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MACQUARIE ISLAND GEOPHYSICAL OBSERVATORY, ANNUAL REPORT 1970

by

J.R. Meath

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SUMMARY

The operation of a seismograph and two La Cour variographs was maintained at Macquarie Island throughout 1970.

An EMI digital clock and a new power and timing control panel were installed as part of the program of standardization of equipment at BMR's Antarctic observatories. New combined scale-value and orientation coils were placed over the normal-run H and D variometers after minor modifications.

From July to September a microseism survey of the northern plateau was carried out in an effort to find an improved seismometer site where microseismic activity is appreciably less than that experienced at the present recording site. This survey is described in a separate report.

Scientific results are also published separately.

1. INTRODUCTION

During 1970 the author was responsible for the maintenance of the Macquarie Island seismological and magnetic observatories. He succeeded K.F. McCue in December 1969 and was relieved by M. McDowell in December 1970. All accommodation and logistics were provided by the Antarctic Division, Department of Supply.

The seismological observatory has been in operation since 1950, and the magnetic observatory since 1951. Previous instrumentation and operations have been described in earlier reports, e.g. those by Sutton (1969) and Muir (1968).

The instruments used were La Cour normal-run and rapid-run variographs and a short-period vertical-component Willmore seismometer coupled to a BMR recorder.

2. MAINTENANCE

Geophysics office

This building was erected in early 1968. Basic construction is of prefabricated insulated sections of 'Hardiflex' held together by a system of internal tie rods. Windows are timber-framed and double glazed to provide insulation.

In January, the fascia board over the porch was removed and trimmed. The sign 'GEOPHYSICS-BUROMIN' was applied to it before it was replaced.

Later in the year, a concrete step was constructed at the entrance and a track was cleared through the seal wallows across to the Physics building. This was covered by gravel for consolidation.

The water supply to the dark room became blocked intermittently during April, so the system was flushed using the fire pump. A vent pipe was installed to remove air blockages, and the water filter was replaced.

A hole in the southern gable permitted drift snow to accumulate in the ceiling during October; as a result the ceiling fire detectors were triggered by a short circuit during a thaw. The detectors were sealed using a special plasticine insulator, and the gable was patched with thin sheet lead, attached by self-tapping stainless steel screws.

All exterior timberwork, the fire buckets, the water drum, and the garbage drum were painted in November.

Door hinges were oiled once a month. Water leaks were frequent around the western window, and all attempts to arrest these were only temporarily successful.

A twin-flex cable was laid under the floor from the anteroom to the inner office to supply 24-volt d.c. emergency battery power to the EMI digital clock.

Seismic vault/office

No internal maintenance was done during 1970, in anticipation of the phasing out of seismic recording at the vault. However, the junction between the vault and office was resealed using a rubber strip dipped in a bituminous compound ("blackjack"). The roof was painted with a mixture of this material and kerosene, and the walls were scraped and painted. Owing to excessive wind abrasion the western wall was undercoated before final painting. During March the steps to the vault were cleared of a heavy overgrowth of vegetation.

Variometer hut

The external plastic sheeting has remained intact since it was fitted in 1965 and no defects were noticed. The exposed timbers were freshly painted and guy wires were checked periodically. One wire was replaced after being broken by a horse in April. A low rock wall was build in a semi-circle in the lee of the hut to prevent horses and seals from contacting these wires and disturbing the variometers whilst taking shelter from westerly gales.

Absolute hut

The sheeting on this hut also was in good condition. However, water seepage in the southwest corner had caused extensive rotting of the timbers so a corner flashing was made from sheet lead and copper nails.

Either seals or horses broke the southwest corner brace later in the year and this was reinforced using non-magnetic materials. Most of the exposed timberwork was painted in November. The western faces were given special attention. The skylight was found to leak and this was resealed in January.

A three-inch high removable footstand was constructed from pinewood sections using brass screws and placed around the east pier.

Micropulsation hut

The maintenance of this building for the University of Alaska was carried out by the author.

The roof and exterior walls were painted in October and the eaves were repaired and covered with sheet lead to prevent further deterioration. A timber grid was placed at the doorway for convenience during periods of heavy rain, when large pools of water accumulated in the area.

3. MAGNETIC OBSERVATORY

The instruments in operation at Macquarie Island are:

1. La Cour normal-run (15 mm/h) three-component variograph.
2. La Cour rapid-run (180 mm/h) three-component variograph.

Table 2 lists the parameters of these variographs.

The control instrumentation was modified in 1970 and Plate 1 gives a schematic representation of the present system. The changes made were in line with the current program of standardization of equipment at BMR's Antarctic observatories. Alterations were accomplished as far as time and materials were available.

Absolute instruments used during 1970 were:

D : Askania declinometer 505 and circle 620

H : QHMs 172, 177, and 179

Z : BMZ.236

F : Elsec PPM.339

Intercomparisons were made in December 1970 as follows:

D : Dec.333 against Dec.505

H : HTM.704 and QHM.178 against QHM.177

F : PPM.424 against PPM.339

QHM.179 was returned to Melbourne and replaced by QHM.178, which had been overhauled and recalibrated at Rude Skov (Denmark).

Routine

Both normal-run and rapid-run charts were changed between 2355Z and 2359Z daily. These were processed immediately and any adjustments were performed as soon as possible so as to confine minor record losses to the first hour. The H and Z variometer temperatures were read before 2355Z and a plot of Z temperature ordinate (scaled from the photographic record) versus H variometer temperatures (read from the thermometer) was maintained throughout the year.

K-indices were measured and forwarded to Melbourne with the monthly means, baseline values, and scale values at the end of each month.

Twice weekly, control observations were made, usually on Tuesday and Friday, or when magnetic conditions permitted. Scale values for the Z and H normal-run variometers were also obtained twice weekly. In the last week of each month rapid-run scale value and parallax tests were completed, and the difference in F between the west pier and the external auxiliary pier was measured with the proton precession magnetometer (PPM).

Silica gel was replaced in each variometer on the first day of every second month. Anti-misting compound was occasionally applied to lens surfaces.

During July the US oceanographic research vessel USNS 'Eltanin' was operating in the Macquarie Island region. Upon request, it was supplied with K data for July by radio.

Record losses from January 1970 to December 1970 were as follows:

Normal-run. A total of 104 hours comprising: 38 hours - synchronous drive failure or jamming; 30 hours - installation of coils, azimuth determination, and orientation tests; 24 hours - accidental exposure; 9 hours - H fibre replacement; 3 hours - trace adjustments.

Rapid run. A total of 129 hours comprising: 76 hours - carriage not reset or jammed; 24 hours - synchronous drive failure; 12 hours - cover tilted, record partly fogged; 5 hours - adjustment of D lens system; 4 hours - replacement of mirrors; 3 hours - replacement of normal-run fibre; 4 hours - orientation tests; 1 hour - installation of coils, alignment of coils.

Operations and installations

The following work was performed at Macquarie Island magnetic observatory in 1970. Detailed descriptions of the operations are compiled in the station log, and relevant data are supplied in the appendices, plates, and tables listed below.

1. The old scale-value coil wiring for the normal-run variometers was removed and replaced by new wiring in line with the standardization program. A minor H base line value change occurred at this time (see Table 1).

2. The azimuth of a reference line through the variometer room was redetermined by transfer from the absolute hut. Details are supplied in Appendix 1 and Plate 2.

3. New scale-value/orientation coils were installed, modified, and reinstalled on the H and D normal-run variometers. These replaced the original Helmholtz coils (see Plate 3). It was found that light rays to and from the H and Z variometers were obstructed by parts of the coil frames, and the variometers could not be repositioned to overcome this defect. Therefore the offending sections were carefully cut from the coil frames and then the parameters were thoroughly rechecked. Operation was then completely satisfactory.

4. Orientation tests were done on all variometers. Results are listed in Table 4.

5. The magnetic moments of the deflector magnets used in the orientation tests were determined. These were found by placing the test magnets at the first Gauss position with respect to the declinometer magnet, as described by McComb (1952, p. 5). The results are compiled in Table 5.

6. The horizontal intensity and total intensity differences between the east and west piers of the absolute hut were measured using a QHM and PPM (see Tables 7 and 8). These measurements were made in order to determine the vertical intensity pier difference (see Appendix 2).

7. As the old ones had deteriorated, the rapid-run strip mirrors were replaced early in the year.

8. A metal cabinet was constructed from filing cabinet materials to house the new power and timing control panel, the magnetograph control panel, the TMU2 timing program unit, and the EMI digital clock.

9. The Askania circle was cleaned, and the optics were adjusted.

10. On 1 February the quartz fibre in the H normal-run variometer was removed, and sealing wax was cleaned from the suspension brackets. A new fibre was installed and adjustments were made to restore all H traces. This was done in an attempt to eliminate the wide scatter and steep drift of the H baseline values which had occurred since the fibre was installed in 1968; wax had been used in that installation and was suspected to be the cause. Subsequent analysis of baseline valued data has proved this action to be effective.

Malfunctions and difficulties

Various problems were experienced during the year and brief descriptions of these are provided.

1. Trace adjustments on the normal-run variograph were attempted early in the year, and every effort was made to obtain even and sharp traces. This was finally achieved. However, the D trace tended to be too weak during storm activity and on these occasions the lamp current was increased whenever possible. On 3 March the D baseline mirror was tilted in an attempt to obtain improved D trace and D baseline intensities across the slit. Most spot improvements were achieved by movement of the cylindrical lenses.

2. The slightly loose meshing of the synchronous drive on the normal-run recorder drum caused a jerky drum rotation with subsequent breaks in the traces. This was remedied by applying a frictional load in the form of an oiled leather strap wrapped around the end of the drum shaft and given a variable tension by an atached rubber band connected to a lever. This lever could be moved back and forth to adjust the frictional load on the shaft.

3. The rapid-run carriage tended to jam easily, so it was removed, cleaned, and oiled. Jamming or premature jumping of the carriage could also be avoided by applying a small start to the saw-toothed drive shaft.

4. The D lens system on the rapid-run carriage often became maladjusted after removal of the carriage for scale-value tests. This was found to be due to a missing screw in the spring-loaded lens holder; the screw was found and replaced.

5. In April the Z rapid-run magnet became unresponsive and was noticed to be stuck against the western damping block. This was possibly caused by successive earth tremors. The magnet was removed, cleaned, and re-centred on the agate block. A small change in sensitivity was observed in the following scale-value tests. Magnet orientation was measured within the next week.

6. In December 1969 the TMU2 observatory timing unit gave spurious time mark pulses, and this fault was finally attributed to a malfunction in the pulse shaper unit. Transistor Q_2 (2N3566 NPN) was replaced. The TMU2 is very susceptible to transient electrical disturbances caused by switching of electrical appliances.

7. The new power and timing control panel PPT-1 was installed with the EMI digital clock about mid year. The control instrumentation at December 1970 is shown schematically in Plate 1. Difficulties were experienced through triggering of the TMU2 by the 240-volt mains failure relay in the control panel. The relay was left inactive, and notes were left for the succeeding geophysicist as a guide to solving this problem. Strong radio-frequency pick-up was noticed in the control panel meters. However, it is believed that this may be eliminated when the recorder motors are eventually driven by a.c. power from the digital clock via the panel and thus providing a load. At present the a.c. power comes directly from the frequency stabilizer connected to the mains supplied d.c. to a.c. inverter.

8. Problems experienced with the Elsec PPM were:

(a) The instrument gave erratic readings below a critical temperature, and for this reason was stored in the heated Alaskan micropulsation hut between observations.

(b) A loose cable connection was repaired.

(c) High winds blew the detector head off the external pier into rocks. A broken piece of encasing resin was fixed using 'Araldite', which is non-magnetic. The head suffered no internal damage.

4. SEISMIC OBSERVATORY

The system housed within the vault comprised a Willmore Mk II seismometer (free period 0.98 sec), a Geotech control box, a Benioff short-period galvanometer (free period 0.2 sec), and a single-channel BMR drum recorder with a chart speed of 30 mm/min. Time marks were provided at the commencement of each minute by a Mercer chronometer. The duration of the pulse was either 2 or 4 seconds, depending on which chronometer was used.

Lamp power was provided by trickle-charged 6-volt accumulators. Emergency power for the recorder synchronous drive was obtained from a d.c./a.c. inverter connected to the mains supply, and on continuous standby with a bank of dry cells.

Several lamp failures occurred during the year and in each instance a readjustment of the optics was necessary after replacement of the lamp. The battery charger was badly corroded and failed in July. It was replaced by a new Boss charger, Model 4S/R; this provided charging currents from 2-8 amperes into six 24-volt batteries.

Seismic charts were changed daily at 2300Z (11am station time). Any necessary adjustments could then be carried out before the magnetic record changes at 2400Z. A daily time check on the Mercer chronometer was provided by VNG signals via a Labtronics radio receiver - this usually had to be done before 2310Z as station radio transmissions interfered with reception after this time. Seismic records were processed daily and data were sent to Melbourne the same evening.

Of the 215 events recorded, 180 were initially reported to USCGS via Melbourne. Five T phases were identified.

System tests were done at three-month intervals and consisted of seismometer and galvanometer free-period and damping tests and a polarity check. Seismometer free-period was maintained at 1.00 sec. $\pm$ 2% and the system damping ratio at 22:1. Recording was maintained at the O dB attenuator setting throughout most of the year - any other settings and their duration have been noted in the station log. Accumulators were checked every Monday for electrolyte level and specific gravity; connectors were cleaned and greased when necessary.

During station relief activities in early December 1969 the Willmore Mk I seismometer (operative 1968-69) was replaced by a Mk II brought from Melbourne. The Mk I mass was prone to become stuck on its stops and it was later found to have a broken spoke. This was replaced and the free-period set at 0.98 sec. Later in the year the Mk I was used in a microseism survey on the plateau.

The minute and hour hands of the Mercer chronometer 18385 tended to slip at one stage and repairs were attempted but were only temporarily successful. It was decided to return this instrument to Australia for repairs in December 1970. However, on November 21 the main spring of chronometer 21170 collapsed during winding, so it was returned to Melbourne and 18385 retained.

Record losses amounted to 52 hours from December 1969 to December 1970, and were caused by: 19 hours - blown lamps; 24 hours - short on seismometer output; 6 hours - tests and maintenance; 3 hours - replacement of chronometer.

In the period July to September extensive field tests were carried out on the plateau up to 3 km from the vault in an effort to find an improved seismometer site with a significant reduction in microseismic level. At this time repeated clamping and unclamping of the Mk I seismometer mass again weakened one of the spokes, which was replaced. This survey is described in a separate report (Meath, 1971).

5. OTHER DUTIES

Besides carrying out the normal observatory routines described previously, the author was responsible for the operation of the tide gauge for the Horace Lamb Institute for Oceanographic Research (Flinders University). Records were changed every three or four days and time corrections noted daily. Only minor recorder troubles were experienced and all relevant data were noted in a log book which has been forwarded to the Institute.

A three-component (H, D, Z) micropulsation unit was maintained for the University of Alaska. All routine record changes, time corrections, and building maintenance was done by the author; the physicist attended to any major instrument problems.

The master chronometer in the power house was checked daily for the diesel mechanic, and a log of corrections and adjustments was kept near the control unit.

Minor survey levelling was completed for the Antarctic Division in the station area and a new fire main line was surveyed and pegged. The azimuth and elevation of the physicist's synchronous satellite tracking antenna were determined using the theodolite.

In addition to painting the five buildings mentioned earlier, assistance was given where possible in the painting of fire extinguisher boxes, garbage drums, and building signs.

Other activities included carrying of building materials onto the plateau for the biology program, and assisting in bird banding and seal counting.

About ten days were spent as stand-in physicist.

Valuable experience was attained in the culinary arts by assisting the cook during celebrations and by acting as steward and cellarmaster. About two weeks were spent on 'slushy' duties, and frequent assistance was given in garbage runs.

6. ACKNOWLEDGEMENTS

The author wishes to thank all members of the 1970 expedition for their assistance. In particular, electrician R. Hann and physicist B.J. Watkins are thanked for their stand-in duties during the author's absence from the station, and Expedition Assistant W. Denereaz for his advice and help in building maintenance. The cook, W.P.P. Brandt, provided able assistance in the field, and the co-operation of the Officer-in-Charge J. Bennett was greatly appreciated.

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APPENDIX 1

Determination of the azimuth of a reference line in the variometer room

A small lamp was used to mark the end point of the traverse line on the spacing bar fixed to the north wall of the variometer hut (see Plate 2). The physicist then assisted by sighting through the theodolite while the author moved the lamp laterally until the lamp was noticed to be brightest. The focusing was then adjusted and a finer image obtained.

The circle was read three times (refocusing on the filament each time), and the filament position was then marked on the north spacing bar and labelled 1970 TRAVERSE LINE.

A sight was next made on the centre of the E pier in the absolute hut (by sighting both telescopes on one another). Three separate readings were taken, and three observations of the pier telescope sighted on the theodolite established the backsight.

Finally, three separate values of the N mark were taken from the E pier. From these observations the traverse line bearing of 24° 06.2' $\pm$ 0.8' was determined (see Plate 2). It was marked on the spacing bars.

A reference line bearing 29°E was required for alignment of the new scale-value/orientation coils. This direction was chosen (by HQ) as being within 2° of the present declination and in the sense of the secular variation. Thus the scale-value error caused by misorientation of the coils will be insignificant for 15-20 years, if the present trend continues, and frequent re-alignment of the coils will be unnecessary.

This line was established by measuring the distance between the spacing bars and offsetting one end of the line. The separation was 351.5 cm so that 1 mm offset equalled 1 minute of arc.

The estimated maximum error in the direction of the reference line, assuming the azimuth of the "N mark" was correct, was:

Accumulated circle reading errors	= 0.8'
Marking error, spacing bar	= 1.0'
Maximum error	= 1.8'

which is within the required accuracy of 0.1°.

APPENDIX 2

Calculation of the difference in vertical intensity between Pier E and Pier W

Pier W is used for Z (BMZ) observations and Pier E is used for D and H observations; F is observed on an external pier and the results are corrected to Pier E.

When deriving Z baseline values from F and H observations, these two values must be reduced to a common point by the application of station differences. Pier E has been adopted as the common (reference) point at Macquarie Island.

It is therefore necessary to know the difference in vertical intensity between piers E and W for comparison of PPM determinations of Z (obtained from F and H at pier E) and BMZ determinations observed on pier W. As the BMZ cannot be read on Pier E, the following method was applied.

From the relationship

$$Z^2 = F^2 - H^2$$

we derive

$$dZ = (F/Z)dF - (H/Z)dH$$

where dZ, dF, and dH are the differences (Pier E - Pier W) in Z, F, and H respectively. The approximate mean field values in 1970 were Z = 64,000, F = 65,400 and H = 13,000 gammas. Inserting these in the second formula, we obtain

$$dZ = 1.0_2\, dF - 0.2_0\, dH$$

From Tables 7 and 8 the median measured pier differences were dF = -1 and dH = -1 gamma. Hence, dZ = -1 gamma. This is the numerical difference in vertical intensity, in the sense Pier E - Pier W. It is the correction to be applied to Z readings obtained on Pier W, ignoring the general negative sign of Z.

In practice the calculated difference is negligible.

TABLE 1

BASELINE VALUE CHANGES

Variometer (normal-run)	Date	Time UT	Remarks
H	01/02/70	0300	Change of H fibre between 0000 and 0300.
	01/04/70	0000	Change of silica gel in variometer.
	18/05/70	0000	Installation of new coil wiring.
	01/06/70	0000	Change of silica gel in variometer.
	01/08/70	0000	Change of silica gel in variometer.
D	17/01/70	0000	Adjustment of cylindrical lens.
	03/03/70	0000	Tilt of baseline mirror on variometer.
Z		NIL	

TABLE 2

MAGNETOGRAPH DATA

Component		Adopted scale values	Standard deviations		Temperature coefficient gammas/°C
			Scale value	Baseline value	
Normal-run	H	19.30	± 0.06	± 2	±3
	D	2.35 min.	-	± 0.3	-
	Z	20.75	± 0.04	± 3	0
Rapid-run	H	5.4	± 0.04	-	-
	D	1.00	± 0.00	-	-
	Z	6.35	± 0.05	-	-

D values in minutes or minutes/mm

H & Z values in gammas or gammas/mm

TABLE 3

PARALLAX CORRECTIONS

Month	Normal-run			Rapid-run		
	Z	H	D	Z	H	D
Jan.	-	-	-	+40	+30	+10
Feb.	0	0	.20	+40	+30	+10
Mar.	0	+15	-60	-	-	-
Apr.	0	0	-60	+38	+27	+6
May	0	0	-60	+40	+22	+7
Jun.	0	0	-60	+37	+24	+6
Jul.	0	0	-30	-	-	-
Aug.	-	-	-	-	-	-
Sep.	0	0	-30	+38	+24	+8
Oct.	0	0	-30	+38	+23	+8
Nov.	-	0	-30	+38	+24	+8

Correction in seconds; observed time of event plus correction equals true time of event.

TABLE 4

ORIENTATIONS OF VARIOMETER MAGNETS

Component		Date	Orientation Magnet N Pole
Normal-run	H	27/10/70	E 0.°3 N
	D	27/10/70	N 1.°1 E
	Z	27/10/70	N 0.°2 down
Rapid-run	H	31/10/70	E 0.°4 N
	D	31/10/70	N 0.°3 E
	Z	28/04/70	S 0.°1 down

Magnetic meridian used 27.2°E; values corrected to the mean field (H = 13,000 gammas, Z = 64,080 gammas)

TABLE 5

MOMENTS OF ORIENTATION MAGNETS

Magnet	r cm	u minutes	H oersted	M* cgs
Z orient	220	37.5		
		37.9	0.12943	7570
		38.0		
BMZ.236/3	110	34.7		
		34.8	0.12959	870
		34.5		

$*M = Hr^3 (\tan u)/2$

TABLE 6

SCALE-VALUE / ORIENTATION COIL PARAMETERS

Coil Pair	Coil constant (gammas/mA)		Height of centre of coil above resting plane on variometer (equivalent to height of magnet)	Mean non-orthogonality of coils
	Scale value coil	Orientation coil	cm	minutes
H Normal-run	8.04	8.04	13.20 ± 0.05	3 (range 1-5)
D Normal-run	8.04	8.04	11.85 ± 0.05	2 (range 1-4)

TABLE 7

DIFFERENCE IN H BETWEEN PIERS E AND W

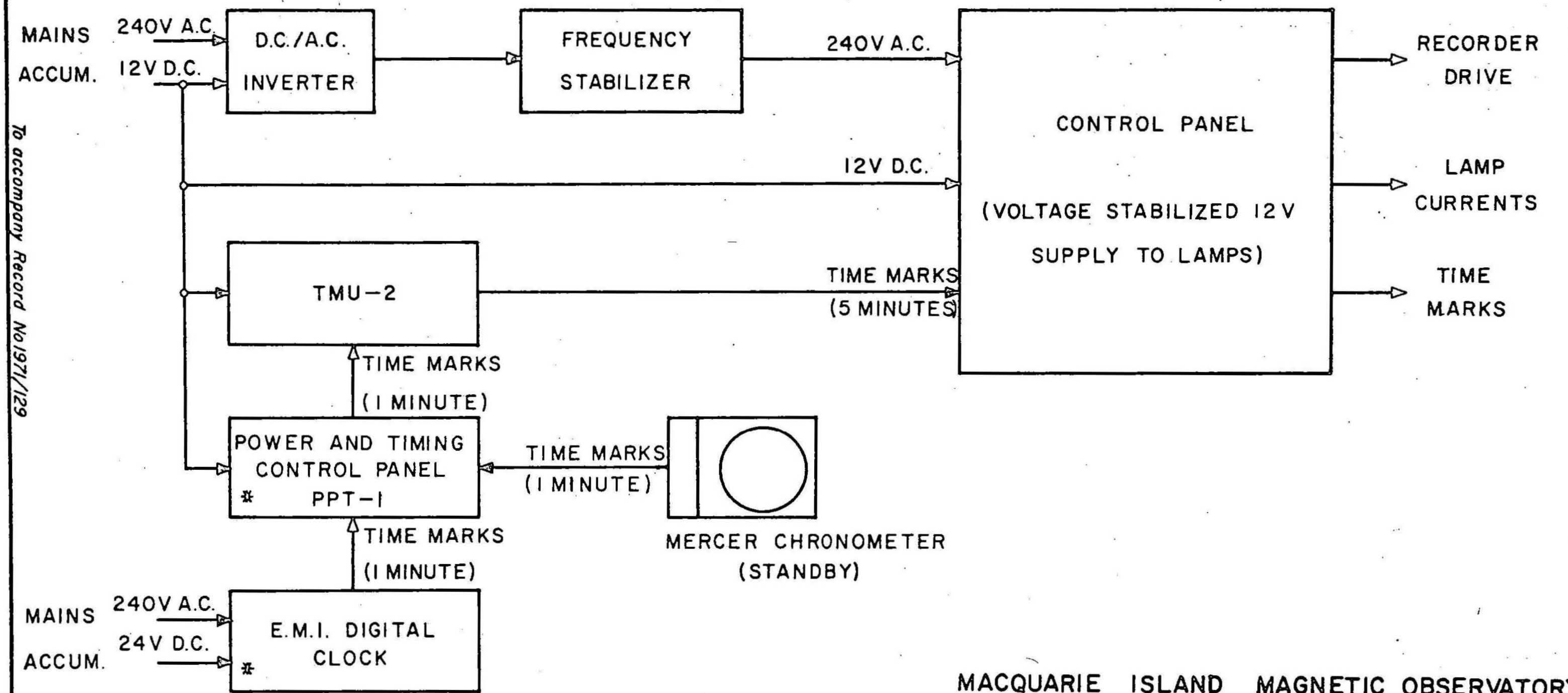
QHM	Date	Pier	H Base at Standard Temp.		Mean difference Pier E - Pier W gammas
179	06/01/70	E	12772 gammas	1	
	"	W	771 "	-1	
	"	E	770 "	-5	-1.0
	"	W	775 "	2	
	"	E	777 "	1	
	"	W	776 "		
177	10/01/70	E	12753 "	-1	
	"	W	754 "	0	
	"	E	754 "	0	-0.3
	"	W	754 "	-3	
	"	E	751 "	0	
	"	W	751 "		
177	14/01/70	E	12762 "	1	
	"	W	761 "	1	-1.0
	"	E	762 "	-3	
	"	W	765 "		
177	19/01/70	E	12757 "	-2	
	"	W	759 "	-2	-2.0
	"	E	757 "	-2	
	"	W	759 "		
			Mean :	-0.8 ± 0.7	

TABLE 8

DIFFERENCE IN F BETWEEN PIERS E AND W

Date	Pier	Count	Total Field gammas	Difference E-W gammas
Jan, 1970	E	36771	65408	0
	W	36771	65408	0
	E	36771	65408	-3
	W	36769	65411	-2
	E	36770	65409	0
	W	36770	65409	0
	E	36770	65409	-4
	W	36768	65413	0
	E	36768	65413	-2
	W	36767	65415	-2
	E	36768	65413	-2
	W	36767	65415	
	E	36755	65436	-4
	W	36753	65440	0
	E	36753	65440	-1
	W	36752	65441	-1
	E	36753	65440	-1
	W	36752	65441	-1
	E	36753	65440	-1
	W	36752	65441	
			Mean :	-1.3 ± 1.8

Hence pier difference in Z = -1 (E-W) gamma



(ACCUMULATORS ON CONTINUOUS TRICKLE CHARGE)

* NEW INSTALLATIONS 1970

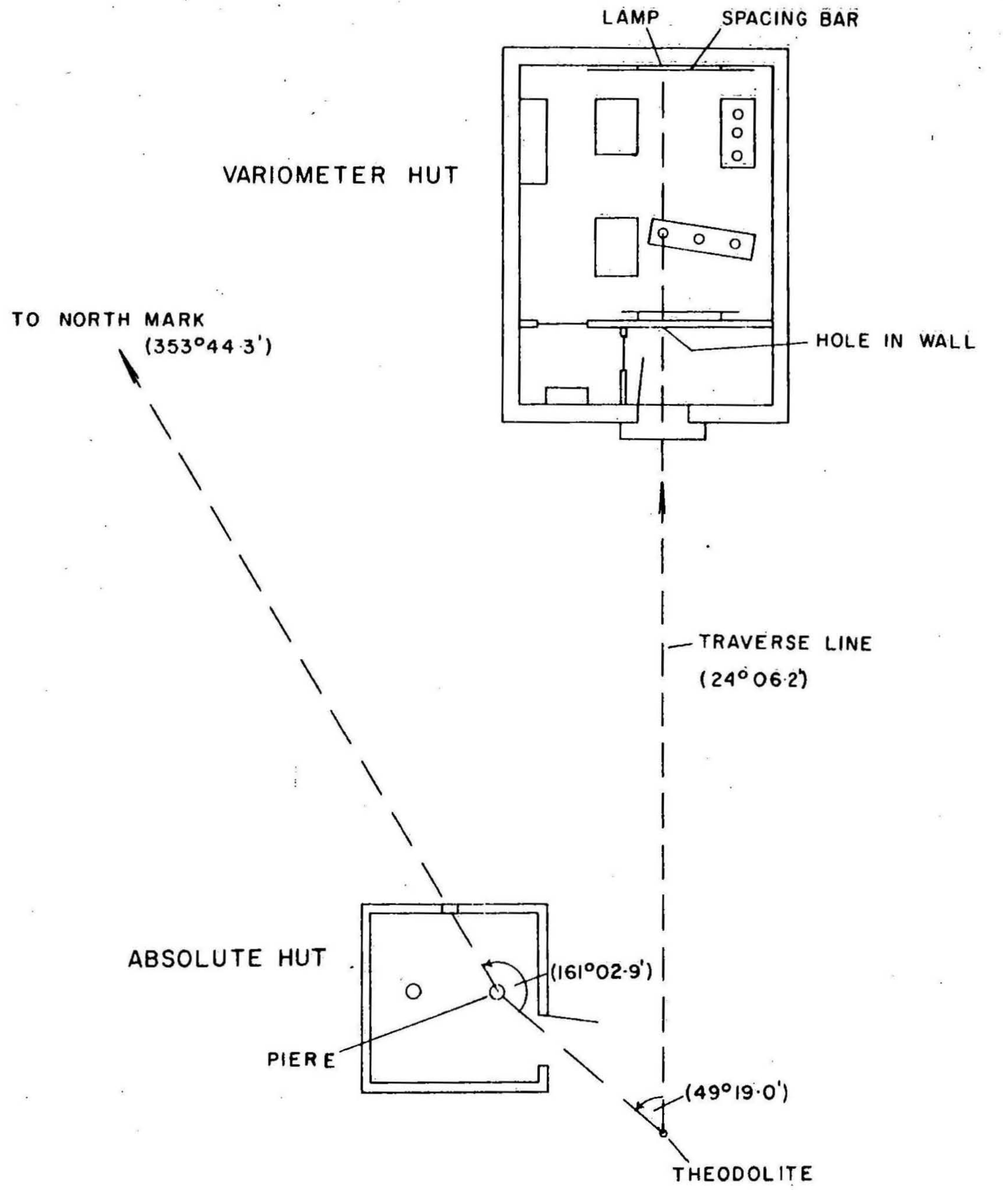
MACQUARIE ISLAND MAGNETIC OBSERVATORY

POWER AND TIMING SYSTEM

PLATE 1

To accompany Record No 1971/129

ANT B9-22A

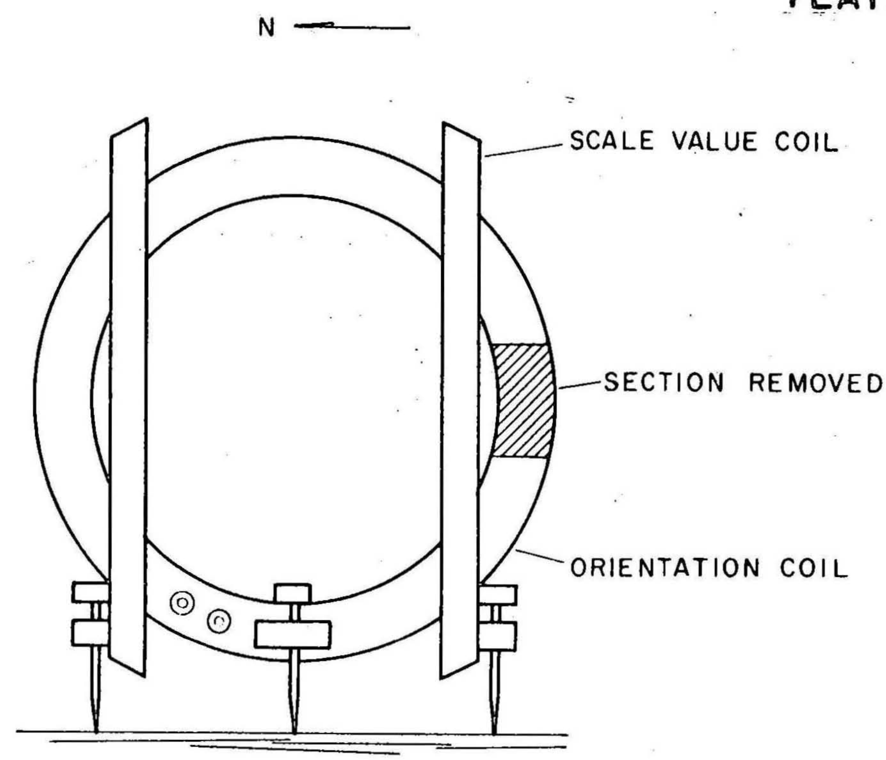


TRANSFER OF TRUE BEARING TO VARIOMETER ROOM

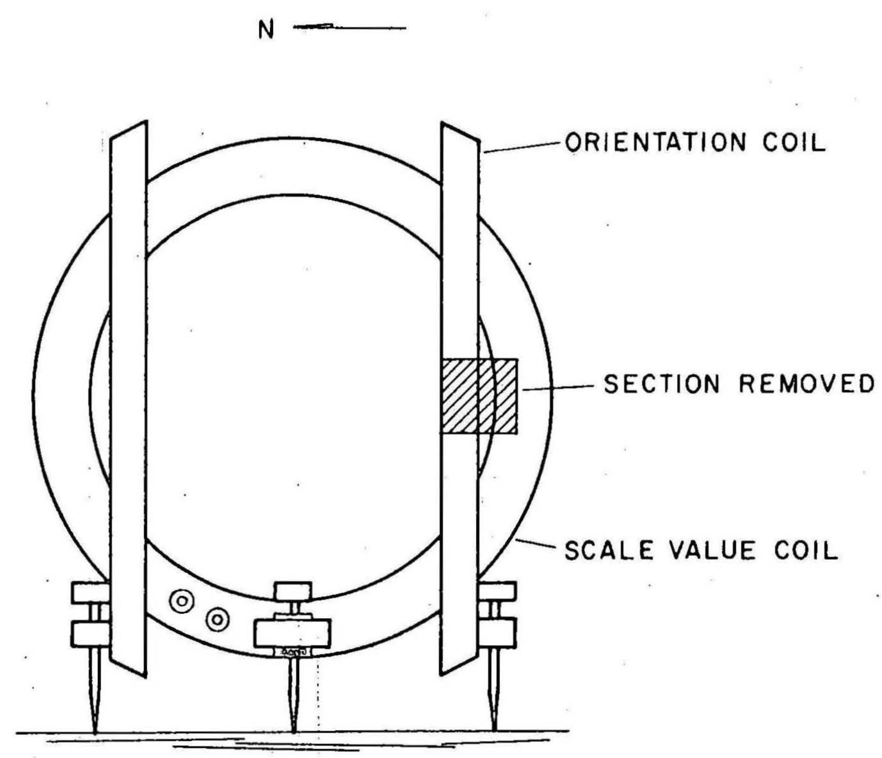
To accompany Record No 1971/129

ANT/B9-23A

PLATE 3



H COIL



D COIL

SCALE-VALUE/ORIENTATION COIL MODIFICATIONS

To accompany Record No 1971/129

ANT/B9-24A