COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1971/13

Macquarie Island Geophysical Observatory, Annual Report, 1969

by

K. F. McCue

Record 1971/13

MACQUARIE ISLAND GEOPHYSICAL OBSERVATORY, ANNUAL REPORT 1969

by

K.F. McCue

CONTENTS

TABLES

APPENDICES

ILLUSTRATIONS

SUMMARY

The normal geophysical programme was carried out in 1969, the year being the twentieth of seismic and the nineteenth of magnetic recordings at Macquarie Island. Instruments comprised normal and rapid-run magnetographs and a vertical-component seismograph.

A seismic site testing project carried out in 1967 and 1968 was extended in 1969 to include the plateau area. The best site tested during 1969 should give a reduction in background noise of 2:1 compared with the existing vault.

A new tide gauge was constructed for the Oceanographic Research Institute at Flinders University, after the original gauge ceased functioning. Various tests and modifications were carried out during the year, resulting in a system which should require little maintenance during 1970.

The University of Alaska micropulsation programme was continued uneventfully; the only modification was to increase the magnetic tape recording speed by replacing the synchronous drive motor.

1. INTRODUCTION

The Bureau of Mineral Resources Geology & Geophysics (BMR) has carried out a programme of geomagnetic and seismological observatory work at Macquarie Island since the early 1950s. Previous Records describe the observatories, their history and operations (e.g. Major, in preparation). This Record outlines operations from 14 December 1968 to 9 December 1969, when the annual changeovers took place.

The work is part of the Australian National Antarctic Research Expeditions (ANARE) programme, for which the Antarctic Division, Department of Supply, provided logistic support and accommodation.

The station was visited by the ANARE vessel Nella Dan on 22-23 March 1969, returning from Antarctica; P.M. McGregor (H.Q. Observatory Group, Canberra) inspected the observatory during this visit, and left test equipment which was not available when the author left Australia.

2. GEOMAGNETISM

Both the normal-run (15 mm/hr) and rapid-run (180 mm/hr) La Cour magnetographs operated continuously during 1969. Control observations were carried out twice weekly except during the author's absence on field trips or when the magnetic activity was too high. The absolute instruments in use were: QHMs 177, 178, 179, Askania Declinometer 640505, BMZ 236 and Elsec proton magnetometer PPM 339. QHM 178 was replaced by QHM 172 at the changeover in December 1969. All the Macquarie Island QHMs will be returned one by one for replacement of their fibres, as it has been found that old fibres are affected by humidity.

During the outgoing changeover, comparisons were carried out using instruments QHM 172, HTM 154 and Askania Declinometer 313. A comparison PPM was to be used but arrived damaged, and no total intensity (F) comparisons were obtained.

An Elsec proton magnetometer, measuring total intensity (F), was used in conjunction with the QHMs to give a Z baseline value independent of the BMZ. It is planned to replace the BMZ by the PPM in control observations, though still retaining the former on standby. During the year, corrosion of plug-in-unit terminals on the Elsec caused a month's loss of results.

The detecting bottle had to be used on a pier about 20 feet east of the absolute hut, because the PPM hardware is magnetic.

To relate the PPM reading at the external pier (PM) to a value at the BMZ pier (PW), total intensity differences between these piers were measured each month. The mean result was

$$PW = PM - 11 \pm 0.5 \text{ gammas}$$

Magnetograph details are summarized in Table 1. Preliminary monthly mean values of D, H, Z, and F are given in Table 3.

Normal-run magnetograph

During the year 97½ recording hours were lost owing to: the drive becoming disengaged (36½), cover on backwards (12½), loose slit on recorder (26½), adjustments or tests (19), and minor causes (3).

H variometer. Considerable baseline drift and scatter, similar to that of the previous year, continued. This followed replacements of the variometer fibre in 1968 (Connelly, in prep.). The scatter increased from mid-June, and the standard deviation of baseline values increased from 1.7 to 2.6 gammas.

On 1 July, on request from Head Office, the temperature compensating assembly of the H variometer was removed and all screws were tightened, as it was suspected to be a source of the trouble. The effective length of the bimetallic strip was inadvertently increased from 0.25 mm to 0.38 mm during this operation.

The prism was also adjusted to remove ghost images and to increase the H trace ordinate, which on quiet days coincided with the baseline.

Despite the adjustments both scatter and drift continued. The characteristic shape of the baseline drift, which exhibited a maximum at midwinter and a minimum during summer, seemed to indicate some unknown seasonal influence on the variometer.

The H scale value remained unchanged throughout the year.

D variometer. The D time marks, which had been missing since July 1968, were restored in mid-January 1969. The cover over both trace and time-mark globes was slightly out of position and its leading edge had been obstructing the light from the time-mark globe to the D variometer.

During May, June, and July a step of one minute occurred in an otherwise constant baseline value. No reason could be found for the jump.

No Helmholtz coil was associated with the D variometer and when the H coil was used for the D orientation and scale value tests, it obscured the H trace. For this reason only one scale value test was carried out during the year. A value of S_D = 2.34 min/mm was obtained; this was consistent with the adopted value of S_D = 2.35 min/mm used for the previous five years.

Z variometer. Both the Z baseline and scale value were constant throughout the year. Comparison of Z baseline values from the BMZ and PPM instruments indicated that there was less scatter in values using the PPM, and the BMZ correction was -74 gammas.

A slight displacement of the recorder slit, which occurred whenever the cover was replaced too heavily or slightly out of position, resulted in the loss of both Z temperature and baseline traces. The slit was too insecurely held and periodically worked loose.

Rapid-run magnetograph

The record loss of eight days during 1969 was caused mainly by the drive becoming disengaged. The gears of the synchronous motor and recorder drum had to be only lightly engaged or they tended to seize, resulting in jumps in the magnetogram.

The three strip mirrors were not surface-reflecting ones and also were not of the correct width. Double images produced in the mirrors caused thick traces which appeared to be out of focus. The records were often grey and unevenly exposed when light was transmitted through the unbacked section of the mirrors from the trace lamp, onto the paper. The mirrors were temporarily backed with a strip of wood until the correct mirrors, which were on order, could be supplied.

Scale values for the three variometers remained constant throughout the year (Table 1).

Orientation tests

A constant-current power supply with variable output up to 1 amp was constructed for the H and D variometer orientation tests (Plate 1). The 12-volt d.c. supply was a non-magnetic, portable, motor-cycle battery.

Because the Avometer contains a large magnet, the meter and current supply for the Helmholtz coils were set up in the absolute hut. An extension lead was used from the output to the coil connexions in the vault anteroom. The H rapid-run coil was used for both the H and D orientation tests.

A wood-enclosed deflector magnet with magnet moment M = 7595 c.g.s. units (Major, in prep.) was used for Z normal-run orientation and the BMZ No. 3 magnet with M = 890 c.g.s. units was used for the Z rapid-run tests. However, the trace deflections were so small that the larger magnet would be suitable for both tests.

The results are shown in Table 2.

Auxiliary systems

Magnetograph calibrator. Shortly after being received in March, a BMR magnetograph calibrator MCO-1 was installed to replace the old system of dry cells, meter, and 'helipot'. One hundred yards of eight-core cable was also provided so that the equipment could be set up in the geophysical office. During unloading the cable drum was lost and not discovered until June. Hence the calibrator was mounted in the vault anteroom, where it produced no observable effect on the magnetograph.

D.C. power supplies. One recurrent trouble was an intermittent fading in trace intensity in both normal and rapid-run recorders. This problem was aggravated by the use of stale developer, which considerably reduced the contrast. Its prolonged use was made necessary because insufficient was supplied in December 1968. The developer should be changed every week because it will not last the recommended nine days when left in the covered tray.

Late in the year, the fading intensity was traced to a drop in line voltage, so two constant-current power supplies were constructed. These units (Plate 1) were each capable of delivering a constant current up to 500 mA. By changing to silicon power transistors the load current could be increased to 1 amp. These supplies effectively eliminated the trace fading. They will have to be redesigned to cope with the new BMR lamps which are planned for installation in 1970, and which will draw heavier currents.

Absolute time-mark system. The manual time-mark system used in absolute observations was changed so that the visual indicator lamp and the trace globe were no longer in series; a simple relay circuit wired into the control panel was used. Although the series system gave positive indication that the complete system was operating, variable line losses caused variable time spots.

3. SEISMOLOGY

The seismograph in operation throughout the year consisted of a Willmore Mk.1 vertical seismometer coupled to a Benioff (0.2 sec) galvanometer and a single-drum BMR photographic recorder. The chart speed was 30 mm/minute.

Minute time marks were derived from the five-second long closure of a Mercer chronometer. Daily time corrections were obtained by comparison with radio VNG, Lyndhurst, Victoria, but the fluctuating chronometer rate made interpolations unreliable. At the end of the year, erratic corrections of up to six seconds were not uncommon. The chronometer was returned for service in December 1969.

No magnification data could be obtained with the Willmore seismometer and only one determination of the seismic constants was made in the year. The seismograph constants are shown in Table 4.

The magnification factor was only about 5000 owing to the high microseismic noise level, and this is the reason why only 75 earthquakes were reported to ISC after final analysis of the records.

A number of T phases, including one T_R phase (Cooke, 1967), were recorded and four local earthquakes were sufficiently close to be felt at the station. The largest was an earthquake that occurred on 17 June 1969. USCGS obtained a body wave magnitude of 6.1 and an epicentre at 52.6°S, 159.7°E, which is about 190 km NNE of the base. A maximum Modified Mercalli intensity of 5 was experienced at the camp. Intensities of MM4 were assigned to the other three shocks which were felt.

A report on the seismic site testing programme is given in Appendix 1.

4. OTHER DUTIES

The construction and operation of a replacement tide gauge are reported in Appendix 2.

Micropulsation recorder

The University of Alaska recorder was attended to daily as in previous years.

Buildings

The seismic vault was painted late in the summer. The geophysics office had only recently been constructed (Connelly, in prep.) and the magnetic huts were covered with corrugated plastic sheeting which required no attention. To prevent the records being coated with slime each time there was a landslide in the water catchment area, a filter was installed in the water line to the office darkroom.

To facilitate magnetic absolute readings, non-magnetic lamps were mounted over the instrument piers in the absolute hut as had been done at Toolangi. With this addition, the declinometer circle and telescope could be used with the QHMs for the whole year.

Station duties

As well as the necessary 2½ weeks of 'slushy' duty which all station personnel are required to do, extra camp duties were carried out in the capacity of assistant surgeon, assistant cook, record librarian and surveyor.

5. ACKNOWLEDGEMENTS

The co-operation of all the 1969 party was much appreciated, especially that of John Canham, the O.I.C., who assisted with instrument maintenance, Dr Adel Mattar and Martin Betts, who changed the records during the author's absences, and Eric Hansen, the diesel mechanic, for many hours spent on the tide gauge.

6. REFERENCES

COOKE, R.J.S., 1967 - Observations of the seismic T phase at Macquarie Island. N.Z. J. Geol. Geophys. Vol. 5.

CONNELLY, J.B., - Macquarie Island Geophysical Observatory, Annual Report 1968. Bur. Min. Resour. Aust. Rec. (in preparation).

MAJOR, J.A., - Macquarie Island Geophysical Observatory, Annual Report 1967. Bur. Min. Resour. Aust. Rec. (in preparation).

TABLE 1

MAGNETOGRAPH PARAMETERS

Component		Scale Value	Standard Deviation	
			Scale Value	Baseline
N/R	H	23.7	0.04	2.2
	D	2.35	-	0.2
	Z	20.7	0.04	(BMZ) 1.7
				(ELSEC) 1.6
R/R	H	5.5	0.08	
	D	1.0	0.01	
	Z	6.3	0.06	

D results in min and min/mm.

H & Z results in gammas and gammas/mm.

TABLE 2

ORIENTATIONS OF VARIOMETER MAGNETS

Component		Reference field	Orientation of North Pole
N/R	H	13058	E 0.8°S
	D	27.2°E	N 1.0°E
	Z	64109	N 0.3° Down
R/R	H	13050	W 0.2°N
	D	27.2°E	N 0.5°W
	Z	64098	S 0.3° Down

TABLE 3

PRELIMINARY MEAN VALUES OF MAGNETIC ELEMENTS BASED ON SELECTED QUIET DAYS

Month	D (E)	H	Z	F
	° '	gammas	gammas	gammas
January	26 59.0	13,049	-64,112	64,427
February	27 00.4	036	112	424
March	01.4	029	112	423
April	01.9	022	108	417
May	03.1	027	113	423
June	02.9	019	108	416
July	03.5	021	097	406
August	04.2	018	098	406
September	04.7	022	093	402
October	04.8	017	084	392
November	05.6	020	083	392
December	04.7	033	072	384
1969.5	27°02.3'	13,026	-64,099	64,409

TABLE 4

SEISMOGRAPH CONSTANTS

MACQUARIE ISLAND	(MCQ) 54° 30'S, 158°57'E Elevation 14 metres
Seismometer free period	0.95 sec.
Galvanometer free period	0.2 sec.
Galvanometer damping ratio	1 : 8
System damping ratio	1 : 6.5

APPENDIX 1

SEISMOGRAPH SITE TESTING

Introduction

A programme was commenced in 1967 to find a site on Macquarie Island which would have a microseism noise level at least 40% lower than that experienced in the existing vault.

During 1967 and 1968 the test area was confined to within 300 metres of the vault, which is situated at the end of Wireless Hill on the northernmost end of the Isthmus. The only additional equipment available for these tests was a 300-metre reel of cable, which explains the distance limitation.

No site with the required noise reduction was found during these tests.

1969 programme aim

A portable, clockwork-drive, Esterline Angus recorder and pre-amplifier were provided in March so that the southern end of the Isthmus and the northern portion of the plateau could be tested. Without two seismometers simultaneous recordings were impossible, so an alternative method, to precede and follow the test site recording by control observations in the vault, was used.

Test period

The very rapid changes in meteorological conditions which occurred on the Island, limited the maximum test time to one hour. Even with this duration, it was found that the noise level varied considerably between the two vault control observations and this made site comparisons difficult. The station anemometer charts were scaled after each test and the maximum gust and average wind speed were compared for the three test intervals. Note was also made of surf conditions before and after the observations.

During tests it was desirable to have a high vault noise level so that trace amplitudes could be easily compared. Often, ideally noisy days were accompanied by rain or heavy fog so that test opportunities were few.

Results on the Isthmus

Sixteen tests were carried out at ten sites on the southern end of the Isthmus. Of these, only two gave the required 40% drop in noise level when wind was the major contributor to the microseisms.

During periods of heavy surf on either coast, the background noise level is very high everywhere on the Isthmus.

The two quieter seismometer sites were located (1) at the base of a basaltic rock stack near the new geophysics office and (2) on solid rock at the northern end of Tent Hill.

Future buildings planned for the area in the vicinity of (1) could alter the noise pattern there. Also the site is directly below one arm of the station's main radio transmitting vee, and during a test at an adjacemt site when a radio 'sked' was in progress, there was severe interference to radio signals.

Results on the plateau

The practical limit to the distance of a site from camp is governed by the length of cable and type of amplifier or the maximum line-of-sight distance (depending on whether information is cbled or telemetered to the recorder). Surf noise usually decreases with distance from the coast so the expected quietest area would be near the island's axis, which is up to 5 kilometres from the sea.

These flat central areas are lake-bound; hence much of the ground is soft and waterlogged except along the perimeters where there are numerous jagged rock outcrops.

Fourteen tests were conducted at nine sites on the plateau. The last two sites examined were appreciably quieter than the vault. They were situated about 500 metres south of Scoble Lake on the east side of a smooth hillock. To a depth of half a metre, the hillock consisted of consolidated clay and fragmented rock.

Four confirmatory tests showed that the ratio of site noise to vault noise varied from 0.4 to 0.9 (see Plate 2) as the sea condition changed from rough to smooth and the wind from strong and uniform to gusty and variable.

No frequency analysis of the records was possible, though the 'grass' on the vault trace record appeared far thicker than that on the plateau site record.

There was no water seepage into the seismometer pit in almost a month, unlike a number of the other plateau and Isthmus sites which tended to fill with water very quickly.

Conclusion

The most favourable drop in noise level at the plateau site was obtained with high surf pounding the coast. Both surf and wind microseismic noise are lower at the plateau site than at the vault.

Simultaneous comparison tests in 1970 should confirm that this particular site is better for the future location of the Macquarie Island seismic vault.

APPENDIX 2

REPORT ON OPERATION OF TIDE GAUGE 1969

Introduction

A tide gauge built on the isthmus during early 1967 ceased functioning late in November 1968 and three subsequent attempts to permanently restore the syphon during December and January failed. A gate valve in the line which was thought to be the trouble was overhauled by the diesel mechanic but still no syphon could be maintained. Owing to the large building programme undertaken in the December-March period, insufficent labour could by mustered to tackle the task of digging up the old line, which obviously had a small leak, and not enough pipe was available in the base to replace the whole line.

It was decided to build a new tide gauge nearer the sea with a more streamlined fluid flow and better filtering. A site was selected, on the north end of Hasselborough Bay, in the lee of a large rock outcrop, to provide suitable protection for the instrument from the heavy easterly surf which occasionally pounds the coast. In fact the site is only a few yards from the place where the syphon line from the old tide gauge entered the water.

Construction of the new tide gauge and hut, see Plate 3, commenced on 25 January, and the first record was obtained on 28 February. Lack of materials for the well severely limited the design and resulted in an under-damped system, though given sufficient experimenting time this could be easily remedied.

The syphon line was again used with an unbroken inlet line 36 feet long, compared with the 100 yard multiple sectioned line of the old system. Instead of using a gate valve to constrict the pipe inlet for more efficient high frequency filtering, a replaceable nozzle was designed in conjunction with a protective triple filter as shown in Plate 3.

Construction

Three 44-gallon drums, from which the ends had been removed, were welded together and added to a fourth drum with base intact. A steel plate was welded to the top drum to provide a platform for the recorder. In the absence of large diameter piping a 4.5-inch polythene pipe was attached to the inside of the drum cylinder. On the opposite side, just above the base of the second bottom drum, a 1-foot square hole was cut with an oxyacetylene torch to give access to the base of the well and to take the syphon inlet tube. The 3/4-inch internal diameter rubber syphon hose was attached to the well via a copper L fitting screwed then glued into the polythene.

Using a portable jack hammer a hole was dug through rock and consolidated clay to a depth, determined by levelling, of about 1.3 feet below the lowest observed tide. The drum structure was then lowered into the hole and a prefabricated hut was erected around it. The hut was made extremely rigid by rock-bolting three steel ribs, which were screwed to the frame and to the surrounding rocks in three orthogonal directions. The outside was then surrounded with large boulders to a height of several feet. The inside floor of the hut was concreted and the drums were filled first with sand to cover the syphon line, then with small pebbles as far as the base of the top drum.

To provide protection from seals, the syphon line, on leaving the drums, was passed through a 5-inch hard rubber fire hose coupled to a steel pipe which ended in the filter shown in Plate 3. Bronze fire fittings were used throughout and the filter remained intact during 1969.

The tide gauge recorder was modified slightly to allow the counterweight to run outside the drums for ease of calibration. After passing over the 1:10 reduction gear wheel, the cable passed through a hole in the back of the instrument then over a pulley located over a 4-inch arm attached to the base of the tide gauge instrument.

Operation

The first record commenced on 28 February using the 1/8 inch nozzle. The syphon was easily set up by filling the well with sea water until no more air was seen escaping from the inlet end of the syphon line. The nozzle was then inserted and operation commenced. Inspection of the record showed that the system did not sufficiently damp wave action so a week later the 1/8 inch nozzle was replaced by a 1/16 inch nozzle. (The nozzles were removed simply by filling the well; this forced the nozzle out of the line after the filters had been removed).

The immediate effect was a reduction in wave amplitude plus a flattening of the tidal peaks which was thought to indicate an overdamped system. However it was discovered that the sliding pen holder was catching on the vertical guide so the assembly was removed and highly polished with brasso. It was found preferable to use no oil at all on the slide.

At the same time the 1/16 inch nozzle was replaced by a 3/32 inch section which although better than the 1/8 did not give sufficient damping of wave frequencies during heavy seas. The two were interchanged again on 5 May. Some record loss resulted from pen lifting off the paper due to incorrect levelling of the instrument.

During late June very high tides showed some limitations in the tide gauge as the counterweight had a maximum travel distance of only 4½ feet between the floor and the top constraining pulley. In late July the effective well height was increased by 1 foot by lifting the instrument onto a steel framework mounted over the well. When the float was removed it was found to have developed a small hole which possibly could have caused the slight flats at tide peaks.

The enamel coated steel float was replaced with a polystyrene float; however this proved unsuccessful. The poor performance of the tide gauge in this period was also partially caused by a gradual blockage of the nozzle with very fine sand. This was not realised till the syphon inlet was examined in mid October and the nozzle was found to be almost completely blocked.

Finally in early November an ideal float was discovered. This comprised a 4 inch diameter plastic bottle containing water ballast to adjust the floatation height. The 1/8 nozzle was again installed despite under damping and good records were then obtained till the end of the year.

Calibration

At low tide on 5 December 1969 the tide gauge was calibrated by filling the well with sea water, then reading the rate at which water level dropped. This was simplified by standing a staff behind the counterweight then directly measuring the height each half minute. Plotting height h(t) against time t resulted in a value for the time constant at high tide $T_o = 3.5$ minutes with the 1/8 inch nozzle. The results of this test are shown in Plate 4 and in the table at the end of this appendix.

Level

A level was run from Blake's Bench Mark in Garden Cove to the top of the polythene well. No relationship between well water level and chart reading was determined until November. Thus absolute tide heights before 11 November 1969 cannot be determined. The results of the survey are shown below.

Height of top of well above B.B.M. = 0.88 feet

" " chart baseline above B.B.M.= 2.19 feet

" " recorder drum base above B.B.M. = 2.15 feet

Distance of water level to well top = 8.14 feet

when chart reading = 3.13 feet.

TABLE

CALIBRATION OF TIDE GAUGE

5 December 1969

Time in Minutes (t)	Relative water height (feet)
0	0.23
0.5	0.55
1.0	0.88
1.5	1.13
2.0	1.45
2.5	1.68
3.0	1.90
3.5	2.13
4.0	2.32
4.5	2.49
5.0	2.63
5.5	2.75
6.0	2.85
6.5	2.93
7.0	3.02
7.5	3.08
8.0	3.13
8.5	3.18
9.0	3.20
9.5	3.21 - Level
10.0	3.21
10.5	3.22
11.0	3.24 - Tide falling
11.5	3.28
12.0	3.28

PLATE I

Figure I ORIENTATION POWER SUPPLY

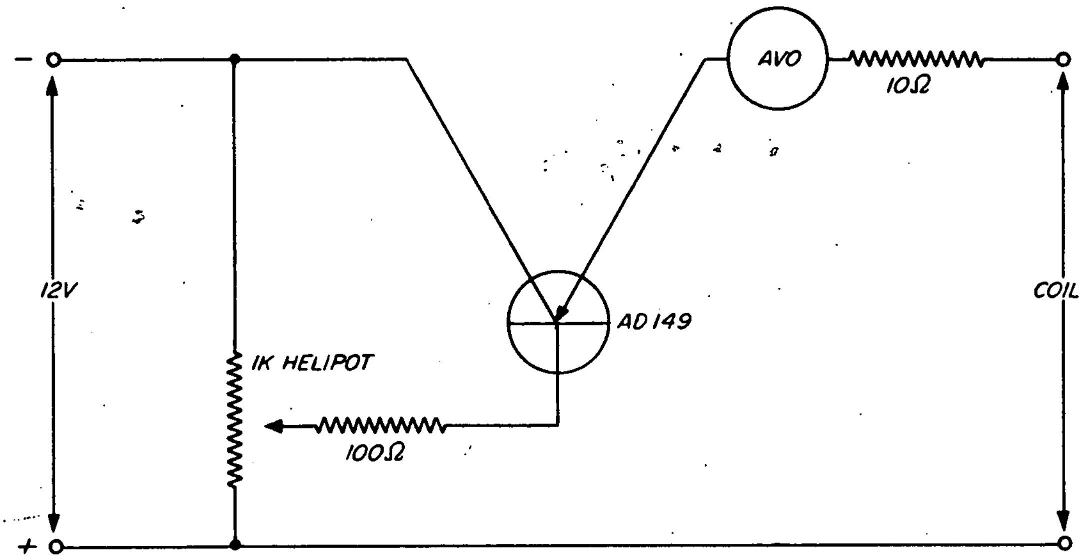
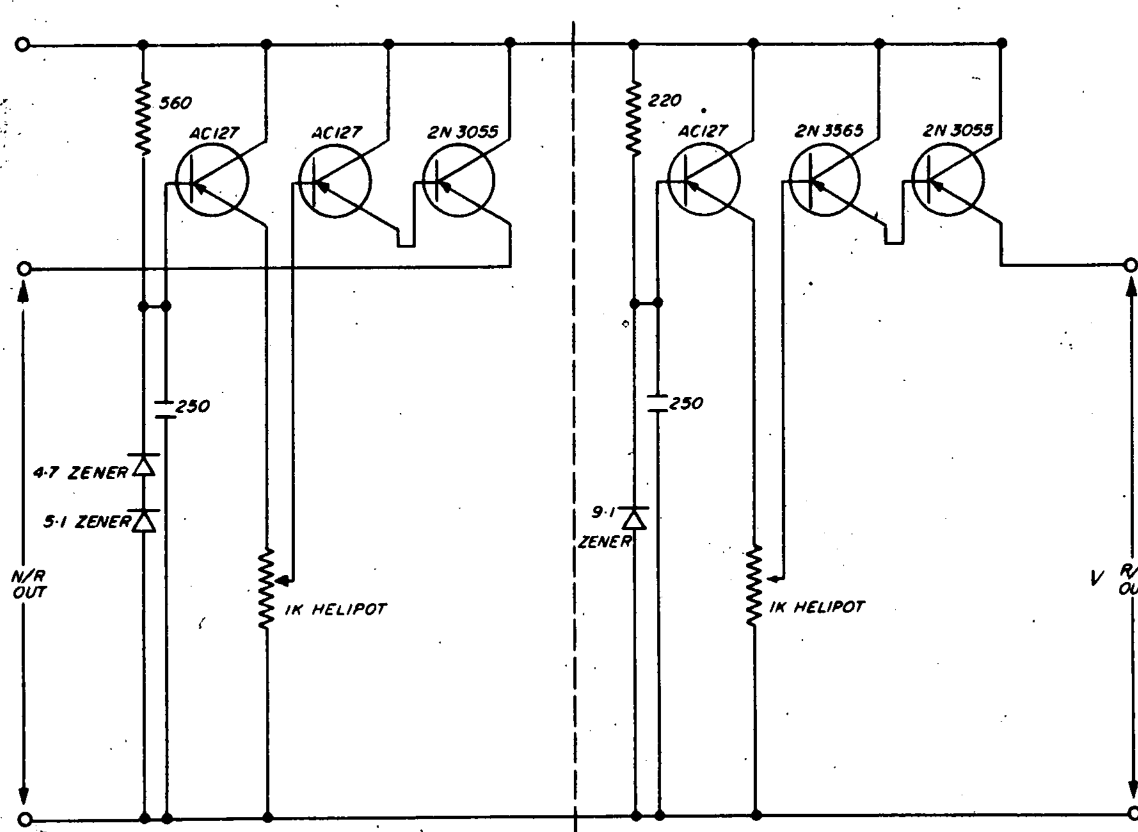


Figure 2 D.C. POWER SUPPLIES



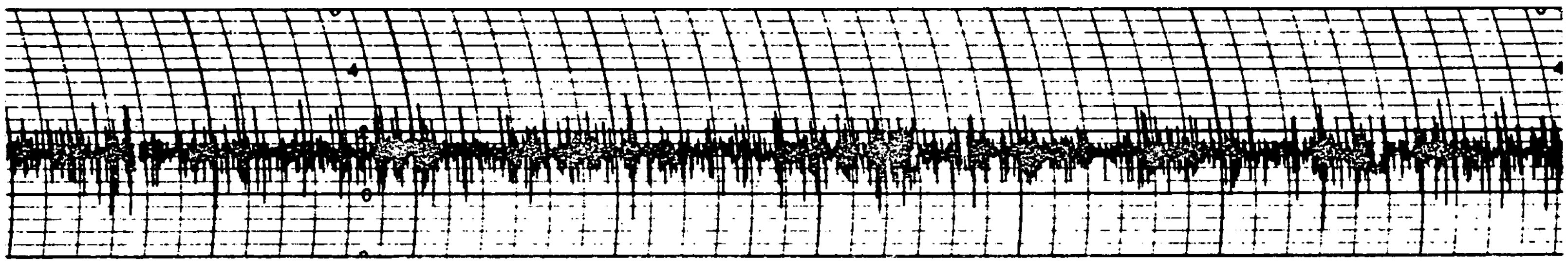
VOLTAGE REGULATOR FOR N/R AND R/R TRACE CURRENTS.
NOTE: ALL TRANSISTORS CAN BE REPLACED BY 2N3055 POWER SILICON.

TO ACCOMPANY RECORD NO 1971/13

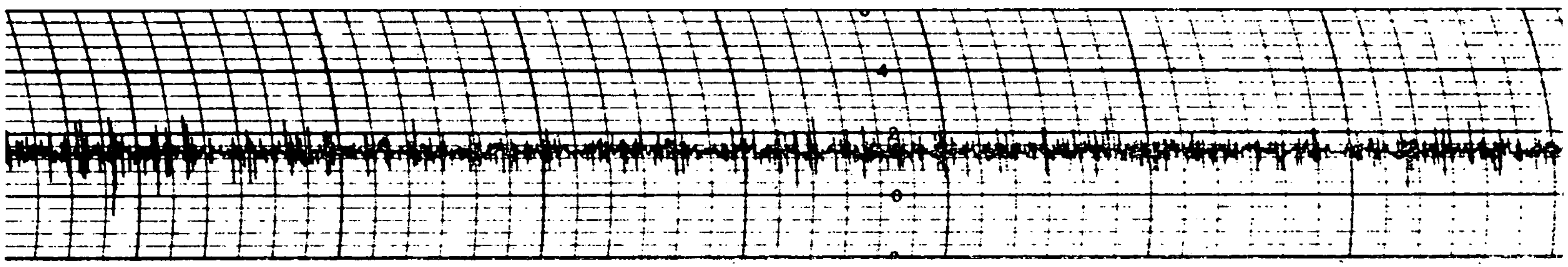
ANT/B9-5A

PLATE 2

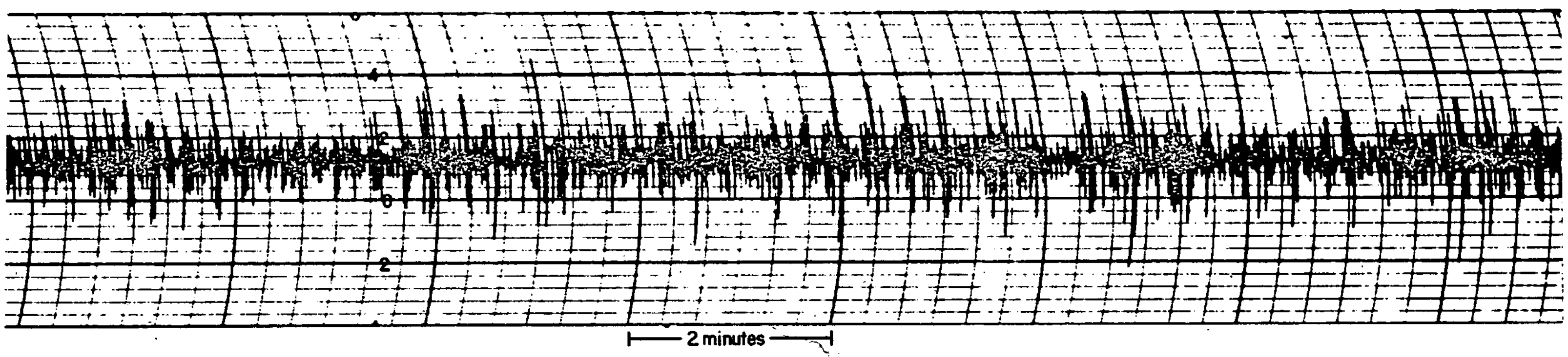
VAULT : 2224 → 2238 31 August 1969



PLATEAU: 0228 → 0242 01 September 1969



VAULT : 0744 → 0800 01 September 1969



MACQUARIE ISLAND

SEISMOGRAMS AT PLATEAU AND ISTHMUS SITES

TO ACCOMPANY RECORD NO 1971/13

ANT/B9-7

PLATE 3

Figure 1

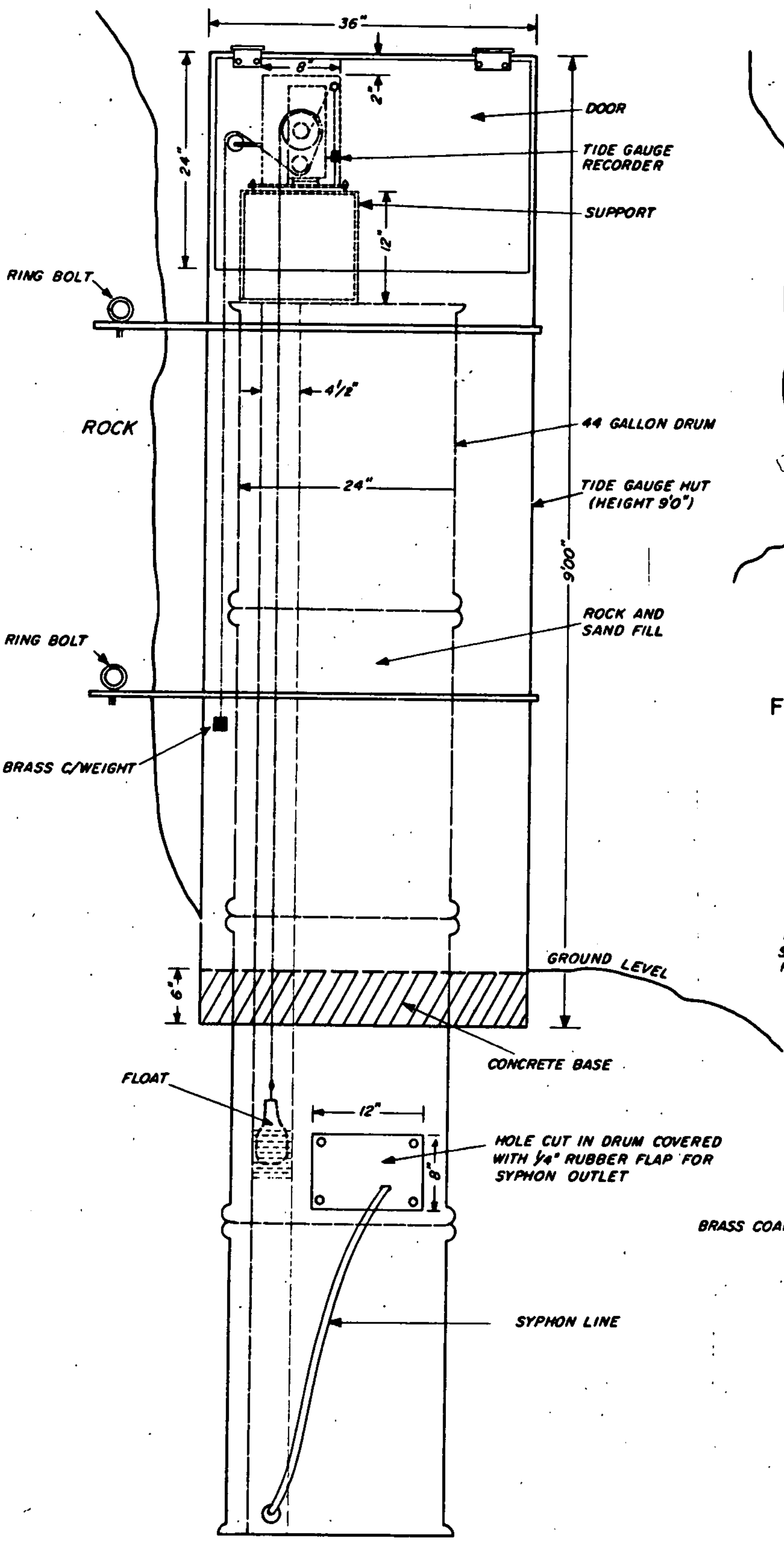


Figure 2

VIEW FROM TOP

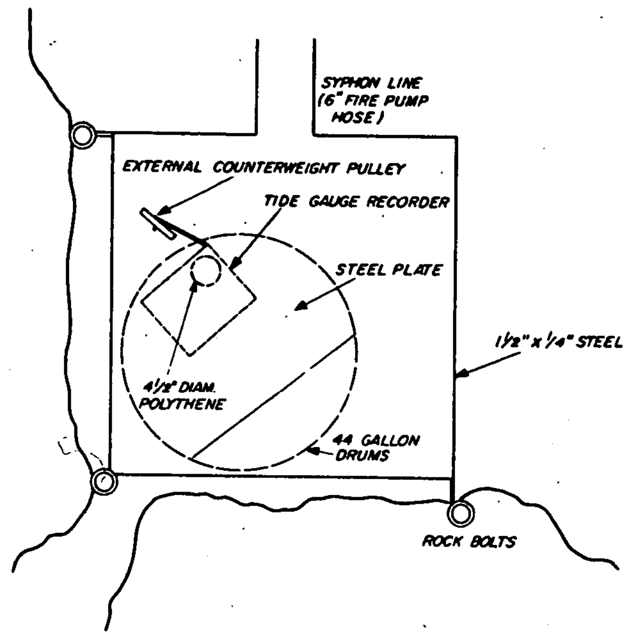
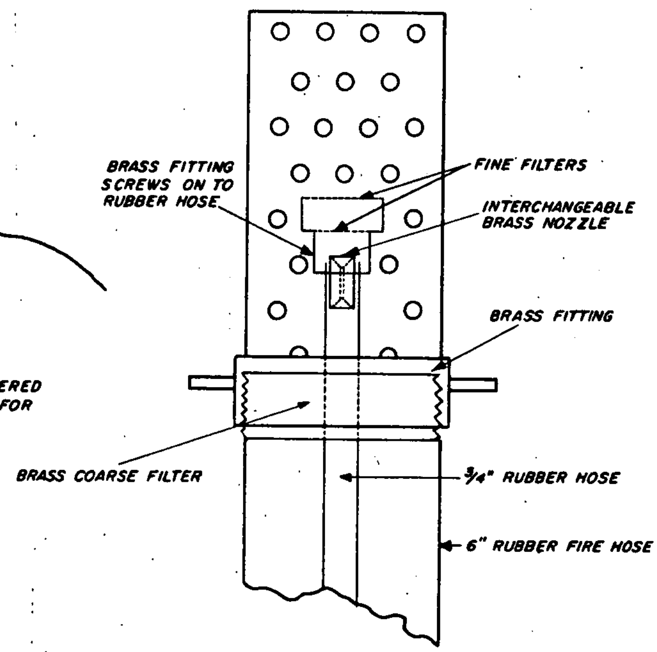


Figure 3

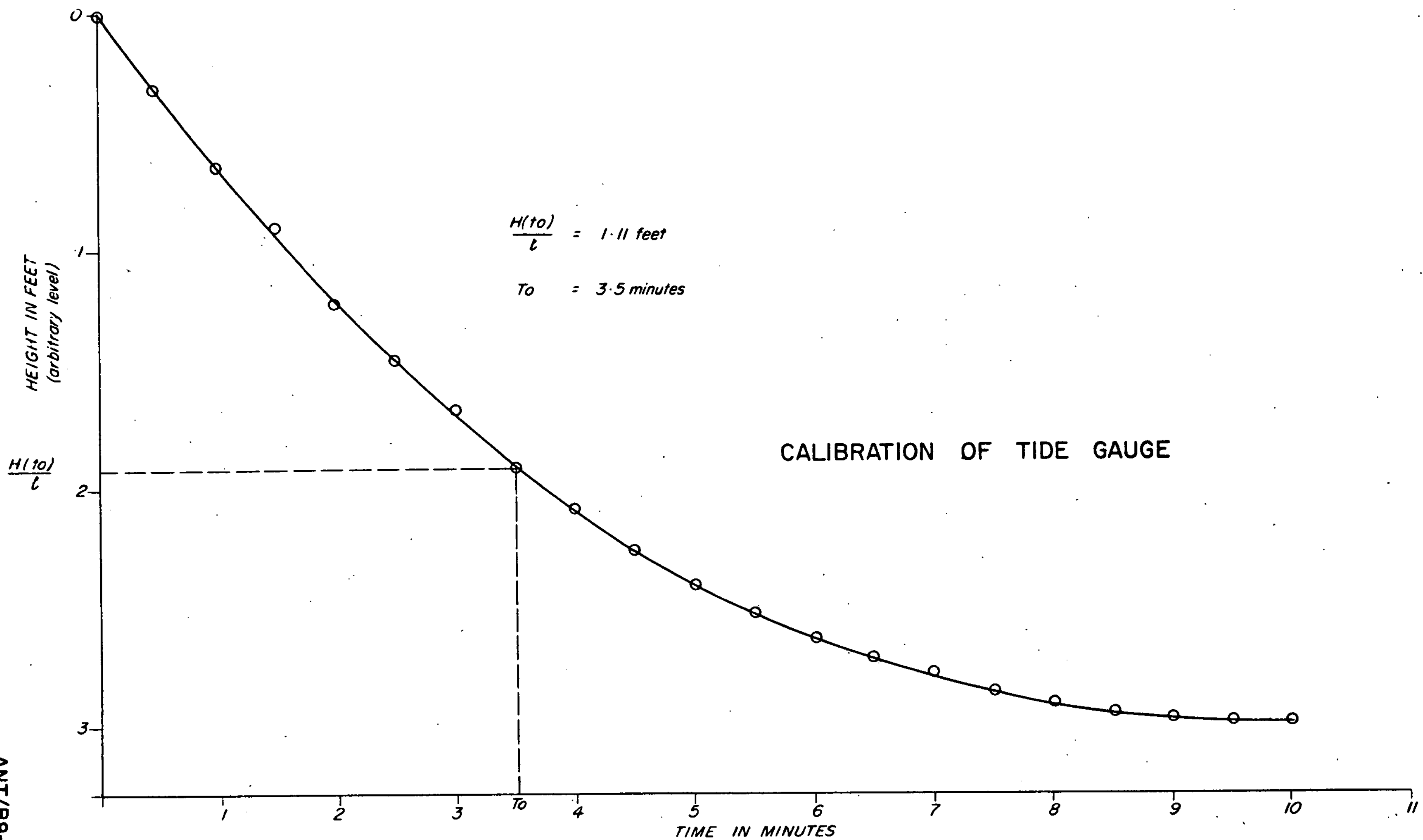
END OF SYPHON LINE



MACQUARIE ISLAND, 1969

TIDE GAUGE

TO ACCOMPANY RECORD NO 1971/13



ANT/B9-6A

PLATE 4