll. This made the rocket nearly a full stellar magnitude brighter—when it was clean. In preparing the V-2 for firing, checking and testing components, dirty hands and shoes, darkened the white paint considerably. I protested and got them to put on the white paint the last thing. This helped. On one of the earlier rockets, Edson and I repainted the entire V-2.

There was a distinct advantage in painting the rockets flat white, with a few parts flat black. The flat teture gave a better "acceptance angle" for more stations in different directions. The white is pretty non-selective and various types of optical instruments could use that portion of the spectrum which was to their best advantage. For example, the Askania Cine-Theodolite could add ten to twenty miles to their range by using red filters as compared to using yellow filters and diaphragmming apertures.

I wanted to find better 35 mm film, some that might resemble the newer Eastman emulsions on plates, which were finer-grained and had higher contrast. Mr. Eddie Murray of BRL suggested Panchromatic Shellburst film. Aberdeen sent down to White Sands several rolls of this film.

Then on 5 December 1946, the great day came. V-2 Round 16 had its firing time delayed, hour after hour. It was fired shortly before sunset. The turbulence in the air had settled down and the sky was beautifully clear. "Bright Eyes" was ready. The V-2 took off at a lower angle then usual. It was in full phase illumination by the sun. No film jams, everything worked! Atkinson, a G.I., tracked the missile for a long time, until it faded out of the tracker's guide binoculars. As we learned later, it was at a slant distance of 110 miles, and the images were good enough to measure the angle of attitude. Except for the scratches, the film was a great success. Mr. Cobb worked most of the night making enlarged prints, which he exhibited at the post-shoot critique the next day. These photographs literally stole the show. The photographs unmistakably showed a precessing-yawing behavior after burn-out, which had never been photographed before. They revealed an instability in flight which was unexpected, theoretically. They imagined the V-2 to retain the angle of attitude at the instant of burn-out thru-out the ballistic part of the trajectory until it reached the denser layers on the down-leg where air-resistance would stream-line it into the trajectory path. But instead, the rocket tumbled. Why? The V-2 flame showed remarkable changes in forms as the rocket gained speed and ascended into thinner and thinner layers of the atmosphere.

The missile people immediately saw the value of such telescope records for purposes of studying missile performance in flight. Upper atmosphere research people wanted to know the attitude of the rocket at each instant of flight because the angle of attack affected the readings in their experiments aboard. Attitude could be measured to an accuracy of one degree. Aberdeen was besieged with urgent requests for more tracking telescopes. From now on I was in a position to set the time-of-day limits on the firings of many of the missiles.

There were a few who ignored my firing time recommendations and fired in the middle of the day. Some rounds went wrong and they were around to see what the tlescope films might show. The images were too soft to yield the data that they wanted, and one engineer accused us of not knowning how to focus the telescopes. "Turbulence . . .", I explained. "Ridiculous, nonsense, why I can take my camera out and get sharp pictures of the landscape right at noon," he said. "What is the focal length of your camera?" I asked. "Fifty millimeters." "Our focal lengths are 20 feet and more," I said. He still failed to realize the implication and accused me of telling him stories. I was never so disgusted with anyone in my life because he should have known better.

It was soon learned that visual observations of rockets in flight were untrustworthy because the sequence of events were too quick for the eye. Also the rapid meandering of the rocket image in the field of view from tracking errors is not conductive to seeing well—a situation very different from watching a planet's image in an equatorially-mounted and smooth clock-driven telescope. So the visual observations were given up, and another camera was attached to the telescope for insurance in case the camera on the other telescope had a film jam.

To meet the acute demand for more tracking telescopes, small cassegrain reflecting telescopes were put on some of the Askania Cine-Theodolites. The use of such optics doubled their range in obtaining coordinate data.

The success of Shellburst Panchromatic film in the tracking telescopes led to its immediate adoption by all the theodolites, because it improved their range in ob-

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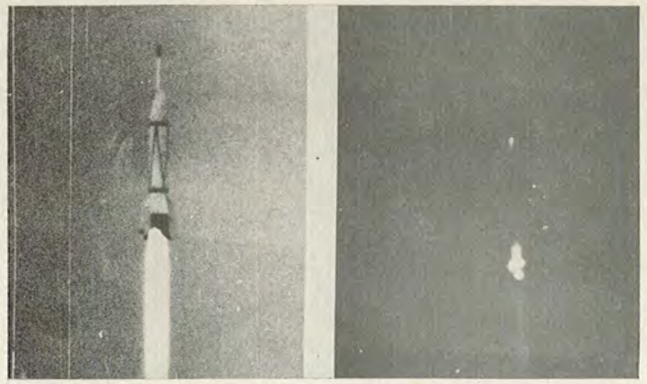
The first tracking telescope, "Bright Eyes", at F-star station, and its crew. Left to right: Dr. James B. Edson, Mr. Petruzzella (timing control), next two men's faces familiar but names cannot be recalled by author, Pvt. Ralph Konegan (tracker), "Curly" . . . ?, Pvt. Moreno. (U. S. Army photo)



"Bumper" two-stage rocket fired 24 February 1949, taken with "Bright Eyes" at a distance of 6 miles southwest of launcher. Left: "Bumper" shortly after take-off, a few miles high. Right: Cut-off of the V-2 at a height of 19 miles; above it, the WAC Corporal starting up, destined to reach a record altitude of 250 miles three minutes later. (.U. S. Army photo)

THE TRACKING TELESCOPE (Cont.)

taining missile images. Telemetering people liked Shellburst for their records, also. With more telescopes and more than 35 mm cameras, the footage of film to be processed increased sharply. The time was ripe to initiate sensitometry control in evaluating the condition of stored unexposed film and processing efficiency. By measuring the density of film samples exposed through standard calibrated opacity strips, it is possible to determine the sensitivity gradient. The contrast factor for Shellburst Panchromatic film is about double that used in commercial photography. The tolerance in both exposure time and processing is correspondingly more critical. The strength of processing chemicals gradually deteriorates with respect to both time and area of emulsion surface processed. Sensitometry control permits a reliable determination of the state of the developer solutions, so that one does not have to dump them prematurely by rule of thumb, nor run the risk of using them too long. This results in a great saving to the government and improves the qaulity of the film record. Mr. Darrel Lassiter was placed in charge of film processing. He and his assistants did a splendid job.

The correct exposure time in the field under widely varying lighting conditions posed a real problem. Administrative duties in the Optical Measurements Branch did not allow me much time to undertake such a study. It was linked with atmospherics and sensitometry in a complex way. I asked for light meters and was told I didn't need any! We finally got the light meters and the field crews were instructed on how to use them. This yielded more reliability in obtaining good photographic records. By keeping the exposure down within the lower portion of the "H and D" density curve, loss of image detail from photographic turbidity was held to a minimum without sacrifice of maximum contrast. Without the light-meters, it would not have been possible to take advantage of this situation without undue risk in loss of contrast resulting from under-exposure below the critical limit called "the toe" of the H & D curve.

Fortunately, a physcicist with considerable experience in photographic photometry at the Bureau of Standards, Mr. Gerald K. Neeland, showed up at my home one evening. After an interview, I decided he was just the man to undertake the necessary research along the lines described above. He was resourceful and devised several instruments out of scrap material. Many practical things were learned which increased the reliability of operations in the field.

Mr. Neeland and Mr. Lassiter set up the extensive sensitometric control. The first problem is to make the exposures correctly in the field, the second is to process the film correctly. It is advisable to force the development of the tracking telescope films a little because the long focal ratios that they are obliged to use leaves them a little short on light. But it is a serious mistake to under-dvelop in order to remedy an over-exposure, because the quality of such processing is impaired. Due to the "Raleigh Scattering" of light in the atmosphere, which is inversely proportional to the fourth power of the wave-length, one should alway use the "deepest" (that which transmits the longest wave-length) filter as the amount of available light will allow. There is an exception to this rule in the case where trajectories are low and close and the lighting is against the camera; then the silhouette strategy is more advantageous. When there is light to spare, neutral density filters should not be used. If there is too much light for a deep red filter, then it is better to shorten the exposure time by changing the sector angle of the rotating shutter. This minimizes tracking error smearing of the images, and also there is a better chance to catch a brief moment when there is a lull in turbulence. Dr. Fred S. Hanson undertook much of the theoretical work pertaining to sky illumination, exposures and filters.

There is not enough space to describe other tricks which were useful in getting better telescope records. The sum total of all these factors and cooperative efforts of many people have made it possible to push the performance of all long-focus instruments close to their theoretical resolving power, maximum efficiency in light power, and haze penetration. It may be of interest that the smallest rocket detail resolved on the photographs subtended an angle of slightly less than one second of arc, which is equivalent to resolving two points one foot apart at a distance of 50 miles. This, of couse, was under extremely favorable and rare conditions. It was attained with a focal length of 25 feet. Longer focal lengths have been tried, but they never did any better than the shorter focal lengths. The best daytime seeing occurs about sunset. Frequently, the seeing is good enough to obtain 2 second of arc detail. For several hours around the middle of the day, the turbulence smearing does not allow anything better than 5 to 10 seconds of arc resolution of detail. The amount of detail that can be photographed varies inversely as the square of these numbers. Consequently, 100 times as much detail may be photographed near sunset as compared to what can be done around noon.

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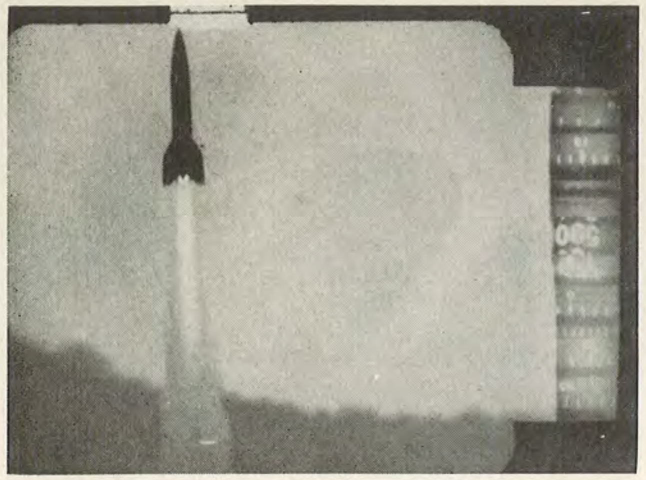


Frame from a telescope film showing a V-2 very shortly after take-off. The film was made with Telescope 3 almost 20 miles east of the launcher. Note the Organ Mountains in the background. Note particularly the near-schlieren effect of the boundary layer spreading from the jet flame. (U. S. Army photo)

THE TRACKING TELESCOPE (Cont.)

These facts are of the greatest importance in scheduling firing times of missiles if attitude and event data are required.

It is of interest to mention some of the important findings and functions contributed by tracking telescopes:

1. The diamond shock nodes in the jet flame of a rocket disappear suddenly within a space of a few frames (for cameras run at 16 frames per second) when the rocket reaches trans-sonic velocity.

3. During the last second of burning the rocket jet flame shows a lop-sided structure, which apparently exerts unsymmetrical thrust and causes the rocket to precess or tumble. For rocket experiments requiring stability in attitude, it was obviously necessary to cut off the fuel just a second or two before one of the propellants would have become exhausted. This information was essential to the successful launching of a two-stage rocket such as Bumper, which climbed to a height of 250 miles.

4. The manner of opening of ribbon parachutes at great altitudes could be studied for the purpose of improving their reliability in lowering animals and apparatus to the ground.

5. With the aid of timing pips on the side of the films, record the attitude of the rocket to an accuracy of one degree to link in with telemetered experiment data.

6. It is possible to ascertain the manner and nature of explosions and fires aboard the rocket, and the failure of structural parts through critical stages such as the sound barrier.

7. Record the performance of guidance commands to the missile.

8. With spectrographic attachment to the telescope, detect improper fuel burning by the appearance of hydrocarbon bands in the spectrum of the alchohol-oxygen jet flame. Also, measure temperature of jet-flame.

9. Measure to an accuracy of one foot the miss distance of guided missile-drone or target tests, and the manner of destruction of live war-heads.

10. Measure the attitude of bomb drops.

11. There were several other important findings which cannot be revealed because of security reasons.

The success of the first tracking telescope brought four more. They were reflectors. Some obtained their amplification of focal length by small camera lenses; others by cassegrain mirrors. Telescopes II and III were mounted on M45 machine gun mounts. Telescope IV was the first 16-inch mirror, and was mounted on a 90 mm gun mount and set up on Mule Peak at 8,100 foot elevation, 40 miles from the launchers. Telescope V was a twin cassegrain on an old Radar Search Mount, and stationed on a high hill near St. Augustine Pass at 5414 feet.

Later, another family of tracking telescopes was added, known as "IGORS". These have 16- and 18-inch diameter mirrors with F6 ratios. They have high-speed Mitchell 35 mm movie cameras, capable of frame speeds up to 120 per second and exposure times as short as 1/2000th second. These were the factors that yielded the famous drone-Nike pictures, resolving on succeeding frames the details of a very sudden event, and freezing the turning of the propellers and the motion of the Nike. There are now nine IGORS, located on the floor of Tularosa Basin. They are generally operated at their primary focal lengths of 96 and 108 inches. They are equipped with amplifying lenses which can boost the focal lengths to 300 inches or so when more scale is desired.

Many Askania Cine-Theodolites have had their original optics replaced with longer focal lengths. The optics for 15 instruments were designed, ground and mounted by White Sands FDL personnel.

Most of the long focal length instruments in use today at White Sands Proving Ground were built by the Ballistic Research Laboratories at Aberdeen Proving Ground in Maryland, except for the optics, which were contracted out. The photographic engineering with its experimentation and developed techniques was largely accomplished by White Sands personnel. The Photographic Processing Section has become one of the foremost in the country for volume and quality largely the result of the requirements of long focus photography.

The successful development of the tracking telescope has led to its adopted use at other proving grounds. Representatives from other proving grounds in this country and abroad have beat a path to our doors, seeking consultation on this highly developed science and technique from our experts.

The tracking telescope has had a profound influence on the development and expansion of White Sands Proving Ground and its program of work—all within a period of ten years from a precarious beginning. • • •

BOOK

The Viking Rocket Story, by Milton W. Rosen, Harper & Brothers, New York, 1955, 242 pgs.

Rocketry has been waiting for this book for ten years, for it was back in 1945 that the author persuaded the Naval Research Laboratory to embark on a program of study of the upper atmosphere. Part of this program was a project to develop a large upper-atmosphere sound rocket.

The rocket **Viking,** holder of the world's single-stage altitude record, is the result.

The Viking did not come about easily, as the author points out repeatedly. First there were turbine troubles, then vibration troubles in the unique gimballed motor, then fin construction problems. There was Viking 8, which tore loose during static firing, and Viking 10, which exploded on the launcher during the first launching attempt. But Viking rockets have been fired at sea, at night, and under all conditions. Each one had its problems; each one was a different missile.

Milton Rosen has long talked about the problems of development and the problems of reliability of rockets, particularly in connection with several proposed space flight schemes. This book gives some indication as to why. It's hard to conceive of the problems and troubles encountered in flight testing, particularly when you are working with a device which is, essentially, new and untried . . . and each Viking rocket was, since no two were alike.

But the book does not concern itself primarily with the various Viking rockets. It is the story of the men who fired them . . . and many are familiar names to you—Hank Hardin, Ed Munnell, Joe Pitts, Capt. P. D. Quirk, Nat Wagner, Herb Karsch, Allen Niles, Clyde Tombaugh, and other members of the NM-WT Section of the ARS. It is **their** story, for the book is dedicated to the men of Viking. It is a compelling story of their actions, their hopes, their achievement, much of it taken directly from notes made on the spot and tape recordings of firings. It is authentic.

Much of the book was written right at WSPG. Most of it takes place there. It is the type of book you cannot put down until you have finished it.

Milton Rosen is known to many of you as a top-flight rocket man. He is a member of our National Board of Directors. He was primarily responsible for the proposal to the National Science Foundation to undertake the study of the utility of an unmanned satellite. Yet, in **The Viking Rocket Story,** Milton Rosen emerges also as a sensitive, engaging writer and a historian of the highest caliber. His book will, we are sure, rank high in the literature of rocketry during the pre-space-flight era. Most important of all, it belongs in your library.

REVIEWS

GOING INTO SPACE

by A. C. CLARKE—2.50

117 pages, 30 photographic plates 6 figures

Harper and Brothers, New York, 1954

The brief introduction to the problems and possibilities of space travel is Arthurs C. Clarke's third non-fiction book on space travel. The reader for whom this book is written is the young person, perhaps of high school age, with scientific bent but who has not yetbecome acquainted with rockets and space travel. Inorder to set the book in the proper vein, Mr. Clarke uses a slightly different style from that in his earlier works, (**Interplanetary Flight** and **The Exploration of Space.**)

There is little change in the factual material from his earlier books but in the brief descriptive coverage, the material is necessarily over simplified and many of the statements that are made should be qualified.

A few of the analogies, such as the eagle and wren story, (p. 29)* and statements like "a space man can fly like a bird," when in a weightless condition, (p. 47) emphasizes the point Mr. Clarke is making but cannot stand up under critical examination.

Although many experts question the soundness of some conclusions which have been reached about practical uses of an earth satellite space station, Mr. Clarke enumerates the possibilities with little reservation.

The brief mention of Dr. Robert H. Goddard in the historical section certainly does not do justice to the man who pioneered liquid propellants, pumps and stabilization controls. The photographic plates and drawings are interesting but not unusual.

On the whole the book is quite readable and is a good but simplified introduction to space travel. Due to a few weak points, the neophyte reader will very likely pick up a number of false ideas although the book is generally correct throughout.

If you have read either of Mr. Clarke's previous books, or if you have had anything more than a passing interest in space travel, it is doubtful that you will find any new information in "**Going into Space**".

*The step rocket principle is illustrated by the story of the wren who, betting that he can fly higher than the eagle, wins by riding unnoticed on the eagle's back.

MISfires . . .

A Rocket Man's Dictionary of Bureaucratese

Inasmuch as rocket people will undoubtedly run up against such things as office procedures, administration, and a lot of other junk that piles up in an "IN" basket, we think it may be of some help to define the somewhat ambiguous terminology used in this tremendously broad field of bureaucratism into which a lot of rocketmen have found themselves thrust. **Non illigitimus carborundum.**

A PROGRAM: Any assignment that can't be completed by one phone call.

CHANNELS: The trail left by interoffice memos.

STATUS QUO: The mess we're in.

TO EXPEDITE: To confound confusion with commotion.

EXPEDITER: One who does the same while riding fast planes and staying at good hotels.

EFFICIENCY EXPERT: A guy who trains expediters.

COORDINATOR: A guy who has a desk between two expediters.

LIAISON OFFICER: A person who talks well and listens better, but has no authority to make a definite statement.

CRITERIA: Measures which the other guy uses to underestimate what you have already overestimated the deal to be worth.

INCENTIVE PROGRAM: A scheme to titillate a submerged urge.

TO ACTIVATE: To make carbons and add names to the memorandum.

UNDER CONSIDERATION: Never heard of it.

UNDER ACTIVE CONSIDERATION: We're looking in the files for it.

IN TRANSMITTAL: We're sending it to you because we're tired of holding the bag.

A CONFERENCE: A place where conversation is substituted for the dreariness of labor and the loneliness of thought.

A CLARIFICATION: To fill in the background so detailed that the foreground must go underground.

A MODIFICATION OF POLICY: A complete reversal which nobody admits.

POINT UP THE ISSUE: Expand one page to fifteen pages.

TO SPELL OUT: To break the big hunks of gobbledygook down into little hunks of gobbledygook.

REFERRED FOR APPROPRIATE ACTION: Maybe your office knows what to do with this.

(next page, please)

Contest Winner—

"What do you mean, **cut-off?** We're coming up on x-minus one minute!"

This issue's fin for the cartoon caption goes—with all due apologies to Nat Wagner—to Lou Stecher. Unless some more captions are received from the wits of the Section, we may have to start a new contest. Five-dollar bills are still available for useable captions, however.

A Rocket Man's Dictionary (cont.)

SYNTHESIS: A compounding of detailed bewilderment into a vast and comfortable confusion which offends no one.

PROCEDURE: Everyday routine rigamarole.

LETTER OF TRANSMITTAL: A way to pass the buck.

A SURVEY IS BEING MADE OF THIS: We need more time to think of an answer.

FURTHER SUBSTANTIATING DATA NECESSARY: W've lost your stuff; send it again.

TO EXPLORE THE RAMIFICATIONS: And, brother, just wait until you see what we think of!

CONFIDENTIAL MEMORANDUM: There wasn't time to mimeograph this.

NOTE AND INITIAL: Let's spread the responsibility for this.

SEE ME, OR LET'S DISCUSS: Come down to my office; I'm lonesome.

(To be continued . . .)

ENGINEERING TYPES

Rare Birds of the American Southwest

Compiled by

R. K. AUDOBURNE

FIE KINGBIRD (Avis Altissima)

Field Marks: 45 - 50 feet from nose to tail, the Fie Kingbird is one of the largest of the southwestern birds. The species is gradually changing; measurements in the last year or two show that the belly diameter has increased from 32″ to 45″. There are no wings, and the four symmetrically located tail surfaces seem to be gradually disappearing. Their shape is now triangular according to the most recent observations. Coloring is predominantly white with a single black ring near the nose, and another just forward of the tail. Occasionally the forward ring is missing and the nose may be more silvery than white.

Similar Species: The European Man-O-War bird (Veetoo) is approximately the same length from nose to tail but has a considerably larger and varying belly diameter. The tail surfaces of the European Man-O-War bird are also considerably larger and differently shaped than those of the Fie Kingbird so that confusion of the two should seldom occur.

Range: Generally southern New Mexico, although a few years ago a reliable report was received from the neighborhood of Christmas Island in the Pacific Ocean.

Comments: The Fie Kingbird has been seen higher above the earth's surface than any other bird except for the lesser Man-O-War Bird (western) which once, after having been mated with a Veetoo, made an exceptionally high flight.

It has been speculated that the increased belly diameter has resulted from the bird's desire for food to improve its flight performance. A few days before one of its flights high above the earth, the bird holds tight to the ground and with a tremendous roar that lasts several minutes tests its flight equipment. In one case it is known that the bird lost its grip on the ground and suddenly found itself up in the air. After a short flight it settled fairly quickly back to earth.

The hunting of Fie Kingbirds is generally prohibited, but one that had temporarily become a local menance had to be subdued by a shot from a carbine. The injury was not fatal and this same bird was later observed flying as well as ever.

Other Names: Viking, Milton's Missile, Ringtailed Ion-Catcher.

POST-SHOOT CONFERENCE

There have been disturbing rumors of something called "Operation Bacchus" floating around. Nobody seems to be able to put his finger on the source of this rumor, nor any information concerning it. A rocket using wine for a propeliant, maybe?

Wonder if the president of our Holloman-Alamogordo Region, Lt. Col. John P. Stapp, has broken the sound barrier in his rocket-powered sled, the "Sonic Wind"? Last we heard, he was lengthening the track so he wouldn't have to call for the services of the recovery section.

Lt. Col. John P. Stapp, USAF (MC), was elected as Regional President of the NM-WT Section's Holloman-Alamogordo group at the meeting of 15 April 1955 in Alamogordo, N. M. Col Stapp, billed as the "fastest man on earth", reached a speed of 632 mph. in December 1954 on his rocket-powered sled, the "Sonic Wind", ass part of a series of experiments to determine human tolerances to accelerations, winds blast, and jolt. Walter L. Andre was elected vice-president of the group, and John A. McCurdy will serve as secretary-treasurer.

On Armed Forces Day, 21 May 1955, White Sands Proving Ground opened its doors to the public for the first time in its history. Visitors were treated to a display featuring the Nike missile system, the Corporal missile, and the Honest John. The White Sands Signal Corps Agency prepared a series of displays showing how chain radar is used at WSPG, and how range communications are maintained. Post Ordnance carried young visitors for rides in tanks and jeeps, much to the delight of the youngsters. Army Aviation was represented by an L-19 and an L-20 parked on display. A section was reserved for historical missiles such as the V-1, the V-2, the WAC Corporal, and the Hermes. Conducted tours were made of the non-classified areas of the proving ground, and motion pictures were shown. On this historic occasion, cameras were permitted in the display area, as everything shown was unclassified.

Speaking of rumors, a strange vehicle bearing the name of an unknown contractor has been seen in many of the inner areas of White Sands. Anybody have any notion what a ship and drydock outfit is doing with rockets . . . and out in the desert to boot?

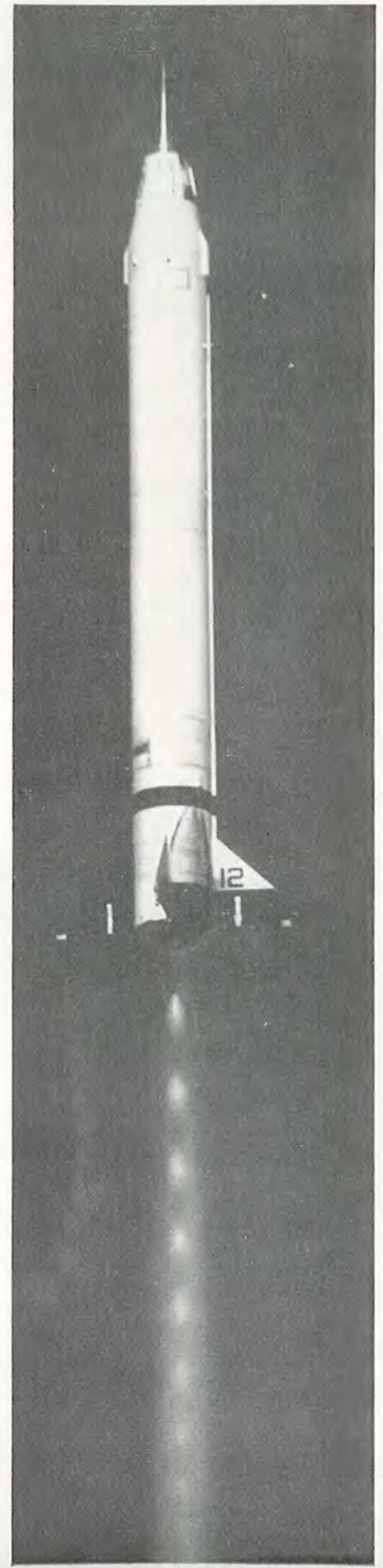
Who was the one who had the initials "ARS" removed from the emblem on the ARS lighters, tie clasps, and recognition pins? If this is an economy move, why isn't it reflected in the price of the item? Can somebody give us any answers?

The May issue of "Jet Propulsion" contained two articles by prominent Section members. If you did not attend the El Paso meeting or the New York convention last year, be sure and pick up the article on subgravity by Major David G. Simons and the illuminating piece on the satellite search by Fellow Member Clyde W. Tombaugh. We'd like to see more papers similar to these two. How about it?

On 28 April 1955, the Air Force's new high altitude sounding rocket, the "Aerobee-Hi", reached an altitude of 123 miles after firing from Holloman Air Development Center, N. M. The new rocket (above) is an improvement over the standard Aerobee rocket, having a greater thrust. The 28 April shot carried a payload of 230 pounds, the heaviest load ever carried in an Aerobee-type rocket. The firing was delayed for several days due to wind conditions which might have carried the sounding rocket off the White Sands range.

With this issue we are helping White Sands Proving Ground celebrate its 10th anniversary. We feel justly proud to be part of the team working at the rocket capitol of the world, and sincerely hope the next ten years will see as much advance in American rocketry at White Sands. The future holds a great deal in store for White Sands. Nowhere else in the world will you find a rocket range so completely instrumented with cameras, telescopes, chain radar, doppler, and other devices necessary for gathering and reducing data on rocket and guided missile flights. Nowhere else will you find the complete range of facilities offered by White Sands. And nowhere else will you find the Army, Navy, and Air Force working so closely together in such a complex field toward a common goal.

"Beyond the satellite, the future can be only dimly perceived. One thing can be said. As long as men have the curiousity and the courage, the exploration of space will continue to at least the farthest reaches of the solar system."—Milton W. Rosen, The Viking Rocket Story, **page 235.**



SUPER-PERFORMANCE by RMI
WHEN SECONDS COUNT . . .
Rocket engines provide the extra speed military aircraft need for early enemy interception. RMI has pioneered in the application of rocket power for piloted aircraft.
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Ordnance rocket propulsion
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REACTION MOTORS, Inc.
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AFFILIATED WITH OLIN MATHIESON CHEMICAL CORPORATION