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MAWSON GEOPHYSICAL OBSERVATORY
ANNUAL REPORT 1969

by

J.A. Major

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SUMMARY

Geomagnetic and seismological observatories were maintained at Mawson Antarctica during 1969. The main instruments were La Cour normal and sensitive magnetographs and a Benioff seismograph.

Azimuths of the magnetic reference marks and of variometer orientation marks were redetermined by triangulation to the new PAGEOS satellite station. Continuous monitoring of total intensity was commenced in February using an Elsec proton precession system.

Electromagnetic calibrators were fitted to the Benioff seismometers, and complete system response curves were obtained.

Regional magnetic observations were made at Nicholls Island (Amery Ice Shelf area) in January 1969 and at Mount Wishart (Prince Charles Mountains) in February 1970.

1. INTRODUCTION

The Geophysical Observatory at Mawson, Antarctica, was opened in 1955 with the installation of a three-component normal-run La Cour magnetograph (Oldham, 1957). Since that time an insensitive three-component magnetograph and a three-component Benioff seismograph have been installed (Merrick, 1961). A bar fluxmeter which was installed in 1957 was closed down in 1967 (Pinn, 1961; Dent, 1971).

In September 1968 the insensitive magnetograph was converted to medium sensitivity and renamed the normal magnetograph. The magnetograph which had previously been the normal magnetograph was not modified but merely renamed the sensitive magnetograph (Smith, 1971).

Regional magnetic observations were made on 7 January 1969 at Nicholls Island and on 2 and 3 February 1970 at Mount Wishart. The elements measured were H, D, and Z. The results, together with others dating back to January 1968, will be reported separately. This Record describes the work done at Mawson by the author from January 1969 when he relieved R.S. Smith, to January 1970 when he was relieved by M.J.M. Robertson.

The activities comprises the Bureau of Mineral Resources' geophysical contribution to the Australian National Antarctic Research Expedition for which the Antarctic Division, Department of Supply, provided logistic support.

2. MAGNETIC OBSERVATORY

Two La Cour magnetographs were operated during the year; these were known as the normal and sensitive magnetographs. Each magnetograph comprised a D, H, and Z variometer with a La Cour recorder using a synchronous drive.

Scale values

On the average, scale values were determined seven times per month.

Two Askania scale-value coils were installed on the D variometers in February. However, the coil constants were suspect as the scale values obtained were about 4 percent smaller than those obtained previously using Helmholtz coils. A least-squares analysis of observed D versus corresponding D ordinate was carried out to give a direct result. The results of the D scale-value calculations are given in Table 1; H and Z scale values are included in Table 2.

A theoretical non-linearity or "a" factor for H scale-value was calculated for the normal H variometer using equation 172 of McComb (1952). With an optical lever of 1130 mm and an H value of 1.84×10^4 gammas, "a" was found to be 1.8×10^{-4} gammas/mm^2. A least-squares analysis of scale value versus ordinate gave a correlation coefficient of only 0.35, so for both H variometers the adopted scale value was the scale value at ordinate.

The scale value of the sensitive Z variometer changed from 10.5 to 10.2 gammas/mm after the magnet was ground in December to correct an orientation error.

Thermograph scale values and ordinate temperature coefficients

Sensitive H and Z, and normal H thermograph traces were recorded throughout the year. Prior to 26 October the normal Z temperature compensation strip was back to front. On 26 October this was reversed and a normal Z thermograph trace obtained for the first time. Table 2 gives thermograph scale values and ordinate temperature coefficients.

The sensitive Z thermograph was used for all temperature control (being the most sensitive) and it provided temperatures reliable to 0.2°C. On the normal magnetograms the corresponding errors were: H, 1.7 gammas; Z, 6 gammas (until the compensator was adjusted in October). Because of the latter result the sensitive magnetogram was used to derive all Z data.

After reversing the normal Z bimetal strip the temperature coefficient (Q_z) was about 8 gammas/°C and the compensator effect was about 7 gammas/°C. Thus the magnet coefficient was 15 gammas/°C and the strip length should be increased in the ratio 15/7. This change would reduce Q_z to about zero, and increase the thermograph sensitivity.

On the normal magnetogram, Q_H = 7.5 gammas/°C and the compensator effect was 3.5 gammas/°C, so the magnet effect was 11 gammas/°C and the strip length should be increased in the ratio 11/3.5 to give complete compensation.

These results were given to Mawson observatory in 1970 so that the appropriate adjustments could be made.

Magnetograph adjustments and baseline values

Values of the following baselines were obtained for calculation of hourly values: sensitive Z temperature baseline; sensitive Z baseline; normal H baseline; and normal D baseline. Table 3 gives baseline values and the times and causes of changes.

Orientation tests

Prior to making orientation tests, new marks were established in the variometer huts. The setting up of these marks is described in Appendix 1.

Helmholtz coils were used to provide the magnetic fields for testing the H and D variometers. The test fields for the Z variometers were obtained from a bar magnet. Deflections of the normal H variometer were used to determine the moment of this magnet, which was 5180 cgs units. This value was not critical for orientation tests.

The test fields, the recording distance R, the variometer scale values, and the resolving power of the applied fields are given in Table 4. It can be seen that the applied fields were capable of detecting an exorientation angle of 0.1°. This was well within the alignment accuracy of the coils and deflector magnet which was about ± 0.5°.

The results of the tests are given in Table 5.

Absolute instruments and intercomparisons

Absolute observations were conducted on an average of seven times per month.

Quartz horizontal force magnetometers 300, 301, and 302 were used for H measurements; Z was calculated from values of F obtained with Elsec proton magnetometer No. 340 and values of H scaled from the normal magnetograms. BMZ 62 was also used to measure Z; this provided the correction to BMZ 62 through the baseline values.

D observations were made with declinometer 332.

Total-intensity differences between the inside pier S and outside pier A were made on an average of twice per month.

QHM 302 was returned to Australia in March 1970, and was replaced by QHM 174.

A table of intercomparisons is given below.

Mawson Instrument	Comparison Instrument	Date
QHM 300	HTM 704, QHM 174	January 1970
DEC 332	DEC 333	" "
PPM 340	PPM 421	" "
BMZ 62	PPM 340 and H	Weekly during 1969

QHM differences during 1969, as determined from the baseline values, were:

QHM 300 - QHM 301 = -1.6 ± 3.1 gammas

QHM 300 - QHM 302 = -3.1 ± 3.1 gammas

<u>Continuous monitoring of F</u>

In February continuous recording of total intensity was commenced. The equipment was set up at the Ionospheric Physicist's hut as this provided a heated building supplied with power and remote from sources of artificial magnetic disturbance. The equipment comprised PPM 340, a magnetometer recorder type 618, and a Moseley 680 strip chert recorder. Twenty-four volt power was supplied by two 12-volt accumulators charged from a Boss battery charger. The sensing head was tripod mounted about 20 metres from the hut.

The recording was on 12.7 cm wide electrosensitive paper in 24.4-metre rolls. The paper speed was 5.1 cm per hour with a scale value of about 4.3 gammas/mm (500 gammas full chert deflection). This scale value was obtained by setting the 'range' switch of the recorder to 1000 and the magnetometer sensitivity switch S3U to D. Hour marks were provided by the programming unit of the ionosonde.

The purpose of recording was to provide a visual monitor of magnetic disturbance so that control observations could be made during quiet times. The recording accuracy was limited by the digital-to-analogue converter (the 618 magnetometer recorder). By comparing pen position on the chart with proton magnetometer readings it was observed that the D-A converter was not accurate. Although no comprehensive measurements were made the conversion error could have been as great as ±10 percent of full scale readings, i.e. ±50 gammas.

The main problem encountered in the continuous operation of the Elsec proton magnetometer was burning of the contacts of the mechanical relay unit. These burnt contacts introduced noise onto the 'reset line', and prevented the proton magnetometer from cycling. This noise was reduced and operation restored to normal by incorporating a low-pass filter into the external circuit of the electronic 'lock'.

Records were also lost from late November when a gear stripped in the chart drive. A new gear was ordered and recording resumed in January 1970.

3. SEISMIC OBSERVATORY

Equipment

The three-component Benioff seismograph was maintained in continuous operation throughout the year. The system comprised three one-second Benioff seismometers for detecting vertical, north-south, and east-west ground motion. The vertical seismometer was coupled to a 0.2-second galvanometer. Both horizontal seismometers were coupled to 14-second galvanometers. Wiring details are given in Plates 3 and 4.

A triple-drum Benioff recorder provided photographic recording of the seismic data. In April this recorder was serviced. The motor and feed screw were lubricated and the firction clutches adjusted.

The main source of record loss was a dry solder joint in the recorder lamp circuit, which resulted in fading of the east-west trace. This fault was not isolated and repaired until December.

The long mirror of the N-S channel had a crack 2.5 mm wide centred about 7 mm from the quiescent recording position of the trace. The mirror was not replaced because this defect resulted in very little record loss, and also because only one spare mirror was available. New mirrors were reordered.

About one day's vertical record was lost when a growth of ice crystals jammed the inertial mass of the vertical seismometer. On 17 September three 100-watt globes were installed in the seismometer room to prevent the formation of ice crystals.

Data

Preliminary data were cabled direct to the Melbourne office on Tuesdays, Thrusdays, Fridays, and Sundays for inclusion in the United States Coast & Geodetic Survey (USCGS) Preliminary Determination of Epicentres.

Final analysis of the seismograms was performed at Canberra and the data were sent to ISC, Edinburgh.

Eight hundred and fifty-four earthquakes were recorded, the monthly numbers being: January 54, February 28, March 24, April 56, May 77, June 84, July 86, August 124, September 81, October 119, November 82, December 39.

More earthquakes were recorded during the months when the sea ice had formed. During these months the magnifications of all the seismographs were increased. Table 6 gives the attenuator settings used throughout the year. This information in conjunction with the magnification curves enabled ground amplitudes to be determined from the seismograms.

The PKP phases from 14 nuclear explosions in Nevada were recorded at Mawson. Three of these exhibited multiple branch arrivals as the epicentral distance was about 150°. Table 7 gives the origin times and magnitudes determined by USCGS, and the arrival times at Mawson.

Calibrations and adjustments

In April a calibrator control unit was constructed and on 15 May electromagnetic calibrators were installed on the three seismometers. On 18 and 19 May the seismometer free periods were adjusted to 1.00 seconds and the transducer air gaps were equalized. After this, daily pulses of 5 mA were applied to the calibrators to produce test deflections on the records.

On 20 August weight lift tests were performed to determine the motor constant G of the calibrator coils. On 12 and 14 September frequency response tests were carried out on all the seismographs. Driving signals were obtained from a Hewlett Packard low-frequency function generator.

Resistance measurements were made on the two models of galvanometer control box to enable theoretical attenuations to be computed.

The results of the calibrations are shown in Plates 6 and 7, and the galvanometer control box data are given in Appendix 2.

4. ANCILLARY EQUIPMENT

Power supplies

The timing and power supply equipment has been described by Smith (1971). In 1969 a prototype EMI digital clock was sent to Mawson. This proved unreliable. It produced spurious 'minute' pulses and lost 1 millisecond per second. However, it was kept running until 4 October, to provide 50-Hz power for the seismograph and magnetograph synchronous drives. After 4 October power for the seismograph drive was obtained by amplifying the standard 50 Hz from the Auroral Laboratory. Power for the magnetograph drives was obtained from the Transtronics 50-Hz supply.

The Transtronics 50-Hz supply developed an intermittent fault early in November, which the Electronics Engineer traced to a faulty potentiometer. New potentiometers were reordered and in the meantime operation was restored by replacing the faulty circuit board with a spare.

Troubles were encountered with the pyrotenax cables that supply power and time-marks to the seismograph and magnetograph. On 21 January 1969 water entered the magnetic power and timing supply cable at the junction box about 70 metres from the variometer hut. This lowered the resistance between the pair of timing cables to about 10,000 ohms and caused the time-mark lamp to remain permanently alight. The cable was dried out by heating about 1 metre with a blowlamp. The junction box was then sealed with a silicon compound and gave no further trouble.

Faults occurred in the seismograph power and time-mark cable four times during the year. These faults showed up during the summer season when melt water entered breaks in the cable shielding. The main faults were on 24 February, 9 December, and 21 December. Time marks were usually lost before power. This was because with about 10,000 ohms between conductors the time-mark relay would close whereas power distribution was unaffected.

Timing

As the EMI clock was unreliable all timing was taken from Mercer chronometer 21172. This performed very well and had an almost constant rate of about 0.3 seconds per day. From 21 December until the seismograph timing cable was repaired in early January 1970, seismic timing was obtained from chronometer 18786 located at the seismic vault. This was checked daily against a stopwatch set from the caesium clock at the PAGEOS station.

Spurious triggering of the TMU2 programmer continued to be a minor problem.

On 13 February the La Cour pendulum clock, which had been overhauled in 1968, was installed in the variometer control room as a source of emergency timing.

5. MAINTENANCE WORK AND STATION DUTIES

The buildings and equipment were in good condition when the author took over from Smith.

In April new 'Laminex' benches were fixed in the darkroom. The exteriors of the office, absolute hut, variometer hut, and seismograph hut were all painted with bituminous aluminium in December. No interior painting was done.

The sponge rubber lightproofing around some of the variometer piers, the absolute hut pier, and the seismometer pier was replaced with canvas sleeving in December.

Domestic duties including nightwatch, kitchen assistant, snow collection, fuel distribution, and painting and maintenance of communal buildings were performed in addition to the geophysical work. The author was also field storeman for the year.

6. ACKNOWLEDGEMENTS

All the members of the 1969 expedition are thanked for their assistance, advice, and friendship. Particular thanks are due to Peter Neil for his repairs to the seismograph power and timing cable, Peter Griffiths for his repairs to 'black boxes' when they broke down, Mick Glenny for turning a fitting for the theodolite and tripod, and Rowan Webb for his assistance with the field equipment, where he contributed more in time and know-how than the author.

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APPENDIX 1

Transfer of an azimuth from the PAGEOS satellite triangulation station to the absolute and variometer huts

For the meanings of the station and mark designations see Plates 1 and 2.

In October a brass post BP was cemented in the rock about 70 metres from the absolute hut. It was visible both from the absolute pier S and the PAGEOS satellite triangulation station (051 1969 RM.2). The reference direction 306° 35.4' ± 0.05' was supplied by the PAGEOS team.

In November wooden rails were screwed to the magnetic north and south walls of the variometer room. Using an Askania midget theodolite TK-MI, rounds of angles were measured at BP and Q to establish a reference direction R'-R of 301° 30.0' which was marked on the rails.

Angles measures from BP to S were used to check the azimuth of the declination marks. Angles were measured at S using the Askania glass circle (No. 650). The theodolite was graduated in 1.0' intervals with estimation to 0.1'. The Askania circle was graduated in 2.0' intervals with estimation to 0.2'.

Using a protractor, the reference direction R'-R inside the hut was observed to make an angle of about 89° to both the rails. The perpendicular distance between the rails was 354 cm. Accordingly the distance RN of 6.2 cm was marked on the northern rail such that the angle RR'N was 1°. Hence R'-N is normal to both rails and bears 302° 30.0'.

The 1969 October mean magnetic meridian was 298° 05.2'; hence for the orientation tests a meridian of 298° 00.0' was adopted. The meridian direction was established by marking a point M on the northern rail such that NM was 27.8 cm and hence angle NR'M was 4° 30.0'.

Lines parallel to R'-M and passing through the variometers were then found by marking off equal distances from R' and M along the south and north rails respectively. These distances are given in Plate 2.

Note that the new azimuth of the declination mark P measured from the pier S agrees to within 0.6' of the adopted azimuth. This discrepancy could arise from cumulative reading errors in angles measured at BP and S.

APPENDIX 2

Seismograph calibrations and galvanometer control box data

Electromagnetic calibrators, Geotech model 2419A, are fitted to the three Benioff seismometers. These enabled the magnification and response curves to be obtained as follows.

Firstly the '<u>motor constant</u>', G, of the calibrator was determined:

$$G = 980\ (Xp/Xw)\ (W/i)\ .\ 10^5 \text{ newton/ampere}$$

where Xp = trace amplitude (mm) of deflection produced by a current step of i amperes

Xw = trace amplitude (mm) of deflection produced when a mass of W grams is lifted off seismometer mass

These values of G were found:

Vertical seismometer	$G_z = 1.36$	N/A
North-south "	$G_n = 1.42$	N/A
East-west "	$G_e = 1.36$	N/A

The magnification (Mag) is given by

$$Mag = Af^2/K.is$$

where A = trace amplitude (metres) produced by sinusoidal current applied to calibrator

f = frequency (hertz) of applied current

is = amplitude (amperes) of applied current

M = seismometer mass (kilograms) = 107.5 kg

$K = G/4\pi^2 M$

Note that the formula holds if A is in millimetres and is is in milliamps; both must be measured in the same fashion, i.e. either peak-to-peak or centre-to-peak.

The following values of K were determined:

Vertical seismometer	$K_z = 3.20 \times 10^{-4}$
North-south seismometer	$K_n = 3.34 \times 10^{-4}$
East-west seismometer	$K_e = 3.21 \times 10^{-4}$

The frequency response tests yielded a single magnification curve for the Z seismograph and two almost identical curves for the N-S and E-W seismographs. The E-W seismograph response curve was adopted as being representative of the two horizontal seismographs.

During the tests the attenuator setting of the vertical seismograph was 8 and the attenuator settings of both horizontal seismographs were 6½. The resistances in the T attenuators of the galvanometer control boxes were measured at various settings so that magnification curves could be determined for other values of attenuation.

If the seismometer is modelled as a constant voltage source Vs in series with an external resistance Rs, and the galvanometer modelled as a resistive element Rg, the equivalent circuit shown in Plate 9a is obtained. Plate 9b gives a simplification of this circuit.

Vs is an ideal voltage source representing the seismometer

Rs is the resistance of the seismometer coils

Rsd is the resistance of the seismometer damping control

Rgd is the resistance of the galvanometer damping control

Rg is the internal resistance of the galvanometer

Ra, Rb, Rc are the variable attenuator resistances

$Rs1 = Rs + Rsd$

$Rg1 = Rgd \cdot Rg/(Rgd + Rg)$

For the horizontal-component seismographs

$Rsd = 0$; hence $Rs1 = Rs = 500$ ohms

and $Rgd = 0$; hence $Rg1 = Rg = 500$ ohms

For the vertical-component seismograph

$Rsd = 60$ ohms with the seismograph damping control set to 8

$Rg = 20$ ohms and $240 \leqslant Rgd \leqslant 990$ ohms

hence $18.5 \leqslant Rg1 \leqslant 19.6$ ohms

With the galvanometer damping control set to 7, $Rgd = 465$ ohms, hence $Rg1 = 19.2$ ohms.

The ratio of the voltage appearing at the galvanometer to that generated by the seismometer is given by

$$F = Vg/Vs = \frac{Rc\ Rg1}{Rc(Rb + Rg1) + (Rs1 + Ra)\ (Rb + Rg1 + Rc)}$$

Using measured values of Ra, Rb, and Rc, F was evaluated for different attenuator settings. The attenuator settings used for the vertical seismograph were 0, 2, 4, . . . 42. Denoting the corresponding values of F as F(0), F(2), . . . F(42), the following function was evaluated.

$$D(n) = 20 \log_{10} \frac{F(0)}{F(n)} \quad n = 0, 2, \ldots 42$$

This gave the relative attenuation in decibels at various attenuation settings, taking F(0) as reference level (See Table 8).

The attenuator settings for the horizontal seismograph were 1.0, 1.5, 2.0, 2.5, . . . 10.0. Denoting the corresponding values of F as F(1.0), F(1.5), . . . F(10.0) the following function was evaluated.

$$D(n) = 20 \log_{10} \frac{F(1.0)}{F(n)} \quad n = 1.0,\ 1.5,\ 2.0,\ \ldots\ 10.0$$

This gave the relative attenuation in decibels at various attenuation settings, taking F(1.0) as reference level (See Table 9).

These theoretical results were checked by applying current pulses to the seismograph calibrators for different attenuator settings and measuring the deflections on the seismograms.

For the vertical seismograph the ratios

$$\frac{\text{measured deflection at setting } n}{\text{measured deflection at setting } 8}$$

were plotted against attenuator settings as a series of points.

On the same graph the ratios

$$\frac{F(n)}{F(8)}$$

were plotted against attenuator settings as a series of crosses (see Plate 8A).

For the horizontal seismograph the ratios

$$\frac{\text{measured deflection at setting } n}{\text{measured deflection at setting } 6\tfrac{1}{2}}$$

were plotted against attenuator setting as a series of points.

On the same graph the ratios

$$\frac{F(n)}{F(6.5)}$$

were plotted against attenuator setting as a series of crosses (see Plate 8B).

It can be seen that there was close agreement between the two methods of determining relative magnification at different attenuator settings.

Having found the attenuation differences in dB for different settings, a family of curves was obtained from the standard frequency response curve by simply transposing the standard curve by the appropriate number of dB.

These response curves, together with the table of attenuation settings for the year, were used to measure amplitudes of ground motion from the seismographs.

TABLE 1

D SCALE VALUE DETERMINATIONS

System	Askania Coils	Least Squares	Previous Value*	Helmholtz[1] Coil	Adopted
Normal	2.36 ± 0.02	2.35 ± 0.03	2.44 ± 0.01	2.44	2.40 ± 0.02
Sensitive	0.82 ± 0.01	0.84 ± 0.02	0.86 ± 0.01	0.88	0.86 ± 0.008

* Derived by Smith using a Helmholtz coil (1968)

1 One observation in January 1969

TABLE 2

SCALE VALUES AND TEMPERATURE COEFFICIENTS

Component	Scale value: Temperature °C/mm	Scale value: Ordinate gammas/mm	Temperature coefficient gammas/°C
Sensitive			
H	N/D	9.5 ± 0.08	N/D
Z	+1.16	10.5 ± 0.08	Nil
Normal			
H	+6 ca	21.2 ± 0.1	+7.5
Z	+3.0*	22.3 ± 0.2	+25, +8*

* After 1969 Oct 26

TABLE 3

BASELINE VALUES

Time and Date		Baseline value Before	Baseline value After	Remarks
Sensitive Z temperature				
06^h	10/02/69	+34°	-52.0°	Adjustments made to Z variometer to change relative position of Z base, Z trace, and Z temp. trace
00^h	01/11/69	-52.0°C	-51.8°C	Arbitrary step
00^h	01/12/69	-51.8°C	-51.6°C	Arbitrary step
07^h	23/12/69	-51.6°C	-22.2°C	Reground magnet 23/12/69
Sensitive Z (Correction of +3 gammas due to instrument correction of -7 gammas in H)				
06^h	10/02/69	48584	47738	Adjustments to Z variometer to change relative position of Z base, Z trace and Z temp. trace
10^h	08/04/69	47738	47755	Blizzard, wall of hut vibrating against variometer pier
00^h	01/06/69	47755	47760	Arbitrary step
04^h	04/08/69	47760	47776	Blizzard, vibration of pier
10^h	14/11/69	47776	47784	Determining strength of deflector magnet for use in orientation tests
09^h	17/12/69	47784	47794	Lightproofing and driftproofing variometer piers
0655^h	23/12/69	47794	47782	Reground sensitive magnet
0925^h	24/12/69	47782	47722	Adjustments following magnet grinding
0820^h	26/12/69	47722	47725	" " " "
Normal D (Instrument Correction +0.6')				
1600^h	13/02/69	-60° 27.3'	-60° 29.1'	La Cour pendulum clock installed in variometer control room
1500^h	14/11/69	-60° 29.1'	-60° 28.5'	Determining strength of deflector magnet for use in orientation tests
Normal H (Mean instrument correction -7 gammas)				
1000^h	31/01/69	17459	17360	Possible disturbance while checking azimuth lines in hut

TABLE 3 (Cont.)

1600^h	13/02/69	17360	17341	La Cour pendulum clock installed in variometer control room
0800^h	21/07/69	17341	17331	Possibly small step in trace
0600^h	08/11/69	17331	17319	New orientation marks were installed in variometer hut
1300^h	16/11/69	17319	17222	Orientation tests on all H and D variometers
1000^h	19/12/69	17222	17178	Z orientation tests with strong deflector magnet

TABLE 4

ORIENTATION TEST DATA

		Normal			Sensitive		
		D	H	Z	D	H	Z
Applied current	(mA)	300	350	-	100	200	-
Applied field (fa)	(gammas)	2247	2622	2407	749	1498	1228
Optical lever (R)	(mm)	730	1140	1730	2010	1880	1740
Scale value	(mm)	12.8	21.2	22.3	4.6	9.5	10.5
Ordinate change (fn)	(gammas)*	2.6	4.2	4.4	0.9	1.9	2.1
Minimum exorientation angle Ex	(minutes)	4	6	6	4	4	6

* equivalent to 0.2 mm ordinate change

Ex = 3438 fn/fa

TABLE 5

ORIENTATION OF VARIOMETER MAGNETS

Component	Reference field	Magnet N pole	Change/year*
Normal			
D	N 62° W	N 0.8° W	-
H	H = 0.1837	E 0.7° S	0.15° S
Z	Z = 0.4790	N 0.6° U	0.07° D
Sensitive			
D		N 0.1° W	-
H		E 0.7° S	0.15° S
Z		N 1.8° D (a)	D
		N 0.2° D	

* Based on secular variations D 10' W
H zero
Z 100 gammas down

(a) Until 1969 Dec 23

TABLE 6

SEISMOGRAPH ATTENUATOR SETTINGS 1969

Date	Time	Vertical		Horizontals	
		Before	After	Before	After
21/01	0406	18	20	7	6
25/01	(0330)	20	16	6	5½
26/01	(0330)	16	12	5½	5
03/02	(0330)	12	14	5	5½
05/02	1055	14	16	5½	6
21/02	0330	16	22	6	9
25/02	0330	22	18	9	7
28/02	(0330)	18	22	7	9
03/03	(0330)	22	18	9	7
14/03	0323	18	22	7	9
16/03	0335	22	18	9	7
17/03	0335	18	20	7	8
22/03	0330	20	18	8	7
28/03	1155	18	16		
08/04	1155	16	22	7	9
10/04	0325	22	18	9	8
13/04	0310	18	16	8	7
16/04	0320	16	14	7	6½
01/05	0335	14	16	6½	7
04/05	0335	16	14	7	6½
15/05	0327	14	12	6½	6
16/05	(0330)			6	6½
29/05	(0330)	12	10		
09/08	(0330)	10	12		
11/08	(0330)	12	10		
14/08	(0330)	10	8		
30/12	(0330)	8	12	6½	7½

Times in brackets uncertain

TABLE 7

NUCLEAR EXPLOSIONS AT NEVADA RECORDED AT MAWSON

Date 1969	Origin Time	Magnitude	Phase and Arrival Time at Mawson	
30/04	17 00.00.0	5.3	PKP	17 19 50.8
07/05	13 45 00.0	5.8	PKP	14 04 51.0
27/05	14 45 00.0	5.0	PKP	14 34 50.8
16/07	14 55 00.0	5.6	PKP	15 14 51
10/09	21 00 00.1	5.3	PKP	21 19 54.2
16/09	14 30 00.0	6.2	PKP1	14 49 46.0
			PKP2	14 49 50.8
			PKP3	14 49 56
02/10*	22 06 00.0	6.5	PKP	22 25 38.0
08/10	14 30 00.0	5.5	PKP	14 49 50.9
29/10	19 30 00.0	5.1	PKP	19 49 51.3
29/10	20 00 00.0	5.0	PKP	20 19 50.9
29/10	22 01 51.4	5.7	PKP1	22 21 37.4
			PKP2	22 21 41.6
17/12	15 00 00.0	5.5	PKP1	15 19 46.5
			PKP2	15 19 50.6
17/12	15 15 00.0	4.8	PKP	15 34 50
18/12	19 00 00.0	5.2	PKP1	19 19 47.4
			PKP2	19 19 50.6

* This explosion was at Lat. 51.4 N Long. 179.2 E

TABLE 8

VERTICAL SEISMOGRAPH ATTENUATOR DATA

Att	Vg/Vs	*CALAT(0)	CALAT[1](8)	Att Diff	$\frac{F(n)}{F(8)}$	Ra	Rb	Rc
0	8.144×10^{-2}	0.00	-10.89	4.28	3.50	0	0	375
2	4.978×10^{-2}	4.28	- 6.61	2.38	2.14	31	45	180
4	3.785×10^{-2}	6.66	- 4.23	2.20	1.63	45	66	125
6	2.937×10^{-2}	8.86	- 2.03	2.03	1.26	51	82	88
8	2.326×10^{-2}	10.89	0.00	1.89	1.00	57	95	67
10	1.870×10^{-2}	12.78	1.89	1.89	0.804	64	105	53
12	1.505×10^{-2}	14.67	3.78	1.88	0.647	68	114	42
14	1.212×10^{-2}	16.55	5.66	1.64	0.521	74	122	34
16	1.004×10^{-2}	18.19	7.30	1.67	0.432	78	127	28
18	8.280×10^{-3}	19.86	8.97	2.05	0.356	82	131	23
20	6.535×10^{-3}	21.91	11.02	2.13	0.281	85	135	18
22	5.117×10^{-3}	24.04	13.15	2.05	0.220	88	138	14
24	4.041×10^{-3}	26.09	15.20	2.13	0.174	89	141	11
26	3.163×10^{-3}	28.22	17.33	2.30	0.136	90	142	8.5
28	2.425×10^{-3}	30.52	19.63	1.51	0.104	91	144	6.5
30	2.038×10^{-3}	32.03	21.14	1.72	0.0876	94	145	5.5
32	1.673×10^{-3}	33.75	22.86	2.65	0.0719	94	146	4.5
34	1.233×10^{-3}	36.40	25.51	1.44	0.0530	94	147	3.3
36	1.045×10^{-3}	37.84	26.95	2.05	0.0449	94	148	2.8
38	8.252×10^{-4}	39.89	29.00	1.76	0.0355	94	148	2.2
40	6.736×10^{-4}	41.65	30.76	1.61	0.0290	94	149	1.8
42	5.596×10^{-4}	43.26	32.37		0.0241	94	150	1.5

* Calculated attenuation 0 as reference

1 Calculated attenuation 8 as reference

TABLE 9

HORIZONTAL SEISMOGRAPH ATTENUATOR DATA

Att	Vg/Vs		CATLAT(0)*	CALAT(6.5)[1]	Att Diff	F(h)/F(6.5)	Ra=Rb	Rc
1.0	4.226	10^{-1}	0.00	-9.88	0.65	3.12	48	3450
1.5	3.920	10^{-1}	0.65	-9.23	0.75	2.89	70	2400
2.0	3.597	10^{-1}	1.40	-8.48	0.90	2.65	92	1700
2.5	3.242	10^{-1}	2.30	-7.58	0.89	2.39	114	1200
3.0	2.926	10^{-1}	3.19	-6.69	0.93	2.16	138	940
3.5	2.630	10^{-1}	4.12	-5.76	1.03	1.94	160	750
4.0	2.337	10^{-1}	5.15	-4.73	0.99	1.72	182	600
4.5	2.084	10^{-1}	6.14	-3.74	1.00	1.54	204	500
5.0	1.857	10^{-1}	7.14	-2.74	1.10	1.37	226	425
5.5	1.636	10^{-1}	8.24	-1.64	0.78	1.21	249	360
6.0	1.496	10^{-1}	9.02	-0.86	0.86	1.10	271	330
6.5	1.355	10^{-1}	9.88	0.00	1.34	1.00	294	300
7.0	1.162	10^{-1}	11.22	1.34	1.08	0.858	317	250
7.5	1.025	10^{-1}	12.30	2.42	1.24	0.756	339	220
8.0	8.891	10^{-2}	13.54	3.66	1.44	0.656	361	190
8.5	7.531	10^{-2}	14.98	5.10	1.24	0.556	383	160
9.0	6.527	10^{-2}	16.22	6.34	2.04	0.482	405	140
9.5	5.163	10^{-2}	18.26	8.38	3.16	0.381	428	110
10.0	3.589	10^{-2}	21.42	11.54		0.265	450	75

* Calculated attenuation 0 as reference

1 Calculated attenuation 6.5 as reference

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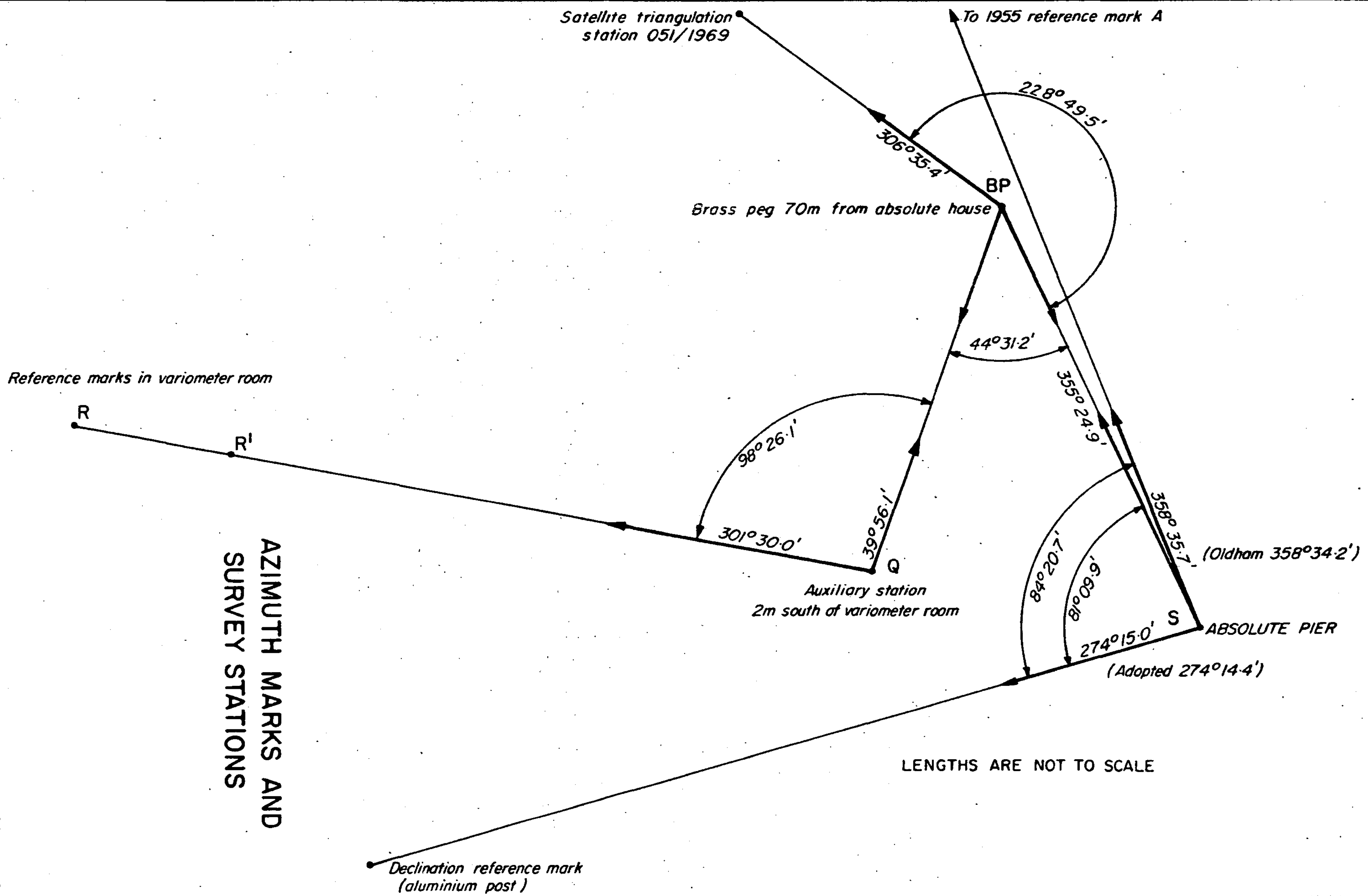
AZIMUTH MARKS AND SURVEY STATIONS



LENGTHS ARE NOT TO SCALE

PLATE 1

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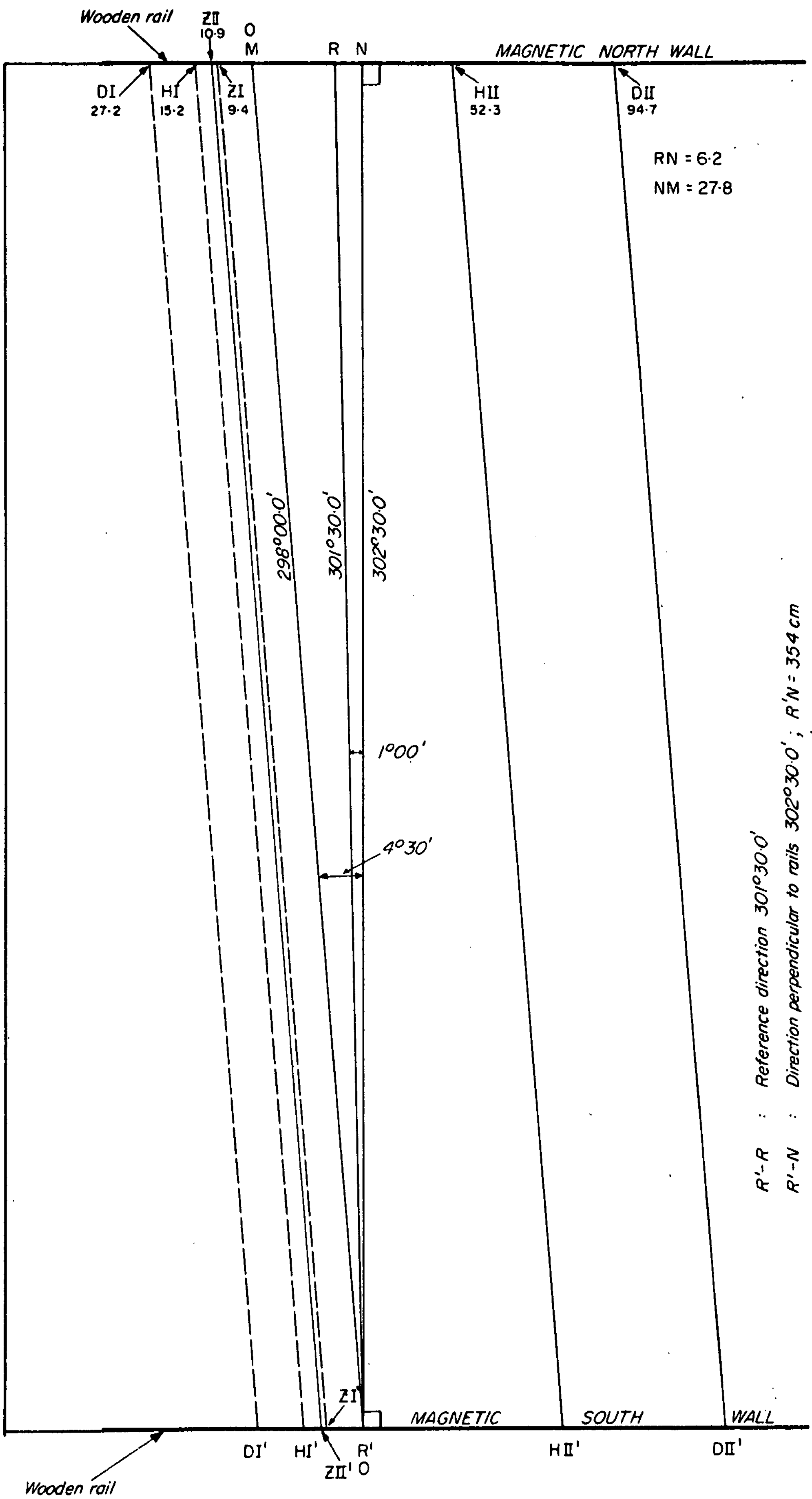
PLATE 2



R'-R : Reference direction 301°30·0'

R'-N : Direction perpendicular to rails 302°30·0' ; R'N = 354 cm

R'-M : Meridian for orientation tests 298°00·0'

HI'-HI, DI'-DI, ZI'-ZI : Lines parallel to R'-M passing through the sensitive variometers

HII'-HII, DII'-DII, ZII'-ZII : Lines parallel to R'-M passing through the normal variometers

Offsets on north wall are given in centimetres from M

ORIENTATION MARKS IN VARIOMETER ROOM

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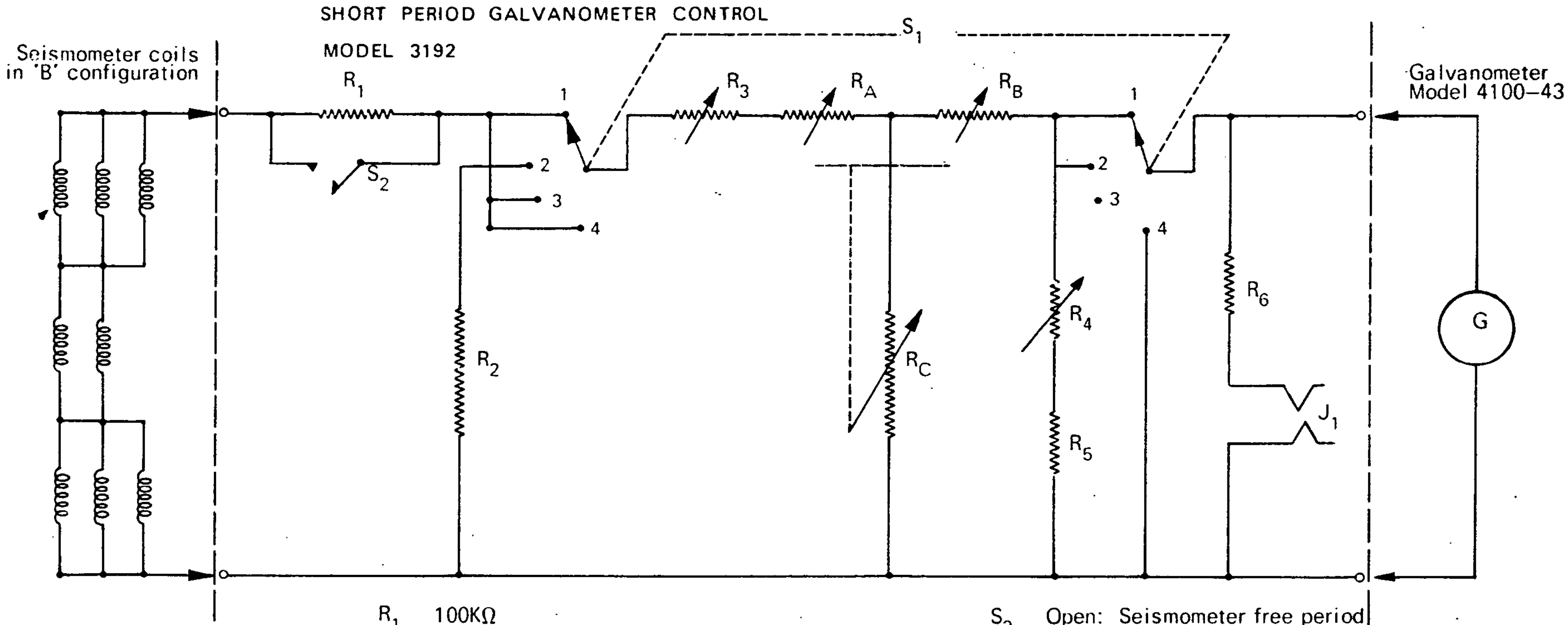
VERTICAL SEISMOGRAPH CIRCUIT



R1 100KΩ
R2 120 Ω
R3 300 Ω Linear seismometer damping
R4 750 Ω Linear galvanometer damping
R5 240 Ω
R6 500K Ω
RA, RB, RC 'T' attenuator resistances
The values are given in Table 8

S1 Function switch (1) Record
(2) Galvanometer damping test
(3) Galvanometer free period
(4) Short galvanometer

S2 Open: Seismometer free period
Close: Record
J1 Galvanometer test jack

Seismometer coils in 'B' configuration input resistance = 146 Ω
Critical external damping resistance = 175 Ω

Galvanometer model 410C–43 Resistance = 20 Ω
Critical external damping resistance = 130 Ω
Free period = 0.2 seconds
Current sensitivity 3×10^{-8} amp/millimeter at 1 metre

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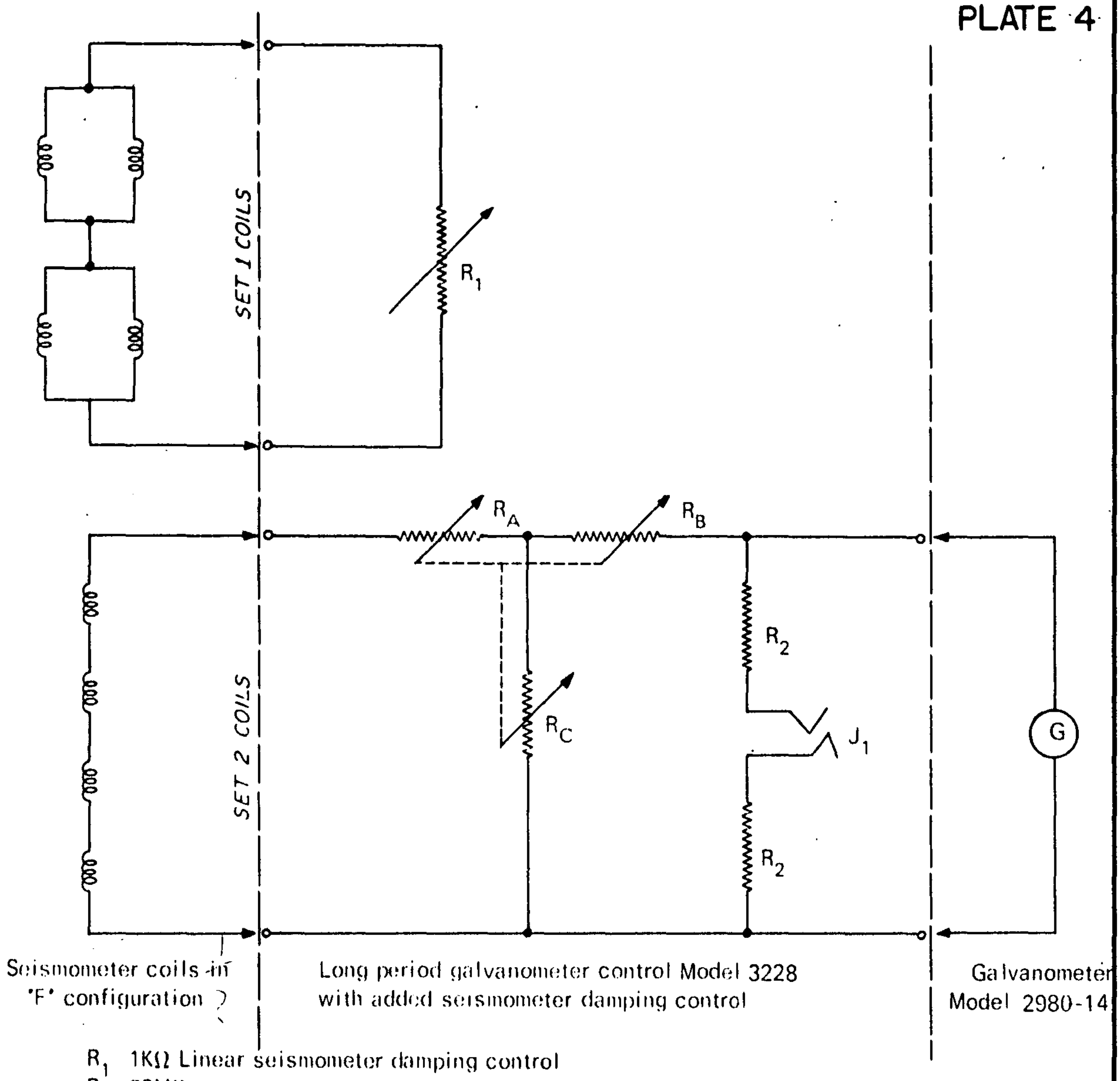
PLATE 3



R_1 1KΩ Linear seismometer damping control
R_2 22MΩ
R_A, R_B, R_C 'T' attenuator resistances
The values are given in Table 9
J_1 Galvanometer test jack

Seismometer coils in 'F' configuration
Set 1 coils
Input resistance ≈125Ω
Critical external damping resistance ≈208Ω
Set 2 coils
Input resistance ≈500Ω
Critical external damping resistance ≈500Ω

Galvanometer model 2980–14
Resistance ≈500Ω
Critical external damping resistance ≈500Ω
Free period ≈14 seconds
Current sensitivity ≈1.1×10^{-9} amp/millimetre at 1 metre

HORIZONTAL SEISMOGRAPH CIRCUIT

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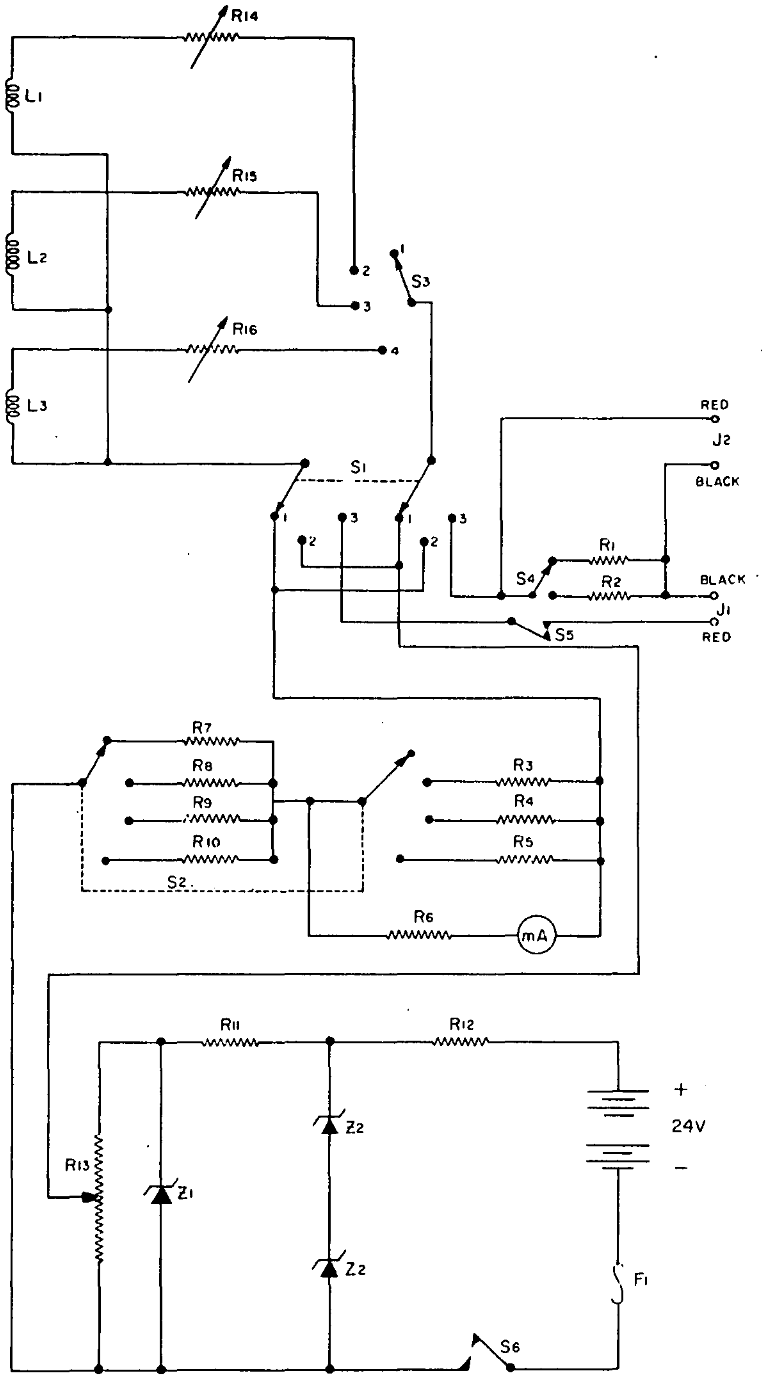


L1, L2, L3 Calibration coils DC resistance ≃ 250Ω

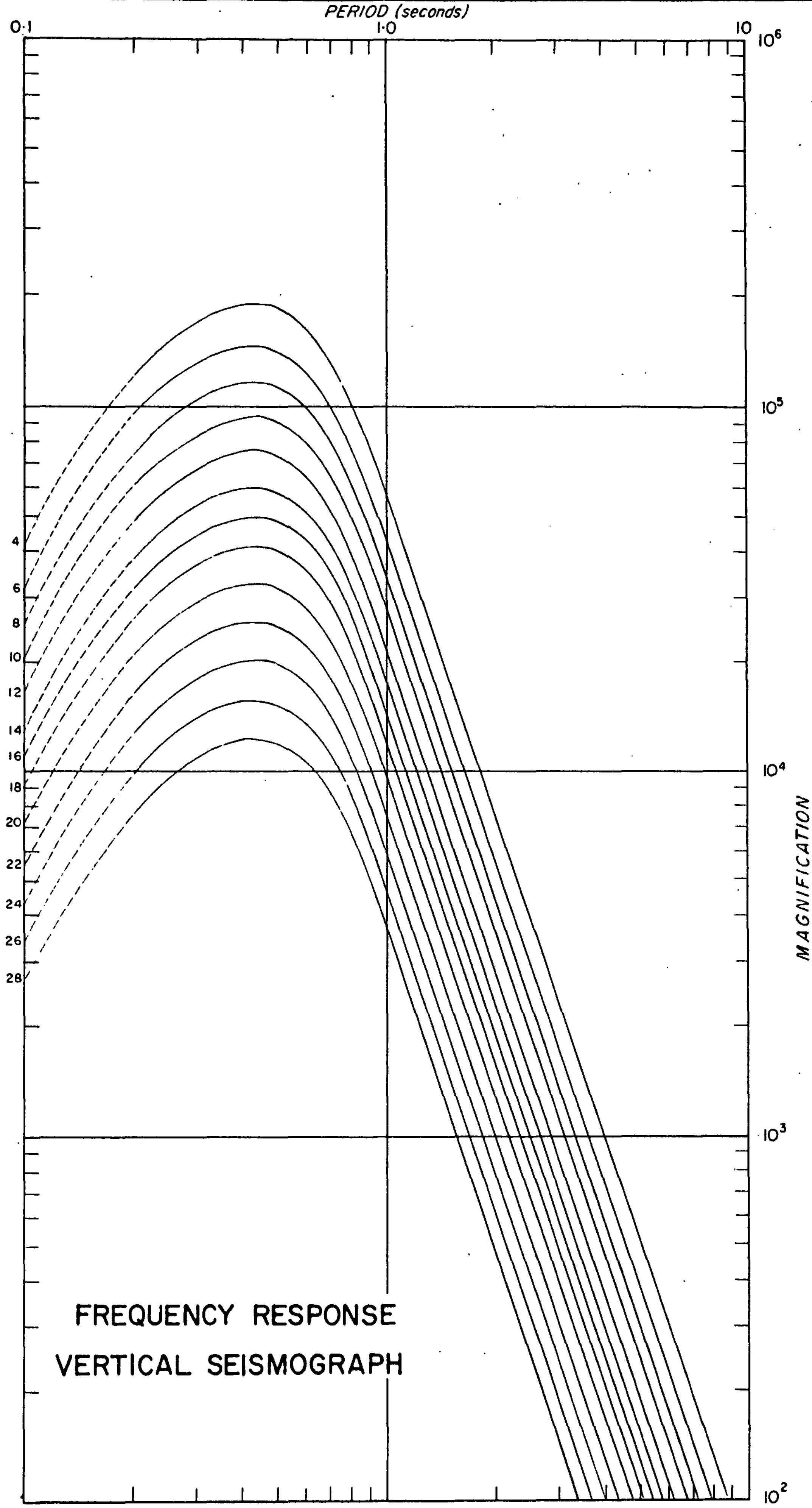
R1	2·354 KΩ	1%
R2	4 KΩ	1% Wire wound
R3	250Ω	" " "
R4	111Ω	" " "
R5	52·6Ω	" " "
R6	900Ω	" " "
R7	10KΩ	5% ½ Watt
R8	1·8KΩ	" " "
R9	680Ω	" " "
R10	220Ω	" " "
R11	300Ω	" " "
R12	200Ω	" " "
R13	10KΩ	5 Watt
R14, R15, R16	10Ω	Trimpot

S1 2 pole 3 position switch
1. Pulse
2. Reverse pulse
3. Signal generator

S2 Meter range selector switch
1. 1mA F.S.D.
2. 5mA F.S.D.
3. 10mA F.S.D.
4. 20mA F.S.D.

S3	Calibration coil selector switch
S4	Current monitor selector switch
S5	Toggle switch, signal generator, on/off
S6	Toggle switch, pulse, on/off
J1	Signal generator input terminals
J2	Voltage monitoring terminals
Z1	Zener diode 12V 1N759A
Z2	Zener diode 9·1V 1N757A
M	Milliammeter 0–1mA DC master model S34 Internal resistance = 100Ω
F1	500 mA fuse

SEISMOMETER CALIBRATION CONTROL



FREQUENCY RESPONSE
VERTICAL SEISMOGRAPH

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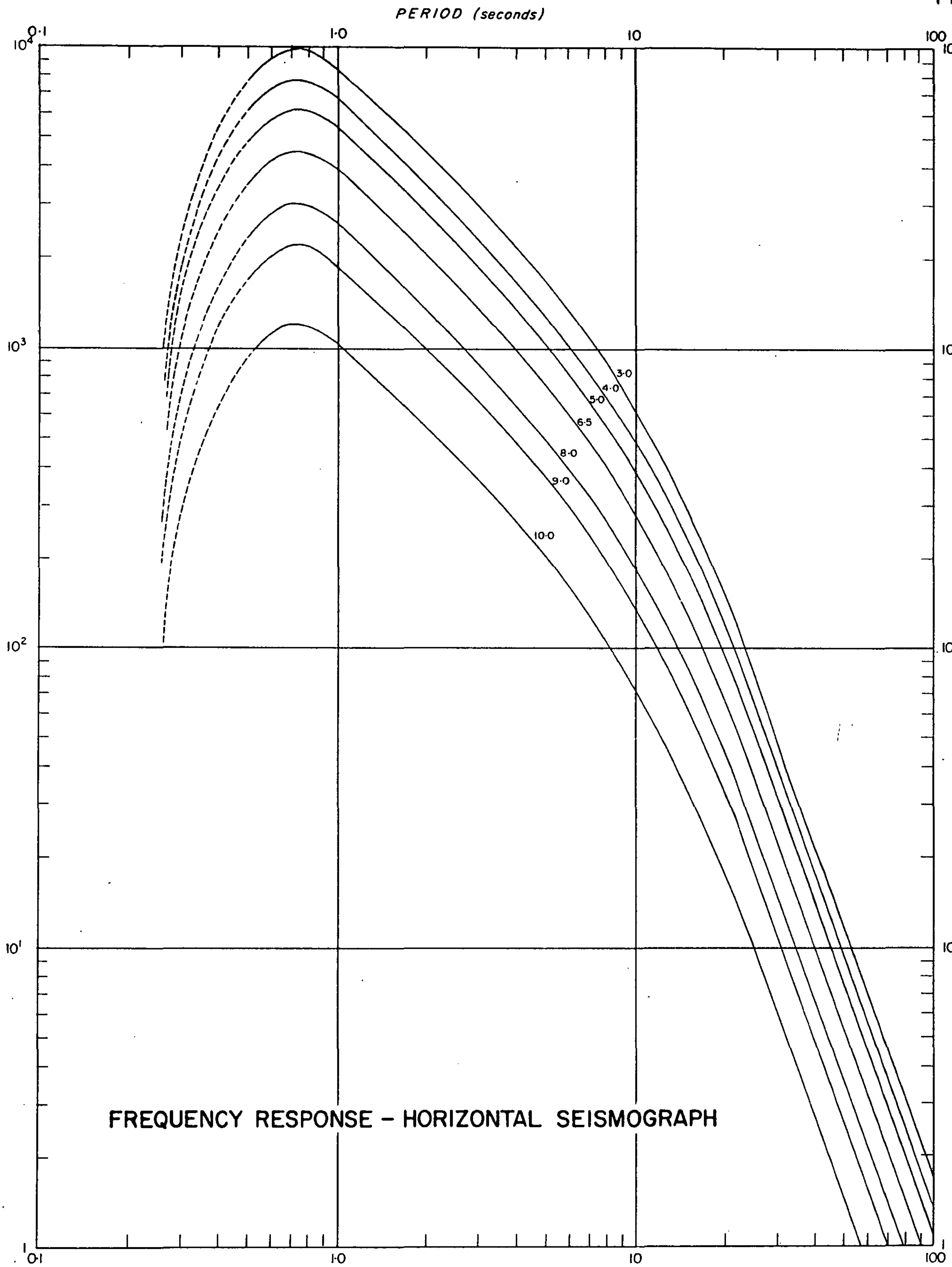
PLATE 7



FREQUENCY RESPONSE - HORIZONTAL SEISMOGRAPH

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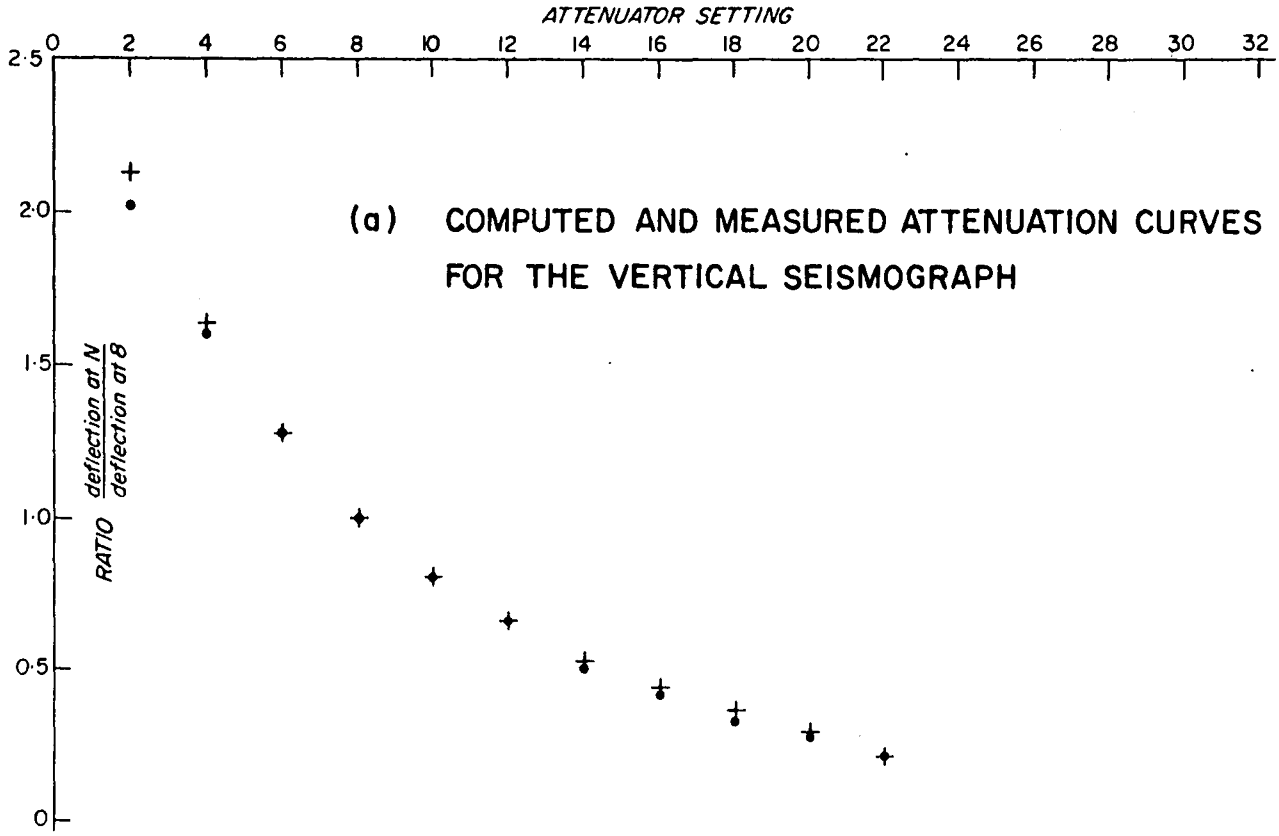
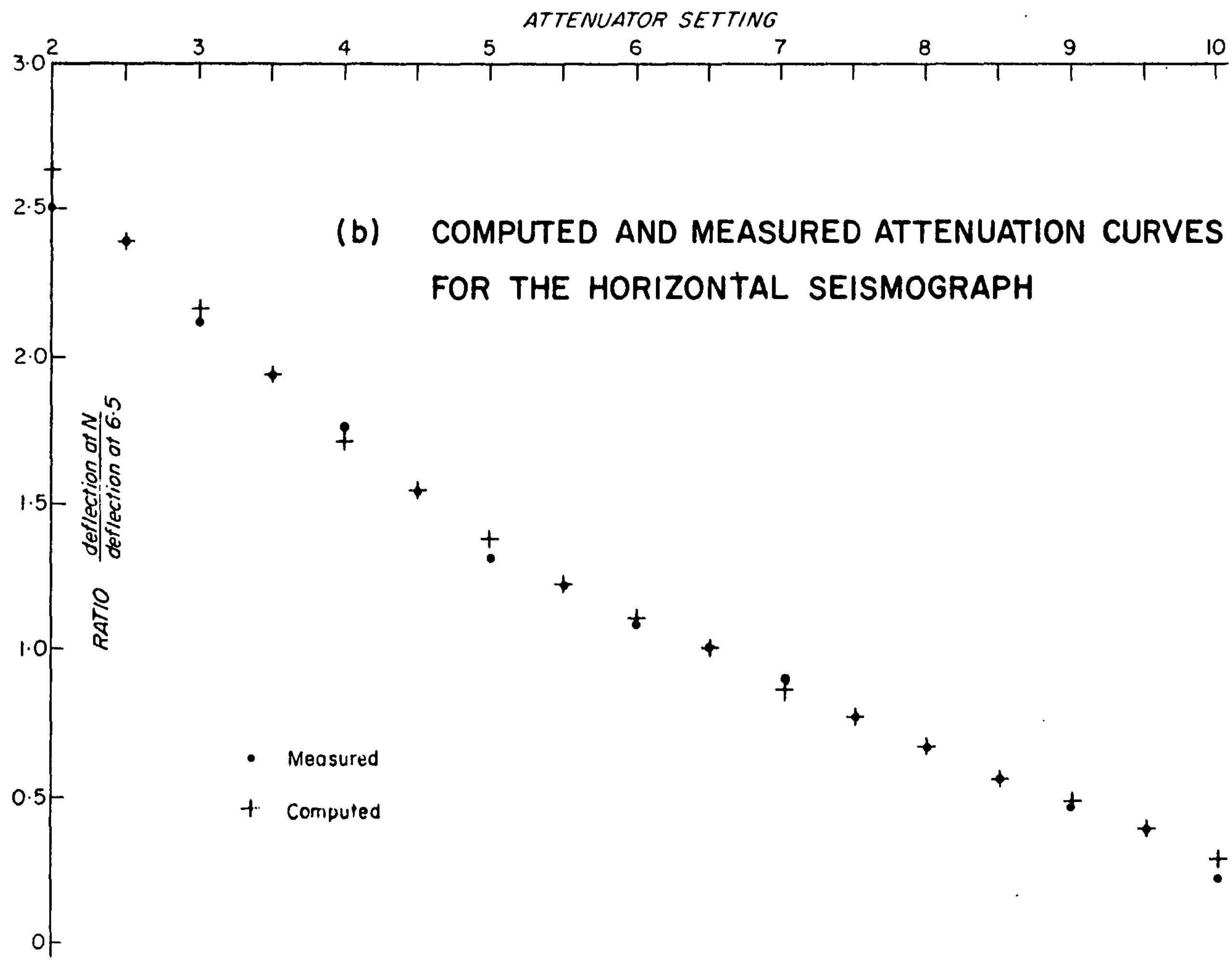
PLATE 8





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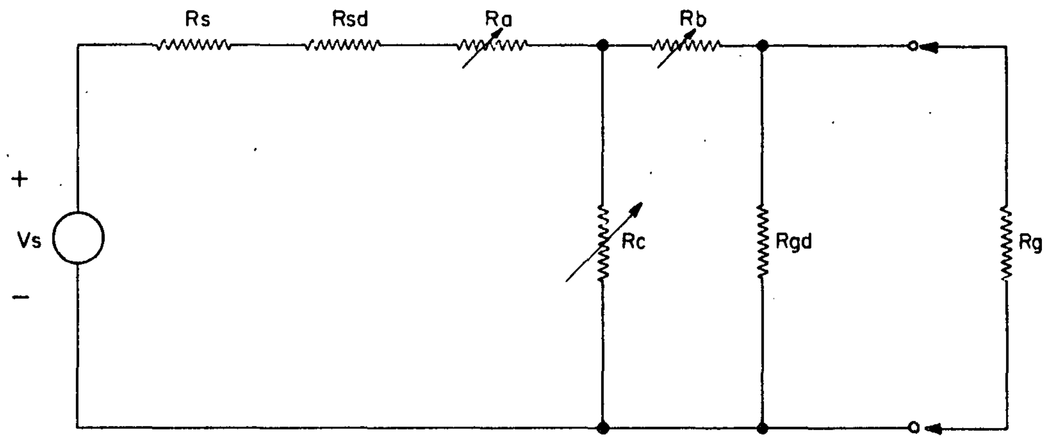
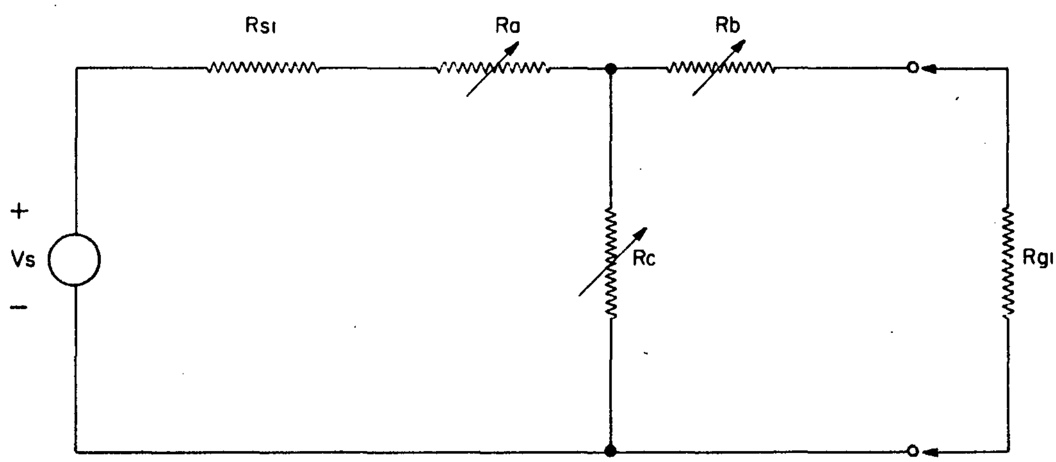
(a) EQUIVALENT CIRCUIT



(b) SIMPLIFIED EQUIVALENT CIRCUIT



$$R_{s1} = R_s + R_{sd}$$

$$R_{g1} = \frac{R_{gd} \cdot R_g}{(R_{gd} + R_g)}$$

SEISMOGRAPH EQUIVALENT CIRCUITS

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