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Operation IVY

PACIFIC PROVING GROUNDS

November 1952

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INSTRUMENTATION FOR BLAST MEASUREMENTS BY SANDIA CORPORATION

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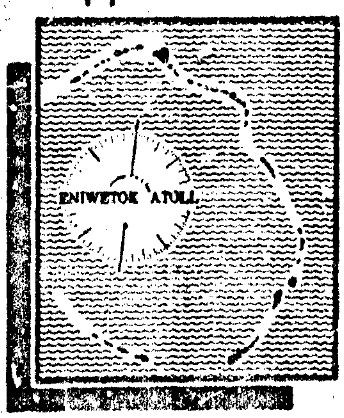

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Report to the Scientific Director

INSTRUMENTATION FOR BLAST MEASUREMENTS BY SANDIA CORPORATION

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ABSTRACT

Operationally, Sandia Laboratory's instrumentation program consisted of shelter installations, gauge installation, and the associated liaison and logistics for Projects 6.1, 6.3, 6.5, and 6.7b. These projects were concerned with blast air pressures, temperatures, winds, and underwater pressures.

The area covered by the measurements extended along the Eniwetok Atoll from Gene to Elmer for which seven shelter installations were made. All shelters were used on Mike shot, and two were used on King shot. A total of 125 electronic information channels were attempted. Eighty-nine channels were assigned on Mike shot and 36 on King shot. A tentative score is as follows:

Mike Shot

58 good	7 partial	24 bad

King Shot

28 good	5 partial	3 bad

In addition to the electronic channels there were 20 self-recording gauges installed for Mike. Nineteen of these gauges were recovered after the shot, and they all provided good information.

After the test all usable equipment was recovered and returned to Sandia.

PREFACE

This report includes the discussion of instrumentation operations on five projects. Since operations on all of the projects were similar, and even overlapping in many instances, no attempt has been made to separate them when this is the case. Individual discussion of the projects in which Division 5233, Sandia Corporation, participated is in Chapter 1.

ACKNOWLEDGMENTS

The authors of this report are much indebted to the persons listed below, who provided individual reports on their phases of responsibility on the Ivy program.

Personnel	Phases of Operations Reported
J. H. Scott	Individual Discussion of Instruments Used; Calibration Equipment and Procedure; Recorder and Playback System
H. S. Swartzbaugh	Construction Liaison
R. E. Pritchett	Electrical Liaison
B. D. Neil	Logistics
L. J. Witt R. B. Bunker	Shelter Installation and Timing
E. E. Wood R. H. Thompson	Short Discussions on the Entire Operation

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CHAPTER 1

OBJECTIVES AND BACKGROUND

1.1 PROJECT 6.1: PRESSURE VS TIME ON THE GROUND

1.1.1 Objective

This project involved studying the pressure field near a reflecting surface so that one may understand how such a surface perturbs the field as a function of pressure, time, characteristics of the reflecting surface, and characteristics of the atmosphere above the surface. It was designed to augment the existing fund of experimental data on the latter by measuring pressure as a function of time, on or near the earth's surface, at various fixed points around Eniwetok Atoll for shots Mike and King. The value of such data to those interested in weapons effects is clear since most objects that one might wish to destroy with (or protect from) an atomic bomb are located on or near the surface of the earth. These pressure measurements may also be used to estimate the yields of the gadgets.

1.1.2 Background

This project might be considered standard from the viewpoint that similar projects have been a part of all like operations since Crossroads. Experiments on past operations had shown that a pressure gauge manufactured by Wiancko Engineering, Pasadena, Calif., was the most satisfactory instrument available for these measurements.

1.2 PROJECT 6.3: SHOCKWIND, AFTERWIND, AND SOUND VELOCITY

1.2.1 Objective

The objectives of this project were twofold, as follows:

1. The measurement of shockwinds and afterwinds at various distances from ground zero.
2. The measurement of sound and material velocities, both prior to and after shock arrival, at various distances from ground zero.

1.2.2 Background

Since this was a relatively new project, feasibility tests on instruments that were to be used on Operation Ivy were run in Nevada during Operation Tumbler-Snapper and have been reported in the Project 19.1c and 19.1d report, WT-505. A total of eleven instruments were tested. They were designed to measure air pressures (both stagnation and side-on) q, wind direction, wind and sound speeds, and air temperature rises caused by shock waves. From this group the Pitot tube and q-Kiel installations were chosen for Ivy.

The sound and wind speed gauge and the temperature gauge were selected to measure jointly the speed of sound and wind. A detailed account of these tests in Nevada was published in WT-505, Operation Tumbler-Snapper, Sandia Laboratory Shock Gauge Evaluation Tests (Projects 19.1c and 19.1d) by Thomas B. Cook, Jr., and Karl Kammermeyer, both of Division 5111, Sandia Corporation.

1.3 PROJECT 6.5: GROUND MOTION SEISMIC MEASUREMENT

1.3.1 Objective

This project involved the measurement of the energy from the Mike explosion which was transported by the ground. The actual measurement involved accelerations along three mutually perpendicular axes at several distances from ground zero. This was done with an eye toward integrating the acceleration, once for velocity and twice for displacement.

1.3.2 Background

This was another new project for Sandia operations. Other agencies, however, have made similar measurements on previous operations. The only entirely new aspect of this project was the method of mounting the instruments. Accelerometers manufactured by Wiancko were deemed the most satisfactory instruments available.

1.4 PROJECT 6.7b: UNDERWATER PRESSURES ALONG REEF

1.4.1 Objective

This project involved the measurement of water pressure as a function of time in the shallow water of the lagoon. Four stations at various distances from zero were instrumented so that pressure attenuation with distance could be documented. These measurements were not considered worth while for King shot.

1.4.2 Background

This project was new to Sandia. The basic instrument used was a pressure gauge, manufactured by Wiancko, modified for underwater use. This gauge was not operationally tested before this operation, because delivery was made directly to the test site.

1.5 PROJECT 6.6: MICROBAROMETRIC STUDIES

This is the only portion of the report in which this project will be discussed since it was deleted during the planning stages.

Sandia had conducted three microbarometric studies in Nevada prior to this operation. The equipment used was the Rieber microbarophone, employing power supplies and amplifiers designed at the Naval Electronics Laboratory, San Diego, Calif., and built by Sandia.

E. F. Cox, of Division 5111, Sandia Corporation, requested that a microbarograph program be extended to Operation Ivy to take measurements on various island groups around Eniwetok Atoll. Originally it was planned to place about 15 such stations on these islands, several of which were to include seismic equipment. All of the microbarograph and seismic equipment proper was arranged for on a loan basis from the Office of Naval Research, and a partial list of the personnel required was drawn up. As planning progressed the program was scaled down in size and finally deleted. The microbarograph manpower requirements would have seriously depleted the ranks of the trained personnel to the extent that Sandia's other projects would have been adversely affected. Poor health conditions and inadequate living accommodations on the outlying islands contributed to the cancellation, as well as political problems which arose in obtaining some of the desired locations. Logistics costs in transporting men and equipment to the locations would have been high. These considerations prompted G. A. Fowler, Director of Field Testing for the Sandia Corporation, to write to A. C. Graves, LASL, requesting that this project be deleted.

CHAPTER 2

ADMINISTRATION AND LOGISTICS

2.1 FACILITIES

Upon arrival of Sandia personnel in the field, the AEC representative at the site was contacted for the space requested in the status reports. One Butler building 30 by 30 ft inside the compound was required for the office and laboratory. This building also contained a dehumidified room 10 by 12 ft for storage of moisture-sensitive material.

A canvas-covered enclosure was attached to the front of the building to provide some protection for the battery filling and charging area. An area 40 by 40 ft adjacent to the building was used for outside storage. In this area a tent 15 by 30 ft was erected for the use of men unpacking and checking in equipment as it arrived at the site. Another tent 15 by 30 ft was used on the islands of Gene and Yvonne by the cable crew (see the map on page 45 for actual island names).

One jeep, three 6 by 6 trucks, two ¾-ton weapons carriers, and four 6 by 6 personnel carriers were drawn from the motor pool for Sandia's permanent use. All of these vehicles were not drawn at the beginning of the project but were acquired as needed. Exchange of vehicles was made at times for the convenience of both Sandia and the motor pool.

2.2 ADMINISTRATIVE DUTIES

A filing system was set up to handle daily bulletins, minutes of meetings, TWX letters, material control records, etc.

Determining transportation needs and making arrangements for them were the primary administrative functions. All Sandia transportation requests were required to be in the Sandia office by 1600 on the day before they were needed. One man coordinated all of the transportation facilities. It was also the responsibility of this individual to arrange for lunches for men expecting to be in areas without lunch facilities and to obtain temporary housing when necessary. This procedure was conscientiously followed except in emergencies.

The use of this plan of operation made it possible for Sandia to eliminate unnecessary trips and prevent duplicate requests for transportation. It also made possible the arranging of schedules with the appropriate facilities that were compatible with the work load and Sandia's requirements. Air, water, and land transportation provided proved to be adequate, and the fullest cooperation was received from those in charge. Use of helicopters greatly aided the work on the islands lacking landing strips.

Other duties performed by this office included the handling of all requests for cash, expense vouchers, memo work, and mail distribution.

2.3 HANDLING MATERIAL

A total of 268,765 lb of material was shipped to the site, and 179,808 lb was returned to Sandia. When the material arrived at the site, it was located in the AEC storage area. The material was relocated in Sandia's area within the compound as space became available, and a list of all the boxes in the storage area was maintained. Material was dispensed on the receipt of a request and was assembled in the storage area and transported by boat, or in emergencies by airplanes, to its destination. Usually equipment was accompanied on shipments up island to prevent mishandling or loss. Complete records were kept of the distribution of equipment and shipping boxes, including an accurate listing of partially unpacked boxes.

After Mike shot, the part of the equipment not required for King shot was returned to the compound area for repackaging and shipment back to Sandia. Eventually all of the repackaging was done in the compound area. The repackaging of all equipment to be returned was completed within two weeks after the final shot.

2.4 DIFFICULTIES AND SUGGESTIONS

On future operations, where adverse weather conditions prevail, it would be desirable to have access to an area protected from the weather for staging and repackaging of equipment. As a result of outside storage and heavy rains, much of the original packaging material was destroyed or severely damaged. Adequate amounts of desiccants should be available for all packaging in order to prevent excessive damage by moisture.

Standard nomenclature should be used on all records of material. This would aid in making inventories and shipping lists. Repackaging could be speeded also by identifying boxes designed for a specific piece of gear.

CHAPTER 3

CONTRACTOR LIAISON

3.1 CONSTRUCTION

Construction of shelters and instrument mounts and the laying of cables were performed on a contract basis by Holmes and Narver Engineers, Inc. (H&N), Los Angeles, Calif. Sandia personnel were used for contractor liaison for the above duties and assisted the contractor in placing underwater gauges and ground accelerometers.

3.1.1 Shelters and Mounts

Inspection of shelters and instrument mounts was continuous throughout the construction period. Such engineering and field modification as was necessary was processed through the A. , Resident Engineer.

All work orders necessary for field changes, alterations, correction of planning errors, and unforeseen necessities were initiated through the J-6 Section office and followed through to their completion by the contractor.

3.1.2 Placing Gauges

(a) Accelerometers. Locations for measurements were selected by the analysis of the logs of previous drillings and core samples from test holes made along the atoll. See WT-604, "Gro Accelerations (and Motion)" by W. R. Perret (Division 5111, Sandia Corporation). holes were drilled and cased, and then a plug was placed in the top of the casing to preven entrance of foreign matter (Fig. D.1). At the time of gauge installation, the casings were c...ned of sand, which had invaded from the bottom of the hole. The bull-plug was placed in the hole by means of a -in. lowering pipe (Fig. D.2). The casing was pulled up 2 ft, and the grout was ~laced around the bull-plug. The 10-in. casing was removed, and the gauge was oriented by means of a sighting mechanism attached to the lowering pipe. The fill was tamped around th bull-plug to the approximate density of the soil before drilling.

Two methods of bonding the plug to the surrounding soil were attempted. The first was to mix cement with the first part of the sand used in the backfill. The ground moisture would wet the mixture, and a bonding would result. This method was not satisfactory, however, and in later placings grout was pumped into the holes.

In order to reduce the transmission of the shock down the lowering pipe, which was left attached during the shot, the pipe was cut below the surface of the ground before the fill was completed.

(b) Water-pressure Gauges. The instruments were mounted on tripod stands so they would be 10 ft above the floor of the lagoon (Fig. D.3). Positioning was accomplished by triangulation

from the shore. Transits were set up on the beach, and walkie-talkies were used for communications. The mount and gauge assembly was lowered to the bottom by a $^3/_8$-in. aircraft cable to which the signal cable was attached. Four such installations were made about 1 mile offshore at a depth of approximately 100 ft. After Mike shot, it was impossible to see either the cable or the mounts from the surface. Grappling hooks were used in recovering the gauges.

3.1.3 Suggestions

In some instances during this operation it took as long as two weeks before work was started on a request submitted to the J-6 Section office. Tracing of the work order invariably proved it had been lost in the contractor's chain of command. Since most of these requests occur late in the program, some method of easily tracing work orders would be highly desirable.

One of the main factors contributing to delays in accepting shelters was the elaborate permanent conduit system called for in the electrical plan. Such delays might be eliminated in the future by calling for permanent electrical installations only where really necessary.

Frequent inspection trips should be made during the early stages of construction. This would permit first-hand observation of the progress of construction, making possible early correction of any misinterpretation of plans.

3.2 CABLING

Belden four-conductor unarmored microphone cable (same electrically as Belden No. 8424), having a $^1/_4$-in. rubber cover, was used for underwater work. Approximately 53,900 ft of underwater cable and 106,650 ft of four-conductor Belden No. 8424 microphone cable were used for land work on these projects.

3.2.1 Splicing

All cables were prefabricated from the 1000-ft factory lengths before installation. The same system of splicing was used for both underwater and land cables. The splice was built up in the following manner:

1. The conductors were cut in such a manner that the conductor splices were staggered.
2. Saturated spun-glass tubing was placed over the individual conductors for insulation.
3. Three layers of Scotch electrical tape held the spun-glass tubing in place.
4. Two layers of varnished cambric tape were then added to protect the conductor splices from the soldering iron heat when splicing the braided shield.
5. Two layers of Scotch electrical tape tightened the splice and filled it out to the size of the cable.
6. Three layers of Okonite rubber tape were then sealed with Okonite rubber cement.
7. Three layers of friction tape were sealed with Okonite quick-drying weatherproof paint.

Visual inspection and tests of resistance to ground indicated no leakage of water into the splices.

3.2.2 Laying the Cable

Laying cables in trenches on land was accomplished by using a 6 by 6 truck with a reel rack. This rack was built by the contractor and was capable of laying 12 cables at once.

In shallow water a bulldozer knocked down any sharp coral heads where the cable was to lay. The cable was laid from a two-wheel pay-out reel towed by a $^3/_4$-ton 4 by 4 truck. Three methods were used for holding the cable in place. Where currents were not swift, a 6 by 6 truck followed the above rig carrying sandbags to be placed on the cable (Figs. D.4 and D.5). If the current which occurred at mean tides presented a problem, the cable was lashed to steel pins driven into the coral. The pins were spaced 2 to 3 ft apart, depending on water current and the location of splices. Cables across beaches, where a solid foundation for the pins was not readily accessible, were buried. Cables on beaches, however, washed out in two or three days, which necessitated that this work be done immediately prior to the scheduled shot day.

Where cable was to be laid in water 4 to 100 ft deep, reel stands were built in a DUKW body. Another DUKW carried sandbags. Two sandbags were tied together and dropped astraddle the cable at distances of 200 to 500 ft along the cable, depending on water current and depth (Fig. D.6).

3.2.3 Difficulties and Suggestions

Underwater cables subjected to strong currents were the source of most of the difficulties encountered. It was difficult to keep the cables in place under these conditions.

All sandbags rotted within 2 to 3 weeks. Bags of grout or sand washed off of the cable leaving excessive distances between anchors. (Bags of grout were less stable than bags of coral sand.) This condition subjected the splices to more stress than was desirable and pulled the cable from under the remaining anchors. It is suggested that on future operations steel pins 3 ft in length be driven into the sand and coral for anchors in shallow water. Spacing would depend on the currents encountered.

The underwater cable used on this operation was not rugged. Some of the cables were crushed, others were ripped open as the result of DUKW's running over them, and chunks were torn from the rubber jacket as they shifted with the tide over sharp coral. It is suggested that light-steel armored cable be used for underwater work on future operations where strong currents are expected.

CHAPTER 4

SHELTER EQUIPMENT

4.1 TIMING

4.1.1 Sequence

The timing sequence used for Operation Ivy was as follows:

−30 min*	MG sets started
−30 min + 15 sec	115 volts applied to Ampex recorder, Consolidated gear, Blue Box, and crystal-controlled timing
−15 sec*	Cal plus on
−5 sec	Cal plus off
0 sec	Blue Box fires
+8 min	Cal plus on
+10 min	All power off

4.1.2 Engineering

At the time of the inception of the program, it was considered expedient to do the major portion of the engineering at Sandia. The timing systems for each shelter were designed and fabricated at Sandia and then assembled at the individual shelters in the field. By prefabricating all interconnecting cables at Sandia, considerable time and labor were saved. The control relays were sealed in lucite boxes with neoprene cement. This precaution provided adequate protection from the humidity and dust conditions existing at the site.

4.1.3 Crystal-controlled Timing and Synch Oscillators

Dual crystal-controlled oscillators and dual power supplies were used to supply timing and synchronization of gauge driving oscillators at each shelter. Gating circuits were so arranged that if a section of a dual failed the alternate would assume control.

A 90-kc signal was divided down by 30 to 1 to give a stable 3-kc signal. One output fed the timing channels on the Ampex recorders where the 3-kc signal was frequency-modulated on the tape. The other output fed the Consolidated oscillator power supplies to synch them together.

---

*Timing supplied by Edgerton, Germeshausen & Grier, Inc. (EG&G).

The oscillators were adjusted to 3 kc with a Hewlett-Packard frequency standard as late as possible before each shot. This standard was adjusted by comparing it with WWV. These units, though accomplishing their purpose, are rather complicated. Some improvement in the count-down circuitry and power regulation should be investigated.

A d-c voltage from the Blue Box was utilized to raise the d-c level of the 3-kc timing signal through a voltage divider network. The jump in the timing signal when the Blue Box fired was the indication of zero time.

4.2 RECORDER AND PLAYBACK EQUIPMENT

Recording and playback equipment that Sandia had used on previous tests was in poor repair and lacked the later advancements in this field. Considering the time and cost involved in repairing and modifying this equipment, the purchase of new equipment seemed more practical. In addition, the return of old equipment had been requested by the military agencies who had purchased it for Greenhouse. Systems manufactured by several companies were investigated, but only one considered satisfactory was available in the quantity required. This system was the Ampex tape recorder Model S-3128 and playback Model S-3129 used in conjunction with the Consolidated system D bridge amplifiers (Fig. D.7).

4.2.1 Operational Characteristics

The recorder block diagram (Fig. 4.1) shows the sequence of wave shapes in the conversion of the 200 per cent a-m wave to a f-m wave.

The instrumentation system, with the exception of the sonic equipment, consisted of a gauge connected to the Consolidated system D carrier amplifier in a bridge configuration. The carrier amplifier fed a d-c output into the Ampex record strip, the information being recorded on magnetic tape as a f-m signal (Fig. 4.2).

The Ampex recorder and playback may be considered an extra step in the orthodox carrier amplifier-oscillograph system. Rather than record the signature from the carrier amplifier directly on an oscillograph, it was converted to a f-m signal and first recorded on tape. The Ampex playback then converted the f-m signal into the signature, which was recorded on an oscillograph.

Primary considerations in choosing the Ampex recording system were its linearity, frequency response, and stability.

(a) Linearity. The linearity of the Consolidated amplifiers is within 1 per cent when terminated in a load of 220 ohms and having a maximum output of 0.6 volt. Linearity of the Ampex record strip or the constancy of the ratio of frequency deviation to input voltage is determined primarily by the positive-bias multivibrator (Fig. 4.3). In all cases tested, using a center frequency of 27 kc with 30 per cent maximum deviation, the linearities of the multivibrators were within 1 per cent. A relation between linearity and per cent distortion was developed showing that, when only second harmonic distortion is predominant, the per cent nonlinearity is equal to the per cent distortion introduced by the record strip. This enabled quick checks of record strip linearities in the field using a distortion analyzer.

Linearity of the Ampex playback (Fig. 4.4) is determined primarily by the differentiation of the square waves. If these differentiated pulses are too broad, the higher frequencies will cause these pulses to overlap. This results in a decreased ratio of area increase to frequency increase at the higher frequencies, with the ultimate result that the linearity curve rolls off. This can be eliminated by sharper differentiation.

The playback is linear when operated into an impedance of 600 ohms or greater. Linearity of the total system from the gauge through playback was within 3 per cent.

(b) Frequency Response. The frequency response of the total recording and playback system, in the case of strain gauges and Wiancko air-pressure gauges, was limited by the

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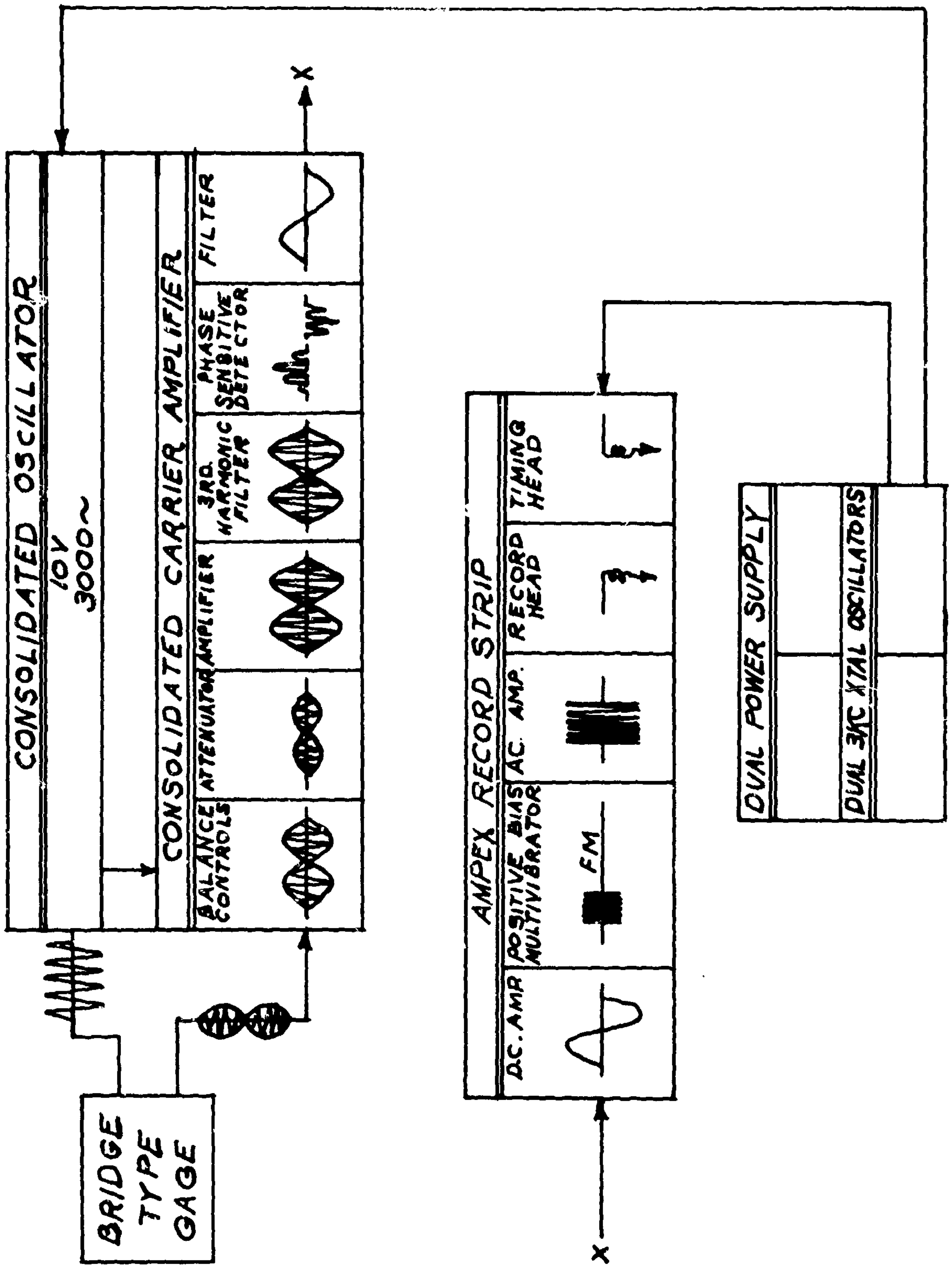

Fig. 4.1—Block diagram of Ivy recording system.

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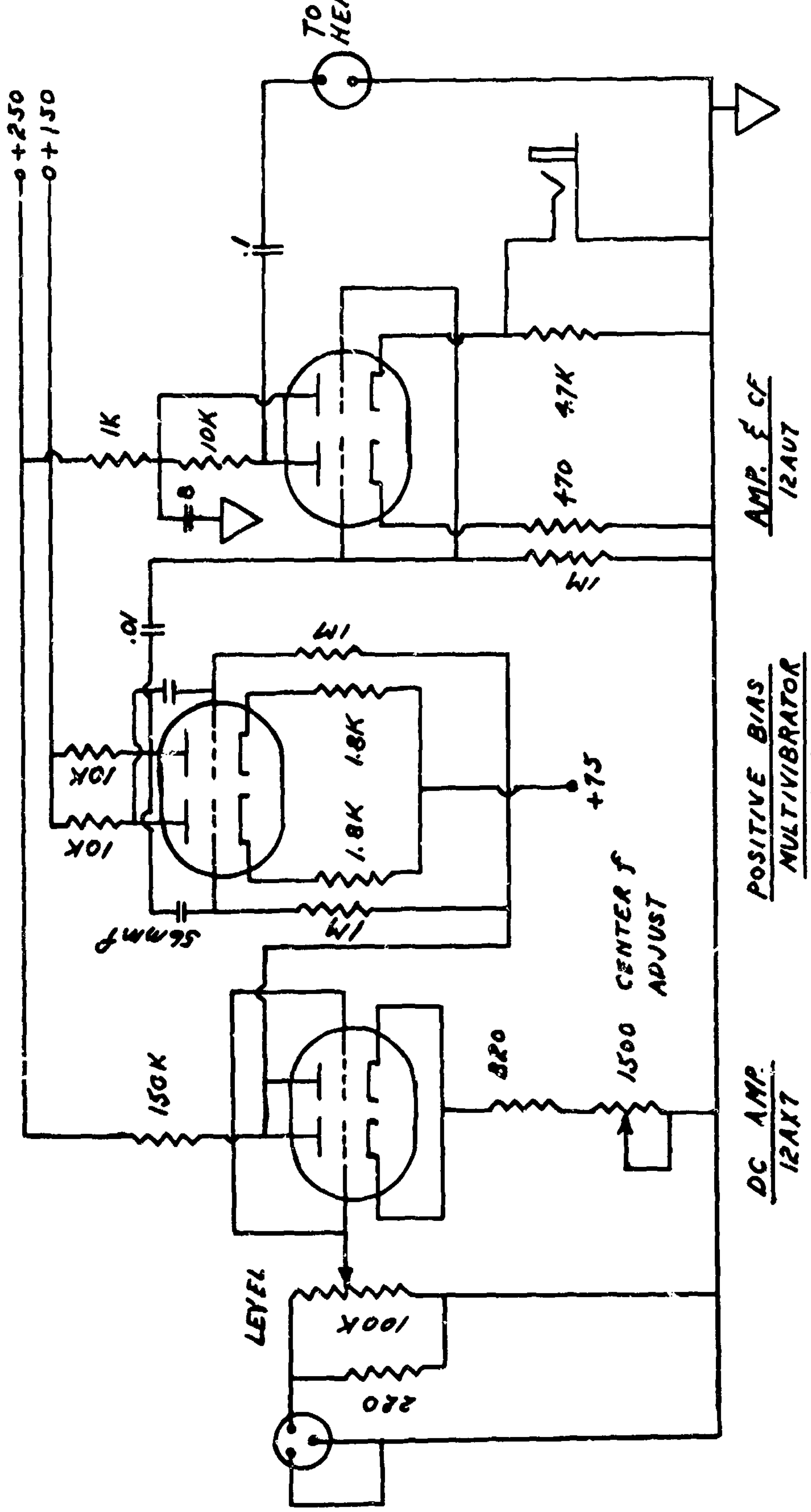

Fig. 4.2—Ampex record strip.

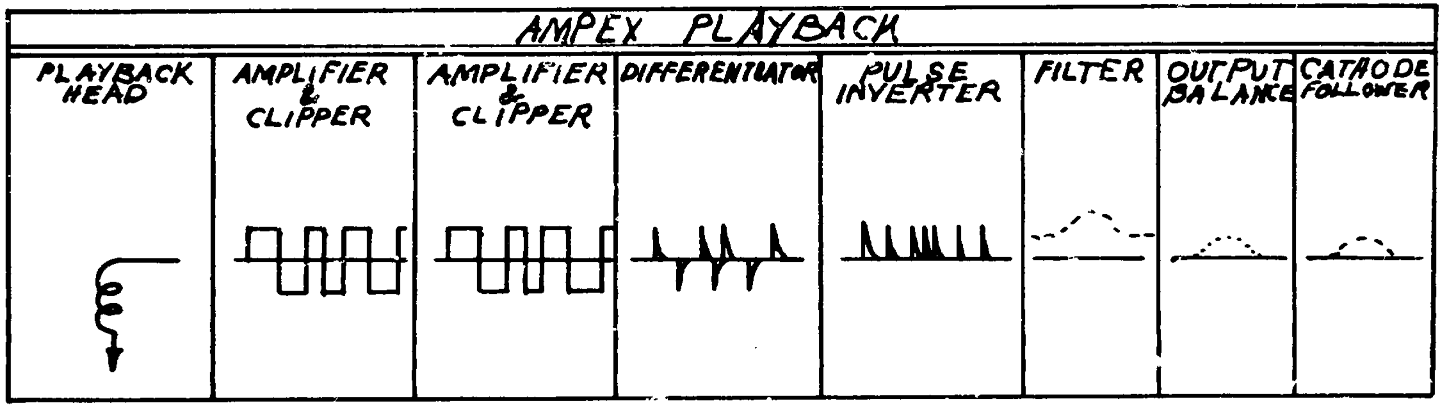

Fig. 4.3—Block diagram of Ivy playback system.

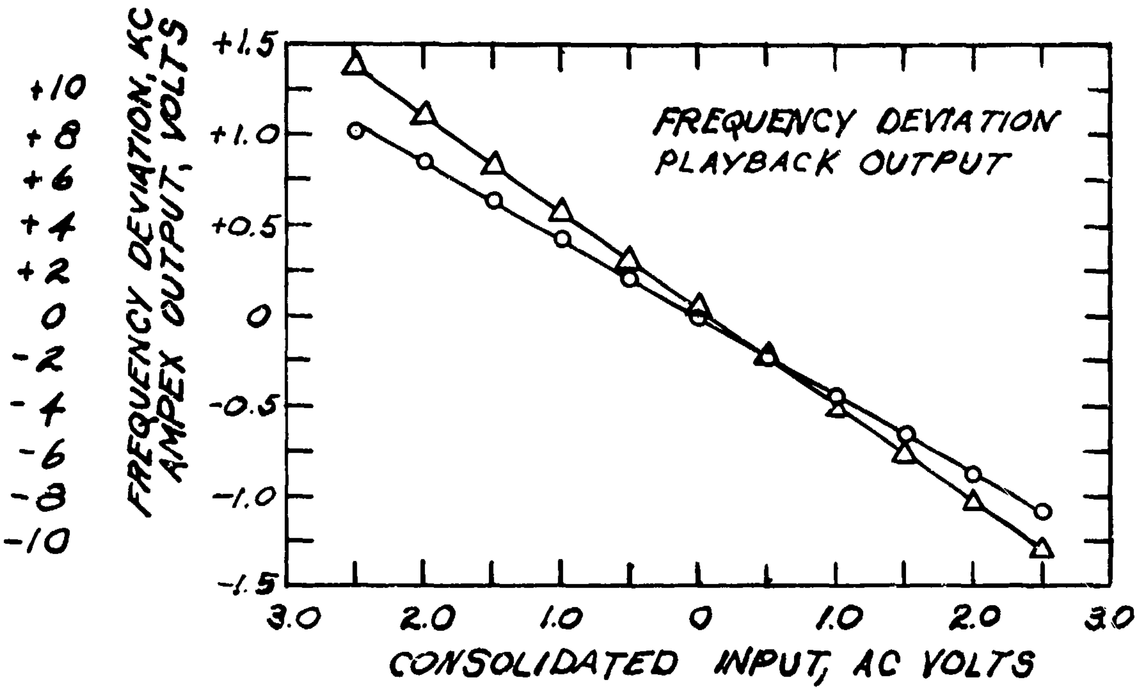

Fig. 4.4—Total system linearity. Ampex gain wide open; playback output across 600 ohms.

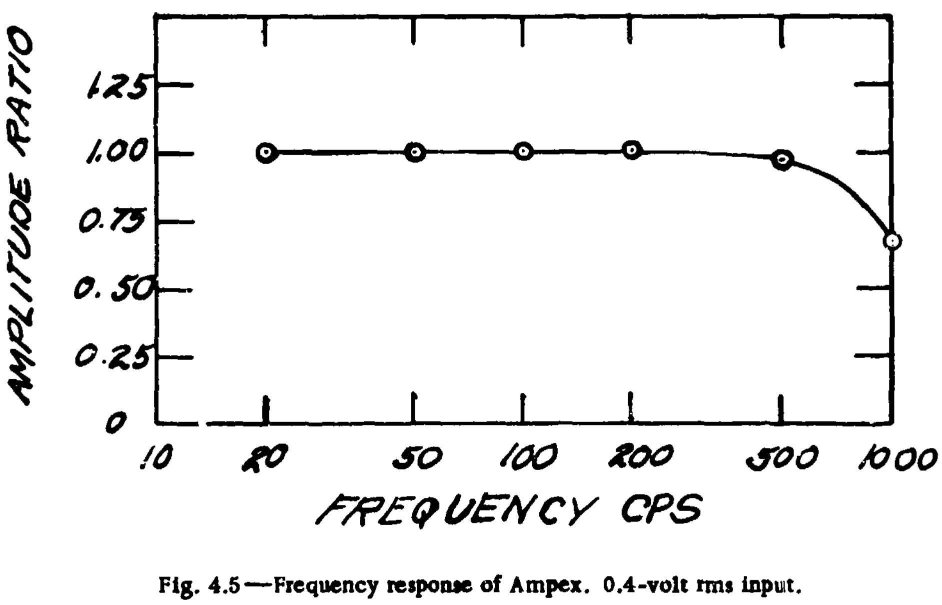

Fig. 4.5—Frequency response of Ampex. 0.4-volt rms input.

Consolidated carrier amplifiers to 500 cps. A response limitation of 20 to 90 cps was imposed by the Wiancko accelerometers, depending upon the range of the gauge. The frequency response of the Ampex system is determined primarily by the integrating filter in the playback. A 250-cps low pass filter was used in most cases, giving 500 cps frequency response as the tape was played back at half speed (Fig. 4.5). The sonic-gauge outputs and 3-kc timing were fed directly into the recorder strip, and the response on these channels was limited to 5000 cps by a 2500-cps integrating filter.

(c) Stability. The stability curves on the record strips (Fig. 4.6) show that after a 20-min warmup, the expected drift of center frequency is on the order of 1 per cent of the full-scale frequency deviation. On this basis, a 30-min warmup was allowed in the field. The Ampex playback stability is poor. Over the normal range of line-voltage variations the playback output varies more than 100 per cent. This was remedied during playback by running the equipment from a constant-voltage transformer.

As the Consolidated amplifiers were working close to their overload region, the neon overload bulbs were removed. Although the bulbs would not fire up to a 0.6-volt output, they could be conducting at this point by going above until the bulb fired, then returning. This is caused by the deionization potential of neon being lower than the ionization potential. If the function being measured went above the peak expected value, the neon bulb could fire and ruin some of the information below the 0.6-volt firing voltage.

4.2.2 Magnetic Tape and Transport Mechanism

(a) Drop Outs. It was discovered before leaving Sandia that drop outs occurred on records. These drop outs consisted of 2- to 10-msec breaks where no information was present. As the drop outs were repeated along the length of the tape, the cause was assumed to be holes or a deficiency of oxide in small regions. In the field it was discovered that the major portion of these drop outs was relocated when the tape was erased and recorded again. The relocation phenomena indicated something peculiar to the recording process. It was found that, if the heads and tape guides were cleaned with carbon tetrachloride before each recording, the frequency of drop outs was greatly reduced. It also became apparent that the drop outs were much more frequent on the outside channels of the tape. Some of the tapes received were wider than 1 in., causing binding troubles on the tape guides. Increased drop outs on the outside heads were caused by crinkling along the edges of the tape. Whenever possible, channels were relocated so that the outside heads would not be used for recording purposes. It appeared that, on the whole, plain-backed tapes had fewer drop outs than silver-backed tapes. It was on this basis that plain-backed tapes were used on Mike shot.

Upon playing the tapes back at Sandia it was found that increasing the back torque of the supply reel practically eliminated the drop out problem.

(b) High-humidity Problems. On Mike shot the tape on one recorder on Mary wound up on the capstan. It was considered possible that the high humidity inside the shelter allowed the tape to absorb moisture and become sticky. This means that, if the tape is thrown either from shock or poor mechanical adjustment, the slack could allow the tape to stick to the capstan and start winding up on it. In one case the tape apparently stuck to the microswitch arm and shut off the recorder (Fig. D.8). It was found that silver-backed tapes do not become as sticky when exposed to moisture as the plain-backed tapes.

By far the most disastrous or serious factor in the operation was the sticking of brakes on the Ampex tape transport. The difficulty was caused by the swelling of the brake bands as a result of moisture being absorbed in the asbestos and corrosion of the brake drum itself. Prior to the blast run no sticking of brakes was noted because the shelters were opened and the equipment was operated frequently. This procedure undoubtedly permitted some drying of the brake systems.

The brake problem on King shot was eliminated by the straightforward and expedient method of removing the brakes. This is not a good practice, since the tape spills on the floor from the

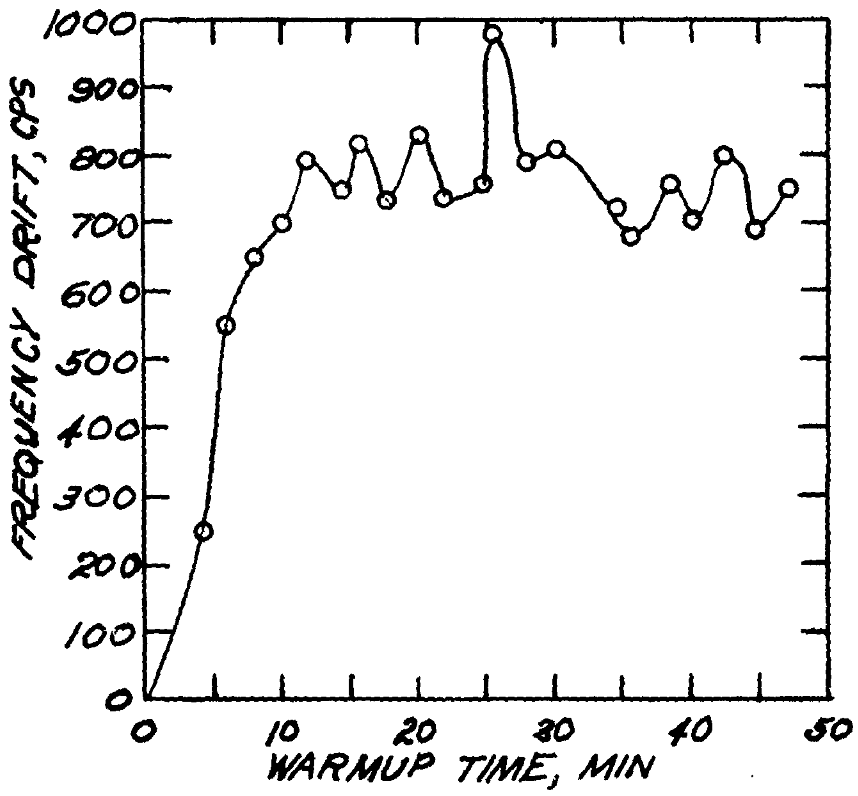

Fig. 4.6—Record of strip frequency stability. Constant line voltage.

inertia of the reels when the power is turned off. The tape was maintained in position before the blast by placing small weights that applied the proper torque to hold the tape in position.

4.3 CALIBRATION PANELS; CAL-PLUS ADJUSTMENT

Operation Tumbler pointed out the need of a system calibration step (cal plus) to be placed on the calibration and blast records to determine gain variations between calibration and blast times. Gain variations over extended periods of as much as 20 per cent have been noted in the Consolidated carrier amplifiers alone. A test on drift characteristics of the cal plus vs set range was performed on Station 606 on Elmer for a period of four days (Fig. 4.7). A calibration step console was designed for Operation Ivy (Fig. D.9), which inserted a voltage within 2 per cent of the peak value of the expected function in series with the gauge output (Fig. 4.8).

The cal-plus adjustment was made by adjusting the cal-plus controls to cancel the set-range voltage from the gauge. The gauge was then returned to balance and the cal-plus voltage reversed 180°, which inserted voltage into the recording channel theoretically the same as the set-range voltage from the gauge.

Difficulty was encountered on low-level channels attributable to the fact that it was impossible to adjust the set-range canceling voltage to have an exact 180° phase reversal with the set-up-operate switch. The reason for this was that both sides of the UTC A-20 transformer were not opened up by the on-off relay, causing capacitive feed-through to ground through the side that was not opened. This problem was realized before leaving Sandia Base, but sufficient relays were not available to put them on both sides. The cal-plus output was set to the desired value on these channels by the use of an oscilloscope.

4.4 MOTOR-GENERATOR INSTALLATION

Some delays were encountered as the contractor had difficulty obtaining motor controls and material specified by Sandia. Since the Century Manufacturing Company could not deliver motor generators (Model DAMG-2544J modified) to Sandia in time for testing, they were shipped direct to the test site.

At the time of installation four motor-generator sets were returned to the field laboratory because of failure of the d-c motors to start. It was experimentally determined that if the polarity of the shunt field and the interpole were cumulative, starting was dependable. With this wiring the MG sets gave reliable service. The voltage and frequency were tested, and the stability was found to be excellent. Over a period of 3 hr, the voltage varied plus or minus 1 volt in 115 volts and the frequency varied plus or minus 1 cps in 60 cps with approximately full load.

Further tests at Sandia indicate that the brush setting in the d-c motor is critical and difficulties were caused by improper adjustment by the manufacturer.

4.5 SHOCK MOUNTING

4.5.1 Mike Shot

The station on Irene (Fig. D.10) suffered severely from shock on Mike shot. The cal-plus off timers were reset by the blast, and a large portion of the Baker recorder was rendered inoperative. The air-pressure shock evidently threw the tape on the Baker recorder in the station on Mary, since tape began to wind on the capstan at exactly the time the air-pressure shock reached the shelter.

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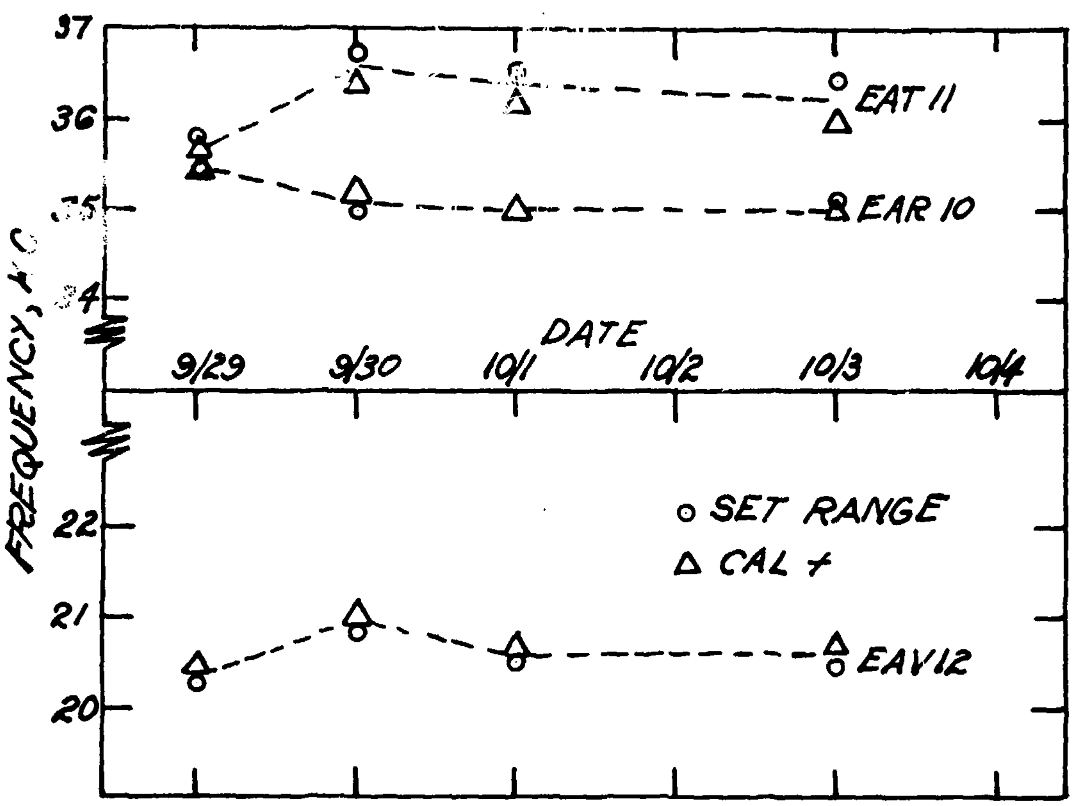

Fig. 4.7—Check on cal plus vs set range on 606.

RESTRICTED DATA—CONFIDENTIAL—SECURITY INFORMATION

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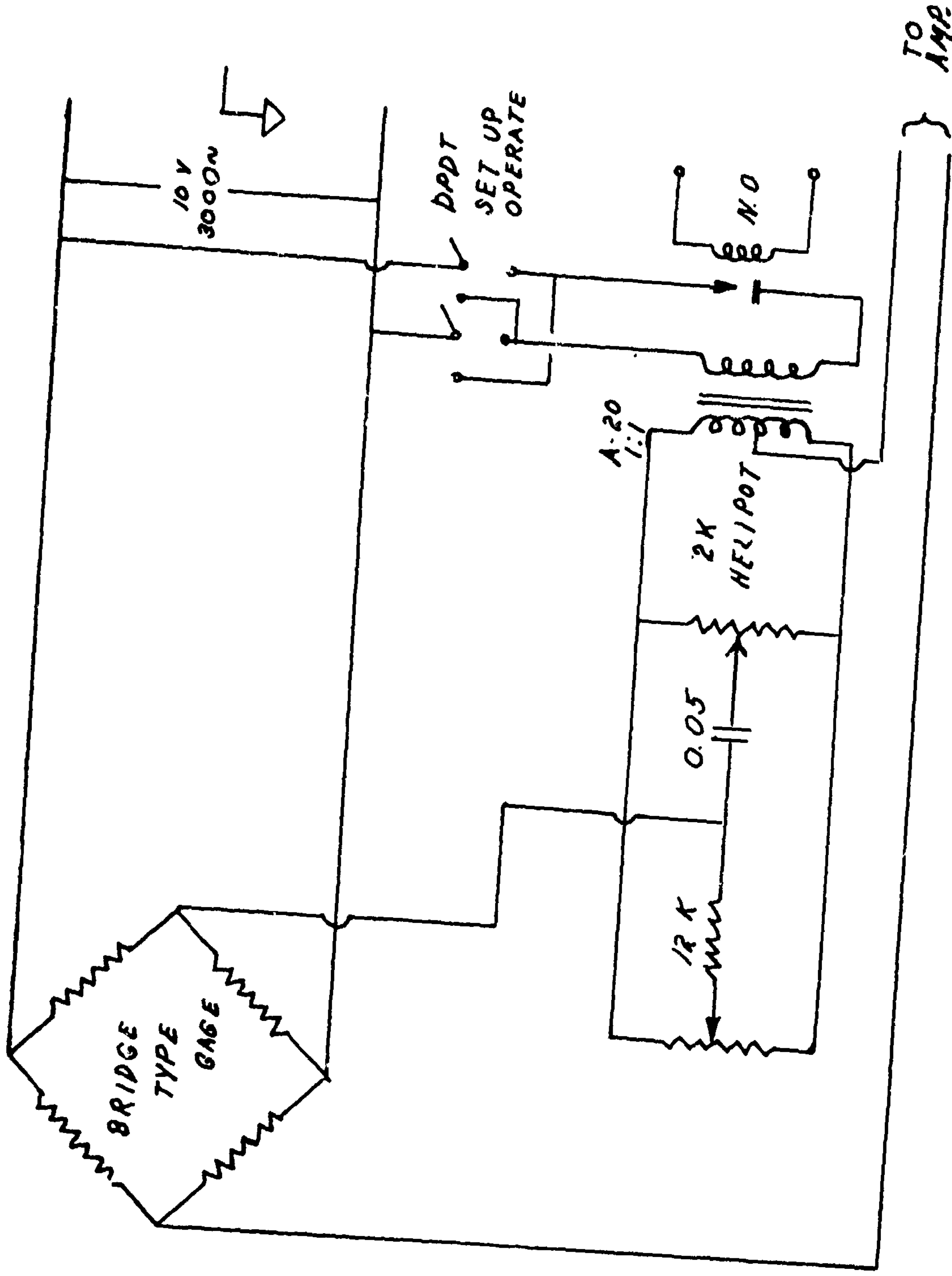

Fig. 4.8—Per channel cal-plus diagram.

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From an examination of the acceleration measurements it did not appear that ground shock had caused any difficulty. Mary station was in a relative low-pressure region, but was entirely above ground, having a large area exposed directly to the air shock. Both Janet and Kate stations were partially buried and encountered little or no difficulties. For shock-mounting arrangement see Fig. D.11.

4.5.2 King Shot

The shock mount difficulties encountered on Mike shot led to improvised shock mounting in the Yvonne shelter for King shot. This shelter was above ground and had little earth covering.

Plywood boards were fastened to the tops of the Consolidated and timing racks, and these racks were suspended from the ceiling using double shock mounts to allow more travel. Sponge rubber was placed underneath the racks to keep them from striking the floor. This type of mounting produced a low resonant frequency.

The Ampex recorders, which were already in the shelter, were placed on double shock mounts at the base, and the ceiling mounts were changed to have shock mounts at each end of the mounting rod to increase the flexibility. The base shock mounts were so stiff that the doubling up did little more than allow increased travel.

Two Ampex recorders were brought to Yvonne from the Sally shelter after the Mike recovery, and these were wired in parallel with the two already in existence to provide backup. Since these were tall racks, they barely fitted between floor and ceiling so that the only shock mounting that could be accomplished was cramming rubberized horsehair between the rack and the shelter, both top and bottom. The calibration console was mounted on sponge rubber, and rubberized horsehair was crammed between and around all the racks.

It is obvious, in the bigger blasts with consequent higher air pressures at the shelters, that the problems of adequate shock mounting are of increasing importance.

4.6 BATTERIES

Hobbs 6-volt 100-amp-hr batteries were used on this operation. Their performance was satisfactory, but the terminals were poorly designed. The terminal protruded about an inch from the main post, and when pressure was applied to tighten the cable the terminal would often break. A better design for future operations would be batteries having a stud coming directly out of the main binding post (Fig. D.12).

CHAPTER 5

INSTRUMENT INSTALLATION AND CALIBRATION

5.1 AIR PRESSURE

All air-pressure measurements were made using Wiancko variable reluctance transducers. This instrument makes use of the pressure induced deformation of a twisted bourdon tube to vary the inductance of a coil, thus generating an electric signal the magnitude of which is proportional to the instantaneous value of the incident pressure. Linearity and damping checks were run on all air-pressure gauges before they left Sandia to ensure that they were in proper operating condition. Gauges selected were damped 0.3 to 0.6 of critical and were within 2 per cent of being linear.

5.1.1 Mounts

Pressures at the surface or grade level were obtained using ground baffles (Fig. D.13). The baffles were 18-in.-square concrete pads placed in the soil flush with the grade, with one, two, or three Wiancko gauges mounted in the center. This type of mount is used to measure the side-on pressure at the surface of the ground. Where these pads were mounted in loose sandy soil, cement was raked into the sand to stabilize the area around the mount.

Pressures above the surface were obtained using baffles 17 in. in diameter with the gauge mounted at the center. This baffle was used to reduce the turbulence at the face of the gauge. The baffles were attached to pipe stands 12 to 15 ft above the surface and oriented with the baffle edge-on toward zero. Wind-tunnel experiments have shown that the pressures this type of mounting measures is a function of the alignment of the baffle with respect to the direction of the blast (Figs. D.14 to D.16). Some experimental data of this phenomenon in the presence of a blas [illegible] attained on King on channels YP1 and YP2. These baffles were aligned approximately 20° to and from the King blast radius.

Side-on pressures were also obtained by the static air-pressure gauges in the Wiancko Pitot tubes (Figs. D.14 and D.17). A description of these will be given later.

5.1.2 Modifications

Before leaving Sandia, it was discovered that the back leak rate on the Wiancko differential-type air-pressure gauges was too short for the long negative phases expected on this operation. From the length of the expected phases, a time constant of between 30 and 45 min was necessary to follow the pressure function within 1 per cent. It was desirable to establish the upper limit on the time constant as short as possible and still follow the slower ambient changes.

Since the air-pressure gauges had been shipped prior to the discovery of this problem, the time-constant adjustments were made in the field. Considerable difficulty was encountered in setting the leak rate between the foregoing limits, and it was found that, by smashing the porous back-leak plug, an infinite time constant could be established easily. The problem then was to determine pressure changes under the worst ambient conditions with a sealed-back leak rate.

To establish this, a 10-psi gauge was mounted on the aluminum roof of the laboratory so it could absorb the heat accumulated by the roof. The gauge was balanced before dawn, and output voltage readings were taken through noon. The maximum pressure change during this recording period was about 0.75 psi, indicating that the ambient pressure changes were negligible compared to pressure variations caused by temperature changes in the back volume.

This pressure or balance change would be the same independent of the full-scale range of the gauge. The figure of 0.75 psi was doubled for a safety factor; that is, the maximum balance change to be expected on a 10-psi gauge with a sealed-back volume was to be within 1.5 psi. Study of the recording system characteristics indicated that a 20 per cent drift in balance could be accommodated. Therefore, all air-pressure gauges with a set range of 10 psi or above were modified to have infinite time constants in the field.

5.1.3 Calibration

Air-pressure gauges, Kiel gauges, Pitot tubes, and the Elmer underwater gauge were calibrated, using a pressure calibration device designed at Sandia. Two such units were built, each consisting of a stretcher-type carrying case housing two regulators, two Heise gauges, an oxygen cylinder, and associated plumbing. To utilize the best range Heise gauge for a particular channel's calibration, each unit had an associated carrying case with five Heise gauges covering the operation's expected pressure ranges. All Heise gauges were checked against a primary standard at Sandia before leaving for the field, and in the field the gauges were periodically checked one against the other.

The accuracy of calibration required on low-pressure channels could not be accommodated with the foregoing equipment, so a water manometer was built in the field to calibrate these gauges. It was a simple U tube, enabling accurate settings of low pressures in inches of water.

5.1.4 Suggestion

It is desirable to return all air-pressure gauges, with the exception of those required for immediate operations, to Wiancko for the installation of variable back-leak plugs.

5.2 PITOT GAUGES

Forward and back wind measurements were made using Wiancko Pitot tubes (Figs. D.14 and D.17). This gauge consisted of a cylindrical tube which was aligned along the blast radius and mounted on a pipe stand so that it was 12 to 15 ft above grade. Differential Wiancko pressure gauges were mounted at each end of the tube. Pressure ports were at each end and about 6 in. back from each end. The end ports respond to the stagnation pressure, whereas the side ports respond only to the side-on pressure. The output of the two differential gauges is then proportional to the velocity head in the positive and negative directions, respectively. A third pressure gauge opened into the side opening of the front differential gauge, thereby giving a channel of side-on pressure.

The pressure gauges on hand for the Pitot tubes had a large ratio of full-scale range to set range in many cases. Since this causes low outputs from the gauge and poor signal-to-noise ratios, these gauges were modified to lower the full-scale range. The parts used came from the spares on hand but were not adequate to finish the job. These modifications made a small improvement, but poor signal-to-noise ratios still existed, especially on the back differential gauges.

In modifying the Pitot gauges it became apparent that the machine fit of the front and back heads was much too close. The threads would seize, making it impossible to either remove or align the head. A looser fit in the future would be more desirable from the modification standpoint.

5.3 AFTERWIND PRESSURE

A Wiancko pressure gauge was mounted in a special triangular concrete mount, facing away from ground zero (Fig. D.18). The mounts were used in place of Pitot gauges which were not structurally strong enough to withstand the expected overpressures on the islands of Irene and Helen. The set ranges of the pressure gauges were less than 15 psi, but gauges were selected which would not be damaged during the relatively high pressures expected during the positive phase. The neon bulbs in the Consolidated carrier amplifiers accomplished a clipping action when the output voltage of the gauge exceeded the operating range of the equipment. Near each triangular mount a ground baffle with a similar gauge setup was also used so the side-on pressure could be determined.

5.4 q-GAUGES

Gauges to measure drag force were designed and built at Sandia (Figs. D.14 and D.19). They are composed essentially of a cylinder aligned with the blast radius. Inside this blast collimating cylinder a bronze lollipop or cantilever beam is mounted, which bends under the force of the blast. At the base of the beam (point of maximum bending moment) four strain gauges are mounted so as to form a four-active-arm bridge, and the gauge is damped by grease at the end of the beam. When the beam is stressed, an electrical output occurs.

The gauges were calibrated by means of machined brass weights. These weights were applied to the center of the lollipop by using a cord and fulcrum arrangement at the mouth of the cylinder.

The two main difficulties encountered with these gauges were low output level and mechanical failure. The output signal in many cases was partially obscured by the noise level. An example of this was a q-gauge on Elmer whose output at set range was 0.3 mv. The strain gauge elements of the gauges could not withstand continual operation during the checkout procedure. When this was discovered, the gauges were removed from the line until just before the shot date. If these gauges are used in the future in their present design, the carrier should be applied to them only during calibration and the blast run.

5.5 KIEL GAUGES

This gauge also consists of a cylinder aligned with the blast radius and is mounted on the same mount parallel to the q-tube (Figs. D.14 and D.19). Inside the cylinder two small tubes face toward and away from zero, respectively. Wiancko variable reluctance pickups measure the pressures within the small tubes. This gauge converts the velocity head to pressure head, thereby giving a measure of total head in both the positive and negative directions.

5.6 SONIC GAUGES

Gauges, designed and built by Sandia, were used to measure sound and wind velocities (Fig. D.14). Each installation consisted of three units: a dual transmitter and two receivers. The transmitter housing was located midway between each of the receivers on a pipe mount similar to a football goal post. The mount was aligned at 45° to the blast radius to help eliminate flow effects. Each transmitter microphone was fed pulses at a 150-cps repetition rate. Simultaneously, a pulse was fed to the interval timer, which after a predetermined time delay, fed a rising triangular wave back to the recorder. As each receiver received the transmitted pulses, it cut off the rise of the triangular wave, causing it to return to zero. In this way the height of the two triangular waves indicated the transit time for the pulse between the transmitter and each of the receivers. Knowing the transit distances and times, velocity of sound as well as wind velocity may be computed.

Installations were made on the islands of Janet, Kate, Mary, Sally, and Yvonne. The Janet and Yvonne installations used batteries to power the gear, whereas Kate, Mary, and Sally were a-c operated. On King shot the d-c installations on Yvonne were converted to a-c, because the short life of the batteries did not permit sufficient running time for continual checkout.

Sonic gauges were calibrated by inserting known time delays between the transit pulse and the receiver pulse. Calibration steps were actually recorded on tape, as well as a free run under the ambient conditions existing at the time of calibration. The approximate wind velocity and direction were noted during the free run to eliminate gross errors.

The main difficulty encountered with the sonic gauge was its tendency to absorb moisture. The microphone holes in the cases left a large space where rain could enter and damage the electronic components. On King shot these holes were sealed as well as possible with tape and caulking compound. These gauges, if used again, should have permanent waterproofing before they are taken into the field.

The battery problem associated with the d-c sonic system was also serious. There was not sufficient capacity for long runs, which hindered the checkout procedure. In the future, a-c gear should be used in all cases possible.

5.7 TEMPERATURE GAUGES

A Sandia-designed bridge-type gauge was used (Fig. D.14). One arm of the bridge was exposed to the heated air from the blast, and the temperature vs resistance properties of the wire used in the active arm caused a change in the output voltage of the bridge. Physically, the gauge is a tube pointed at the blast and mounted approximately 15 ft above the surface. The exposed resistance wire is supported by a string of small studs, which are embedded in a plastic head at the tip of the tube. A metal shield was used to reduce the effect of thermal radiation on the element at zero time.

Calibration was effected by inserting known resistances in series with the active arm. These resistances unbalanced the bridge, giving output voltages equivalent known temperature differences. The ambient air temperature at the time of calibration was measured so as to convert the temperature differences to absolute temperature.

Operational difficulties with this gauge were essentially the same as those discussed in Sec. 5.4, concerning q-gauges. The only additional comment is that the sensing element was more delicate in the case of temperature gauges, and several failed at the incidence of the shock wave.

5.8 SEISMIC MEASUREMENT OF GROUND MOTION

Ground accelerations were measured using Wiancko accelerometers. For each installation three gauges were mounted mutually perpendicular to each other inside a bull-plug. These bull-plugs looked similar to the rounded end of a nitrogen cylinder with a lid attached by bolts welded around the inside periphery of the plug. A right-angle bracket welded to the lid allowed the three enclosed accelerometers to be aligned to measure the radial, tangential, and vertical components of ground acceleration (Fig. D.2).

All accelerometers were selected for damping within the limits 0.55 to 0.75 of critical and linearity within 2 per cent before shipment to the test site.

Six ground acceleration installations were made at an average depth of 17 ft.

Accelerometers with a set range above 1 g were calibrated on a Statham rotary accelerator. Alnico magnets located around the rim of the rotating table induced voltage pulses in a coil located on the case as the table rotated. This enabled accurate rpm settings to be made through the use of a calibrated oscillator and an oscilloscope.

Accelerometers with a set range of below 1 g were calibrated on one of two Sandia-designed tip tables. These tables merely rotated the accelerometer in the earth's gravitational field.

Bull-plugs proved unsatisfactory because a watertight seal was difficult to attain. The gasket design allowed water to leak into the bull-plug along the bolt threads. Caulking compound was used to try to seal these holes, and in some cases the plug was dipped in liquid neoprene. One failure occurred on Janet. However, the contractor still had his equipment in the area, and we were able to retrieve the plug, install new gauges, and reinstall the plug in its initial position. On Mary the plug filled with water after the contractor had shipped his equipment to Bikini. Rather than lose the channels, three gauges were mounted on the walls of the shelter.

To eliminate the sealing problem, the lowering pipe could be attached to the sealed end of the plug rather than the lid. Then, if the plug were long enough, the air trap formed by the inverted cylinder would prevent the water from entering the gauges even if the seal leaked.

5.9 UNDERWATER PRESSURE

Underwater pressures were measured by Wiancko twisted-bourdon-tube-type gauges with a double E core used in an active four-arm bridge configuration. This arrangement has approximately double the output of the single E core type having only a two-active-arm bridge configuration.

The gauge was housed in a ball-like case, the back volume of which was divided into two compartments and filled with oil. An adjustable back leak for setting the time constant (based on the time required for equalization of the pressure on the back of the bourdon tube with that on the front) joined the two compartments. The E cores, bourdon tube, electrical connections, and plastic air bag were mounted on a plug which screws into one compartment of the case. The other compartment had an opening to the outside of the case which was sealed by a plastic diaphragm to prevent the oil and water from mixing when the gauge was submerged in water. Gauges with pressure ranges of 750 and 3600 psi had the back opening sealed with a plug.

The gauges were delivered to Sandia while the personnel were in the field; consequently they were not checked before the shot except by static pressures. Further laboratory tests by the field test group have proved that, unless special precautions are taken to wet the bourdon tube, small bubbles of air become entrapped and increase the response time of the gauge. In the 30-lb gauge the rise time was increased from a normal 0.5 msec to 2 msec, using a step function of 15 lb. Higher-range pressure gauges had somewhat better response times even with air entrapped in the bourdon tube.

Wiancko variable reluctance water-pressure gauges were mounted on the stands discussed in Sec. 3.1.2b (Figs. D.3 and D.20).

5.10 SYMMETRY MEASUREMENTS

Indenter gauges were used to determine asymmetry of the blast wave on Mike shot. A cluster of ten gauges was located on Janet and Alice at the same distance from ground zero. Each cluster of gauges was placed so that the gauges would all lie in a circle 10 ft in diameter around the stations (Fig. D.21).

The gauge consisted of a cylinder mounted on a stake which is pounded into the ground. A piston fitted inside the cylinder has a sharp point at the end of its shaft. This point rests on a copper disk at the bottom of the cylinder. The air-pressure wave forces the point of the shaft into the copper disk, the diameter of the indentation being a function of pressure. The gauge is covered with a rubber gauge cover to protect it from the elements.

5.11 CALIBRATION TECHNIQUES

Calibration of the seven shelters was accomplished by two calibration teams, each under the supervision of an assistant project engineer. Each team carried all of their calibration gear in a covered weapons carrier or a 6 by 6 truck. Aluminum scaffolding was also carried, enabling the teams to move from station to station in a minimum of time.

During calibration the recording equipment was run from island power to conserve the life of the batteries. Mary and Sally did not have island power, necessitating the use of diesel generators.

5.11.1 Bridge-type Channels

1. The zero function output from the gauge was balanced out with the Consolidated balance controls.

2. The peak expected function was applied to the gauge, and the Consolidated carrier amplifier was adjusted so the incoming gauge signal was either in phase or 180° out of phase with the gating voltage of the phase-sensitive detector. This was done by peaking the meter on the front of the amplifier.

3. The gauge was returned to balance, and the Consolidated carrier balance was rechecked. The center frequency of the Ampex positive-bias multivibrator was adjusted to 27 kc plus or minus 50 cycles.

4. The peak expected function was applied to the gauge, and the attenuator on the carrier amplifier was set so the frequency deviation was less than 10 kc. With the calibration console switches in the "set-up" position, the set-range gauge voltage was balanced out. The switches were returned to the "operate" position, and the set-range deviation was noted.

5. The gauge was returned to balance, and the cal-plus deviation was noted. If the set-range and cal-plus deviations were not within 2 per cent of each other, the foregoing procedure was repeated.

6. Three-point calibrations were run in the positive direction, noting the frequency for each setting of the function. Knowing the function steps and the frequency deviation, the linearity was computed. If the linearity was not within 3 per cent, the three-point calibration was repeated.

The method of reading calibration frequencies with a Berkeley counter instead of recording the calibrations on tape greatly facilitated the calibration procedure. These recorded frequencies were then fed back into the Ampex playback from an audio oscillator to achieve calibration steps.

5.11.2 Sonic Channels

The triangular wave form from the sonic gear was capacitively coupled directly into the Ampex multivibrator strip. In order not to overdrive the recording system, the height of the triangular wave on maximum transit time was adjusted to 0.6 volt by means of an oscilloscope. The fixed time delay was adjusted to give a small rise on the minimum transit time.

Calibration tapes were run on each sonic installation. No cal-plus step was available on these channels although there was the possibility of gain change. Correlation between blast and calibration can be established, however, by accurately determining an amplitude for a particular time delay on the calibration record and the new amplitude for the same time delay on the blast record.

CHAPTER 6

RECOVERY OF DATA AND EQUIPMENT

6.1 MIKE SHOT

In most cases the data were recovered by helicopter. The time of record recovery was governed by the Rad-Safe crews. The data were recovered from one to six days after the shot, depending on the radiation level existing on the individual islands. Very little difficulty was encountered in data recovery except at the Irene shelter. Here the contractor moved the sand away from the shelter door so that it could be opened. In one instance the tape was wound around the capstan of the recorder; otherwise the tape needed only to be rewound on the reels and the reels removed from the recorder.

The procedure used in the recovery of equipment was tailored to the time limitations placed by the Rad-Safe crews.

6.1.1 Islands with Low Contamination

An LCM was used to place trucks on the beach for instrument recovery. Instruments and equipment were removed from the mounts and shelter onto the trucks. The LCM returned the equipment to the storage area for packaging and reshipment.

6.1.2 Islands with High Contamination

When the radiation on an island was a definite hazard, an LCU brought a DUKW near the island. The LCU stayed offshore a short distance so it would not become contaminated. Small crews (five or six men and a Rad-Safe monitor) went ashore on the DUKW and into the shelter. After the cables had been cut and the mountings released, the crew was divided. Half of the crew went outside to load the DUKW, and the other half remained inside to hand out equipment. Every 15 min the half crews were rotated so that those on the outside could take advantage of the shielding effected by the shelter. When the shelter was stripped, the whole crew removed the instruments from their mounts. The DUKW loaded with instruments and equipment then returned to the LCU, which returned the gear to the storage area for packaging. The time required for recovery on Irene, which was the only shelter island requiring the safety procedure, was less than 2 hr.

The instrument islands (Gene, Helen, and Noah) were also highly contaminated. No recovery was made on Gene because the instruments were buried from the blast. A few instruments were accessible on Helen, but many were buried. On Noah, the artificial island, instrument recovery was easily accomplished.

6.2 KING SHOT

Little difficulty was encountered in recovering instruments and equipment following King shot. The radiation level on Yvonne was less after King shot than immediately before. Evidently the blast from King shot blew away much of the radioactive material formed by Mike shot. The procedure used for recovery was the same as that discussed in Sec. 6.1.1.

CHAPTER 7

RESULTS

Results of the operation as concluded from reduced data are included in the reports listed below:

WT-602, Air Shock Pressure-Time vs Distance, by G. W. Rollosson (Division 5111, Sandia Corporation).

WT-603, Shock Winds, After-winds, and Changes in Air Temperature Resulting from Large Atomic Bursts Near the Earth's Surface, by M. Cowan, Jr. (Division 5111, Sandia Corporation).

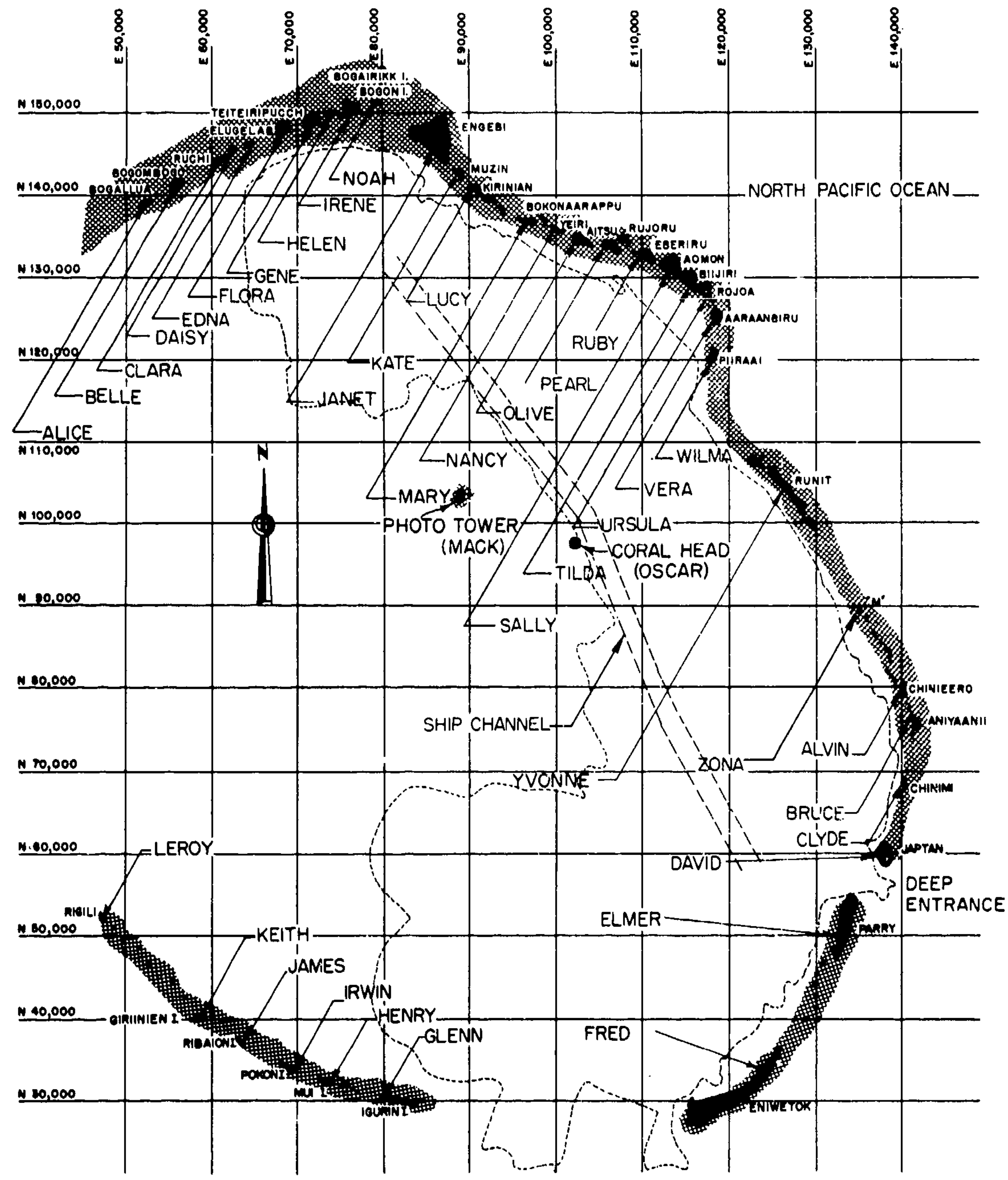
WT-604, Ground Accelerations (and Motion), by W. R. Perret (Division 5111, Sandia Corporation).

WT-605, Underwater Pressure Measurements in the Lagoon, by G. W. Rollosson (Division 5111, Sandia Corporation).

All data were reduced by the Telemetering Analysis Section, 5242-2, Sandia Corporation.

APPENDIX A

MAPS OF ENIWETOK ATOLL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JANET
RUBY
PEARL
OLIVE
NANCY
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VERA
MARY
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(MACK)
URSULA
CORAL HEAD
(OSCAR)
TILDA
SALLY
N
SHIP CHANNEL
ZONA
ALVIN
YVONNE
BRUCE
CLYDE
DAVID
DEEP
ENTRANCE
ELMER
LEROY
KEITH
JAMES
IRWIN
HENRY
GLENN
FRED

MIKE					
ISLAND	MEAS.	CH	STATION. No	MOUNT	SHELTER
GENE	2 AP	2	614	MPB	600
HELEN	2AP, 2W WP	6	615.01-616.01 670.01	MPD, MPE MPG	600
IRENE	2AP, 2W 3 GM	16	615.02 616.02 650.01	MPD, MPE MAC	600
NOAH	2AP	2	610	MPF (10' TWR)	600
JANET	2 AP 11AP (1-WNKO, 10 MNTR) 3 GM WP AP, 8W, T	17	6102 6103 650.02 670.02 611.01	OCE BLDG MPC, MPV MAC MPG 45° TWR.	601
KATE	AP 8W, T 3 GM	13	611.02 650.03	45° TWR MAC	602
MARY	AP. 8W. T 3 GM	15	611 03 650.04	45° TWR MAC	603
OLIVE	2 AP	2	613.01		603
SALLY	AP 8W, T WP 3 GM	14	611.04 670.03 650.05	45° TWR. MPG MAC	604
YVONNE	2AP	2	613.02	MPF (10' TWR)	605
ELMER	AP. 8W, T WP 3 GM	12	612.01 670.04 650.06	15' TWR. MPG MAC	606
ALICE	10 AP (INDTR)	—	6104	MPJ	—

KING		
YVONNE		
22 CHANNELS		
SHELTER 605		
MEAS.	STATION	MOUNT
AP OVER WATER	617.01 617.02 617.03 617.04 617.05 617.06 617.07 617.08	MPH-15' TWR " " " " " " "
AP OVER LAND	6101.01 6101.02 6101.03 6101.04	MPA " " "
2AW	618	15' TWR.
2AW 25V	619.01	45° TWR.
2AW 25V	619.02	45° TWR.
ELMER SH 606		
AP, 8WT	612.02	15' TWR

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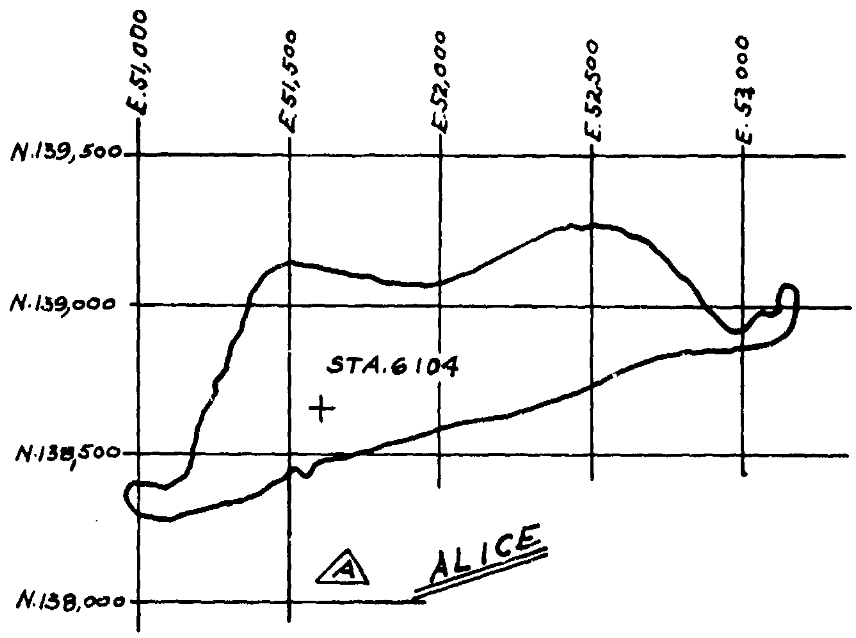

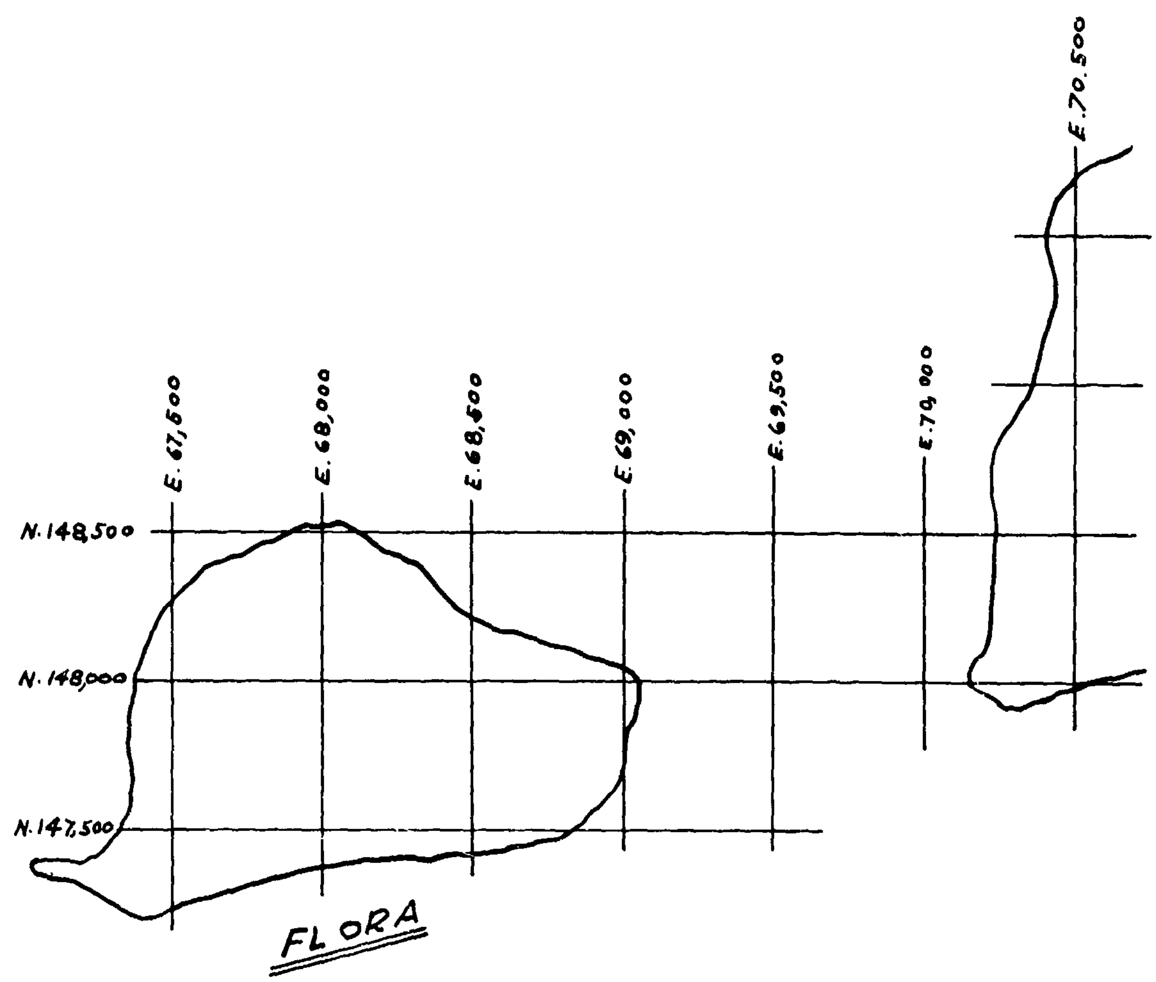

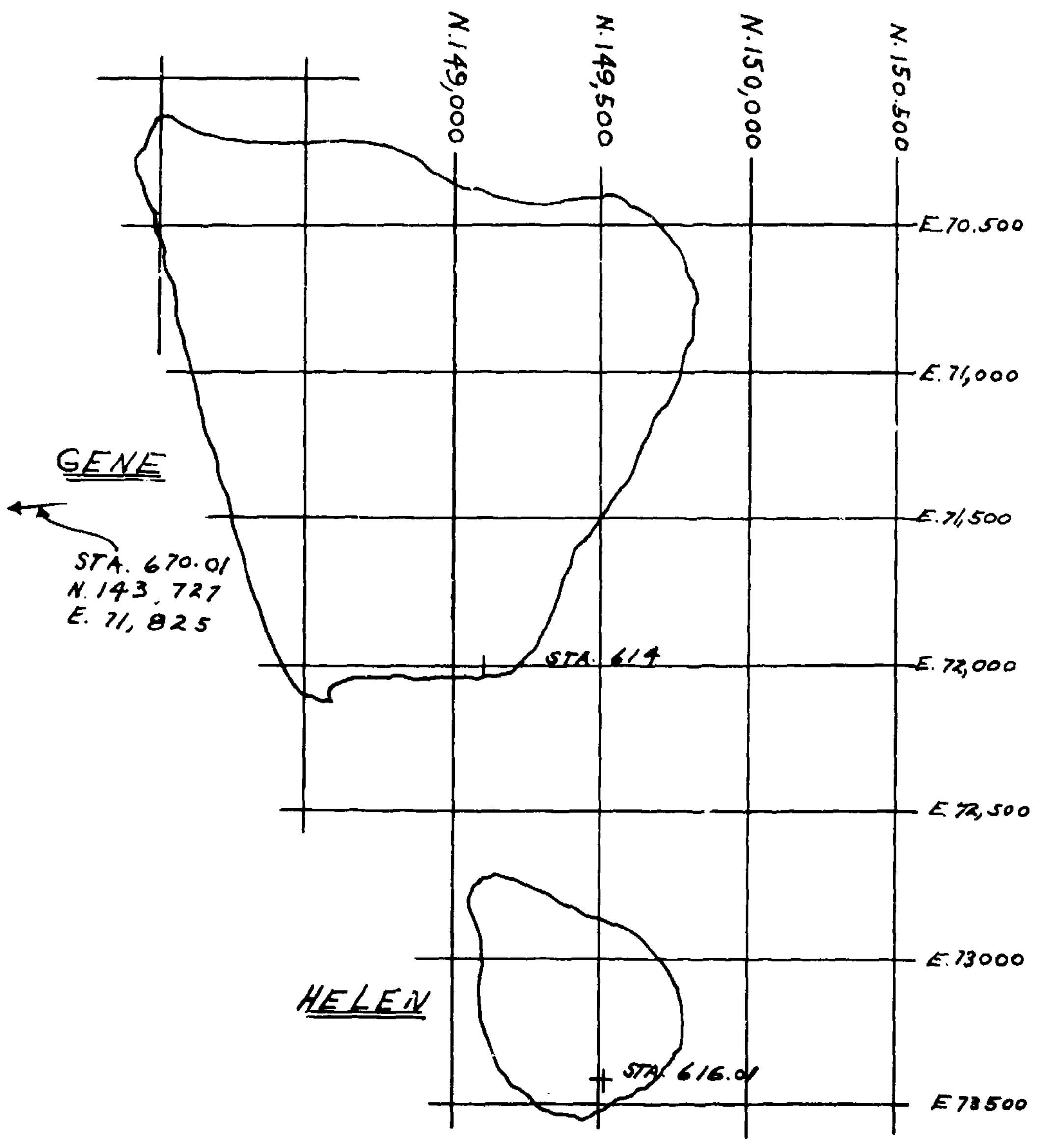
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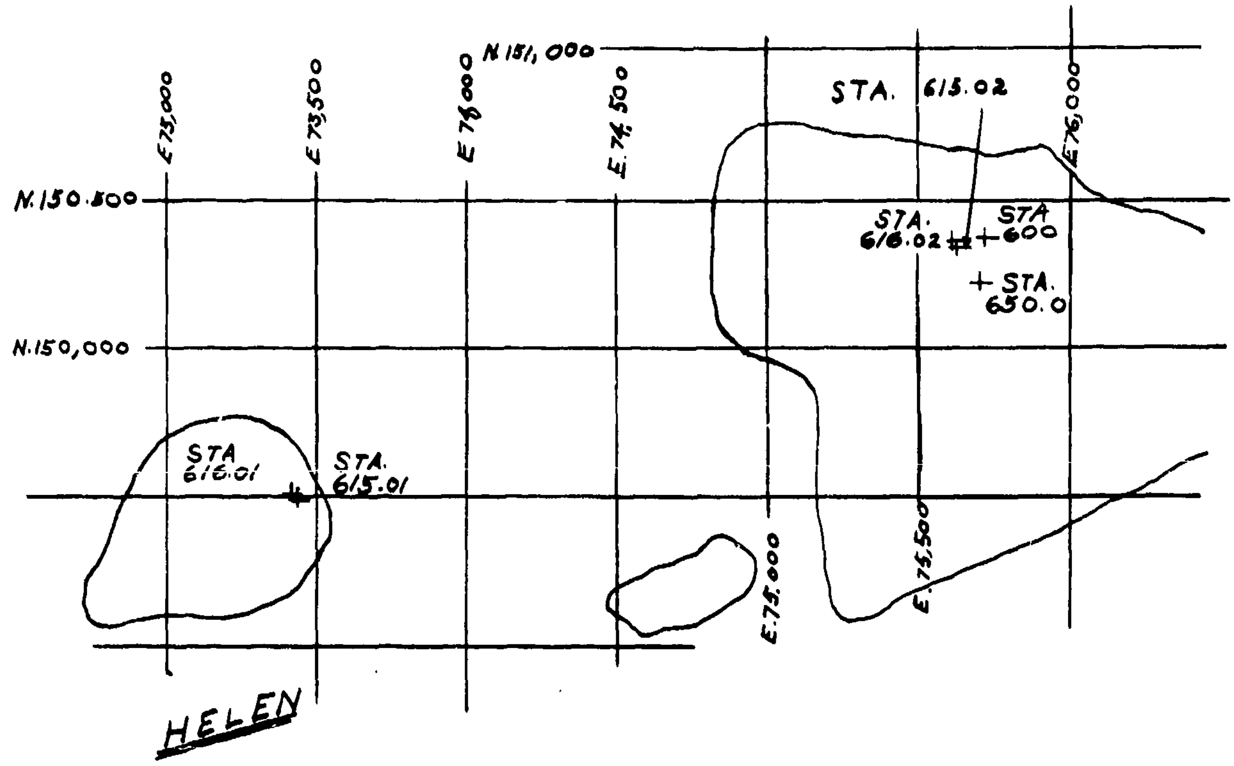
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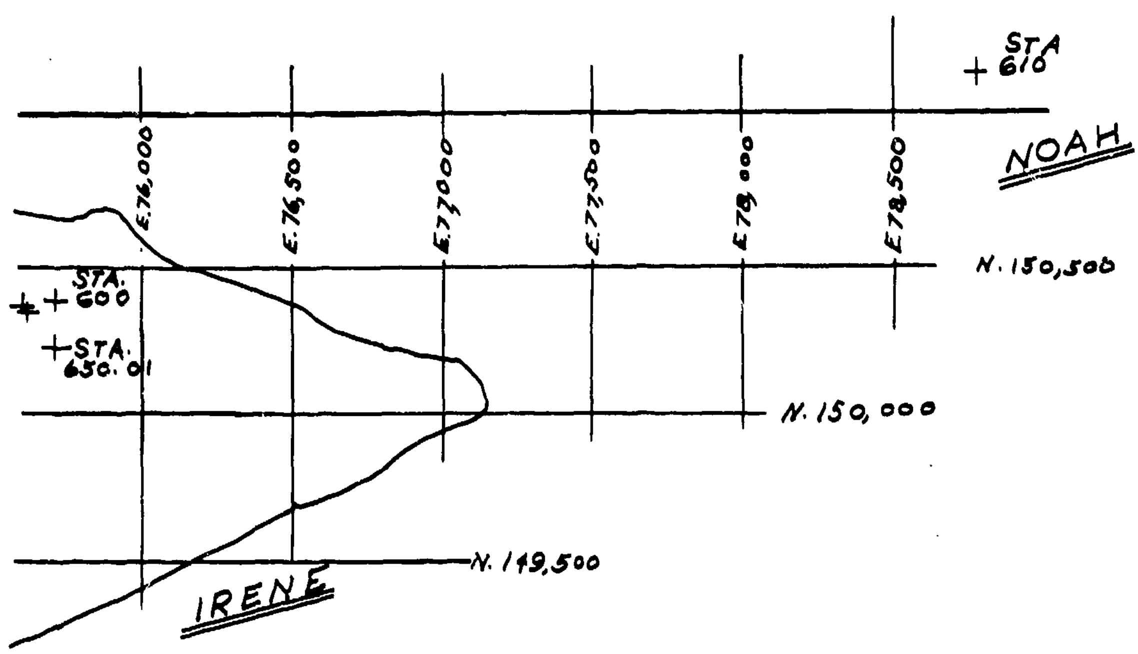
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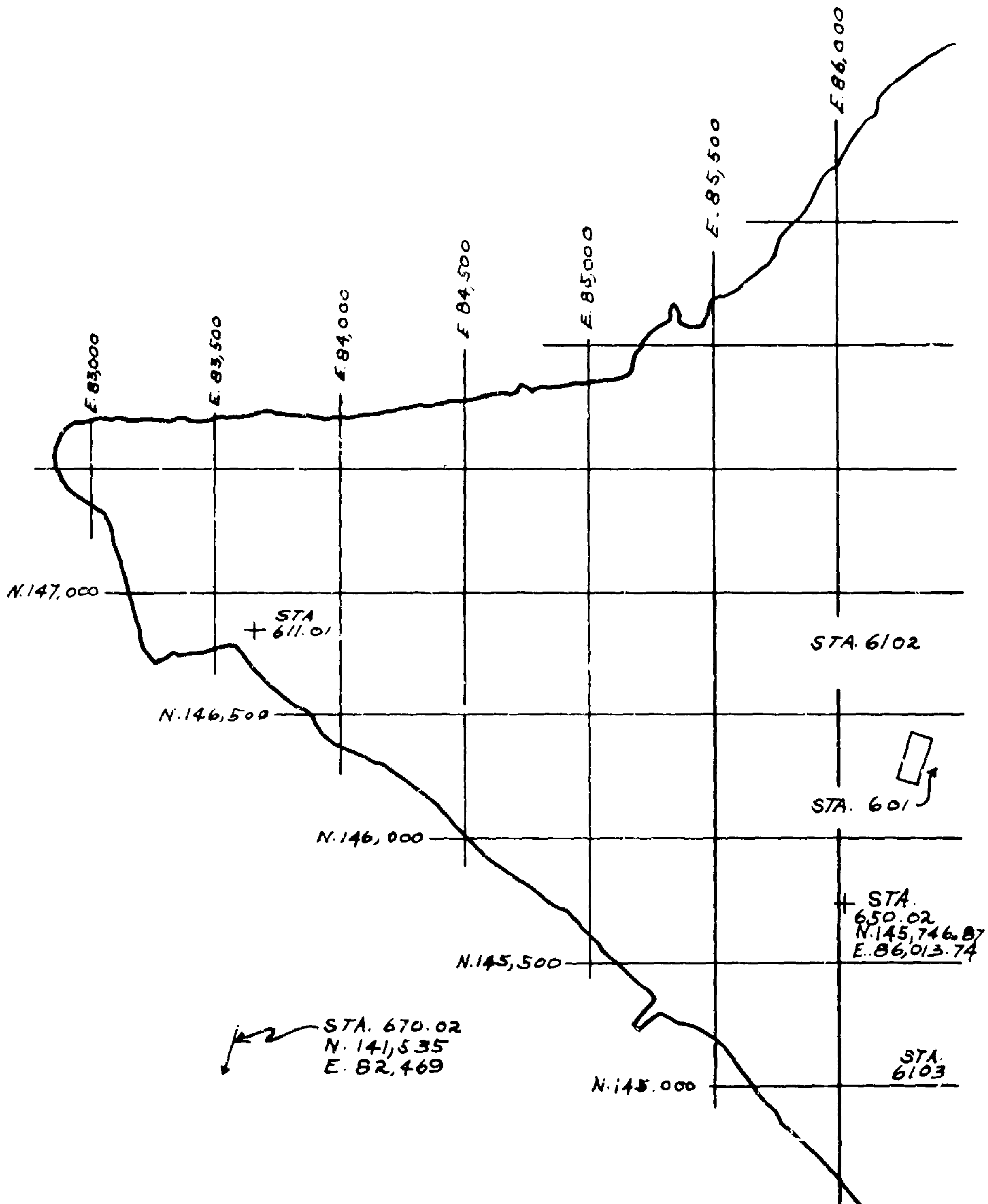

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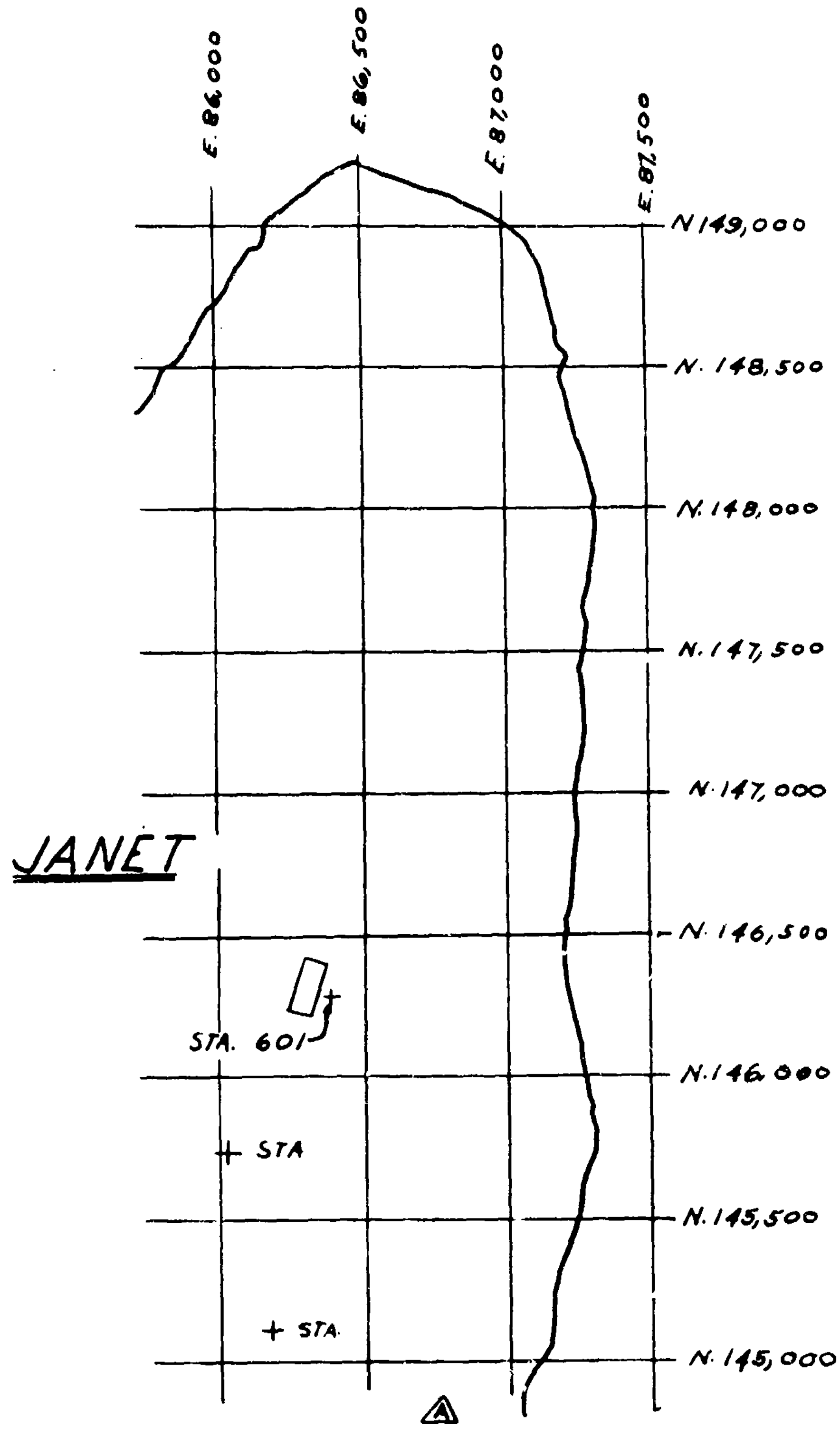

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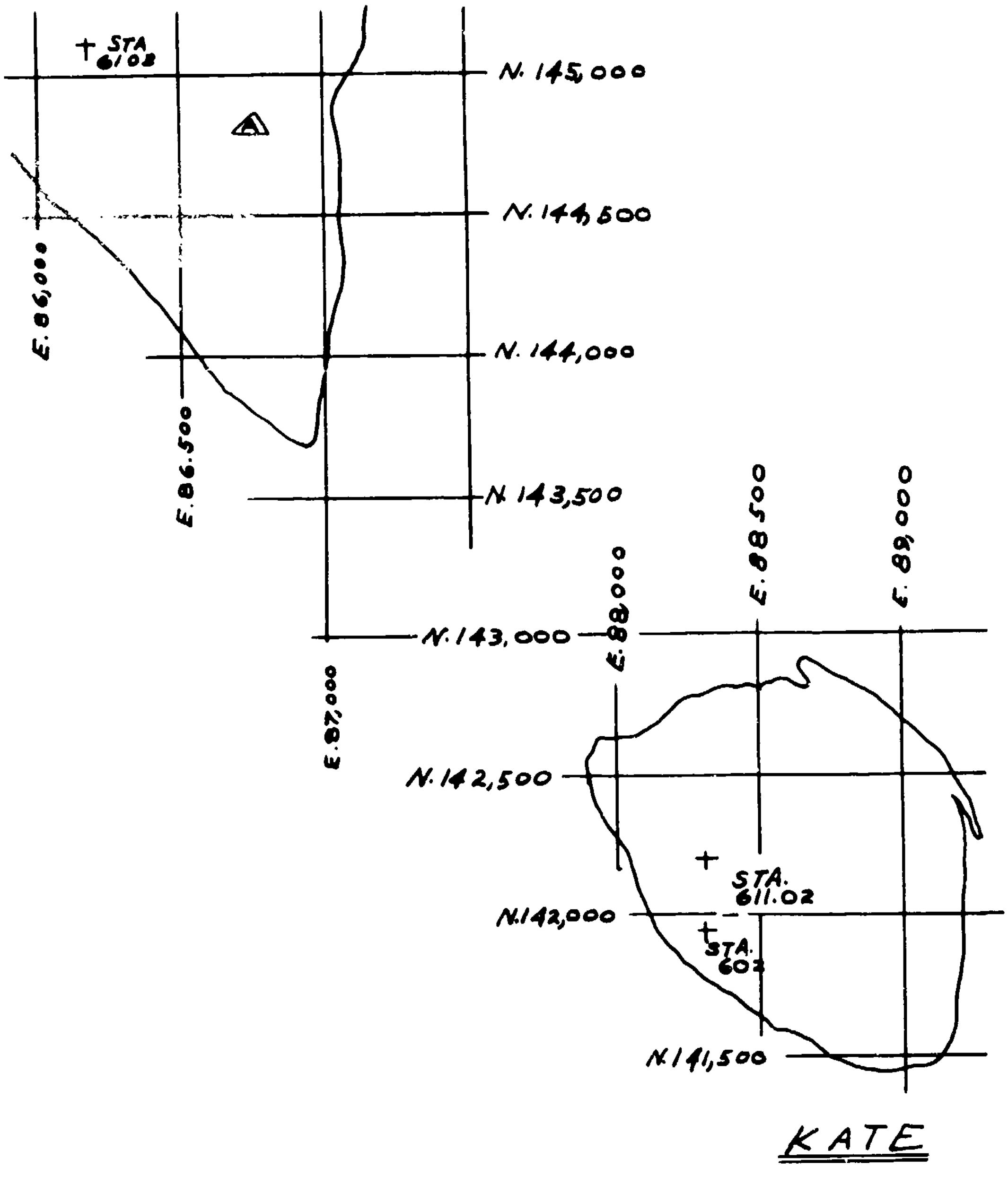

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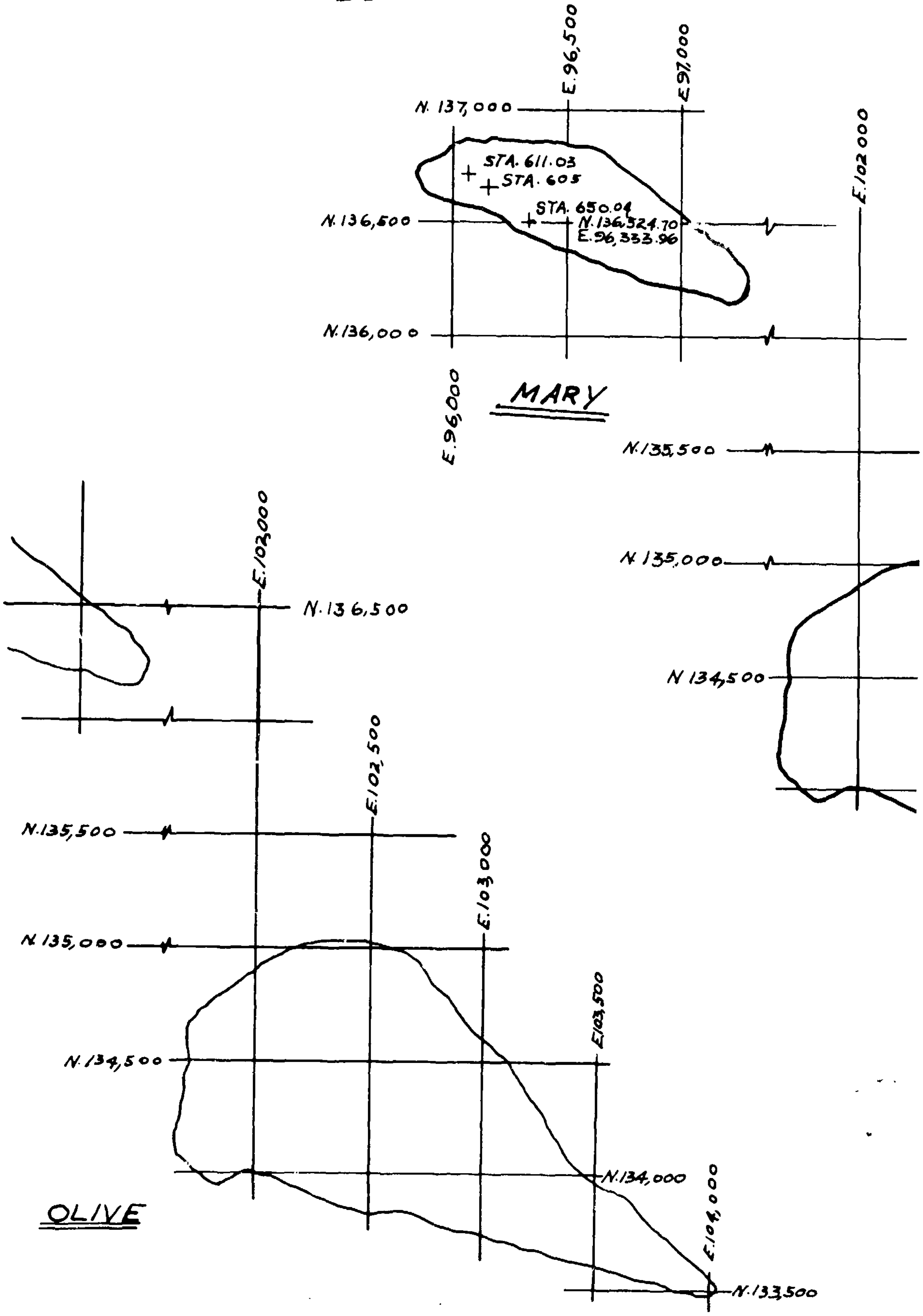
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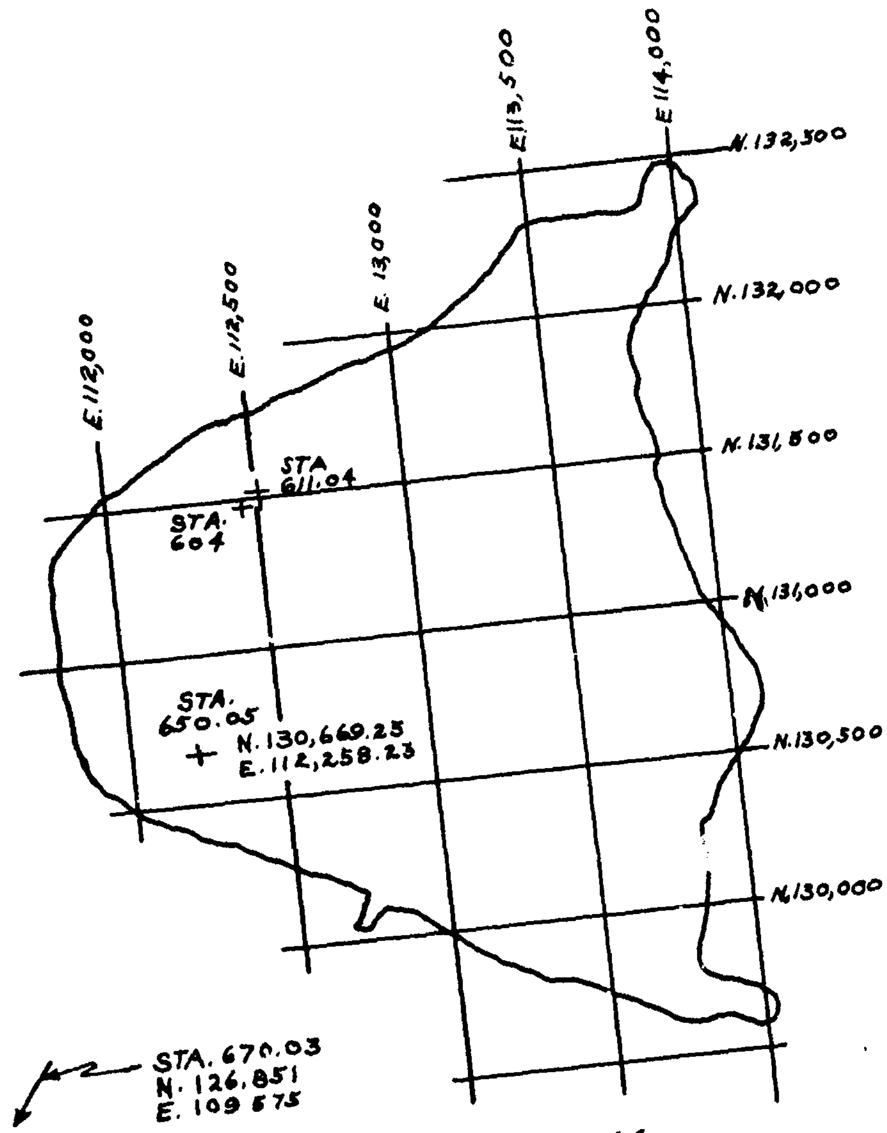
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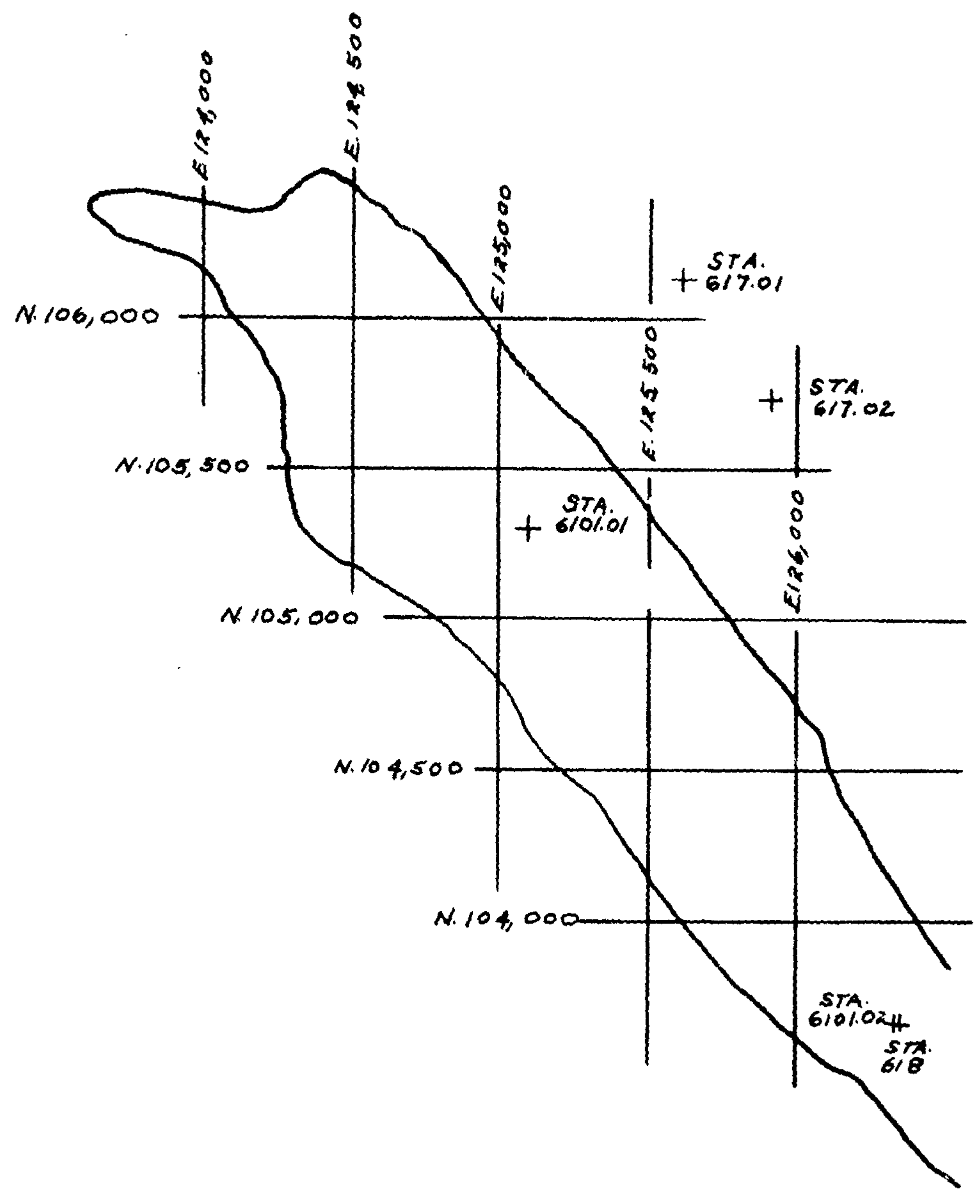
SALLY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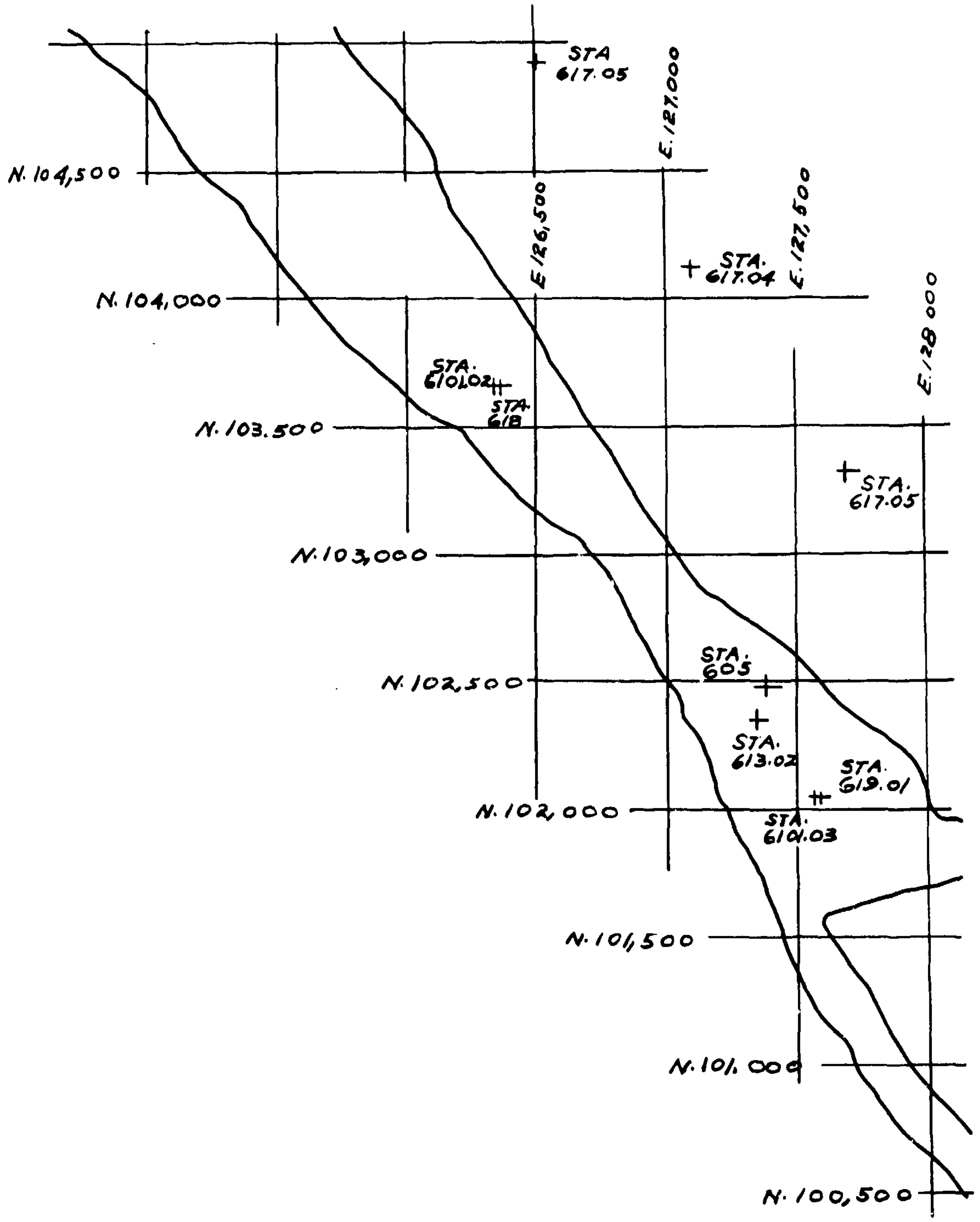
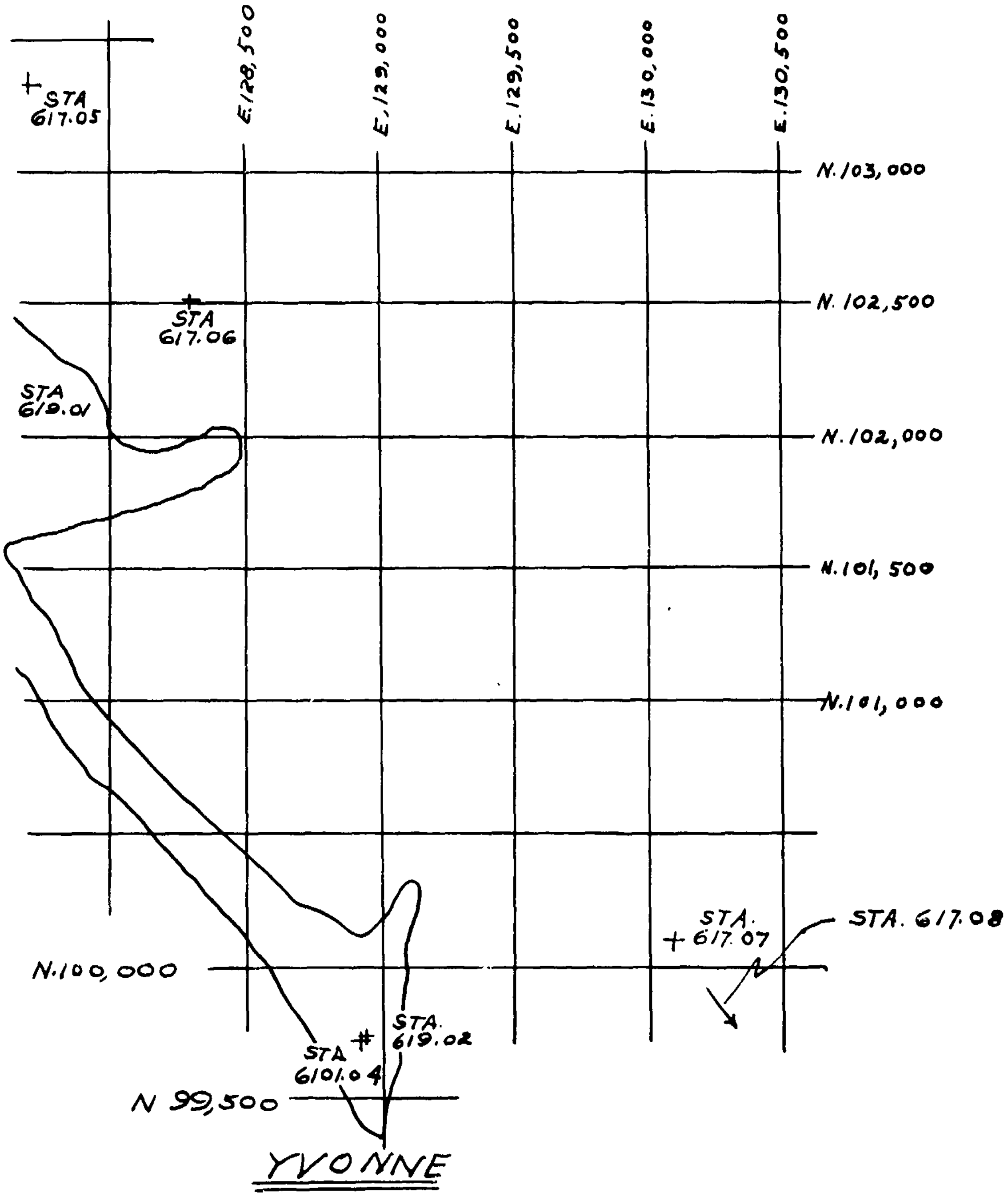
UNCLASSIFIED

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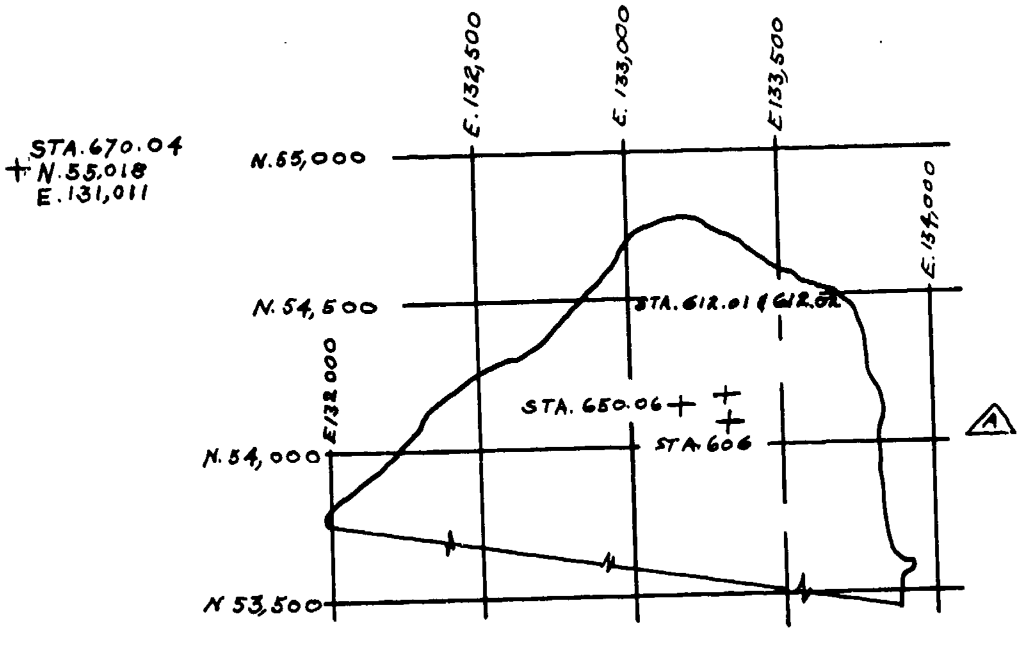


ELMER
(NORTH END)

APPENDIX B

GAUGE LOCATIONS BY SHELTERS

Gauge Code Designations

SAMPLE: YWF 21

Y	WF	21
Location (Island Code)	Type Gauge	Recorder Channel No.

Nomenclature

G	Gene	P	Air Pressure
H	Helen	Q	Q
I	Irene	QF	Forward Kiel
N	Noah	QB	Back Kiel
J	Janet	WF	Forward Pitot
K	Kate	WB	Back Pitot
M	Mary	WP	Static Pitot
O	Olive	T	Temperature
S	Sally	U	Underwater pressure
Y	Yvonne	AR	Radial acceleration
E	Elmer	AT	Tangential acceleration
		AV	Vertical acceleration
		SOF	Front sonic
		SOB	Back sonic

Table B.1—IRENE SHELTER 600

Station No.	Designation	Type mount
614	GP1 GP2	Double ground baffle
615.01	HP3 HP4 HP5	Triple ground baffle
616.01	HP6	Afterwind baffle
615.02	IP7 IP8 IP8	Triple ground baffle
616.02	IP10	Afterwind baffle
610	NP11 NP12	15-ft pipe tower
670.01	IU13	Underwater (offshore of Gene)
650.01	IAR14 IAT15 IAV16	Bull-plug (underground)

Table B.2—JANET SHELTER 601

Station No.	Designation	Type mount
611.01	JT1 JP2 JQ3 JQF4 JQB5 JWF6 JWB7 JWP8 JSOB9 JSOF10	15-ft goal post tower oriented 45° to radius from ground zero
670.02	JU11	Underwater
650.02	JAR12 JAT13 JAV14	Bull-plug (underground)
6102	JP15	On Greenhouse structure 3.1.1-4, 27 ft above surface
	JP16	Same, 4 ft above surface
6103	JP17	Single ground baffle

Table B.3 — KATE SHELTER 602

Station No.	Designation	Type mount
611.02	KT1	15-ft goal post tower oriented 45° to radius from ground zero
	KP2	
	KQ3	
	KQF4	
	KQB5	
	KWF6	
	KWB7	
	KWP8	
	KSOB12	
	KSOF13	
650.03	KAR9	Bull-plug (underground)
	KAT10	
	KAV11	

Table B.4 — MARY SHELTER 603

Station No.	Designation	Type mount
611.03	MT1	15-ft goal post tower oriented 45° to radius from ground zero
	MP2	
	MQ3	
	MQF4	
	MQB5	
	MWF6	
	MWB7	
	MWP8	
	MSOB14	
	MSOF15	
613.01	OP9	10-ft pipe tower
	OP10	
650.04*	MAR11	Accelerometers mounted on shelter
	MAV12	
	MAT13	

*See Sec. 5.8.

Table B.5—SALLY SHELTER 604

Station No.	Designation	Type mount
611.04	ST1	15-ft goal post tower oriented 45° to radius from ground zero
	SP2	
	SQ3	
	SQF4	
	SQB5	
	SWF6	
	SWB7	
	SWP8	
	SSOB13	
	SSOF14	
670.03	SU9	Underwater
650.05	SAR10	Bull-plug (underground)
	SAT11	
	SAV12	

Table B.6—YVONNE SHELTER 605

Station No.	Designation	Type mount
613.02	YP1	10-ft pipe tower
	YP2	
617.01	YP3	15-ft pipe tower on reef
617.02	YP4	15-ft pipe tower on reef
617.03	YP5	15-ft pipe tower on reef
617.04	YP6	15-ft pipe tower on reef
617.05	YP7	15-ft pipe tower on reef
617.06	YP8	15-ft pipe tower on reef
617.07	YP9	15-ft pipe tower on reef
617.08	YP10	15-ft pipe tower on reef
6101.01	YP11	Single ground baffle
6101.02	YP12	Single ground baffle
6101.03	YP13	Single ground baffle
6101.04	YP14	Single ground baffle
618	YWF15	15-ft pipe tower
	YWB16	
619.01	YWF17	15-ft goal post tower oriented 45° to radius from ground zero
	YWB18	
	YSOB19	
	YSOF20	
619.02	YWF21	15-ft goal post tower oriented 45° to radius from ground zero
	YWB22	
	YSOB23	
	YSOF24	

Table B.7—ELMER SHELTER 606

Station No.	Designation	Type mount
612*	ET1 EP EQ3 EQF4 EQB5 EWF6 EWB7 EWP8	15-ft pipe tower
670.04	EU9	Underwater
650.06	EAR10 EAT11 EAV12	Bull-plug (underground)

*Two pipe towers were erected on the same footing at this station to allow for the different azimuthal orientation of the mounts and gauges between the two shots. The instruments were mounted on one tower for Mike shot; then they were removed and mounted on the other tower for King shot.

Table B.8—INDENTER GAUGES

Station No.	Designation	Type mount
6103	None	10 indenter gauges on Janet
6104	None	10 indenter gauges on Alice

Table B.9—MIKE SCORE BY RECORDERS

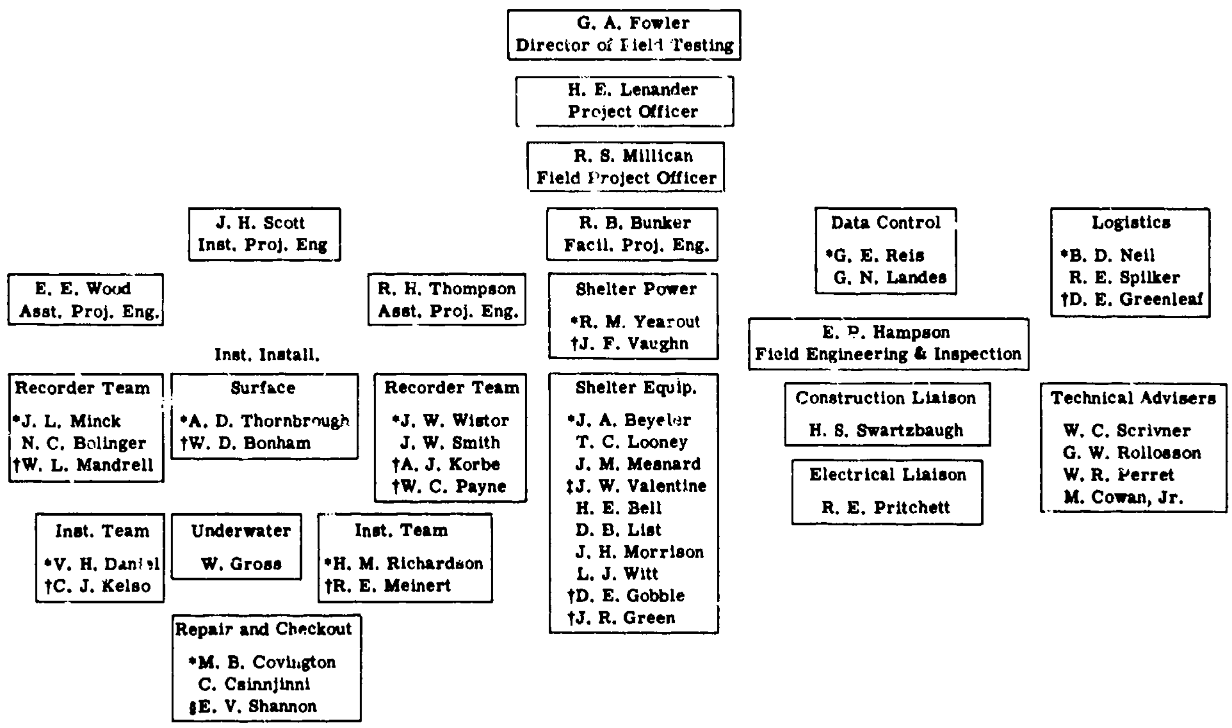
Shelter	Information channels	Ampex recorders	Difficulties
Irene 600	8	A	Sticky brake
	8	B	Pressure shock disabled gear
Janet 601	10	A	Ran correctly
	7	B	Ran correctly
Kate 602	13	A	Ran correctly
Mary 603	8	A	Sticky brake
	7	B	Threw tape when pressure shock hit the shelter
Sally 604	8	A	Ran correctly
	6	B	Tape stuck to microswitch arm
Yvonne 605	2	A	Ran correctly
Elmer 606	12	A	Ran correctly

Table B.10—KING SCORE BY RECORDERS

Shelter	Information channels	Ampex recorders	Difficulties
Yvonne 605	10	A	Ran correctly
	12	B	Ran correctly
Elmer 606	12	A	Ran correctly

APPENDIX C

PERSONNEL



*Group leader; † Military personnel; ‡ Pressure-gauge modification; § Custodian of magnetic tapes and field playback.

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APPENDIX D

INSTRUMENTATION PHOTOGRAPHS

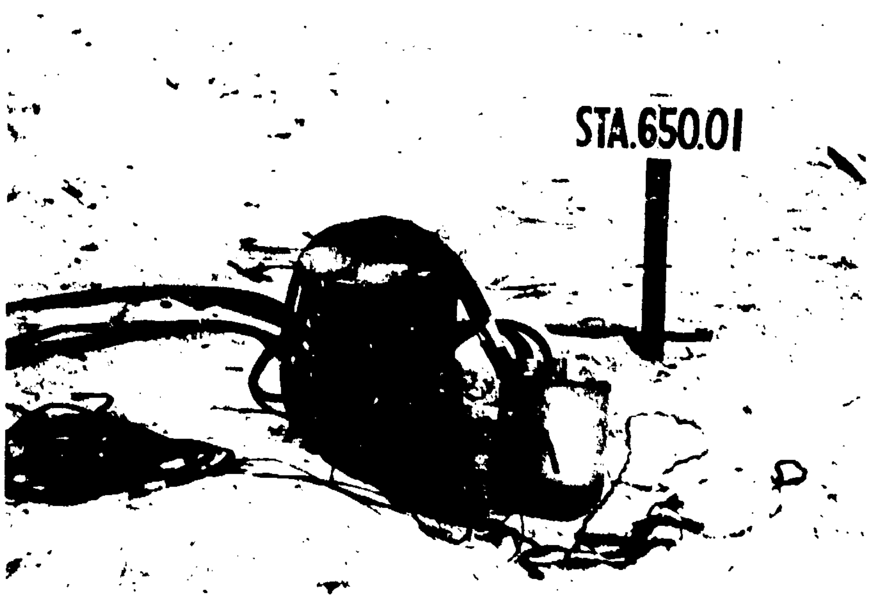

Fig. D.1 — Ground acceleration station showing bull-plug and cased hole.

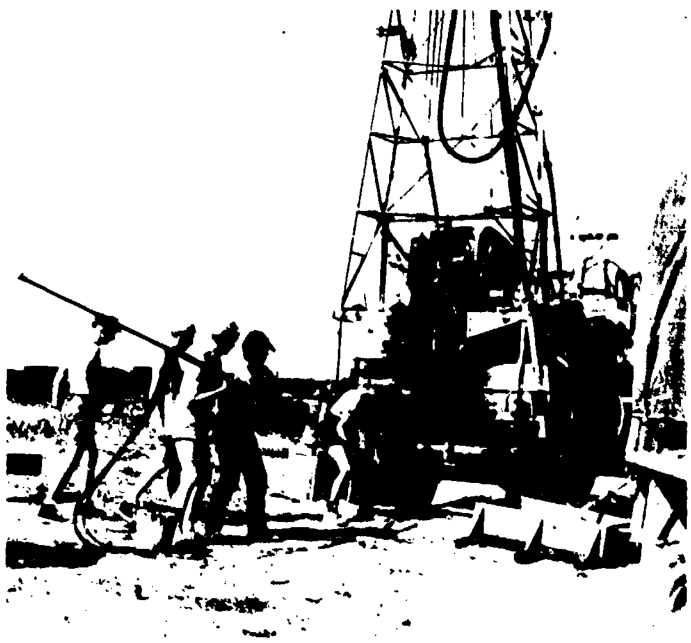

Fig. D.2 — Placing bull-plug.

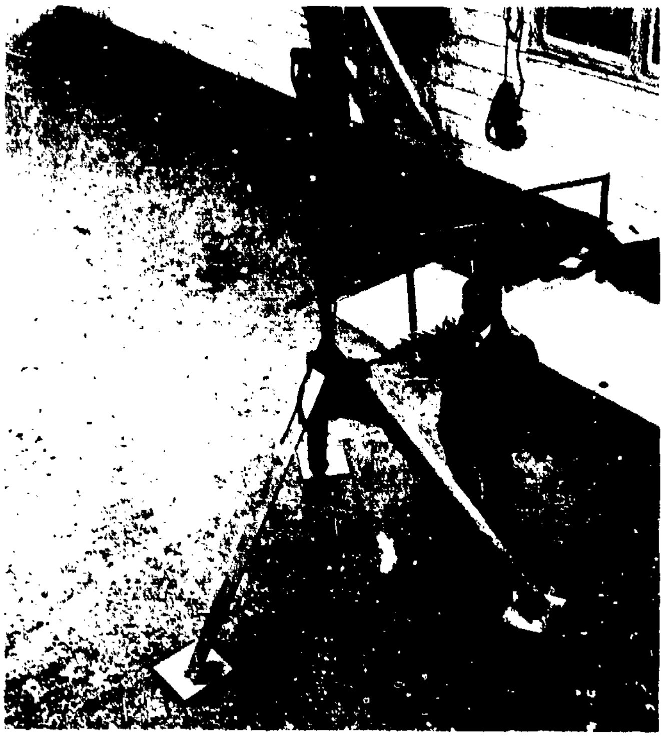

Fig. D.3—Underwater mount and gauge.

Fig. D.4—Method of placing sandbags on cable.

Fig. D.5—Laying cable in shallow water.

Fig. D.6—DUKW laying cable in deep water.

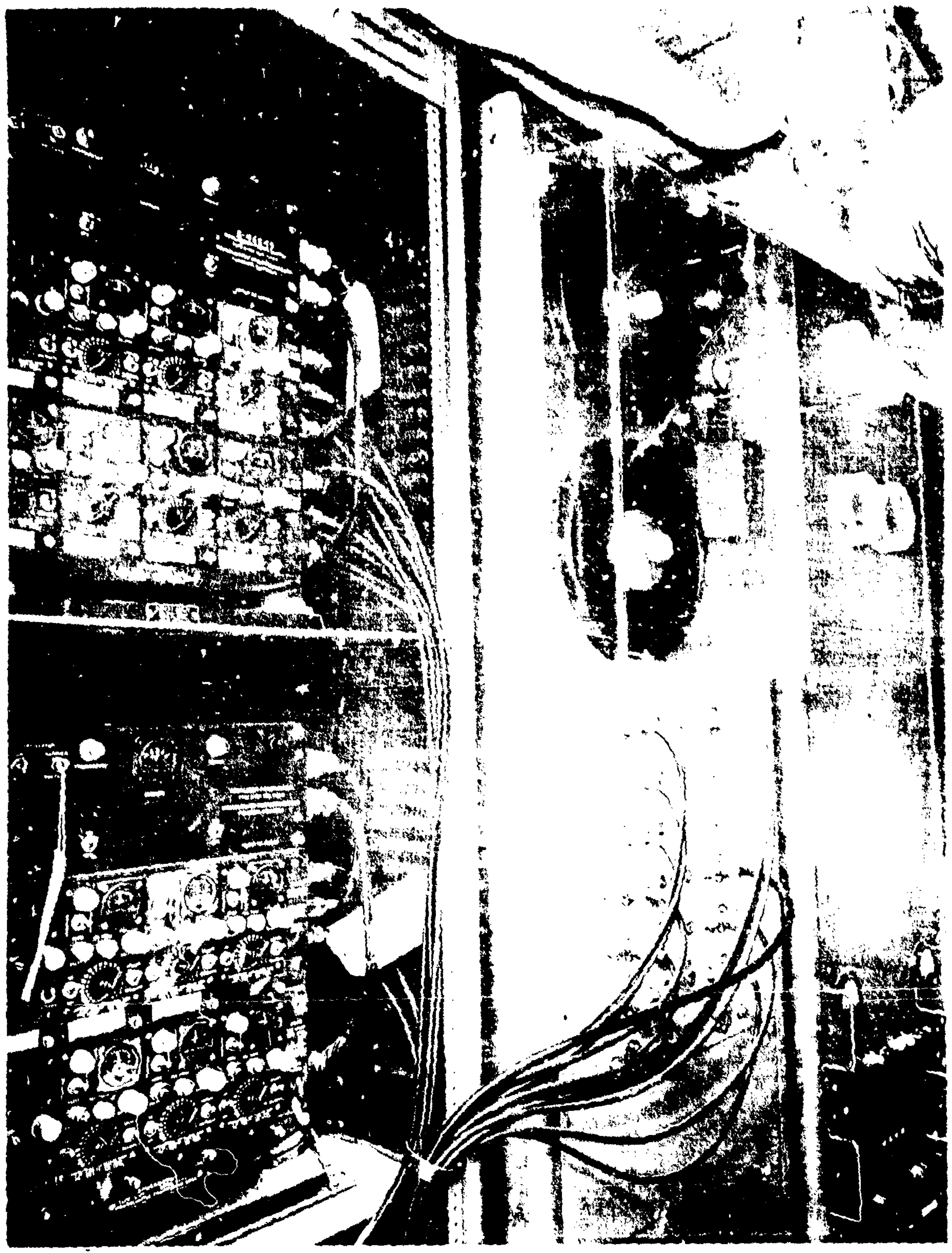

Fig. D.7—Recording equipment in shelter.

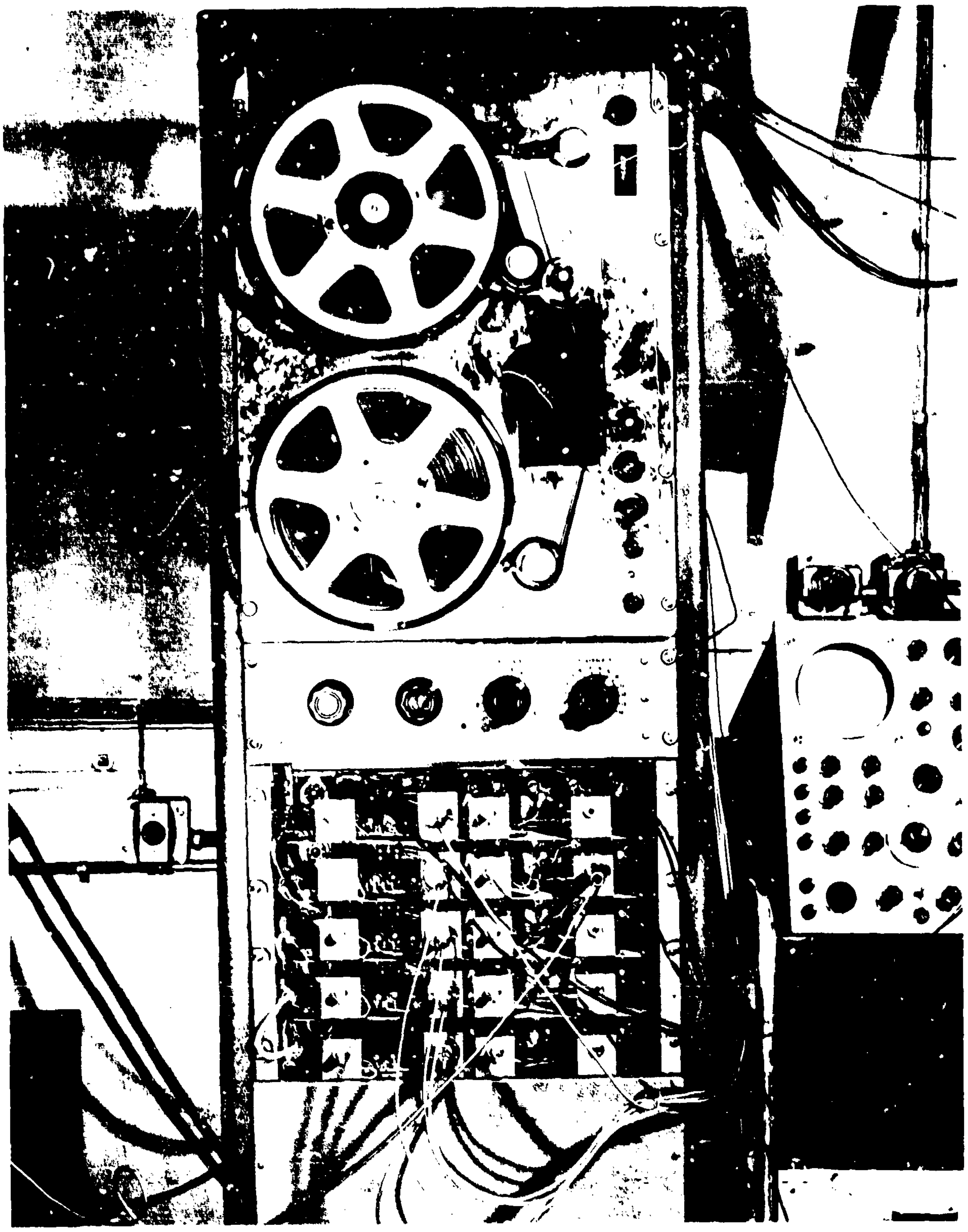

Fig. D.8—Front of recorder panel, showing (1) microswitch arm and (2) capstan.

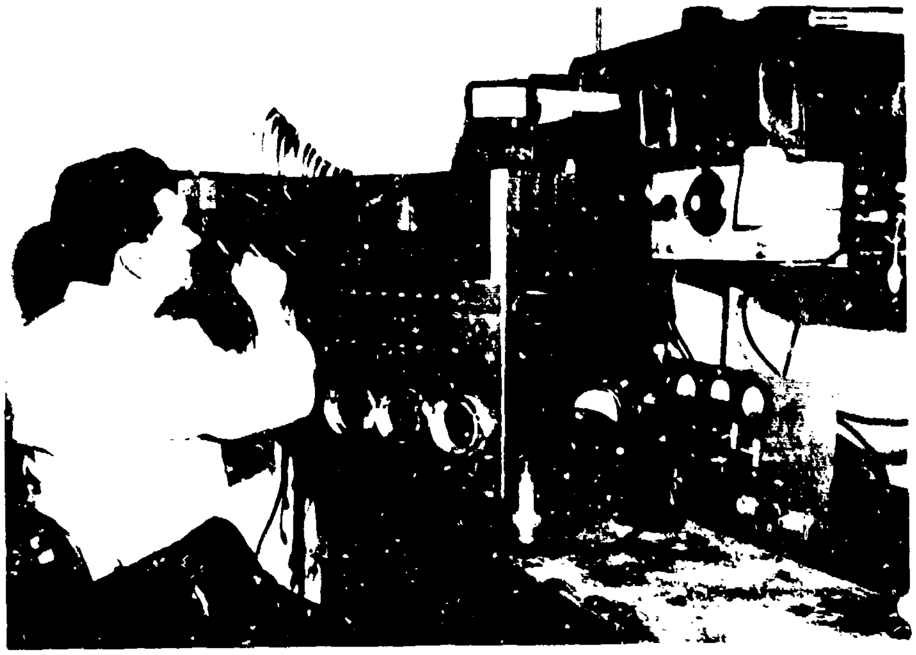

Fig. D.9—Calibration panel.

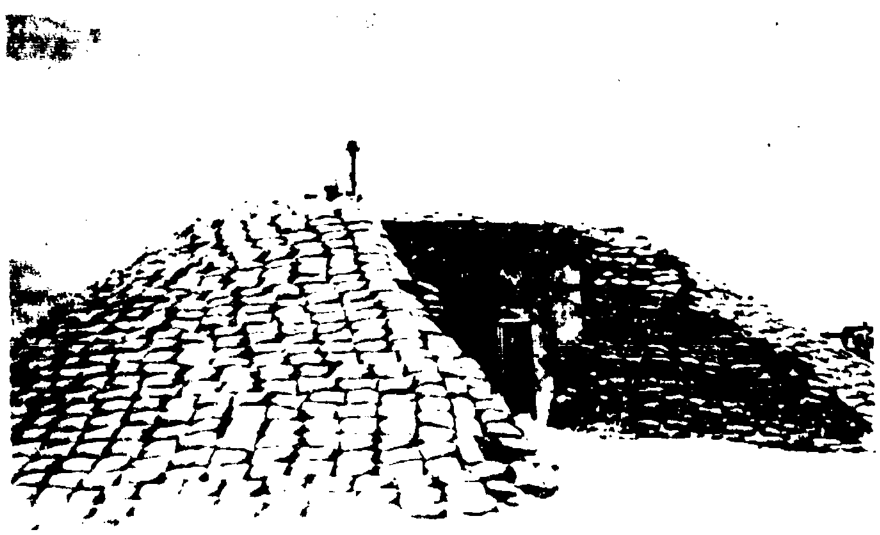

Fig. D.10—Shelter entrance (Irene).

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Fig. D.11—Shock mounting in shelter for Mike shot (Janet).

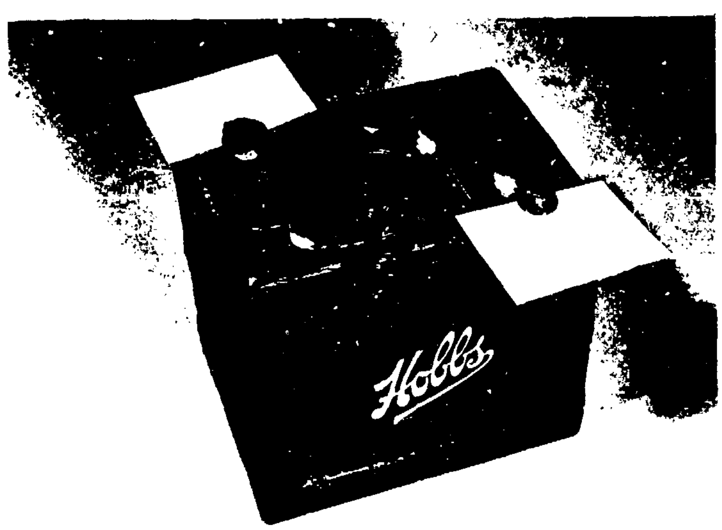

Fig. D.12—Battery, showing terminal failure.

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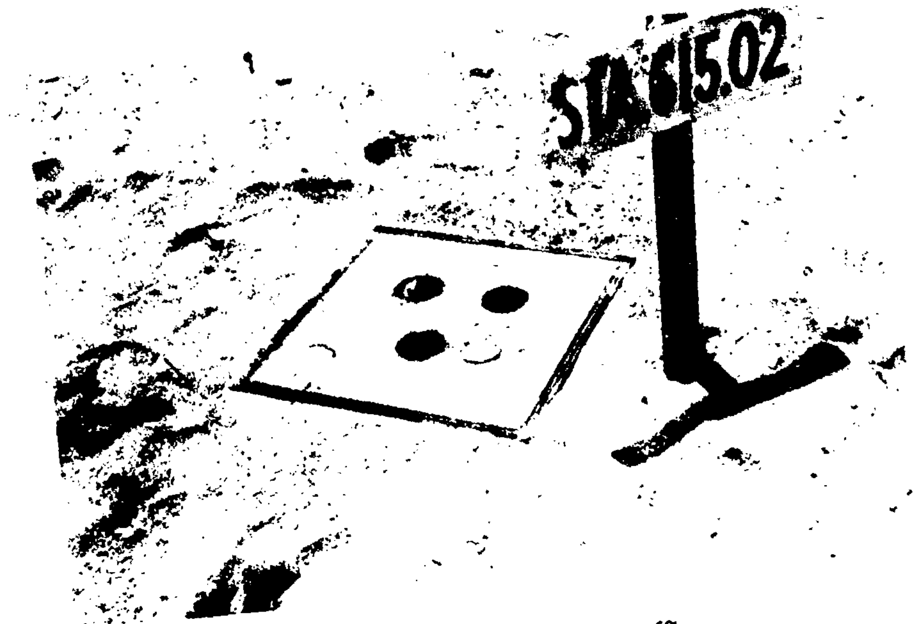

Fig. D.13—Triple ground baffle.

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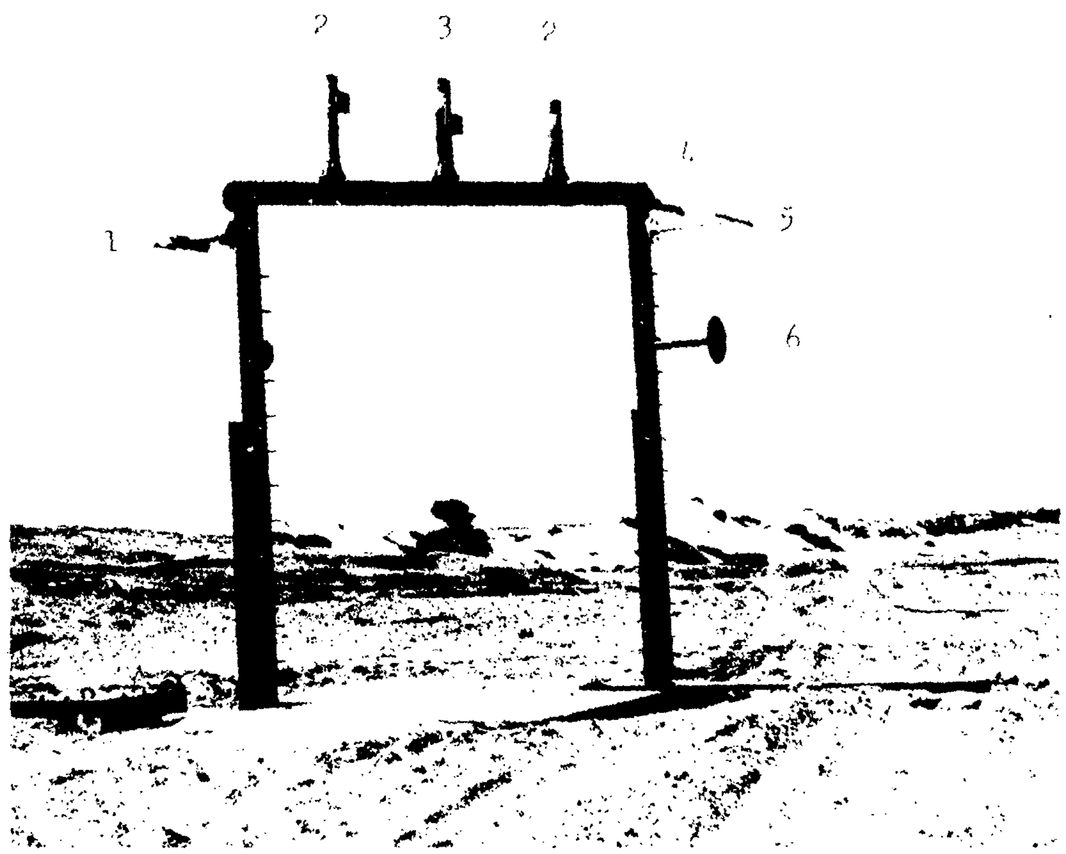

Fig. D.14—15-ft goal-post tower, showing (1) q-Kiel gauge, (2) Swassi receiver, (3) Swassi transmitter, (4) temperature gauge, (5) Pitot gauge, and (6) side-on pressure gauge.

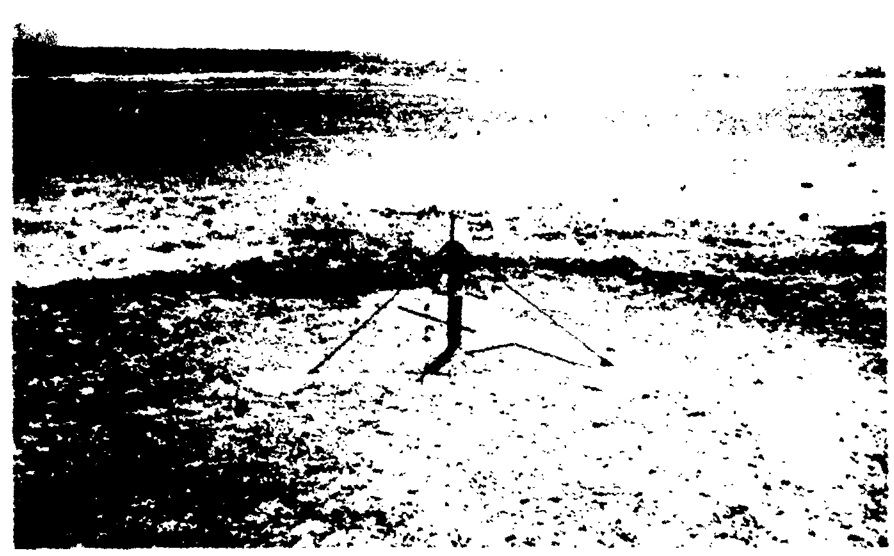

Fig. D.15—15-ft pipe tower (on reef).

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Fig. D.16—10-ft pipe tower.

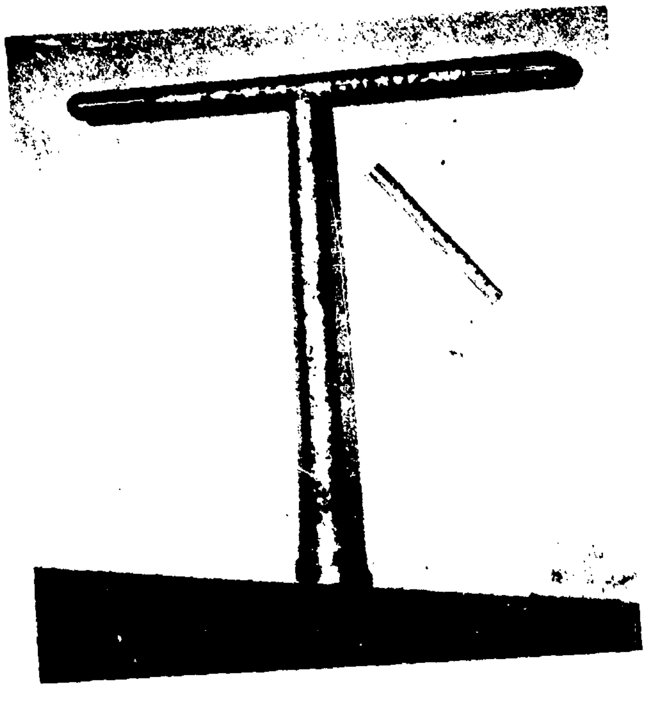

Fig. D.17—Pitot gauge.

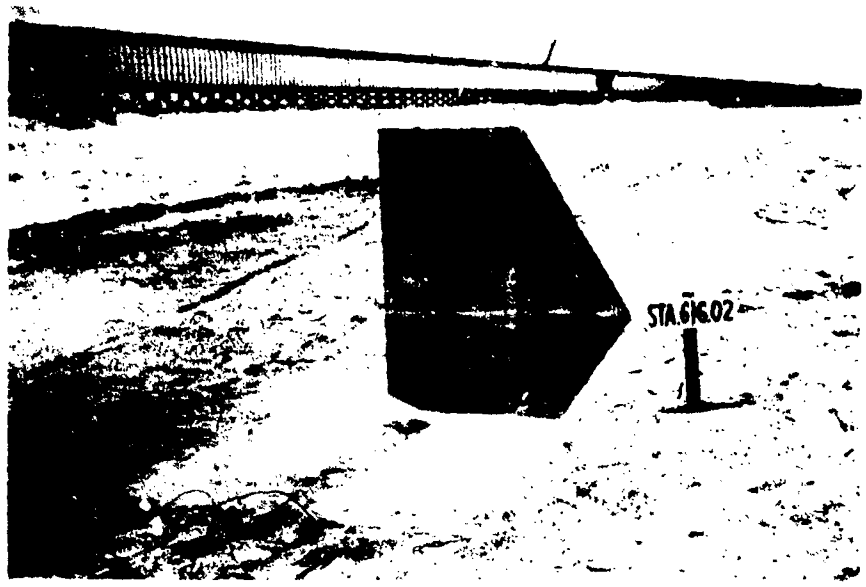

Fig. D.18—Afterwind pressure mount (Irene).

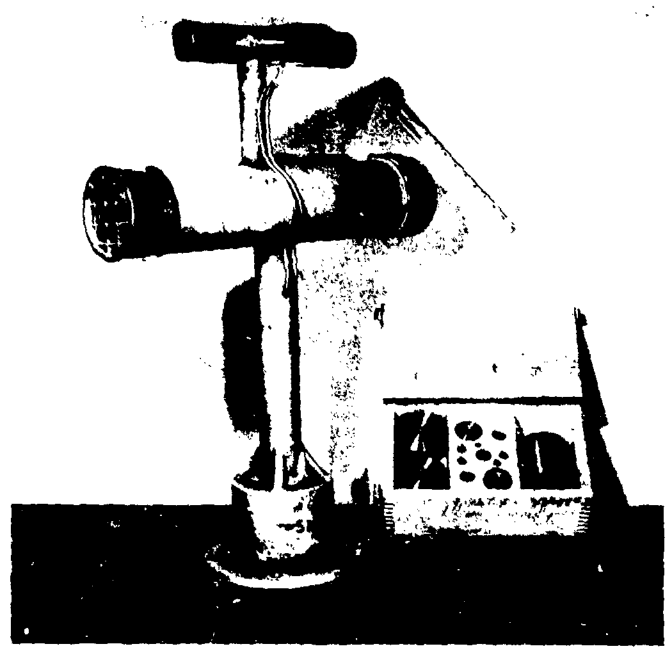

Fig. D.19—q-Kiel mount with weights for q calibration.

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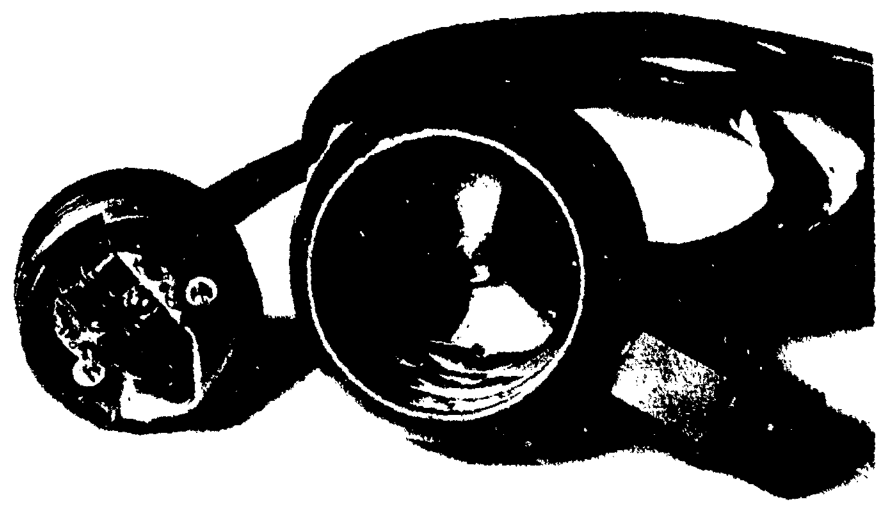

Fig. D.20—Wiancko underwater gauge (exploded view).

Fig. D.21—Indenter gauge layout and single ground baffle (Janet).

RESTRICTED DATA—CONFIDENTIAL—SECURITY INFORMATION

UNCLASSIFIED UNCLASSIFIED

SSTS 26 June 1995

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER
ATTN: OCD/MR. BILL BUSH

SUBJECT: Declassification of Report

The following reports have been reviewed by the Defense Nuclear Agency Security Office (ISTS):

	Report No:	AD No:
AEC	WT-606	467229
	WT-1473	~~611262~~ u/2
	WT-501	514321
	WT-301	479248
	WT-1109	~~617182~~ u/2
	WT-1103	~~611254~~ u/2
	WT-1108	~~611321~~ u/2
	WT-1101	~~460280~~ u/2
	WT-1102	~~611253~~ u/2
	WT-1407	~~452637~~ u/2
	WT-1110	~~617155~~ u2
	~~WT-602~~	~~356274~~ completed
DASA	WT-1403	~~611257~~ u2
	WT-1614	355492
	WT-1155	~~617170~~ u/2
	POR-2280	345753
	WT-9003	~~342207L~~ u/2
	WT-1501	~~350279~~ replaced by AD-490150 ST-A now

The security office has **declassified** all of the listed reports. Further, distribution statement "A" applies to all of the reports.

FOR THE DIRECTOR:

(S)

JOSEPHINE B. WOOD
Chief, Technical Support

Security

Defense Special Weapons Agency
6801 Telegraph Road
Alexandria, Virginia 22310-3398

JUN 11 1997

OPSSI

MEMORANDUM FOR DISTRIBUTION

SUBJECT: Declassification Review of Operation IVY Test Reports

The following 31 (WT) reports concerning the atmospheric nuclear tests conducted during Operation IVY in 1952 have been declassified and cleared for open publication/public release:

WT-602 through WT-607, WT-609 thru WT-618, WT-627 thru WT-631, WT-633, WT-635, WT-636, WT-639, WT-641 thru WT-644, WT-646, and WT-649.

An additional 2 WTs from IVY have been re-issued with deletions. They are:

WT-608, WT-647.

These reissued documents are identified with an "Ex" after the WT number. They are unclassified and approved for open publication.

This memorandum supersedes the Defense Nuclear Agency, ISTS memorandum same subject dated August 17, 1995 and may be cited as the authority to declassify copies of any of the reports listed in the first paragraph above.

RITA M. METRO
Chief, Information Security