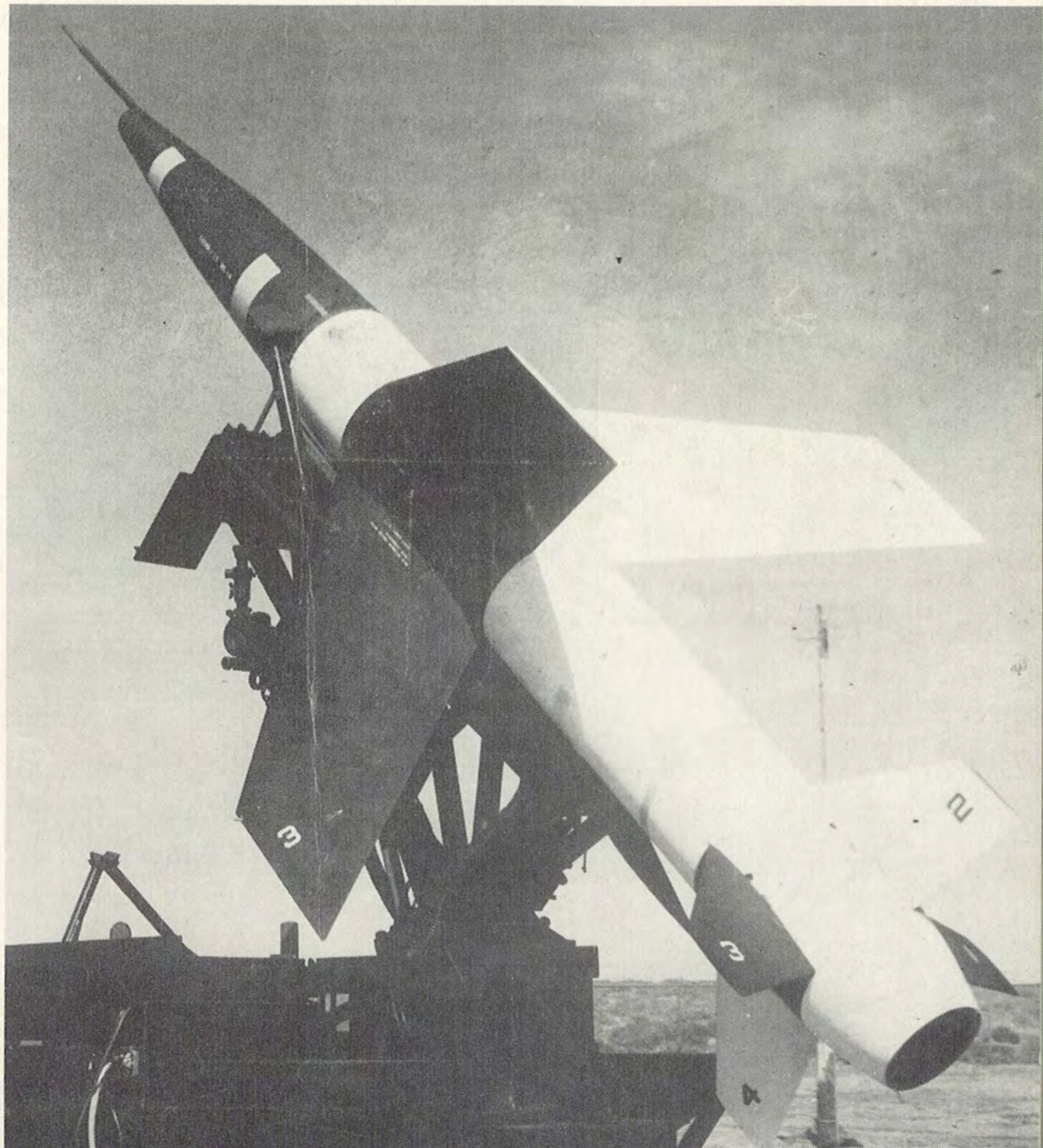
"Missile Away!"

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

Vol. V, No. 1
SPRING
1957

35c



editorial

"NEW WORLDS TO CONQUER"

When Alexander the Great led his invincible army to the boundary of the then known world, he had achieved his goal, he had conquered the world. It is said that he sat down an cried for he had fulfilled his destiny and there was nothing left for him to do.

This experience, to a lesser degree, is one that most of us have had at some time during our lives. We have set a goal to be reached and have devoted the major part of our energies toward the achievement of that goal. When the day of fulfillment arrives, we find ourselves at "loose ends" with an empty feeling of not knowing what to do.

Three years ago, the New Mexico-West Texas Section of the American Rocket Society set up a project; a project to bring about what we considered badly needed reforms and/or changes in the relationship between the National Headquarters and officials and the Sections of the ARS. We felt that the National publication should reflect the interests of the membership, not a selected few. We felt that the Sections should have better representation in the affairs of the Society. We have objected to delays in correspondence, lag time on membership applications, etc. The first move was an effort to correct the first complaint, the lack of a general interest publication. "Missile Away" was established in 1953 on a trial basis. The response was immediate, and gratifying. The editors and board of managers found themselves with a magazine which was growing in popularity. It was only natural that the next step would be an airing of our gripes in the editorial section of each magazine. We feel that the effect of such editorials, written in a constructive manner, has contributed to the good of the Society.

But now we have reached our goal. We have on our hands a magazine, well established and growing. There are no big axes left to grind. As a weapon, "Missile Away!" is no longer needed. During these past three years a great deal of the Section effort has been expended in the advancement of "Missile Away!" to the possible detriment of other projects. Now the time has come for us to branch out into other fields of Section endeavor, fields which will bring into action the greatest number of our membership. For it is a proven fact that a working member is a loyal member. One such project is already working. It was felt that too little knowledge of rocketry in general and WSPG in particular was being passed on to the people in the surrounding communities. A speakers and program bureau has been organized with speakers and program leaders drawn from the ranks of the NM-WT Section. The majority of our work to date has been in the Las Cruces community but when a sufficient number of speakers and programs are available, we plan to branch out to El Paso and Alamogordo. To do this we need the cooperation of our members. We plan to start other projects of a similar nature. Similar in the respect that they are concerned with the advancement of the science of rocketry.

The Officers and Board of Directors of the NM-WT Section feel that "Missile Away!" as it now exists will serve no useful purpose. The National publication "Astronautics" will be a general interest magazine and will be in publication shortly. We have no desire to compete with our National group. We would prefer to join forces with them in their efforts. "Missile Away!" could then return to its original form, a newsletter to Section members. The work expended at present on "Missile Away!" could be channeled into the other projects, to further the Society activities.

That's the way we see it, fellow members and subscribers. What do you think?

GLM

THE NEW MEXICO-WEST TEXAS SECTION OF THE AMERICAN ROCKET SOCIETY, INC.

EXECUTIVE OFFICERS

President: George L. Meredith, 600 Cortez Drive, El Paso, Texas

Vice-President: G. Harry Stine, 1100 Circle Drive, Las Cruces, N. M.

Secretary: F. Donald Moore, 525 Linda Vista, Las Cruces, N. M.

Treasurer: Lyle D. Bonney, 1105 Branson Avenue, Las Cruces, N. M.

BOARD OF DIRECTORS

Keith Hennigh, 1760 South Solano, Las Cruces, N. M.

Nathan Wagner, 1765 S. Alamo, Las Cruces, N. M.

Louis Freudenthal, 538 W. Las Cruces Avenue, Las Cruces, N. M.

Donald D. Keys, P. O. Box 1396, Las Cruces, N. M.

Thomas C. Buell, U. S. Naval Ordnance Missile Test Facility, White Sands Proving Ground, N. M.

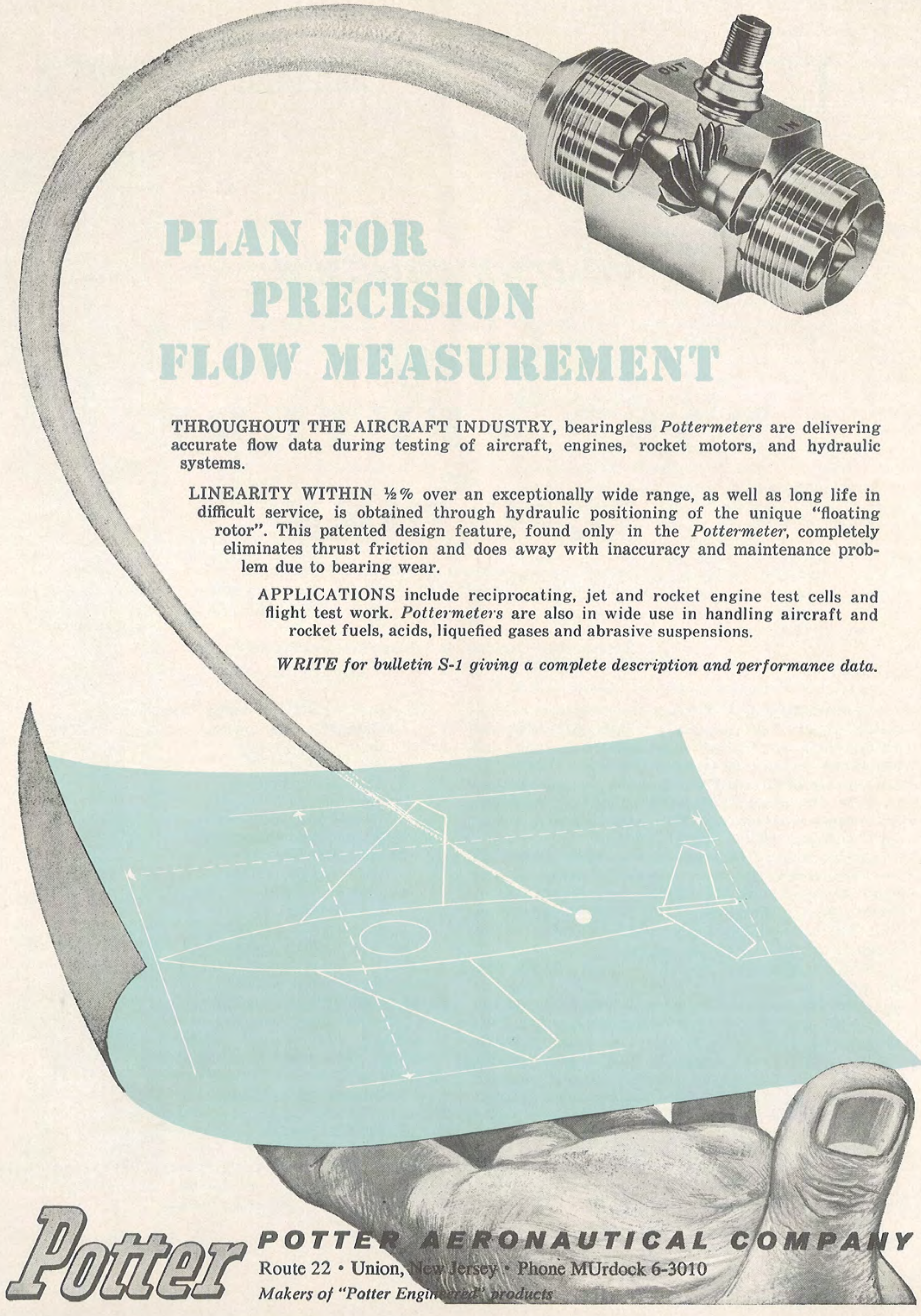
Lawrence W. Gardenhire, P. O. Box 112, State College, N. M.

William H. Fickes, 1417 Boston Drive, Las Cruces, N. M.

Charles M. Johnson, 1720 Foster Avenue, Las Cruces, N. M.

Leroy O. Eaton, 335 Monterrey, Las Cruces, N. M.

Lewis H. Byrd, 1511 Boutz Road, Las Cruces, N. M.



Inter Range Instrumentation Group PAST and FUTURE

by

B. W. PIKE

*Chairman's opening address to the first All-IRIG Symposium, 9-11 October 1956, at Cloudcroft, New Mexico.

**Instrumentation Consultant, U. S. Naval Ordnance Test Station, China Lake, California.

In March 1952, 4½ years ago, the Commanders of the Guided-Missile Test Ranges—AFMTC, NAMTC, and WSPG—held their second Commanders' Conference and established the Inter-Range .nstrumentation Group. The sole purpose of the IRIG was stated by the original charter to be "Interchange of information between the ranges on common problems concerning instrumentation, including data reduction".

At that time, the IRIG was made up of one representative from each of the three ranges, but withing a short time, the Commanders' Conference was extended to its present scope by including HADC, NOMTF, and NOTS. The IRIG was correspondingly extended to consist of one member from each of the six ranges.

After three meetings, the IRIG—recognized the need for greater interchange of technical information—obtained from the Commanders' Conference a broader charter and established seven Technical Working Groups. The IRIG then named itself "IRIG Steering Committee" to enable the use of "IRIG" as a part of the name of each Working Group.The Working Groups consist of one or more Members from each range, and non-voting Associate Members from range-operating contractors or from other government agencies.

The Steering Committee now consists of the six range Members, aided by a Secretariat and by Associate Memmers from ARDC, BUAER, BUORD, OCO, OASD (R&D), NBS (OBI) and NACA.

The nine Technical Working Groups are:

1. Optical Systems
2. Electronic Trajectory
3. Telemetering
4. Tele-Communications (new group)
5. Radio Propagation
6. Photographic Processing
7. Meteorological (new group)
8. Data Reduction & Computing
9. Frequency Coordination

The present IRIG membership (including Associate Members) totals 14 for the Steering Commitee and about 118 for the Working Groups.

HOW DOES IRIG OPERATE?

a. The Steering Committee meets three times a year to exchange information, to establish guidance for the Working Groups, to act on recommendations addressed to the Steering Committee by the Working Groups, and to make recommendations to its parent group, the Range Commanders. The meeting place is rotated, and is usually at one of the IRIG Ranges. Chairmanship is rotated yearly. There is a permanent IRIG Secretariat established at WSPG to serve as a central point for Steering Committee correspondence and IRIG record keeping. The Steering Com-

(next page, please)

mitee Chairman reports to each Commanders' Conference.

b. The Working Groups vary in their procedures. They meet at various places from one to four times a year to exchange information by reports, discussions, and inspection trips, and to formulate recommendations to the Steering Committee. Some groups rotate the Chairmanship annually, others with each meeting. Minutes of all Steering Committee and Working Group meetings are published but the distribution is kept within IRIG.

c. The chief function of IRIG—that of interchange of information on range instrumentation—is facilitated not only by meetings but by direct correspondence, which is authorized by the charter. Another function of the IRIG is to increase overall efficiency through joint procurement or exchange of equipments and services. Here again, the IRIG serves only as a catalyst to stimulate the cooperation between the agencies concerned. Another function of IRIG is to increase efficiency through standardization. Standardization includes establishment of standard nomenclature, of uniform practices and policies, of common procurement specifications, etc. This function requires the preparation of a formal IRIG-Recommendation document bearing the approval of the Steering Committee and carrying an IRIG number. Such a document is not a binding agreement but can be used as the basis for individual action by any member range or as a basis for a cooperative action such as a joint development or procurement program. In the rare instance where an action would require the official concurrence and cooperation of *all* the IRIG Ranges, the IRIG Steering Committee addresses the recommendation to its parent group, the Commanders' Conference.

Figure 1 is given to show the trend of IRIG activity over the past five years.

WHAT HAS THE IRIG ACCOMPLISHED?

a. I believe that the IRIG has been successful in its primary mission of facilitating the exchange of information. The amount of information exchanged can be estimated roughly on the assumption that the average meeting attendance is about thirty man-days. Since there have been approximately 65 IRIG meetings, approximately 2,000 man-days of face-to-face information exchange has taken place. To this one must add an unknown but very considerable amount of direct person-to-person correspondence. The value of this exchange probably cannot be determined, but many people believe that the cost, which is approximately equivalent to the price of one Cadillac per meeting, is justified.

b. In the area of cooperative procurement effort, the IRIG has facilitated several actions. It is conceivable that such cooperative actions would not have occurred without the personal contacts and the information exchange that came about through IRIG meetings. One example is the assistance of the Optical Systems Working Group in the joint procurement of Askania Kth53 Cinetheodolites. Another is assistance in preparing specifications for the FPS-16 instrumentation radars now being made by RCA. Another is a specification, prepared by the Optical Group for a tracking instrument mount called ROTIM.

c. In the area of standardization, the IRIG is beginning to bear fruit. A few examples follow: the first offi-

(next page, please)

cial IRIG standard is IRIG Recommendation No. 101-55, a specification for a method of measuring the speed errors of magnetic tape recorders. This specification was prepared by the Telemetering Working Group. The same group has prepared (with the cooperation of the Frequency Coordination Group) IRIG Recommendation No. 102-55, a revision of the old RDB telemetry standards. The Data Reduction and Computing Working Group has prepared IRIG Recommendation No. 101-56, a glossary of data reduction terms. The Frequency Coordination Working Group has, with the cooperation of several other groups, prepared IRIG Recommendation No. 102-56 on frequency utilization parameters and criteria.

WHAT OF THE FUTURE OF IRIG?

I am convinced—and I believe that most IRIG people are convinced—that the Range Commanders have accomplished a significant increase in the nation's weapon-development potential by providing a mechanism for informal exchange of information in the field of range instrumentation. That the IRIG is recognized as having been an effective type of organization is indicated by the fact that the Commanders' Conference has recently established two additional inter-range groups molded after the IRIG. One of these is on range safety and the other on targets for missile testing. Moreover, formation of an inter-range group similar to the IRIG is being planned by the organizations operating high speed test tracks.

Even though the IRIG is believed to be effective, it is not wise to assume that it could not be made more effective. Nor would it be wise to assume that it will automatically, without continued effort and self analysis, remain effective under the changing circumstances that the future always brings. For an example of an effective organization that failed, consider the Aztecs, who had developed a very advanced civilization by the time the Conquistadores arrived. I have read that each Aztec tribe held frequent ceremonial meetings. (No doubt these meetings resulted in the exchange of large amounts of information and resulted in the publication of standards such as their remarkable stone calendar.) Some students of the Aztec culture hold that their defeat by the incredibly small group led by Cortez was caused entirely by the lack of communication and cooperation between the tribes.

I have served nearly five years as a Steering Committee Member, two years of which was as Chairman. From this experience I have formed the opinion that the IRIG has nearly reached maturity. To attempt to increase the effectiveness of the IRIG through continually enlarging the scope and size of the organization does not appear to be feasible. All IRIG people have other jobs that place a limit on the effort that can be devoted to IRIG work. Already, the effort that could beneficially be devoted to IRIG by its officers exceeds the category of a spare time job.

If my opinion is correct, the only way we can increase IRIG effectiveness is through improving the efficiency of the way we carry on the IRIG work. For some time I have believed that we have very good communication within each group but that better communication and cooperation between groups would increase our overall efficiency. Therefore I instituted the All-IRIG Newsletter and now we are trying, for the first time, an All-IRIG meeting.

The main theme of this Symposium, then, is communication *between groups* for the purposes of disseminating broad technical knowledge, of promoting understanding and cooperation, and of searching for ways to improve our Inter-Range Instrumentation Group. Please keep these purposes in mind during the coming talks and discussion periods.

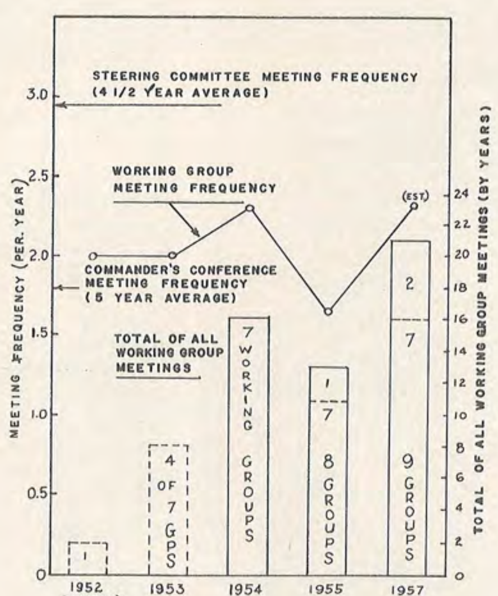


FIG. I IRIG Activity

ELECTRONIC MEASUREMENT *State of the art*

V-10 VELOCIMETER

TRAJECTORY SYSTEMS *and trends*

by

VERNON MILLER

WHITE SANDS PROVING GROUND

There are more ways to "see" where a missile goes than with the eyes. The author describes some of those methods now in use.

I. INTRODUCTION

THE uses of Electronic Trajectory Measurement Systems include trajectory determination to obtain space position, velocity and acceleration; trajectory measurements for flight safety; Miss Distance Indicators; and precise navigation instrumentation.

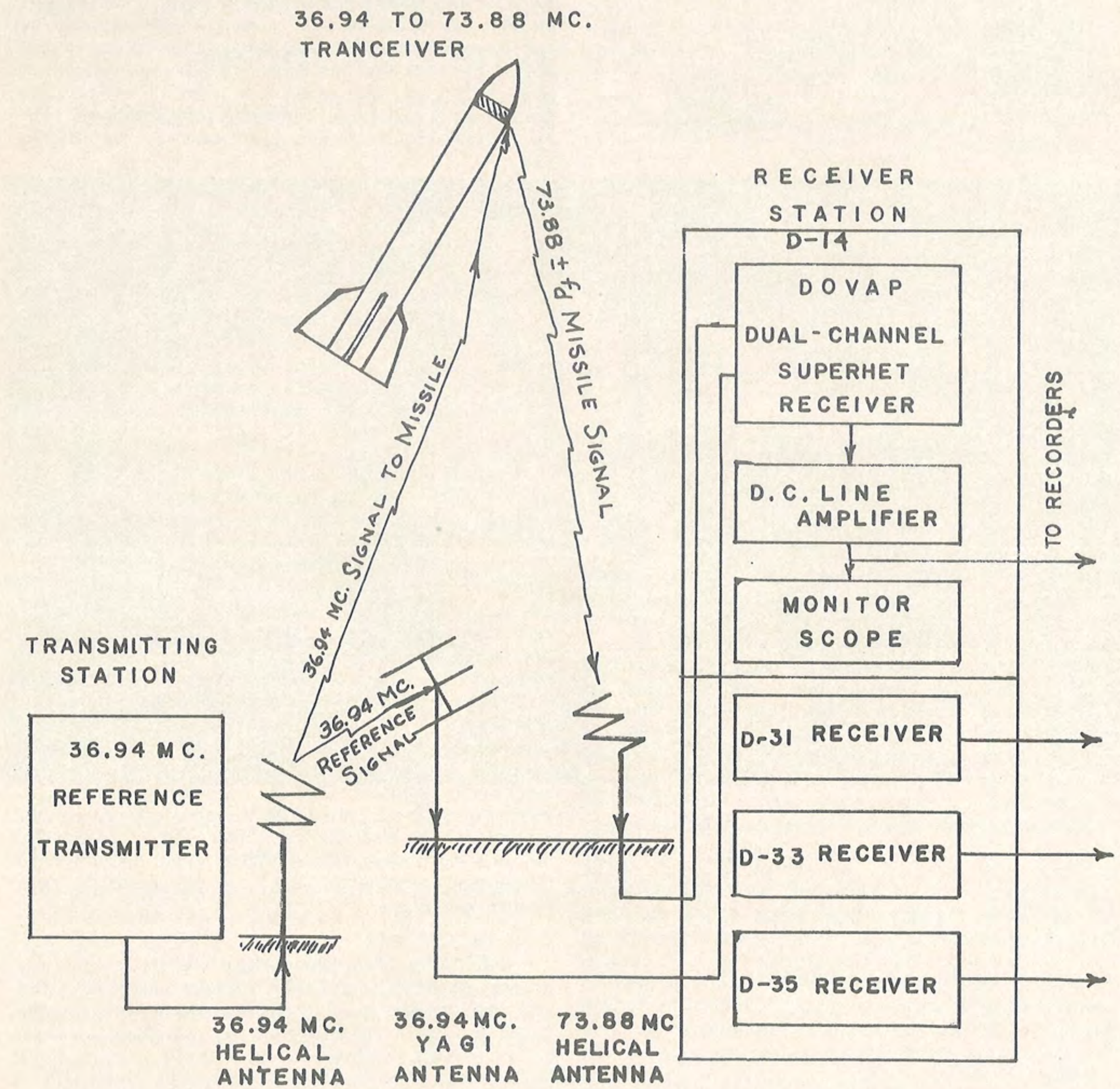
The first significant uses of Electronic Instrumentation Systems occurred during World War II with the use of Radar, Reflection Doppler as a velocity measuring and troop warning device, and DOVAP which was used for measurement of bomb trajectories. Since these systems were available, they were used by instrumentation agencies early in the missile program. Development of additional systems was underway in the late forties. However, as this development progressed, it became apparent that the electronic systems were plagued with obstacles and years of costly development would be required to provide the ultimate systems. In the past several years, as emphasis has been placed on the missile programs, this effort has been intensified, and quite a few of the systems have been tested and proven.

II. CONCEPTS AND DERIVATIVES

The basic fundamental by which all Electronic Trajectory Systems operate is a measurement of propagation time. The measurement of propagation time for radio waves may be accomplished by any of a number of means. The derivatives provided by this measurement may be a pulse time, frequency measurement, or phase measurement. The pulse time measurement will directly yield a range; frequency measurement directly a velocity which may be integrated to produce direct or loop range; and phase measurement to produce either an angle or a loop range.

The systems may be either passive or active—passive being a system requiring no transponder in the missile or other object being measured, and the active requiring a transponder. A third system which may be termed a Hybrid System requires no transponder of its own, but makes use of an RF signal being transmitted from any other device in the missile, i.e., Telemetry Transmitter.

(page 13, please)



DOVAP SYSTEM

ELECTRONIC TRAJECTORY MEASUREMENT SYSTEMS

The systems may be either "multi-station" or so called "single station" systems. A "multi-station" system requires stations distributed over the test range to provide the required geometry; whereas, the "single station" system yields all the necessary measurements at one location to arrive at trajectory data.

III. A SAMPLING OF ELECTRONIC MEASURING SYSTEMS

The following includes a brief description of the principles of the majority of the systems which are currently in use or which are in the latter stages of development. This collection of systems is intended to illustrate applications of the concepts and derivatives and is not all inclusive. In some cases resolution of the system is given. This may be reflective of system accuracy, but should not be understood to imply accuracy.

A. DOVAP

DOVAP (Doppler, Velocity and Position) is a multi-station elliptical system using the doppler principle at radio frequencies for determination of space position of the missile. Basically, the system consists of a ground reference transmitter, a transponder in the missile and a number of ground dual receiving stations. The reference signal (36.94 mc) from the ground transmitter is received by the missile and by each of the ground receivers. In the missile, the reference frequency is doubled and re-transmitted. At each of the receiving stations, the reference frequency is doubled and compared with the signal received from the missile. A doppler beat resulting from the velocity of the missile is produced. This doppler beat is in the audio frequency region and is recorded on film and magnetic tape. An integration of the doppler cycles up to a particular time yields a change of the pathlength from transmitter to missile to receiver for that time. This pathlength is non-directional and so describes an ellipsoid of revolution with foci at the receiver and transmitter. The space position of the missile is computed by solving for the intersection of three or more ellipsoids. The data normally obtained includes three coordinate space position and velocity data with the velocities being derived from position differentials. A radial velocity (available in real time) is obtained from a transmitter-receiver combination located directly behind and in line with the missile launcher. Accuracy of this system is dependent primarily on the geometry of the transmitter and receiver stations, on accurate determination of the wavelength, and on obtaining continuous data at all of the required stations.

B. TRIDOP

The TRIDOP System is very similar to the DOVAP System and applies the same basic principles. The system uses a reference transmitter at 132.48 mc and a transponder frequency of 264.96 mc. A timing signal is transmitted to the receiving stations where it is used as a time base for magnetic tape recording and to provide a 5 KC bias frequency for the doppler data. This bias frequency eliminates ambiguities in the recorded data and facilitates automatic cycle counting from magnetic tape.

C. SECOR

The SECOR (Sequential Ranging) is a spherical three station long baseline system wherein each station measures range to the target. The stations sequentially interrogate the airborne transponder at a rate of approximately 30 samples per second for each station. Sequencing is controlled by a keying transmitter. Range measurement is accomplished by measuring phase delay of each of five modulating frequencies in a servo-driven phase meter. The modulating frequencies and their respective wavelengths are:

491.760	KC	-	2,000 ft
61.470	KC	-	16,000 ft
7.68375	KC	-	128,000 ft
1.92094	KC	-	512,000 ft
0.192094	KC	-	5,120,000 ft

With the frequencies selected, a nonambiguous range to 210 nautical miles and a resolution to 1.4 feet can be attained. Additional DME stations can be added to allow operation as a chain system. Data is recorded locally at each of the stations in digital form on magnetic tape, suitable for input to a high speed computer.

D. COTAR

COTAR is a short baseline single station system used to measure two direction cosines and slant range by phase comparison techniques. The range measurement portion of the COTAR System is identical to one SECOR DME. The direction cosine measurement is accomplished by comparing the phase relationship of the signal emanating from the missile as received at each end of a short baseline. To derive two angular measurements, i.e., azimuth and elevation angles, two baselines positioned perpendicular to each other and intersecting at the center are used. Each baseline is 50 wavelengths long and has additional antennas at 5 wavelengths and 4½ wavelengths to enable resolution of ambiguities. After detection, the received signal is measured in a nulling type servo-driven phase meter which gives a shaft output proportional to the cosine of the space angle. Assuming electrical phase to be measured to ½ degree, the resolution of a direction cosine measurement is expected 40 parts per million. The COTAR System uses a ground transmitter operating on 260.4 mc and a missile transponder operating at 218.5 mc.

E. MOPTARS

MOPTARS (Multi-Object Phase Tracking and Ranging System) is basically a COTAR angle measuring system and SECOR type range measuring system with a multi-target tracking capability. Multitarget operation is obtained by sequentially interrogating the various airborne transponders and simultaneously selecting the corresponding servo phase meter and associated readout circuits. The system is inherently capable of tracking up to five airborne targets simultaneously, but initially will have only three servo-driven phase meters and therefore will be limited to three target operation. Data output will be on dials suitable for photographing. A digital output can be added to the system. Operating frequencies are 366 and 396 mc.

F. DME (AFAC, Eglin)

DME is an instrument providing a slant range measurement and is similar to one SECOR DME station. The system uses a 399 mc carrier which is frequency modulated

(page 16, please)

by four signals. These being:

491.76 KC
61.47 KC
7.684 KC
.9605 KC

The signal is received in the missile and reradiated at 461 mc. At the master ground station, the signal received from the missile is detected and comparison of the four modulating frequencies is made in a servo-driven phase meter. This phase meter provides resolution to +2 degrees which corresponds to a maximum resolution of 5.6 feet. Data is recorded at a 4 per second rate photographically.

G. DORAN

DORAN (Doppler Ranging) is a multi-station elliptical system geometrically similar to a DOVAP System, but which uses phase comparison of four modulating frequencies to provide the loop range. The reference transmitter operates on 132.48 mc and is modulated by the following signals:

749.44 KC
74.944 KC
7.4944 KC
.74944 KC

The transmitted frequency is received by the missile transponder, doubled in frequency to 264.96 mc, and re-transmitted to at least three ground receiving stations. To obtain range, each ground receiver station demodulates the signals from the transponder and the reference transmitter, separates the four range signals, and compares the phase of corresponding range signals.

The range information from the four modulating frequencies corresponds to ranges of 200, 20, 2 and .2 kilometers. From the range information of the three receiving stations, the coordinate position of the missile can be obtained. The data at the receiver stations is recorded on film and tape. Range data from the 749.44 KC signal is transmitted by wire line to a central digitizing station where it is recorded in binary form on tape suitable for playback into an IBM Summary Punch or electronic computer.

I. ROMOTAR

ROMOTAR is an elliptical system very similar to DORAN. Three modulating frequencies are used. These are:

491.17 KC
49.117 KC
4.9117 KC

The system has four ground receiver stations. With one receiver coincident with the ground transmitter, a slant range is directly available and the system reduces to spherical determination. Data is recorded locally at each of the receiving stations with the higher modulating frequencies being translated to frequencies below 3 KC while retaining the phase information. The data is then played back at 1/8 speed, digitized and recorded on punched paper tape for computing. Carrier frequencies are in the 400 to 450 mc region.

J. MIRAN

The MIRAN (Missile Ranging) is a multi-station system using pulse radar techniques for measurement of loop range. The system consists of a master station containing the interrogator and one receiver, and a number of slave receiver stations. The interrogator transmits at 600 mc. The missile beacon is offset and reradiates at 580 mc. The signal from the missile is received at the master station and at each of the slave receivers. The signal received at each of the slave receivers is once again offset and returned to the master station on any of several frequencies in the 620 to 680 mc range. At the master station, pulse time measurements are made and a loop range for each receiver station derived. The data is computed in real time in an analog computer for display on plotting boards and is digitized and recorded on magnetic tape for more precise computing in a digital computer.

K. SPHEREDOP

The Spherical Doppler System is in most respects similar to DOVAP but contains a stable oscillator in the missile thereby eliminating the reference transmitter to missile link. At each of the ground receiving stations, the signal received from the missile is compared to that received from the ground reference transmitter and the resultant doppler recorded. This doppler will contain a bias from the offset between the ground reference transmitter and the missile oscillator. To enable resolution of this additional unknown, the system must use a minimum of four receiver stations.

L. REFLECTION DOPPLER

Microwave Reflection Doppler or what is sometimes called Doppler Radar is in single station microwave device used for radial velocity measurements. A signal, nominally 2600 mc, is beamed toward the missile or object being tracked, and the reflected signal is received in close proximity to the transmitter. Comparison of the transmitted and received signals results in a doppler beat which is directly proportional to the radial velocity of the missile. The signal is recorded on magnetic tape which is played back through automatic digitizing equipment.

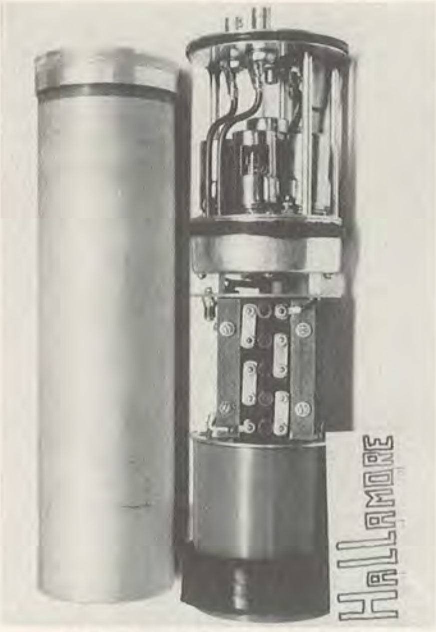
M. RAYDIST

RAYDIST is a hyperbolic system used for either two or three dimensional position measurements. Basic components of the system area ground transmitter (4.135 mc), a missile transmitter, and three receivers for a two dimensional system or four for a three dimensional system. The ground and missile transmitters are offset by 400 cps. At each of the receivers, the 400 cps beat is detected, and using one of the receivers as a master, phase relationship of the 400 cps note from each of the other receivers is measured. The phase measurement is representative of a hyperbola, the transverse axis of which is the baseline between receivers. The system is dependent on receiving continuous phase data to avoid ambiguities. The data output is from a servo-driven phase meter and is recorded on a strip chart. The data is manually counted and prepared for automatic computing.

N. EPI

The Electronic Position Indicator was developed shortly after World War II and was designed primarily for long range hydrographic surveys. Ship position is determined by measuring the round trip time for a radio pulse, initiated on the ship to travel to two accurately surveyed ground stations and return to the ship. This pulse time measurement yields a range from the ship to each of the ground stations, and a two coordinate position is derived. Carrier frequency is 1850 kilocycles. An improved version of the

(next page, please)



DOPPLER TRANSPONDER
(Missile Borne Unit)

EPI, applicable to missile instrumentation, is in process. This system is expected to yield range determination to 500 feet at a range of 500 nautical miles.

O. SARA

SARA (Ship Angle and Range) is a variation of the SECOR DME and COTAR systems to be used as a precise navigational system where it is necessary to have shipboard instrumentation sites. A 50 wavelength COTAR baseline (with additional short baseline for ambiguity resolution) and a SECOR DME are to be used. By sequential gating of the shipboard transponders and of the servo-driven phase meters, the system will be capable of positioning three or more ships. To attain ranges up to 150 miles over water, transmitting frequencies will be in the 15 to 30 mc region. The system will provide real time plotting board data as well as high accuracy data which is needed for determination of the missile instrumentation system geometry.

P. MINITRACK

MINITRACK is the NRL system which will be used to instrument the satellite. This system is identical in principle to the COTAR System (without DME), but contains some unique features because of the requirements for satellite instrumentation. Most significant of these are: the airborne transmitter will operate at 108 mc at 10 to 15 milliwatts and will also serve as the telemetry carrier; the transmitter will be turned on and off by a keyer on the ground to conserve power when the satellite is not within range of the ground stations; and range to 1500 miles is required. The MINITRACK stations will be located in proximity to the prime optical stations, and in addition to precision angular history of the satellite will provide acquisition data for the optical stations.

Q. PARDOP

PARDOP (Passive Ranging Doppler System) is a reflection doppler multi-station type system similar to the DOVAP System. A 132.48 mc transmitter signal is beamed toward a missile or object and is reflected back to three or more ground receiver stations. A phase comparison of the reference signal and the reflected signal at each receiver yields a signal of a frequency proportional to the rate of change in pathlength from reference transmitter to missile and from missile to ground receiver. The data can be recorded on tape and film either at the ground receiver or at a central recording site. A phase lock type of tracking filter is used to improve signal to noise ratio. Space positions and velocity are obtained from the system. The data is expected to be resolved to 0.1 wavelength (about 0.76 feet in range sum).

R. EMA

EMA (Electronic Missile Acquisition) is a single station short baseline system which provides azimuth and elevation angles as acquisition data for optical instrumentation. Angular data is derived from phase comparison of the signal from the missile as measured at the ends of two 8 wavelength baselines. The baselines are perpendicular and intersect at the 3¾ wavelength point. An additional antenna at the intersection is used for ambiguity resolution. An analog computer provides real time acquisition information. The system has been established to use the DOVAP signal (73.88 mc), but may also derive its data from the telemetry carrier.

S. ELSSE

The Electronic Sky Screen Equipment employs a variation of either COTAR or DOVAP systems, when one or both of these systems is aboard a missile, to provide real time data for flight safety. The analog phase data is displayed on either a plotting board or a strip chart recorded to show deviation of the missile from the target line and vertical flight angle.

The COTAR is used as one baseline directly behind the launcher and one baseline off to one side. These are used to measure target line deviation and forward or backward deviation from zenith respectively. Each COTAR baseline is 50 wavelengths long and does not contain additional ambiguity resolving antennas.

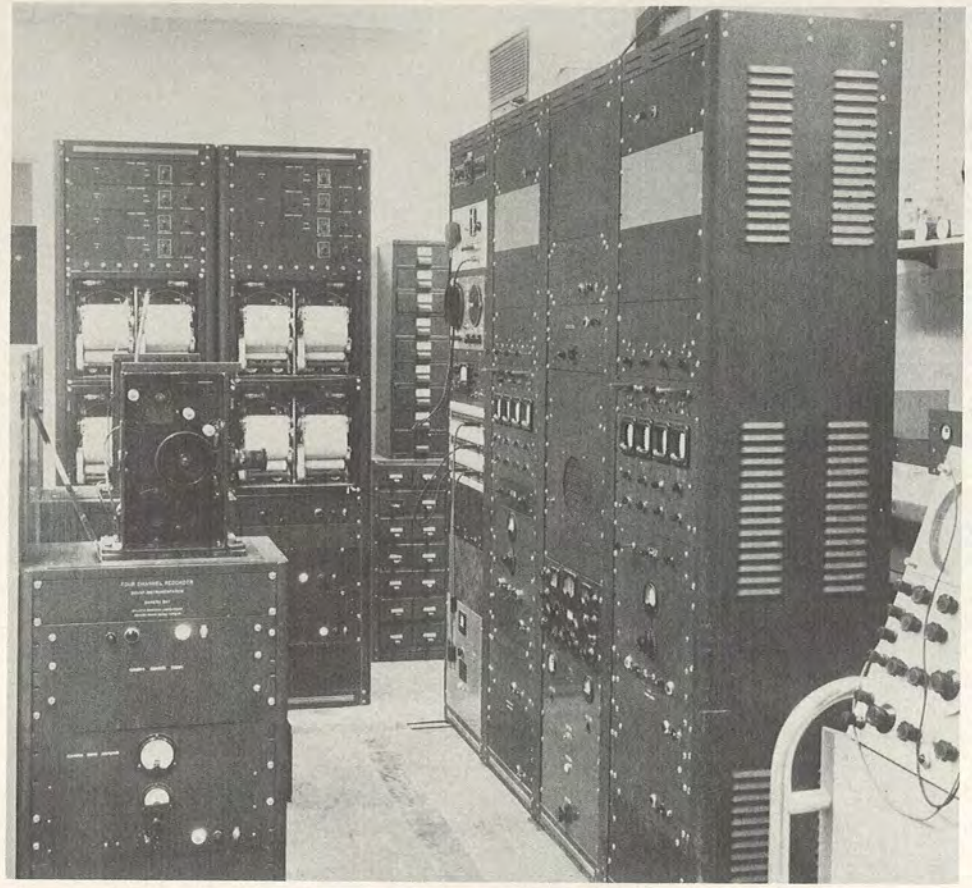
The DOVAP Beat-Beat System consists of two DOVAP receivers spaced 200 wavelengths apart on a baseline behind and perpendicular to the launcher. Phase comparison of the doppler beats from each of these receivers produces a measurement of angular deviation. An additional baseline may be placed off to one side and parallel to the target line to provide two coordinate data.

T. RADAR SYSTEMS

Radar is the classic example of the single station pulse measurement system. However, at the present time, most common use of radar is as a chain system composed of two or more stations each having from two to seven modified 584 type radars. The chain systems are used primarily for range safety and acquisition. The range safety function is accomplished by presenting real time position of the missile on a three dimensional plotting board. Missile position data is transmitted as acquisition data to other types of instrumentation which cannot track the missile during the launch or early phase of the trajectory.

Obtaining ballistic data is a secondary function of the radar. Data is of a low order of accuracy, being good to approximately one and one half mils in angle and 100 yards in range. The data however is in demand because it can be reduced within a few hours after the missile flight.

(next page, please)



CAMP RECORD

The principal recording station for the DOVAP system. Located at the Flight Determination Laboratory at WSPG, the station provides for both paper tape and film recording. The paper tape recorders can be seen in the left background. The cameras used for film recording are not shown.—(U. S. Army photo)

Many versions of modified 584 type radars exist, i.e., MPQ-12, MPQ-18, Mod-I, Mod-II, etc., however, except for range, these are not radically different. Maximum range of the modified radars is 400,000 yards whereas the original 584 was 84,000 yards and maximum power has been increased from 250 KW to 400 KW. Receiver sensitivity has been improved by using a modified preamplifier.

Recent advances in the radar field have included conversion of the Nike radar system to instrumentation use and development of the FPS-16. Both these systems will yield data more accurate than is presently obtained. Eventually, most 584 type radars will be replaced by the FPS-16. The FPS-16 is a high precision instrument and will yield data at least one order of accuracy better than the modified World War II radars.

U. FIRING ERROR INDICATORS

Since Miss Distance Systems are very numerous and quite varied and a descriptive report would in itself be a treatise, only some generalizations about the basic principles will be described.

Some of the material is classified and the summary will be given verbally, but not included as printed material.

IV. GENERAL

The outstanding advantages of Electronic Trajectory Measurement Systems are that the systems are relatively insensitive to weather, remote operation of all or parts of the systems is practical, the systems can be capable of handling almost unlimited range, and since the original data is normally in electrical form, the systems are easily adaptable to automatic data handling processes or to real time data reduction.

The chief difficulties encountered with the electronic systems are that the systems are not immune to atmospheric noise or interference and are ofttimes susceptive to refraction errors. Since the desirable frequency bands have become very crowded, there cannot be an unlimited use of new or expanding systems.

In planning for the use of Electronic Trajectory Systems, there are some factors which should be considered in determining applicability of the system to the range. These are:

A. It should be ascertained that the missiles to be

(next page, please)

instrumented can accommodate the transponder and antenna for the particular system.

B. The "single station" systems are a necessity where real estate geometrically suitable to the flight path is not available. On the other hand, the "single station" system may be both more costly and less adaptable to a range where the multi-station systems can be properly situated.

C. If multi-station systems are contemplated, the requirements for data relay links should not be prohibitive.

D. Consideration should be given to the frequency requirements to determine if there will be excessive interference, or if the terrain may cause excessive multi-path problems.

E. Systems may have better data for one type of trajectory than another and it should be ascertained that the system to be used is not weak for the typical trajectory to be measured.

F. The minimum as well as the maximum range measurements required.

G. The reliability and/or backup within the system.

H. Data processing complexity, time and cost.

I. Accuracy and resolution of the system as compared to data requirements, and cost of the system as compared to value of the data.

V. TRENDS AND AREAS OF CURRENT EMPHASIS

Current development of Electronic Trajectory Measurement Systems is most significantly emphasized in the following areas:

A. Refinement of the higher frequency systems to provide systems with little refraction error for high altitude missiles.

B. Further development of low frequency systems to obtain extremely long range instrumentation for lower altitude missiles and surface craft.

C. Incorporating into systems, means for automatic elimination of errors caused by refraction and variation of propagation velocity.

D. Obtaining more simplified means of measuring vector miss distance with a passive system, and since accurate miss measurements for high closure rates require the continuous sensing capability of electronic systems, to intensify MDI developments.

E. Devising systems which allow for easier mechanization of data handling and providing high accuracy systems which can be integrated into real time control.

F. Expansion of existing techniques to instrument multiple missiles or other objects.

G. Miniaturization of transponders to make the systems applicable to a wider variety of missiles.

H. Further improvement of systems to provide more immunity to interference and noise.

More recently, missile agencies have become aware of the need to consider instrumentation requirements along with conception of the missile, and to make specific provisions in design to include the instrumentation necessities. Ultimately, we should have systems in which trajectory, telemetry and real time control are a single integrated system.

MISSILE AWAY!

Goes to a Party

Mr. & Mrs. George Meredith

"Costume Prize Winner" Johnson

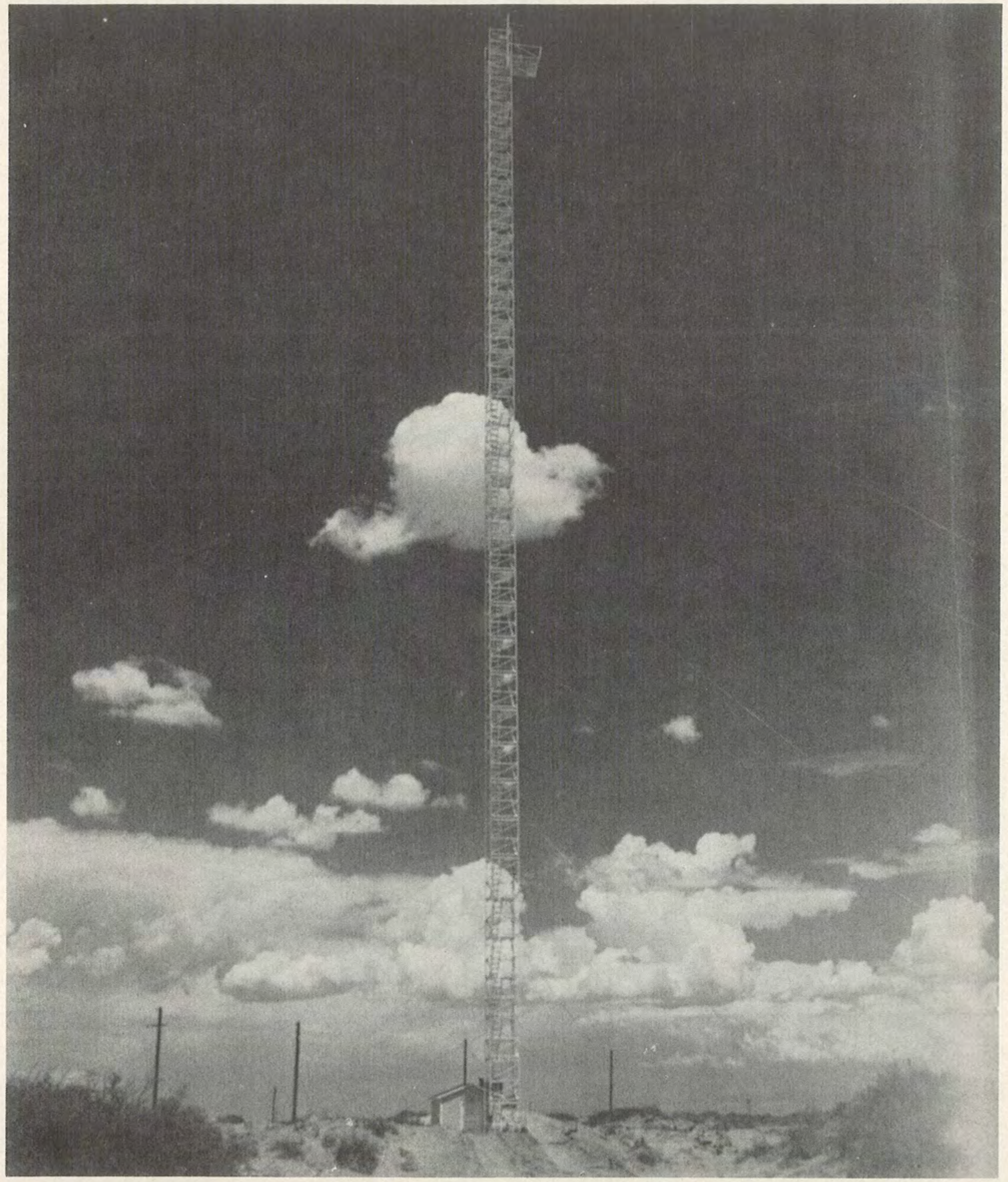
SECOND ANNUAL SPACE BALL

If you were invited and didn't come, you probably hate yourself. Those who came enjoyed themselves or at least gave a good imitation of people having a good time. The music was excellent and the dance floor was smooth. The costumes were few but showed ingenuity and planning. The pictures on these pages show a few of those uninhibited folk who came in costume. One couple, not photographed, came as angels, complete with wings. If you missed this one, now is the time to begin planning for the party next year when we will have the third annual SPACE BALL.

Louis Freudenthal & Ken "Space Casualty" Allin

Harry Stine, Alma Wagner & George Meredith

MISSILES and METEOROLOGY



Everybody talks about the weather but here we have a group of people who not only talk about weather but do something about it. They tie the weather into a firing schedule, in an effort to prevent the loss of time and money.

THE mission of the Meteorological Working Group for the Inter-Range Instrumentation Group is to interchange information between the ranges on common problems concerning instrumentation, including the operation, design, and development of meteorological instruments; and research "on meteorological problems which might have importance in the interest of National Defense".

Weather affects not only the personnel and tracking equipment involved in an ordnance test, but most important the performance of the missile itself. During the design stage of a missile, careful consideration must be given to the atmospheric conditions likely to be encountered, both during test procedures and for actual use in the field. For example, a missile that could not operate effectively in winds of more than moderate strength would be of little use in a war zone where strong cross winds were the rule. Therefore, meteorologists who have an advance knowledge of problems to be overcome can provide valuable consultation service concerning atmospheric factors that could influence design, operational planning, missile performance, and assessment of trajectory data.

The following are many of the miscellaneous relations of the atmosphere and ordnance:

1. Analysis of flight—Was missile in homogeneous air mass or were there pronounced density and wind changes, such as when a missile goes through a front?

2. Computation of air speed of missile from absolute trajectory.

3. Effects of atmospheric conditions upon launching and guiding mechanisms.

4. Development of ballistic wind and ballistic density tables.

5. Use of forecasted or statistically derived atmospheric conditions to insure that the missile will follow a safe trajectory.

6. Effects of atmospheric conditions on the skin temperature of a missile.

7. Drag, errors due to incorrectly computed or observed atmospheric conditions.

8. Effects of atmospheric conditions on sound transmission from explosions.

9. Forecasting or statistical computation of radar and radio atmospheric "ducts" in a blind area.

10. Computation of atmospheric structure in a "blind" area, lacking reports, for altimeter corrections on a bombing run, or for pressure-pattern guidance.

11. Effects of atmospheric humidity on infrared transmission and fuze tests.

12. Computation of lapse rates and density ratios in blind areas.

13. Effects of horizontal and vertical wind gusts on missiles and aircraft and probabilities of encountering such in blind areas.

14. Effect of wind on dispersion.

15. Computations of probable soil temperatures to be encountered by land mines.

16. Atmospheric refraction corrections for range photography.

17. Probabilities of occurrence of temperature, pressure, wind, etc. extremes, surface and aloft, over operating areas.

18. Effects of ambient temperature and radiation on propellent temperature and radiation on propellent temperature.

(next page, please)

19. Atmospheric "boils" and photography.

20. Computations of standard deviations of winds aloft over ocean areas and probabilities of certain wind shears occurring under given surface conditions.

21. Forecasting of condensation trails of aircraft.

Items of discussion at the initial meeting of the Meteorological Working Group held at Naval Ordnance Test Station, China Lake, California, 22, 23, 24 May 1956 follow:

I. REQUIREMENTS OF USING SERVICES.

A. *Question:* How do Range Contractors present their requirements?

1. Naval Ordnance Test Station: First, a project proposal that is to be conducted at Naval Ordnance Test Station is submitted to the Bureau of Ordnance, to Commander, NOTS, to the Test Department, and then to the Project Engineering Division. An Experiment Specification is then issued prior to date of test with the requirements listed. A typical Experiment Specification might call for surface and aloft wind, pressure, temperature, humidity and density, increments desired and levels. Another calls for winds along trajectory of firing line with east or west components, which are taken by three double theodolite soundings from balloons released at different intervals.

The contractors usually beforehand, state their requirements. In this respect they are usually guided by NOTS Project Engineers as to what can be given. Most seem satisfied, although some desire more accurate data than we can give them at present.

A scheduling meeting is held once a week to determine what tests will go, resolve conflicting times and determine the coverage they can get. The schedule is firm for a week ahead. For projects of any magnitude a preliminary report will be issued and giving as much time as deemed necessary to give the supporting services notice of requirements.

2. Patrick Air Force Base: At Patrick there are four stages leading to presentation of requirements:

a. A preliminary survey by the Commander to see if a project can be handled.

b. If he gives the go-ahead, the project officer visits the people concerned. An estimate is made and outlined in a booklet entitled "Project Guidance".

c. Then test requirements are written up. A "Range Handbook" gives an outline of instrumentation required. This is sent to the base where a "Data Acquisition Plan" is made and sent "upstairs" where the final Test Plan is written up as firm. One to six months prior to arrival on base of the project, an "Operational Requirements" is written up and sent to the Base. This is the basis for the fourth and final stage.

d. O. D. (Operational Directive) is written which outlines every phase in detail and is followed to the letter during execution of the project.

3. White Sands Proving Ground: Requirements presentation is essentially the same. Approval by all concerned is gained before program is submitted to range for test. Personal contact is made whenever possible to have requirements spelled out ahead of time.

4. Edwards Air Force Base: Requirements presentation also similar. Aberdeen Bombing Mission, NCA, and plane contractors ask for rawin support for each run, winds, temperatures, pressures and densities. Rawin is a transportable radio direction finder designed to automatically track a balloon-borne radiosonde transmitter. This system is used to make atmospheric soundings which comprise measurements of wind speed, wind direction, pressure, temperature, and humidity throughout the vertical extent of the sounding.

5. Holloman Air Development Center—Extension of White Sands Proving Ground, have a "Program Review Information Sheet". Contractors establish requirements and also firing limitations. This information sheet is usually preceded or supplemented by personal contact with the contractor.

6. Rest of group present indicated that methods already stated covered their procedures quite well.

B. Application of data by user. Not as much knowledge of this subject by the group as would seem profitable was generally displayed. It was brought out that sometimes data requested by the user is not necessarily what he needs or could best use. Also, some weather units had made definite efforts to get this information with little success. It was stated at one Base much use of temperature was made in computing Mach number and correcting for diffraction. In ballistics, both pressure and wind were important. How this data is incorporated and its weight compared to other factors should be known by the weatherman in order that he can more definitely know the accuracies required. This indicates personal research into the ballistics and missiles field by the weatherman. At Sandia Base after winds are reduced to a graph, they are fed into trajectory problems on a one to one basis, demonstrating the importance attached to this factor.

C. Tolerances of data acceptable to user. There are varying tolerances requested, but in general the tolerances as given for the GMD-1A Rawin Set Signal Corps Tests and Sandia Corporation were acceptable. A few requests for wind to 1 foot/second and one degree, temperatures within 1° Centigrade to 100 millibars pressure, and 0.3 of 1% error in altitude.

II. PRESENT ABILITY TO MEET REQUIREMENTS.

A. *Instrumentation and techniques employed.*

1. Naval Ordnance Test Station, China Lake, California.

Use standard rawinsonde, single and double theodolite balloon soundings, smoke puffs for specific level winds and surface observations with mostly standard, some slightly modified, equipment. Coverage is tailored to the test if possible to give more accurate data. Can meet present requirements quite well, but accuracies asked for on some future tests are beyond the limits of present equipment.

2. Patrick Air Force Base.

Using rawinsonde, surface observation, double theodolite balloon soundings, upper air observations from plane. Low level winds are critical. Everything is reduced to graphical form and submitted to the data reduction unit. Can use GMD-2 Rawin Sets, a modification of the GMD-1A Rawin Set, as soon as they are available. This is true of all the ranges.

3. White Sands Proving Ground.

Using standard equipment with two sites on a north-south plane. Taking simultaneous soundings which with others in the area allow analysis of the area through use of "D" values, differences between actual pressure and standard pressure values. It is done this way to eliminate space variability. It is believed that this will bring about

(next page, please)

a 30% increase in accuracy. Tolerances of GMD-1A Rawin Set are published for contractors and they seem satisfied at present.

4. Holloman Air Development Center.

Works closely with White Sands Proving Ground. Have started a 4 hour rawin release schedule interpolating data between.

5. White Sands Proving Ground.

Signal Corps tests equipment for field services. Take detailed surface winds with varied types of operations, double theodolites, drag cord anemometer, thirty aerovanes. Better data is always being requested, resulting in an attempt to get new and better equipment.

6. Edwards Air Force Base, using standard equipment plus a three cinetheodolite network for reduction of data. The main mission is to provide data for flight tests. Supports Air Weather Service with regular run plus runs for flight tests and Aberdeen Bombing Mission. Requirements apparently met but data is sent to Pasadena and how it is used is not known.

7. Naval Ordnance Missile Test Facility has a time problem. Wind data is needed for preflight checks and also at time of firing. Preflight has to be taken and worked up in a very short time. Gustiness near surface is a problem. Discussed some classified work and problems.

8. Eglin Air Force Base supported mainly by Air Weather Service rawins and pibals (pilot balloon soundings), and uses an MSQ-2 (modified 584 Radar Set). The Air Proving Ground range requirements are not stringent. Have a chaff program in progress for more accurate winds. Have a micro-network of towers using Beckman-Whitley instruments telemetered into recorders in a van. Automation is believed to be the most important future development in gathering and reducing data.

9. Sandia Corporation gathers, reduces and applies data. Have some ordinary and some very stringent requirements. Tests have been run on GMD-1A Rawin Set using phototheodolites and will be run at intervals. Use GMD-1A Rawin Set, 403 Mc Radiosonde and 584 Radar Set. Radar data is ordinarily used if smooth. Projects are underway to further automation.

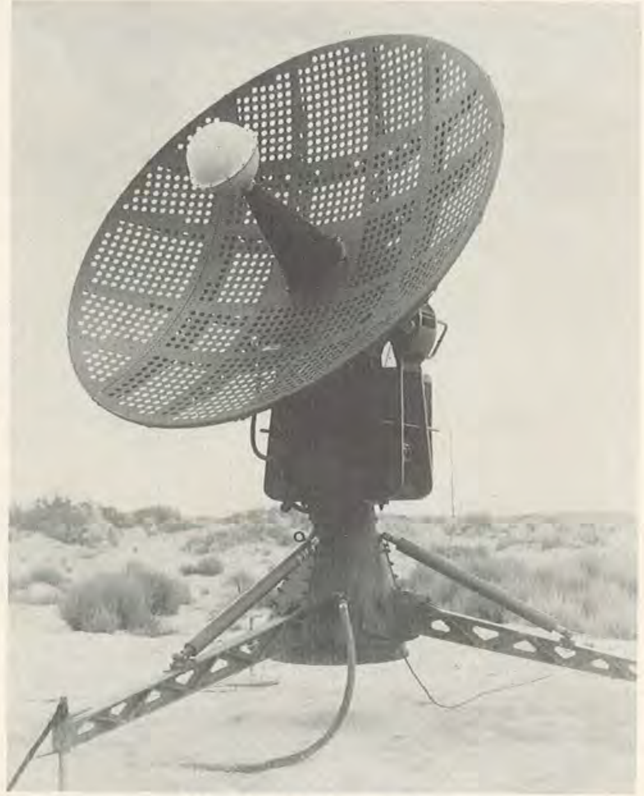
10. Signal Corps Engineering Laboratory. Job is meteorological support and producing tactical equipment. Laboratory can provide better instruments, but the field instruments are a compromise between what can be provided and those cheap enough for field use which will give satisfactory results. These results may not necessarily be satisfactory for test range work. A very interesting discussion of work in progress and methods show that very promising developments are in the mill. Also results of some work in test phases has already been published. There were numerous questions on measuring winds, capabilities of balloons and other equipment, and causes of failures answered in this session.

III. REDUCTION AND PRESENTATION OF DATA

Several methods were presented. In general, data was presented in the increments desired by the user, if at all possible. It was shown that other than standard methods were constantly being devised to give more information with less manpower involved.

A. *Some of the methods discussed.*

1. IBM reduction of double or triple theodolite winds. In some cases this is not feasible because of the necessity of getting winds as soon as possible.



Weather Radar Antenna

2. Double theodolite reduction on plotting boards. Two methods in this line were discussed.

3. Reducing all data to graphical profiles from which data reduction unit can pick any increment that users desire.

4. Use of spatial mean soundings to eliminate variability.

5. Some Automatic Reduction with Rawidar.

6. Presentation on a standardized form is the general case, with increments as desired by user.

IV. FUTURE NEEDS

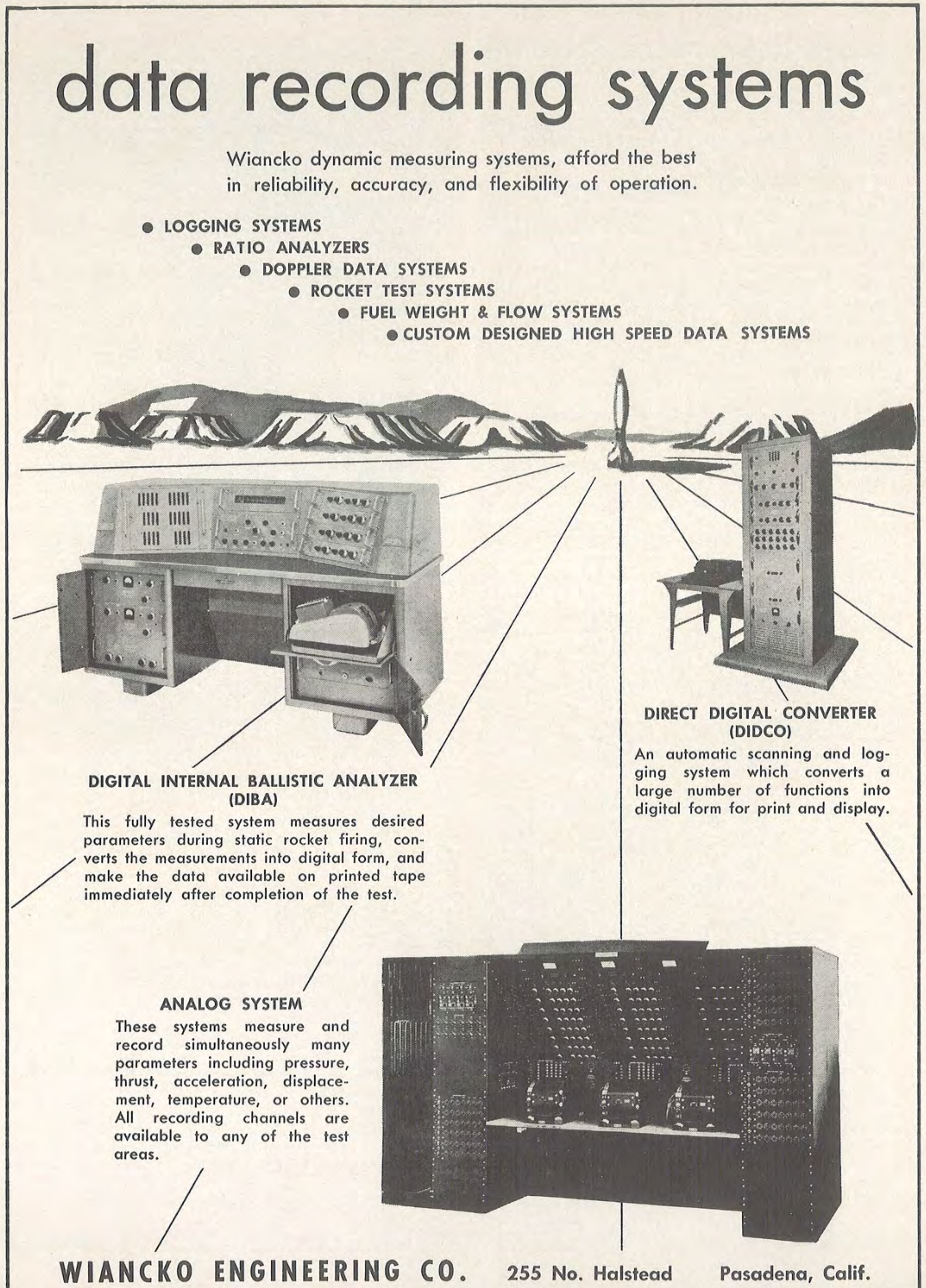
A. Make it known to the Steering Committee and Range Commanders that they do have weather support.

B. More emphasis on preplanning.

C. Need for better pressure data at high altitudes. It was brought out in this respect that the pressure height curve depends on the accuracy of the temperature rather than the pressure. The hypsometer, an instrument which utilizes the vapor pressure vs. temperature characteristics of a liquid in the measurement of ambient pressure, offers improvement along this line, thus giving better heights for wind computation.

D. A more dependable humidity element. A measure of radiation may be the solution to this problem. Another idea was to develop a good densitometer, an instrument to indicate density, and work backwards for humidity. The refractometer, measures refraction, was reported as being accurate, but very delicate and measuring a tremendous amount of data change. Another idea was independently measuring height and temperature to get vapor pressure.

(page 27, please)



METEOROLOGY—

E. A specialized analog computer for fast reduction of winds.

F. Need accurate method of observing and predicting visibility in a 20 to 50 mile range for optical work, at present no satisfactory instrument has been developed to measure visibility. This problem is being attacked by the Optical Group at Eglin Air Force Base with no conclusive results as yet. Mr. Arnold (Signal Corps) stated that research is being done on particle size and number, but would need a lot more work to tie it into a visibility study.

G. Standardization of test ranges. If new and better equipment and method are devised, all the test ranges should have them. Even standardized equipment may need modification at different ranges.

H. More automation because of manpower shortage. Instruments designed to give the answers without computation.

I. Better methods of reproduction.

J. More intense "pilot balloon" lights or different colored balloons for dawn and sunset soundings. It was pointed out that at present there are five colors of 30 gram balloons available. Only three types are generally purchased.

V. SUGGESTED IMPROVEMENTS

A. More automation of equipment.

B. Standardization of equipment for test ranges insofar as feasible.

C. Better reproduction methods.

D. Expendables to fit the job rather than those for general field use.

E. Handbook of existing facilities at ranges with automatic distribution to members.

1. It was stated that Patrick Air Force Base has a small wind tunnel, Naval Ordnance Test Station, China Lake, California, has a Standards Laboratory, an All-Weather Laboratory, and Edwards Air Force Base has almost anything desired.

VI. RESEARCH PROJECTS

A. Getting spatial winds "xyz"—research is being done by White Sands Proving Ground. Was pointed out that a method of getting small scale winds by photographing smoke puffs against a grid on a balloon has been devised. Research on acoustic anemometer is in progress.

B. Eglin Air Force Base Optical Group conducting visibility studies.

C. Naval Air Missile Test Center, Point Mugu, California, doing research in radio propagation.

D. Naval Ordnance Test Station, China Lake, California, has proposed a project to conduct further research on the tropopause and jet stream over that area.

NOTE: It was pointed out that most of the ranges were operational and research work was conducted by research agencies under contract to the government, or by other members of their organization.

VII. RECOMMENDATIONS

It can be seen that all of the items listed under "Future Needs" and "Suggested Improvements" could be rephrased and included under this heading. In addition or in repetition are:

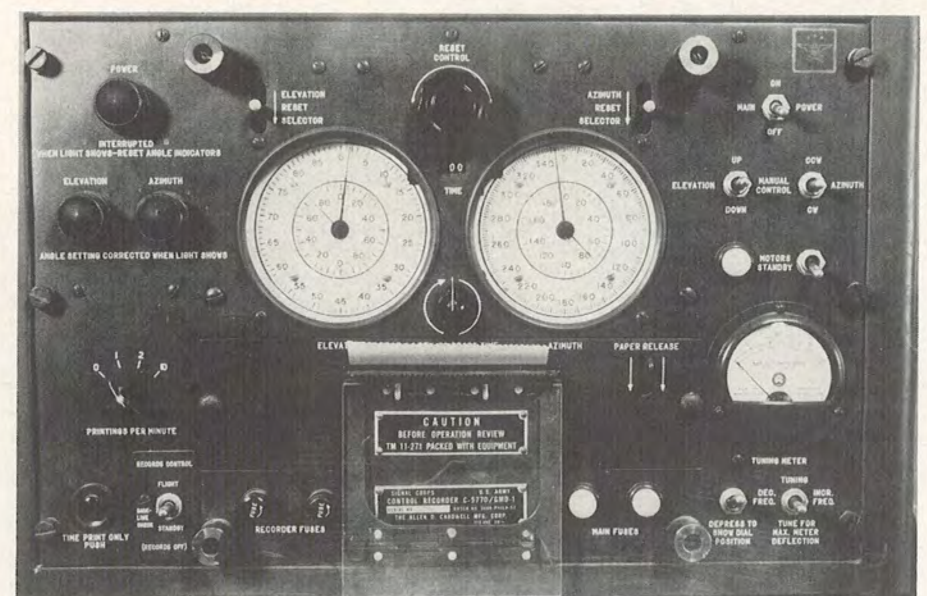
A. Weather groups on these ranges are supporting tests involving a tremendous amount of money and should have the green light to obtain the best equipment and expendables available in order to give the best service. Should tie in with long range plans.

B. Let the Steering Committee and Range Commanders know that they do have a Weather Support and should utilize it to the fullest extent.

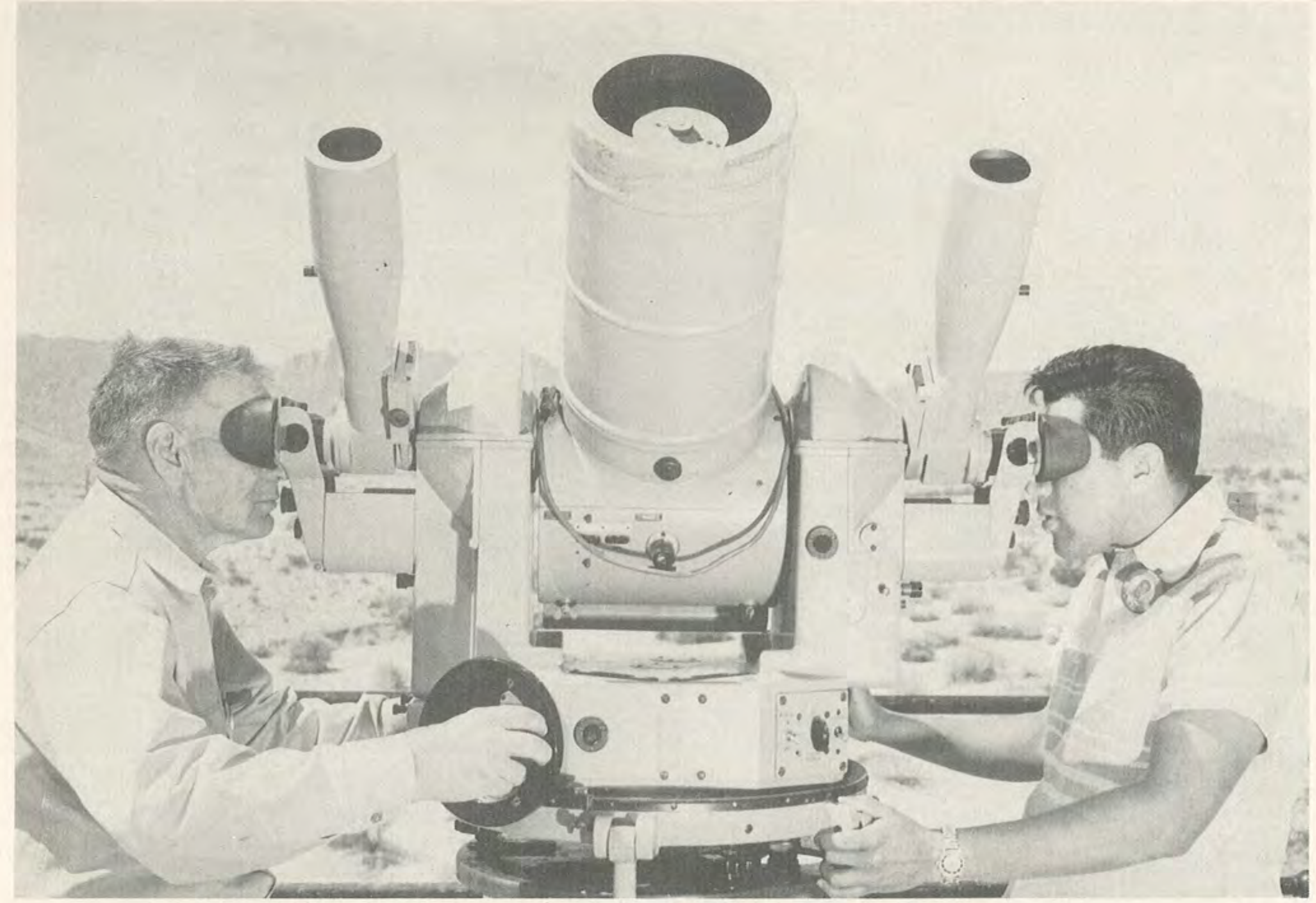
C. Personal contacts should be made between Project Engineers and Weathermen to determine how needs can best be met.

D. More lead time should be given in preplanning to determine requirements and get equipment necessary to meet them.

E. Bibliographies of pertinent publications be circulated to all member ranges and kept up to date. Also, list equipment that could be loaned to other ranges for short periods.



WEATHER DATA RECORDER



OPTICAL SYSTEMS

Beyond bi-focals and baby Brownies

The Optical Systems Working Group is an outgrowth of a plan to coordinate the present efforts in the field of optical instrumentation and to disseminate the information gained from research, development and field test of both techniques and equipment.

The need for the exchange of information and the coordination of efforts exerted by the various ranges is a direct result of the demands for increased knowledge of the behavior of potential weapons in free flight. Initially, during the era of muzzle fired projectiles, the problem of determining the essential characteristics of the projectile such as muzzle velocity, attitude, initial trajectory and rate of deceleration were solved through the use of sky screens and attitude cards. With the advent of the rocket the instrumentation problems became more numerous. To be sure the characteristics required in gun fired projectiles were still of interest. In addition, many new problems were encountered that were beyond the capability of the instrumentation then in use. New problems, for example, arose in connection with a desire for more detailed knowledge of the trajectory during the accelerating period. Ballisticians required a knowledge of the velocity and acceleration, the burning distance and time. The aerodynamicists needed detailed information concerning the stability of both roll stabilized and fin stabilized projectiles, the spin velocity and many similar parameters.

The new problems presented a definite challenge to the range instrumentation personnel. In their early endeavors

(next page, please)

they attempted to solve all problems through the use of the photographic process. As time progressed, new techniques were investigated and tried to the extent that today we have augmented the optical approach with such diverse techniques as telemetry, pulse radar and C. W. radar.

Each one of these systems is plagued by limitations imposed by the atmosphere. The optical systems suffer from variations in the transmissivity of the atmosphere which at times completely nullify their utility. Electronic systems suffer a much greater loss in accuracy than optical systems because of the marked increase in tropospheric refraction at radio frequencies and the deleterious effects of the ionosphere. The net result is that no one system will solve all of the problems. One must be prepared to utilize the capabilities of all systems to effectively operate a rocket or missile test facility. It is indeed fortunate that most of the test ranges have recognized this factor and are supporting a well balanced program in various fields of instrumentation.

In this work each range is faced with its own specific problems that are to some extent unique to that particular range. The uniqueness is associated with the climatology, the geography and the type missile programs encountered. Despite these differences, a great number of problems fall into a common area. To most effectively utilize the manpower available at the missile test ranges, to profit by the successes and failures of the other activities and to economize on the funds expended in the field of instrumentation development, it is essential that good coordination with a free exchange of information be maintained between the cognizant individuals at the various ranges. Wherever practicable, requirements of the various ranges should be consolidated into a single course of action. The Range Commanders, recognizing the need for better coordination among the missile test ranges, authorized the establishment of IRIG. As the organization took hold, it gained the enthusiastic support of the management groups of the three services, and attracted the interest of organizations seeking information concerning missile instrumentation techniques and equipment for application to associated fields of endeavors.

The Optical Systems Working Group is that element of the Inter-Range Instrumentation Group which deals with optical data collection devices and their associated equipment. The group advises other groups on problems involving the design or use of such devices, either as individual units or as data collection systems. The group, today, is a healthy organizational component of IRIG. It has experienced a steady growth in membership and activities represented. Our last meeting, held at Naval Proving Ground, Dahlgreen, for example, consisted of representatives of 15 military establishments. Attendance reached a total of 44 individuals present. The group has grown also in the manner in which various problems are approached. As is generally the case in the early association of men with a common interest, the Optical Systems Working Group members went through a learning process wherein each range discussed its accomplishments in the field. As we listened to the other man's approach to a problem similar to one that we faced, we learned something that we could apply, at least in part, at our home station. Gradually, we brought our more difficult problems to the group and were assisted by the collective thinking of the experts in the field. Through these sessions we learned to understand and respect our fellow members. Of equal importance, we learned to recognize that our own individual problems were not quite as unique as we had once believed. Having passed this hurdle, we were ready to start pooling and cataloging our problems; to isolate those areas where group action might conserve manpower, eliminate duplication of effort and produce a more effective instrument. Specific cases of this type of action are readily found in the minutes and documentation of the OSWG. For example, one of the first problems we tackled was the coordination and resolution of a number of problems associated with adapting the Askania Cine-Theodolites to the specific field and data requirements of the various ranges. Through the close teamwork maintained between the Management Groups of the three services, as well as the appointing of a single Project Engineer to represent all three services, the way was cleared for a frank discussion of the problem within the working group. The group diligently tackled this problem, many times working in regular sessions during the late hours of the night. The outgrowth of this effort has been:

1. The incorporation into the Kth 53 instrument of built-in flash lamps to which the camera shutter could be synchronized, thus eliminating second order errors introduced by erratic tracking.

2. The incorporation of time presentation on each frame of the film taken by the camera thus eliminating the time spent in correlating the records of the various cine-theodolites and referencing them to range "zero" time.

3. The simplification of data presentation on the film, and a gain in accuracy through the use of an improved vernier presentation.

4. Improvement in wiring and increased slip rings to handle the timing an flash lamps control circuits.

5. The improvement in reliability and useful life of the camera movement.

6. The modification of the aperture plate to eliminate the confusion that existed when one attempted to find a small image on the film in the presence of dust specks.

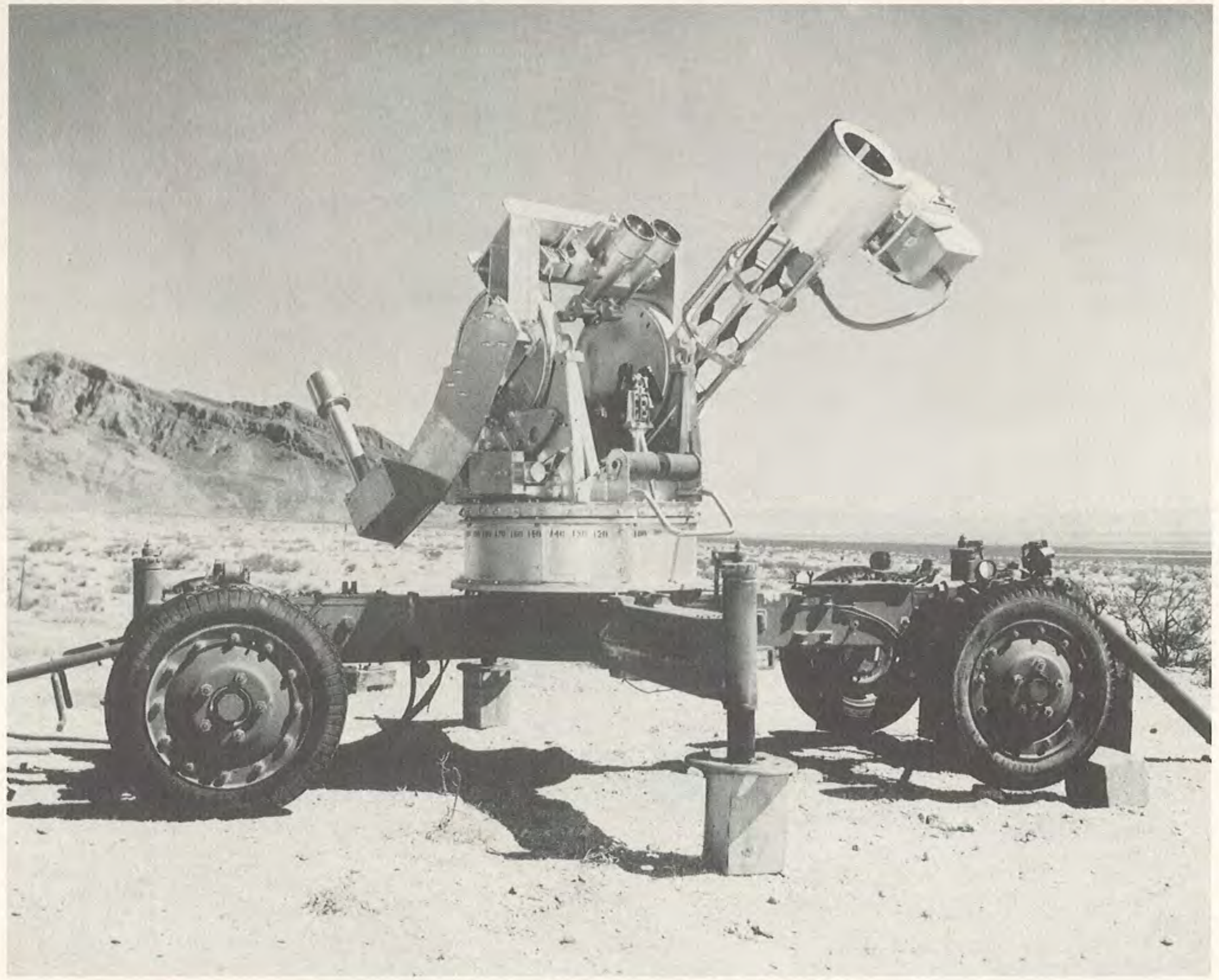
7. The improvement of sighting telescopes in optical design and mechanical mounting. In addition, provision was made for a change in power to permit optimizing the apparent object size and the prevalent attenuation and shimmer in the atmosphere at the time of operation.

8. Provisions were made for the use of interchangeable optics so that the instrument would be adaptable to both the problem of aircraft tracking and small missile tracking.

Most of the above changes have been completed and are in use in the field. Some are going through the final stages of engineering and fabrication to adapt them to equipment already delivered. Despite this work, cine-theodolites still appear as an item for discussion at each session of the working group since many problems still exist that are vital to the efficient and reliable utitlity of the data from this type equipment. We have, for example, the problem of maintaining background density on the photographic record at a reasonably constant level.

All photographers are aware of the variation in sky brightness from zenith to horizon and from east to west

(next page, please)



MOBILE TELESCOPE (Events & Attitude Recording) STATION

and still photographers normally compensate for the variation by adjusting the relative aperture of the lens system. In the case of tracking instruments the necessary adjustment is difficult to make and thus we find that an average setting is generally made. This average setting, coupled with the use of high contrast films generally used in missile is tracking, produce a marked variation in film density as a missile is tracked along its trajectory. The variation in density detrimentally affects the success of our data reduction personnel in finding the missile images. Through the efforts of the OSWG and its member ranges, various approaches to this problem were tried and compared. For the most part, our requirements have been consolidated and a concerted effort is being made by the Air Force Armament Center to effect a solution that will benefit all users of cine-theodolites and allied instruments.

The problem of automatic data readout of both main scales and boresight correction has received serious consideration by this group. A survey was made of the state of the art, the problem was discussed within both the data reduction and optical systems groups and action is presently under way in developing and adapting the more promising schemes to field instruments. Without detracting from the present efforts being exerted in this field, I would like to emphasize the fact that this problem is perhaps one of the most serious problems facing the test ranges today. Although particularly serious in the field of optical instrumentation due to the numbers of tracking instruments involved, the basic problem concerns all tracking instrument systems and many data reduction organizations both within the Government framework and in the various contractor organizations. It would therefore appear desirable to set up a special ad-hoc group to thoroughly study the problem from all points of view. This group could forward its recommendations and findings to IRIG for consideration and action by the management representatives of the three services.

The problems of increasing the reliability of acquiring a target with optical tracking equipment and of improving the time on track through broken cloud foreground have been with us for many years. Through discussions of the

(page 33, please)

OPTICS—

group, interest has been stimulated and ideas exchanges to the point where today several devices exist, at least in prototype, that are capable of indicating an error tracking signal to the operators. One system is under development for automatically slaving optical trackers from a remote external system. Upon completion of the prototype equipment, it is planned to run an evaluation and comparison tests of the automatic and aided manual modes of operation. It is planned to again review this problem within the group following the evaluation in an effort to determine the extent of the requirement for this type equipment and the course of action to be taken by OSWG.

These problems and others like them are by no means solved. They are, however, recognized as problem areas, have been discussed within the OSWG, requirements have been consolidated, and development is under way within the framework of the member ranges to provide workable solutions. Optical and instrumentation experts at some of the member ranges have been critically examining their problems of range instrumentation in terms of equipment and manpower. They very early recognized that the existing approach consisting of a multiplicity of highly specialized equipment dispersed along the ground, and requiring separate tracking personnel and support facilities, was not only wasteful of manpower in the field. It presented another, perhaps even more serious problem. A bottleneck began to develop in data reduction that was aggravated by the time required to correlate position data from one set of equipment with the attitude and documentary records obtained by other equipment. Further complications were added by the requirement of both high speed and extended time coverage of missile programs. An analysis of the problem indicated the logic of utilizing a single highly precise large mount to handle both the triangulation problem associated with position determination and the attitude and documentary requirements. Data from the various cameras could be time correlated to a high degree of accuracy through the use of both synchronous and pulse cameras operating from a single unit per station.

While the above work was going on, groups at other activities were investigating the tracking and mount stability problems associated with the use of high powered optical systems involving feed lengths up to 500 inches. Through discussions in the working group, it became apparent that, although the final configuration with regard to optical systems and cameras were different, the two systems had a great deal in common with regard to the base or mount structure. Further, it was recognized that such a mount had definite utility in other fields of ground based missile instrumentation.

Recognizing the above points of apparent similarity, the IRIG instructed OSWG to bring the various groups together and investigate the feasibility of consolidating the various programs as far as possible.

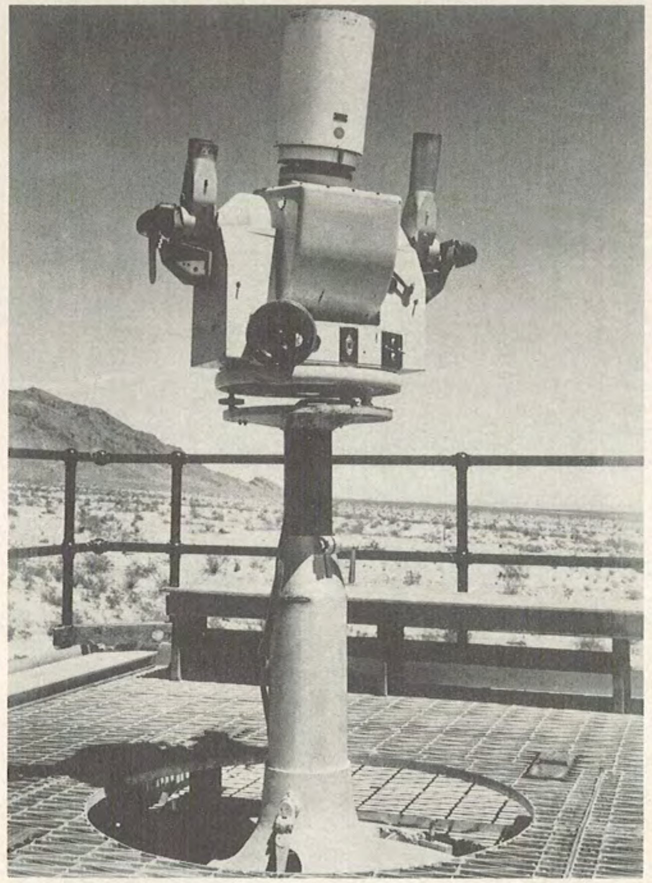
Upon receipt from the working group of the military requirements for a consolidated mount that incorporates sufficient flexibility to accept a large telescope or a number of smaller instruments, IRIG instructed the group to prepare a technical exhibit for ROTIM, a basic Tracking Instrument Mount. At about this same time the Optical Group became aware of a Small Missile Telecamera Mount under development at the Army Ballistic Research Laboratories, Aberdeen. A representative of OSWG visited BRL in May this year and BRL personnel attended the last OSWG meeting at NPG, Dahlgreen. During these discussions, it became apparent that some concern existed as to the suitability of the SMT mount as a ROTIM substitute. In analyzing the characteristics of the SMT, it was recognized that the instrument may very well meet the immediate needs of many ranges. Further, the SMT is almost ready for use. It must be pointed out, however, that the SMT will not meet all of these needs either with regard to tracking rates or in regard to precise coordinate measuring instrument. Since ROTIM is a composite exhibit that grew out of present and projected requirements of the member ranges and was considered desirable by all participating organizations, it follows that ROTIM as specified will meet these requirements and may well meet future requirements of other ranges.

Accordingly, the OSWG has recommended to IRIG that continued support be tendered to the ROTIM development to whatever extent possible.

In accordance with the increasing requirements for more extensive and/or more accurate data, the personnel in the various phases of the instrumentation art have began to more critically examine not only their instrumentation but also the manner in which the instruments are used and the environment to which they are subjected. It is the concensus of our group that the electro-magnetic frequencies in the region of 6×10^6 megacycles have by far the greatest potentialities for determining the true direction of a target from a point of observation. To utilize this potentiality, we must put special effort into both controlling the mechanical precisions of the guiding and supporting structure and in understanding the instrument environment. Previous studies have clearly indicated that optical instruments must be raised above the region of high turbulence near the ground. It has been agreed, for the most part, that the optical line of sight should be raised approximately 25 feet above existing terrain. Yet despite this agreement, the structures utilized by the various ranges are of entirely different designs. While this problem is beyond the scope of the Optical Systems Working Group, it is mentioned here with the hope that the same general type of coordination that exists among the member ranges in the field of instrumentation might be extended into the field of structures and facilities.

The protection of the instrument from the deleterious effects of differential solar heating has in recent years attracted serious attention. The group, acting through an Ad Hoc Committee, has looked into the problem, compared the requirements against equipment available from industry, compiled a summary of the requirements and made recommendations for the OSWG direct to IRIG. In this and similar cases it would appear that a mechanism must be set up between the IRIG and the management representatives of the Bureau and Command levels of the three services to effect a mechanism of procurement of items common to the field of instrumentation. It would appear that such an arrangement could save the government a great deal of money and professional time spent in preparing necessary procurement documents and monitoring separate contracts.

(next page, please)



OPTICS—

In conclusion, I would like to point out a few observations that I have made in the few years the group has been active:

1. The group is quite obviously fulfilling a need in the field of range instrumentation, as is evident by a steady growth in the number of stations represented in our meetings.

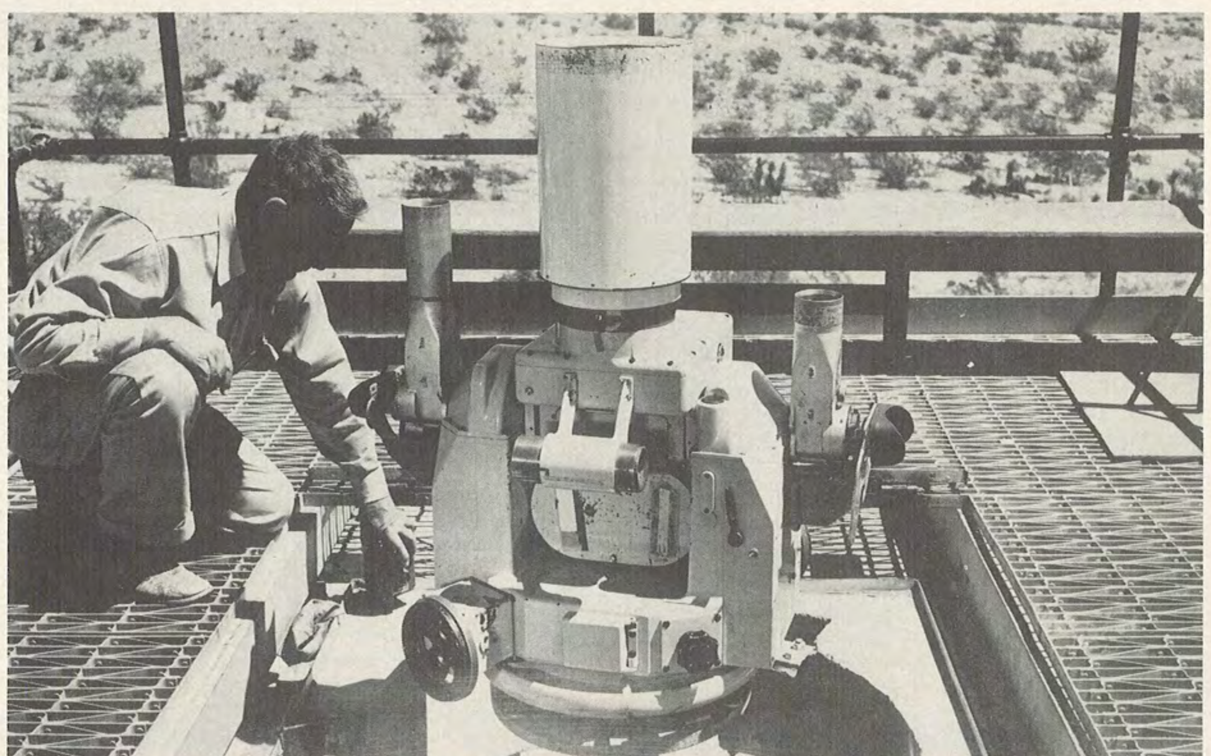
2. The group is conscientiously attempting to solve many problems in the field of optical instrumentation. The establishment of Ad Hoc Committee in several fields of effort and the agendas for each meeting clearly indicate the extent of the effort.

3. Despite the work accomplished to date, we appear to be recognizing new problems faster than we can solve them.

4. We need to improve our working arrangements with other groups. Joint meetings do not appear to be the answer in view of the greater demands for travel. Perhaps we all need improved coordination at home with our corresponding counterparts in other working groups.

5. A mechanism is needed to facilitate the conversion of ideas and recommendations originating at the working group level to action.

U. S. Modified Hi-Speed Cinetheodolite



W.S.P.G. Station Chief Elevating Instrument with Hydraulic Hoist to Operating Position.

STATUS of the FREQUENCY COORDINATION PROBLEM

According to the policy statement issued by the Interrange Instrumentation Group (IRIG), the Interrange Frequency Coordinating Group (IFCG), is charged with recognizing, studying and recommending solutions to frequency coordination problems as they affect the operation of range-type instrumentation. The Group advises other working groups regarding transmitter and receiver characteristics to insure minimum interference between instrumentation and other devices emanating or receiving electromagnetic energy.

In a sense, the area of instrumentation with which the IFCG is concerned is the frequency spectrum itself, or that portion which is utilized for transmission and reception of information. Currently, the area of interest extends from a few hundred kilocycles to approximately 40 kilomegacycles. As the state of the art advances, these limits will undoubtedly be extended. To define the area of interest more precisely, it is necessary to analyze, step by step, each factor which contributes to spectrum utilization and its attendant problems. For simplicity, frequency coordination can be separated into two distinct phases, administrative and technical. The technical phase, being more straightforward, will be discussed first.

As you are all aware, the radio spectrum is exploited for countless uses, including: communications, data transmission, telemetry, missile tracking and control, flight safety, velocity measurement, miss-distance measurement, altimeters, navigational aids, television, instrumentation initiation and many more. Transmitters and receivers may be air-borne or ground-based, fixed or mobile. Transmitted power may be of the order of megawatts or microwatts. Modulation schemes are many and varied.

Despite these variations there are, fortunately, a few basic parameters that are common to all systems. First in importance, perhaps, is the amount or type of information desired. Systems may require extremely broad or relatively narrow bandwidths. Common practice usually results in systems whose omitted spectrum is much broader than is actually required for adequate transmission of data. In many cases, this condition is due to state-of-the-art limitations. In the majority of cases, however, this waste of spectrum is simply due to the fact that no effort has been made to utilize minimum power or emission bandwidth. Time, too, is a factor. Requirement for continual 24 hour operation raises many more problems than a need for just a few minutes of range time. Time sharing is a standard technique of all frequency coordinators.

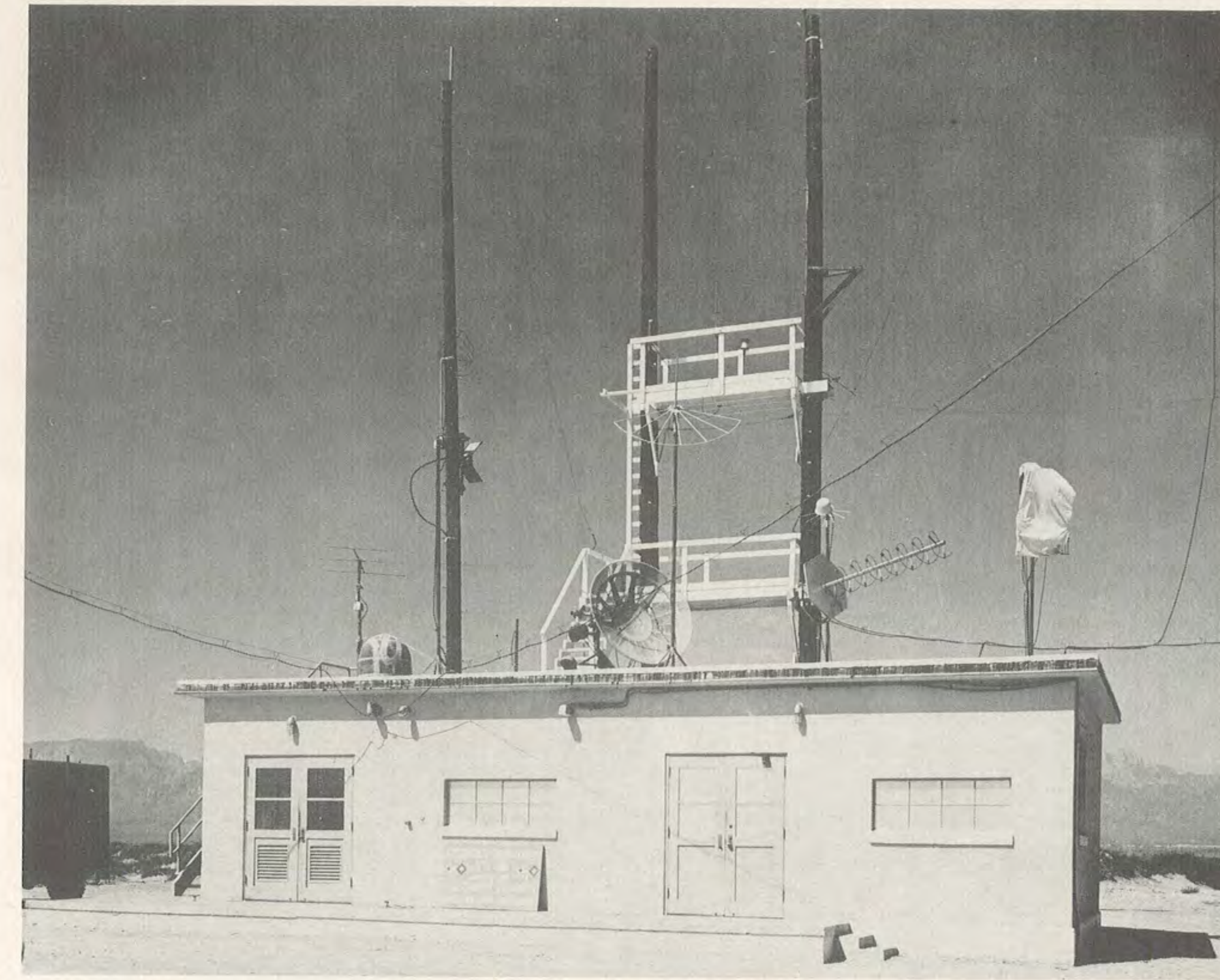
Geography is also a prime consideration. Terrain and distance considerations frequently aid the coordinator in permitting operation on identical or adjacent channels.

Associated with the transmitter or transmitting system are several characteristics or parameters: operating frequency, tuning range, power, emission bandwidth, coding, type antenna, spurious radiation, transmitting antenna characteristics, etc. Tuning range can be quite significant. If a system is committed to a single frequency or narrow band, conflicts can be quite serious. If flexibility in choice of operating frequency is available, effecting of coordination is generally simplified.

But, the receiver is, perhaps, the heart of the technical problem. For, it is the receiver or receiving system which experiences the interference. Associated with the receiver are a number of parameters: the RF and IF bandwidth, the selectivity and sensitivity, the spurious responses, characteristic of the receiving antenna and a more difficult quantity to evaluate, the susceptibility to interference, which is a function of all of these quantities.

Interference is a catchall word, frequently heard at proving grounds, and has many connotations. A communications circuit may be "jammed" to such an extent that it is unusable. Such a condition may involve considerable

(next page, please)



Fixed Frequency Monitoring Station

loss of manhours, it may result in the delay or cancellation of a mission, it can even result in damage to property or loss of life. Interference to data transmission systems such as radar tracking, telemetering or DOVAP, can destroy valuable data, resulting in a wasted missile test. Since the cost of many missiles is of a high order, it is easily seen that loss or deterioration of data is of considerable concern. The results of interference to control or flight safety systems can be well imagined.

It is also interesting to note that many reports of interference are due to equipment defects, improper adjustment or adequate performance on the part of the operator. The human factor will always be with us, but even here steps can be taken to simplify equipment so that human error will be less likely.

But, it is the "system-bandwidth", the actual amount of spectrum required by the transmitter-receiver system, which is of major concern to coordination personnel. Briefly, how close in frequency can two systems be operated simultaneously? As has been indicated, conservation of spectrum should be of prime concern to all instrumentation users. Needlessly broad or spurious emission of relatively high levels will invariably plague users. Broad receiver selectivity will result in unnecessary cases of interference. The total spectrum required by the system, therefore, should be considered and held to a minimum. In many cases, this figure is not considered and often not known. Since the spectrum is extremely congested at most proving grounds, it can be seen that system criteria are, or should be, of great concern.

It should be emphasized that minimization of system bandwidth, from the point of view of the transmitter and receiver is not academic in nature. The spectrum is a limited resource. Flagrant exploitation must inevitably, as it has already in many areas, result in extremely serious problems.

To appreciate the magnitude of the problem, a series of charts have been prepared to illustrate spectrum usage in one region, the New Mexico-West Texas Area has been chosen as representative. Since the data contained on the charts is classified, discussion concerning the information will not be given here. (Exhibition of Frequency Utilization Slides.)

A specific example at this point may clarify some of the generalizations made above. Telemetry provides an excellent case in point. Two major telemetry techniques are in common use. FM-FM is a relatively broad band system

(next page, please)

requiring approximately 250 kc. This technique provides a large number of continuous channels which are capable of handling information requiring relatively broad bandwidth. At present, the accepted system bandwidth for most proving grounds is 2 mc although equipment is available which will reduce this quantity to 1 mc. Naval Air Missile Test Center accepted bandwidth is 1 mc.

PDM-FM is an electronically commutated system whose bandwidth is of the order of 50 kc. System bandwidth here is also 2 mc although it is generally accepted that 500 kc is attainable.

As only 20 mc is available to telemetry users, it can readily be seen that the securing of equipment which would permit narrower bandwidths would allow range users greater freedom, resulting in fewer delays and consequently improving overall range efficiency. Desirable equipment modifications include improved stability of transmitter or receiver, usually by means of crystal control and narrowing of receiver selectivity characteristics.

Another technique which can be utilized by telemetry users, or other personnel employing instrumentation devices, is the closed-loop or minimum radiation technique. This procedure involves checkouts of systems which ordinarily represent approximately 90-95% of actual on-the-air time. If radiation can be severely reduced during checkouts, the scheduling problem is greatly simplified, permitting far more time for "hot" missions.

A further consideration is the selection of types of telemetry and number of RF channels. Many users of FM-FM could use PDM-RM or mechanical commutation, reducing the requirement for RF channels.

In general, the technical problem is not insurmountable. Much can be done by proving grounds to improve the situation.

On the other hand, the administrative aspects are far more involved. These cannot be adequately treated here. However, a few basic points can be mentioned. In the entire presently usable spectrum, only the band 225-400 mcs can be considered to be "exclusively" assigned to the military services. This band is allocated, primarily to communications. All other military frequency assignments are made on a shared or non-interference basis. The implications of this state of affairs is far-reaching indeed. Should interference to non-government or non-military government activities be caused by military operations, such operations can be brought to a halt. If the condition persists, the system may have to be abandoned, at least in certain areas. Even if interference is not caused, but only experienced there is little that can be done to silence users who have primary or exclusive authorization. Since five years or more are required for development of a new system, it can be seen that the cause for concern is great.

Selection of an operating frequency for a new system, therefore, is not a simple matter. It has been the experience of coordination personnel, however, that selection of operating frequency has not been given thorough consideration by developing agencies. For a variety of reasons, off-the-shelf items are usually utilized or modified slightly in the hope that no major problems will arise.

In a sense, the administrative machinery for frequency assignment is an important influencing factor in the problem. For example, in the past, spectrum conservation has not been considered. A detailed engineering analysis of each request is not and cannot be made, due to personnel limitations and existing regulations. The result is, frequently, a system which uses far more power or bandwidth than is actually required.

Another factor in the administrative process is the lack of requirement for consideration of receiver characteristics. A user, authorized a specific frequency with appropriate power and bandwidth, may use any receiver,—even one which is much broader than is necessary to handle the emission involved. Emphasis should be made here that no agency exists in the Department of Defense which approves proposed equipment from the standpoint of spectrum conservation.

This state of affairs should not be taken as criticism of those branches in higher headquarters responsible for frequency allocation. The problem is extremely complex, involving channels to the Joint Chiefs of Staff, the Congress and the President himself. It is not a simple matter and will not be belabored here. A chart, issued by the Office of Defense Mobilization, may serve, at this point, to illustrate the complex coordination procedure. (Exhibition of Telecommunication Administrative Channels.)

In brief, this is the current status of frequency utilization as applied to the proving grounds. No mention has been made of tactical implications, although these can be imagined. As far as the proving grounds are concerned, however, the problem is not insoluble. A few major steps can be taken.

1. The IFCG has published a list of Frequency Utilization Parameters and Criteria (IRIG Recommendation No. 102-56). Dissemination and consideration of these parameters would result in more efficient usage of the frequency spectrum.

2. Improved spectrum management procedures can be implemented and enforced by test ranges. Such procedures include:

a. Use of closed loop minimum radiation techniques.

b. Procurement of narrow band systems for telemetry and other instrumentation systems.

c. Requirement for contractors to utilize minimum number of RF channels and narrower band telemetry when use of such systems is feasible. (This criteria also be applied to systems other than telemetry.)

d. In summary, the aim of spectrum management should be: minimum power, minimum bandwidth, minimum time on-the-air.

3. Closer coordination between users and coordination personnel. Essential characteristics should be cleared prior to equipment development.

00000th TECHNICAL SERVICE UNIT
WHD: 000

SUBJECT: Death of Government Workers and Enlisted Man.

TO: All Section Heads

1. It has been brought to our attention that many employees and enlisted men are dying and refusing to fall over after they are dead. *THIS MUST STOP!!*

2. On or after October 1, 1957 any employee found sitting up after he (or she) has died, will be dropped from the government payroll at once (or within ninety (90) days). When it can be proven that he (or she) is being supported by a bench or property clearly marked "U. S. Government" an additional ninety (90) days will be granted. The following procedure will be strictly followed:

a. If after several hours, it is noted that a worker or enlisted man has not moved or changed position, the supervisor will investigate. Because of the highly sensitive nature of government workers and enlisted men, the close resemblance between death and their natural working attitude necessitates that the investigation be made quietly so as not to distrub the person if he (or she) is asleep. If some doubt exists as to the true condition of the person, extending a government check is a fine test. If the employee or enlisted man does not reach for it, it may be assumed that he (or she) is dead. In some cases, however, the instinct is so highly developed that a spasmodic reach or reflex action may be encountered. *DON'T LET THIS FOOL YOU.*

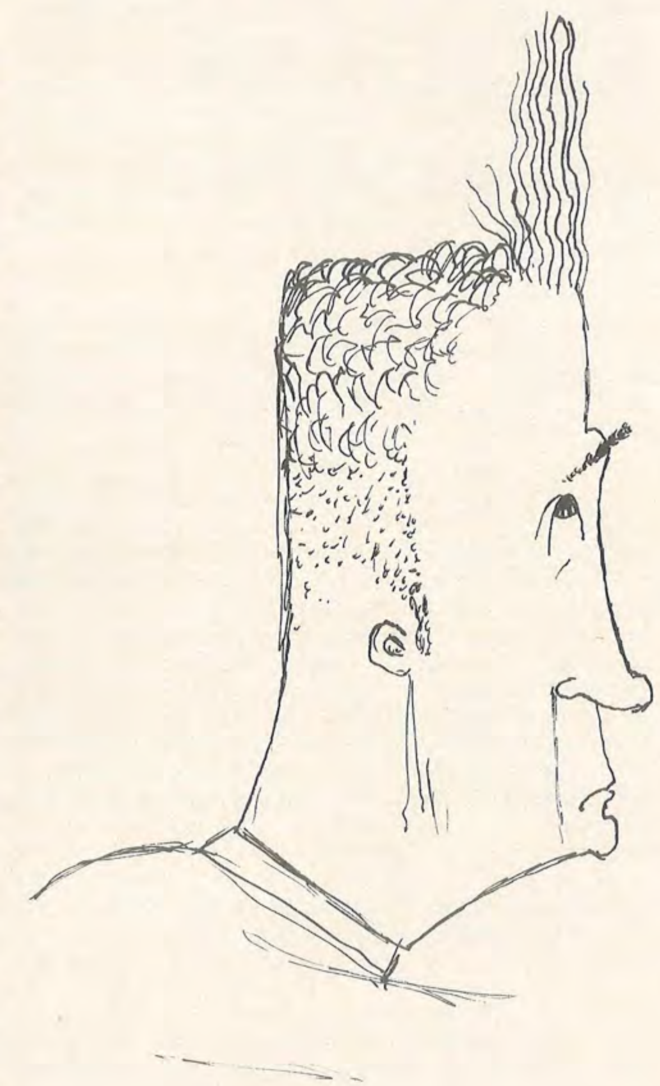
b. In all cases a sworn statement must be filled out by the dead person on a special form, PU66-78. 334½/10. Fifteen (15) copies will be made, three copies are to be sent to Washington, D. C., and three copies are to be given to the deceased. *Destroy the rest.*

c. On ORDBS Form 22W "Application for Permanent Leave" complete in full. Be sure to include correct forwarding address (if known). If he (or she) cannot write, an "X" be witnessed by two other employees or enlisted men, preferably alive. Complete procedure by pushing body to one side to make room for next incumbent.

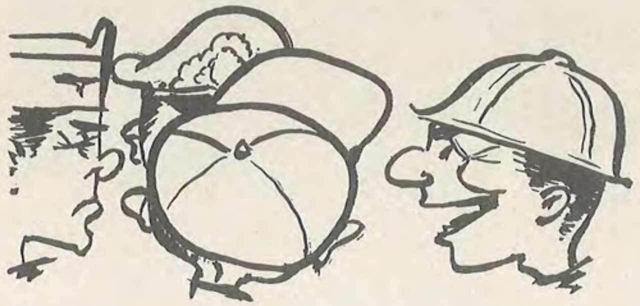
BY ORDER OF THE COMMANDING GENERAL:

R. MORTIS,
Col. MC, USA.

ENGINEERING TYPES



I LIKE IT THIS WAY



post shoot conference

LEE TRAFTON

Two meetings have been held since the last issue. In the Feb. meeting held Feb. 25th, we goofed and didn't get the meeting notices out, but about twenty-five people showed up anyhow. Those who did not attend missed a most interesting program. Mr. Lee Trafton, of Management Services, spoke on the subject of "MANPOWER". He discussed the history of manpower and traced the development of the need for manpower since the beginning of civilization. He pointed out that the changes in the demand were due to the changing economic needs. He discussed briefly the specialization of the manpower needs, with examples drawn from the rocket and guided missile field.

* * *

For the March meeting (March 25) we wish to thank Cook Research Laboratories and the regional manager, Mr. Richard Mayes, for making available to us the film on parachute testing using a high speed rocket sled as a carrier parachute package.

* * *

There has been some response to the appeal for speakers and program leaders to help in the public relations program now going on. However, the response has not been as good as we had hoped. The bulk of the speaking engagements are still being handled by a few of our members. There must be something about your work or the field of rocketry in general that you would like to talk about. It may be just what we need to fill a program request. Let us know about it, why don't you? The speakers pool is beginning to function again. Feb. was a busy month with seven (7) programs being presented. In March there were no engagements. In April several programs have been scheduled in Las Cruces and one in El Paso. We are not soliciting programs in El Paso at this time because of the problems involved such as distance, road blocks and the fact that most meetings are held at noon. We hope at a later date to extend the El Paso programs.

* * *

On April 6 the Section prepared an exhibit for the High School Science Fair at Union High School. The exhibit was made up primarily from the private collections of the individuals involved. Included in the exhibit was: (1) a Lark guidance system (2) a demonstration of a radio control link, (3) various small rocket motors, (4) a Dynajet motor and test-stand (we had planned to have a static firing but bad weather kept us inside), and various types of rocket equipment and models. We had also planned to demonstrate the Rock-a-Chute, a model rocket incorporating a parachute recovery system, but had to cancel because of weather. (Just like the big rockets do.) We don't like to brag but we have heard a number of favorable comments on the show. The demonstrations committee did a fine job. We would like to expand the demonstrations capabilities but to do so we need help. We need ideas and equipment. If you have either and want to get into the act, just contact Don Keys, chairman of the demonstrations committee.

* * *

We just got word that the National group of the ARS has a new magazine coming out shortly. It will be a general interest magazine in the rocket and guided missile field and will be named ASTRONAUTICS. We hope that it will be a tremendous success . . .

A LETTER FROM THE PRESIDENT

TO: ALL A.R.S. MEMBERS, SUBSCRIBERS AND READERS OF "MISSILE AWAY!"

It is with mixed emotions that I make the following announcement. I shall not try to soften the blow but instead speak bluntly. **THIS WILL BE THE LAST ISSUE OF "MISSILE AWAY!".**

When the magazine was started in Dec. 1953, we felt that there was a need in the rocket and guided missile field for a general interest publication of that type. That the feeling was a correct one is evidenced by the growth of the publication (150 copies in Dec. '53 — 2500 copies in the last issue), and by the fact that the national headquarters has established a new general interest type publication, which will begin publication in August. I have seen a dummy of the new magazine and have talked to the Editor, Mr. Hersey. It will be an interesting, readable type magazine, dealing with all phases of rocketry and missile work, with a minimum of "banjo music" as the equations of JET PROPULSION have been called.

With the advent of the new magazine, ASTRONAUTICS, the need for MISSILE AWAY! will no longer exist. Our function is being carried on by our national organization as is fitting and proper. We are happy to see this happen. At the same time, there is a feeling of sadness on the part of those who have worked on the magazine for so long. I wish that I could give credit to all of those people whose contribution of time and talent have made MISSILE AWAY! the success that it has been. But they are too many and space is too brief. But to all of you, wherever you are, we thank you.

TO OUR ADVERTISERS: Some of you have been with us from the beginning, but long term or short, we appreciate your confidence and support. We thank you for your patience, when we have been late in publication. We hope that you feel that our work has been worthwhile. We have enjoyed our association with you and regret that it must come to an end.

In behalf of the officers and directors of the New Mexico-West Texas Section of the American Rocket Society and the Editors and staff of MISSILE AWAY!, I wish to repeat my sincere appreciation to all of you, whatever your category, for all that you have done.

sincerely,

GEORGE L. MEREDITH
Pres: NM-WT Section,
American Rocket Society