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MACQUARIE ISLAND GEOPHYSICAL OBSERVATORY WORK, 1964

by

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SUMMARY

The author maintained the BMR seismological and geomagnetic observatories at the Macquarie Island ANARE base during 1964. The instrumentation included a vertical, short-period seismograph, and normal and rapid-run magnetographs.

Regular routine observatory data will be published elsewhere, but data on minor local seismic events, probably not recorded at any other stations, are presented.

1. INTRODUCTION

At Macquarie Island the seismological observatory has been in operation since 1950 and the geomagnetic observatory since 1951. The instruments in operation in 1964 comprised two La Cour magnetographs (a normal-run and a rapid-run instrument) and a vertical-component short-period Benioff seismometer with a BMR recorder.

Gregson (1965) has described the 1963 operations. The author was in charge of the observatories from 20th December 1963 until 9th December 1964, and was succeeded by R. G. Sutton.

Earlier reports such as those of Gregson (1965), van Erkelens (1961), Hollingsworth (1960), and Turpie (1959) include descriptions of observatory buildings, routines, and the installation of equipment.

2. MAINTENANCE

All huts and equipment on Macquarie Island are subject to continual corrosion owing to the very damp atmosphere and rigorous climate. Sand and sea spray whipped up by high winds are blown through the camp almost continuously so that deterioration of buildings presents a very real problem.

Maintenance can be divided into two broad classifications:

1. Station maintenance
2. Observatory maintenance.

Station maintenance

All expedition members are required to assist in the work necessary to maintain and improve the station.

Kitchen and mess duties occur periodically throughout the year. In 1964 during the summer season, with enlarged scientific staff, mess duties occupied four consecutive weeks, but after March they were taken a week at a time. During these periods there is little time for other than essential geophysical work.

In the first months of occupation the works programme, involving erection of new buildings, installation of tanks, etc., demanded considerable time and, throughout the year, Saturday afternoons were generally devoted to regular station duties such as shifting of fuel drums and the stacking of timber and garbage runs. Painting was done as a joint effort by the party during September, October, and November, whenever weather permitted, and seal branding occupied the first week of November.

It should be emphasised that the geophysicist is often expected to spend two days per week or the equivalent on general camp projects.

Observatory maintenance

Magnetic. Owing to priorities assigned by ANARE, the magnetic huts were not painted at all during 1964, but in December they were in fair condition. The exposed western side has been sand blasted almost bare, while on the other parts of the exteriors older layers of paint have peeled off in large sections owing to the dampness of the plywood panels beneath. In wet weather water trickles down the inside walls of the variometer hut, but on no occasion did dampness affect magnetic recording in the hut. With winds up to 103 m.p.h. recorded on the camp anemometer in 1964 no movement of the buildings could be detected, although the records would almost certainly have been affected if the variometer hut had moved.

In January both skylight windows of the absolute hut were removed (the cracked one replaced) to caulk leaks which occurred around the glass during rainy periods, and the western window that had been temporarily sealed with masonite was replaced. During high winds in October a window on the southern face of the hut shattered. This was also replaced.

The door of the absolute hut fitted poorly and vibrations of the building during strong winds were often enough to set it free and swinging wildly. In August the door was removed, about a quarter inch was planed off it, and the lock was renovated.

During the elephant seal breeding season in September the outside instrument shelter was knocked over and the battery box pushed askew. The former was repaired and re-sited and the latter righted. It is strongly recommended that during the breeding season a concerted effort be made to keep the area around the magnetic huts free from female seals by chasing them daily. This will avert problems (access to the area, banging on hut walls, etc.) such as those caused by a harem which developed close to the variometer hut in 1964.

Early in the year an exterior light was fitted to the extreme southern corner of the variometer hut. This was an advantage during the shorter days, as the afternoon magnetic routine was often done after dark. Every precaution was taken to ensure the fittings were free from magnetic material.

Seismic. The condition of the office and darkroom is quite good, but the unlined galvanised iron on the darkroom roof shows extensive patches of rust, especially at the edges, where much has been eaten away. It is hoped that the application of a thick coat of silverfrost in October will have delayed further deterioration, but this roof must be replaced at the earliest opportunity.

Considerable time was spent improving office accommodation and darkroom facilities. Exterior lamps were installed at the top and bottom of the steps leading to the office, with two-way switches at either end. This was of value during the winter and at night. The darkroom light switches were replaced by exterior type switches to prevent shocks received when touched by hands wet with fixer. Power points backed by asbestos were installed in the unlined storeroom, which prevented short circuits in damp weather.

Early in the year a handrail was added to the most exposed section of the steps leading to the office. This measure considerably lessened the risk of being blown off the steps in high winds.

In June a new P.A.X. telephone which included circuitry for automatic fire detection was installed. Detectors were placed in the office and darkroom. The office circuit however, was disconnected in September because it was on an extension from the surgery which was re-sited at that time. The office will be reconnected through the new surgery when it is built in 1965.

Electrical heating was available for the office and vault even during periods of emergency power. The darkroom and office were kept at about 70° F by a thermostatically controlled heater. This assisted in keeping the Mercer chronometer (temperature dependent) at a reasonably constant rate, as well as facilitating thorough record drying. The vault heater was required to prevent condensation on the lenses, which caused seismograph trace fogging. Also the paper is more sensitive as the higher temperature lowers the relative humidity, which enables the trace lamp to be run with lower current, thus increasing lamp life.

Leaks occurred in both the office darkroom section and the vault during 1964. Leaking through the join between the wooden office section and the concrete vault is a perennial problem, and though this leak was caulked in the autumn, leaks reappeared in the spring. During driving southerly rain in winter, leaking occurred between the concrete slabs of the vault roof. Water falling on the recording drum resulted on two occasions in some loss of record. This was a minor leak and no further record loss occurred when the recording unit was relocated on the pier.

During the year cracks in the darkroom and around the darkroom door were blocked to make it light proof, the benches were reorganised and covered with lino to prevent the wood becoming caked with fixer and developer, and the office desk was widened by four inches and covered with lino.

The darkroom water supply caused some trouble during the year. The sink top, which was in poor condition, blocked up occasionally and was replaced. The inlet from the spring on Wireless Hill was periodically blocked with slime, and the only solution to this was to clear out the inlet tank monthly. As well as this the section of pipe buried across the valley to carry overflow to the kitchen tanks, blocked up and had to be dug up.

During winter the temperature often dropped below freezing and on three occasions remained there for about five days. Though only the upper three inches of the darkroom tank froze over, the water supply stopped when the water in the ten-foot connecting pipe froze. In the spring this latter was replaced by bowser hose made of rubber approximately $\frac{3}{8}$ inch thick. The area around the tank outlet and the darkroom inlet have been well insulated and these measures should greatly limit future freeze-ups.

The exteriors of the office, darkroom, and storeroom were thoroughly painted and the insides of the office and darkroom were brightened with suitable colours.

The tools were found to have been greatly affected by the damp salt air, and although still fairly serviceable, were not in good condition. They had been stored in a heated cupboard constructed in the storeroom, but early in the year were soaked in oil, wiped with penetrene and set up on a shadow board on the darkroom wall. The air here is warmer and drier and so should assist in keeping them in reasonable working order, but I suggest they be cleaned with penetrene at least yearly.

On two occasions the office radio aerial blew down during storms. The first time the wire parted at the distant anchor section, which was easily rejoined, but on the second occasion a considerable rusted length in the middle had to be replaced.

4. MAGNETIC OBSERVATORY

Magnetograph operation

The instrumentation in 1964 was identical to that in 1963 (Gregson, 1965). Routine recording of both magnetographs continued with only minor adjustments during the year.

Record losses for the year totalled approximately 135 trace hours for the normal-run instrument and 180 for the rapid-run. Much of this was due to mechanical drive failure, although the refocusing of the Z-trace early in the year, three lamp failures, and frequent camp power failures contributed significantly to the rapid-run total.

The La Cour clockwork drives for the normal-run magnetograph were generally unsatisfactory. Early in the year these stopped on a number of occasions. Each time the drive was taken apart, cleaned, and replaced, only to stop again after a limited period, in spite of application of various cleansing agents (alcohol, ether, kerosene, watch oil, etc.). When all drives became unreliable a clock-work drive borrowed from a meteorological instrument was modified to drive the recording drum. This was checked thoroughly for magnetic properties, and at the requisite distance from the variometers had no measurable effect. From then on, no normal-run trace loss occurred due to drive failure.

The rapid-run recorder was driven by a Venner synchronous motor, which was most reliable. Early in the year, however, sledge trouble occurred intermittently, but this was overcome by thorough cleaning and use of a suitable weight.

It should be emphasised that as much as half of all trace loss can be attributed to purely mechanical drive failure. Five useless drives (four normal-run, one rapid-run) were returned to Australia at the end of the year, and if the present drive system is to be continued, it is recommended that at least some of the observatory drives be interchanged with Head Office annually. No facilities exist at Macquarie Island to maintain these. Alternatively, Venner synchronous motors are considerably more reliable in this climate and had it not been for numerous camp power failures throughout the year one would have been installed on the normal-run recorder.

As these synchronous motors operate on currents of the order of 10 milliamps, it should be neither too difficult nor too costly to have them vibrator-driven from the 6-volt accumulator. The possibility of this as a permanent modification should be investigated.

The La Cour pendulum clock had a somewhat erratic rate throughout the year, varying from day to day depending on wind velocity (shaking the walls), temperature, humidity, etc., but a daily rate of 8 seconds gaining was most common even with the fine adjusting weight wound fully out. To avoid complications arising from resetting the minute hand regularly, and also interpolating time corrections, a different method of clock adjustment was introduced toward the end of the year. The clock was compared with the Mercer chronometer at about 2330 GMT, immediately prior to record change. Then the pendulum was stopped for the number of seconds necessary to set it 3 seconds slow. Because the clock had a general rate of eight seconds per day it would usually be five seconds fast and so could be reset easily. In this way the correction at the beginning of the day was 0.0 minute and at the end of the day rarely exceeded -0.1 minute.

On three occasions the rapid-run trace lamp fused necessitating readjustment and refocus of the light spots.

Early in the year intermittent faults in the absolute time-mark relay were traced to deterioration in the circuit joints and these were re-soldered. Also fluctuations in lamp intensity in the rapid-run unit were caused by poor contacts in the lamp socket and a new lamp holder was installed.

The battery charging circuit was modified to allow continuous trickle charging. This ensured that the electrolyte level was always satisfactory and avoided cell damage by excessive charging rates. Measurement showed that a current of 250 mA greater than the load was suitable; a two-ohm potentiometer in the charging circuit allowed this to be achieved.

Control observations

Absolute observations in 1964 were done with a DCK Kew pattern magnetometer No. 158, QHMs 178 and 179, and BMZ 64. During each changeover the QHMs and BMZ were compared with instruments sent from Toolangi: QHM 177, long-range BMZ 221, as well as proton precession magnetometer MNZ-1 No. 1. Preliminary results indicate that on both occasions the intercomparison observations produced consistent results.

Weekly absolute observations provided good baseline control, and there was little difficulty in carrying these out on reasonably quiet days (1964-65 are Years of the Quiet Sun). Experience showed the most suitable period of the day to be immediately after record change as this was not only the quietest time, but also the period when the sun is at its highest. This was important during the short dull winter days.

Preliminary baseline values are quite steady. On only one occasion was there a marked baseline change. This was a sharp jump which occurred in November when the H variometer was disturbed during orientation tests. Table 1 includes standard deviations of the observed from adopted values.

Little difficulty was experienced with the absolute instruments except that the QHM 178 thermometer was broken early in the year and replaced by one sent down in March, and on 4th April the BMZ magnetic was bumped while unclamped, resulting in the displacement of the magnet from the knife edge. This was carefully reset and although a small change occurred in neutral division, no detectable baseline change occurred. As in previous years trouble was experienced with breakage of the DCK fibre, as there is no way of clamping it while removing or inverting the magnet. D baseline scatter was noticeable during the year; more reliable results should be given by the Askania declinometer introduced at the end of 1964. The azimuth mark normally used for the D observations was Anchor Rock. The alternative 'Post' mark, used when visibility was poor, was checked for azimuth as soon as possible afterwards, since strong winds moved it slightly from time to time.

Normal-run H and Z scale-value determinations were made weekly and D scale-value determinations three times throughout the year. There is some scatter in these results (see Table 1) but no evidence of overall drift. Note that because the H magnet is not damped, and H is small, the magnet took six minutes to settle, even though the deflecting field is not applied impulsively.

Rapid-run scale-value measurements were made monthly. The H and D scale values remained quite steady but the Z scale value increased from 6.3 to 8.6 through the year (Table 1 and Plate 1).

All determinations were made with Helmhotz-Gaugain coils. The scale values adopted for 1964 are shown in Table 1.

Data distribution

Data reported monthly comprised K-indices and preliminary monthly mean values based on ten selected quiet days. Special effects, sudden commencements, storms, etc. were reported after return to Australia.

Quiet day (Sq) curves

Sq curves were constructed for the first weeks of the year but the variation was very small for H and Z and it was felt that no inaccuracy would result from considering the curves as straight lines; this should be as accurate as using the quiet curve of a day almost a week away as is frequently necessary. For very quiet days the best criterion for 0 or 1 K-scalings is probably 'smoothness'.

The D variometer, being sufficiently sensitive, shows the Sq variation, and curves for D were prepared in the following way:

1. Select four of five quiet days for the month (spread out if possible)

2. Scale mean hourly ordinates

3. Mean these, transfer to graph paper

4. Transfer these ordinates to plastic sheets

5. Construct curve with French curves

Orientation tests

The mean meridian used for November 1964 was 26° 19.9'. The orientation tests were carried out on the H and D variometers of both magnetographs, and the results are shown in Table 2. The accuracy values given in the table are derived from the estimated errors in aligning the coils, measuring deflections, etc.

4. SEISMIC OBSERVATORY

Seismograph operation

Observatory recording continued on from 1963. The instrumentation consisted of a short-period vertical Benioff seismometer and a single-drum BMR recorder. The seismometer period was 1.00 second and the galvanometer period 0.2 seconds.

Time marks (in the form of trace deflections) were obtained from a Mercer chronometer and a mirror-relay in the light source. Some trouble occurred with chronometers during the year. The balance wheel spring of Chronometer 18683 broke in January, 19090 had intermittent contact trouble until these were properly cleaned, and the winding chain of 18789 broke in September; 19090 and 18683 had four-second contacts from 56-60 seconds and hour contacts of twenty seconds between 40-60 seconds. Chronometer 18789 had only minute contacts from 00-05 seconds. This necessitated putting on manual time marks during the day because all minute marks were identical and power failures averaged three or four per week, which made their identification difficult. In fact if the rapid-run magnetograph (with hour marks) had not been driven by the camp power, periods between two power failures on the same day would have been impossible to interpret.

Total record loss for the year amounted to 95 hours. The principal reasons for this were lamp failure on three occasions, leakage of roof above recorder twice, seismometer tests, power failures, and driving motor failure once.

In general the focus of the trace was very good. To obtain this, painstaking care was required when renewing the light source globe after a lamp failure.

Microseismic disturbance due to surf and wind necessitated various attenuation settings. On exceptionally calm days a setting of 28 dB could be used. On normal windy days 30 dB or 32 dB was required and in gales 34 dB was required. Attenuation settings were recorded in the seismic log.

Instrument tests

Annual seismometer tests were carried out in May. They were the determination of free periods, damping, and magnification.

The mass was recentred and aligned, and the period adjusted to 1 second (within 1%).

The seismometer damping was adjusted to give a 17:1 ratio of initial deflection of spot to overshoot. The magnification was determined by the weight lift method using weights of 5 and 10 grams for different attenuation. The results were as follows:

Attenuation	Magnification at 1 c/s
22	9850 ± 50
24	7950 "
26	6200 "
28	4850 "
30	3950 "
32	3150 "
34	2450 "
36	2000 "

Chronometer comparison

In previous years daily corrections have been measured at Macquarie Island at about 1700 EST, the Mercer chronometer being compared with WWV Washington or WWVH Honolulu. This time of day proved the most suitable, reception of both stations generally being very poor during the earlier daylight hours. Invariably reception was best on 5 or 10 Mc/s, but fading during magnetically disturbed periods and interference from stations close in frequency often made reception difficult.

The possibility of comparing the chronometer immediately before record change each day was investigated and it was found that reception of Australian Post Office Time Signal transmission from VNG was usually excellent. These time signals are monitored from Mount Stromlo. The time pips as transmitted are of the same order of accuracy as WWV, but are more accurate on reception since the shorter path distance reduces time lag and dispersion caused by ionospheric variations. This lag for VNG is of the order of one hundredth second compared with one twenty-fifth for WWVH and one fifteenth for WWV. Indeed in the early afternoon it was not unusual to record time differences of up to one seventh second between WWV (15 Mc/s) and VNG. Investigation with directional aerials revealed that on these occasions the signal on WWV was being received on the 'long' path. In general slight differences could always be audibly discerned between VNG, WWVH, and WWV.

VNG broadcasts continuously on 12, 7.5, and 5.5 Mc/s with 1000-c/s pips every second except the 59 of each minute; there are no pips in the first minute of each hour when the call sign and transmission frequencies are broadcast in voice. Though pips in each minute are identical, no ambiguity should arise when the chronometer has a fairly constant daily rate of a fraction of a minute, but as a precaution a weekly 'minute check' can be done at the hour or against WWV or WWVH.

Shocks recorded

Preliminary seismic data were reported to Head Office twice weekly. As in previous years the heavy microseismic disturbance limited the number of shocks recorded. Final analysis of the records using the USCGS data revealed 92 teleseisms. Seven minor earthquakes were felt at Macquarie Island in 1964. In all, phases from 268 earthquakes were identified during the year. A list of those probably not recorded by any other station is given in Appendix 1.

Notes

(a) The major Alaskan earthquake that occurred on 28th March was recorded at Macquarie Island. Several hours later the tide gauge revealed a general rise in sea level on ten inches from the tsunami.

(b) Local earthquakes were felt as one impulse or shudder lasting only one or two seconds. Most of the ground movement recorded on the seismometer lasted less than a minute. An interesting observation is that six of the seven felt quakes occurred in pairs, as may be seen in the following table:

Date	Felt by (18 people total)	Estimated (modified Mercalli)
8th March	11 in camp	III +
18th July	1 in camp	II
28th July	5 in camp	III +
2nd November	17 in camp	IV +
3rd November	2 in camp, 1 at Bauer Bay	III (camp) IV (Bauer Bay)
24th November	2 at Hurd Point	III
27th November	5 in camp	III +

Estimation of felt intensity was often difficult owing to high wind velocity and pounding surf.

(c) Six T-phases were identified positively.

5. ACKNOWLEDGEMENTS

The author is grateful for the general co-operation of the 1964 ANARE party and in particular the assistance of T. W. Gadd and R. O. Nunn for continuing routine recording during his absence on field trips. A special mention is due to N. Stair for providing the clockwork drive which enabled the normal-run magnetograph to operate for the last eight months of the year.

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TABLE 1

Magnetograph data

Magnetograph	Element	Scale value	Standard deviation	
			Scale value	Baseline value
Normal	D	2.35	-	0.4
	H	24.7	0.13	5.1
	Z	20.6	0.09	5.7
Rapid run	D	1.02	0.01	-
	H	5.4	0.02	-
	Z	6.3 - 8.6	0.02	-

D values in minutes, minutes/mm

H and Z values in gammas, gammas/minute

TABLE 2

Variometer magnet orientations

Variometer	Date	Magnet north pole
Normal D	17th November	North, $0.9^\circ \pm 0.3^\circ$ East
H		West, $0.7^\circ \pm 0.3^\circ$ North
Rapid Run D	10/12th November	North, $0.1^\circ \pm 0.1^\circ$ East
H		East, $0.9^\circ \pm 0.1^\circ$ North

APPENDIX 1

Minor Earthquakes recorded at Macquarie Island

Recorded phases of all major earthquakes have been reported to ISRC. These totalled 100, including teleseisms, major local shocks, and the seven felt earthquakes discussed in the text. The following list includes all other earthquakes recorded at Macquarie Island, probably none of which has been recorded elsewhere.

The time listed gives only the day, hour, and minute preceding the first recorded phase (invariably P). The arrival times of other phases, if any, are not given.

December 1963

211018	220701	221603	231219	241801	280245
291557					

January 1964

011307	011502	050955	080015	110202	141049
170624	181608	191700	211405	230130	241249
250900	281942	302205			

February 1964

011315	020059	022312	042233	042258	100145
100347	110035	110041	110550	120331	120553
121541	122236	130010	130035	142046	191520
202257	221212	230305	270233	292359	

March 1964

011308	020333	020435	022247	040702	041121
051819	072015	081408	082049	091809	161416
181259	181722	240108	250224	301022	

April 1964

071330	071934	112022	140600	140820	141120
220834	221706	232045	232059	232120	240605
292121					

May 1964

140601	140923	180601	180644	181321	281133

June 1964

061835	180954	181604	190341	201603	221033
252012	260523				

July 1964

031657	110553	152134	181618	261628	280002
280204	282102	290042	290115	301219	

August 1964

020113	021934	031449	031551	040207	051128
120022	120023	120211	140526	160841	201709
260606	270749				

September 1964

031433	130019	182340	190008	190014	200240
220712	221337	231554	231737	290234	

October 1964

011045	040920	080913	140226	150648	162212
171739	192147	200739	222230	230154	241655
271237	290800				

November 1964

011702	030042	031942	052255	061143	080519
100555	112002	140258	140342	150954	200332
211919	221713	230918	231224	250804	271843
301520					

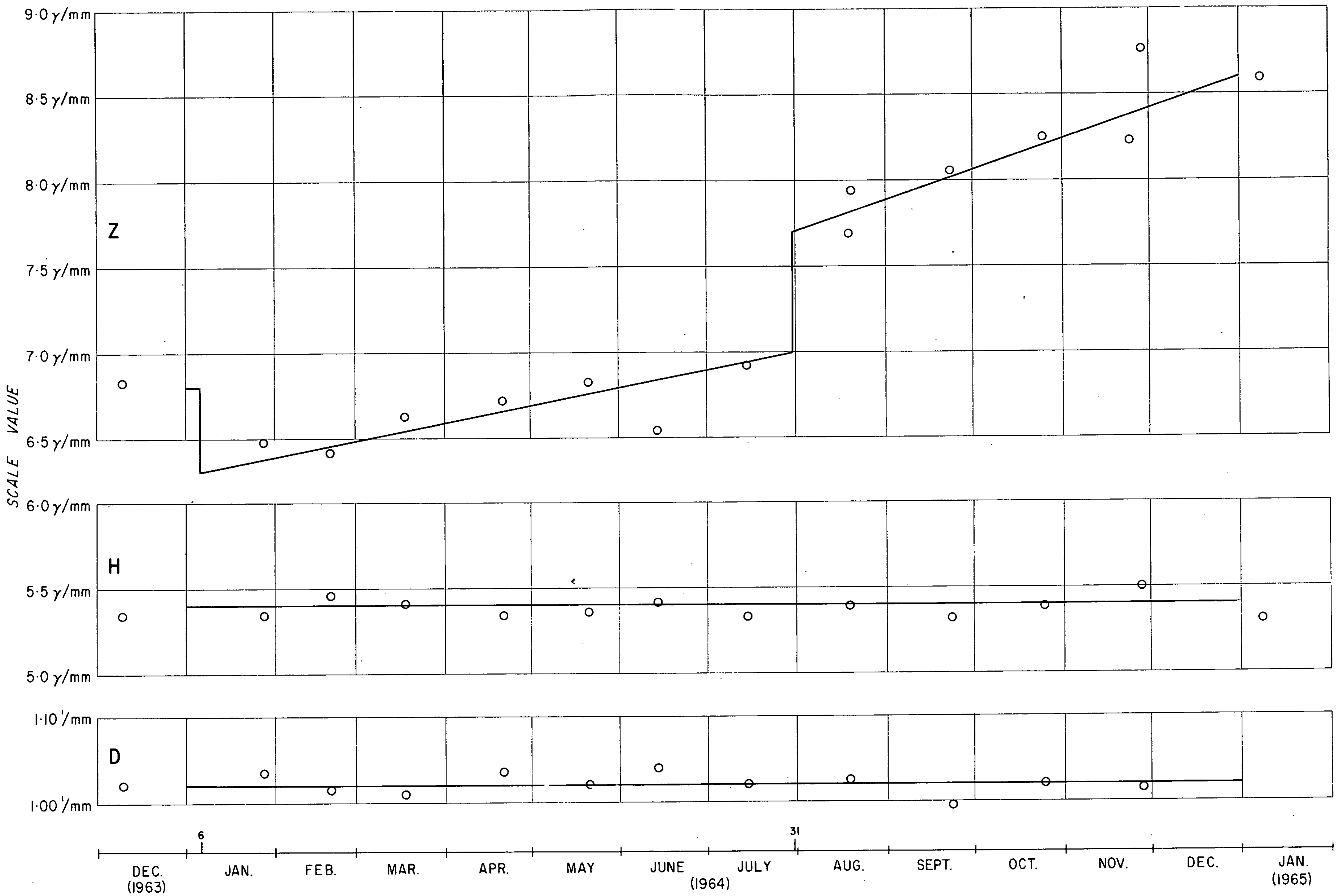
December 1964

051926	070926	081443	081500	081536	092318

Six T-phases were positively identified. Arrival times of the Maxima are given in days, hours, and minutes and tenths of minutes.

December 1963	210709.5	July 1964	260846.7 281855.4
August 1964	300850.3	October 1964	120955.2
December 1964	060315.9		

PLATE I



MACQUARIE ISLAND 1964

OBSERVED AND ADOPTED STATIC SCALE VALUES FOR RAPID-RUN MAGNETOGRAPH

(Observation made using Helmholtz coils)

TO ACCOMPANY RECORD No. 1967/116

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS G82/2-16