"Missile Away!"

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

Vol. IV, No. 3
FALL
1956

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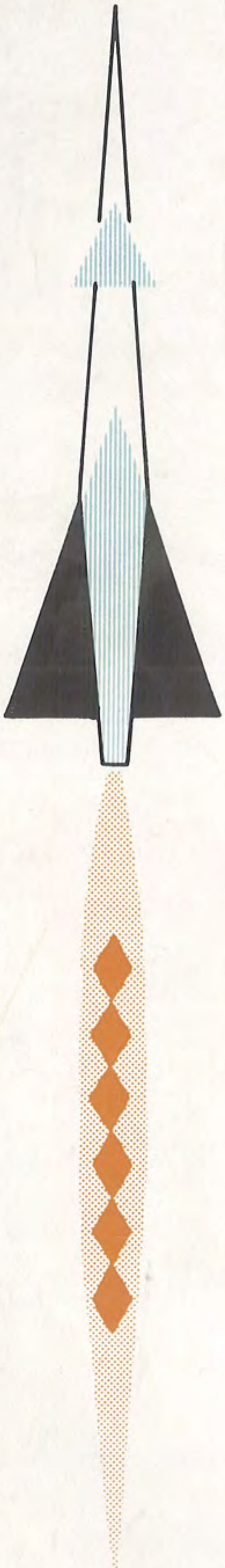

THE NEW MEXICO-WEST TEXAS SECTION
OF
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"Missile Away!"

Vol. IV, No. 3
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CONTENTS

SPECIAL SUPPLEMENT:
(NM-WT Section Members only)
"Little Black Box", courtesy Benson-Lernher Corp.

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.

editorial

"THIS SPACE RESERVED . . ."

We had originally intended to use this page for a blasting editorial against a recent ruling of the National Board of Directors.

But we're not going to. We are going to wait.

Briefly, the situation is this. ARS President Noah S. Davis' July 1956 letter to all section presidents contained the following:

"Some of the Section publications have been soliciting advertising on a national basis and in certain cases this has been done through direct appeal to the top "brass" instead of going through the advertising representatives. This National solicitation has not only caused confusion due to the differences in advertising rates and publication dates, but in some cases has caused ill feeling on the part of the advertising agents. This hurts the ARS reputation.

"For these reasons I have been instructed by the Board of Directors to call this problem to the attention of each Section President and to instruct them that the Society could not approve the solicitation of advertising from any but local suppliers, and that this solicitation must be made through legitimate advertising channels. I feel sure that each of you will cooperate in this matter."

National Headquarters admits directing this in part at this magazine and further admits that it was calculated to put us out of business completely; we cannot exist without advertising.

We do not like this.

A ten megaton editorial blast has already been approved by our own Board of Directors since we feel the edict is somewhat dictatorial.

However, we are saying nothing right now because we are going to be given a chance to speak in our own defense. A special meeting of the National Board of Directors, the staff of *Jet Propulsion*, the staff of the California Sections' *Rocket Newsletter*, and the staff of *"Missile Away!"* will convene in New York City on or about 27 November to discuss the entire matter.

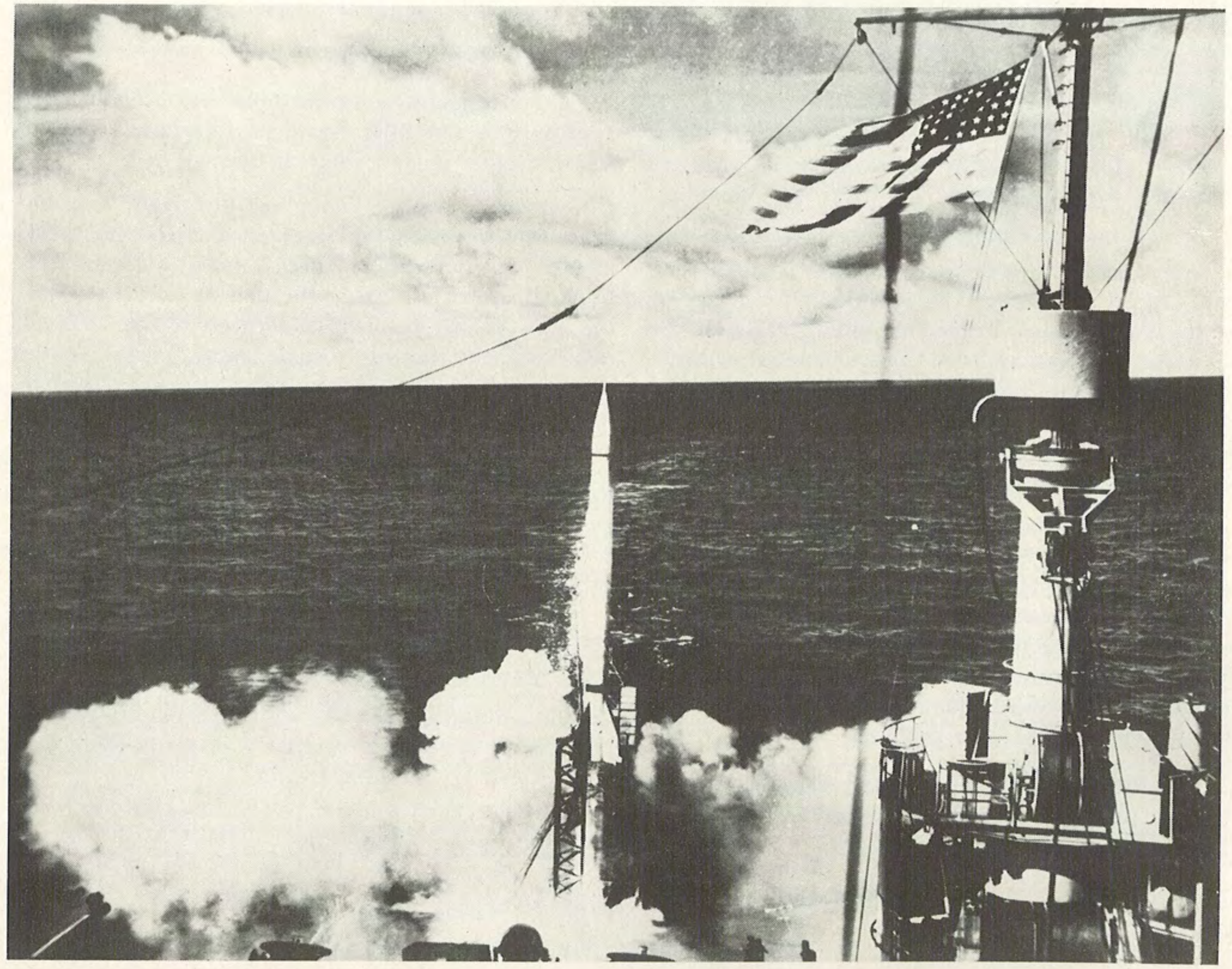
The National organization is being big enough to let us speak our piece, so we are withholding our scorching editorial pending the outcome of the meeting. The editorial will be placed in the files of the Winter issue and used if conditions warrant.

However, we'd like to know the reactions of our readers. They will, to a great extent, determine what we will say at the November meeting.

How about it? Do you want the magazine to go on? Get in touch with the ARS Board of Directors or the staff of this magazine.

—G. H. S.

"OPERATION REACH"



Diary of a Rocket Engineer

by

ALLEN NILES

NAVAL RESEARCH LABORATORY

The Viking was a sea rover, and this was proved by the men of the Navy and the Martin Company when they took Viking rocket #4 to sea aboard the USS Norton Sound. Here, for the first time, is the actual day-by-day diary of one of the men who fired Viking #4, setting a milestone in the history of rocketry and of the sea. These letters from the author to his wife tell the story better than any technical report . . .

Dear Dorothy,
We sailed at 1000 this morning. It is rough due to ground swells and ship is rolling enough to make most of us uncomfortable, if not sick.

April 27
Ship is still rolling—everybody sick. Ed Munnell sickest.

April 28
Sea is smoother and we are able to be around little bit, except Ed. He is still bad off. Engineers found the trouble in our heating system so we have heat in our bunk room now. We have been frozen.

April 29
It is beginning to get warm now so we don't need the heating system. We have been having terrible movies every nite but most of us go anyway. The sound tracks are beat up so bad we can't understand much but noise. Worked all day.

April 30
Worked half day, and put on shorts in afternoon. Got lot of razzing from guys—fellows of my physique. Saw 3 flying fish. They are pretty little things—very graceful.
Lot of the press on board, including many who were at Sands for #2. Clete Roberts who made recorded interviews of lot of us at that firing is aboard. Said his recorded broadcast of that firing is being considered for some prize as best piece of reporting for 1949. He played the recording for us—it was very impressive but my interview had been cut out, tho he had the interview leading up to mine . . . .
The destroyer Ozborne looks reassuring and menacing at same time. We broke out ammunition and had our guns readied Thursday. Suppose that is standard practice for Navy but it seems exciting.

May 1
Engineers invited some of us down to see the engine room. We visited that and then Hank and I went to see the steering gear to see if "Oil Gear" made any. This ship steering

(next page, please)

The USS 'Norton Sound' off Christmas Island in the South Pacific with Viking #4 still perched on the main deck aft. (U. S. Navy photo)

gear is a conglomeration of G.E., Vickers, and Roote Bros. No "Oil Gear". After this I went up on bridge to see telescope. The telescope was removed because of rain earlier but officer on bridge showed me all the equipment used for running ship—radar, navigation, communication—the works. He let me steer for 15-20 minutes. Our course was a little erratic—but I steered.

Finished up my roll of film and turned it into photo office for processing and censorship. I took lot of pictures I didn't think I could account of security but he said I'd probably get most of them tho it takes long time for release, up to 6 months. I went to store to get more film and found they had only one roll left. That will have to cover everything til we get to Honolulu.

We have news broadcasts every day by some of the commentators on board. They also include instructions and warnings for Polywogs as our initiation into Royal Order of King Neptune is coming up soon. There is one observer on board from the Air Force, a Colonel, young fellow. They announced that he made the remark that B-36 could do anything the Norton Sound could do and do it better, so he is to be a SPECIAL CASE.

Hank said his letter day by day just says: Mon. Hank sea sick—Tues. Hank sea sick—Wed. Ditto, etc., etc. He has been sick much of the time.

Because Cosmic Ray group is having trouble with equipment our firing date has been moved up to May 8, Mon. Now we are going to Christmas Island first, this Fri. and Sat. then going out to fire Mon. if rocket and conditions are right.

May 2

Weather has been very hot and sultry for several days. Bunkroom has been stuffy and uncomfortable. We are, since yesterday, passing thru a storm belt and sea is rough, rains often and generally not so good. Because it is so rough we are not working on Viking today. Many are sea sick bad and most of us do not feel good.

Wednesday

Sea is very rough today—took it well for several hours but got me down in aft. Sun is intense and bothers too. It is an extra thrill to climb our rocket's gantry when ship is rolling. I had to work up there much of day.

Thursday

Another rough day. Captain invited group of us for dinner in his cabin tonite. Had fine dinner, excellent service—could have enjoyed it more if I had felt better.
We are to anchor offshore of Christmas Island tomorrow morning. We could have been there today except we have been zig zagging over course for tests. Christmas Island is a coral reef and has no good anchorage so we are not

anchoring over night. Following some checks on rocket tomorrow morning some of us will be able to go ashore in aft. Will take some pictures. Naturally.

Friday

We got to Christmas Island O.K. but as there was some electrical trouble we didn't get to our work til late aft and couldn't go ashore for waiting. We are to go tomorrow.

May 6

We finally went ashore on a beautiful day for color pictures. I went slightly trigger happy and took about 30 shots. Got few of the natives, mostly the men doing their work on coconut plantation. Christmas Island is claimed by New Zealand and U.S. The natives, Polynesian, are contract workers for British government imported to harvest coconuts. The native men are fine physical specimens and look intelligent too.

Dr. Newell and Lt. Hill and I explored the island and found a beautiful lagoon with green water which contrasted with white sand, blue sky and clouds—made beautiful sight and I hope pictures. We chased some small sharks (me in underwear) but they were too fast. Caught some blow fish though. There are some beautifully colored fish there, brilliant blue, pale blue, gold and red (separate fish that is). There are many curious sea animals too like crabs of various kinds. We all collected pretty shells and coral. I got a big bunch if I can get it home. Had to carry most of it all day and for miles but got it on ship. Some film has to be processed and censored by Navy and won't have it for long time. Have only five pictures left and ship's store is sold out. These will go for initiation ceremonies which come up Monday if the Rocket goes O.K. tomorrow. Hold your thumbs!

Paul Smith says I am to get on rocket at 6 a.m. so will turn in now. Got back aboard ship at 5:45 this aft and we are now under way for firing station across equator, should cross about 7-8 a.m. tomorrow.

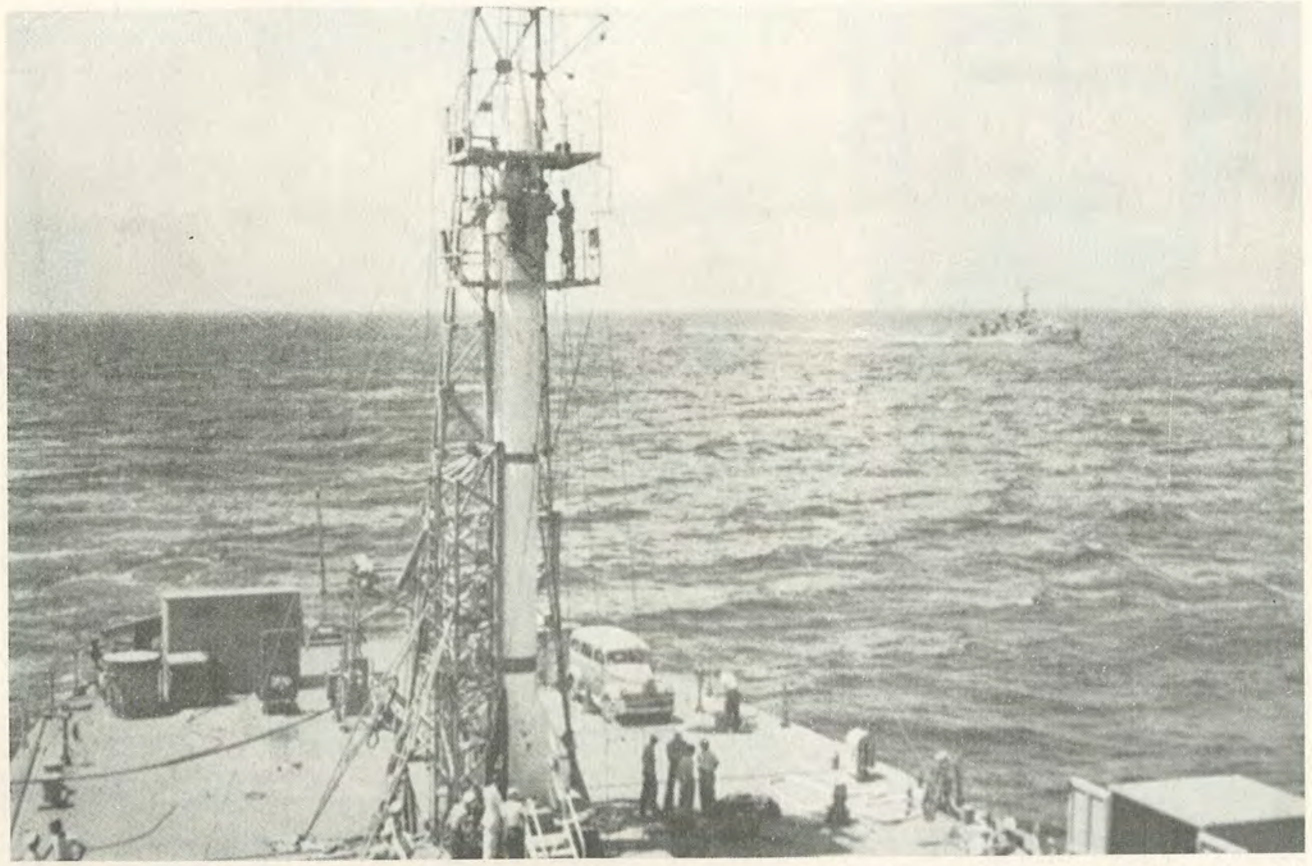
Sunday

Got on rocket at 5:30 this morning. Worked hard all day. We were ready on time but weather was overcast. We chased holes in the clouds all afternoon and when we found a hole had trouble . . . I finished my day at 11:30 p.m. long day, hard day. Sunburned tho I have two more days before initiation so burn should not be so painful to paddlings.

Monday

Spending day drying out connections and parts. Some other repairs . . . .

Wonder if you hear any of Clete Roberts reports on our progress. He is radio commentator for L.A. station K.F.W.H. He sends his recorded commentaries back by short wave and understand many other stations are carrying his program on us. We have also with us reporters for Los Angeles Times, L. S. Mirror, Popular Science, Argosy, Fortnight, and Life. Life is being covered by Navy publicity man.



With the destroyer 'Ozborne' bringing up the rear, the 'Norton Sound' plows through the South Pacific while Viking men work on the rocket. (U. S. Navy photo)

OPERATION REACH . . (Cont'd)

Laundry is awful hard on stuff. My socks and underwear are taking beating. Both my red shorts are minus seats now. Had saved one pair for yesterday fueling operation for photography reasons and when I took them off there was no seat in them. Those pictures should go over BIG.

Tuesday

Another delay . . . .
My bunk is top one of tier of 3 and right under a hatch which is open to deck in this warm weather. Well, as I said I was lying down with just my shorts on and looking up to deck with almost closed eyes when I saw Hank up there. He looked at me and a grin came over him just like Warren when an idea hits him. He came back in a second with a wet mop which he splashed on my bare stomach. I vaulted out of bunk to floor 6 foot below. No damage except dirty stomach.

Wednesday

Boys still working on controls and are not much encouraged. They worked all last nite. We sailed in close to Jarvis Island but no one was able to take off to go ashore. Jarvis is just north of the equator, is 1.9 miles long and 1 mile wide. It has no vegetation but millions of birds. There is school of tuna feeding near by. There is a lighthouse (unmanned now) and radio station there. It is American owned.

We have had several man overboard drills. A dummy is thrown overboard and life boat is sent out after him. This is a precarious operation and is not always accomplished rapidly so I am going to stay aboard.

Thursday

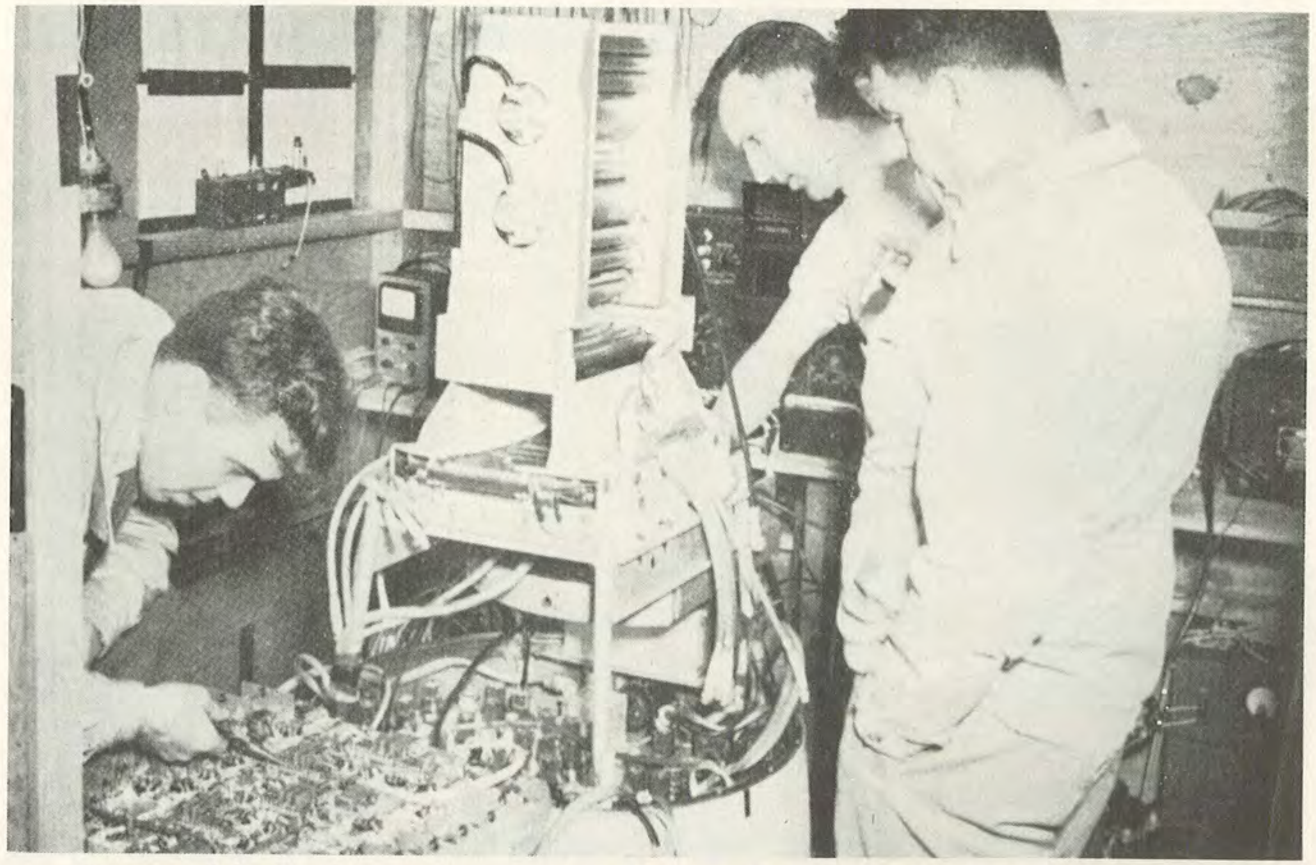
Everyone has their fingers crossed as preparations for firing proceed. It is 1100 now and I am waiting for my duty. Firing time is not set as yet . . . .
O.K. WE DID IT. I got the word to put in H2O2 which went in fast and thereafter X-time proceeded on schedule with no holds right down to FIRE. This is very good and very unusual.

It was a beautiful flight with max. alt. of 106.4 miles. We were carrying 900# of instruments as against max. designed 500 so everyone is very happy and very tired.

Initiations proceedings started at supper. Crazy uniforms on many of us lowly Polywogs. Barr was made up as a Viking 5". The Air Force observer, Colonel, had a tremendous hat with propeller on front. I am charged with impersonating a physicist and with trying to make "Life" cover by wearing violent colored shorts.

May 12

Davy Jones came aboard this morning and welcomed the good ship Norton Sound into the realm of King Neptune. King Neptune is to come aboard at 12:30 and the real fun commences. A dunking pool is set up with the barbers chair on edge around so it will tip over backwards into



The men of the instrumentation group work on the cosmic ray equipment which will go into the nose of Viking #4 on the 'Norton Sound' (U. S. Navy photo)

King Neptune holds court aboard the 'Norton Sound' to initiate the lowly rocket men polywogs into the exhaulted ranks of Shellbacks. (U. S. Navy photo)

pool. The Shellbacks all have clubs made of canvas tubes stuffed with rags and soaked in salt water.
Well, I got called up on the Watch. Had to put on divers shoes, weight 20# each and pace the deck for half an hour. I also had to wear a pile-lined long parka coat, to keep warm, here just off the equator. I was instructed to keep moving or else. Well, I did all right until I got interested in some flying fish, schools of them scared up by the ship—pretty little fish—and stopped for a while. I was promptly made to run for one minute and that is no snap with 20# shoes and a rolling deck.
That stretch was over and I got to thinking this initiation was a snap and not near so tough as I'd heard—just good clean fun. We had lunch then, fried shrimp, and I felt even better—Then the fun began!
We lined up on deck and went thru the proceedings in front of King Neptune and his associates. We were pummeled all the way and my bottom is a mass of welts and bruises. We were tried by Royal Court. Kissed the Royal Baby's belly smeared with grease. We were squirted with yellow dye and put on electric table. We were shocked many times and a quinine solution was squirted in our mouth and then we climbed up to Royal Barber's Chair. All this includes constant swatting. The Barber made like he was cutting civilians' hair but didn't. The sailors really got chopped up terribly.

Then the chair tipped back into the big pool and crew kept ducking you until finally you were pushed out onto the deck, given another electric shock and told to crawl the rest of the way, about 75 feet, between double row of shellbacks with shilahahs. Well the civilians took an awful beating but the sailors got worse. Many hurt and went to ship hospital.
Anyway I'm a *shellback* now and am going to hang onto that card you bet.
At night I went out on the fantail to watch the phosphorescence. This is caused by a small marine animal which clusters and phosphoresces when disturbed as by ships' propellers. It looks like many green balls of fire in the water, some big, some small.
The Southern Cross is getting low in the southern sky, Big Dipper is plain but North Star was not visible last night as yet. This may have been partly due to clouds on the horizon. We went thru a storm and rough water all night. Still little rough.

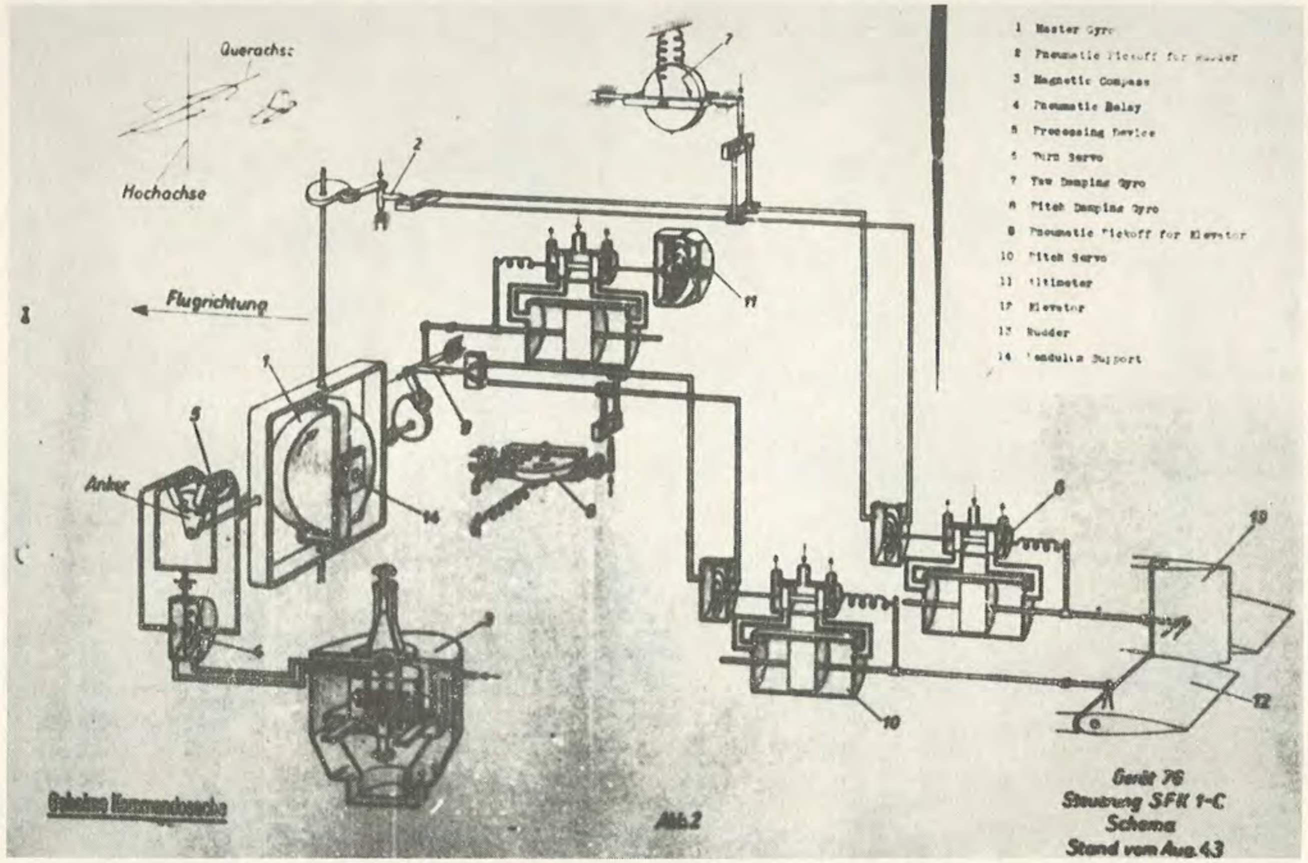
Sat. May 13

Everyone taking it easy today. Other night I got roped into a card game, bridge, partner Milt Rosen. After several hands, I discovered we were playing contract which I know nothing about. After I opened a bid with 4 no trump Milt says, "Think I better give him a few pointers on bidding." In any case I had good hands and we beat by big margin.

Sunday

Happy Mother's Day.
Taking it easy today. Planning on what to do at Hawaii. We will not dock til late in aft tomorrow as they are going thru some gunnery exercises . . . .
See you about 28 May . . . .

CONTROL SYSTEMS



for German Guided Missiles—

excerpted from Technical Report No. 237-45
U. S. Naval Technical Liaison Mission
in Europe
1945

A. GENERAL

1. *Introduction.* The control systems for German guided missiles can be conveniently broken down into the following classifications:

- (a) Stabilization Control
  - (1) Gyro systems
  - (2) Servo mechanisms
  - (3) Air control surfaces
- (b) Steering Control
- (c) Homing systems
- (d) Miscellaneous systems
  - (1) Signal systems
  - (2) Telemetering systems

The above classifications should not be considered as mutually exclusive, since servo mechanisms and control surfaces are also associated with steering and homing control. Telemetering is not a control system at all, but since it ties in very definitely with control systems, it is treated in this section.

This report is not an attempt to give a detailed description of each German guided missile control device, but is rather a broad survey of the entire field of control systems in use or in the development stage. In addition, an effort has been made to show the various devices. Detailed descriptions of the various control and homing systems will be given in the following technical reports published by the U. S. Naval Technical Mission in Europe:

No. 158-45. Electronics as Applied to German Guided Missiles.
No. 109-45. German Infra-Red Equipment in the Kiel Area.
No. 127-45. German Infra-Red Devices and Associated Investigation.
No. 201-45. Acoustic Steering Control for the X-4 Missile—"Dogge."
No. 273-45. German Infra-Red Homing Device "Emden".
No. 274-45. German Infra-Red Homing Device "Karussell".

2. *Stabilization Control.*

(a) *General.* In the field of stabilization control of guided missiles, a division into three convenient categories is possible, i.e., gyro systems, servo mechanisms, and aerodynamic control surfaces. Certain of the German guided missiles were gyro-stabilized in only one or two axes, while others were spin stabilized; i.e., the missile was stabilized in the line of flight by being allowed to rotate around its longitudinal axis. This method of spin stabilization was used primarily on missiles such as X-4 having four wings. Rotation was effected by means of trim tabs on the trailing edges of the wings. This method balances out inaccuracies in manufacture. Tolerances which formerly had to be held to 0.1% can now be allowed to become 1%. This in turn paves the way for mass production of guided missiles and allows the use of cheaper materials.

(b) *Gyro systems.* Gyro systems for German guided missiles range all the way from the elementary single gyro without damping "flip-flop" system used in "Hecht" to the complicated three gyro electronically damped system used in the "Wasserfall". Some rotating missiles, such as X-4, use gyro commutator systems only as a means of translating steering control from Cartesian coordinates into the proper pulses to be fed to the servos operating the control surfaces.

In general, it can be said that free gyros were being used in most of the German guided missiles. At the same time, German scientists realized the advantages to be gained by using rate gyros and a considerable amount of research effort was being expended in the development of this type of gyro. There was also a tendency toward using a second gyro for damping rather than relying on mechanical or electrical damping.

The following can be considered as the stabilizing systems most widely used in German guided missiles:

(1) Flip-flop type using one gyro without damping to give roll stabilization. Used in "Hecht". Most elementary type, but gives excessive roll.

(2) Flip-flop type using one gyro with mechanical damping to give roll stabilization. Used in Feuerlilie 25 and gave satisfactory results.

(3) Flip-flop type using single gimbal-mounted gyro with electrical positioning and damping for roll stabilization. Used in Hs 117, Hs 293, Hs 298 and Enzian. Very satisfactory especially with spoiler aerodynamic control.

(4) Flip-flop type using two gyros with rate for damping. Used in Fritz-X. Satisfactory when used with spoiler control.

(5) Fixed azimuth steering using two gyros, with rate gyro for damping. Used in BV 246.

(6) Variable azimuth and variable attitude steering with master gyro and yaw and pitch damping gyros. Used in V-1.

(7) Program attitude control with fixed azimuth steering and roll stabilization. Uses two gyros with electronic and feedback damping. Used in A-4.

(8) Attitude control in three axes by means of three free gyros and electronic damping. Used in Wasserfall.

(9) Stability along axis of flight obtained by allowing missile to rotate about its longitudinal axis at a rate of one to two revolutions per second. Space stabilized gyro commutator used to translate steering control signals from Cartesian coordinates to the proper pulses to be fed to the servos. Used in X-4, X-7 and Rheintochter 3.

The leading manufacturer of inexpensive gyros for guided missiles was Firma Th. Horn, located in Plauen and Leipzing. Horn gyros were used in both the Renschel and the X series of missiles. Askania built the more precise gyros required for V-1 and A-4, while Albert Patin was the leading manufacturer of automatic pilot gyro systems.

(c) *Servo Systems.* In the field of servo-mechanisms the Germans showed considerable originality and ingenuity. Although they began by using hydraulic and pneumatic servo-mechanisms, they soon realized that better and more reliable operation could be obtained from electric servos.

The inherent disadvantage of hydraulic and pneumatic systems is that they are non-linear in response in the vicinity of the zero position. This of course leads to sluggish and inaccurate transmission of information from the steering and stabilization gear to the control surfaces. For this reason, there is a consistent trend toward the use of electrical servo systems and in October 1944, the servo systems in use on German guided missiles were as follows:

70% Electrical
16% Hydraulic
14% Pneumatic

The electrical servo systems used by the Germans were all quite similar because the Strasburg-Kehl remote radio control which was almost universally used required a system which would respond to square wave modulation frequencies of 5-10 cycles per second. The overall mechanical and electrical system was always designed so that its natural period of vibration was of the order of 5-10 cycles per second. In this way, the entire system was always vibrating at or near its natural resonance frequency and proportional control was exercised by the variation in the length of time the control surfaces were in one extreme position or the other. In order to obtain this type of proportional on-off control, relays and electromagnets were quite generally used in the smaller missiles. In the larger missiles, transformers and drive motors were used in order to meet the larger power requirements.

The hydraulic and motor drive servo systems were usually built by Askania or Siemens, while the electromagnetic types were designed and assembled by the companies manufacturing the missiles, although of course Siemens or AEG relays and parts were generally employed.

(d) *Control Surfaces.* One of the principal reasons the Germans were as successful as they were in the perfection of guided missiles of Hs 293 and Fritz X class, was

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CONTROL SYSTEMS . . . (Cont'd)

because they were willing to experiment with new types of aerodynamic control in order to steer these devices. Dr. Max Kramer early recognized the advantages of spoiler steering, and used it successfully in the Fritz-X. Later he further improved the spoiler method by introducing the rake spoiler as used in the X-3, X-4, and X-7. Likewise, Dr. Wagner introduced the trailing edge spoiler in his design of the later Henschel series missiles.

Control of a missile through the air by the trailing edge spoiler system is gained by having hinged spoilers mounted on the trailing edge of the aerodynamic surface and vibrating perpendicular to the center line of the wing section at about 10 cycles per second. Control is effected by the variation of duration of stay at each limit of travel. When no control is to be applied, the time durations in each limit are equal. When a turn is desired the duration in one limit is lengthened, while the time in the other limit is correspondingly reduced. In this way proportional control is achieved. The maximum dimensions for such spoilers was determined as 2.2% of the chord at the section where the spoiler operates. In other words, if the wing is tapered the spoiler will also be tapered or have a maximum flat plate dimension equal to 2.2% of the smallest chord section which will be covered by the spoiler.

Models using this type of aerodynamic control were first tested in a small wind tunnel at DVL and then later in a larger tunnel at Gottingen. The results showed that this type of control gave small and constant hinge moments over a large range of subsonic Mach numbers which is very advantageous for the use intended. This system also gave much less drag when operated and thus reduced the yaw moment. From the operational standpoint it was also found that this system reduced the time lag in the operation of the controls from about 0.5 seconds to 0.2 seconds.

When tests were completed in August 1942, these controls were incorporated in the Hs 293 A-2, but were never used operationally as by the time this bomb had been brought to the series stage, the German Air Force had no aircraft left for anti-shipping operations.

This type of aerodynamic control will be referred to as "spoiler control" in the individual reports on the Henschel series of missiles.

In the A-4 and Wasserfall, carbon fins in the jet stream were utilized for control purposes at low speeds in addition to the tail fin control surfaces. In Rheintochter the control surfaces were mounted in the nose of the missile because it was felt by certain German aerodynamicists that this was the best system for guiding supersonic flak rockets. In Enzian, ailerons were used not only for left-right steering, but also for elevation control.

In general, it can be said that most of the radical changes in aerodynamic control were proposed by Dr. Kramer, Dr. Wagner, and various members of the Peenemunde aerodynamic organization, which later became known as EMW (Electromechanische Werke). Wind tunnel measurements in connection with these design changes were made at LFA, Braunschweig, and at the University of Goettingen.

3. *Steering Control.*

(a) *General.* Most of the German technique of guiding missiles was based on the Strassburg-Kehl system as developed jointly by Telefunken and Strassfurt Rundfunk. This system depended on optical means for keeping the missile in line with the target and used 50 megacycle radio remote control modulated with four audio frequencies. The Strassburg-Kehl system was used extensively in the Hs 293 and Fritz-X operations and was the most reliable system the Germans had.

Coordination of the German guided missile remote control program was under the direction of Dr. Theo Sturm of the Stassfurt Rundfunk GMBH. He was appointed by the Speer Ministry and had charge of coordinating all research and development work on remote steering systems. Meanwhile a great deal of theoretical work was being done on this subject by Prof. Fischl of DSF (Deutsche Forschungsanstalt fur Segelflug) but there is little evidence to indicate that the results of these studies were being used by the industrial groups who were actually developing the systems. Possibly the reason for this was the lack of interchange of information, caused by bombing of transportation and communication systems.

(b) *Wire Control.* When it began to appear that the Strassburg-Kehl system might be subjected to enemy jamming, a 24 CM radio control system, having the code name "Kogge" was developed by Telefunken and wire control systems began to make their appearance. Of the wire systems, the "Dortmund-Duisberg" system used a modulated carrier, while the "Duren-Detmold" was a DC system, based on polarity and marginal relay operation. Another factor which contributed to the development of wire control systems was the shortage of vacuum tubes in Germany toward the end of 1944. The situation was so acute that the production of all guided missiles requiring more than two vacuum tubes was ordered to be stopped.

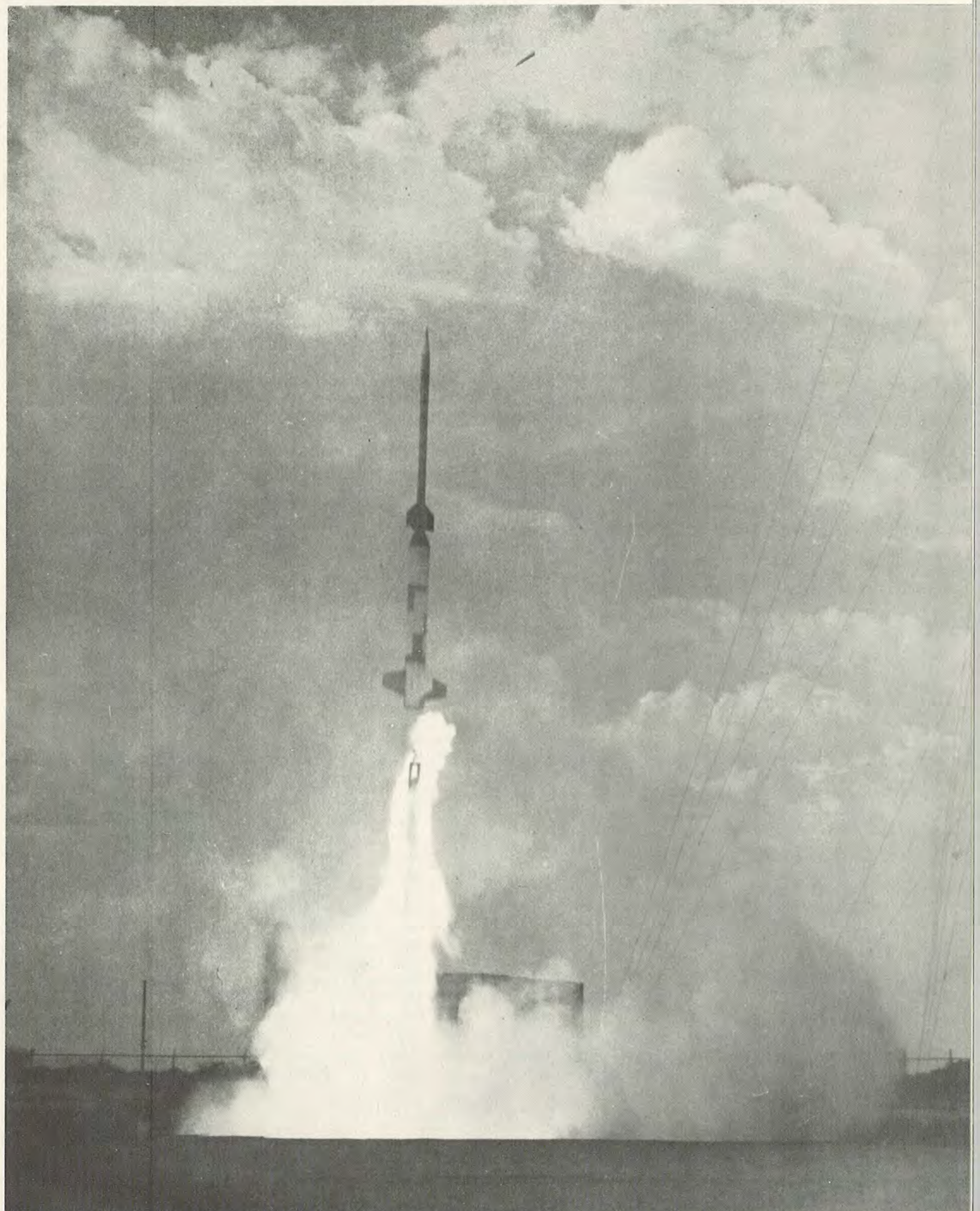
One method of wire control is effected in the following manner. A coil of very fine steel wire (0.22 mm in dia.) is mounted on each wing tip of the missile and a mating coil is mounted on the parent aircraft. During flight of the missile the wire is pulled from the inside of the coil and paid out by the missile moving away from the parent aircraft and the natural forces of wind resistance on the wire. The average coil of wire is about 3½ to 4½ inches in outside diameter and about 10 to 12 inches long. Much larger coils of wire had been used experimentally paying out a total length of wire from both coils (missile and mother aircraft) up to 30 km with electrical contact being kept at all times. The wire is not stretched tightly between the missile and plane but actually moves very little relative to the ground after leaving the spool in either the missile of the mother aircraft. The wires are covered with varnish base insulation so that if the two wires (one from each wing tip) should become crossed in mid air an electrical short would not result.

This type of control was patented by the Siemens Co. in 1917, and during World War I the Zeppelin company tried unsuccessfully to build a device using this idea. Prof. Wagner and Dr. Kramer again started to develop this method of control beginning in 1940. Kramer used a 3 wire cable with a single coil while Wagner used 2 wires and 4 coils (2 coils in both the missile and the carrier aircraft.) Prof. Wagner and his group had studied the theory of unreeling of wire and found that the stiffness of the wire and the gravity forces are negligible. The wire will always come out in loops in such a shape that the centrifugal forces and the wire tension are balanced. It was established that the wire must be permitted to apply forces

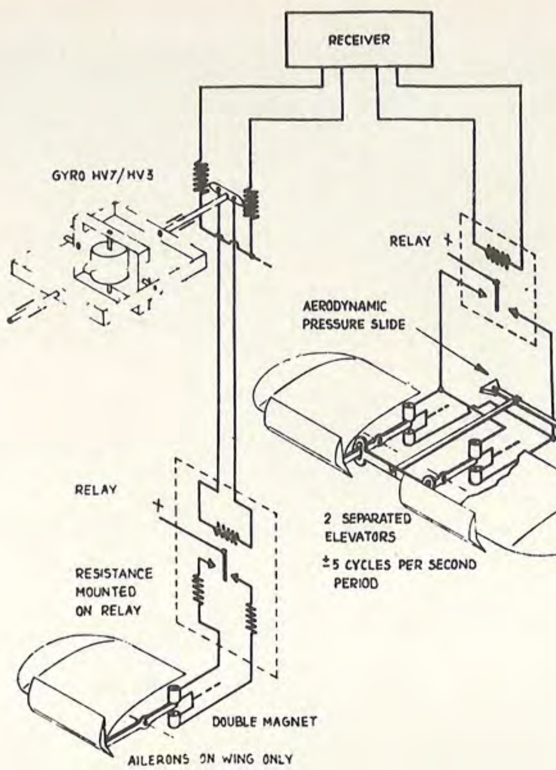
(page 16, please)

i. g. y. special . . .

Nike-Cajun goes aloft for geophysics (U. S. Army photo)



CONTROL SYSTEMS . . . (Cont'd)



AERODYNAMIC "SPOILER TYPE" CONTROL
DIAGRAM FOR Hs. 293
TYPE 1

The proportional control system used on the Henschel Hs. 293. Control of the missile was affected by limiting the stay of the control spoilers at one end of their swing as they oscillated. (Drawing from original documents.)

to the missile while unreeling. An arrangement of wire in a conical reel permitted a speed through an exit nozzle up to 170 m/sec. Dr. Kramer, who was also working on guided missiles, later prepared a coil of single strand wire on the outside of a spindle and allowed the wire to run against the guide. The tension in the wire was 3 times greater during the unreeling process than for the Wagner arrangement, but speeds through the exit nozzle up to 240 m/sec. could be tolerated. However, at these higher speeds trouble was encountered with the varnish insulation being scraped off the wire and electrical difficulties were consequently encountered. In both cases the ends of the coil caused great difficulty and much testing and care in the construction was needed to complete a successful development.

This system presents a great advantage in that the signals sent over the wire could not be jammed. It did, however, add another problem to make the overall missile more complicated, limiting the missile in range to the length of the wire.

The German engineers considered this an excellent method of control but did not care to use it over home territory because the expended wire caused considerable trouble with communications and resulted in injuries to personnel and livestock.

(c) *Flak Rocket Control.* For the control of flak rockets, the problem of steering becomes considerably more complex, because the target is moving so much faster and can move in three axes. The simplest system developed was the "Burgund" which uses optical tracking and the "Strassburg-Kehl" control system. However, for poor visibility conditions, a radar version had to be designed having the code name "Elsass". The decimeter version of the Elsass was to be known as "Brabant".

In addition, work was being done on a television design of Elsass known as "Elsass-Lothoringen" and a radar beam guiding system known as "Papagei". The Papagei system depended upon a conical scanning ground radar system for beam guiding the missile. If the missile were right on the beam, no modulation would be apparent in the output of a receiver located in the missile. On the other hand, if the missile were not on the beam, the amplitude of the modulation would be a measure of the deviation from the beam. The phase of the modulation would provide a measure of the deviation angle. The Papagei system had been under development under various urgency priorities for two or three years, but in 1945 there is no evidence to indicate that the project was near completion.

Early in the A-4 program, it became evident that the azimuth accuracy of the A-4 would have to be increased and for this purpose a radio beam system, similar to the ordinary aircraft navigation beam system, was used for azimuth guiding of the A-4. This system was known as the "Leitstrahl" (guiding beam) and also had the code name "Victoria". For more accurate guiding of the A-9, a radar guiding beam system was under development known as the "Freya-Erstling". This system was to be based on either phase difference measurements or a lobe comparison method. Development work was being carried on at Firma Gema, which built the Freya radar and was under the supervision of the EMW (Electromachinische Werke) organization.

4. *Homing Devices.*

(a) *General.* In the middle of 1943, when the Germans were beginning to suffer extensive damage from bombing raids, they came to the belated realization that some form of defense must be developed immediately. Therefore they decided to concentrate on the development of large flak rockets which were to be equipped with homing devices and proximity fuses. For the latter development, a special commission for the development of homing devices and proximity fuses was appointed, having as its head Prof. Gladenbeck of AEG. He had as his assistants Dr. Runge, of Telefunken and DVL; Dr. Hilgers, of AEG, who was in charge of steering and stabilization control; Dr. Benecke, of Telefunken, in charge of acoustic devices; Dr. Dziewior, in charge of electronic devices; and Dr. Riedel of Rheinmetall-Borsig, in charge of influence proximity fuses.

By June 1944, several homing device projects were under way which were presumably being developed for specific flak rockets, such as the Wasserfall, Rheintochter, Schmetterling, and Enzian. Most of the time-consuming development work had been completed and all that remained was the actual flight testing. The latter could not be carried out because of difficulties due to bombing of transportation, communication and testing facilities.

In March 1945, plans were under way to concentrate the entire German guided missile industry in the vicinity of Nordhausen.

The engineers working on homing device projects were to occupy a certain part of the tunnels at Woffleben and the following were selected as the projects upon which the entire research effort should be concentrated:

(1) Infra-red
Emden, AEG, Dr. Hilgers for Hs 117
Madrid, Kepka for Hs 117, Wasserfall
Hamburg, ELAC, Dr. Kutscher for Hs 117
Karussell, Dr. Weiss, EW for X-4

(2) Acoustic:
Dogge, Dr. Benecke, Telefunken, for X-4
Luchs, Dr. Schoeps, RPF for X-4

(3) Electromagnetic (Radio)
Max, Blaupunkt, Dr. Gullner for Wasserfall
Windhund, Dr. Gross, RPF for Hs 117
Moritz, Dr. Pressler, RPF for Hs 117

(4) Television:
Sprotte, Dr. Moeller, Fernsch for Hs 117

As can be seen from the above list only a few of the developments which headed the list in June 1944 retained their high priority ratings. Quite a few of the leading projects had been assigned a lower priority and in their stead, several new developments had come to the fore. In general, it can be said that the infra-red devices were nearest to a production status and the radio projects were the least advanced. Of the acoustic devices, Dogge was nearest to the production stage, but little is known concerning actual flight performance data.

(c) In addition to the homing device projects which have been previously mentioned and which were considered by the Germans to be the more important ones, the following projects are also worthy of note:

(1) Infra-red:
Krebs—Dr. Orthuber, AEG
Widder—Dr. Hilgers, AEG
Netzhaut—Dr. Orthuber, AEG
Doppellinse—Dr. Orthuber, AEG
Armin II—Dr. Kutscher, ELAC

(2) Acoustic:
Pudel—Dr. Kramer, Ruhrstahl A. G.
Vesuv—Dr. Hecht, ELAC
Bulldogge—Dr. Tragge, RPF
Baldrian—Dr. Benecke, Telefunken
Marder—Dipl. Ing. Muck

(3) Electromagnetic (Radio):
Dackel—Dr. Oettingen, RPF
Blaulicht—Dr. Heymann, RPF
Schnabel—Telefunken

Thus it can be seen that there were at least 25 well-defined homing device projects in the infra-red, acoustic, electromagnetic and television fields on which German scientific development efforts was being expended in the period immediately preceding the cessation of hostilities.

5. *Miscellaneous Systems.*

(a) *Signal Systems.* In addition to steering control signals, it is sometimes desired to transmit other types of signals or commands from the control point to the guided missile, such as a detonation signal or a signal to cut off the propulsion unit. For instance, in radar ground control of flak rockets, it might be desirable to detonate the missile from the control point when the radar range of the target and the range of the missile coincide. Therefore, Stassfurt Rundfunk G.m.b.H. developed a system for transmitting a "fifth command" over the Strassburg-Kehl system while still using only four modulation frequencies. This system is based on a principle similar to the one on which the phantom circuit in telephony operates.

In the control of A-4, the time at which the rocket motor was cut off was quite critical and various methods were used in order to effect cutoff at exactly the correct instant. Unquestionably the most accurate system was one in which the velocity of the A-4 was measured by a radio system making use of the Doppler effect. However, there were too many failures with this system and therefore the integrating accelerometer was employed. The first of these was the "Iller" using a rotating gyro as the integrating device. An improvement on this was the "Isar", an electrolytic device utilizing the charging of an electrolytic cell as the integrating unit. The latter gave better accuracy than the "Iller", but not as good as the Doppler effect system.

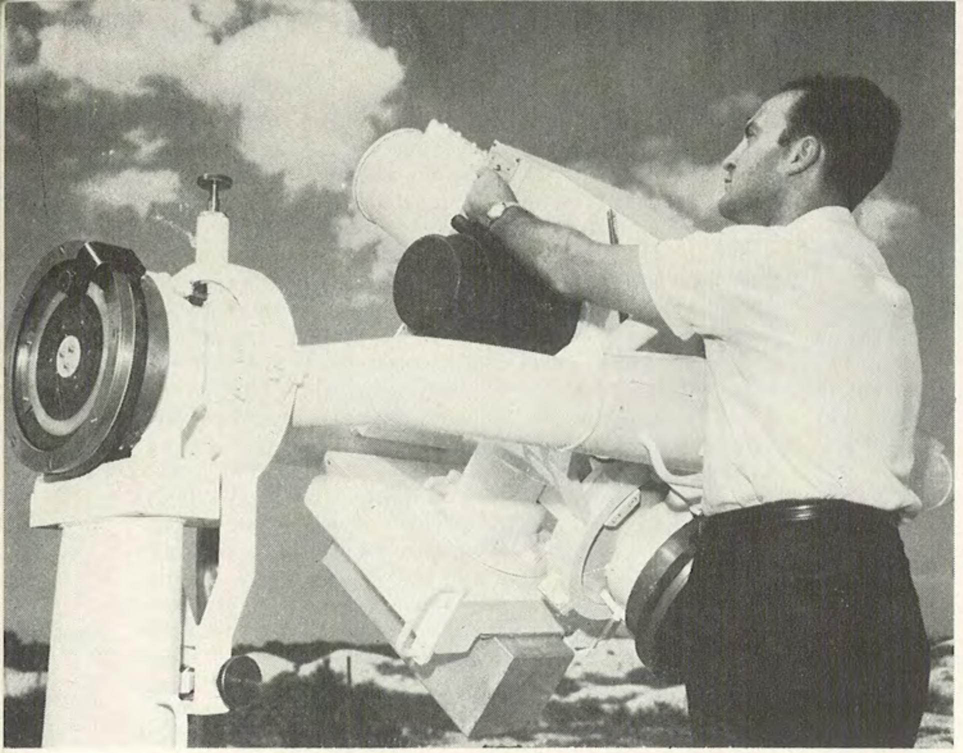
(b) *Telemetering systems.* In order to determine operating rocket motor temperatures, air pressures, velocities, etc., encountered when guided missiles are in flight, the Germans employed telemetering to its fullest extent. This was especially true in the case of the A-4, but they also were using telemetering in their research work on smaller missiles.

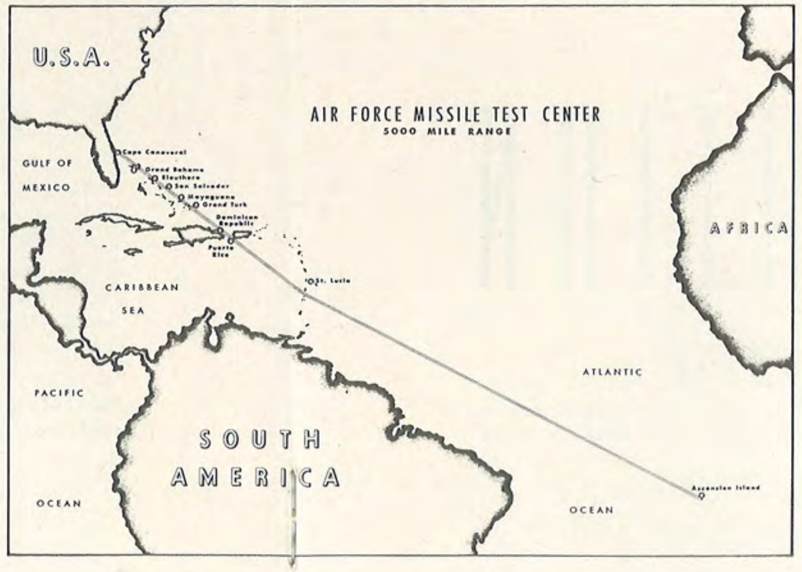
The code name for the telemetering system used with A-4 was "Messina" and there were four variations. Messina I used an RF carrier with 5 continuous AM audio frequency channels and 5 black-white channels to indicate rocket motor cutoff, temperature rise above a certain point, etc. Messina Ib was quite similar except that it used frequency modulation of the audio channels as a measurement basis. The Messina Ic was a projected system using 10 microsecond pulses and thus giving higher peak power and greater range for the same weight of equipment. In addition, there was a telemetering device, Messine II, using phase displacement as the measuring device. This system was quite bulky and heavy and therefore never reached the production stage.

Another telemetering system developed by the Forschungsanstalt Graf Zeppelin at Stuttgart-Ruit was called the "Stuttgart" and was to be used for telemetering the Feuerlilie F-55. It employed frequency modulation as a basis for measurement.

The following Technical Reports by the U.S. Naval Technical Mission in Europe give more detailed descriptions of certain of the signal and telemetering systems:

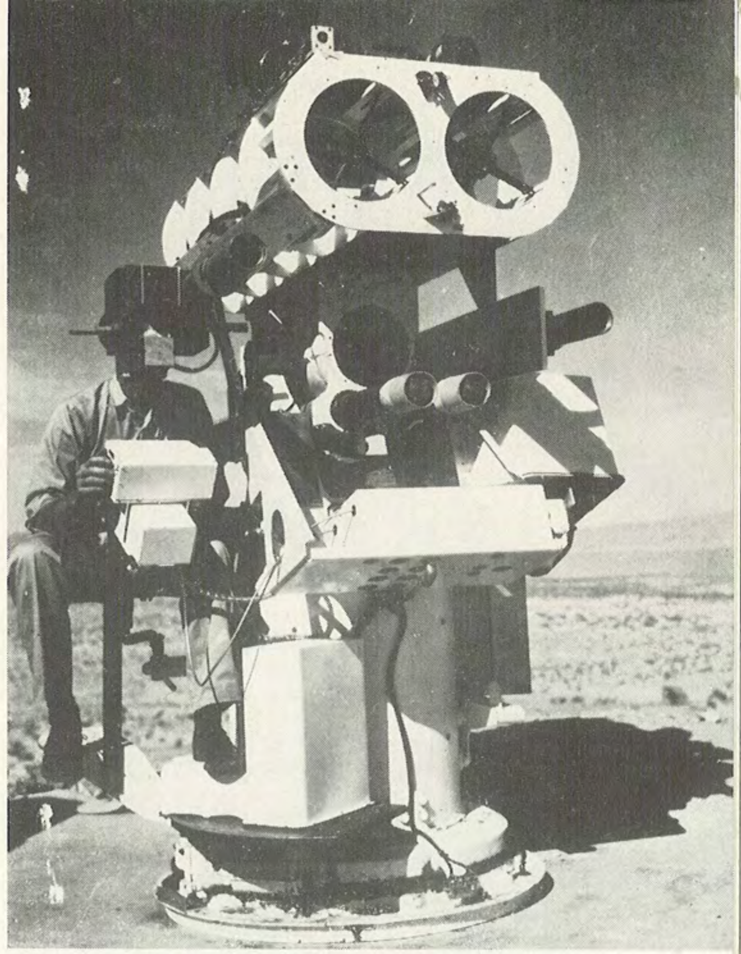
No. 180-45. Structural Flight Test Equipment Developed or Used by the Peenemunde Group.
No. 285-45. A Radio Telemetering Receiver (Messina II).


Bowen CZR-1 camera ready to provide position data.



Missiles from Cape Canaveral

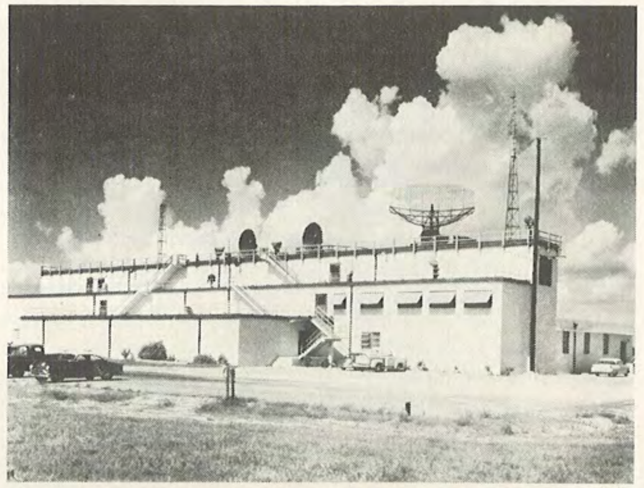
Operations at the Air Force Missile Test Center


Sandia Tracking Telescope with 3 optical systems and acquisition aid.

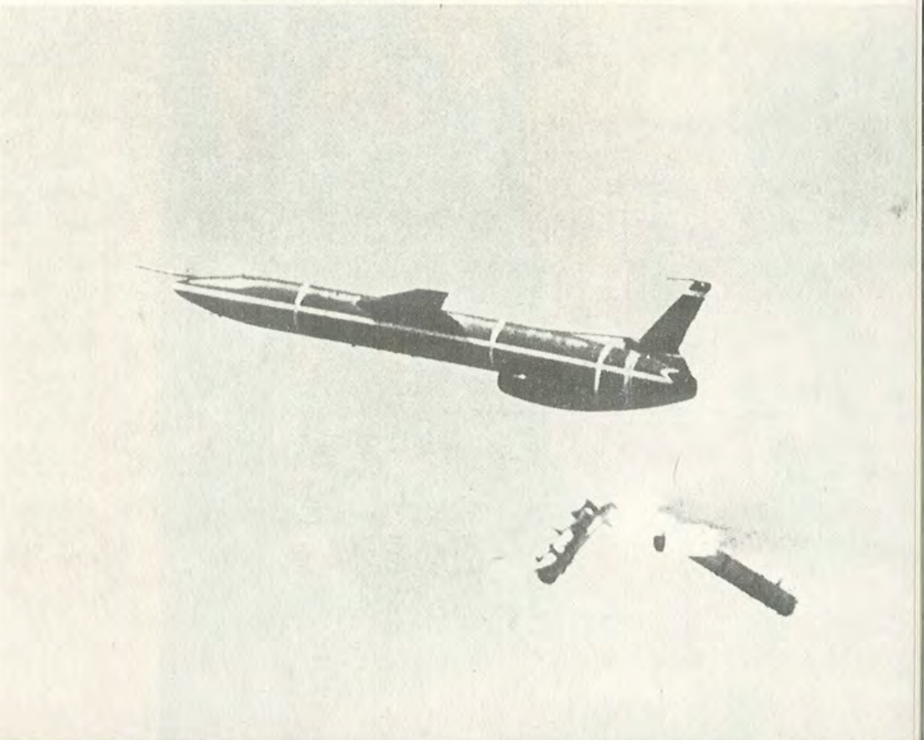
(U. S. Air Force photographs courtesy office of Information Services, AFMTC.)


Tension and relaxation, — the operations room of Central Control.

Matador moves out—


Nerve center — Central Control Building

Shark seeks its intercontinental target—



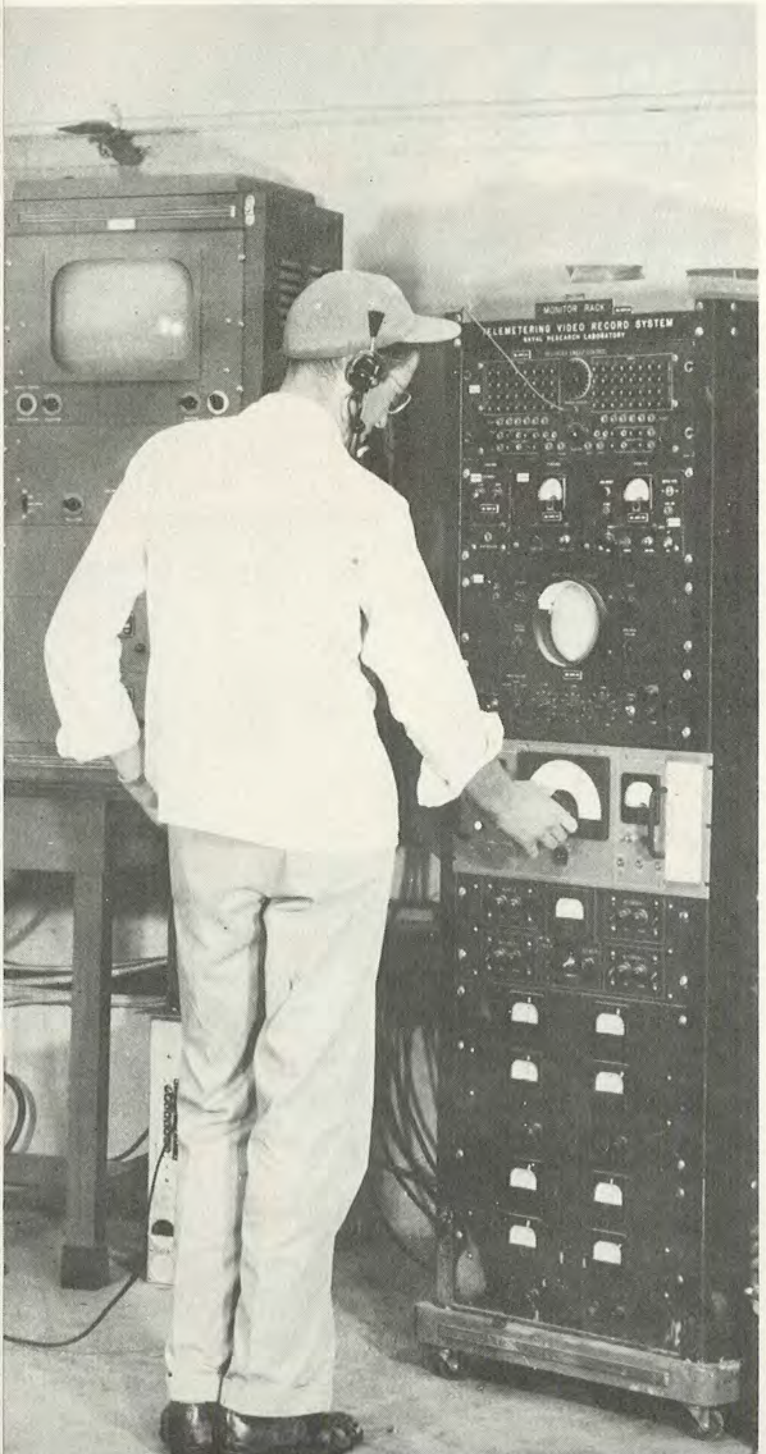
SYSTEMS EVALUATION

Telemetry and Drone Control

by

W. H. FICKES

WHITE SANDS SIGNAL CORPS AGENCY



I. INTRODUCTION

The testing of guided missiles and instrumentation systems within the White Sands Proving Ground-Holloman Air Development Center and Ft. Bliss Areas in conjunction with other military activities in the New Mexico-West Texas Area has resulted in an unparalleled utilization of almost all of the entire usable radio frequency spectrum. The failure of "frequency users" to realize that the frequency spectrum approaches a practical limit has resulted in the development of some equipment having inefficient spectrum utilization and poor interference susceptibility characteristics. Consequently, this has led to stringent frequency coordination of the activities of all agencies in the area involved. The three services, Army, Navy, and Air Force, being cognizant of this problem established the Office of the Area Frequency Coordinator (AFC) to coordinate military frequency usage within the state of New Mexico and other United States territory within a radius of 150 miles of White Sands Proving Ground (WSPG). The AFC is authorized to act locally to eliminate or minimize interference problems by several methods, including use of technical adjustment to equipment which may initiate or receive interference as a result of other activities in the area.

Since there are a large number of transmitters and receivers in the WSPG Integrated Range Area, it is essential that complete information relative to the technical characteristics of the equipment be available to the AFC, so that action can be taken to eliminate or minimize interference problems. Generally, the available information is quite limited and completely inadequate to be used as a basis for valid decisions. This inadequacy is magnified many times when one considers that the cost of certain missiles is of the order of several hundred thousand dollars.

To insure interference-free conditions to all agencies concerned, it is frequently necessary to conduct tests or a system evaluation to determine precise requirements and limitations of individual systems. This evaluation obtains pertinent data relative to necessary system bandwidth which includes: the overall receiver bandwidth, the interference characteristics of the receiver, (the electromagnetic environment in which the receiver must operate) spectrum analysis and spurious radiations of the associated transmitter, frequency stabilities, etc. all of which must be considered to arrive at a specific "clear channel" requirement. Another criteria, not normally considered by a frequency "user", which is becoming more and more significant, is that of spectrum conservation. That is, can the system bandwidth be narrowed and if so what recommendations or modifications can be adhered to without adversely affecting the system's function? Some test results and procedures, associated with system evaluation of "telemetry" and "drone control", are given in the following text.

II. GENERAL CONSIDERATIONS

Frequency provisions must be determined which will assure satisfactory operation of a particular equipment item or an entire system under development.

Conditions must be determined for satisfactory co-channel or adjacent channel operation.

Standards must be formulated as a basis for establishing appropriate frequency assignments.

Analysis of specific interference problems or potential interference problems must be performed.

Data must be secured to form the basis for modification of equipment to make it less susceptible to interference or to reduce its capacity to cause interference. This data, based upon laboratory or field measurement, must also be utilized to determine appropriate actions for radio silence, such as sector blanking, synchronization, etc.

III. SPECIFIC CONSIDERATIONS

The effects of temperature, pressure, humidity, acceleration, vibration, shock, operating time, and supply voltage must be determined relative to the following parameters:

Transmitters:

Frequency, power, spectrum analysis, spurious emissions, modulation sensitivity, dynamic response, VSWR and "fidelity".

Receivers:

Sensitivity, selectivity, frequency stability, "fidelity", isolation of intermediate frequency, intermediate frequency selectivity, intermediate frequency sensitivity, intermediate frequency stability, image rejection, spurious radiation, VSWR, dynamic responses, automatic gain control, automatic frequency control, interference characteristics and noise figure.

Another significant, and often the controlling factor, is that of the OPERATOR. In many cases, this variable must also be evaluated relative to the aforementioned parameters.

IV. TELEMETRY[1]

General

In general, telemetry is the process by which a particular item of information is made available at a point remote from the information's origin. Specifically, and in the case at White Sands Proving Ground, it shall be defined as a system utilizing an electrical or electromechanical device (transducer) for measuring a quantity, a modulator (encoder), a radio transmitter for transmitting the result in electromagnetic energy (215-235 MCS), a receiver capable of receiving the energy and a decoder giving an indication of the original quantity measured. Users are striving for an overall accuracy of less than one percent and in some specialized cases accuracies to one tenth of a percent have been achieved. Short descriptions of the three major types of telemetry utilized at White Sands Proving Ground are given:

FM/FM (frequency modulated-frequency modulation)

A maximum of 18 subcarriers having a frequency ratio of 1.3:1 are deviated +or−7.5% by the end organs (transducers) in the missile. The upper five subcarriers, however, may be deviated +or−15% if alternate channels are omitted. Deviations generally arise from a voltage information of 0 to 5 volts (the 0 representing a —7.5% deviation and a +5 volts signal representing a +7.5% deviation of the respective subcarrier). These 18 subcarriers are "added" and modulate the RF transmitter with a maximum deviation of 125 KCS. The FM ground receiver has its IF discriminator output injected through appropriate band selection filters, into respective subcarrier discriminators, and the original information is finally recorded photographically, with magnetic tape, or on wire. If some of the subcarrier channels are only telemetering an "off" - "on" condition then commutation can be applied and the effective number of channels can be increased considerably. The general subcarriers in use are listed in APPENDIX I.

PWM/FM OR PDM/FM

(pulse width or duration modulated—frequency modulation)

and PDM/PM

(pulse duration modulated—phase modulation)

PDM/FM

This system usually consists of 28 channels of information (with two synchronizing channels), each respective channel being sampled 30 times per second. A coder converts the input signal into pulses whose width are proportional to the input voltage and whose rise time is limited to 10 microseconds. This modulation is applied to a modulator which shifts the carrier frequency during the "on" time of the pulse, i.e., similar to frequency shift keying.

PDM/PM

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This system is similar to PDM/FM except that modulation is used to phase modulate a crystal controlled oscillator. In this case the actual modulation on the carrier is the differentiated pulse. This system, however, requires an integrator circuit at the receiver to recover the original pulse width information.

PPM/AM

(pulse position modulated—amplitude modulation)

In this system the data is contained in the position of a pulse with respect to a set of reference pulses. Pulse widths of 3.5 microseconds and pulse recurrence frequencies of 300-5000 per second are used.

Specific

Techniques and laboratory methods for the determination of representative telemetry systems' interference susceptibility and spectrum utilization are given below:

Intermodulation Distortion

The possible effects of intermodulation occurring between uniformly spaced radio frequency carriers operating simultaneously within a telemetry band have caused some concern and hence an investigation was performed on two typical telemetry receivers. Previous work in this field indicated that intermodulation is due to a a nonlinear transfer characteristic existing within the system and generally, as in the case of a receiver, results from the nonlinearity of the plate current curve of the first RF amplifier and or other vacuum tubes. Examples of other nonlinear devices are: crystal diodes, poor connections, oxide coatings, etc.

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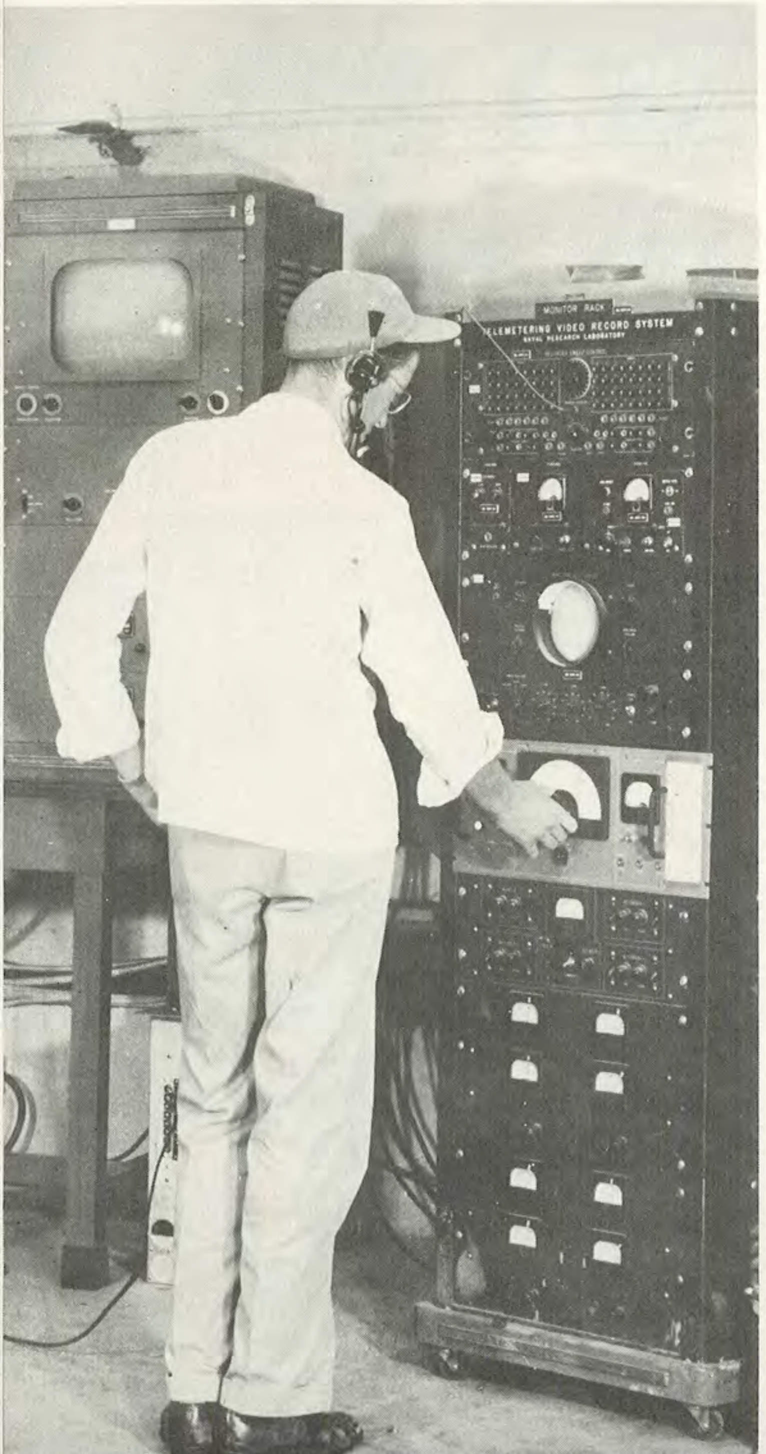

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SYSTEMS EVALUATION . . . (Cont'd)

Since current through any nonlinear device, such as a vacuum tube, is *not* a linear function of input voltage, it must be approximated by a power series—generally a Taylor Series. From the tubes characteristic curve, values at e=0 for output current and all of its derivatives may be computed. Use of the Taylor Series results in:

$$I_b = f(0) + f'(0)\,e + \frac{f''(0)\,e^2}{2!} + \frac{f'''(0)\,e^3}{3!} + \ldots$$

Since the series will normally be convergent for the device considered, values of the derivatives of the transfer characteristics will decrease in magnitude with increasing order. Therefore, higher input voltages will be required to produce observable high order nonlinear effects.

For *second* order nonlinearity, frequencies are seen to be of a general type:

$$A+B=C,\quad A-B=C$$

For *third* order nonlinearity frequencies are seen to be of a general type:

$$A+B+C=D,\quad A+B-C=D,\quad 2A-B=C, \text{ etc.}$$

Example: Assume uniform spacing of channels to be 4.0 MCS.

Let: D=215 MCS
A=219 MCS
B=223 MCS
C=227 MCS
Then if: A+B−C=D′
219+223−227=D′
D′=215 MCS, also=D

For *fifth* order nonlinearity frequencies are seen to be of a general type:

A+B+C−D−E=F
2A+B−C−D=E
A+B+C−2D=E
2A+B−2C=D
3A−B−C=D
3A−2B=C, etc.

As can be seen from above, the *even* order nonlinearity frequencies will not fall into any of the adjacent channels unless frequency allocations are such that the difference of frequencies would be near the IF amplifier frequency. For *odd* order nonlinearity, frequencies will be generated in the neighborhood of one of the originating channels.

Test results confirmed the prediction that interferences could be grouped at operating frequencies. One receiver was found to produce intermodulation distortion when the individual input carrier powers exceeded −35 dbm while the other receiver operated with individual carrier powers up to −25 dbm without producing intermodulation distortion. The relative high power levels, normally would not exist, particularly as in the case of WSPG where the minimum geographical spacing is in excess of three miles. The chart shown in APPENDIX II was compiled to indicate the minimum physical separation between a four channel telemetry system and any common receiver unit. Should the operations be confined to a much smaller area as in ship board operations then cross modulation could, in all probability, result in considerable distortion.

Interference Characteristics (including image rejection, IF isolation, spurious responses, etc.)

Since telemetry systems must, of necessity, utilize low power transmitters which emit relatively wide band signals, companion receivers must be extremely sensitive and possess sufficient bandwidth to receive such transmissions with virtually no introduced or additional distortion. Since the majority of operations are of a "single-shot" nature, the telemetry channel must be completely clear of interference. Thus, quite extensive tests for the obtaining of data and information relative to the interference susceptibility of the telemetry receivers are essential. The general factors which must be considered in regard to receivers and transmittrs are previously outlined in paragraph III.

Representative data on two types of telemetry receivers, are shown in APPENDIX III.

Representative data on a crystal controlled PM Transmitter are shown in APPENDIX IV.

Based upon the data shown in Appendix III and IV, it appears that the limiting factor, of the system is the receiver and particularly the cross modulation distortion parameter. The data of this particular test indicates that, in order to provide distortionless operation (due to cross-modulation) the necessary spacing for a 15 microvolt simulated control signal and a 1500 microvolt potential interference signal channel, spacing of 1.00 MCS for receiver #1 and 0.975 MCS for receiver #2 are required. Therefore two megacycles between transmitting frequencies appears to be a reasonable minimum requirement. The two megacycle spacing is appropriate for systems in which a non-crystal-controlled transmitter is utilized, (normal transmitter frequency drift: 500 KCS) and allows for a 250 KCS emission bandwidth, and a 250 KCS safety factor. If the transmitter had been a crystal-controlled type and the RF and IF bandwidth of the receiver were narrowed somewhat, a *one megacycle spacing* would suffice. This should be a goal of all telemetry users. Utilmately, 500 KC spacing may become an attainable value.

V. DRONE CONTROL

General

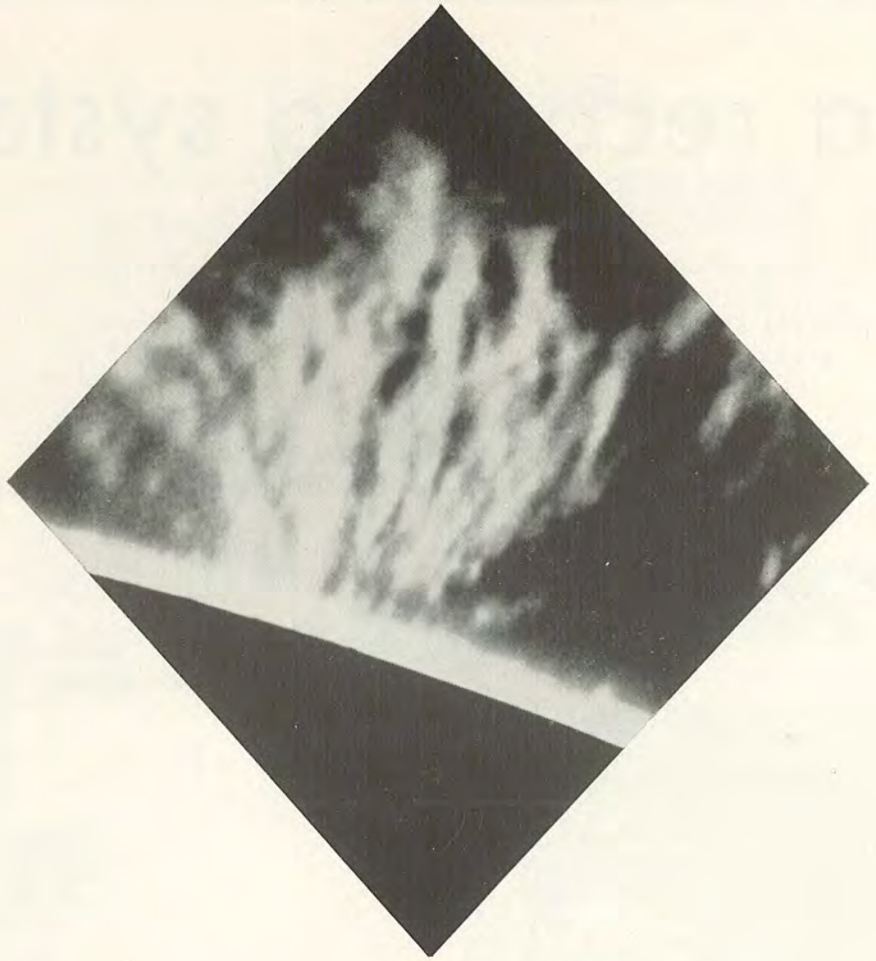
"Drone control" shall be defined here as a remote control system for an aerial target in which a radio link is employed. It may consist merely of a modulator and transmitter at the control station (either land based or airborne) and a receiver and decoder in the target or drone whose activities are being controlled, or it may be a combination of transmitter and receiver at both locations, (as a radar and transponder or beacon.)

Radio Controlled Aerial Target[2]

Probably the simplest drone system is utilized for Radio Controlled Aerial Targets (RCAT). These light aircraft are remotely controlled and are used as targets for anti-aircraft gunnery practice and/or as missile targets. This drone control system employs a VHF transmitter, (56-85 MCS) usually located on the ground, modulated 90% AM with one of five tones (300, 650, 955, 1390, and 3000 cps) corresponding to and UP, DOWN, LEFT, RIGHT, and PARACHUTE RELEASE. The companion (airborne), Treceiver is a superregenerative type and hence is inherently susceptible to radio interference.

Representative bandwidths of the receivers at the 3, 6, 12, 20, and 40 db pts are 0.32, 0.46, 0.69, 0.84 and 1.20 MCS respectively. Most receivers, however, require a clear channel of 1.0 MCS (center frequency +or−500 KCS) for a control signal level of 30 microvolts and a potential interference signal of 500 microvolts. This statement is true for potential interference signals of a CW or narrow band FM

(next page, please)



SYSTEMS EVALUATION . . . (Cont'd)

nature but is somewhat modified when high modulation frequencies in an AM transmitter are encountered. It would be entirely possible to operate RCAT receivers successfully within a comercial TV band, particularly in the +3 to +5.5 MCS portion of the TV channel, providing the following information is known:

The specific geographical location involved.
The time of day and season of year.
The power and elevation of antennas.
The antenna characteristics.
The intermediate ground contours.
The J/S ratio required. (potential interference to control signal)
The selectivity of the receiver, etc.

Radar[3]

In drone control range safety systems when the "interrogator" is a "S" band radar, several problems have arisen due to the following factors:

S band operations in the WSPG area are somewhat limited in frequency range, (in the neighborhood of 2800 MCS) because of the unavailability of equipment which is capable of operating over a wide frequency range.

The majority of S band users employ magnetrons of a fixed frequency, limiting operational flexibility. This condition frequently involves a complete analysis of the radar systems, including the transmission lines and antennas. Most existig radars utilize stub supported lines which are frequency sensitive.

The S band radar population is very dense.

Wide emission bandwidths are utilized of the order of 5 MCS at the 3 db pts and 30 MCS at 20 db pts.

Techniques which have been employed successfully at WSPG to eliminate and/or minimize mutual interference between these radars operating in close proximity are given:

Tight Synchronization—If two or more radars have master range units which are "similar" (i.e., the ranging units have nominal crystal controlled oscillators of the *same* frequency in conjunction with the *same* algebraic arrangement of frequency dividers), then one radar can be designated as a "master station" which is responsible for initiating a PRF sync pulse to be ultilized for external synchronization of any number of adjacent radars without any adverse effects to any radar concerned.

Loose Synchronization—If two or more radars have master range units which are "dissimilar" (i.e., the ranging units have crystal controlled oscillators of *different* frequencies, or if on the same frequency they have a different algebraic arrangement of frequency dividers) then one radar can again be designated as a "master station" which is responsible for initiating a PRF sync pulse to be utilized for external synchronization of any number of adjacent radars with a slight deterioration of the information available to the radars being synchronized. This deterioration arises from an apparent, but known amount of skip trigger.

Sector Blanking—If the aforementioned techniques are not feasible due to circuit limitations or operational requirements, then the radar initiating the interference can have its emission confined to specific azimuths, providing effective sector blanking.

The use of radar beacons of the crystal-video type, with relatively little selectivity has also presented a serious interference problem. Pulse coding helps to some degree to

SYSTEMS EVALUATION . . . (Cont'd)

overcome this difficulty, but in general, a pre-selector cavity is needed. This too has objectionable qualities due to spurious and harmonic responses at higher frequencies. Contrasting differences between beacons of the crystal video and the superheterodyne type are shown in Appendix V. In a congested area use of superheterodyne receivers rather than crystal video types is desirable.

VI. CONCLUSIONS

It has been the intent of this paper to indicate some of the empirical methods which must be employed in the evaluation of receiver-transmitter systems to obtain information upon which valid frequency allocations can be made. It is the goal of a system evaluation to arrive at a system bandwidth figure which in essence is a consideration of receiver characteristics, emission bandwidths, system vulnerability and all other parameters related to conservation and optimum utilization of the frequency spectrum.

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APPENDIX I

TELEMETRY SUBCARRIERS IN USE

Channel	*Center Freq*	*Freq Response*
1	400 cps	6 cps
*2	560 cps	8 cps
*3	730 cps	11 cps
*4	960 cps	14 cps
*5	1300 cps	20 cps
*6	1700 cps	25 cps
*7	2300 cps	35 cps
*8	3000 cps	45 cps
*9	3900 cps	60 cps
*10	5400 cps	80 cps
*11	7350 cps	110 cps
*12	10,500 cps	160 cps
*13	14,500 cps	220 cps
*14	22,000 cps	330 cps
*15	30,000 cps	450 cps
16	40,000 cps	600 cps
17	52,500 cps	790 cps
18	70,000 cps	1,050 cps
Optional Bands		
A	22,000 cps	660 cps
B	30,000 cps	900 cps
C	40,000 cps	1,200 cps
D	52,500 cps	1,600 cps
E	70,000 cps	2,100 cps

*-Preferred Bands

A. This band may be employed by omitting the 30 kc band.

B. This band may be employed by omitting the 22 and 40 kc bands.

C. This band may be employed by omitting the 30 and 52.5 kc bands.

D. This band may be employed by omitting the 40 and 70 kc bands.

E. This band may be employed by omitting the 52.5 kc band.

APPENDIX II

MINIMUM PHYSICAL SEPARATION BETWEEN A FOUR CHANNEL TELEMETERING SYSTEM AND ANY RECEIVER UNIT

(All Channels Transmitting the Same Power)

Receiver	Max. Distortionless Input (dbm)	Power Transmitter (watts)	Min. Operating Distance (feet)
#1	−25	2.0	1120
		5.0	1775
		10.0	2500
		50.0	5620
#2	−35	2.0	3550
		5.0	5560
		10.0	8000
		50.0	17000

Computational Formulas

$$E = \frac{3\sqrt{5}}{d} \sqrt{P_1 G_1}$$

P_1 = Power Transmitter (watts)
G_1 = Transmitter antenna gain over dipole
d = Distance between antennas
E = Field intensity V/M

$$P_2 = \frac{E^2}{120\pi} \frac{(3\lambda^2)}{8\pi} G_2$$

P_2 = Power delivered to matched load by receiving antenna (watts)
λ = Wavelength (Meters)
G_2 = Receiving antenna gain over dipole

Assumptions: Transmitting antenna gain : 0.0 db
Receiving antenna gain 8.5 db
(page 29, please)

SYSTEMS EVALUATION . . . (Cont'd)

APPENDIX III

TEST	RECEIVER #1	RECEIVER #2
1. Overall Bandwidth: (3 db pts.)	1.250 MCS	0.540 MCS
2. AFC Capture and Drop Out Frequency (15 uV signal) Capture / Drop Out	+0.50 MCS −0.60 MCS +2.0 MCS −2.75 MCS	+0.50 MCS −0.75 MCS +0.80 MCS −1.00 MCS
3. Image Rejection	75.9 db	47.0 db
4. Discriminator Linearity. Correlation Coefficient for +or—300 KCS	0.9957	0.9990
5. Cross Modulation Distortion (Necessary channel spacing for the introduction of *no* cross modulation distortion to a 15 u volt simulated control signal and a 150 u volt potential interference signal)	1.00 MCS	0.975 MCS
6. AFC Distortion: (% distortion increase as function of AFC correction) Center f.	2.65%	3.4%
+250 KCS	0.15%	0.60%
+500 KCS	0.30%	3.00%
+750 KCS	0.55%	9.6%
Total	(3.65%)	(16.6%)
7. 20 db Quieting	9 u V	9 u V
8. IF Selectivity (3 db points)	795 KCS	510 KCS
9. IF Isolation	92.6 db	86.0 db
10. AFC Control Ratio (i.e.=ratio of +or—800 KCS RF carrier shift to IF shift)	21.4	4.7

APPENDIX IV

REPRESENTATIVE DATA ON CRYSTAL CONTROLLED PM TRANSMITTER

(Average of five samples)

1. Variations with Supply Voltage (+or—10%):
   (a) Frequency stability 0.003%
   (b) Power: within 34% of rated
   (c) Deviation sensitivity: within 15.5% of rated
   (d) Distortion (% of rated): within 13.3%
2. Variation with Atmosphere:
   (a) Frequency stability:
      (1) —60°C to +80°C at 25.6 in Hg—within 0.1%
      (2) —60°C to 0°C at 1.25 in Hg—within 0.005%
   (b) Power:
      (1) —60°C to +80°C at 25.6 in Hg—within 66% of rated
      (2) —60°C to 0°C at 1.25 in Hg—within 27%
   (c) Deviation sensitivity for —60°C to 180°C at 25.6 in Hg or for —60°C to 0°C at 1.25 in Hg: within +or—3% of rated.
   (d) Distortion: within +or—10% of rated for aforementioned conditions (c)
3. Variation with Acceleration (0, 10, 20, 40, 60, 75 G's both perpendicular and parallel to the tube axes—each acceleration 30 seconds or more in duration):
   (a) Frequency stability: within 0.005%
   (b) Deviation sensitivity: no significant change
4. Variation with Vibration:
   In general the units functioned satisfactorily with 5 and 10 G's at 30 cps and 5, 10, 20, and 40 G's at 70, 300 and 500 cps in both planes of vibration.
   (a) Frequency stability: within 0.005%
   (b) Power: decreased 35% at 40 G's of 500 cps
   (c) Deviation sensitivity: no significant change
   (d) Distortion: increased slightly with higher acceleration and higher vibration frequencies.

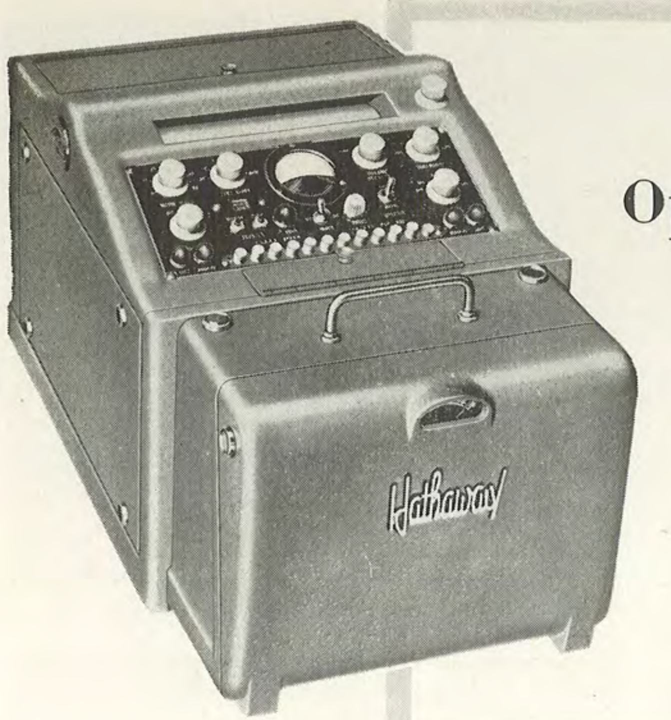
APPENDIX V

CONTRASTING DIFFERENCES BETWEEN BEACONS OF THE CRYSTAL VIDEO TYPE AND THE SUPERHETERODYNE TYPE

TEST	*Crystal Video Beacon*	*Superheterodyne Beacon*
Sensitivity	—40 dbm	—50 dbm to —80 dbm
Interference Susceptibility (J/S ratio) where S=—25 dbm and interference frequency equals control frequency +:		
0 MCS	—17.5 db	—28 db
5 MCS	—16.5 db	—10 db
10 MCS	—15.5 db	+19 db
Selectivity		
3 db	400 MCS	3.4 MCS
10 db	710 MCS	7.2 MCS
20 db	3800 MCS	11.4 MCS

AUTHORITY

The contents of this technical paper: "Systems Evaluation Telemetry and Drone Control" is authorized for public release as per: Public Information Office (Mr. Haggard), White Sands Proving Ground, New Mexico, 14 February 1956.



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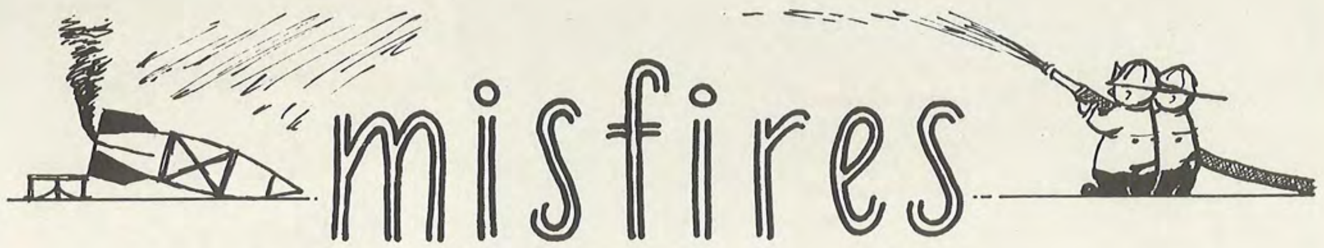

"Just Tear The Top Off The Nearest Acid Drum..."

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So, gang, before that evening sun goes down, sneak out to your local postoffice and send us your name so you'll be the first one in your block to get this real guided missile.

If you happen to be the *second* one in your block to get one, that will be all right, because just by following the handy instructions you'll be able to wipe out the first guy in the block who got one, provided he doesn't know you received one.

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Caution! If your guided missile beats the postman to your door, duck! Otherwise we cannot make this offer to you again.

GLOSSARY OF MISSILE TERMS AS USED AT PATRICK AFB

ANTENNA: Uncle Joe's wife

BC-4: Large dose of headache powder

COTAR: A tarry substance made out of Co.

COUNTDOWN: What happens after a boxer is knocked out.

DIPOLE: Very sick tadpole.

DATA INVERTER: Electronic engineer who gets things mixed up

DRONE: PAA Employee

DDM/T: Advanced type of insecticide

ELSSE: The Borden Cow

FASTAX: Quick-acting form of EX-LAX

IMPACT AREA: World's largest hope chest

LOX: Smoked salmon. Eaten with bagles.

MIDOP: Personal possessive form of DOP: as in MIDOP, HISDIP, YOURDOP, etc.

MINITRACK: Very short race course

MISSILE: Device similar to skyrocket which goes haywire after being set off.

PHOTOMULTIPLIER: Person who makes double exposures.

RECOVERY: Getting well after a shoot

RADAR DISH: Good-looking girl who operates electronic device.

SKID STRIP: Burlesque on Skid Row

SECOR: Naval version of Air Corp.

SOFAR BOMB: Bomb with very limited range.

STACKED HELICAL: A helical who is well built.

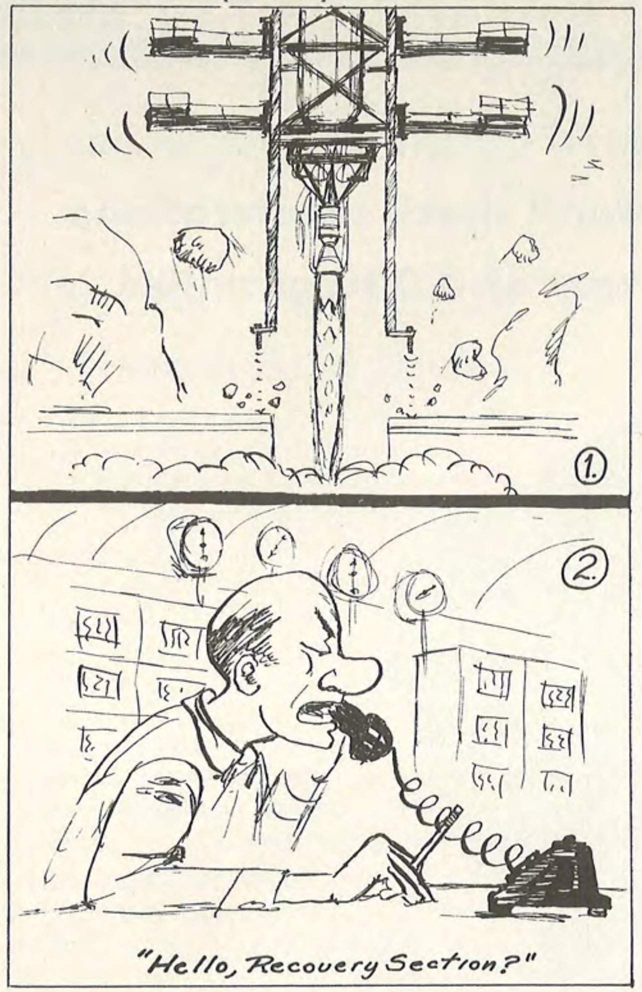
TAIL FIN: $5.00 used for immoral purposes.

T-TIME: Five O'clock. One lump or two?

(page 34, please)

"MISSILE AWAY!"

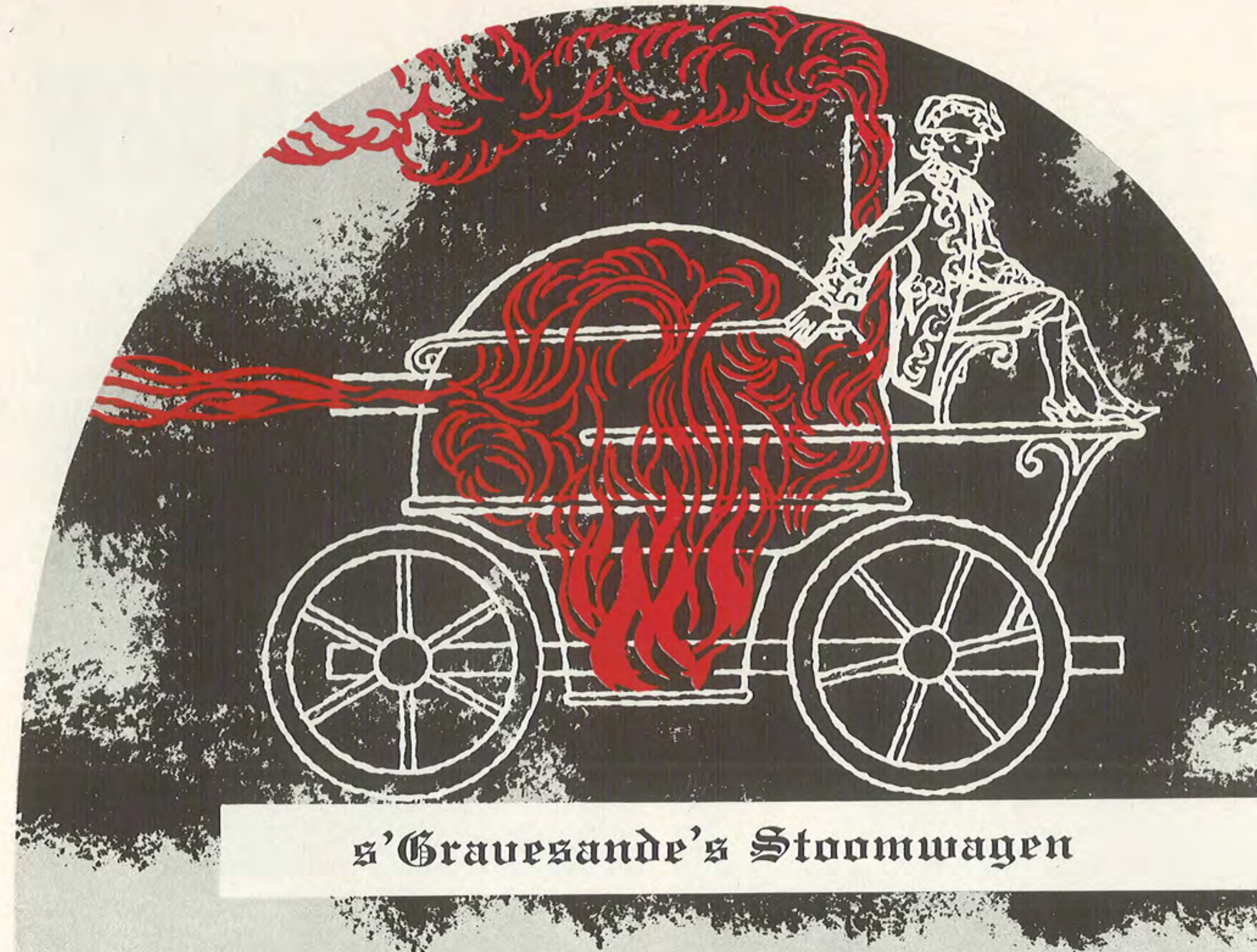
MISFIRES . . . (Cont'd)

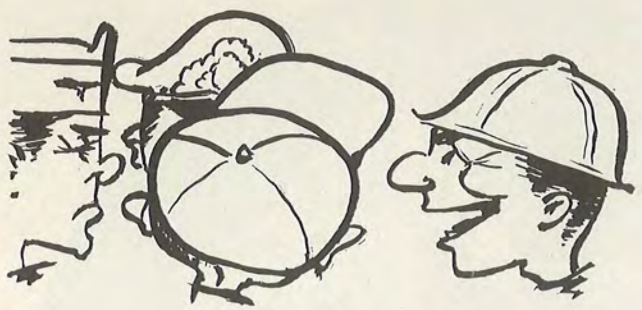


ENGINEERING TYPES

— by Wagoner —

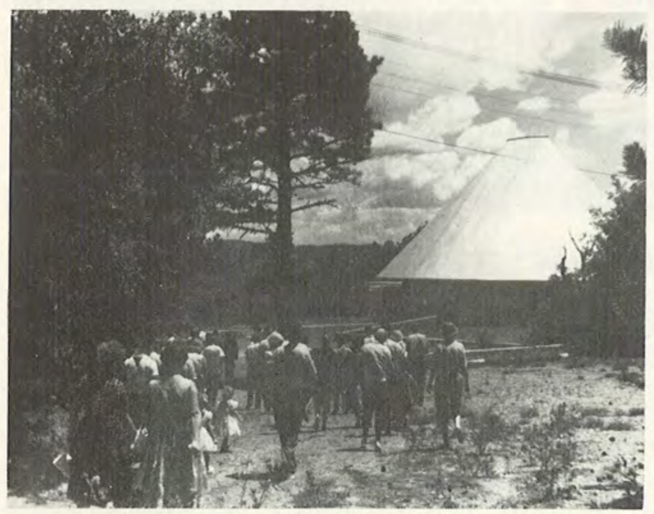
SO WHO GIVES A DAMN ABOUT MUSIC ?





post shoot conference

Watch for the Winter Issue of "Missile Away!". It will be a special issue devoted entirely to astronautics, the first time we have done such a thing. Thus far, the issue promises to be something both unusual and worth waiting for.



The monthly meeting on August 12, 1956 will not be soon forgotten by the Section members. A field trip was arranged to the Sacramento Peak Observatory of the Air Force Cambridge Research Laboratory. After motoring across the desert from El Paso and Las Cruces, the cavalcade was joined by the Holloman-Alamogordo members and then proceeded into the high (9000 feet MSL), cool Sacramento Mountains just to the East of Alamogordo and the WSPG range. The group convened at the Observatory, located on Sacramento Peak and known in the postal directory as the town of Sunspot, New Mexico. At noon, Dr. Henry J. Smith took the group on a special tour of the facilities, starting with the meteor station. The world's largest coronagraph was next on the tour. The 26-foot spar at Sac Peak is the largest solar telescope in the world, and will enable solar scientists to gain much new information about solar activity. Also located at Sac Peak are two more coronagraphs—one on a 10-foot spar and the other a small, 4-inch coronagraph.

The field trip was held in conjunction with the Astronomical Society of Las Cruces, N. M.

Recent releases in the missile world included the Army's Little John artillery rocket, their Dart anti-tank missile, and a brief description of the LaCrosse missile. Little John is one of the Honest John family of field artillery rockets, and is somewhat smaller than its ancestor, the Honest John.

The Air Force has revealed its Hypersonic Test Vehicle (HTV) with which it is studying heating effects at high Mach Numbers.

The Navy also brought out from under wraps the ASP rocket. Although the name stands for Atmospheric Sounding Projectile, the rocket picked up another name when it was tested at WSPG. Optical trackers maintained that ASP stood for Awfully Speedy Projectile!

Also out of the bag for IGY is the Nike-Cajun sounding rocket, a two-stage affair capable of taking 100 pounds of instruments about 90 miles up. Along the same line is the Terrapin rocket, developed by Republic Aviation for the University of Maryland and capable of hoisting instruments to 100 miles.

Nothing new as yet on the ICBM's and IRBM's, although those are the "magic words" in the business these days.

Frank Koen, Jr., dropped us a line from Patrick AFB where he is working for Ramo-Wooldridge. Look for more dope on Patrick AFB in this magazine, since Frank has done a fine job of digging up photos and releases for us.