MINNOVA INC.

GEOPHYSICAL REPORT ON AN
BOREHOLE PULSE EM SURVEY

MT. SICKER PROPERTY, HOLES MTS-41, MTS-60, MTS-61, MTS-62, MTS-63, MTS-64, MTS-65 MTS-68 and MTS-70

LATITUDE: 48°52'N LONGITUDE: 123°47'W
NTS: 92B/11E

AUTHOR: DENNIS V. WOODS, Ph.D., P.Eng.
Geophysicist

DATE OF WORK: 12-20 December 1988
DATE OF REPORT: 6 March 1989

827160

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ILLUSTRATIONS

INTRODUCTION:

On 12-20 December 1988, a borehole Pulse EM survey was carried out on **Minnova Inc.** boreholes **MTS-41, MTS-60, MTS-61, MTS-62, MTS-63, MTS-64, MTS-65, MTS-68** and **MTS-70** on the **Mt. Sicker** property, Vancouver Island.

The purpose of the survey was to explore for possible zones of conductive sulphide mineralization in the vicinity of the drillholes, not necessarily intersected by the holes.

PROPERTY LOCATION AND ACCESS:

The **Mt. Sicker** property is located about 10 km northeast of Duncan, B.C. on Vancouver Island. Access is via logging roads off the Lake Cowichan highway 1.5 km east of the Trans Canada highway.

BOREHOLE PULSE EM TECHNIQUE:

The Crone borehole pulse EM system is a time domain downhole EM instrument capable of detecting conductive mineralization intersected by the drillhole or lying offhole. The borehole pulse EM system utilizes a special downhole receiver coil, 600 m cable and winch in conjunction with a standard PEM transmitter and receiver normally employed in surface surveys.

The primary field is produced by a 150 m by 150 m square surface loop driven by the 500 watt PEM transmitter. Large loop surveys (e.g. 500 m by 1000 m) using the 2000 watt transmitter, and small loop surveys using the 10 m diameter portable equipment, can be carried out depending on the depth and size of the expected conductive target.

The time derivative of the secondary EM field is measured using an axial receiver coil lowered down the diamond drillhole. The minimum size of drillhole which can be accommodated is AQ (1 3/4" diameter). The receiver obtains eight samples of the secondary field during the primary field off-time. Sample times range from 0.15 to 6.4 ms after primary field shut-off on a 10.8 ms transmitter time base.

Multiple transmitter loops may be used to provide various loop to conductor coupling geometries in order to obtain conductor attitude and position information. A complete survey of a given borehole may entail logging the hole from five transmitter loop setups. One of these loops would be approximately centred over the area of interest with the remaining four loops away from and distributed around the borehole.

When an anomalous response is observed in a borehole log from a single transmitter loop, the nature of this anomaly allows the determination of the location of the conductive source relative to the drillhole. As shown by Woods and Crone (1980, Figs. 7 & 8), the response can indicate whether the borehole is intersecting the centre of the conductor, the margin of a conductor, with the bulk of conductive material away from the hole, or whether the conductor is entirely off-hole.

Model study curves for various conductor to borehole geometries from Woods (1975) are employed in the interpretation. Quantitative analysis of the conductor's attitude, position and conductance is made using nomograms presented by Woods, et al. (1980). Computer plate modelling, using the routines developed by Dyck, et al (1980), can be used to confirm the interpretation.

In the case of a dike-like or tabular conductor, the magnitude of an anomaly varies with the angle that the primary field cuts the conductor. Thus, the degree to which coupling is obtained to the conductor, in coverage of a borehole from several loop setups, will provide information on the attitude and position of the conductive mineralization.

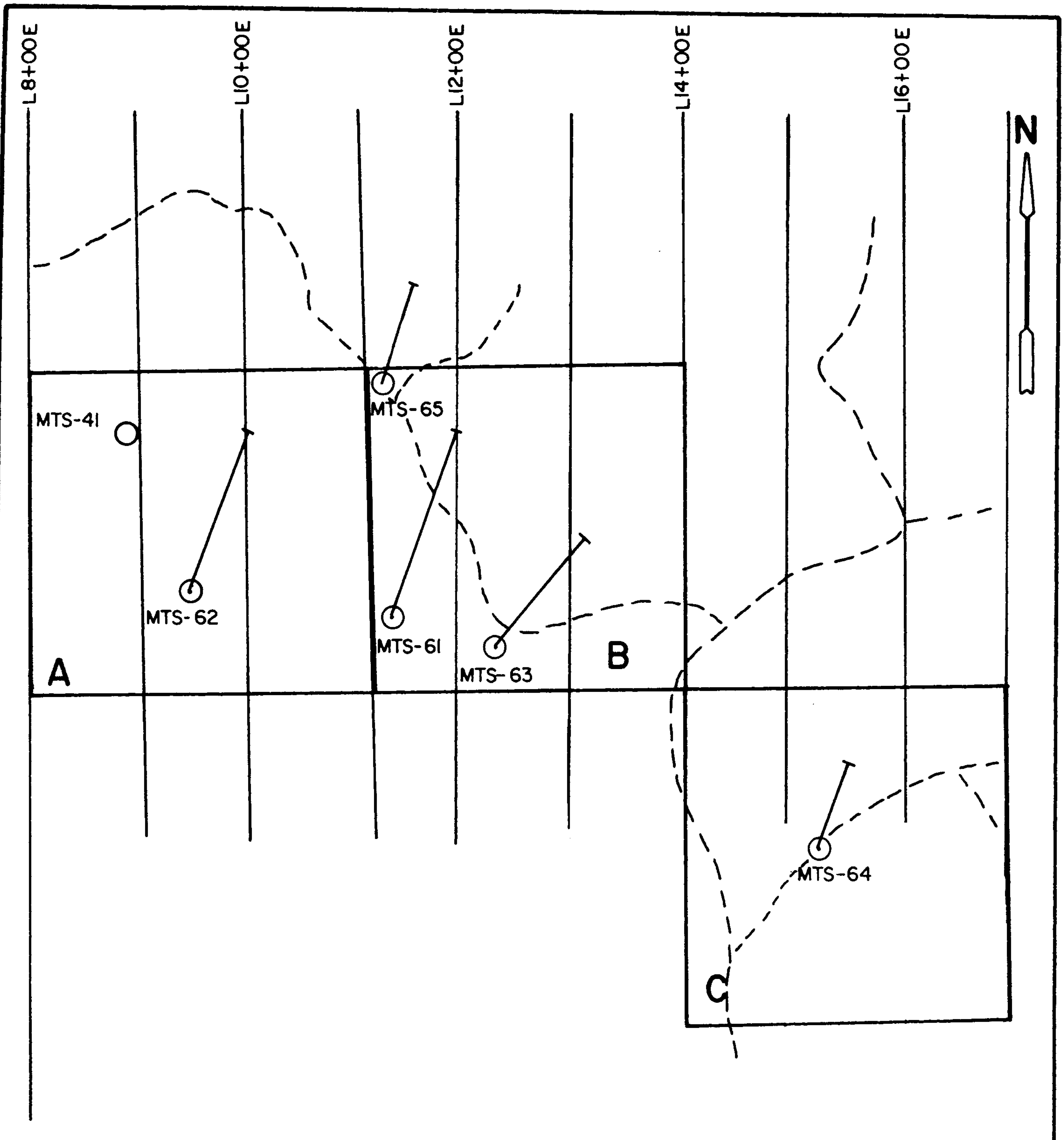
If the conductor tends towards a more spheroidal shape, the anomaly character will change, as well as its magnitude, when the primary field angle is altered. This occurs because the eddy currents are not constrained to flow within a conductive sheet. Thus, multiple transmitter loop coverage can also provide information on the shape of a conductive body.

In practice the responses observed in field situations are much more complex than those of simple models, but the results are sufficiently interpretable that the method has general acceptance and a number of discovery case histories exist.

SURVEY PROCEDURE:

Holes **MTS-42, MTS-60, MTS-61, MTS-62, MTS-63, MTS-64, MTS-65, MTS-68** and **MTS-70** were surveyed on 12-20 December 1988 using the Crone 2000 watt PEM 8-channel transient EM system. Five different transmitter loops were laid out around the holes as shown in Figure 1. Loops A to D were approximately 300 by 300 metres and loop E was 100 by 300 metres. These loop sizes and positions give maximum EM coupling for the geologic structure in the vicinity of the drillholes. Primary and secondary field readings were taken every 10 m down the holes with the instrument set at a constant maximum gain of 100%. The use of the higher powered transmitter and 300 m x 300 m transmitter loops increases the ability to detect weakly conductive zones and decreases the noise level on the later channels.

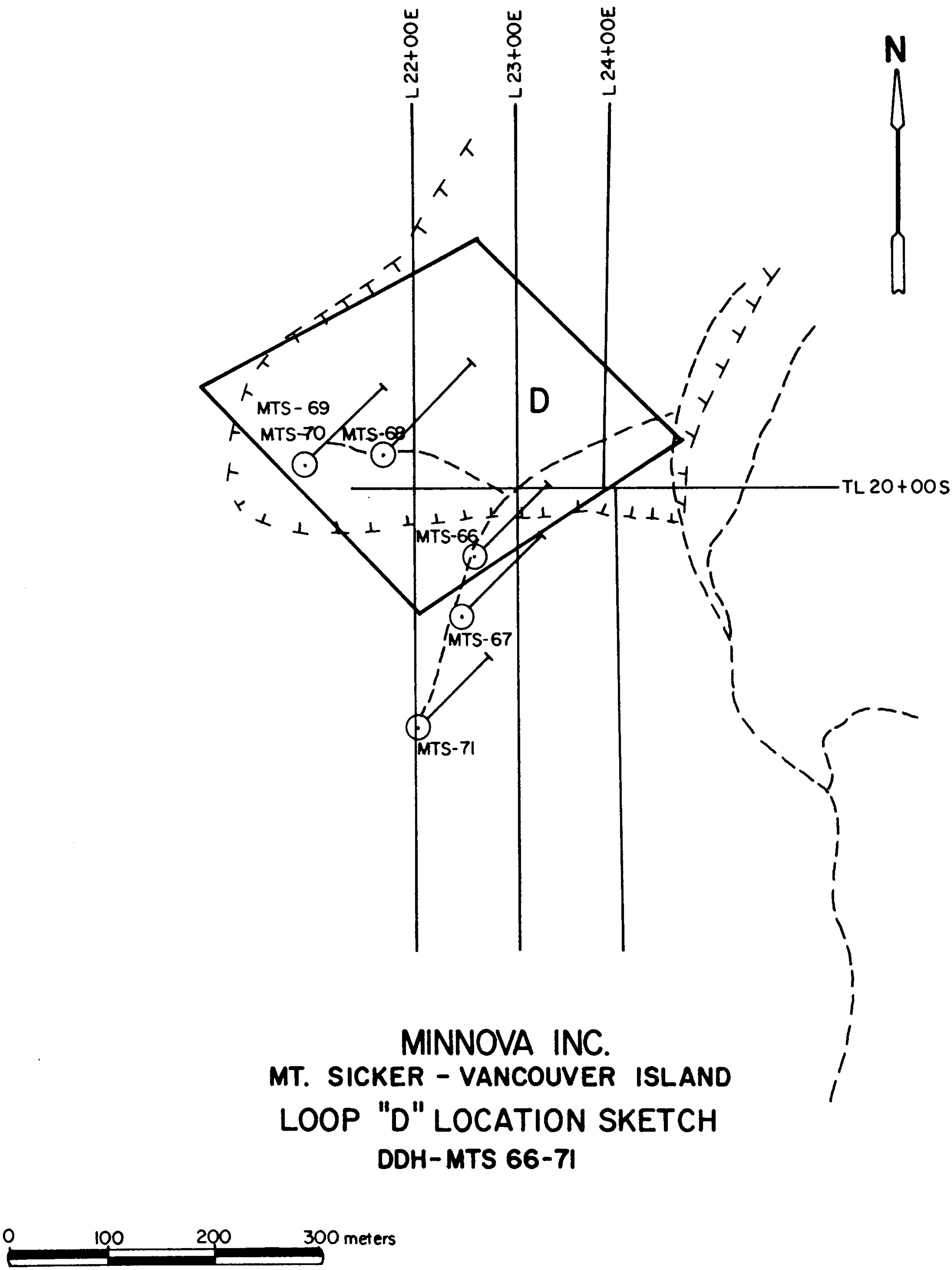
The boreholes were initially dummy probed to insure an open passage for the PEM receiver probe. During these tests it was discovered that **MTS-66, MTS-67, MTS-69** and **MTS-71** were blocked near the top of the hole and hence were not surveyed using the PEM receiver. In addition, **MTS-63** was found to be blocked at 235 m depth, however, since this was below the depth of interest, this hole was surveyed.



MINNOVA INC.
MT. SICKER - VANCOUVER ISLAND
LOOPS "A,B & C" LOCATION SKETCH
DDH-MTS 41 & 61-65

0 100 200 300 meters

FIG. 1A


L 22+00E
L 23+00E
L 24+00E
N
D
MTS - 69
MTS-70
MTS-68
TL 20+00S
MTS-66
MTS-67
MTS-71
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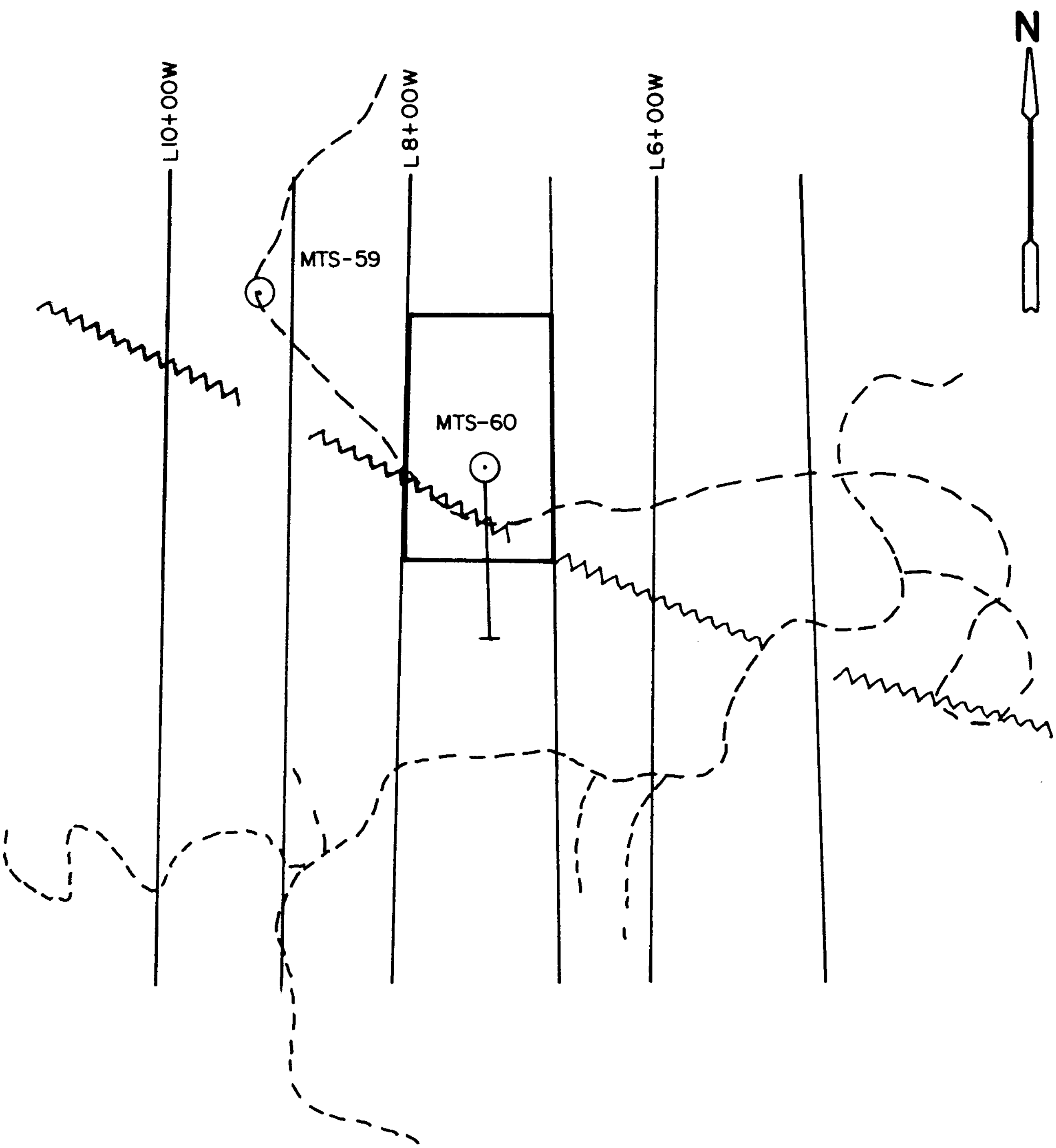
MT. SICKER - VANCOUVER ISLAND
LOOP "D" LOCATION SKETCH
DDH-MTS 66-71
0
100
200
300 meters

FIG. 1B



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MT. SICKER - VANCOUVER ISLAND

LOOP "E" LOCATION SKETCH

DDH - MTS 60

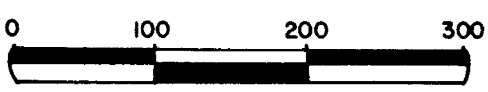


FIG. 1C

DISCUSSION OF RESULTS:

No significant anomalous responses are noted in the borehole PEM profiles shown in Figures 2 to 11. The secondary field profiles display only the typical background response from primary field induction in the host rocks of the area. This background response tends to parallel the primary field, as for example near the top of **MTS-65** (Figures 4 and 5).

The only feature of note in the borehole profiles is a low, broad amplitude increase near the bottom of **MTS-65.** This is probably due to a general increase of the host rock conductivity toward the bottom of the hole - possibly due to a sedimentary unit. Small, single-station anomalies, particularly in the later channels, (e.g. at 100 m depth in **MTS-65** - loop B), are probably related to sferic noise.

CONCLUSIONS AND RECOMMENDATIONS:

Although sulphides were reportedly encountered in some of these boreholes, there is no indication of any conductive mineralization in the immediate vicinity (i.e. within 50 to 100 m) of boreholes **MTS-41, MTS-60, MTS-61, MTS-62, MTS-63, MTS-64, MTS-65, MTS-68** and **MTS-70.**

Massive sulphide occurrences are known to be quite localized in the Sicker Group volcanics and hence difficult EM targets to locate. In addition, the sulphide mineralization may not form conductive targets detectable by EM methods (e.g. Coronation zone). Previous borehole PEM surveys on the **Mt. Sicker** property (Woods 1987, 1988a and 1988b) have failed to detect any significant conductive mineralization. The only recognizable anomalous responses are due to sedimentary units. Hence, the cost effectiveness of the borehole PEM method should be critically re-assessed before doing further surveys. Other methods, such as downhole IP, may provide more useful information in spite of the much smaller search radius of this technique.

Respectfully submitted,

Dennis V. Woods, Ph.D., P.Eng.
Geophysicist

REFERENCES:

Woods, D.V., 1975: A model study of the Crone Borehole pulse electromagnetic (PEM) system; unpublished M.Sc. thesis, Queen's University, Kingston, Ontario.

Woods, D.V. and Crone, J.D. 1980: Scale model study of a borehole pulse electromagnetic system; C.I.M. Bulletin, vol.73, no. 817, pp.96-104.

Woods, D.V., Rainsford, D.R.B. and Fitzpatrick M.N. 1980: Analogue modelling and quantitative interpretation of borehole PEM measurements (abstract only); EOS Transactions of the American Geophysical Union, vol. 61, no. 17, pp. 414-415.

Woods, D.V., 1987: Geophysical Report on a Borehole Pulse EM Survey Mt. Sicker Property Hole MTS-34 for Minnova Inc., White Geophysical Inc.

Woods, D.V., 1988a: Geophysical Report on a Borehole Pulse EM Survey Mt. Sicker Property Holes MTS-45, MTS-46, MTS-47 and MTS- 48 for Minnova Inc., White Geophysical Inc.

Woods, D.V., 1988b: Geophysical Report on a Borehole Pulse EM Survey, Mt. Sicker Property, Holes MTS-53, MTS-54, MTS-55 and MTS-57, for Minnova Inc., White Geophysical Inc.

SPECIFICATIONS – CRONE BOREHOLE PULSE EM EQUIPMENT

PROBE:
- Measures dB/dt of axial-component of borehole
- Ferrite cored antenna with preamplifier and self contained power supply (Ni.-Cd. rechargeable)
- 30 hours continuous operation
- Weight: 3.6 Kg.
- Length: 1.63 M.
- Diameter: 2.9 cm (for "E" holes and larger)
- Pressure tested to 13.8 MPa (2000 PSI)

WINCH ASSEMBLY:
- 3 speed gear box, gear ratios 1:1, 2:1, 3:1
- Optional power winching for deep holes
- Borehole cable capacity of up to 2000 meters
- Portable

UNDERGROUND PUSHROD SYSTEM:
- For use in horizontal boreholes (‹ 45 degrees)
- Powered Pushrod assembly for holes › 500 meters

BATTERY SUPPLY:
±12 VDC, two internal, rechargeable, 12V gel type batteries

MEASURED QUANTITIES:
Primary shut-off voltage pulse (PP). Time derivative of the transient magnetic field by integrative sampling over eight, contiguous time gates (microseconds).

CH. NO.	WINDOW	WIDTH	MID PT.	REL. GAIN	WINDOW	WIDTH	MID PT.
PP	-100 to 0	100	-50	1.00	-200 to 0	200	-100
1	100 to 200	100	150	1.00	200 to 400	200	300
2	200 to 400	200	300	1.39	400 to 800	400	600
3	400 to 700	300	550	1.93	800 to 1400	600	1100
4	700 to 1100	400	900	2.68	1400 to 2200	800	1800
5	1100 to 1800	700	1450	3.73	2200 to 3600	1400	2900
6	1800 to 3000	1200	2400	5.18	3600 to 6000	2400	4800
7	3000 to 5000	2000	4000	7.20	6000 to 10K	4000	8000
8	5000 to 7800	2800	6400	10.00	10K to 15.6K	5600	12.8K
	10.8ms. Time Base				21.6ms. Time Base		

READOUT:
Readings are output on an analog meter (6V FSD), over three sensitivity ranges (X1, X10, X100). Data retrieval made by channel select switch.

TIMING:
A telemetry link ("sync.") is maintained by radio signal, or a back-up cable, between the transmitter and the receiver, and is meter monitored.

SENSITIVITY:
Adjustable through a ten turn, calibrated gain pot.

SAMPLING MODES:
"S & H" (Sample & Hold)
The receiver averages 512 (10.8 ms), or 256 (21.6ms), readings for all channels, and stores the results for display.
"CONT" (Continuous)
A running average for all channels is stored, enabling the operator to reject thunderstorm spikes and power line noise by visual inspection.

SPECIFICATIONS – PULSE EM TRANSMITTER EQUIPMENT

MOTOR GENERATOR:

4-1/2 H.P. Wisconsin, 4 cycle engine with belt drive to D.C. alternator; maximum output 120V, 30 amps; external gas tank; frame unit weight: 33 kg, shipping: 47 kg.

REGULATOR:

Controls and filters the alternator output; continuously variable between 24V and 120V D.C.; 20 amp maximum current; weight: 10 kg, shipping: 24 kg.

PEM WAVEFORM TRANSMITTER:

Controls bipolar, on-off waveform and linear current shut-off ramp time. Radio and cable time synchronization with housing for optional crystal clock sync system; on-off times for 60 Hz areas 8.33ms, 16.66ms, 33.33ms; for 50 Hz areas 10.0ms, 20.0ms, 40ms; for analog PEM operation 10.9ms, 21.8ms; linear controlled current shut-off ramp times of 0.5, 1.0 and 1.5ms; monitors for shut-off ramp operation, instrument temperature, Tx loop continuity, and overload output current; automatic shut-down for open Tx loop. Weight: 12.5 kg, shipping: 22 kg.

REMOTE RADIO, ANTENNA AND MAST:

Used for radio timing synchronization on large survey grids; range up to 2 km; radio has 12V rechargeable gell cell battery supply; antenna is fiberglass mounted on a 4 section aluminum mast each 2m long. Radio weight: 2.7 kg, shipping: 6.0 kg; mast and antenna shipped as bundle: 6.4 kg.

OPTIONAL CRYSTAL CLOCK TIMING LINK:

Installed in the Digital Rx and external box mounted to be plugged into PEM-Tx. Gel rechargeable power supply. Weight: 10 kg, shipping: 15 kg.

WIRE, SPOOLS AND WINDERS:

Transmitter wire is usually No. 10 or No. 12 AWG copper in 310m or 410m lengths, 1 length per spool; 2 spools in a shipping box; winder is mounted on a magnesium packframe.

MULTI-TURN MOVING COIL:

7 turn, 13.7 meter diameter Tx loop with plugs to break into 2 sections. Aluminum or copper wire and various coverings depending on area being used.

BATTERY POWER SUPPLY:

24V, 20 amp hour; rechargeable battery supply for use with PEM-Tx as power source rather than motor-generator-regulator. In aluminum case, with clamp connectors. Weight: 20.5 kg, shipping: 29 kg.

- Battery chargers supplied for all rechargeable battery units
- All instruments and equipment operational from -40°C to +50°C.
- Shipping boxes are reusable plywood construction with closed cell foam shock protection.

STATEMENT OF QUALIFICATIONS

NAME: WOODS, Dennis V.

PROFESSION: Geophysicist

EDUCATION:

B.Sc. Applied Geology
Queens' University

M.Sc. Applied Geophysics
Queen's University

Ph.D. Geophysics
Australian National University

PROFESSIONAL ASSOCIATIONS:

Registered Professional Engineer
Province of British Columbia

Society of Exploration Geophysicists

Canadian Society of Exploration Geophysicists

Australian Society of Exploration Geophysicists

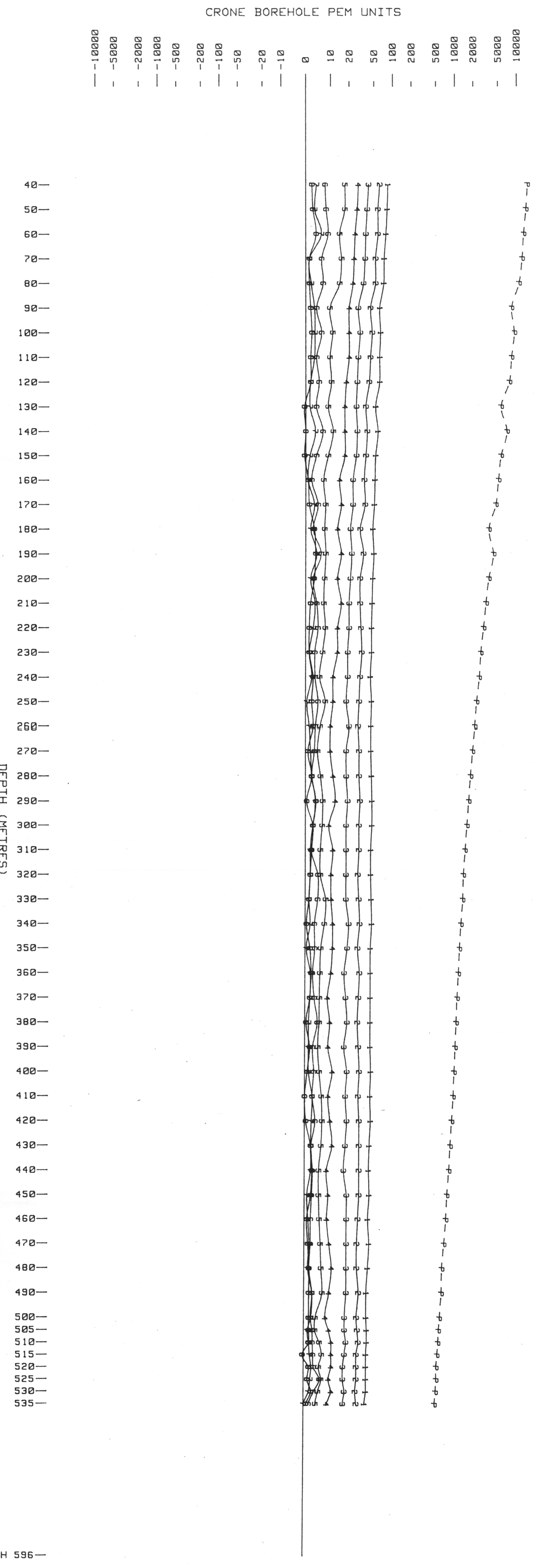
President, B.C. Geophysical Society

EXPERIENCE:

1971-79
- Field Geologist with St. Joe Mineral Corp. and Selco Mining Corp. (summers).
- Teaching assistant at Queen's University and the Australian National University.

1979-86
- Professor of Applied Geophysics at Queen s University.
- Geophysical consultant with Paterson Grant & Watson Ltd., M.P.H. Consulting Ltd., James Neilson and Assoc. Ltd., Foundex Geophysics Geophysics Ltd.
- Visiting research scientist at Geological survey of Canada and the University of Washington.

1986-88
- Project Geophysicist with Inverse Theory and Applications Inc.
- Chief Geophysicist with White Geophysical Inc.



INSTRUMENT: CRONE PEM

TIME BASE: 10 MSEC

CONSTANT GAIN 100%

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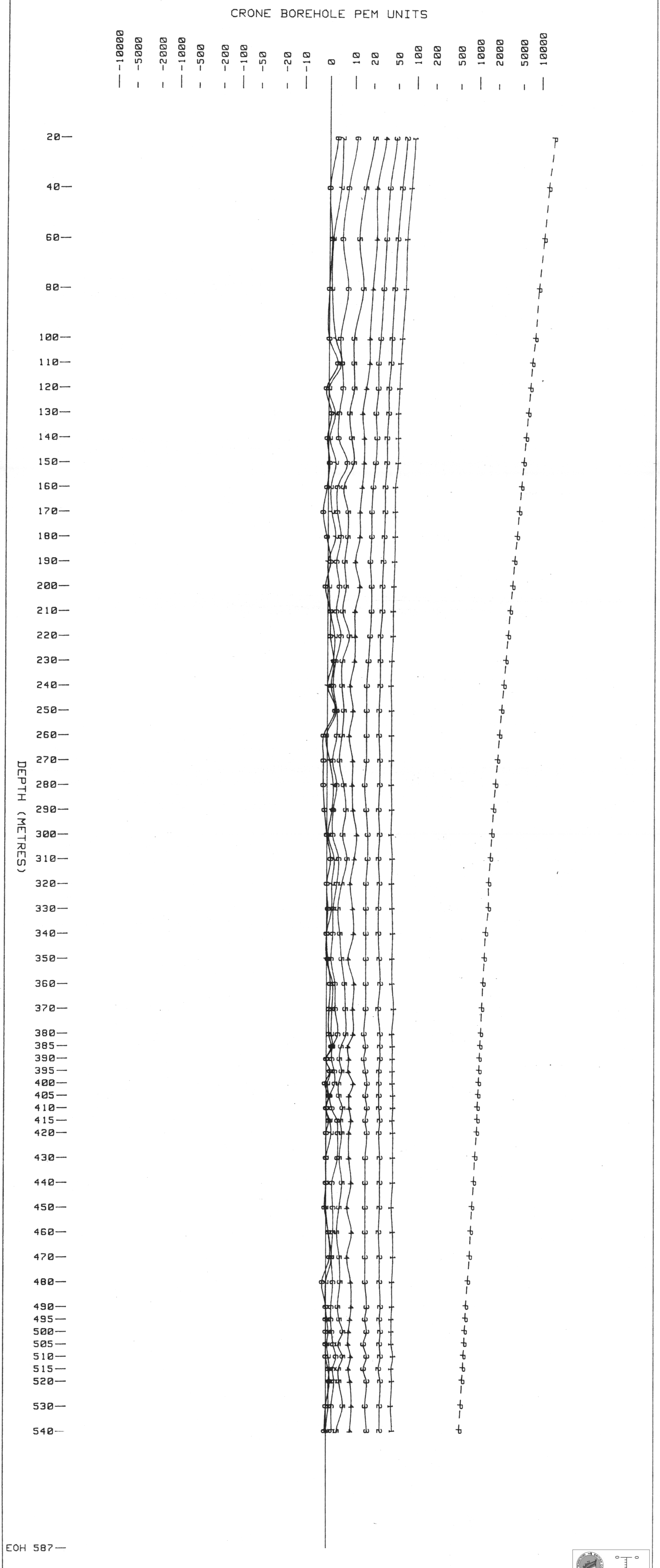
MT. SICKER PROJECT
BOREHOLE PULSE EM SURVEY
DDH MTS-41 LOOP A

DATE: DEC/88

FIG. 2



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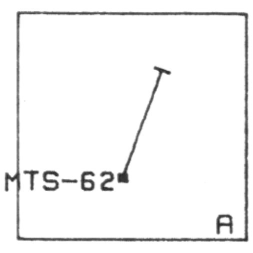
CONSTANT GAIN 100%



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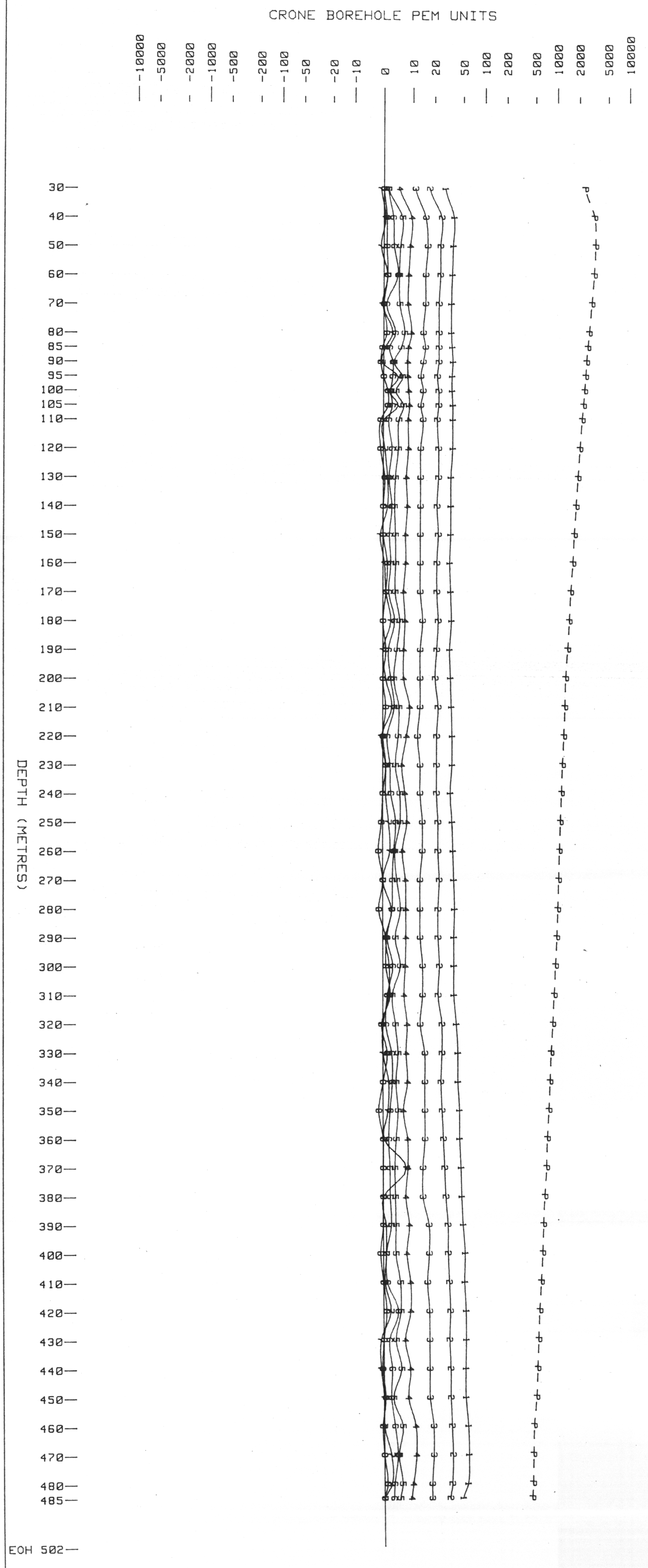
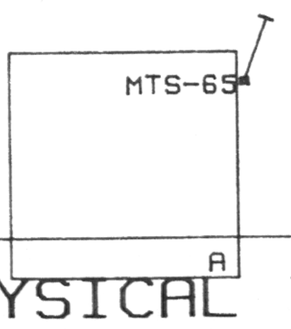
BOREHOLE PULSE EM SURVEY
DDH MTS-62 LOOP A

DATE: DEC/88

FIG. 3





INSTRUMENT: CRONE PEM

TIME BASE: 10 MSEC

CONSTANT GAIN 100%

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BOREHOLE PULSE EM SURVEY

DDH MTS-65 LOOP A

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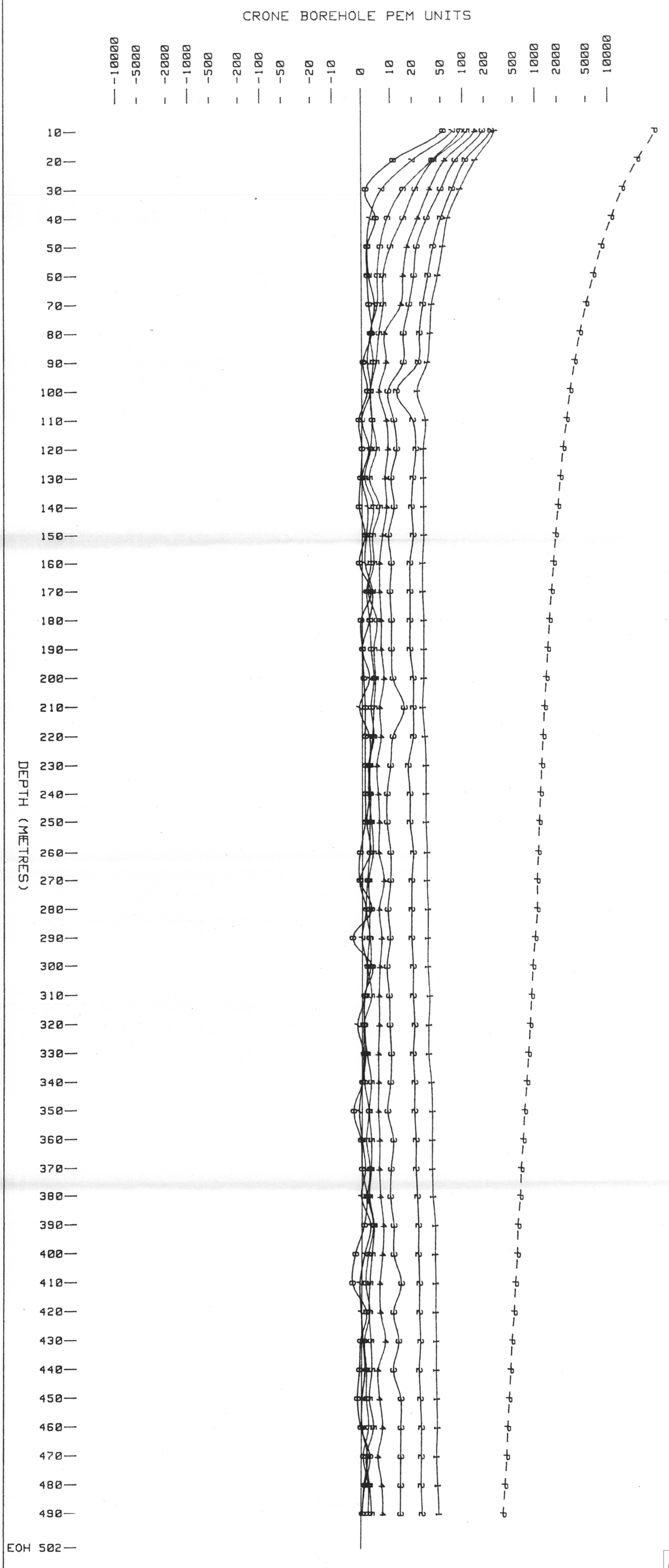
FIG. 4



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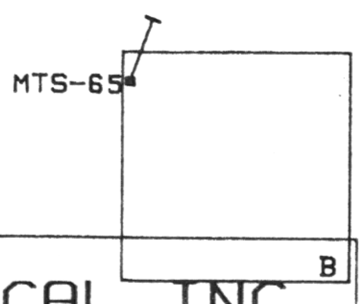
TIME BASE: 10 MSEC

CONSTANT GAIN 100%



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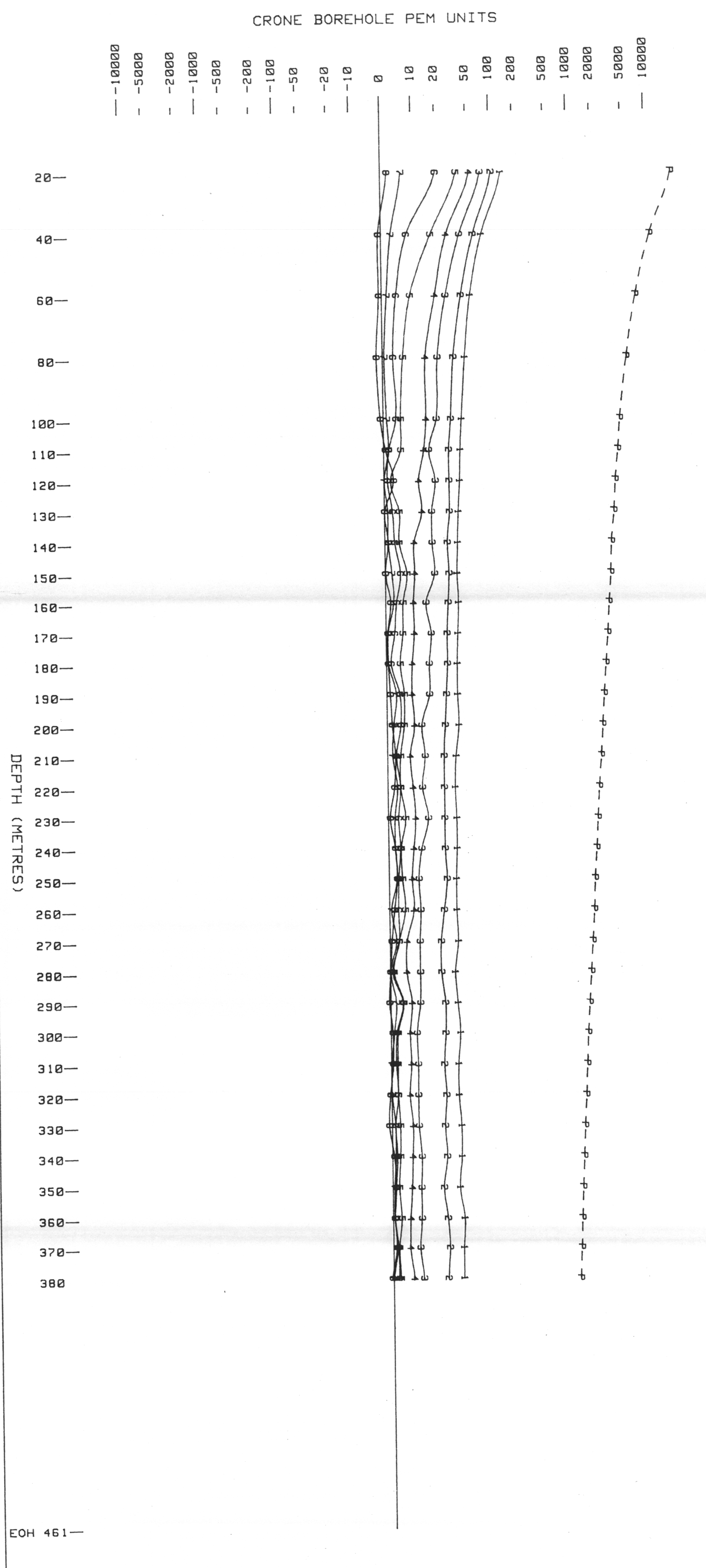
MT. SICKER PROJECT
BOREHOLE PULSE EM SURVEY
DDH MTS-65 LOOP B

DATE: DEC/88

FIG. 5



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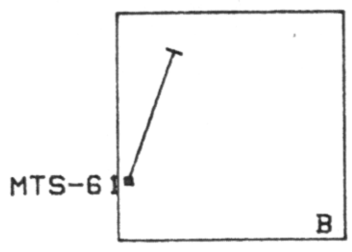

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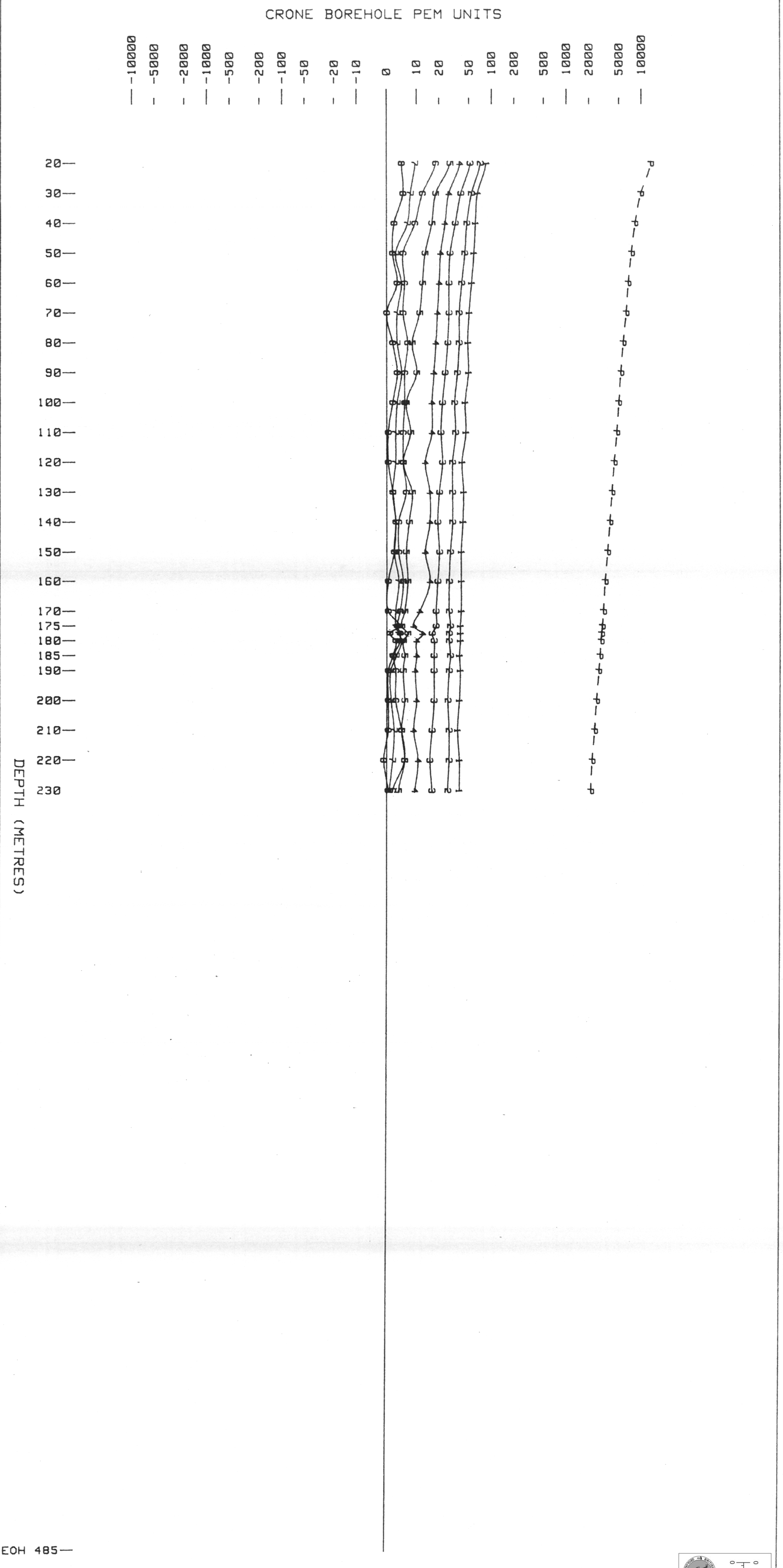
MT. SICKER PROJECT
BOREHOLE PULSE EM SURVEY
DDH MTS-61 LOOP B

DATE: DEC/88

FIG. 6



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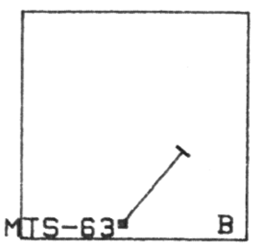

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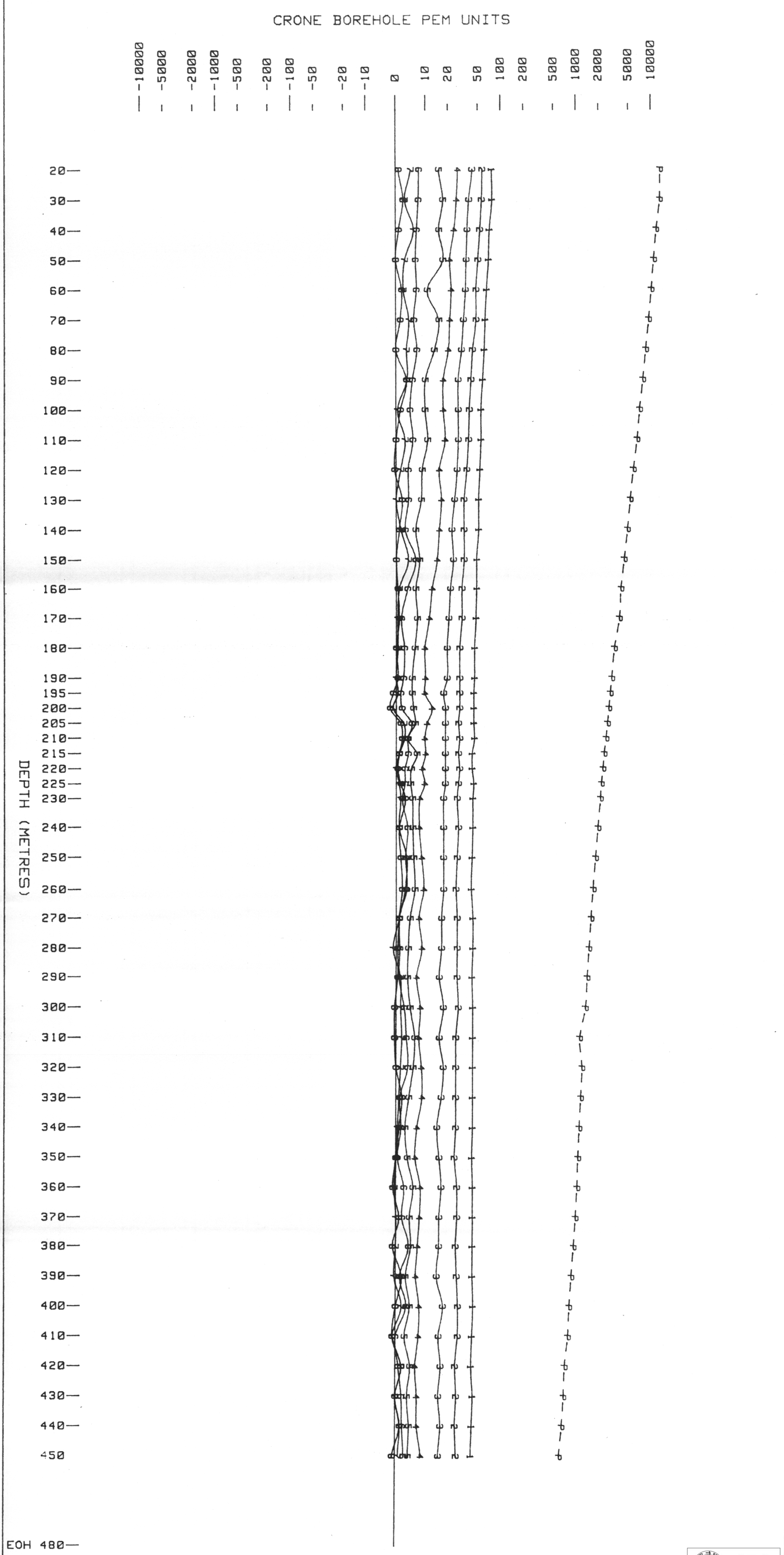
MT. SICKER PROJECT

BOREHOLE PULSE EM SURVEY

DDH MTS-63 LOOP B

DATE: DEC/88

FIG. 7



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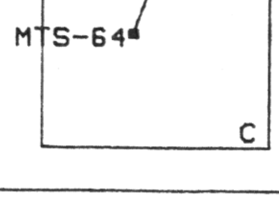
TIME BASE: 10 MSEC

CONSTANT GAIN 100%



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BOREHOLE PULSE EM SURVEY
DDH MTS-64 LOOP C

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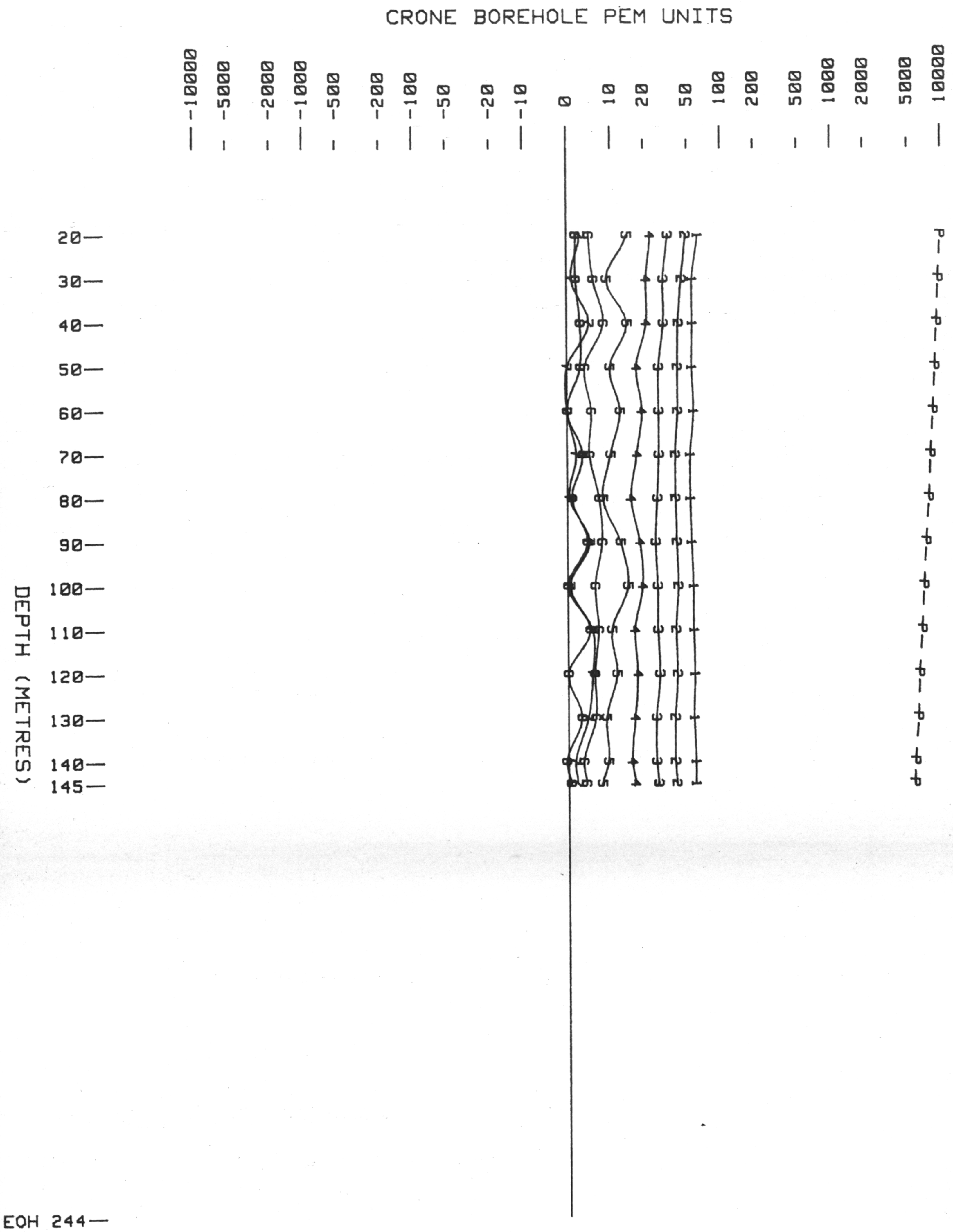
FIG. 8



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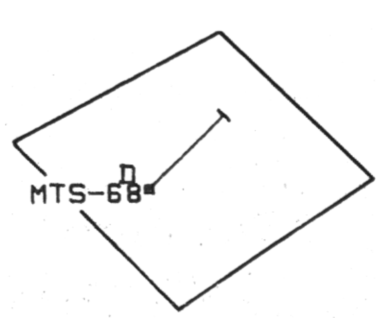
TIME BASE: 10 MSEC

CONSTANT GAIN 100%



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BOREHOLE PULSE EM SURVEY

DDH MTS-68 LOOP D

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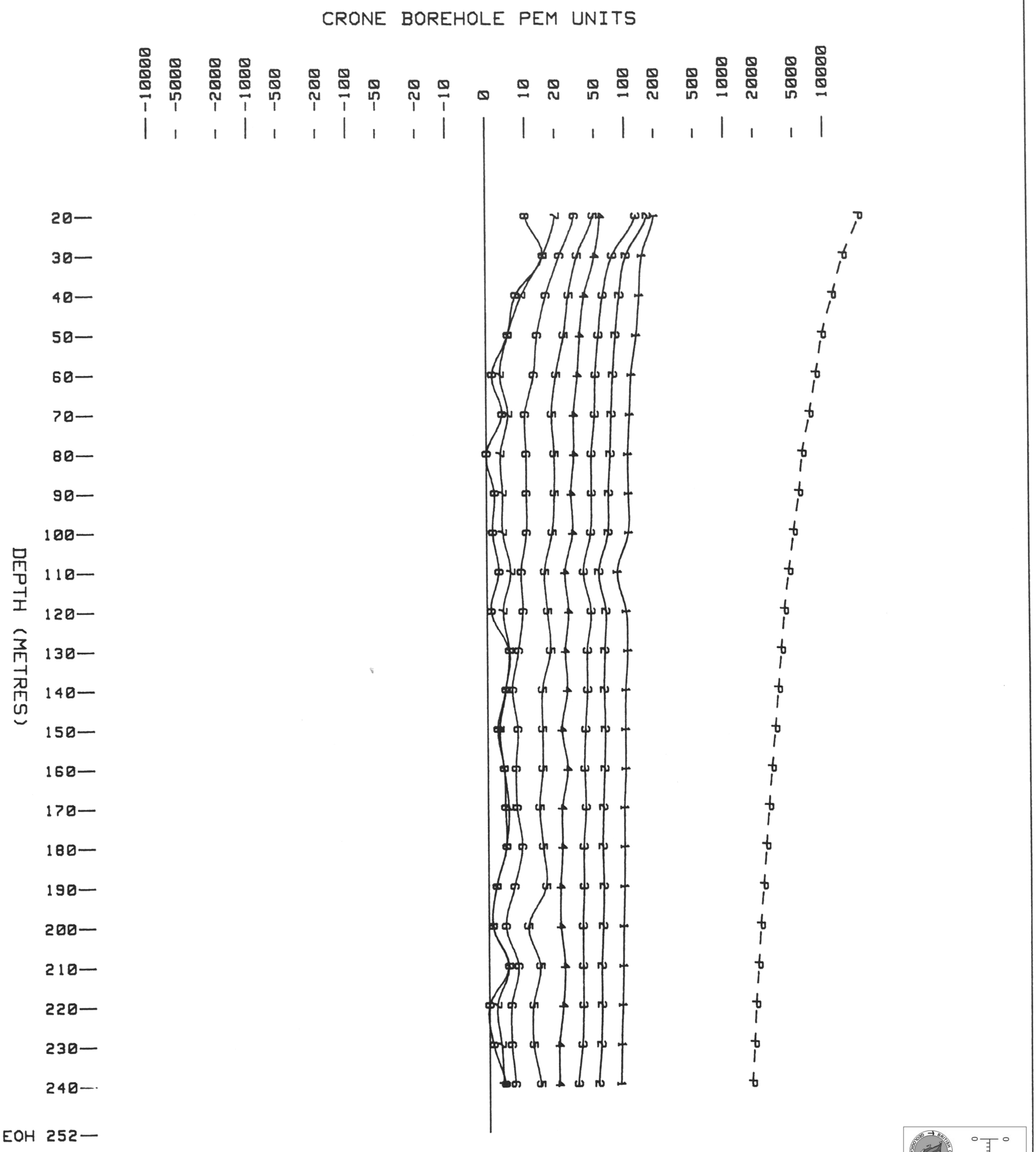
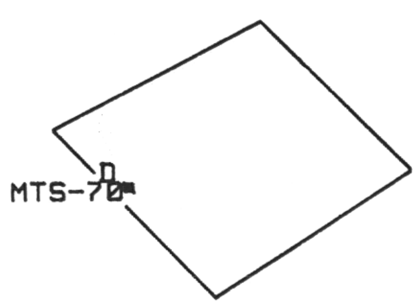
FIG. 9





INSTRUMENT: CRONE PEM

TIME BASE: 10 MSEC

CONSTANT GAIN 100%

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BOREHOLE PULSE EM SURVEY
DDH MTS-70 LOOP D

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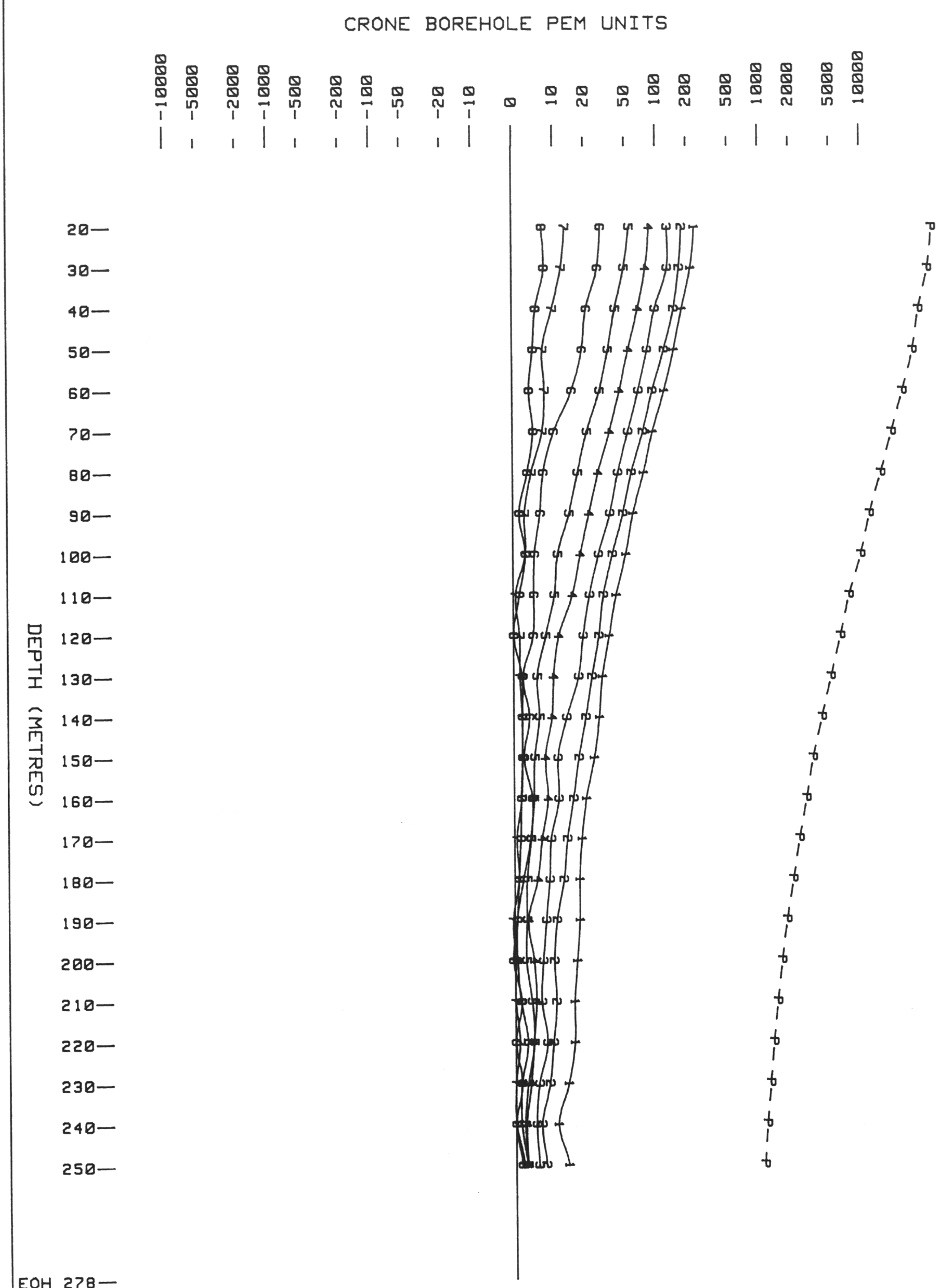
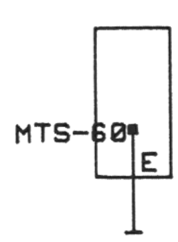
DATE: DEC/88

FIG. 10





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TIME BASE: 10 MSEC

CONSTANT GAIN 100%

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BOREHOLE PULSE EM SURVEY

DDH MTS-60 LOOP E

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FIG. 11

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