BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

RECORD 1981/17

MACQUARIE ISLAND GEOPHYSICAL OBSERVATORY

ANNUAL REPORT 1977

by

MICHAEL J. SEXTON

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SUMMARY

The normal geophysical program was carried out at Macquarie Island during 1977. The geomagnetic observatory utilised La Cour normal-run and rapid-run magnetographs, whilst the seismological observatory consisted of two start-period seismographs: one for vertical and one for horizontal component of motion.

Fortunately very few problems were encountered during the year and most equipment failures were of short duration and easily repaired. Towards the end of the year, work commenced on clearing a site for the new science block to house the geophysics office.

A large earthquake (MS 6.7) which occurred about 75 km from the island on 21 July was felt with intensity MM VI.

1. INTRODUCTION

This Record describes the operation of the Macquarie Island Geomagnetic and Seismological Observatories when they were the responsibility of the author, from 1 January 1977 until 19 November 1977.

The seismological observatory commenced operations in 1950 and the magnetic observatory in 1951. The observatories are operated by the Bureau of Mineral Resources, Geology & Geophysics (BMR), of the Department of National Development & Energy, as part of the program of the Australian National Antarctic Research Expenditions (ANARE). The Antarctic Division, Department of Science, provided facilities and logistic support for this work. Table 1 gives the geographic co-ordinates of both observatories. The observatory history will be given in the annual report for 1980 (Davies, 1981).

The author succeeded Peter Gidley, who stayed on until March 1977 to complete the author's training. The 1978 incoming geophysicist was Peter Davies.

2. GEOMAGNETISM

The geomagnetic recording instruments were La Cour normal-run (20 mm/hr) and rapid-run (180 mm/hr), three-component magnetographs. Bi-weekly scale value and baseline determinations were made to calibrate the normal-run magnetographs, whilst rapid-run scale values were determined monthly (Tables 2 and 3). The Z variometer thermometer was read daily to calibrate the temperature trace on the normal-run magnetograms (Table 4). Magnetic K-indices, preliminary monthly mean values, baseline values, and scale values of each element were telexed to the BMR office in Melbourne each month. Table 5 summarises the data obtained during 1977 and Table 6 is a summary of the annual mean data since 1967.

Normal-run magnetograph

D variometer: The D variometer functioned well throughout the year. In February, the D baseline trace was lost after the collimating lens was slightly knocked. Tightening the support for the lens remedied this problem. After the July 21 earthquake, the D variometer trace was lost but was soon restored to near its original position. In late October, the D time marks temporarily disappeared after a blown time-mark lamp was replaced.

H variometer: During June, adjustments made to the optical system in order to decrease the thickness of the H-baseline resulted in the loss of the H trace for a day. The H trace was also lost for 12 hours after the earthquake. The temperature coefficient determined for the magnetograph was about 2.6 nT/^{o}C and 3 nT/^{o}C was adopted for data reduction.

Z variometer: The Z-variometer magnetic and temperature traces were lost for a day in March and June, when the width of the slit was adjusted.

Several times during the year, the silica gel in the variometer was changed. This usually caused shifts in the trace ordinates, particularly of the Z variometer trace, and hence changes in baseline values. Because of the very moist atmosphere of Macquarie Island, changing the silica gel is probably ineffective. The temperature coefficient was difficult to determine, due to scatter in the observations, but was small so a value of 0 nT/^{o}C was adopted.

Rapid-rum Magnetograph

This instrument functioned quite well throughout the year. The only record losses were caused by failures to reset the carriageway properly or to put down the scale value shutter, and by the effects of the 21 July earthquake. Many of the reserve traces were faint, as the silvering of the long mirrors and reserve prisms was in a poor state. Unfortunately no replacement prisms were available.

Scale values

The MCO-1 calibrator functioned very well all the year, only the batteries needing to be replaced. The current was measured using a 'Data Precision' digital multimeter. This meter had one faulty cell in the battery pack and needed to be operated with the battery charger connected to obtain consistent results. The charger failed in August and another one was built to replace it. A replacement battery charger and battery pack arrived in November 1977.

Absolute instruments

Absolute instruments used during the year were:

H: QHMs No. 177, 187, and 179

D: Askania declinometer 640505 with circle 640620

Z: BMZ236

F: Elsec Proton-Precession Magnetometer (PPM) 592/421.

The PPM was used on Pier W, to derive Z values (called Zp) from a combination of F measured by the PPM and H obtained from the magnetogram. These readings was related to the standard pier (Pier E) using the inter-pier difference, which was determined monthly with PPM. The inter-pier difference was less than 1 nT.

BMZ observations were made monthly on Pier W. Comparison with Zp values yielded an instrument correction for BMZ 236. The mean difference obtained was:

$$Zp - BMZ\ 236 = 69 \pm 3\ nT$$

This compares with a value of 48 nT obtained in 1976 (Gidley, in prep.), the BMZ correction having changed suddenly in May 1977, from approximately 45 nT to 69 nT. This could have been associated with changing the silica gel for the first time in a long while.

Intercomparisons

Intercomparisons were made in November 1977 between QHM 172, HTM 704 and QHM 177; declinometer 640812 and circle 50810 and declinometer 640505 with circle 640620, Elsec PPMs 421, 429, 424 and Geometrics PPM No. 1023. The results were:

QHM 172	-	QHM 177	=	+18.4 nT
HTM 704	-	QHM 177	=	-11.1 nT
Decl 812	-	Decl 505	=	+2.1 min
Geometrics 1023	-	PPM 429	=	0 nT

Proton magnetometers 421 and 424 unfortunately were erratic and no instrument differences could be obtained. PPM 421 was returned to Australia and PPM 424 remained at Macquarie Island. These results compared favourably with the values obtained in November 1976:

QHM 172	-	QHM 177	=	+18.3 nT
HTM 704	-	QHM 177	=	-9.8 nT
Decl 812	-	Decl 505	=	+2.0 min
PPM 424	-	PPM 421	=	-1.6 nT

From intercomparisons made at Toolangi in November 1976 and 1977, instrument corrections were determined for QHM 172 and HTM 704.

QHM 172 = -2.26×10^{-3} H nT

HTM 704 = $+0.16 \times 10^{-3}$H nT

This yields a correction of -0.74×10^{-3}H nT for QHM 177.

The annual mean differences between the Macquarie Island QHMs were:

QHM 177	-	QHM 178	=	7 nT
QHM 177	-	QHM 179	=	7 nT

Orientations

During August and October, the orientation of each variometer magnets was determined. The results are given in Table 7. Considering the effects of the 21 July earthquake and the subsequent adjustments to restore the traces, the measured orientations compare well with previous results (Gidley, in prep.). The procedures for conducting magnetic orientation tests are adequately described in other reports (Hill, 1973; Gidley, in prep.) and the relevant theory can be found in McComb (1952).

3. SEISMOLOGY

One vertical component seismograph and one horizontal (N-S) component seismograph operated during 1977. Both systems functioned well with only minor losses.

The vertical system consisted of a Willmore Mark II seismometer, a Geotech telemetry amplifier, a Geotech discriminator, a galvanometer control box, a galvonometer, and a 60 mm/min Geotech recorder. The telemetry amplifier and discriminator were first incorporated in the old plateau seismograph system (McMullan, 1974), when the seismic signal was telemetered via landline to the geophysics office. Although these components may not be necessary, it was decided to keep them in use. A spare cable was made to bypass the amplifier and discriminator should either one fail. The only problem encountered with this system was radio interference (R.F.) from an amateur radio transmitter. This problem was remedied by re-orienting the radio aerial with respect to the seismic vault.

The horizontal system consisted of a Willmore Mark I seismometer, a galvanometer control box, a galvonometer, and a 60 mm/hr BMR photographic recorder. This system suffered from very poor stability of the optical system. Several readjustments were necessary during the year.

Depending upon wind and sea conditions, the galvanometer control boxes were set at different attenuation levels. Under normal conditions, the vertical and horizontal attentuations were set at 32 dB and 4 dB respectively. On the few fine days in summer, settings of 30 dB and 2 dB were possible; whereas during a storm, settings of 36 dB and 8 dB were necessary. Table 8 lists the galvanometer control box settings used throughout the year.

Calibrations

No method of calibrating the horizontal seismometer was available. The vertical seismometer, however, was calibrated on four quiet days during the year. The results were similar each time and are summarised in Figure 1.

The seismometer calibration is performed in three steps: a weight lift test, a current pulse test, and a dynamic test. In the weight lift test, a small mass (eigher 0.048 g or 0.125 g) is placed on the seismometer indicator pointer and rapidly removed. The force applied is equivalent to the gravitational force on the small mass. In the current pulse test a rod with a magnet at its upper is substituted for the normal indicator pointer; a current applied to a calibration coil around the magnetic end of the rod produces a force on the seismometer mass. Equating the forces applied to the seismometer mass in both tests permits the determination of the motor constant of the calibration coil. The dynamic test determines the magnification of the seismometer at different frequencies by using a sine wave generator (0.2 Hz to 16.4 Hz) to drive the seismometer mass via the calibration coil and the magnetic rod. Since the motor constant of the coil has been previously determined, the seismometer response can be easily calculated using the theory outlined by Gregson et al (in prep.).

Seismic data

Preliminary seismic data were telexed twice per week to the Melbourne Office of BMR, where they were then telexed to the United States Geological Survey (USGS) for the preliminary determination of epicentres (PDE). Final analyses were made in Canberra and the data were sent to the International Seismological Centre (ISC) in Newbury, UK. The final bulletin contained 474 events. Earthquakes which are listed in the PDEs and located near Macquarie Island are given in Talbe 9.

A large number of local earthquakes were detected during the year. Of these, over 100 were aftershocks of the large earthquake felt on the island on 21 July. A histogram of S-P times versus frequency (Fig. 2) shows the spatial distribution of the local earthquakes. The aftershocks of the large earthquake, with S-P in the 7-9 s range, are dominant. Before the earthquake a different distribution was obtained (Fig. 3) and the minimum in the S-P range 8-9 s suggests aseismicity in the region of the large 21 July earthquake prior to its occurrence. Table 10 lists the earthquakes felt on the island during 1977.

The large earthquake of 21 July took place about 75 km north of the island and with an intensity VI on the Modified Mercalli Scale.

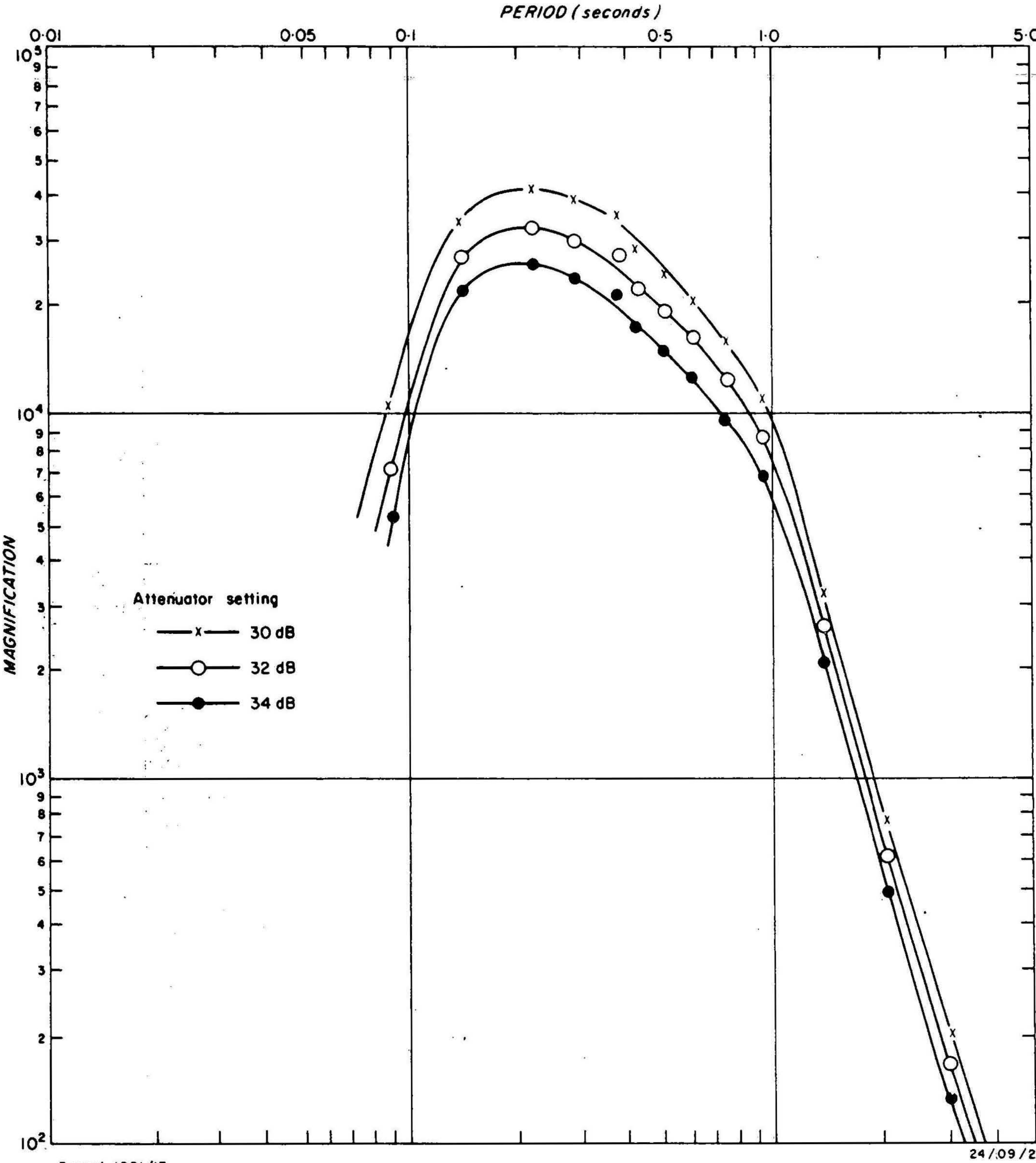

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Fig. 1 Response curve, vertical seismograph, Macquarie I. 1977

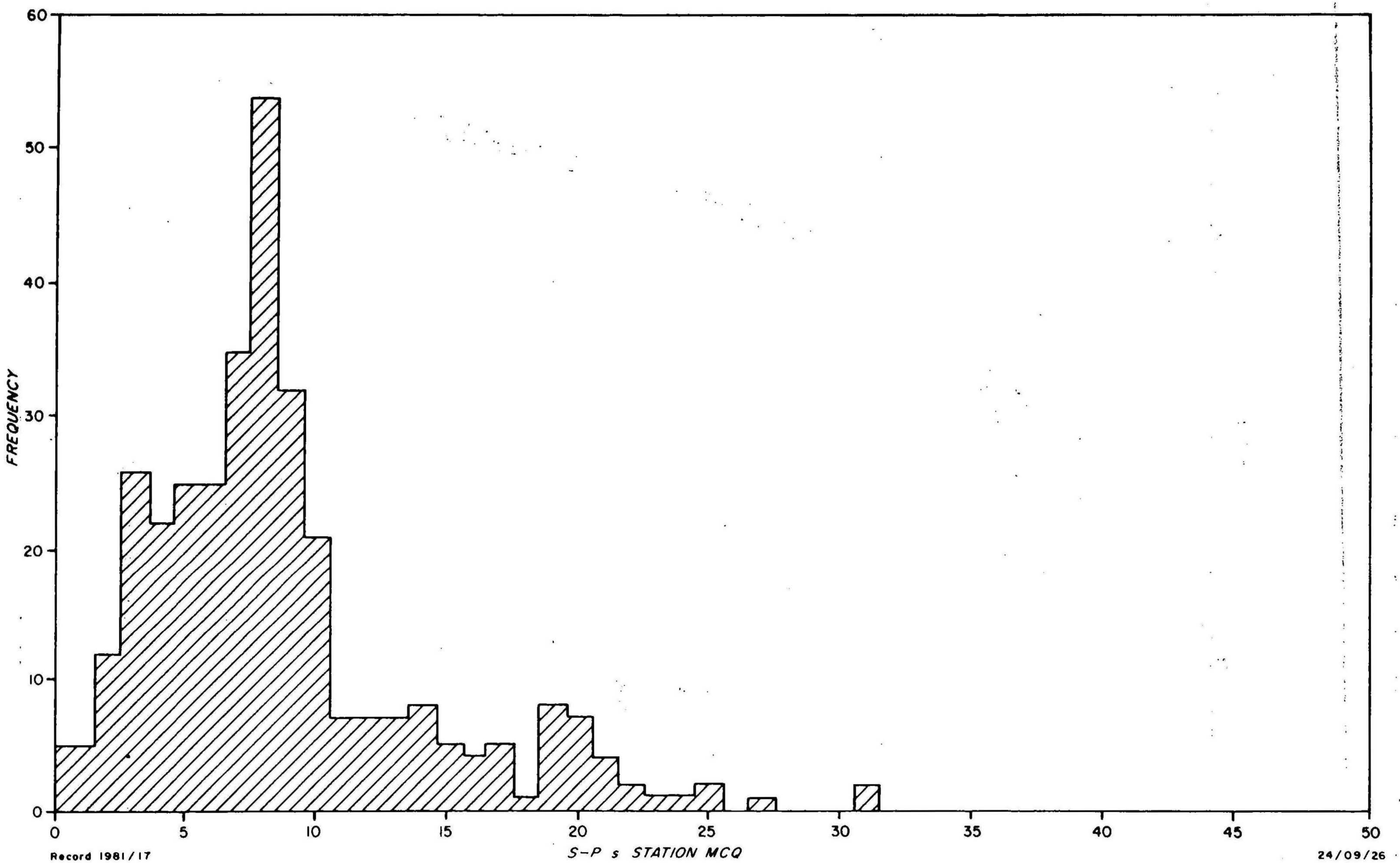

Fig. 2 S − P intervals for local earthquakes 01 Jan − 31 Dec 1977

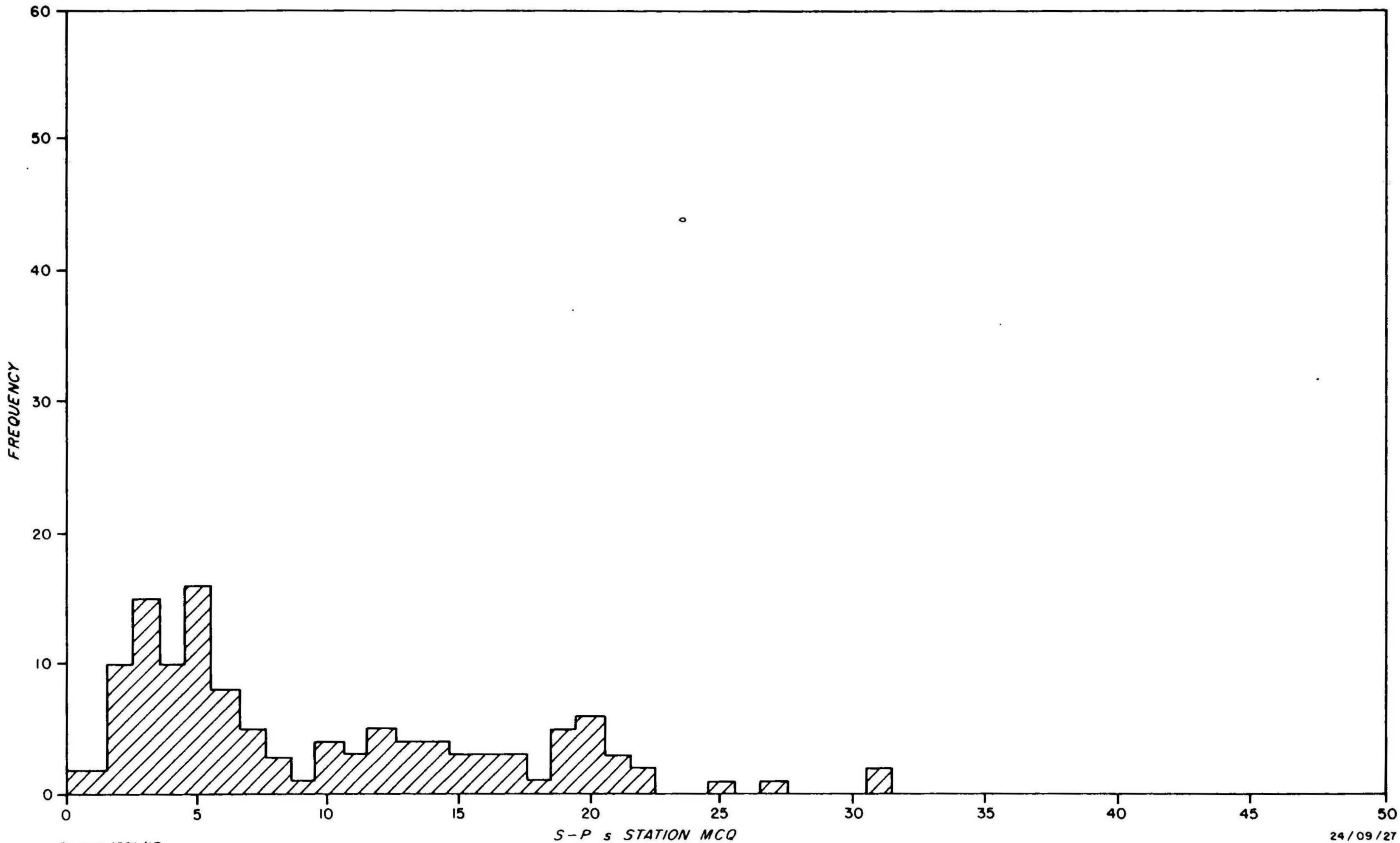

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Fig. 3 S-P intervals for local earthquakes 01 Jan-JULY 1977

No structural to buildings took place although books, tins of food, and some electronic equipment in the radio workshop were knocked from their shelves. A total of 302 stations around the world recorded the earthquake, and a body-wave magnitude of 6.4 was determined from 23 observations. Using P-wave first-motion data a focal-mechanism determination was attempted, but the result was indeterminate.

4. EQUIPMENT MODIFICATIONS

Fortunately most of the equipment functioned very well all the year and no major changes to either the magnetic or the seismic systems were necessary.

In early May, the EMI clock failed after the supply batteries were accidentally shorted out. The fault was traced to transistor BFY50. Whilst repairing the clock, the radio technician investigated irregularities in the 50-Hz square-wave pulse from the clock to the inverter. He made the modifications shown in Figure 8 and the clock functioned perfectly for the remainder of the year.

The digital multimeter battery charger failed during the year. A replacement charger was built and allowed the digital meter to be used for the remainder of the year.

5. BUILDING MAINTENANCE

The magnetic absolute and variometer buildings at Macquarie Island are now beyond the help of routine maintenance. Significant rotting has developed in large timbers forming the main frame, and they urgently need replacing. Wind-driven rain and sea-spray are also finding ways into the interior lining of both buildings, causing paint to lift away from the walls. An attempt was made to dry the absolute house using heaters, but only the north and east walls would dry sufficiently to allow painting.

As the present geophysics office is marked for removal, only the wooden window frames and doors were painted. An area under the roof was sealed to prevent snow from entering.

The seismic vault roof was caulked on the western side to stop water entering the building. Although this building is still quite sturdy, water is entering along the base of the roof. Some thought should be given to refurnishing the walls and flashing around the roof to extend the life of this very useful building.

6. OTHER ACTIVITIES

During 1977, a major building program was carried out. Assistance was given to erect fibro-cement sheeting and to mix concrete for the large new store and to paint the power house, kitchen, and exterior of the mess.

The author performed the physicist's routine for a few days whilst the physicist was on a field trip, and in the summer helped pencil for the surveyor during sun and star observations. The biologist regularly dissected elephant seals for his studies and help was given to him on several occasions. Counts of leopard seals and branded elephant seals were made during the author's daily runs along the beaches.

Assigned camp duties included operation of the greenhouse, care of the library, and bottle washing in the brewery. Three weeks were spent as "donga-slushy" and 2½ weeks as "kitchen-slushy". Another three days during the year were spent as cook during the Cook's absences down the island. Help was also regularly given on garbage and fuel supply runs.

7. ACKNOWLEDGEMENTS

The author would like to thank all expeditioners in 1977 for their co-operation. In particular the assistance of Art Coolidge (physicist) and Ken Hanson (radio technician) was much appreciated. Art carried out the daily routines whilst the author was absent from the base, and spent a great deal of time helping with the repair of the invertor. Ken repaired the EMI clock and in the process carefully explained the workings of the clock circuitry.

Finally thanks are extended to Peter Gidley who stayed over for the summer 1976-77 in order to complete the author's training.

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TABLE 1

MACQUARIE ISLAND STATION DATA

	MAGNETIC	SEISMOLOGICAL
Name:	Macquarie Island	Macquarie Island
Code:	MCQ	MCQ
Latitude:		
geographic	54° 30.0'S	54° 29.9'S
geomagnetic	-61.1	
Longitude:		
geographic	158° 57.0'E	158° 57.4'E
geomagnetic	243.1	
Elevation: (m)	8	14
Foundation:	Basalt	Basalt

TABLE 2

MAGNETOGRAPH PARAMETERS

COMPONENT	MEAN OBSERVED SCALE VALUE	ADOPTED SCALE VALUE	STANDARD DEVIATION SCALE VALUE	STANDARD DEVIATION BASELINE	TEMP COEFF $nT/^{o}C$
Normal-run					
H	19.50	19.50	0.07	2.5 nT	+2.6*
D	2.37	2.37	0.01	0.5 min	-
Z	20.91	20.90	0.09	2.7 nT	0
Rapid-run					
H	5.29	5.3	0.10	-	-
D	1.00	1.0	0.01	-	-
Z	6.57	6.6	0.03	-	-

D scale values are in minutes/mm

H and Z scale values are in nT/mm

* 3.0 $nT/^{o}C$ adopted for data reduction

TABLE 3

ADOPTED BASELINE VALUES, NORMAL-RUN MAGNETOGRAPH

FROM Date 1977		Hr Min (UT)	BASELINE VALUE	REMARKS
Horizontal Intensity				
01	Jan	00 00	12634 nT	
11	May	00 00	12639 nT	Change silica gel
22	July	00 00	12614 nT	Earthquake
Declination				
01	Jan	00 00	26° 27.3'E	
22	July	00 00	26° 30.5'E	Earthquake
Vertical Intensity				
01	Jan	00 00	63789 nT	Virtually constant all the year

TABLE 4

NORMAL RUN Z THERMOGRAPH, 1977

PERIOD					OBSERVED SCALE VALUE (St)	BASELINE (Bt)
01	Jan	to	10	May	1.485	-67.1
11	May	to	21	July	1.442	-64.4
22	July	to	30	Aug	1.496	-65.6
01	Sep	to	10	Oct	1.480	-66.2
11	Oct	to	31	Dec	1.530	-70.6

$T^{o}C \quad = \quad Bt + St.t$

where t = ordinate of temperature trace (mm).

T = Z variometer temperature

TABLE 5

PRELIMINARY MONTHLY MEAN GEOMAGNETIC VALUES AND K-INDEX 1977

MONTH	D (East)	H, nT	Z, nT	F, nT	K
January	$27^{\circ}54'.8$	12816	-63862	65135	2.02
February	$27^{\circ}55'.7$	12813	-63863	65136	2.10
March	$27^{\circ}57'.3$	12808	-63859	65130	2.05
April	$27^{\circ}58'.1$	12802	-63872	65142	2.37
May	$27^{\circ}59'.0$	12806	-63869	65140	1.73
June	$27^{\circ}59'.7$	12802	-63866	65137	1.14
July	$28^{\circ}02'.0$	12799	-63866	65136	2.05
August	$28^{\circ}00'.6$	12796	-63864	65133	2.36
September	$28^{\circ}01'.5$	12799	-63864	65134	2.25
October	$28^{\circ}01'.6$	12797	-63854	65124	2.30
November	$28^{\circ}03'.1$	12796	-63851	65121	1.95
December	$28^{\circ}03'.9$	12788	-63841	65109	1.72
Mean	$27^{\circ}59'.8$	12802	-63861	65132	2.00

TABLE 6

GEOMAGNETIC ANNUAL MEAN VALUES 1967-1977

YEAR	D (East) ° '	I ° '	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)
1967	26 46.5	-78 28.5	13084	11681	5894	-64166	65486
1968	26 54.7	-78 29.7	13053	11639	5908	-64132	65447
1969	27 02.3	-78 30.8	13026	11602	5921	-64099	65409
1970	27 09.6	-78 32.1	12996	11563	5932	-64078	65383
1971	27 13.3	-78 33.3	12963	11527	5930	-64032	65331
1972	27 22.1	-78 34.4	12937	11489	5947	-64008	65302
1973	27 27.6	-78 35.8	12905	11451	5951	-63985	65273
1974	27 34.3	-78 37.6	12865	11404	5955	-63959	65237
1975	27 43.2	-78 38.2	12847	11373	5976	-63926	65204
1976	27 51.6	-78 39.1	12822	11336	5992	-63891	65165
1977	27 59.8	-78 39.9	12802	11304	6010	-63861	65132
Mean Annual Change	+07.33'	-01.14'	-28.2	-37.7	+11.6	+30.5	-35.4

TABLE 7

ORIENTATIONS OF VARIOMETER MAGNETS

DATE	COMPONENT		REFERENCE FIELD	MAGNET N POLE	ORIENTATION	N POLE
13 Aug 77	Normal	H	12802 nT	E	0.34°	N
		D	28.0°E	N	0.98°	E
		Z	63866 nT	N	0.51°	Down
24 Oct 77		H	12802 nT	E	0.32°	N
		D	28.0°E	N	0.97°	E
		Z	63866 nT	N	0.38°	Down
11 Oct 77	Rapid	H	12802 nT	W	1.71°	S
		D	28.0°	N	0.0	
		Z	63866 nT	S	1.20°	Down
24 Oct 77		H	12802 nT	W	1.56°	S
		D	28.0°	N	0.19°	W
		Z	63866 nT	S	1.11°	Down

TABLE 8

SEISMOGRAPH ATTENUATOR SETTINGS, 1977

MONTH	DAY	TIME	ATTENUATION (dB) Vert.	Horiz.	MONTH	DAY	TIME	ATTENUATION Vert.	(dB) Horiz.
Jan	01	0008	32	2	April	01	0007	30	2
	17	0006	34	2		02	1445	32	2
	19	0315	32	2		04	0004	34	4
	22	0228	30	2		20	0020	32	2
	23	0008	32	2		21	0005	34	2
	25	0008	34	2		22	0016	34	4
	28	0003	30	2		28	0006	36	6
	30	0003	32	2		29	0006	34	4
	31	0003	34	2	May	02	0030	32	2
Feb	01	0005	34	4		06	0016	30	2
	07	0004	34	2		07	1400	32	2
	08	0006	34	4		09	0020	34	4
	14	0005	32	2		10	0006	32	4
	21	0015	34	2		12	0030	30	2
	27	0016	32	2		15	0020	32	2
	28	0012	30	2		16	0006	34	4
Mar	02	0005	32	2		18	0030	36	6
	02	1406	34	4		19	0006	34	4
	11	0750	32	2		22	0006	32	2
	13	0004	34	4		25	0006	34	4
	19	0012	32	2	June	01	0006	32	4
	20	0008	34	4		02	0106	34	4
	23	0050	32	2		07	0035	32	4
July	10	0007	30	2		12	0002	34	4
	11	0005	32	4		16	0025	32	4
	21	0005	32	4		19	0020	34	4

TABLE 8 (cont)

MONTH	DAY	TIME	ATTENUATION vert	(dB) horiz	MONTH	DAY	TIME	ATTENUATION vert	(dB) horiz
July	22	0005	30	2	Oct	05	0005	32	2
	26	0010	32	4		10	0005	36	6
	27	0030	34	4		10	1336	34	4
	28	1400	32	4		15	0005	34	6
	30	0005	30	4		17	0025	34	4
	31	0005	32	4		18	0035	34	6
Aug	01	0005	34	4		19	0035	34	4
	02	0005	32	4		20	0005	32	4
	06	0015	30	4		21	1420	36	8
	09	0035	32	4		22	0010	34	6
	11	0015	34	4		24	0005	36	8
	15	0005	32	4		25	0015	34	6
	21	0005	34	4	Nov) Dec)	See 1978 annual report			
	28	0015	32	4					
	30	0045	34	6					
Sep	08	0020	32	4					
	18	0035	30	4					
	19	0010	32	4					
	24	0005	34	4					
	31	0040	32	4					
Oct	03	0015	34	4					

TABLE 9

EARTHQUAKES NEAR MACQUARIE ISLAND, LOCATED BY USGS

DATE	ARRIVAL TIME (UT)			GEOGRAPHIC CO-ORDS		DEPTH	MAGNITUDE	
1977	HR	MIN	SEC	LAT. °S	LONG, °E	KM	MB(GS)	MS
Jul 21	11	53	22.5	53.863	158.602	33	6.4	6.7
Jul 21	12	34	29.3	53.722	159.594	33	5.6	
Sep 11	05	07	29.7	59.631	150.286	33	5.4	5.1
Sep 26	04	56	57.1	60.039	150.585	33	5.3	5.7

TABLE 10

EARTHQUAKES FELT ON MACQUARIE ISLAND, 1977

DATE	P-ARRIVAL TIME HR	MIN	SEC	M.A.G. MB(GS)	DIST. KM	MM Intensity at ANARE STATION
Jan 14	03	33	57.8		50	II
Feb 13	21	18	18		80	III (at Hurd Pt)
May 22	04	33	16.0		30	IV
Jul 21	11	53	28.4	6.4	75	VI
Jul 21	12	11	04		75	V
Jul 21	12	34	41.7	5.6	75	V
Jul 21	15	33	19.0		65	III
Jul 21	18	58	54.1		30	III
Sep 23	19	52	29.0		20	III