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INSTALLATION OF A 10-ELEMENT SHALLOW-BURIED ARRAY

AT THE UINTA BASIN SEISMOLOGICAL OBSERVATORY, VERNAL, UTAH



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TECHNICAL REPORT NO. 65-28

# INSTALLATION OF A 10-ELEMENT SHALLOW-BURIED ARRAY AT THE UINTA BASIN SEISMOLOGICAL OBSERVATORY, VERNAL, UTAH

THE GEOTECHNICAL CORPORATION
3401 Shiloh Road
Garland, Texas

5 May 1965

## IDENTIFICATION

AFTAC Project No: VT/1124
Project Title: Operation of Three Observatories
ARPA Order No: 104-60
ARPA Code No: 8100
Contractor: The Geotechnical Corporation, Garland, Texas
Date of Contract: 1 July 1963
Amount of Contract: $1,179,833
Contract No: AF 33(657)-12373
Contract Expiration Date: 30 April 1965
Program Manager: B. B. Leichliter, BR8-8102

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CONTENTS, Continued

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ILLUSTRATIONS, Continued

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## ABSTRACT

Previous studies indicated that the effect of wind-generated noise on an array of seismometers is significantly reduced if the individual elements of the array are buried to a depth of approximately 200 feet. This report outlines, in some detail, the installation of a buried array at the Uinta Basin Seismological Observatory. Major considerations in such an undertaking included the selection of the most effective array pattern and the most suitable instrumentation to be used. In addition, the drilling, logging, and casing of the holes is outlined, and a brief section on the local geology is included. This report does not attempt to evaluate the effectiveness of the shallow-buried array, but merely documents the procedures and considerations utilized in the installation of a shallow-buried array.

# INSTALLATION OF A 10-ELEMENT SHALLOW-BURIED ARRAY AT THE UINTA BASIN SEISMOLOGICAL OBSERVATORY, VERNAL, UTAH

## 1. INTRODUCTION

### 1.1 AUTHORITY

This is a report of the work done on Project VT/1124/S/ASD, AMENDMENT 7(31), dated 24 August 1964. The authority for this work is contained in a Supplemental Agreement to Contract AF 33(657)-12373, dated 1 July 1963, and the statement of work is included as appendix 1 to this report. Project VT/1124 is under the technical supervision of the Air Force Technical Applications Center (AFTAC) under the overall supervision of the Advanced Research Projects Agency (ARPA).

### 1.2 GENERAL

Seismometers were operated in shallow boreholes at several locations, including the Uinta Basin Seismological Observatory (UBSO), prior to the installation of the 10-element buried array. Preliminary investigations indicated that the effect of wind-generated noise is practically eliminated at a depth of approximately 200 feet. These tests also indicated that microseismic noise is slightly less at 200 feet when the wind is not blowing. As a result of these preliminary tests, a decision was made to locate all of the instruments of the UBSO array about 200 feet below the surface to increase the capability of the array during high wind, as well as to improve the signal-to-noise ratio.

This is the first array of its kind, and should provide data useful for comparison with data from other arrangements of seismographs and for planning other shallow-hole arrays.

## 2. ARRAY CONFIGURATION (TASK 1c(1))

### 2.1 GENERAL

The statement of work specifies that recommendations should be made for the best 10-element array configuration that will fit within the boundaries of the present UBSO site, and also for the optimum array pattern and number of elements to be used if boundary conditions are disregarded. An extensive investigation was undertaken by personnel of The Geotechnical Corporation (Geotech) and by Texas Instruments Incorporated (TI) to recommend the optimum array configuration.

The surface array now in operation at UBSO is located on Government land that was withdrawn from the public domain by the Bureau of Land Management specifically for the observatory. The area consists of a block of four sections[1] and is about 2 miles square.

Originally, Geotech proposed to place the 10 shallow holes near the 10 surface vaults. This proposal was based primarily on recommendations made by TI during a meeting of Geotech and TI personnel. Texas Instruments based their recommendation primarily on the fact that, in their opinion, this configuration would afford the most effective comparison of the surface and buried arrays. In compliance with a request from AFTAC, however, Geotech continued the investigation to determine the most satisfactory configuration for the UBSO buried array.

### 2.2 EVALUATION OF POSSIBLE ARRAY PATTERNS

An array pattern can be described in terms of shape, overall dimensions, and spacing of the individual seismometers. The array configurations presently in use at the Wichita Mountains Seismological Observatory (WMSO) and the Blue Mountains Seismological Observatory (BMSO) are both characterized as follows:

a. Equilateral triangular shape;

b. Uniform seismometer spacing.

[1] Sections 4, 5, 8, and 9 in T6S, R21E, SLBM, Uinta County, Utah

The array configuration presently in use at UBSO is characterized by a shape intermediate between triangular and hexagonal and by nonuniform seismometer spacing. The responses of each type of array as a function of wavelength to waves from two directions for equally weighted summation outputs are shown in figure 1. The wave directions shown correspond to maximum and minimum array symmetry, and are 30 degrees apart for each array. The curves in figure 1 indicate that better results may be expected from a summation output with the type of array in use at WMSO and BMSO than from the array in use presently at UBSO. In general, the sharpness of the cutoff and the degree of cancellation of shorter wavelength noise is greater with an array composed of equally spaced seismometers.

It is not expected that unequal weighting of individual seismometer contributions to the summation output of the present UBSO array would compensate for the relative ineffectiveness of the cancellation of short wavelength noise. Frequency filtering of the individual seismometers could be expected to produce effective cancellation of coherent noise over a wider range of wavelengths for the array with unequal seismometer spacing; however, the deleterious effect of incoherent noise will be greater than for the array with equal spacing.

Based on limited noise data, aliasing of wavelengths within the frequency band of interest will not occur if the length of a side of the smallest triangle, or length of a segment of the smallest "Y," of seismometers within the array at UBSO does not exceed approximately 1.0 km. The length of the segments of the smallest "Y" in the present UBSO array is 0.5 km. For large arrays, unequal spacing would reduce the number of seismometers required; and because the signal band of interest would extend toward longer, rather than shorter periods, larger spacing toward the perimeter of the array would be desirable. For a 10-element triangular array within the presently allotted space at UBSO, however, equal spacing throughout the array can be obtained without exceeding minimum spacing requirements.

Equal spacing has an advantage in that it provides greater cancellation of wavelengths in the stop band for the summation output without decreasing the potential benefits of selective frequency filtering (isotropic machine processing). The triangular array has the disadvantage that characteristics vary more with direction than do the characteristics of the surface array at UBSO.

Averaged over the band of desired noise attenuation (wavelengths from 1.2 to 3.5 km), the minimum effectiveness of summing a 10-element triangular array is approximately equal to the minimum effectiveness of summing the UBSO surface array, but is more nearly constant with wavelength. In addition, the maximum effectiveness of summing a 10-element triangular array is appreciably greater than the maximum effectiveness of summing the UBSO array.

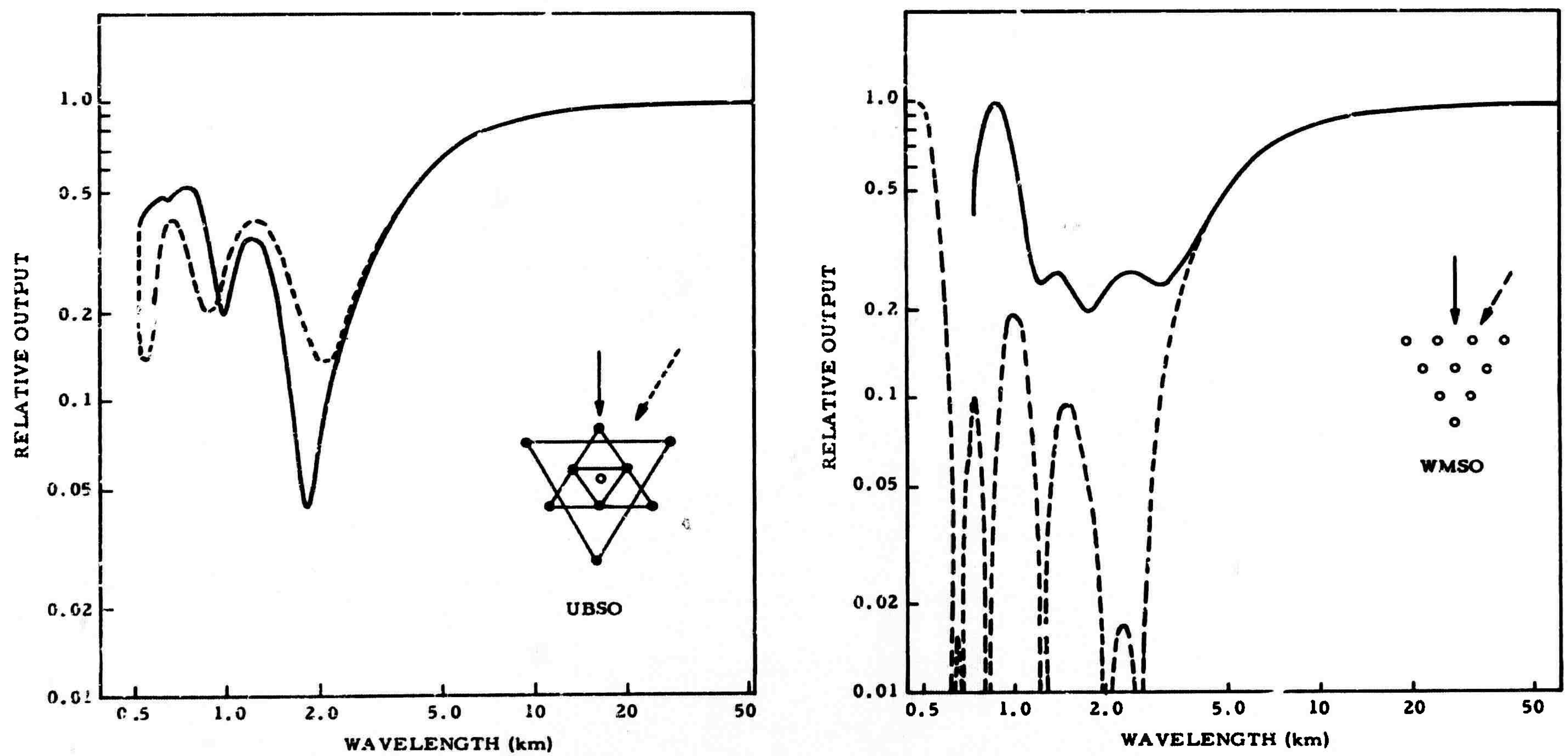



**Figure 1. Wavelength response of UBSO array summation and WMSO array summation**

As a result of these studies, the 10-element array pattern shown in figure 2a was recommended for the following reasons.

a. The array geometry provides uniform spacing of seismometers within a triangular area.

b. The array can be extended to 15 or 19 elements without losing the advantage of equal spacing of elements as shown in figures 2b and 2c. The additional elements shown in figure 2c would reduce the directivity of the array response as well as enlarge the array.

c. The array can be expanded with increased (unequal) spacing, as shown in figure 2d. The choice between the larger array shown in figures 2b, c, and d can best be made after detailed characteristics of the noise are known from the 10-element buried array.

d. Preliminary investigations indicate that extension of the proposed array would afford greater improvement in array characteristics than would extension of an array identical to the surface array at UBSO, both from the standpoint of summation (visual analysis) and machine analysis.

The theoretical study indicated that the triangular array pattern was superior to the existing surface array pattern; however, the adoption of the existing surface array pattern would offer several advantages. These are:

a. The access roads and cable routes to the surface installations can be used in the construction of the buried array with no additional cost.

b. Because the surface vaults are accurately located, no additional surveying would be necessary if the buried-array instruments are located at the surface installations.

c. The corresponding elements of both arrays can be evaluated if the existing array pattern is chosen.

d. The multiple array processor that will be designed for the surface-array pattern and installed at UBSO during the summer of 1965 can be used with both the surface and buried arrays.

On 2 October 1964, we were notified by the Project Officer that "the borehole array should duplicate the UBSO surface array pattern, with the boreholes drilled near the vaults of the surface array." Figure 3 is a portion of the

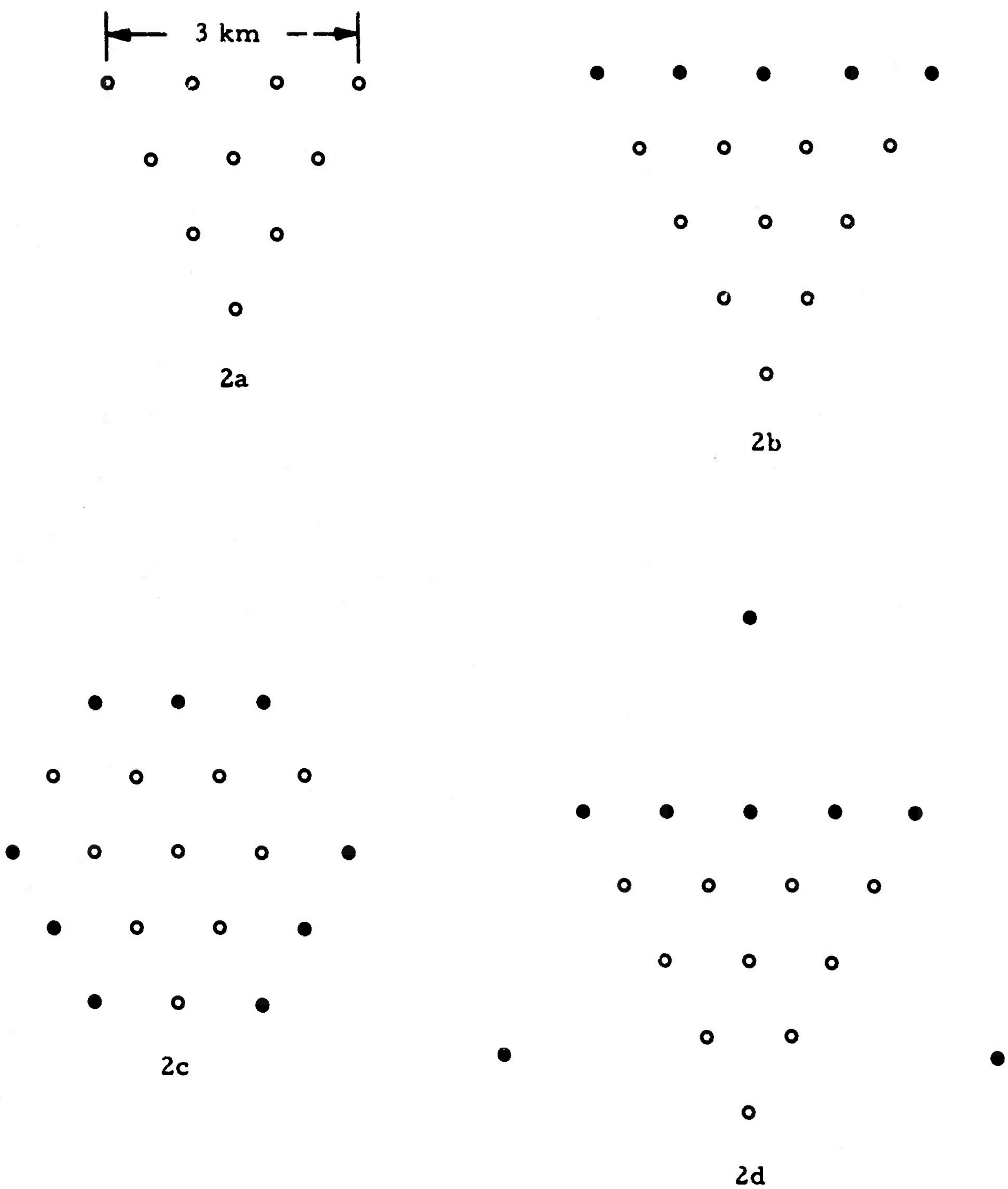



Figure 2. Proposed array configurations

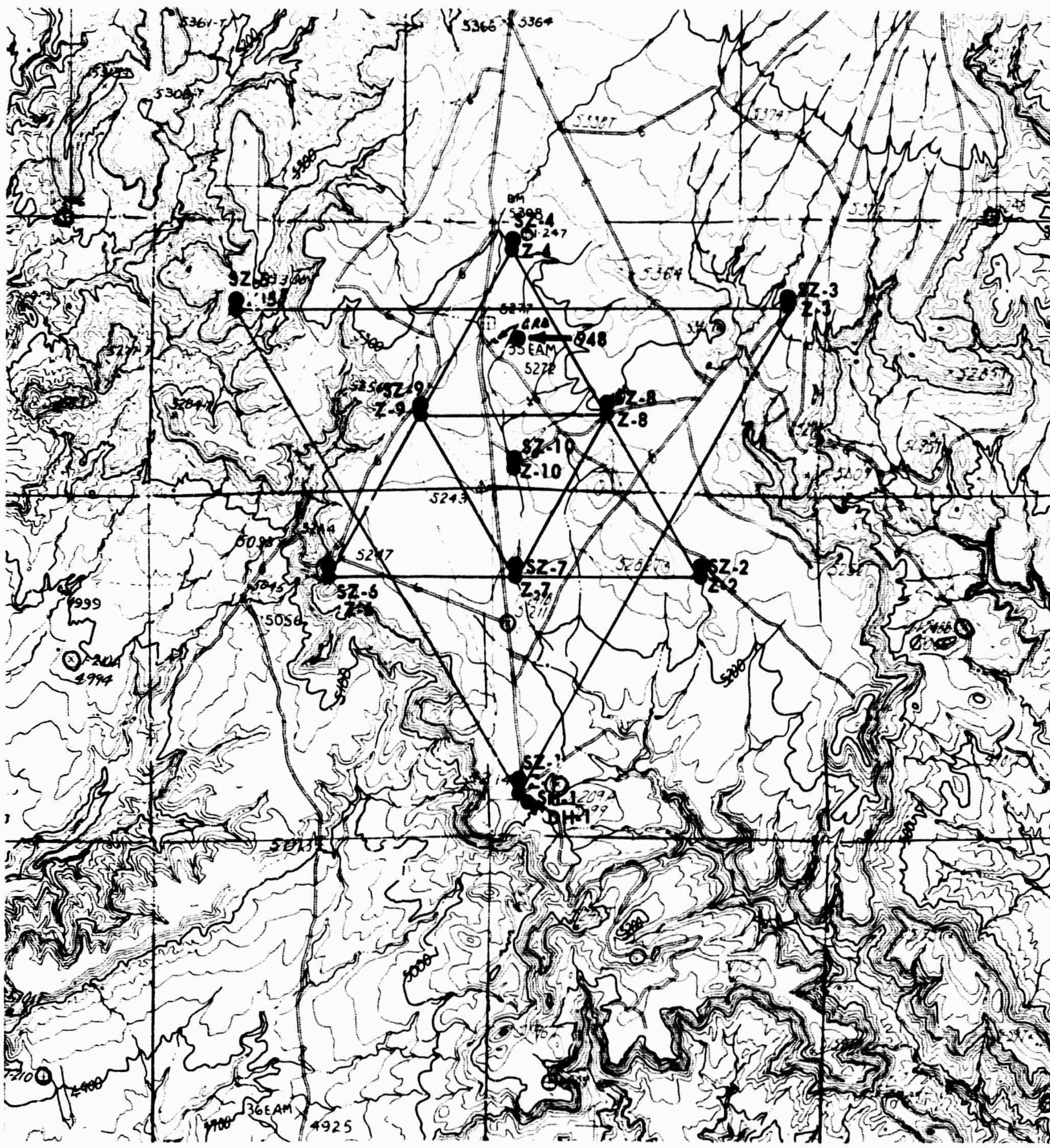



**Figure 3. Topographic sheet showing both the surface and the approved buried-array patterns**

USGS preliminary, Vernal No. 1 SE, 7.5-minute topographic quadrangle sheet showing both the surface and the approved buried-array patterns.

## 3. SITE PREPARATION (TASK 1c (2))

### 3.1 GEOLOGY

The Uinta Basin Seismological Observatory is located on the north flank of the Uinta Basin, a broad asymmetrical syncline trending east-west which lies to the south of the Uinta uplift in northeastern Utah. Figure 4 is a geologic map of the UBSO area; figure 5 is a hypothetical northeast-southwest cross-section of the Uinta uplift and Uinta Basin. The outcrop within the array area consists of the Duchesne River formation, which is overlain locally by thin Quaternary terrace deposits. The Duchesne River formation consists of fluviatile, buff to gray, thinly to thickly bedded (up to 10 feet), friable, cross-bedded sandstones; irregularly interbedded with dark red, poorly cemented claystone and siltstone, and coarse, quartzite pebble to cobble conglomerate.

### 3.2 PREPARATION OF SHALLOW HOLES

#### 3.2.1 General

Each shallow hole is located 100 feet due north of its corresponding surface-array element with the exception of Z-8. This hole was drilled 125 feet due north of Z-8 because of difficult terrain. Each individual hole is identified by the letters "SZ" followed by the number of its corresponding surface-array element; e.g., SZ-1, SZ-2, etc. The buried-array configuration is shown in figure 3.

Specifications were developed for the design, drilling, logging, casing, and completion of the 10 shallow holes. These specifications are given in appendix 2 to this report and a summary of the shallow-hole preparation is shown in table 1.

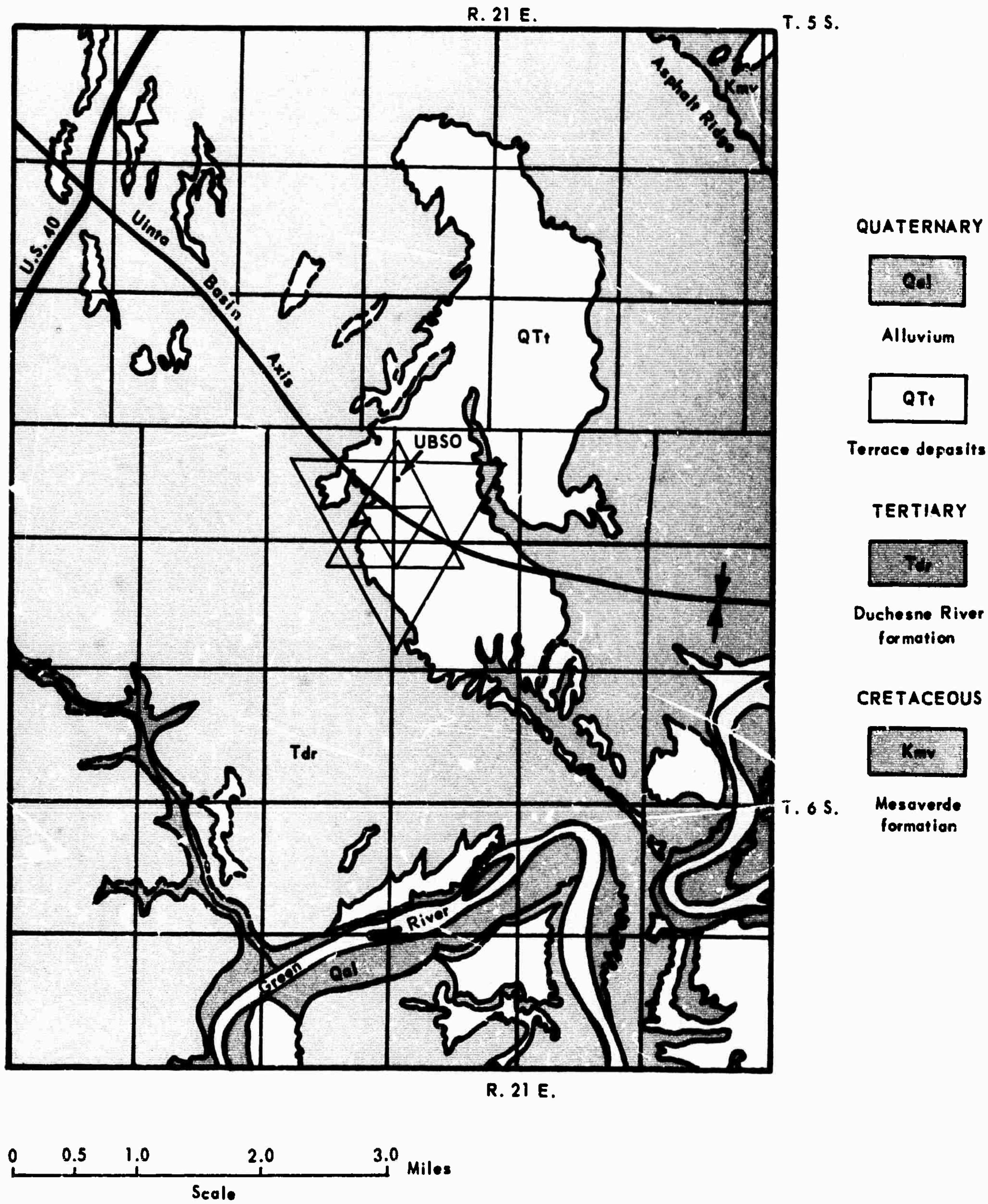



Figure 4. Geologic map of area (after Utermann and Utermann)

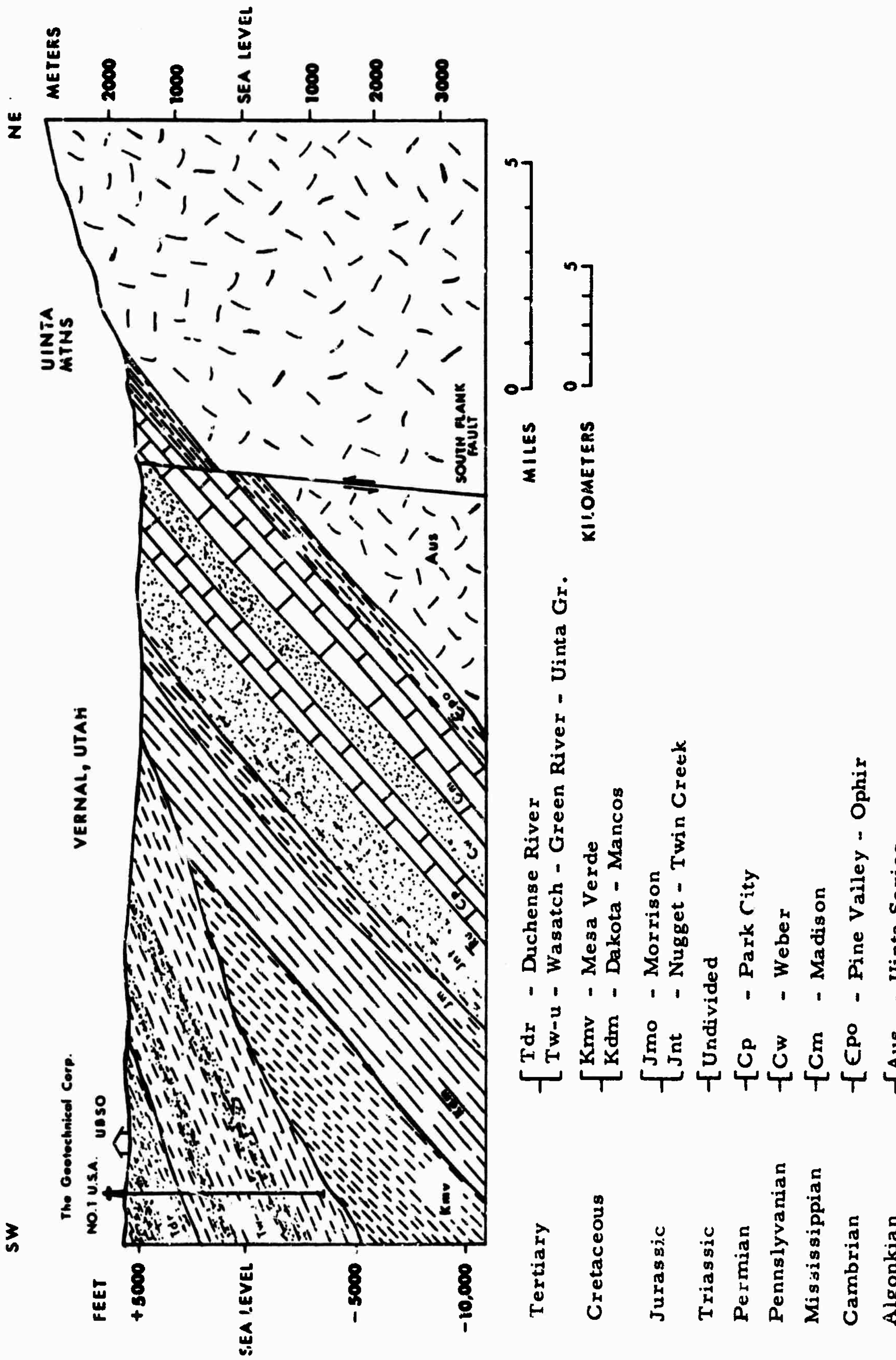



Figure 5. Hypothetical cross-section of the Uinta uplift and Uinta Basin

## Table 1. Summary of shallow-hole preparation

| Hole No. | Commenced (1964) | Completed (1964) | T.D. hole (ft) | Casing point (ft) | T.D. inside csg (ft) | Hole diam (in.) | Sax cmt | Max dev (deg) | Water sands | Logs |
|---|---|---|---|---|---|---|---|---|---|---|
| 1-250 | 1 Nov | 4 Nov | 255 | 255 | 249 | 9-7/8 | 46 | 0 | None | S, D, C, IE, CD |
| 2-250 | 11 Nov | 18 Nov | 255 | 255 | 249 | 9-7/8 | 46 | 1/2 | None | None |
| 3-250 | 22 Nov | 28 Nov | 255 | 255 | 249 | 9-7/8 | 47 | 2 | Slight show at 155 ft | None |
| 4-250 | 25 Nov | 27 Nov | 255 | 255 | 249 | 9-7/8 | 46 | 1 | None | None |
| 5-250 | 28 Nov | 30 Nov | 255 | 255 | 249 | 9-7/8 | 46 | 1-1/2 | None | None |
| 6-250 | 29 Oct | 1 Nov | 255 | 255 | 249 | 9-7/8 | 46 | 1 | None | None |
| 7-250 | 18 Nov | 24 Nov | 255 | 255 | 249 | 9-7/8 | 46 | 1-3/4 | None | None |
| 8-250 | 21 Nov | 28 Nov | 255 | 255 | 249 | 9-7/8 | 47 | [illegible] | None | None |
| 9-250 | 18 Oct | 27 Oct | 255 | 255 | 249 | 9-7/8 | 46 | 1 | None | None |
| 10-250 | 4 Nov | 11 Nov | 255 | 255 | 249 | 9-7/8 | 46 | 1/2 | None | [a] |

[a]Hole 948 - Logged to 500 ft in lieu of No. 10-250 — S, D, C, IE, CD & 3-D

Note: All holes are cased with 7-5/8-in. o.d., 24-lb, H-40 API steel casing, i.d., 7.025 in.

S = Sonic
D = Density
IE = Induction
CD = Dipmeter
3-D = Birdwell
C = Caliper

### 3.2.2 Drilling

Several available drilling contractors were investigated and their equipment inspected. The drilling contract was awarded to the lowest bidding contractor of the six who were invited to bid.

Because of previous experience with drilling difficulties in the area, and in the interests of meeting rigidtime schedules, the following drilling techniques were employed:

a. Six-inch-diameter holes were initially drilled to a depth of 255 feet with a specialized air-percussion drilling rig, requiring 8 to 10 hours per hole. Figure 6b shows this rig in operation. The drilling of each hole was closely watched for the presence of ground water. No trace of water was encountered in any hole except SZ-3, where a very slight show was encountered at 155 feet in amounts too small to measure or to impair the operation of the air-percussion drilling tool and bit.

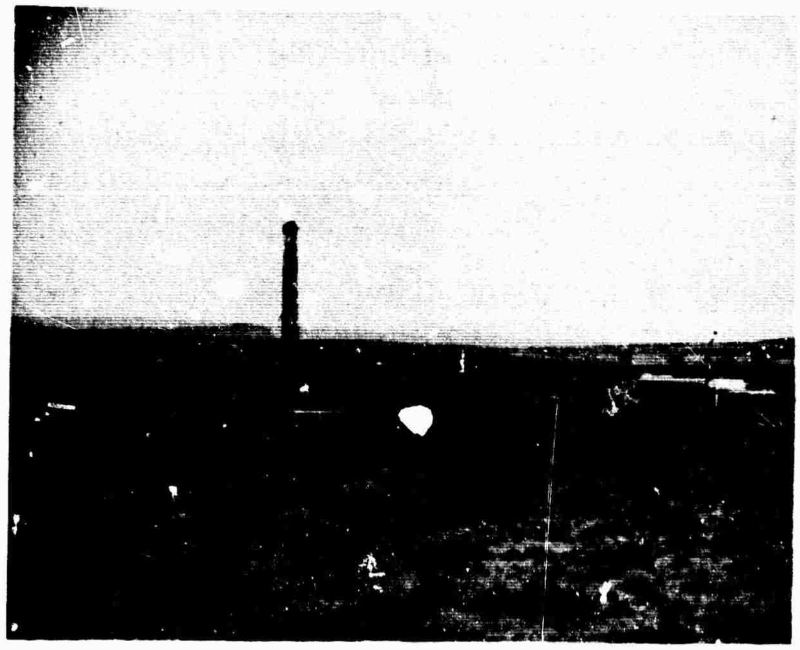
b. Each hole was then fluid-reamed to a diameter of 9-7/8 inches and casing was set and cemented, using a small conventional rotary drilling rig. This process required 4 to 6 days per hole. Figure 6a shows this operation in progress.

c. The completed holes were tested and bailed dry of fluid with a small truck-mounted water-well bailing machine, requiring on the average 1 hour per hole.

Drilling equipment arrived at the site and drilling operations began on 18 October 1964. Heavy snow and severe winter weather seriously hampered operations after 11 November 1964. The 10 holes were completed and ready for seismometer installation on 1 December 1964. Figure 6c shows one of the completed and capped holes.

### 3.2.3 Logging

To obtain a better understanding of the geological conditions that might affect the seismic signal-to-noise ratio, two of the holes in the array were logged by several geophysical methods. Originally, it was planned to log SZ-1 and SZ-10; however, SZ-10 was not logged because of extremely difficult drilling conditions. Unconsolidated boulder-size material in the upper 50 feet of the hole created fall-in problems and the bit stuck on three different occasions as it was being brought out of the hole. The hole could not have been logged without running the risk of losing a logging tool in the hole, fishing, and finally



a. Conventional rig in operation

b. Air-percussion rig in operation

c. Completed shallow hole No. 9-250

Figure 6. Drilling operations, UBSO shallow holes

losing the hole itself. A 500-foot test hole (No. 948) was being drilled under another project, 0.3 mile north of SZ-10, concurrent with our operations. This 500-foot test hole was logged instead of SZ-10. Twice as much section was logged at no additional expense, because the same minimum depth charges applied.

A list of the logs taken in SZ-1 and the 948 hole follows; copies of several of these logs are included as appendix 3 to this report.

SZ-1

| Log | Remarks |
|---|---|
| Conventional sonic | Borehole compensator and integrator devices would not function |
| Sonic amplitude, compressional | Successful |
| Sonic amplitude, shear | Would not function |
| Formation density and caliper | Successful |
| Induction electric | Successful |
| Long normal | Successful |
| Continuous dipmeter | Successful |

948 Hole

| Log | Remarks |
|---|---|
| BHC sonic, integrated | Successful |
| Sonic amplitude, compressional | Successful |
| Sonic amplitude, shear | Would not function |
| Formation density & caliper | Successful |
| Induction electric | Successful |

| | |
|---|---|
| Long normal | Successful |
| Continuous dipmeter | Successful |
| Birdwell 3-D (P- & S- velocity) | Successful |

The correlation of the two suites of logs confirmed the location of the axis of the Uinta Basin as shown on the map in figure 4; i.e., the continuous dipmeter indicated that the axis of the basin lies between the two holes.

In addition to the logs taken in SZ-1 and the 948 hole, sample drill cuttings of the strata were collected at 10-foot intervals from each of the 10 holes. These samples were examined and lithologic sections were constructed. Figure 7 is an idealized fence diagram that illustrates the extreme horizontal variations that are typical of the Duchesne River formation.

## 4. SELECTION OF INSTRUMENTATION (TASK 1c(3))

A seismograph system in which all seismometers would be operated in shallow holes had not been completely assembled and tested at the inception of the UBSO buried-array project. Many of the components, such as recorders, line protectors, and termination equipment, used in conventional installations could be easily adapted for the buried array; however, many of the major components, such as seismometers and amplifiers, had to be tested and proven adaptable to the proposed project.

The various components for the system were collected at the Garland plant. After modification, assembly, and testing, many of the components were shipped to the observatory. A console, containing most of the central equipment, was completely assembled and wired at the Garland plant so that it could be used for testing as other components became available. A complete list of the equipment used in the buried array is included as appendix 4 to this report.

## 4.1 SEISMOMETER-AMPLIFIER COMBINATION

4.1.1 For the following reasons, it was decided to install the amplifier at the hole in which the seismometer is placed and to transmit data to the CRS by a frequency-modulated (FM) carrier:

a. The effect of line noise is reduced because the seismometer output is smaller than the output of the larger seismometers that have been used in the past.

b. More cable deterioration can be tolerated if data are transmitted in the FM state instead of the unamplified analog state.

c. The stability of seismograph frequency response, phase shift, and magnification is improved. This improved stability allows improved equality among the operating characteristics of different seismographs in the array.

d. The pulses normally observed on the traces when lightning occurs are reduced.

e. Equipment damage due to lightning is reduced.

4.1.2 Four instrument systems were considered for the buried array:

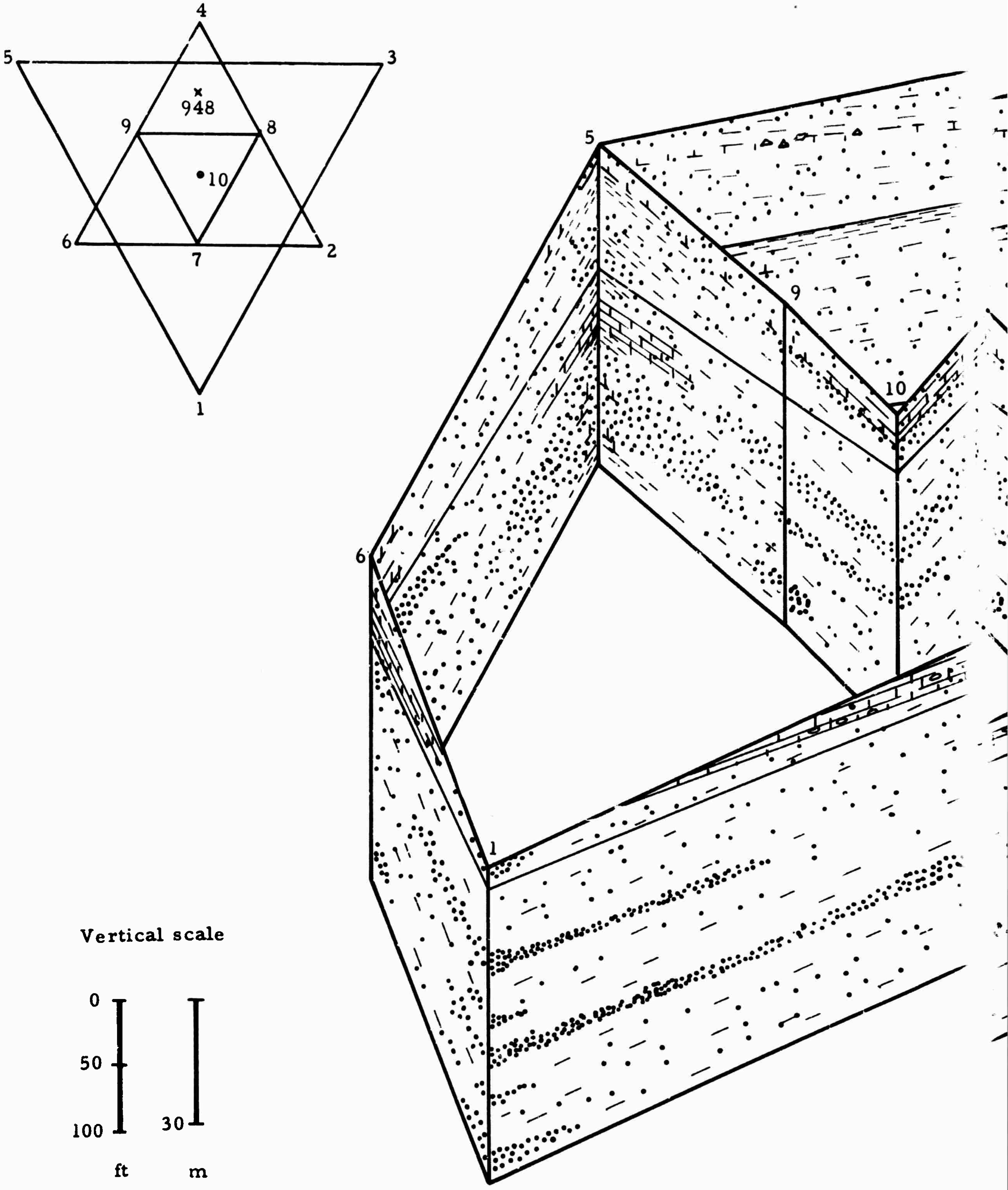
a. The Geotech Portable Short-Period Seismometer, Model 18300, with the FM Phototube Amplifier, Geotech Model 12613-1;

b. The Hall-Sears Model HS-10-1 seismometer with the Texas Instruments Model RA-3 parametric amplifier;

c. The 18300 seismometer and the RA-3 amplifier;

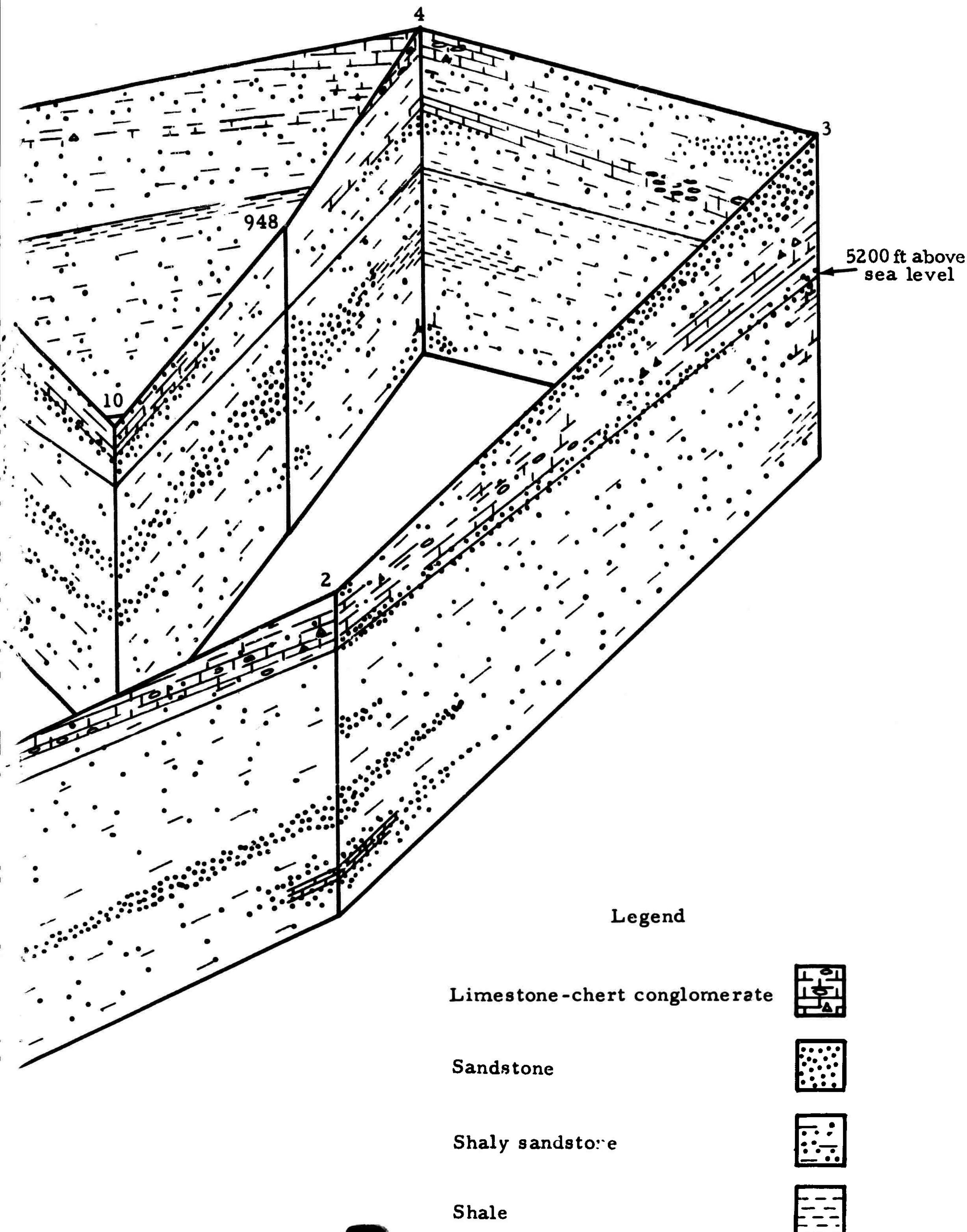
d. The HS-10-1 seismometer and the FM PTA.

Combination d was expected to be noisier than the others. Combination c would be satisfactory but is more expensive than the others and requires high-impedance seismometer coils, which would have delayed delivery. Combination c had not been tested and testing of combination d had been less extensive than testing of combinations a or b. More systems engineering would be required if either combination c or d were selected. Therefore, only combinations a and b were considered.




A

Figure 7. Panel map of sedimentary section, UBSO bu




B

Vertical exaggeration: 4.92
45 degree projection

..ction, UBSO buried array

The characteristics of the two systems are discussed in the following paragraphs and are summarized in table 2. The two systems are approximately equal in system noise level, resolution, and dynamic range.

4.1.3 The Hall-Sears seismometer-RA-3 amplifier combination offered the following advantageous characteristics:

a. The seismometer is less susceptible to damage during installation.

b. The amplifier and voltage-controlled oscillator (VCO) could be housed within the hole casing, eliminating the necessity of a separate container.

c. The input power requirement of the amplifier and VCO is less.

d. Smaller hole and casing diameters would suffice.

4.1.4 Characteristics of the Hall-Sears seismometer-RA-3 amplifier combination that would be disadvantageous for operation in a small array are listed below:

a. The natural frequency of the seismometer cannot normally be adjusted to 0.8 cps. This is undesirable because direct comparison of a buried array with the surface array at UBSO would be most meaningful if seismograph responses are matched.

b. The natural frequency of the seismometer varies excessively with variations of temperature, angle of instrument tilt, and direction of tilt (see table 2).

c. The variation of natural frequency with tilt is not repeatable from one seismometer to another.

d. Adjustment of the natural frequency of the seismometer is difficult under field conditions.

e. Replacement of parts or repairs which require disassembly of the seismometer cannot be made in the field.

4.1.5 The Portable Short-Period Seismometer, Model 18300, utilizes a magnet as the suspended mass and in the Hall-Sears Seismometer, Model HS-10-1, the magnet is a part of the stationary frame. No problem with change in mass

## Table 2. Comparison of seismograph systems

| | Seismometer: Hall-Sears Model 10-1<br>Amplifier: TI Model RA-3 | Seismometer: Geotech Model 18300<br>PTA: Geotech Model 12613 |
|---|---|---|
| Ability to equalize to JM response | Difficult | Readily accomplished |
| Range of adjustment of seis. natural frequency | Approximately 0.9 to 1.1 cps (variable) | 0.75 to 1.1 cps |
| Ease of adjustment of seis. natural frequency | Low-resolution adjustment, relatively difficult to accomplish under field conditions | High-resolution adjustment readily made by rotation of knob on case |
| Maximum natural frequency change with instrument tilt | 0 to 6% at 4°<br>3% to 20% at 6° | 1% at 4°<br>3.2% at 6° |
| Predictability of the effect of tilt on natural frequency | Not predictable; varies with direction of tilt and from seismometer to seismometer | Predictable |
| E. M. calibrator | Designed - not tested | Designed - preliminary tests completed |
| Weight-lift calibrator | None available - not considered practical to design | Designed - preliminary tests completed |
| Response to horizontal motion relative to response to vertical motion | Less than 4% at any frequency within the band of interest | Less than 3% at any frequency within the band of interest |
| Hole casing diameter o.d. | 5-1/2 inches | 7-5/8 inches |
| Susceptibility to damage during installation | Not expected to be a problem | More susceptible than Hall-Sears, but not expected to be a problem |
| Ease of repairs in the field | Not repairable | Repairable |
| Variation of natural frequency with temperature | 12% for 50°F change | 0.4% for 50°F change (at 1 cps natural frequency) |
| Dynamic range | 70 dB minimum | 70 dB minimum |
| Expected system noise level | Approx. equal to 0.1 mμ at 1 cps | Approx. equal to 0.1 mμ at 1 cps |
| Power required | 12 Vdc 0.40 watt regulated | 22-28 Vdc, 2.25 watts unregulated |
| Voltage-controlled oscillator | Performance tested in bread-board stage. Packaging to be designed | Included in PTA |
| Location of amplifier | In upper end of casing or in buried container at surface near hole | In buried container at surface near hole |
| Effort required to equalize response characteristics among the seismographs in the buried array | Difficult because of the unpredictable variation in seismometer natural frequency with tilt and temperature | Similar to effort required to present JM array |

position due to the effect of the proximity of the hole casing would be encountered with the Hall-Sears seismometer. It is anticipated, however, that the change in mass position of the Model 18300 seismometer due to the casing will not be a problem because the mass position can be preset to compensate for the effect of the casing.

An additional advantage would be gained by installing the 18300 seismometer-FM PTA system in the buried array at UBSO. A long-term operational evaluation of this system would become available for comparison with the operational evaluation of the Hall-Sears-RA-3 system to be used in the subarray scheduled for installation at Miles City, Montana, as part of the LASA program.

Based on the field tests and evaluation, we recommended that the Geotech Portable Short-Period Seismometer, Model 18300, and the Geotech PTA, Model 12613, be used in the buried array at UBSO. On 17 September 1964, the Project Officer approved our recommendations for the seismometer-amplifier combination. The specifications for the 18300 seismometer and the 12613 PTA are included as appendices 5 and 6 to this report.

## 4.2 FREQUENCY RESPONSE

The frequency response of the Johnson-Matheson (JM) seismographs used in the surface array is very nearly an inverse of the short-period microseismic noise spectra at UBSO. The frequency response norms and tolerances are shown in figure 8 and listed in table 3. Because these norms and tolerances have proven to be the most effective specifications, the same norms and tolerances were adopted for the seismographs of the buried array. In addition, this will allow a comprehensive comparison of the buried array with the surface array.

## 4.3 PRESSURE CASE MODIFICATION KIT, NO. 23374 (for Model 18300 seismometer)

Because the 18300 seismometers are to be operated in 7-inch i.d. cased holes, it was necessary to design a pressure case and holelock that would require a minimum of modifications to the seismometer. To meet this requirement, the Pressure Case Modification Kit, No. 23374, was designed for the 18300 seismometer. This modification includes a mild steel pressure case, holelock, and weight-lift calibrator. The steel case provides sufficient magnetic shielding so that tests and adjustments made on the seismometer at the surface will be valid when the instrument is placed in the well casing. A Geotech Holelock,

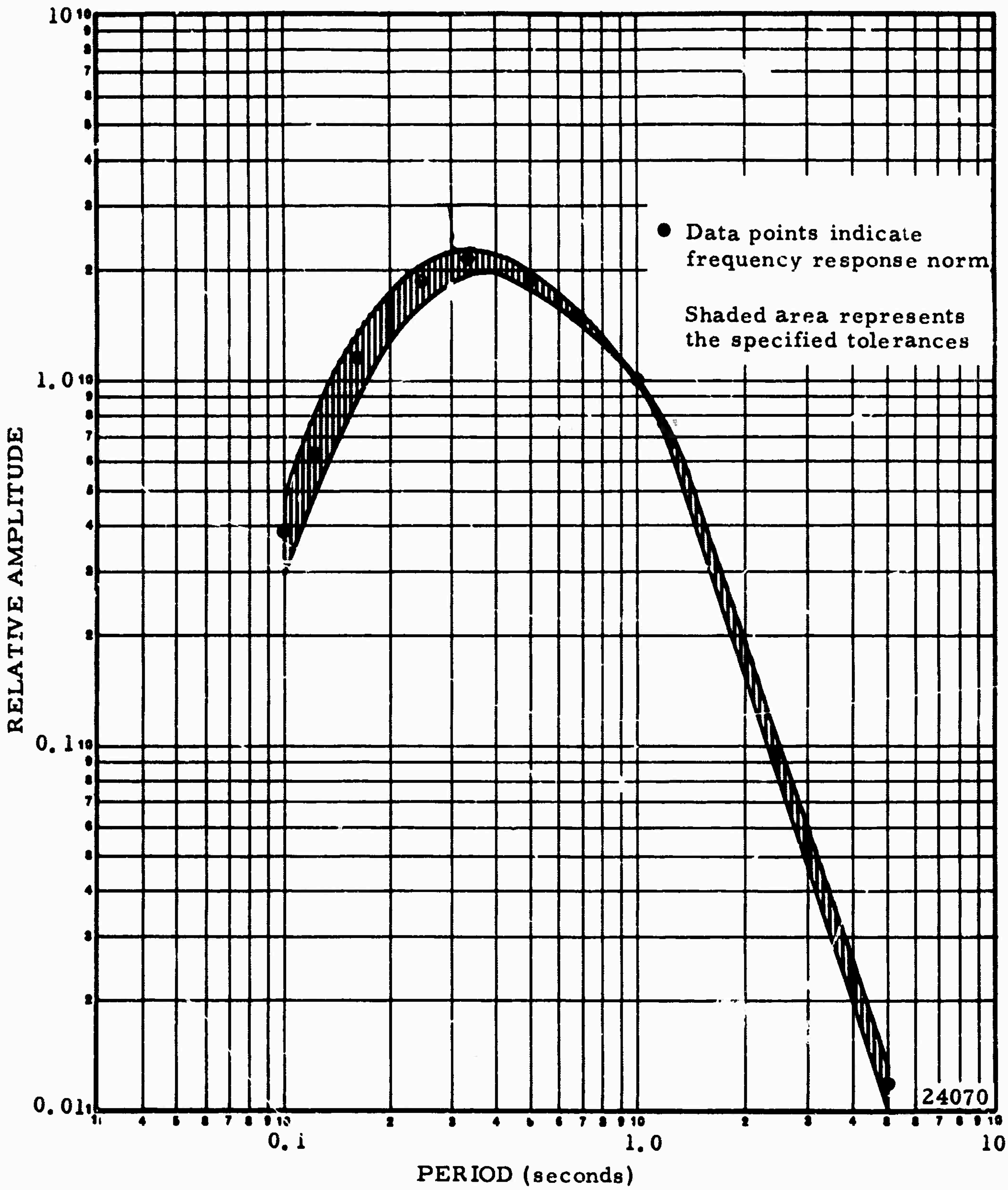



Figure 8. Frequency response norms and tolerances for the shallow-buried and surface arrays at UBSO

Model 22350, was modified to fit the pressure case and is included in the modification kit. All parts of the holelock are resistant to the corrosive conditions that may be encountered in the hole.

Table 3. Short-period frequency response norms and tolerances

| T (Sec) | f (Hz) | TOL (%) | Normalized values Norm | Max | Min |
|---|---|---|---|---|---|
| 5.0 | 0.2 | 10 | 0.0113 | 0.0124 | 0.0102 |
| 2.5 | 0.4 | 7.5 | 0.0950 | 0.102 | .0878 |
| 1.25 | 0.8 | 5 | 0.685 | 0.720 | 0.651 |
| 1.0 | 1.0 | 0 | 1.00 | 1.00 | 1.00 |
| 0.67 | 1.5 | 5 | 1.52 | 1.60 | 1.44 |
| 0.5 | 2.0 | 5 | 1.90 | 2.00 | 1.80 |
| 0.33 | 3.0 | 7.5 | 2.12 | 2.28 | 1.96 |
| 0.25 | 4.0 | 12 | 1.87 | 2.09 | 1.64 |
| 0.167 | 6.0 | 20 | 1.15 | 1.38 | 0.920 |
| 0.125 | 8.0 | 25 | 0.64 | 0.800 | 0.480 |
| 0.1 | 10.0 | 25 | 0.370 | 0.463 | 0.278 |

In addition to the pressure case and holelock, the modification kit contains a weight-lift calibrator. The 18300 seismometer contains an EM calibrator as standard equipment and the addition of the weight-lift calibrator eliminates the necessity to pull the seismometer from the hole when it is desired to determine the calibrator motor constant. Figure 9 shows the seismometer without the case and figure 10 shows the modified unit used in the buried array at UBSO. The specifications for the No. 23374 Modification Kit are included as appendix 7 to this report. Due to the limited time available, the hydrostatic pressure specification listed in appendix 7 was not actually laboratory tested; however, the case was theoretically designed to withstand pressures far in excess of those to be encountered in the holes at UBSO. Tests are currently being conducted to test the pressure case in the laboratory.

## 4.4 MASS-BLOCKING UNIT

The suspension members of the 18300 seismometer can be damaged if the instrument is moved in the casing with the mass unblocked. To eliminate any possible damage when the seismometer is raised or lowered in the hole, a remote mass-blocking unit was designed. The device consists of a 6-V battery, a 10K potentiometer, and a switch. The potentiometer controls the current

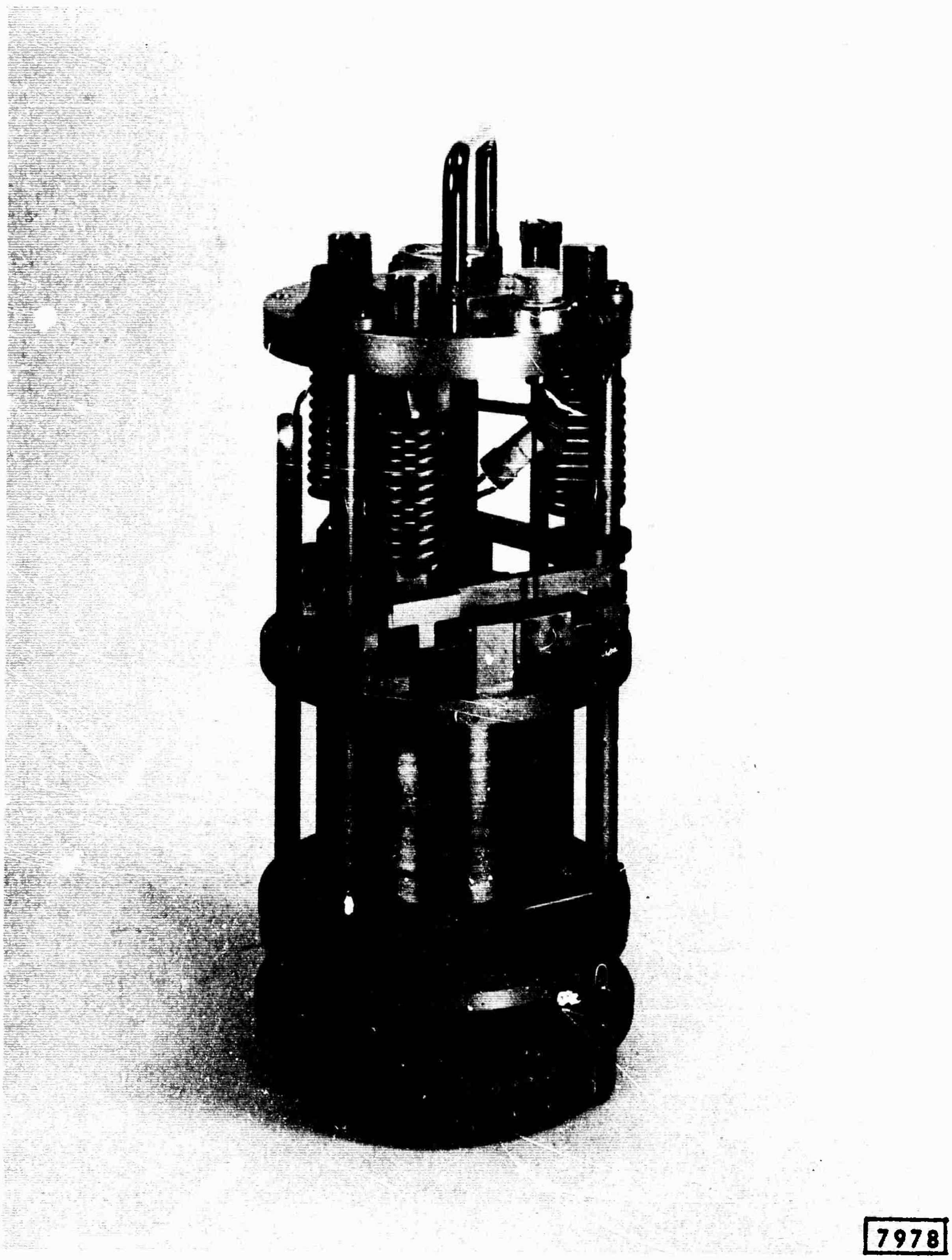


Figure 9. Geotech Portable Short-Period Seismometer, Model 18300

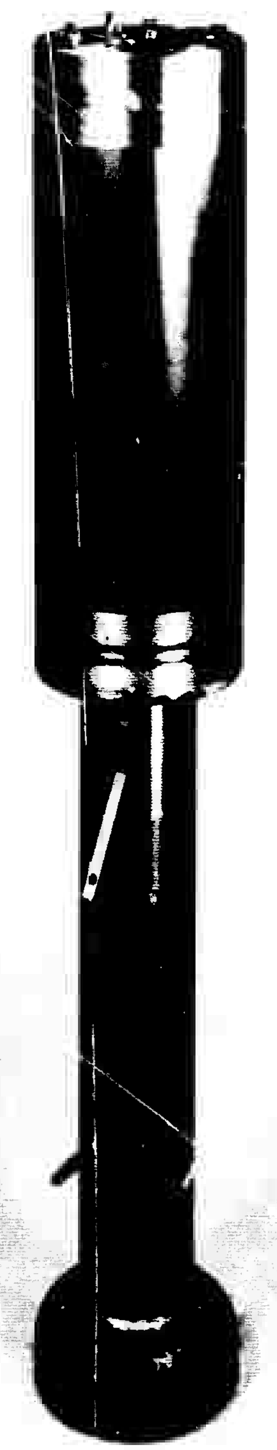


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Figure 10. Model 18300 Seismometer with Pressure Case Modification Kit No. 23374 installed

through the data coil of the seismometer and prevents any damaging transient pulses while the unit is being connected. The control is slowly adjusted to provide maximum current, applying a restraining force of approximately 1.5 pounds to the mass, causing it to rest on the bottom stop. Figure 11 is a schematic diagram of the mass-blocking unit.

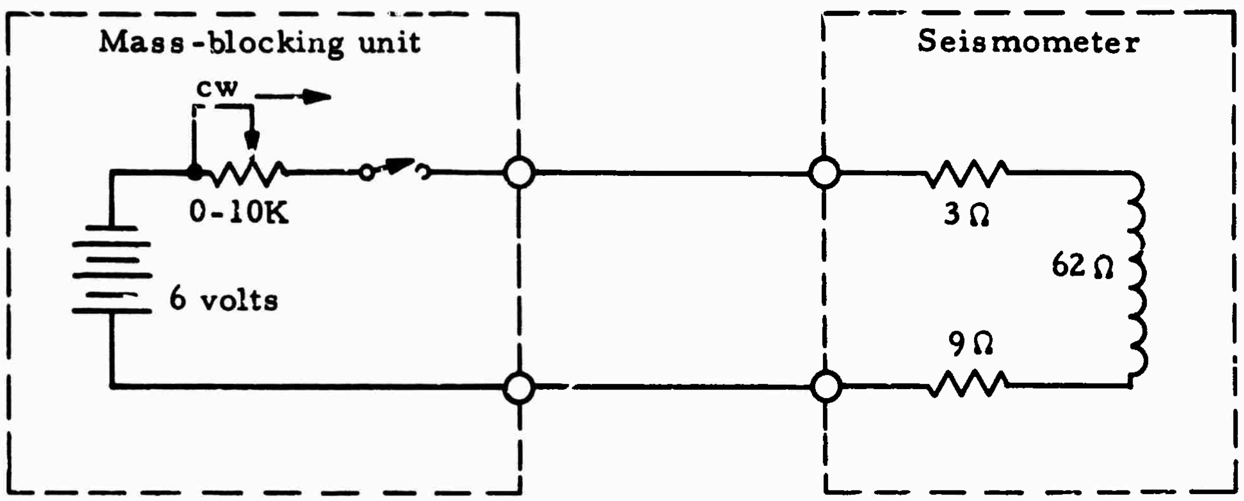



Figure 11. Schematic diagram of mass-blocking unit

## 4.5 MASS POSITION DETECTOR UNIT

Because it is desirable to check the mass position after the seismometer has been positioned in the well casing, a unit was designed that, in conjunction with a portable oscilloscope, can be used to perform mass-position tests. Any abnormal shift in mass position caused by temperature change or mechanical disturbance of the suspension members can be discovered and corrective measures taken.

Current is applied to the data coil with the proper polarity to force the mass to the bottom stop. It is then allowed to oscillate freely while the output waveform is observed on the oscilloscope. The polarity of the current is then reversed to force the mass to the top stop. Again the mass is released (allowed to swing freely) while the output waveform is observed. From these two output waveforms, the ambient position of the mass can be determined. If the two waveforms are without distortion and have similar peak amplitudes, the mass is properly centered. If a single distortion is observed on the first waveform, the mass is positioned slightly above the center of the range. If no more than two distortions occur on either waveform, the mass is positioned within 1/16 inch of the center of the range. Satisfactory operation will result with the mass positioned within these limits. If more than two distortions are observed on either waveform, the mass is poorly positioned and should be recentered. Figure 12 illustrates the mass-position tests and shows a schematic diagram of the test equipment.

## 4.6 SEISMOMETER CABLE AND LOAD-BEARING CONNECTOR

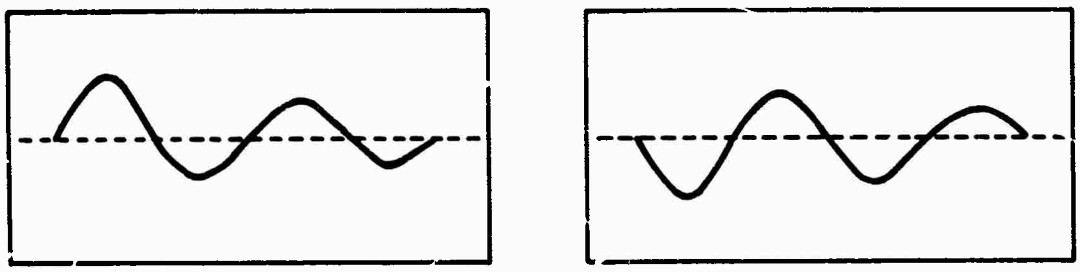
Because the seismometer had to be lowered into the hole by the same cable that would transmit data to the PTA, an electrical cable capable of supporting the weight of the seismometer had to be specified and procured. In addition to the cable, a load-bearing connector that would not damage the electrical conductors had to be designed.

The most suitable cable was the U.S. Steel type 3-H-1 (modified). Type 3-H-1 (modified) is a three-conductor cable with three separate ground wires sheathed in a two-layer armored covering. The cable strength is rated at 6, 600 pounds.

After an extensive investigation failed to locate a suitable load-bearing connector, a pressure-tight connector was designed to secure mechanically the external steel armor of the cable to the seismometer case. A shear pin mechanism is incorporated into the connector to assure that the cable will separate at the connector if the seismometer is stuck in the hole. This will facilitate the recovery of the instrument using conventional fishing tools.

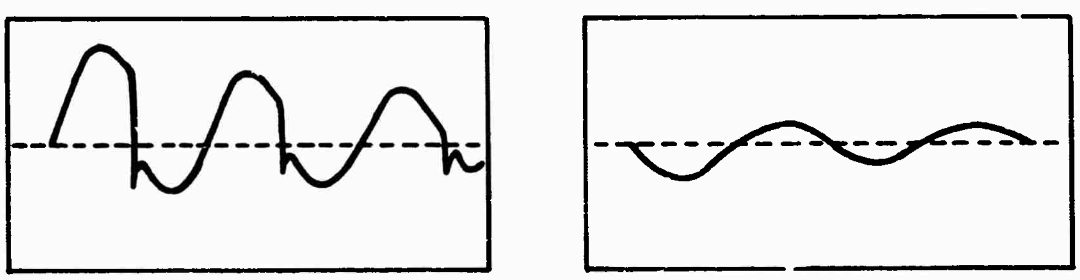
## 4.7 SEISMOMETER-HANDLING EQUIPMENT

Portable equipment that could be mounted in the bed of a pick-up truck was needed to position the seismometers in the well casings. Several designs and products were considered before the system was assembled. The system consists of a Geotech Portable Winch, Model 22521, mounted on an aluminum frame that is placed in the bed of a truck and a Gearhart-Owen Portable Mast Assembly, Model 6505-00. Some consideration was given to manufacturing the mast assembly at the Garland plant; however, a suitable commercial unit was available. The mast assembly is clamped to the well head and the seismometer is lowered or raised in the hole by the truck-mounted winch through a series of pulleys located on the mast.



a. First step b. Second step

Waveforms observed during mass-position tests of a seismometer with a properly positioned mass



c. First step d. Second step

Waveforms observed during mass-position tests of a seismometer with the mass positioned approximately 3/32 inch above the center position

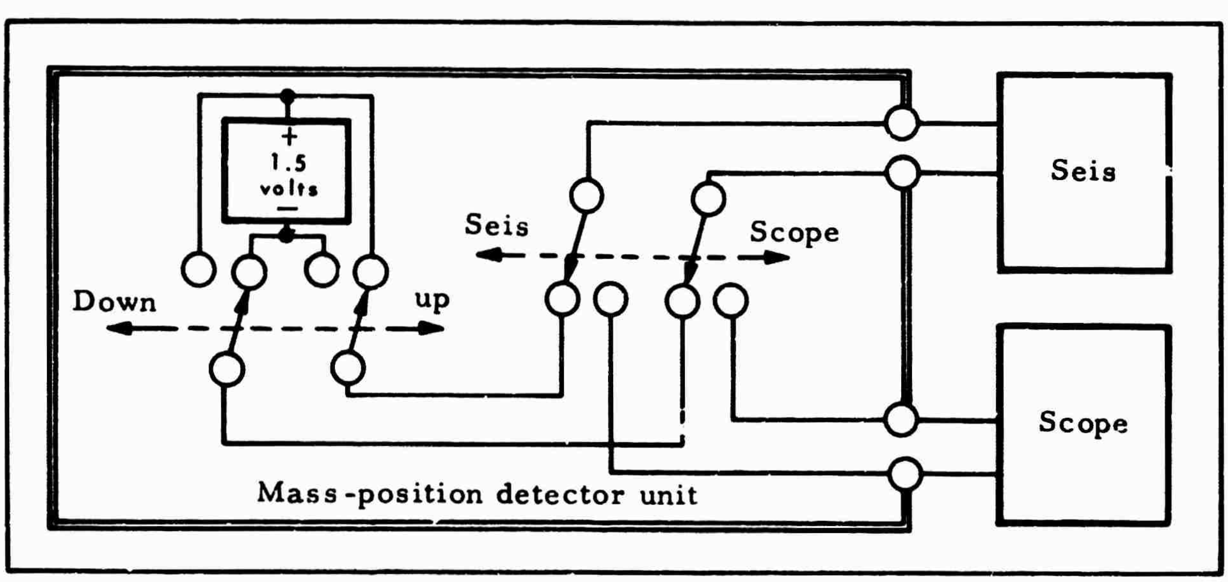



Figure 12. Mass-position test arrangement

## 4.8 WELL-HEAD ASSEMBLY

A device was required which would seal the well, provide an outlet for the seismometer cable, and secure the upper end of this cable. The assembly should also provide lightning protection for the seismometer cable and a high-quality ground termination for the remote equipment. A standard well-casing bull-head was modified to fulfill all these requirements. A sketch of the well-head assembly is shown in figure 13.

## 4.9 GALVANOMETER-DAMPING ADJUSTMENT

A galvanometer-damping-adjustment modification was added to the FM PTA's. This modification makes it possible to adjust the galvanometer damping without removing the PTA cover. The modification consists of the resistive network shown in figure 14. The 300-ohm fixed resistor and the 2000-ohm potentiometer provide continuous adjustment of the galvanometer damping.

In addition, two sizes of magnetic shunts are provided that may be used to reduce the damping in small discrete steps. Figure 14 also illustrates the relationship between network resistance and galvanometer damping.

## 4.10 SURFACE FACILITIES EMPLACEMENT

Because the amplifiers, data control modules, and lightning protection equipment were to be installed at each hole site, it was necessary to provide a weather-proof environment which would minimize temperature effects and mechanical vibrations. Commercial metal boxes with watertight lids were selected to be modified for this application. An emplacement was designed that allowed the boxes to be seated into a pier-like structure containing approximately 2 yards of concrete. Insulated covers were designed to fit over this installation to further protect the equipment from the effects of wind and temperature changes. Figure 15 is a generalized sketch of a typical surface installation.

## 4.11 TRANSMISSION LINES

Considerations of reliability, availability, and cost indicated the use of spiral-four cable for the field transmission lines. Geotech Isolation Filters, Models 19275 and 19275A, which allow simultaneous transmission of power and FM data on a single cable, were specified to reduce the amount of cable

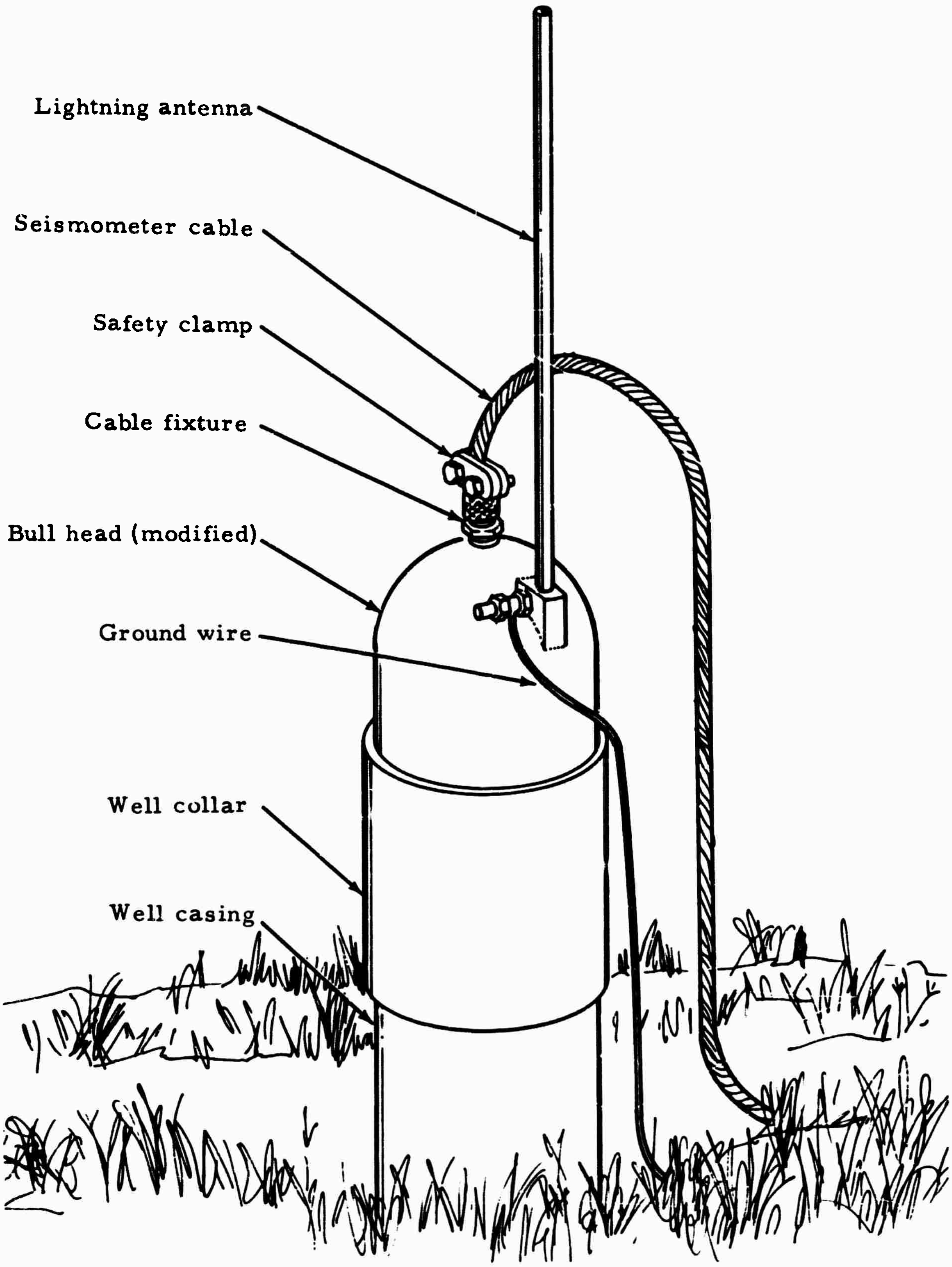



Figure 13. Well-head assembly for the shallow-buried array at UBSO

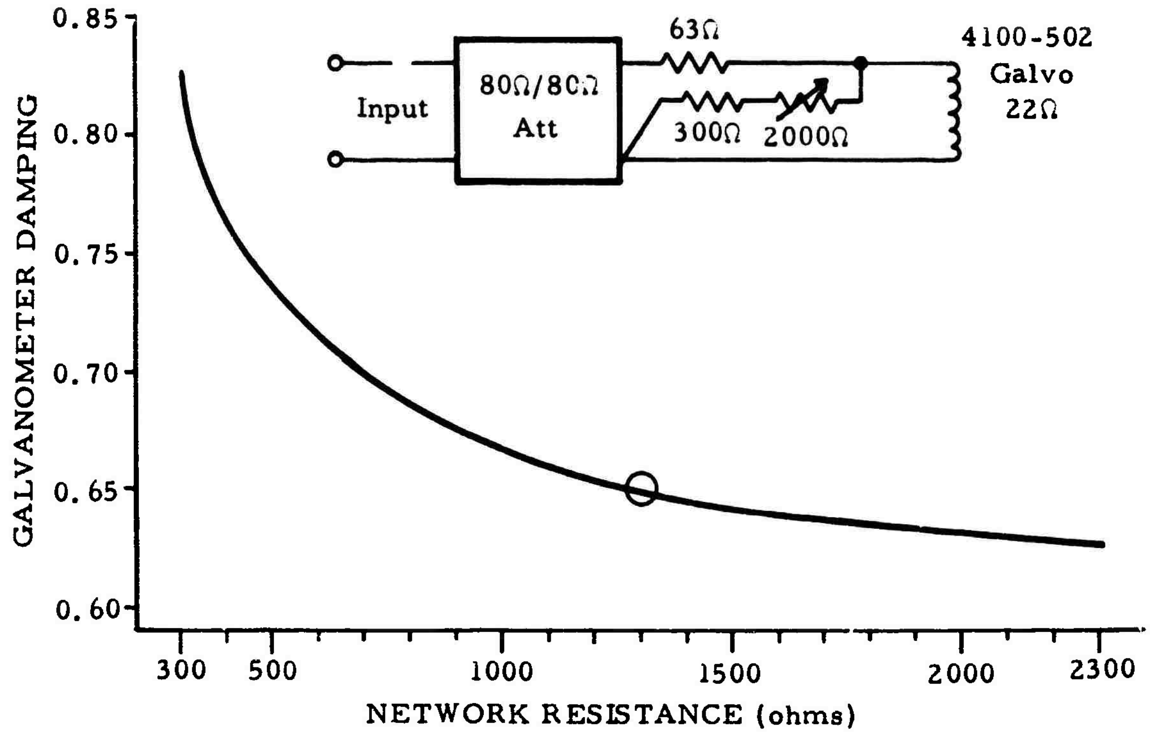



**Figure 14.** Galvanometer damping adjustment modification and the relationship between network resistance and galvanometer damping

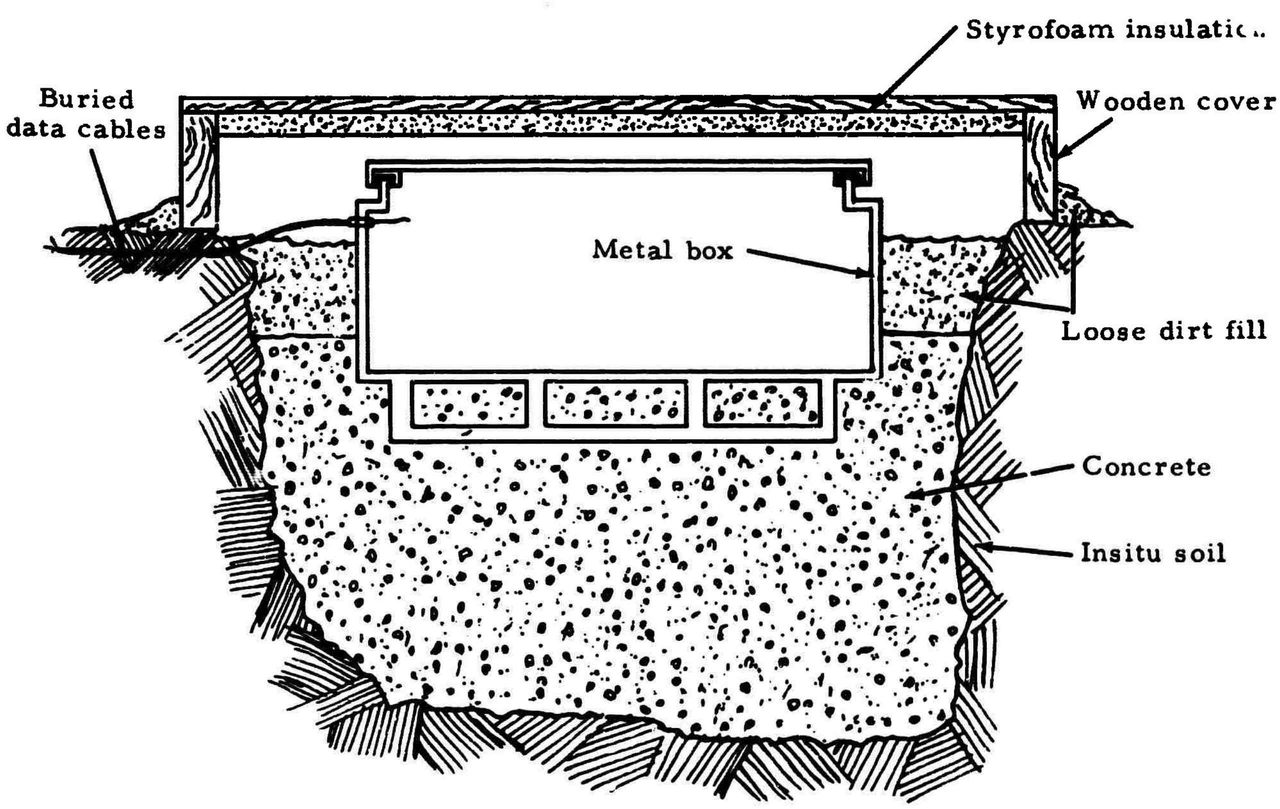



**Figure 15.** Cross-sectional sketch of remote termination boxes

required. However, it was necessary to provide two cables to each hole site, one for data and power and one for calibration. It might have been possible to have used a single cable to transmit all three channels; however, there was a possibility that the calibrations would not have been valid due to the presence of the FM signal. Extra arc discharge protectors were recommended at the remote termination boxes and standard station protector boxes were specified for the line terminations at the CRB.

## 4.12 CENTRAL RECORDING BUILDING EQUIPMENT

A tape recorder and data discriminators with solid-state electronics were selected for the UBSO buried-array system to reduce maintenance problems and to increase system reliability. Solid-state units were also selected to furnish power to the PTA's. If conventional vacuum-tube electronics were used, the stand-by battery bank could not furnish sufficient power to operate the buried-array system, even if the surface array were disconnected. The selection of solid-state circuitry makes it possible to operate either array in the event of a commercial power failure. The other components used in the CRB are standard observatory equipment of proven reliability. A complete list of all equipment used in the system is included as appendix 4 to this report.

### 4.12.1 Magnetic-Tape Recorder

Two magnetic-tape recorders were available that would neet the specifications set forth in AFTAC MAGNETIC-TAPE RECORDING STANDARDS, PROJECT VELA-UNIFORM, AFTAC TECHNICAL REPORT VU-62-1

Both the Geotech Model 17554 and the Minneapolis-Honeywell (MH) Model LAR7460 have solid-state circuitry; however, the Geotech recorder is equipped with a 0.03-ips transport speed, whereas the LAR7460 is capable of 0.3 ips. The MH LAR7460 was the magnetic-tape recorder approved by the Project Officer because of its similarity to the units presently in use at the observatory and because MH agreed to an earlier delivery date. The procurement specifications for the magnetic-tape recorder are included in appendix 8 to this report.

### 4.12.2 Frequency-Modulated Discriminators

The Geotech Model 15216 FM discriminators were originally proposed for the buried-array system at UBSO. Because of power requirements, however, the vacuum-tube circuitry of the Geotech discriminator made the unit unsatisfactory. Geotech is in the process of designing a solid-state FM discriminator, but these units were not in production. An investigation of commercially available discriminators revealed that the Genisco Model A206 FM discriminator would fulfill our requirements. The procurement specifications for the FM discriminators are included as appendix 9 to this report.

### 4.12.3 PTA Power Supplies

Power for the PTA's is transmitted from the CRB over spiral-four cable. Because of the various lengths of line to each hole site, various voltages are required so that the power is within the acceptable range of 22-28 volts dc at the PTA. Four Lambda LH 124 FM solid-state power supplies were incorporated into the system to furnish this power. Three of the units are to be operated continuously; the fourth serves as a stand-by unit. Several of the Lambda LH 124 features that make the unit desirable for the buried-array system are listed below and the complete specifications are included as appendix 10 to this report.

Short circuit protection;
Overload protection;
Regulation: .015%/$^{o}$C;
Ripple: Less than 250 microvolts RMS.

## 5. INSTALLATION AND CALIBRATION OF THE ARRAY (Task 1c(4))

### 5.1 GENERAL

Site location, drilling, casing, and installation of the spiral-four field cable were completed before the major equipment components arrived at the observatory.

To verify the suitability of the installation procedures, handling equipment, and seismograph circuits, the installation program was planned so that a single element would become operational at the earliest possible date. The installation of SZ-4 was completed without incident. Simultaneous recording of this seismograph and the corresponding surface element (Z4), both operating at 540K magnification, was initiated on 11 December 1964. Approximately 10 days later, a preliminary data format was placed in service on the buried-array Develocorder. This format consisted of four shallow-buried seismographs, the corresponding surface seismographs, and a summation and filtered summation of the shallow-buried seismographs. The PTA's for these elements were operated in the analog mode because the FM discriminators had not been received. As a result of the analog operation, it was necessary to provide each PTA with a separate power supply, thus limiting the number of seismographs that could be operated simultaneously. After all seismometers were installed and operated for a short period of time, the installation and testing was suspended pending the receipt of the data discriminators.

During the second week of January 1965, preparations were made to transfer the system to the FM mode, including tests of the magnetic-tape recording equipment and PTA's. The discriminators were received and tests of these instruments were completed during the third week of January. Figure 16 is a drawing of the equipment console as installed in the CRS.

A temporary format was placed in service as each FM PTA became operational. Because of the many tests and adjustments performed on the system during the third week of January, the usefulness of these seismograms is limited. All system tests and adjustments were completed and the final formats (table 4) were placed in service on both the magnetic-tape recorder and the Develocorder on 28 January.

An evaluation of the effectiveness of the shallow-buried array is not within the scope of this report; however, figures 17 through 20 are included to show the responses of both the surface and buried arrays to wind-generated noise.

## 5.2 INSTALLATION PROCEDURES

The actual procedures used to install various components of the UBSO buried array are outlined in this section. A step-by-step method of presentation is used in several cases in the interest of clarity and brevity; on-site photographs of the installation are also included.

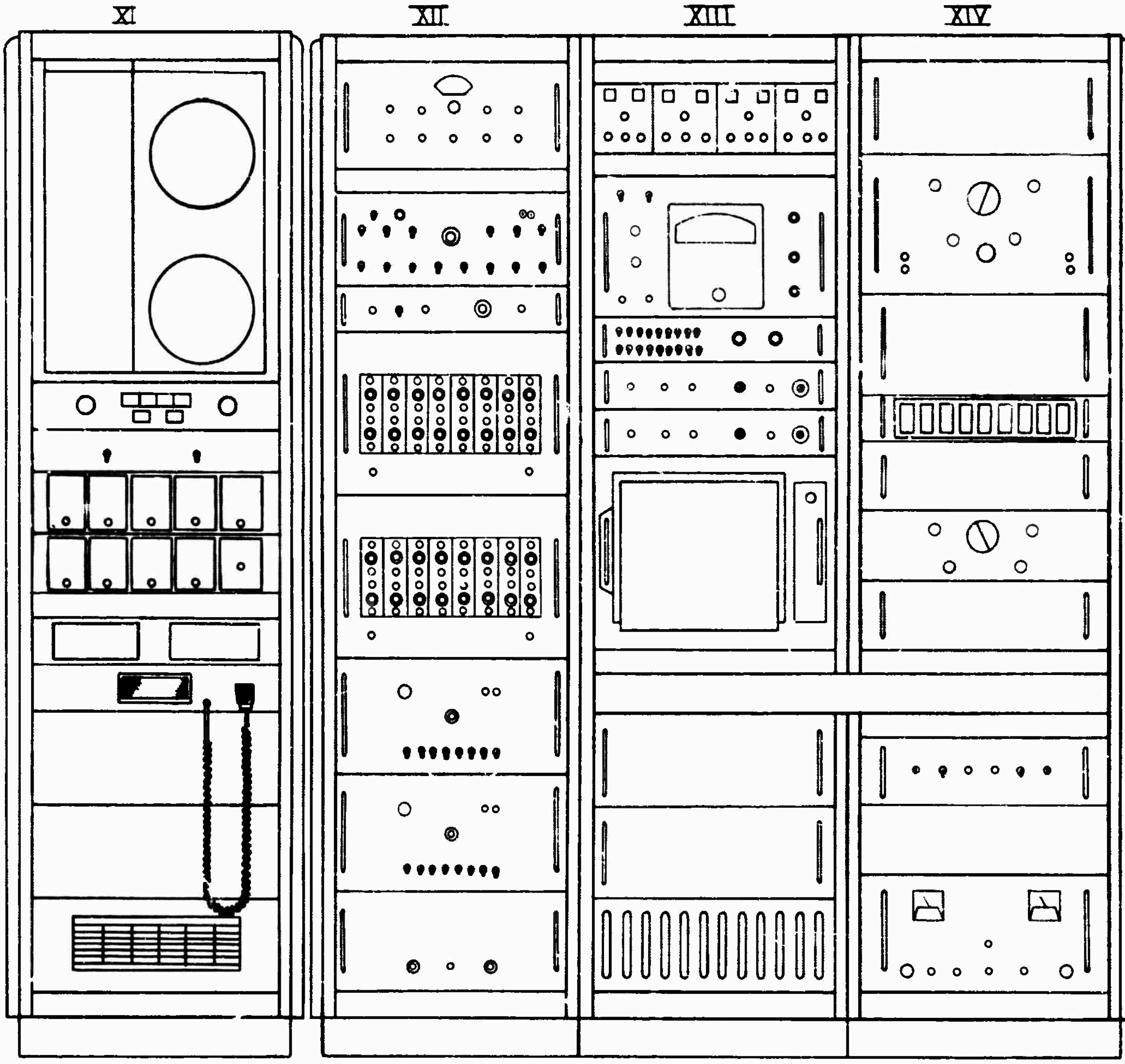
### 5.2.1 Installation of Remote Termination Boxes

#### 5.2.1.1 Site Requirements

a. Within 20 feet of well-head;

b. Nearly level terrain;

c. Accessible to excavation equipment and cement delivery vehicle.




TAPE RECORDER
HONEYWELL
MODEL # 7460

KROHNHITE FILTER
#330AR8
BLANK PANEL 1¾
CALIBRATION CONTROL
GEOTECH # 9300
CALIBRATOR
GEOTECH #9212A
DATA CONTROL FRAME
GEOTECH #5791
WITH 8EA. MODULES
#5792B
DATA CONTROL FRAME
GEOTECH #9212
WITH 8EA. MODULES
#5792B
SIGNAL ISOLATOR
GEOTECH #6722A
SIGNAL ISOLATOR
GEOTECH #10169A
DEVELOCORDER
SWITCHING UNIT
GEOTECH #5970

BLANK PANEL 1¾"
POWER SUPPLY
LAMBDA #LH124FM(4EA.)
BLANK PANEL 1¾
CALIBRATION CONTROL
UNIT
GEOTECH #9228
CALIBRATION SWITCHING
UNIT
GEOTECH #8048A
HELICORDER AMPLIFIER
GEOTECH #4983
HELICORDER AMPLIFIER
GEOTECH #4983
HELICORDER
GEOTECH #2484-2
BLANK PANEL 1¾
TABLE TOP
GEOTECH #4921
BLANK PANEL 7"
BLANK PANEL 7"
BLOWER McLEAN

BLANK PANEL 7"
FUNCTION GENERATOR
H-PACK #202AR
BLANK PANEL 7"
DISCRIMINATOR FM
GENISCO. 11EA.
BLANK PANEL 5¼"
FUNCTION GENERATOR
WAVETEK #102R
BLANK PANEL 5¼"
TABLE TOP
GEOTECH #4921
BLANK PANEL 1¾"
POWER AMPLIFIER
GEOTECH #9281
BLANK PANEL 5¼"
POWER CONTROL UNIT
GEOTECH #7679A

Figure 16. Operating console with instruments, UBSO subsurface array

Table 4. Summary of UBSO Buried-Array Data Formats

| | Develocorder | | Magnetic-tape recorder |
|---|---|---|---|
| Channel number | Data block 5014 | Data block 5016 | Data block 5013 |
| 1 | TEST | SZ 10L | STS |
| 2 | SZ 10L | SZ 1 | SZ 1 |
| 3 | Z 4 | SZ 3 | SZ 2 |
| 4 | Z 10 | SZ 5 | SZ 3 |
| 5 | Z 7 | SZ 2 | SZ 4 |
| 6 | Z 1 | SZ 4 | SZ 5 |
| 7 | TEST | SZ 6 | Comp[d] |
| 8 | SG[a] | TEST | SZ 6 |
| 9 | SGF[b] | ΣSSF[b] | SZ 7 |
| 10 | TEST | ΣSS[c] | SZ 8 |
| 11 | SZ 4 | SZ 7 | SZ 9 |
| 12 | SZ 10 | SZ 8 | SZ 10 |
| 13 | SZ 7 | SZ 9 | ΣSSF |
| 14 | SZ 1 | SZ 10 | WWV & Voice |
| 15 | TEST | WI | |
| 16 | WWV | WWV | |
| | Recorded from 21 Dec 1964 to 19 Jan 1965 | Recorded from 23 Jan 1965 to 15 April 1965 | Recorded from 28 Jan 1965 to 15 April 1965 |

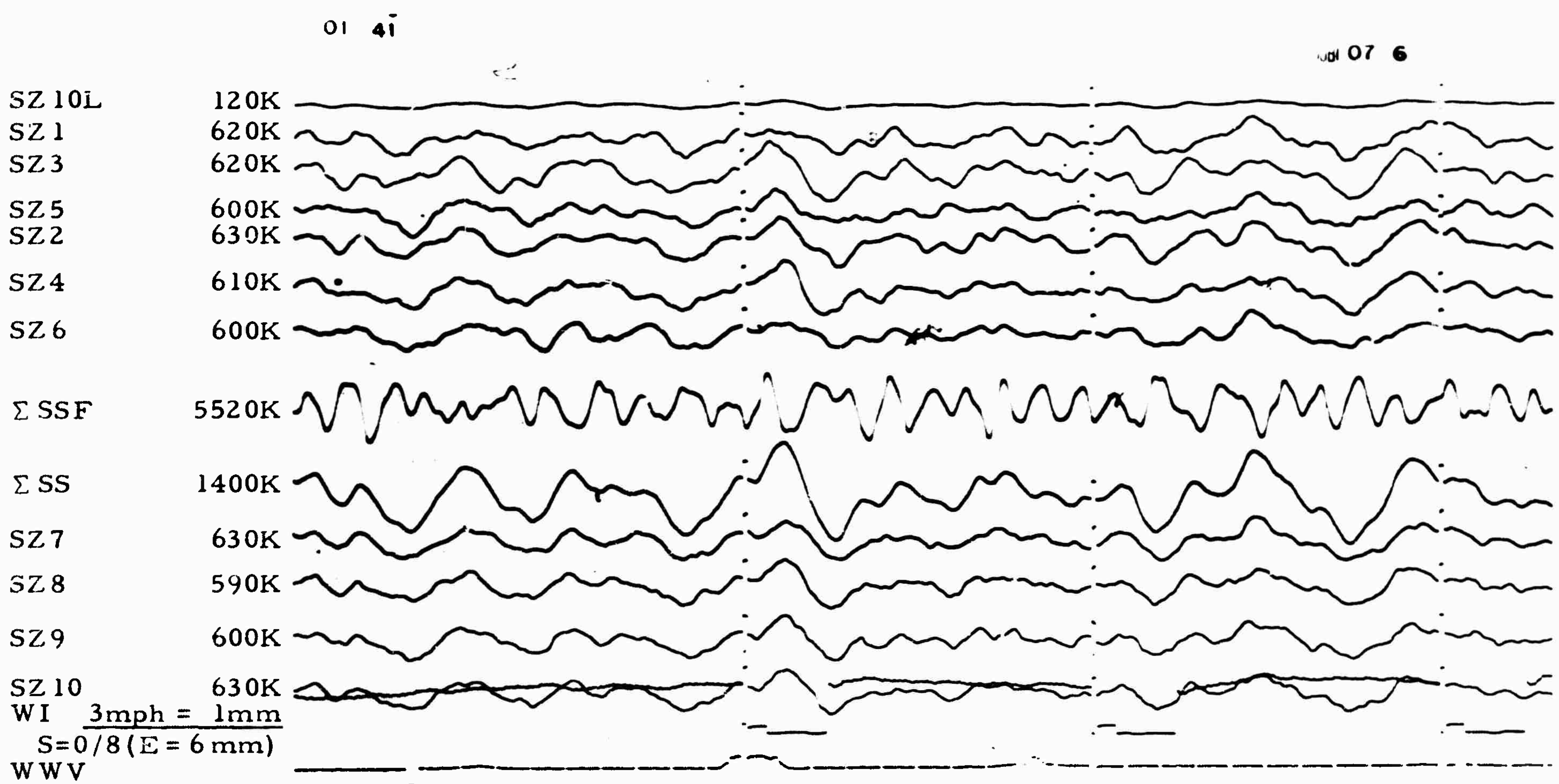
[a]Summation of SZ 1, SZ 4, SZ 7, and SZ 10

[b]ΣG and ΣSS filtered:

| | | |
|---|---|---|
| Low cut-off frequency | - | 0.8 Hz |
| Low cut-off rate | - | 18 dB/octave |
| High cut-off frequency | - | 3.0 Hz |
| High cut-off rate | - | 18 dB/octave |

[c]Summation of SZ 1 through SZ 10

[d]Compensation




UBSO
Run 076
17 Mar 65
Data group 5016

Figure 17. UBSO seismogram illustrating the response of the shallow-buried array to a wind from the SW at 18 mph (X10 enlargement of 16-mm film)

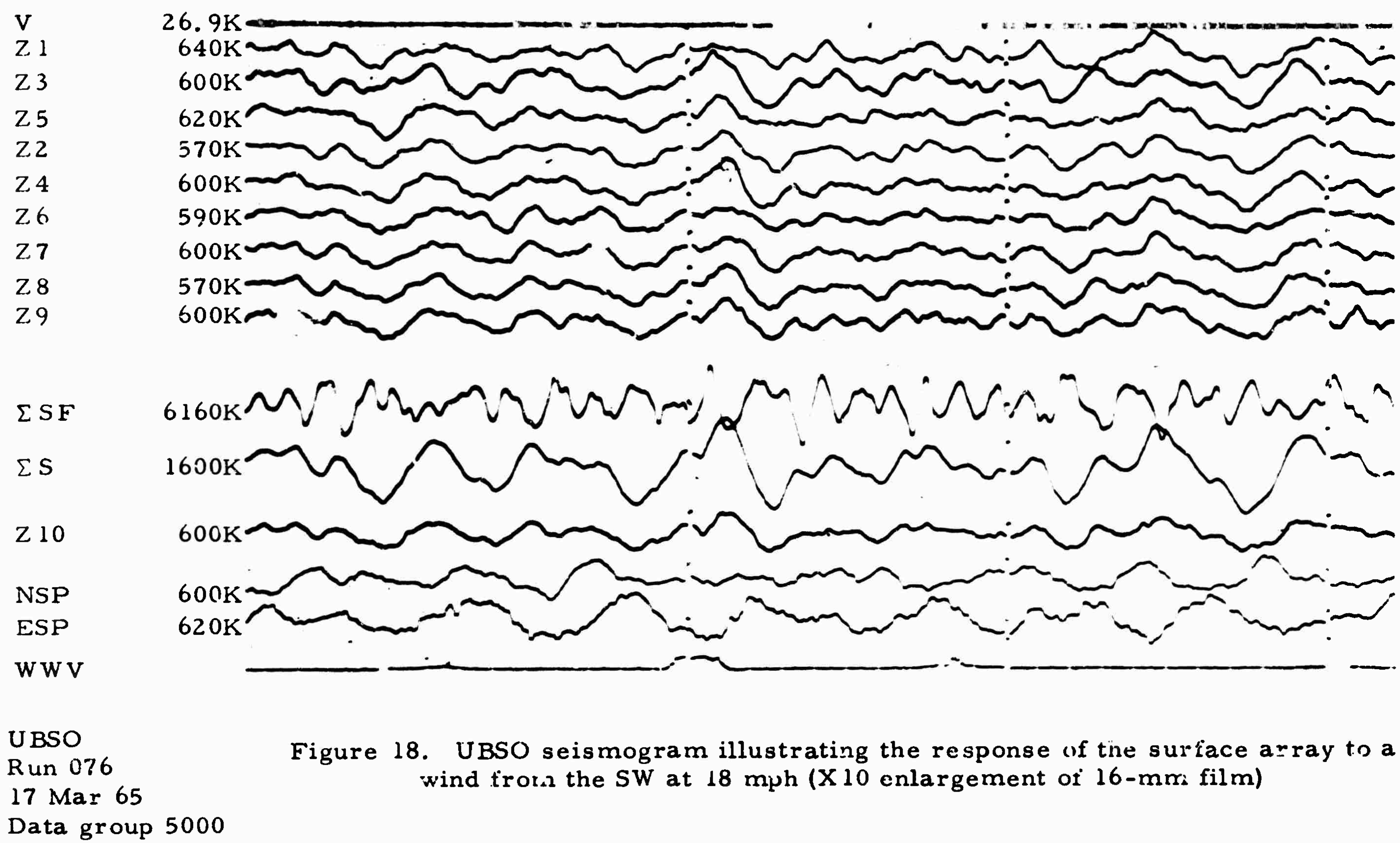
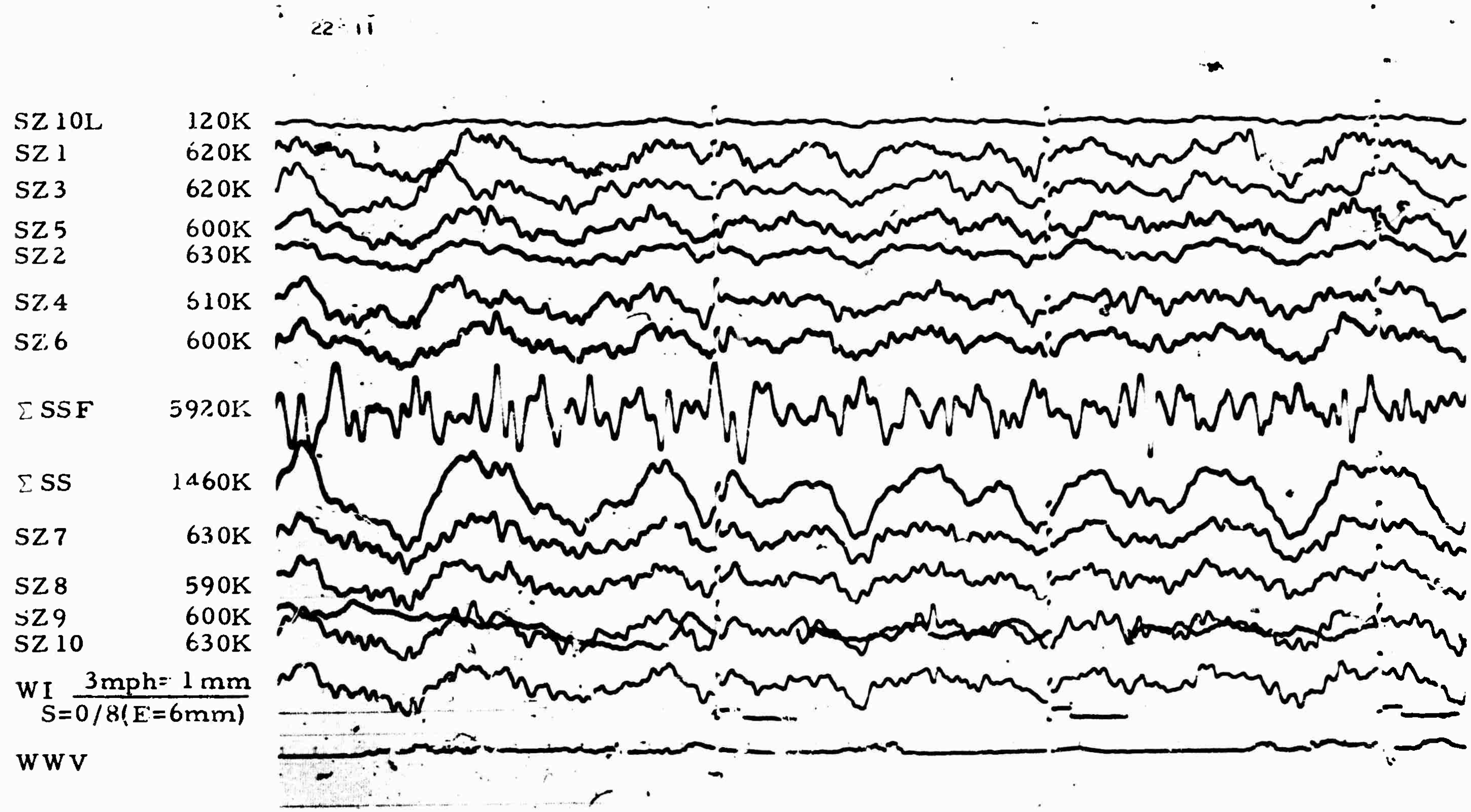
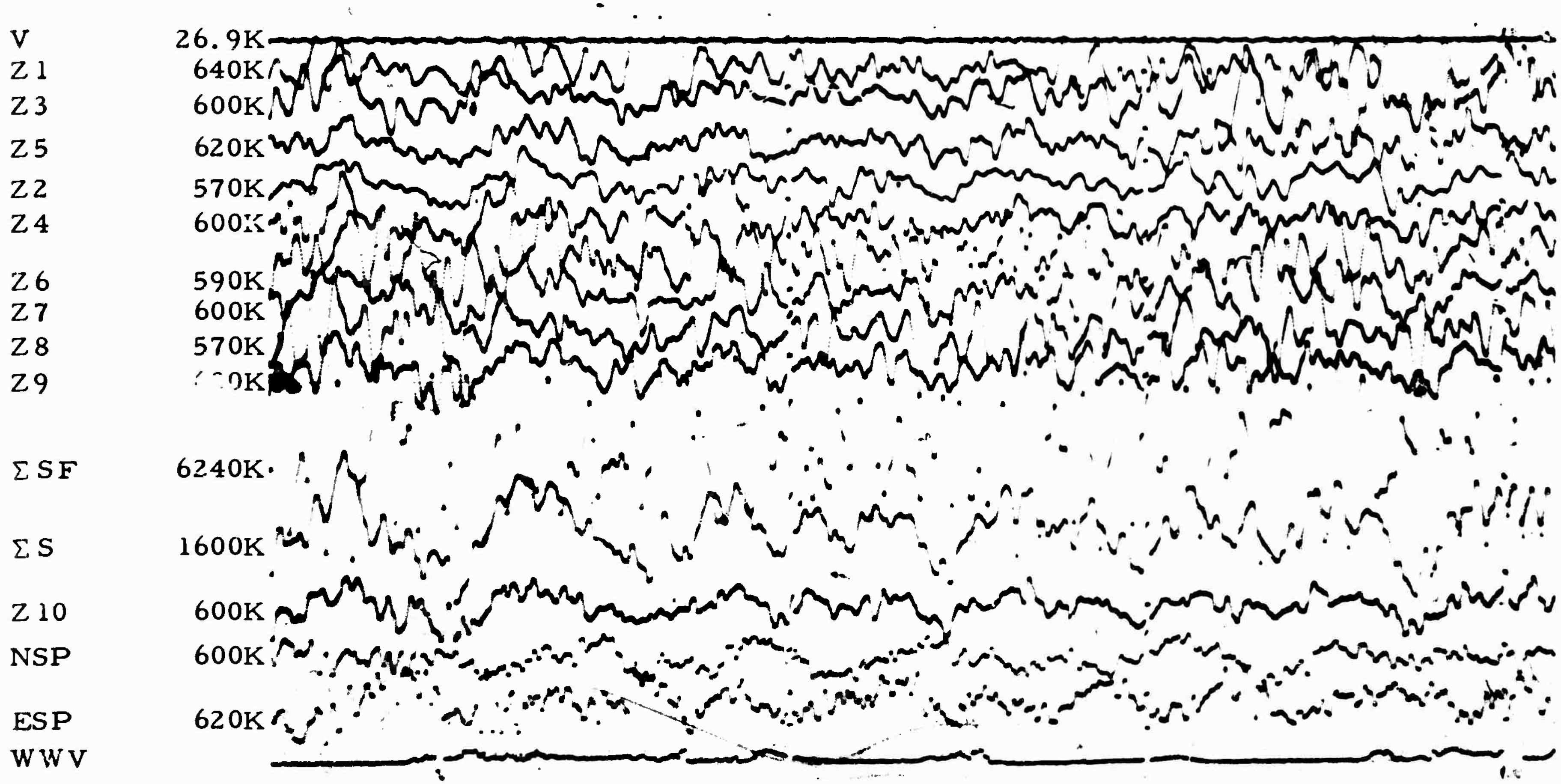



Figure 18. UBSO seismogram illustrating the response of the surface array to a wind from the SW at 18 mph (X10 enlargement of 16-mm film)




UBSO
Run 076
17 Mar 65
Data group 5016

Figure 19. UBSO seismogram illustrating the response of the shallow-buried array to wind-generated noise. Wind from WSW at 39 mph with gusts to 54 mph (X10 enlargement of 16-mm film)




UBSO
Run 076
17 Mar 65
Data group 5000

Figure 20. UBSO seismogram illustrating the response of the surface array to wind-generated noise. Wind from WSW at 39 mph with gusts to 54 mph (X10 enlargement of 16-mm film)

5.2.1.2 Installation Procedure

a. Excavate pit approximately 4 feet square and 3 feet deep.

b. Fill pit with cement to approximately 6 inches of ground level.

c. Place remote termination box in the pit, tilt and work the box to remove any trapped air, and place approximately 100 pounds of weight on top of the box. (The cable inlets on the box should be covered with masking tape for this operation.)

d. After the cement has set, fill the area around the box to ground level with loose soil.

e. Prepare the area around the box to allow proper seating of the weather shield and to allow proper drainage.

f. Distribute the excavated material to reduce wind effects.

Figure 21 shows the remote termination box with the weather shield removed, and figure 22 is a photograph of a completed box and its contents.

5.2.2 Installation of the Seismometer

a. Position the winch truck approximately 20 feet from the well-head with the winch facing the well-head squarely. The winch truck is shown in figure 23.

b. Remove the well-head cap.

c. Install the hoist assembly with the boom in a horizontal position.

d. Place the seismometer assembly with the seismometer cable attached in a vertical position adjacent to the well-head.

e. Lay out the seismometer cable, installing the cable in the top and bottom blocks of the hoist assembly.

f. Attach the cable at the winch drum; operate the winch to wind up the cable on the drum, leaving about 20 feet of slack.

g. Lift and secure the boom of the hoist assembly in the vertical position. Figure 24 shows the winch truck, mast assembly, and the seismometer.

Figure 21. Remote termination box with weather shield removed

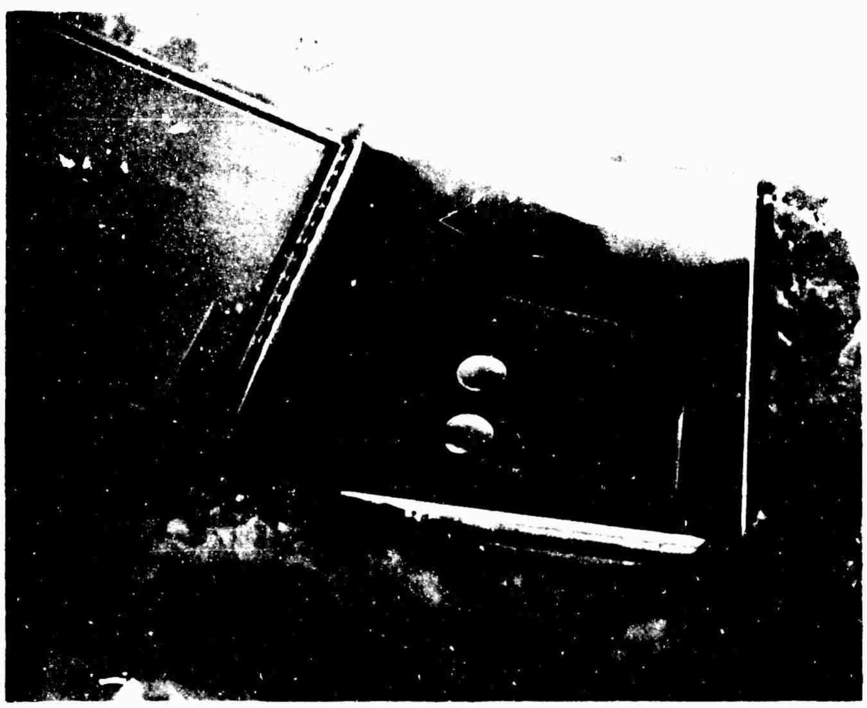


Figure 22. Remote termination box


Figure 23. Winch truck

Figure 24. Winch truck, mast boom, and seismometer

h. Remove the top cover of the pressure case and unlock the mass, checking the mass position.

i. Make final continuity checks on all seismometer circuits.

j. Attach the mass-blocking attachment to the winch drum. Connect and operate this device to position the mass on the bottom stop, verifying proper operation by examination of the mass-position indicator.

k. Replace and secure the top plate of the pressure case.

l. Set the trigger mechanism on the holelock.

m. Operate the winch to lift the seismometer above the well-head, guiding the seismometer by hand.

n. Operate the winch to lower the seismometer into the well casing slowly, guiding the seismometer by hand so that the trigger mechanism does not operate inadvertently.

o. Continue to lower the seismometer into the casing, monitoring the cable tension by hand as the instrument descends.

p. Operate the winch at reduced speed as the instrument approaches the bottom of the casing.

q. Stop the winch when the instrument reaches the bottom of the casing. This may be determined by cable tension and by sound issuing from the well casing.

r. Lift the seismometer slowly by hand; an audible click should be heard when the trigger mechanism operates.

s. Lift the instrument slowly another 2 feet, then test the cable tension to assure that the holelock has secured the seismometer in the casing.

t. Secure the seismometer at the well-head using a top clamp assembly.

u. Remove the cable from the winch drum and the hoist assembly. Remove the hoist assembly from the well-head.

v. Slide the well-head assembly and its associated fixtures down the cable. Hold this assembly and the cable in position above the well-head and remove the top clamp assembly.

w. Continue to hold the cable in position as the well-head assembly is threaded into its final position and tightened.

x. Release approximately 6 inches of cable into the well casing, then tighten the cable fixture and cable clamp.

y. Route the seismometer cable to the remote termination box, insert the cable through the fixture, coil the excess cable in the box, secure the cable conductors to the protector block, and tighten the cable fixture.

z. Perform the mass-position test; connect the data and calibration circuits and complete the preliminary tests on the seismographs.

Figure 25 is a photograph of a completed installation showing the well-head assembly and remote termination box.

### 5.2.3 Ball-Lift Calibrators

The equivalent weights of the ball-lift calibrators were tested before the seismometers were placed in the holes by comparing deflections induced by the calibrators with deflections produced by 200-mg weight-lifts. The equivalent weights of the ball-lift calibrators were tested again after the seismometers were installed in the holes. In the latter tests, the deflections caused by the calibrators were compared with deflections caused by current step functions in the electromagnetic calibration coils.

The average difference in equivalent weights determined by the two methods was 2.8 percent and all differences were less than 6 percent. The results of the tests are summarized in table 5.

An agreement of 6 percent or less was considered satisfactory. Several factors contribute to any observed discrepancy. The equivalent weight of the ball-lift calibrator is slightly dependent on the mass position of the seismometer. A plus or minus 25-percent displacement of the mass from its center position will result in a 3-percent change in equivalent weight; a change of 50 percent will result in a 6-percent change in equivalent weight. The mass position changed slightly after the instrument had been lowered into the hole; but tests indicated that the mass was still within the plus or minus 1/16-inch (25 percent

Figure 25. Well-head assembly and remote termination box after installation

Table 5. Summary of ball-lift equivalent weight tests

| Inst. | Ser. No. | Equivalent weight before installation mg | Equivalent weight after installation mg | Change % |
|---|---|---|---|---|
| Z 1 | 574 | 44.6 | 42.0 | -5.7 |
| Z 2 | 576 | 40.2 | 41.2 | +2.3 |
| Z 3 | 473 | 46.2 | 43.5 | -5.7 |
| Z 4 | 577 | 44.5 | 44.0 | -1.1 |
| Z 5 | 477 | 46.4 | 44.5 | -3.9 |
| Z 6 | 573 | 44.8 | 45.0 | +0.3 |
| Z 7 | 479 | 44.3 | 46.0 | +3.8 |
| Z 8 | 478 | 43.7 | 44.3 | +1.3 |
| Z 9 | 578 | 45.1 | 46.6 | +3.2 |
| Z 10 | 480 | 42.6 | 42.3 | -0.6 |

of total travel) tolerance. If the mass changed from center position at the surface to plus or minus 1/16 inch of center in the hole, a change of 3 percent would be observed in the equivalent weight. In addition, tests conducted at WMSO have proven that the greatest reading accuracy that can be obtained when the measurements are taken from Helicorder records is 0.5 percent. To make the comparison outlined in the first part of this section, four measurements were necessary; thus, a possible reading error of plus or minus 2 percent is present in the tests.

The equivalent weights determined after the seismometers were installed will be used for the periodic determination of the electromagnetic calibrator motor constant.

### 5.2.4 Seismograph Frequency Response Procedures

After all seismometers had been installed, frequency response checks were run on all seismographs of the buried array. The frequency response norms and tolerances were previously shown in figure 8 and table 3. The standard procedure for performing frequency response checks of the surface-array elements is to change the attenuation of the system at the PTA when the trace deflection becomes extremely small. However, the PTA's are located at the seismometer site in the buried array and it is impractical, and at times impossible, to get to the instrument location because of bad weather. When frequency response checks are performed on the buried-array seismographs, the calibration current is changed instead of the PTA attenuation. The frequency response data are summarized in table 6.

When frequency response is checked, the attenuation of the Develocorder traces is increased 12 dB at the data control modules and the sensitivity of the magnetic-tape recorde channels is reduced 12 dB by adjusting the deviation control on each recording oscillator. These attenuation settings should be used for an operating magnification of approximately 600K. If the operating magnification is to be changed appreciably, these attenuation factors should be altered; however, the magnetic-tape recorder sensitivity should be changed only in increments of 6 dB.

Table 6. Frequency-Response Procedures

| Calibration period (sec) | Calibration frequency (Hz) | Calibration current (ua) | Current factor | Approximate expected deflection (mm) |
|---|---|---|---|---|
| 5.0 | 0.2 | 250 | 1.00 | 10.0 |
| 2.5 | 0.4 | 250 | 1.00 | 21.0 |
| 1.25 | 0.8 | 250 | 1.00 | 40.5 |
| 1.00 | 1.0 | 250 | 1.00 | 37.5 |
| 0.667 | 1.5 | 250 | 1.00 | 25.0 |
| 0.500 | 2.0 | 250 | 1.00 | 18.0 |
| 0.333 | 3.0 | 1000 | 4.00 | 37.0 |
| 0.250 | 4.0 | 1000 | 4.00 | 17.0 |
| 0.167 | 6.0 | 4000 | 16.00 | 16.5 |
| 0.125 | 8.0 | 4000 | 16.00 | 5.0 |
| 0.100 | 10.0 | 4000 | 16.00 | 2.0 |

APPENDIX 1 to TECHNICAL REPORT NO. 65-28

## STATEMENT OF WORK TO BE DONE

24 August 1964

# STATEMENT OF WORK TO BE DONE

AFTAC Project Authorization No. VELA/T/1124/S/ASD, Amendment 7 (31)

1. Work to be Done. Amend the Statement of Work to be Done of AFTAC Project Authorization No. VELA T/1124/S/ASD, Amendment No. 5, dated 2 May 1963, by adding the following requirement:

ic. Shallow-Borehole Array at UBSO

(1) Recommend the optimum array pattern that can be confined within the boundaries of the UBSO site for a 10-element shallow-borehole array; also, recommend the optimum array pattern and number of elements when site boundaries are disregarded.

(2) After approval by the AFTAC project officer of the 10-element shallow-borehole array pattern, drill, case, cement, and complete a shallow hole at each seismometer location in the array pattern. Log selected shallow holes, as necessary, to provide data for the study of the geological factors affecting seismic signal-to-noise ratio.

(3) Provide the necessary array instrumentation and recording equipment for the 10-element shallow-borehole array, using existing components when possible. Approval by the AFTAC project officer of the seismometers and amplifiers selected for the array must be obtained.

(4) Install the array instrumentation and recording equipment. Perform the necessary calibrations and tests to assure proper operation of all equipment.

2. Time Schedule. The UBSO shallow-borehole array should be in normal operational use not later than 31 December 1964.

APPENDIX 2 to TECHNICAL REPORT NO. 65-28

SPECIFICATIONS FOR EACH OF TEN 250-FOOT CASED HOLES

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# SPECIFICATIONS FOR EACH OF TEN 250-FOOT CASED HOLES AT LOCATIONS TO BE DESIGNATED WITHIN THE UBSO ARRAY NEAR VERNAL, UTAH

1. Hole depth: Approximately 255 feet below surface; deviation will be less than 5 degrees from the vertical.

2. Hole diameter: 9-7/8 inches or larger if necessary to take 7-5/8 inch casing.

3. Drilling mud: As necessary.

4. Bits: As necessary.

5. Logs: Of each of four holes, continuous from total depth to surface:

a. Transit time integrated, borehole compensated sonic log plus sonic amplitudes, compressional and shear;

b. Formation density log, and caliper.

Of one of above four holes continuous from total depth to surface:

a. Birdwell 3-D velocity log (P & S).

Of two of above four holes continuous from total depth to surface:

a. Conventional induction electric log with long normal;

b. Continuous Dipmeter (Poteclinometer) log.

6. Casing: Approximately 260 feet of 7-5/8-inch o.d. 24 pound H-40 8 round thread, range 1 or 2 (as available) steel casing of API specifications, new.

7. Cementing accessories:

One 7-5/8-inch casing float shoe
One 7-5/8-inch baffle plate
One 7-5/8-inch cementing plug
One 7-5/8-inch centralizer to be run on bottom casing collar
1 pound of thread lock compound

8. Run casing to approximately 3 feet above bottom and establish circulation through casing before cementing.

9. Cement to be common Portland, mixed 6 gallon/sack; approximately 45 sacks required to circulate to surface.

10. Cementing to be done by rig pump, circulated to surface, displaced by clear water. Bump plug, set pipe down on bottom, shut in under 200 pounds pressure, and wait on cement 12 hours minimum.

11. Drill out any cement on top of plug with clear water, check depth of plug, and circulate the hole clean.

12. Bail dry, wait 1 hour for fillup and check for leaks.

13. Leave top casing collar 18 inches above ground level.

14. Provide and install well cap made from 7-5/8-inch thread protector.

15. Fill pits and level around well-head.

16. No tripod pad required.

17. First hole to be commenced immediately, drilled with due diligence and completed as soon as possible. All other holes to be drilled in the same manner, with a new hole being started immediately after each preceding hole is completed. Geotech may require contractor to operate the rig in excess of normal working hours in the interest of meeting its completion requirements.

18. Catch, wash, sack, and label clean cuttings samples at 10-foot intervals from surface to total depth in each of the 10 holes.

APPENDIX 3 to TECHNICAL REPORT NO. 65-28

## GEOPHYSICAL LOGS

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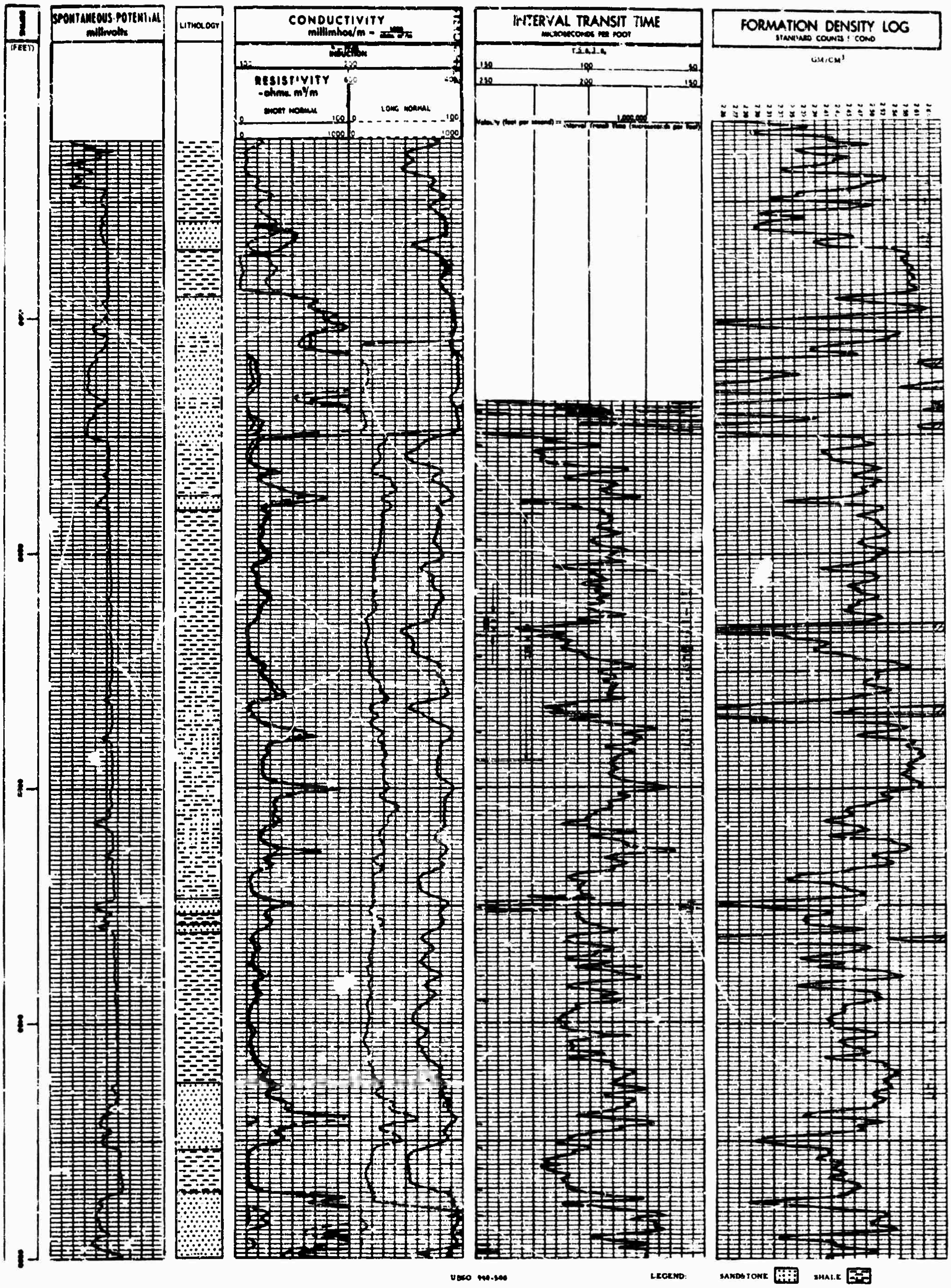
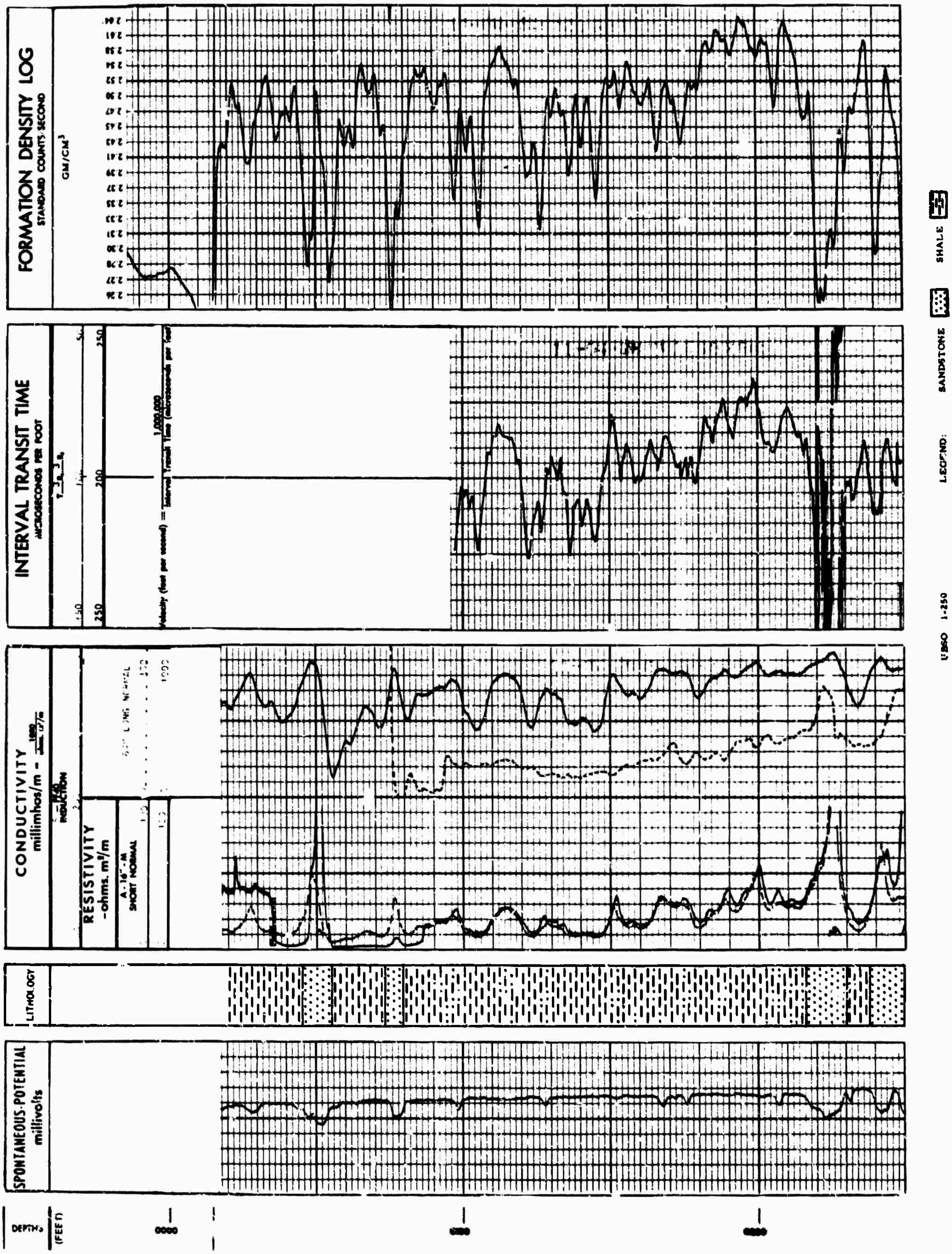

(FEET)
SPONTANEOUS POTENTIAL
millivolts
LITHOLOGY
CONDUCTIVITY
INDUCTION
RESISTIVITY
SHORT NORMAL
LONG NORMAL
INTERVAL TRANSIT TIME
MICROSECONDS PER FOOT
FORMATION DENSITY LOG
LEGEND:
SANDSTONE
SHALE


FORMATION DENSITY LOG
STANDARD COUNTS/SECOND
GM/CM³
INTERVAL TRANSIT TIME
MICROSECONDS PER FOOT
CONDUCTIVITY
millimhos/m
INDUCTION
RESISTIVITY
-ohms. m²/m
SHORT NORMAL
LITHOLOGY
SPONTANEOUS-POTENTIAL
millivolts
DEPTHS (FEET)
LEGEND:
SANDSTONE
SHALE

# APPENDIX 4 to TECHNICAL REPORT NO. 65-28

## LIST OF EQUIPMENT

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## MANUFACTURED PARTS

| Quan | Part No. | Manufacturer | Description |
|---|---|---|---|
| 11 | 23374 | Geotech | Shallow-hole vertical seismometer |
| 10 | 23521 | Geotech | Well-head assembly |
| 11 | 12613-1 | Geotech | Phototube amplifier |
| 10 | 23592 | Geotech | Remote termination box |
| 1 | 7148 | Geotech | Station protector |
| 1 | 7842 | Geotech | Station terminal |
| 1 | 8048A | Geotech | Calibration switching unit |
| 1 | 9228 | Geotech | Calibration control unit |
| 2 | 7149A | Geotech | Data line terminal |
| 10 | 19275A | Geotech | Isolation filter |
| 1 | 6722A | Geotech | Signal isolator |
| 1 | 10169A | Geotech | Signal isolator |
| 2 | 4983 | Geotech | Helicorder amplifier |
| 1 | 2484-2 | Geotech | Helicorder |
| 2 | 5791 | Geotech | Data control frame |
| 16 | 5792B | Geotech | Data control module |
| 1 | 5970 | Geotech | Develocorder switching unit |

| Quan | Part No. | Manufacturer | Description |
|---|---|---|---|
| 1 | 9300 | Geotech | Calibration control |
| 1 | 9212A | Geotech | Calibrator |
| 1 | 4000C | Geotech | Develocorder |
| 1 | 11219 | Geotech | D. C. regulator |
| 1 | 9231 | Geotech | Power amplifier |
| 1 | 7679A | Geotech | Power control unit |
| 1 | | Geotech | Galvo test set |
| 1 | 6734 | Geotech | Develocorder console |
| 1 | 23282 | Geotech | Operating console |
| 11 | 19275 | Geotech | Isolation filter |
| 10 | 5874A | Geotech | Line termination module |
| 1 | 22628 | Geotech | Mast and sheave assembly |

## PURCHASED PARTS

| Quan | Part No. | Manufacturer | Description |
|---|---|---|---|
| 1 | 7460 | Honeywell | Magnetic-tape recorder |
| 1 | 23-25-220 | Sola | C. V. transformer |
| 1 | 321A | Hewlett-Packard | Oscilloscope |
| 1 | 102 RZ | Wavetek | Function generator |
| 4 | [illegible]124FM | Lambda | Power supp[illegible] |
| 1 | [illegible]-1 | Lambda | Rack adapter |
| 1 | 310A | Triplett | VOM |
| 11 | | Genisco | Discriminator |
| 1 | | Genisco | Disc housing |
| 1 | 510A | Cadre | Transceiver |
| 1 | 510-1 | Cadre | Power rack |
| 1 | 330AR8 | Krohn-Hite | ULF filter |
| 1 | | Wavetek | Rack-mounting module |

## HARDWARE

| Quan | Manufacturer | Description |
|---|---|---|
| 1 | Geotech | Station & data line terminal mounting & assembly |
| 1 | Geotech | Develocorder installation materials |
| 1 | Geotech | Console power hardware |
| 1 | Geotech | Cable & cable hardware |

APPENDIX 5 to TECHNICAL REPORT NO. 65-28

SPECIFICATIONS

PORTABLE SHORT-PERIOD SEISMOMETER, MODEL 18300

# SPECIFICATIONS

## PORTABLE SEISMOMETER, MODEL 18300

### 1. DESCRIPTION

The Portable Seismometer, Model 18300, is designed for use in field operations where a small, light-weight, short-period, moving-coil-type seismometer is desired. The seismometer weighs less than 25 pounds and has a 10.9-pound mass. The seismometer may be operated in either the horizontal or vertical position, and the period is adjustable from 1.33 to .91 second (0.75 to 1.1 cps).

The main coil consists of four separate and equal windings of 390 ohms each, and may be connected to provide seismometer resistances from 97.5 to 1560 ohms.

The seismometer is equipped with a calibration coil and has provisions for making weight lifts.

### 2. SPECIFICATIONS

| | |
|---|---|
| Natural frequency | |
| Horizontal operation | Adjustable 0.75 to 1.1 cps |
| Vertical operation | Adjustable 0.75 to 1.1 cps |
| Weight of inertial mass | 4.75 kg (10.9 pounds) |
| Transducer | |
| Type | Moving coil (velocity) |
| Damping | Electromagnetic |
| Maximum flux density | 5200 ± 100 gauss |
| Transducer coil | |
| Number windings | 1 to 4 on common form |
| Resistance | 390 ohms per winding |

(Coils may be connected internally as required. Furnished with four coils connected in parallel unless otherwise specified.)

| | |
|---|---|
| Operating temperature range | -60 to ±140°F |
| Least vertical spurious mode frequency | 104 to 105 cps |
| Size | 6 5/8" dia x 13 inches high |
| Weight | 25 pounds |
| Shipping weight | 35 pounds |
| Accessories furnished | Weight lift calibration kit<br>Mounts for horizontal operation<br>Instruction manual |

APPENDIX 6 to TECHNICAL REPORT NO. 65-28

## PHOTOTUBE AMPLIFIER, GEOTECH MODEL 12613

# Technical Data

## PURPOSE

This amplifier is designed to amplify very low-level voltages or currents in the infrasonic region of the spectrum. Interchangeable plug-in boards make it possible to select circuits for either an analog or an FM carrier output. Other special features include sealed optical and electrical components, and the ability to operate unattended for long periods of time.

## OPERATING CHARACTERISTICS

INPUT CIRCUIT
- NUMBER - 1
- TYPE - Unbalanced
- IMPEDANCE - 80 ohms
- ATTENUATION - 0-42 db, and infinity; bridged-tee attenuator with 6 db attenuation per step

ANALOG OUTPUT (Model 12613)

NUMBER - 1
TYPE - Single-ended or balanced
IMPEDANCE - Less than 1K ohm
VOLTAGE - 15 v, p-p, into open circuit; 12 v, p-p, into 10K ohm (recommended min load resistance)
SENSITIVITY - 1510 v/rad

DATA PASSBAND - 3 db down at 0.01 and 5 cps, when Galvanometer, Geotecn Model 4100-501 is used

GAIN - 700K, nominal, with model 4100-501 galvanometer and standard filter
NOISE LEVEL - 0.01 microvolt, rms, max in data passband at max gain, referred to input (rms is taken as 0.16 long-term p-p value)

DYNAMIC RANGE - 60 db (from noise level to clipping level)
LINEARITY - ±2% (from noise level to 75% of clipping level); based on best straight line with 1 cps sinusoidal signal
DRIFT - 0.1 microvolt, max/4hr; referred to input after stabilization

TEMPERATURE - Will operate from -52° to 52°C (-60° to 125°F) where diurnal swing of 21°C (70°F) at a rate not greater than 5.8°C (10°F)/hr is applied

HUMIDITY - 0-95% relative humidity

ADJUSTMENTS - Will operate within specifications with adjustments at intervals of not less than 6 months

GAIN VS. TEMPERATURE - ±10% of gain at 25°C (78°F); after 10 hours stabilization at constant temperature and within temperature specifications

POWER SUPPLY VARIATION ±1% in gain/10% change of supply voltage, outside the passband

FM OUTPUT (Model 12613-1)

NUMBER - 1
TYPE - Unbalanced
VOLTAGE - 1.3 v, rms, square wave, with 600-ohms load

BANDWIDTH - 500-2500 cps

CENTER FREQUENCY - 1550 ±25 cps

MODULATION SENSITIVITY - 24 cycles/microvolt, nominal

NOISE LEVEL - Same as analog

DYNAMIC RANGE - 70 db, min (from noise level to clipping level)

LINEARITY - ±2%, to greater than 75% of clipping level (based on best straight line with 1 cps sinusoidal signal

TEMPERATURE - Same as analog

HUMIDITY - Same as analog

ADJUSTMENTS - Same as analog

MODULATION SENSITIVITY VS. TEMPERATURE - ±10% of modulation sensitivity at 25°C(78°F); after 10 hours stabilization at constant temperature within temperature specifications

MODULATION SENSITIVITY VS. HUMIDITY - ±1% variation within humidity specification (other factors constant)

POWER SUPPLY VARIATION - ±3% in modulation sensitivity/10% change of supply voltage, outside the passband

## POWER REQUIREMENTS

DC POWER
- VOLTAGE - 24 v nominal; may vary from 22 to 28 v
- ANALOG OUTPUT - 2 w (max) at 24 vdc
- FM OUTPUT - 2.25 w (max) at 24 vdc

## PHYSICAL CHARACTERISTICS

BASIC DIMENSIONS
- HEIGHT - 267 mm (10.5 in.)
- WIDTH - 218 mm (8.6 in.)
- DEPTH - 382 mm (15.1 in.)

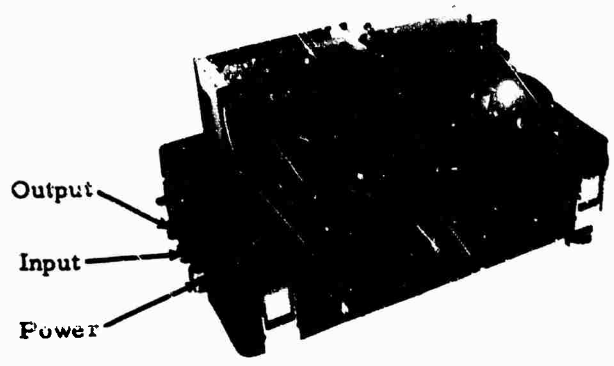
NET WEIGHT - 11.4 kg (25.5 lb)

SHIPPING WEIGHT - 15.9 kg (35 lb)

SHIPPING VOLUME - 2.8 x $10^{-2}$ $m^3$ (1 cu ft)

## CONNECTORS

INPUT - Receptacle 10-74714-7P (Bendix); mating plug MS3106-14S-7S
OUTPUT - Receptacle 10-74711-3P (Bendix); mating plug MS3106A-10SL-3S
POWER - Receptacle 10-74711-4P (Bendix); mating plug MS-3106A-10SL-4S




Side view of instrument

## ACCESSORIES

GALVANOMETER - Model 4100-(     ); 4100-501 is standard (1 furnished)
CIRCUIT BOARD - Low-frequency amplifier; for analog. Part No. 14585; for FM, Part No. 14254; (1 furnished)
CIRCUIT BOARD - Bandpass Filter, Part No. 14513 (0.01 to 5 cps); 1 furnished for analog configuration
CIRCUIT BOARD - Voltage-Controlled Oscillator, Part No. 14291; 1 furnished for FM configuration
POWER SUPPLY - Model 16139

ORDERING INFORMATION
Please specify by numbers shown below for desired configuration:
- 12613- Analog
- 12613-1- FM

APPENDIX 7 to TECHNICAL REPORT NO. 65-28

# SPECIFICATIONS
# for
# NO. 18300 MODIFICATION KIT

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# GEOTECH PRELIMINARY SPECIFICATIONS

## PRESSURE CASE MODIFICATION KIT, MODEL 23374

### PURPOSE

The Pressure Case Modification Kit, Model 23374, converts the Portable Short-Period Seismometer, Model 18300, into an instrument designed for operation in a shallow hole. The depth and/or "head of water" should not exceed 500 feet.

The operational and performance characteristics of the seismometer are unchanged by the conversion of the instrument with this kit.

The kit consists of adapter parts for the seismometer necessary for installation in the pressure case. To complete the kit, a hole lock is provided for depth positioning, a weight-lift calibrator for remote operation of instrument calibration, and a load-bearing signal cable with six conductors to connect the instrument to top of the hole.

This instrument designed for use with the Buried Array System.

### OPERATING CHARACTERISTICS

| | |
|---|---|
| Operating characteristics (seismometer) | See specifications for the Model 18300 |
| Operating depth (nominal) | 76.2 m (250 ft) |
| Hydrostatic pressure | |
| At nominal operating depth | 110 psi |
| At max operating depth | 220 psi |
| Cable loading | |
| Ultimate working load | |
| Fail-safe shear pin | 500 kg (1100 lbs) |
| Weight-lift calibrator | |
| Equivalent weight lift | 50 mg |
| Operating signal | 12 ma at 12 volts |
| Coil resistance | 1000 ohm |
| Hole lock depth adjustment | Infinite |

### PHYSICAL CHARACTERISTICS

| | |
|---|---|
| Mount (seismometer to case) | |
| Mechanical | Coupled |
| Electrical | Insulated |

| | |
|---|---|
| Case diameter (outside) | 168 mm (6.63 in.) |
| Length* (including holelock) | 1.26 m (49.56 in.) |
| Length* (excluding holelock) | 0.67 m (26.4 in.) |
| Instrument weight* (including holelock) | 39 kg (86 lbs) |
| Cable length (nominal) | 91.4 m (300 ft) |
| Cable diameter (U. S. Steel No. 3-H-1 modified) | 7.6 mm (0.30 in.) |
| Cable weight (300 ft) | 20.4 kg (45 lbs) |

*Excluding cable and connectors

ENVIRONMENTAL

| | |
|---|---|
| Design hydrostatic pressure (case) | 2,500 psi |
| Temperature (operational) | -51 to 60°C |
| Corrosion resistance | |
| Case and holelock | Stainless steel or nickel plate |
| Cable | Plow steel (zinc plate) |

APPENDIX 8 to TECHNICAL REPORT NO. 65-28

SPECIFICATIONS
for
MAGNETIC-TAPE RECORDER/REPRODUCER SYSTEM

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## SPECIFICATIONS
## for
## MAGNETIC-TAPE RECORDER/REPRODUCER SYSTEM

### 1. SCOPE

The magnetic-tape recorder/reproducer system will be an instrumentation grade system in the intermediate price range It will be operated under field conditions, but will normally be exposed to controlled temperatures. The system will be operable in the temperature range of +40° to +120°F with relative humidity from 0% to 95% without condensation. The system is to be 14-track record and 14-track reproduce on 1-inch wide 1.0- or 1.5-mil base tape. The tape used will conform to MIL-T-21029A (SHIPS) specifications. Record and reproduce are to take place simultaneously. Unless otherwise specified, all system components shall conform to IRIG specifications per IRIG Recommendation No. 101-60, approved 23 March 1960.

### 2. FIELD EQUIPMENT

The following equipment shall be included in the field system.

a. One (1) tape transport for 1-inch wide 1.0- or 1.5-mil base tape with a speed of 0.3 ips. Other speeds are allowable and desirable. Transport is to accommodate 10-1/2-inch NAB standard or precision reels. Accommodation for a 14-inch reel is allowable and desirable. Transport to have fast forward, fast rewind, record, playback and stop controls. The transport will be provided with a hinged dust-tight cover over the front. Cover will have glass or plastic window through which the operation of the transport can be observed. The system will automatically restart when power is restored after a power failure.

b. One (1) record head group, 14 tracks per inch.

c. One (1) reproduce head group, 14 tracks per inch.

d. Twelve (12) FM recording oscillators capable of operation at 270-cps center frequency with ±40% deviation. Controls for adjusting center frequency and deviation shall be readily accessible. It shall be possible to activate the record modules for adjustments without operating the transport.

e. One (1) FM flutter compensation reference generator capable of operation at 270 cps for 0.3-ips recording speed to have specifications adequate to fulfill system synamic range specifications.

f. Voice /WWV recording/reproducing amplifiers with speaker. System will be capable of intelligible voice reproduction at a reasonable audio level. Unit is to have on-off switch and volume control. Record and reproduce shall occur simultaneously. (This shall be tested at 10 feet from the instrument rack with the inspectors intelligibility of 95% of the recording on the first pass of the tape.)

g. Two (2) FM data discriminators capable of demodulation at 0.3 ips (270-cps center frequency.) Circuitry shall be included to make possible compensated playback of one reproduce channel or monitoring of two channels uncompensated. The discriminators shall be provided with plug-in center frequency units for 270 cps and plug-in data filters 0 50.0 cps. An additional filter (0-12.5 cps, 1/4 bandwidth) shall be supplied for each of the two discriminators.

h. One (1) head-switching panel to allow monitor of the output of any two reproduce heads with either of the two FM data discriminators.

i. One (1) blower panel (if needed).

j. One (1) microphone.

k. System to be mounted in an instrument rack. Equipment to be completely wired and equipped with necessary power supplies and connecting cables. All interconnections to be made with standard plug-in type connectors. Any overflow equipment which must be mounted in an adjacent rack is to be equipped with connecting cables and connectors. Rack wiring will conform to good wiring practice.

l. All data input and output connections will be accessible from the rear of the rack, and will be made with individual connectors. The connectors will be selected so that inputs and outputs cannot be intermixed.

m. Two (2) copies of instruction manuals per system. These manuals shall include those instructions that are necessary to operate and maintain the recorder and a complete list of replaceable parts.

## 3. SYSTEM PERFORMANCE REQUIREMENTS

### 3.1 CONDITIONS

All performance requirements are to be met over the ranges of +40°F to +120°F, 0% to 95% relative humidity without condensation, and with the necessary power as given in section 3.6. The system will operate continuously. The system will meet specifications after being subjected to an acceleration of 3 g's.

### 3.2 SYSTEM

a. Dynamic range - signal-to-noise ratio. On the FM channels, when recording at 0.3 ips, the dynamic range will not be less than 36 dB when played back uncompensated. The dynamic range will be increased to not less than 46 dB when flutter and wow compensation is used. The signal-to-noise ratio referred to in this specification is the ratio of the full-scale rms output to the maximum residual system noise at any frequency as measured over any 1-minute time interval using a data filter allowing full bandwidth capability (dc to 50 cps). The metering device used to measure the residual system noise must have a bandpass extending to the lowest frequency observed as shown by a dc scope. (Hewlett Packard 403A ac voltmeter or equivalent.) When 1/4 bandwidth (0-12.5-cps) filters are used, the dynamic range will be increased to 40 dB for uncompensated playback and 52 dB for compensated playback.

b. Frequency response (record and reproduce combined):

1. FM recording at 0.3 ips 0-50 cps flat ±1/2 dB;
2. FM recording at 0.3 ips 0-12.5 cps flat ±1/2 dB;
3. Voice recording and reproduction to be adequate for intelligible voice reproduction at a reasonable volume level (can be heard and understood at a distance of 10 feet).

c. Linearity: Ac and dc linearity to deviate no more than 2% of full scale (output voltage from 40% deviation) from a best straight line over the full bandwidth of the channel.

d. Dc drift: Dc drift to be no more than 0.5% of full scale (output voltage resulting from 40% deviation) in 1 hour or more than 2% of full scale in 24 hours after 1-hour warmup and at constant temperature. Drift due to temperature not to exceed 0.1% per degree F.

e. Sensitivity drift: Sensitivity drift to be no more than 1% of full scale in 24 hours after 1-hour warmup.

f. Harmonic distortion: Total harmonic distortion to be less than 2% at any frequency in the bandpass.

### 3.3 TAPE TRANSPORT

a. Tape speed accuracy: Tape speed deviation to be less than ±0.5% from nominal at all transport speeds, and as needed to meet dynamic range specifications.

b. Tape stacking: The transport shall stack tape neatly and pack it tightly in any mode.

c. Start and stop times: At 0.3 ips shall be less than 3.0 seconds required to achieve stable tape motion, less than 1.5 seconds required to stop. Fast-mode speed in either direction 3 minutes for 2500 feet of tape. Stop time from the fast mode shall not exceed 5 seconds.

### 3.4 HEADS, RECORD, AND REPRODUCE

a. Interstack tolerances: Gaps within any pair of stacks to be separated by 1.500 ±0.0005 inches;

b. Interchannel tolerances:

1. Static gap scatter to be within 0.0001 inch in any head stack.
2. Dynamic time error to be no more than 2 milliseconds between tracks 1 and 14 and no more than 1 millisecond between any two adjacent tracks.
3. Static time accuracy between channels adequate to meet dynamic range specifications. Static time error not to exceed tolerances quoted above under dynamic time error.
4. Crosstalk between two channels to be not greater than -50 dB, except that FM carrier crossfeed into the voice channel shall not be more than 6 dB above the threshold of audibility when the reproduce amplifier is operated at maximum gain.

c. Track configuration to be per IRIG specifications.

d. Channel 14 is designated as the voice/WWV channel.

3.5 FM RECORD/REPRODUCE SYSTEM

a. Input level: 1 to 25 V rms for ±40% carrier deviation.

b. Input impedance: No less than 100,000 ohms (balanced).

c Output level: No less than 1 V rms nominal across a 10,000-ohm load impedance at normal recording level. With level adjustment to cover at least a 42-dB range.

d. Output impedance: Not more than 27,000 ohms, unbalanced to ground. Load impedance smaller than 10,000 ohms may result in reduced signal level, but shall not result in increased distortion, nor exceed linearity specifications.

3.6 POWER

The system can be supplied with the following types of power:

a. 115 ±10 Vac, 60 ±5 cps, unregulated;
b. 115 ±2 Vac, 60 ±5 cps, regulated;
c. 115 ±15 Vac, 60 ±0.0003 cps, unregulated, 70 watts;
d. ±11 14 Vdc, unregulated.

## 4. GUARANTY AND INSPECTION

The manufacturer guarantees performance according to this specification for a period of 1 ye[illegible]om date of acceptance.

The manufacturer shall permit observation of testing of random completed units by a Geotech engineer at the manufacturer's plant at any unannounced time during execution of a contract.

APPENDIX 9 to TECHNICAL REPORT NO. 65-28

# SPECIFICATIONS
# FOR A SOLID-STATE FM DISCRIMINATOR
# AND RACK-MOUNTED HOUSING

# SPECIFICATIONS FOR A SOLID-STATE FM DISCRIMINATOR AND RACK-MOUNTED HOUSING

The unit described in these specifications is a rack-mounted package containing up to 14 solid-state FM discriminators and their power supplies.

## 1. ADMINISTRATIVE

1.1 An operation and maintenance manual shall be included with each device. Included in the manual will be operating instructions, maintenance instructions, principles of operation, a schematic diagram, and a parts list. The manual shall be of good commercial quality.

1.2 The device shall be warranted for a minimum of 90 days against faulty workmanship or materials.

1.3 Included with each unit shall be a quality control check list outlining tests performed on that individual unit and their results. It shall be verified by the manufacturer's quality control department.

## 2. PHYSICAL SPECIFICATIONS

2.1 The unit shall mount in a standard 483-mm (19-inch) relay rack with a panel height of 178 mm (7 inches). It shall not be in excess of 430 mm (17 inches) deep, exclusive of mating connectors, which will add no more than 63 mm (2-1/2 inches) to the overall depth. Handles will be supplied with the unit.

2.2 Weight shall not exceed 23 kg (50 lbs).

2.3 The front panel shall be painted per Geotech Specifications 1468-9. Note that all metallic surfaces shall be treated to prevent corrosion.

2.4 The face of the front panel shall carry, in letters or figures, the following engraved identification:

a. Functional name of the assembly 4.76 mm (3/16 inch) high and white filled;

b. Model number assigned by the manufacturer 4.76 mm (3/16 inch) high and white filled;

c. All controls, switches, meters, and other indicators on the panel will be identified with letters or figures 3.18 mm (1/8 inch) high and white filled.

2.5 All fuses shall be accessible from the front of the unit and shall be mounted in indicating-type fuse holders.

2.6 Mating connectors shall be supplied by the manufacturer. A separate connector shall be used for each discriminator input and each output. All connectors shall be of the MS3100 series.

2.7 The housing shall be designed to afford ready access to all circuit components for maintenance or adjustment purposes. The accessibility could be provided by a rotating, slide-mounted chassis. Monitor jacks will be available on each discriminator or the front panel, so that each discriminator input and output may be monitored.

## 3. ENVIRONMENTAL SPECIFICATIONS

The unit shall meet all specifications of DSE-4 for sheltered equipment.

## 4. PRINTED CIRCUIT BOARD SPECIFICATIONS

All printed circuit boards used in this unit shall meet the requirements of DSE-3.

## 5. OPERATING CHARACTERISTICS

### 5.1 Individual discriminator

5.1.1 Input

| | |
|---|---|
| Type | Single-ended (shall be capable of double-ended operation) |
| Coupling | Ac; flat within ±2 dB from 500 cps to 2500 cps, 3 dB down (± 1 dB) at 250 cps and 5000 cps. 12 dB/oct cutoff rate at frequencies above 5000 cps and below 250 cps |
| Impedance | 600 ohms |
| Level | 0.1 to 10 V p-p |
| 5.1.2 Center frequency | 1550 ±25 cps |
| 5.1.3 Deviation range | ±45% |
| 5.1.4 Sensitivity | 0.1 V/1% deviation. A trim control with a 30% range shall be provided |
| 5.1.5 Linearity | Deviation from the best straight line (by the least-squares method) does not exceed 1% of full scale over the full bandwidth |

| | |
|---|---|
| 5.1.6 Dynamic range | 80 dB, as determined by the ratio of full scale output in volts, peak-to-peak, (±45% deviation on the input) to output noise in volts, peak-to-peak, with center frequency on the input. (Zero deviation). |
| 5.1.7 Frequency response | Flat within ±0.25 dB from 0.05 cps to 5.0 cps, 3 dB down (± 1 dB) at 0.01 cps and 10 cps. Low-frequency cutoff rate of 6 dB/oct and high-frequency cutoff rate of 12 dB/oct |
| 5.1.8 Phase response | To be specified by manufacturer |
| 5.1.9 Crosstalk | See paragraph 5.2.3 |
| 5.1.10 Output | |
| Type | Double-ended (shall be capable of single-ended operation |
| Impedance | 500 ohms maximum |
| Capability | ±5 V, open circuit to 8.2 [illegible] load |
| Drift (zero and sensitivity) | Less than ±0.01%, of full scale output, per 1°C of temperature change and less than ±0.1% per week at any constant temperature |
| Carrier loss protection | The input to the output filter will clamp to 0 Vdc within 3 msec after loss of input signal |
| 5.1.11 Regulated supply voltage | +9 Vdc, common, and -9 Vdc with a maximum power level of 1 watt. Voltage regulation to be specified by manufacturer and to be compatible with section 5.2 |

## 5.2 Discriminator Housing and Power Supplies

5.2.1 Will house up to 14 of the FM discriminators described in paragraph 5.1 and provide regulated power for each unit.

5.2.2 Power inputs

| | |
|---|---|
| Voltage | +11 to +14.5 Vdc and -11 to -14.5 Vdc with grounded center tap |
| Ripple | Up to 0.5 volts peak-to-peak on each leg |
| Maximum power | 20 watts with 14 discriminators at ± 14 Vdc input level |
| Regulation | The power supply for the discriminators shall be sufficiently regulated so that any change of input voltage within the specified range shall change the output less than 0.01% of full scale output |

5.2.3 Crosstalk — Crosstalk between any two channels will be down by at least 100 dB with an input signal level of 10 V p-p at frequencies from 500 cps to 2500 cps

## 5.3 Reliability

The unit shall be designed such that any mode of failure in one of the discriminators shall not affect the operation of the balance of the discriminators. Further, the internal power system shall be designed so that a failure of any one section of the internal power system will shut down only one-half of the discriminators.

APPENDIX 10 to TECHNICAL REPORT NO. 65-28

# SPECIFICATIONS
# for
# PTA POWER SUPPLIES

# Let's look closely at LAMBDA's new LH line of All Silicon

# ¼ and ½ RACK POWER SUPPLIES

## Features of low-cost MODULAR-SUBRACK models

TEMPERATURE COEFFICIENT .015%/°C

LH SERIES
¼ AND ½ RACK MODELS
TO SERVE ALL YOUR NEEDS

REMOTELY
PROGRAMMABLE AND
CONTINUOUSLY VARIABLE

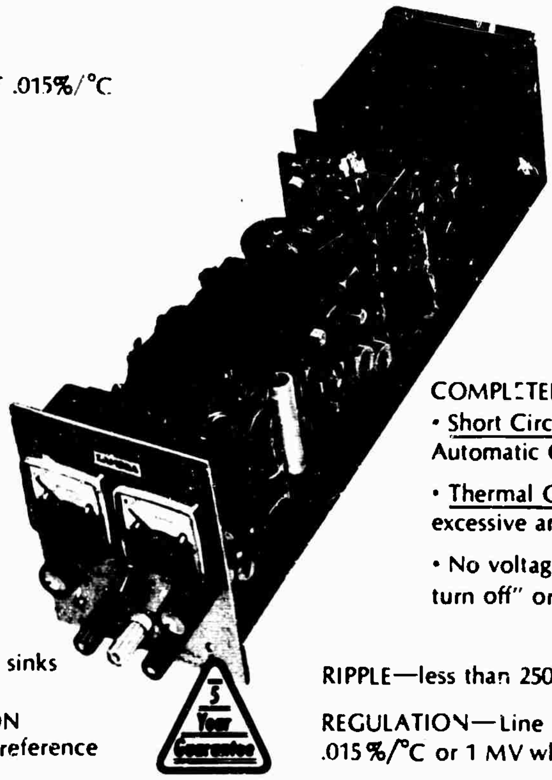
PERFORMANCE-
GUARANTEED FOR 5 YEARS

MEETS RFI SPECIFICATIONS-
MIL-I-26600, Class 3

WIDE VOLTAGE
AND FREQUENCY RANGE—
105-135 VAC, 45-480 cps

CONVECTION-COOLED—
no blowers, no external heat sinks

SERIES/PARALLEL OPERATION
and ± output to a common reference




COMPLETELY PROTECTED
- Short Circuit Proof—Continuously Adjustable Automatic Current Limiting
- Thermal Overload Protection against excessive ambient temperatures
- No voltage spikes due to "turn on, turn off" or power failure.

RIPPLE—less than 250 microvolts rms and 1 millivolt P-P

REGULATION—Line or Load—
.015%/°C or 1 MV whichever is greater

### CONDENSED TENTATIVE DATA

**DC OUTPUT—VOLTAGE REGULATED FOR LINE AND LOAD**

| MODEL | VOLTAGE RANGE | CURRENT RANGE AT AMBIENT OF:(1) 30°C | 50°C | 60°C | 71°C | SIZE H W D | PRICES (EFFECTIVE MAY 1 1964) CHASSIS (2) MOUNTING | NON-METERED | METERED (3) |
|---|---|---|---|---|---|---|---|---|---|
| LH 121 | 0-20V | 0-2.4A | 0-2.2A | 0-1.8A | 0-1.5A | 5-5/16" x 4-3/16" x 15-5/16" | $154 | $159 | $184 |
| LH 122 | 0-20V | 0-5.7A | 0-4.7A | 0-4.0A | 0-3.3A | 5-5/16" x 8-1/2" x 15-7/16" | $255 | $260 | $285 |
| LH 124 | 0-40V | 0-1.3A | 0-1.1A | 0-0.9A | 0-0.7A | 5-5/16" x 4-3/16" x 15-5/16" | $149 | $154 | $179 |
| LH 125 | 0-40V | 0-3.0A | 0-2.7A | 0-2.3A | 0-1.9A | 5-5/16" x 8-1/2" x 15-7/16" | $264 | $269 | $294 |

(1) Current rating applies over entire voltage range

(2) Non-metered models with flush panel (add suffix S to model number)
LH 121-S and 124-S: 4-5/16" × 3-13/16" × 15-5/16"
LH 122-S and 125 S: 4-5/16" × 8" × 15-7/16"

(3) Metered models with front panel controls (add suffix FM to model number)