COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1967/29

MUNDARING GEOPHYSICAL OBSERVATORY.

ANNUAL REPORT 1965

by

P.M. McGREGOR

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SUMMARY

During 1965, basic observatory programmes were continued in geomagnetism, ionospherics, and seismology at the Mundaring Geophysical Observatory. Instruments used included an Eschenhagen normal magnetograph, a Cossor ionosonde, and a World-wide Standardised Seismograph.

The seismograph at Kalgoorlie, installed in 1964, was kept in continuous operation and was thoroughly calibrated. Another seismograph was installed at Boulder to improve the location of seismic events associated with gold mining.

A State-owned seismograph was set up at Kununurra, and preliminary steps were taken towards the establishment of a regional seismograph in the Pilbara.

1. INTRODUCTION

The Mundaring Geophysical Observatory came into being on on 18th March 1959, although operations were begun at the Gnangara magnetic observatory site in June 1957. Descriptions of the observatory and an outline of activities there to the end of 1964 have been given in three previous Records (see McGregor, 1966); this Record summarises the work done during 1965.

2. STAFF AND VISITORS

Staff

Observatory staff are listed in Table 1 and others associated with the observatories operations in Table 2. Staff absences, for other than recreation leave, are summarised in Table 3.

P.M. McGregor returned from a tour of duty at Macquarie Island on 26th March. I.B. Everingham acted as observer-in-charge during his absence; he addressed the A.P.E.A. at Adelaide in March (" Major structural features of the Perth Basin ") and the Astronomical Society of Western Australia in May (" West Australian Earthquakes "); from 17th to 20th May he attended a programme meeting of the committee of the Bass Strait Upper Mantle Project (BUMP) at Melbourne.

Some staff members inspected the U.S.S.R. oceanographic ship "VITYAZ" (January) and a Project Magnet survey aircraft (May).

Visitors

Notable visitors included Drs Lubimova, Zablinskaja, and Kanaiev (R/V "VITYAZ"), Mr J.H. Crowe (USN Oceanographic Office), Mr W.N. Green (US Coast and Geodetic Survey) and Mr L.S. Prior (BMR)

3. OPERATIONS

Department of Works programme and maintenance

Jobs carried out under the Department of Works programme by contractors were:

Office (December): all exterior painting, except boundary fence; 1965/66 vote.

Ionosphere house (February): interior painting; fitting of stainless steel surround to darkroom sink; re-arrangement of electrical outlets; 1964/65 vote.

Seismograph vault (June): replace linoleum and interior painting of console and entry rooms; fit new main door; seal leak at mains cable entry; lay kerbing on east side of turning area to divert surface water around vault; 1964/65 vote.

Gnangara (June): replacement of main roof bearers, absolute house; 1964/65 vote.

Residence (July): replace hot water unit.

Another job requisitioned for 1964/65 was the lowering of an ineffective agricultural drain near the laboratory, but no tenders were offered for it; the Department of Works was to complete it by day labour. The laboratory block (Lot 74) was contoured (by Gregson) and the results used in a long term overall drainage proposal submitted to the Department of Works. The work on the seismograph vault was not satisfactory and formed the subject of a complaint to the Department; their estimated cost of remedial work was given to headquarters for attention in 1966.

Improvements effected by observatory staff included;

(a) enlargement of the sink surround in the ionosphere house

(b) fitting of fluorescent light fixtures in the Records and Store rooms;

(c) replacement of sliding door track by heavier duty type (Bangor 210) in the machine shop;

(d) fitting of curtain track and valance boxes in laboratory light-trap;

(e) laying of 400 ft of concrete slab paving at Gnangara from entry to auxiliary house and variometer vault (to link up with existing path);

(f) laying of 500 ft of one-inch plastic ("Dicon") water pipe from store tank to all buildings.

Plant and equipment

No major items were purchased. Among the most useful acquisitions were: a Rapidograph "Variant" pen set of 7 items, a split-second (1/10) stop watch, a "Maggy" lamp, and a decade resistance box (Sullivan, dual dial, 0.001 ohm to 1.1 megohm).

Items constructed (by Woad) at the Observatory are mentioned later with the equipment for which they were made.

The annual stocktake of accountable stores was made during 29th and 30th November.

Power plant and vehicles

No record was lost through failure of the generating plant, which was serviced weekly and overhauled periodically by the Stores and Transport Branch.

The Holden sedan and station sedan on weekly hire covered 22,000 miles, of which about 17,000 miles resulted from everyday operations. The remainder were covered in travel to the Kalgoorlie outstation, urgent deliveries, etc.

Library

The usual registration and binding of periodicals was carried out. Text books received were: "The Earth's Core and Geomagnetism" (Jacobs), "Principles of Geodynamics" (Scheidegger), "Radio Astronomical and Satellite studies of the Ionosphere" (Aarons), "Earthquakes and Earth Structure" (Hodgson), and "Advances in Geophysics" Vol. 11.

4. SCIENTIFIC PROGRAMME

Geomagnetism

Normal magnetograph. The Eschenhagen 20 mm/hour magnetograph continued in operation. Record losses were higher than in previous years mainly owing to errors made by the relief attendant. Losses from other causes were in H (6 days) following the spontaneous rotation of the magnet on 30 December 1964, and Z (7 days each in May and September) when the magnet jammed against a damping block. It is not known how the Z magnet moved bodily to allow it to foul, although it did so during weekly visits to the vault.

Adjustments made were the lowering of the D variometer (5th July) to increase the trace intensity, and re-securing of the H sensitivity magnet against its upper stop (26th October). Abrupt changes in baseline values occurred after these adjustments and on eleven other occasions (three D, five H, and three Z).

Four of the H changes were caused by magnetism of the scale-value coil; when left 180° away from its normal position it produces a trace movement of about 2 mm (5 gammas). The effect is negligible for other positions, so replacement of the coil former is not warranted.

It is probable that the slipping of the H sensitivity magnet down its support caused the rotation of the recorder magnet in December 1964. That it had moved was not noticed until inspection of the variometer in October when interchanging the D and H scale-value coil bases. It is also significant that the temperature coefficient derived from baseline values after December 1964 was 3.0 gammas/°C compared with 1.5 gammas/°C in earlier years. This suggests that the sensitivity magnet became anti-parallel to the recorder magnet at that time.

Between these abrupt changes, D baseline values showed a tendency to vary with temperature as in previous years; H values were constant and Z values nearly so. The standard deviations of observed values from adopted values are:

Element	Standard deviation	
	Baseline value	Scale value
D	0.23 minute	-
H	1.6 gammas	0.01
Z	2.4 gammas	0.02

Standardisation and station differences. Proton magnetometer MNZ1 was used to give standard values of F in April and Z in September to October. On both occasions simultaneous values of Z were measured with BMZ120; in April QHM293 was read immediately before and after each comparison. The corrections obtained for BMZ120 were +305 gammas (April) and +302 gammas (October). No other standardisations were made. Corrections applied to all instruments are given in Table 4.

Previous suspicions regarding the BMZ pier (1964 annual report) were confirmed by extensive measurements on it and pier Nw (proton pier), before (Sm.1) and after (Sm) its reconstruction on 14th July when the original brass legs were replaced by sand-lime bricks. Table 5 lists the corrected station differences to be applied to all data for 1957 to 1965.

All BMZ comparisons were re-examined and allowances were made where necessary for the station differences. The resultant final corrections for 1956 to 1965 are shown in Plate 1.

Analysis of the Z baseline values for 1964 to 65, observer-by-observer, gave these approximate results (in gammas):

Observer	Difference from mean	Standard Deviation
A	+2	2+
B	0	1+
C	-1/2	2-
D	-1 1/2	2+

This indicates that all observers are about equally consistent, and that two observers may differ by 3 or 4 gammas (corresponding to 0.2 division on the eyepiece scale). It is apparent that all regular observers should be used in a BMZ comparison and allowance made for change of personnel, particularly at one-man stations.

Accessory equipment. Continuous recording of dH/dt by the induction loop commenced on 17th May; prior to this, recording had been restricted to the three Regular World Days each month. No analysis of the records was made.

The La Cour H and D variometers were installed in the laboratory by the Antarctic trainees and run for a few weeks in October. A Ruska Z-variometer from Wilkes station was operated from July through October to check its performance in normal surroundings. Daily scale-value determinations showed a fairly steady and rapid decrease of sensitivity but there were no obvious trace discontinuities. It will be re-installed at Gnangara to allow baseline control.

The pendulum clock was removed from the vault (December) ·er some loss of time marks, and replaced by the standby chronometer ·ch transistor relay. Excessive backlash (± 1 minute) had developed in the minute hand, making it impossible to get time marks over the hourly cycle. The cause was wear of the square section hole in the clutch plate; peening with a hammer restored its shape and reduced the backlash to that in the gear train.

During a severe electrical storm (3 a.m., 22nd November) the time-mark lamp burned out, the Z trace showed a shift of 2 mm (11 gammas), and electric wiring at the vault junction-box fused. The Z shift was apparently not permanent as judged by control data. Inspection of the terminations in all the fuse boxes showed that they required renewing and the matter was placed in the hands of the Department of Works.

An artificial light source was fitted over the QHM pier (Ne). It comprises five 40-watt globes behind an 18-inch square ground perspex sheet. The unit slides on track so that it can be moved from over the pier during summer when it is not required.

Data and reductions. There were no changes in the data distribution schedules. Absolute procedures were streamlined by reducing the observation times noted to the first and last, and the preparation of QHM tables listing $C + c_1 t - c_2 H \cos \phi$ as a function of temperature.

In the mean hourly values reductions progr mme, items completed were: plotting sheets for Watheroo 1956-58 and Gnangara 1957-60, parameter sheets 1961-63 (CDC 3600), and descriptive text (in bi-annual lots) for Watheroo 1953-58 and Gnangara 1959-62. Tabular descriptions of magnetic storms and lists of K Indices and C figures were compiled for Gnangara 1957-58.

Miscellaneous requests attended to were for magnetogram copies (Dr Schlich, France; Mr L. Heisler, RRB Sydney) and for D diurnal variation data (Dr Mayaud, France).

The provisional annual mean values at Gnangara and the algebraic change from 1964.5 were:

D	-2° 51.7'	(0.0 minute)
H	23,906 gammas	(-10 gammas)
Z	-53,496 gammas	(+ 5 gammas)

Monthly mean values suggest that D may be starting to become more negative and Z may be starting to become more positive; H is continuing the decrease that started about 1958.

Ionospheric physics

Ionosonde. The quarter-hourly sounding schedule was continued using the Cossor 7562C ionosonde. In addition, continuous (one-minute programme) soundings were made from 5 a.m. to 10 p.m. on the Regular World Days in March and June; in accordance with an I.P.S. instruction, similar soundings due in September and December were not made.

Other continuous soundings were made in two-hourly sequences at selected times covering S-66 satellite passages during January 13th to 24th, June 18th to 29th, and September 13th to 26th.

A major loss of record occurred in March when a component break-down was followed by prolonged failure to locate it. This mainly accounted for the increase (to 9%) of missing F2 region critical frequencies (foF2). The break-down of losses from non-ionospheric causes was: film run-out 0.2%; camera failure 1%; component failure 1%; programme failure 0.5%; and observer 2.5%. The first source was reduced markedly over previous years by the insertion of a film footage counter in the winder used for division of bulk supplies. It comprised a Veeder-Root counter fitted with 1-ft circumference rubber-coated wheels and concealed illumination.

Data and publications. There were no changes in the hourly data derived, or the distribution programme. Frequency plots were prepared for the six Retrospective World Intervals so far declared for the I.Q.S.Y. 1964-65. All continuous sounding records were deposited at I.P.S. Sydney.

The annual mean noon value of foF2 was 6.2 Mc/s; this, together with the graph of monthly mean values confirms that frequencies are trending upwards as the new solar cycle (No. 20) progresses. Another feature was the occurrence of intense sporadic E (Es), particularly in December.

Seismology

Recordings were made at the observatory (station code MUN) and at Kalgoorlie airport (KLG) throughout the year. In November a hybrid two-component instrument was set up on loan to the Lake View and Star (LVS) goldmining company at Boulder, and the Western Australia Public Works Department's Willmore vertical seismograph brought to operation at Kununurra (ORD).

A series of calibrations were made on MUN and KLG components. These are fully described by Gregson (in preparation).

A site on the airport at Wittenoom Gorge (WTG) was selected for the installation of a seismograph in 1966. Preliminary arrangements were made with the D.C.A. for this project, which is part of the Observatory's long-term programme on regional seismicity and structural studies.

Standard system (MUN). On 28th January the long-period Z galvanometer fibre broke (of its own accord) and was replaced the next day. All long-period seismometer free periods were reduced from 30 to 15 seconds (29th April) in accordance with a USCGS instruction. Some trouble was experienced with the stroboscope in May and it was replaced in June; otherwise the entire system operated satisfactorily.

Benimore system (MUN). This was operated throughout except for a few days in August when the recorder was used at Kalgoorlie for noise and period studies. These were made in response to a request by Professor Black (London) for information in connection with a rock-mechanics project; they were made during a maintenance visit to the KLG instrument. Periods from a local event were 0.18 second for P and 0.12 second for S.

In April the original 1 r.p.m. recorder motor was replaced by one of 4 r.p.m. giving maximum and minimum paper rates of 216 and 54 mm/min. In conjunction with the stronger lamps (fitted in 1964) excellent recordings are given at the higher rate. From August the recorder was run at 216 mm/min from 9.30 a.m. to 3.30 p.m. and at 54 mm/min for the rest of the day to give better resolution of daytime quarry blasts (and any local events). Wear of the spiral and bevel gears required their replacement in December.

KLG system. Considering the distance of the station from Mundaring, record output was reasonably satisfactory. The main losses occurred through a power supply failure, loss of timing when the programming units were incorrectly re-assembled, tilting of a galvanometer mirror, and a loss of sensitivity on one component.

To prevent future incorrect connections, all the power supply, radio programmer, and chronometer relay inter-connections were converted to multicore cables and canon connectors. At the same time a meter was fitted in the chronometer relays to show the power supply voltage, and to give a visual indication of time-mark operation. A revised circuit diagram (Plate 2) was drawn. It includes the schematic diagram of an adaptor constructed for use with the transistor radio, which was modified by the insertion of a miniature jack plug in the battery supply ("On-off") line.

The loss of sensitivity was overcome by replacing all the potentiometers in the damping and matching networks by appropriate fixed resistors. After this, a long-period wandering on one component (which had existed since installation) disappeared.

LVS System. This comprised a Benioff triple-drum recorder, two horizontal Willmore seismometers (0.8 seconds) and two Benioff galvanometers (14 seconds). The 30 mm/minute recorder was driven at double speed, requiring 12-hourly record changes. The unit was installed (by Everingham and McGregor) in a concrete floored cellar at the company's store (Chaffers). It was calibrated to enable the bearings of local events to be determined.

The company provided all photographic supplies and ttendants, and processed the records in return for observatory interpretation of events. The project will last about six months.

Data and publications. Two changes were made in the reporting of teleseismic data. Those for the USCGS epicentre programme were sent twice-weekly by telegram from 19th July, instead of by daily aerogrammes. This was initiated after the visit of Mr W.N. Green, the aim being the "...acceleration of the location and publication of epicentres". The telegrams are sent to the American Embassy (Canberra) in a form permitting "...automatic data handling and accurate data transcription". A weekly aerogramme was sent as a check on the system.

In October the use of mark-sense cards for I.S.R.C. final data was abandoned, the information being supplied to headquarters for transmission on punch cards. This form of reporting commenced with January 1965 data for KLG, and June 1965 for MUN. The final bulletins listed 788 P-type arrivals at MUN and 349 at KLG for the year.

Seismicity notes. The Record on the seismicity of Western Australia to 1965.5 was completed (Everingham, 1966); Tables 2 and 3 in it are to be supplemented by Tables 6 and 7 of this Record, which contain regional and local events. Plate 3 brings the previous seismicity map up to date to 1966.0. Table 8 lists other main Australian earthquakes, the data for which have been abstracted mainly from USCGS Data Reports. Lists similar to Tables 6, 7, and 8 will be included in subsequent annual reports so that the information will be readily available for various studies.

Activity in the Yandanooka/Cape Riche zone was the least of any year since recording commenced in August 1959, only seven events being recorded from it (Table 7). On the other hand shocks occurred in parts of the State where little or no activity had previously been reported.

Earthquake numbers 46, 47, 48, and 52 (Table 6) occurred in the Indian Ocean off Carnarvon; in conjunction with previous shocks they suggest that active zones may exist on both sides of the Perth and Carnarvon Basins, but not close to their margins. Shocks No. 49 and No. 51 occurred on the Archaean part of the Shield, further inland than any before recorded; shock No. 51 is the only one known to have occurred between the active zones along the eastern and western edges of the Australian Shield.

Seismic events, KLG. Between 7th November 1964 (when recording began) and the end of 1965, 116 events were recorded from the mining area. Sixty of them were most probably due to blasting, as judged by their appearance and times of occurrence. Of the remainder (referred to here as 'rock-bursts'), 35 were felt and/or caused damage in the mining area.

All the events are listed in Table 9, which includes abstracts of mining companies' reports. Three of them (1964 December 2, 1965 June 10, and 1965 August 24) were recorded at Mundaring allowing determination of their magnitudes, and (by comparison of seismograms) the magnitudes of the others. The smallest 'rockburst' (relative amplitude 1.0) was of magnitude M_L=0.7, which is the order of the blast magnitudes. The only other events from Kalgoorlie recorded at Mundaring since August 1959 were on 1964 February 22 (M_L=2.7) and two on 1964 March 9, (M_L=3.9 and 3.0).

A relative strain release value has been allotted to each 'rockburst'. Strain release has been assumed proportional to trace amplitude to the power 3/4 (Richter, 1958). Trace amplitude (relative amplitude of Table 9) is the resultant of the maximum horizontal trace deflections and probably refers to Rayleigh waves. The cumulative release pattern is shown in Plate 4.

Effects in the mines could be a result of natural tremors, or of mining activity; the instrumental data lend support to the second view. The rock-mechanics project to be undertaken by one of the mining companies in 1966 should allow resolution of this question.

5. ACKNOWLEDGEMENTS

The assistance of the State Controller, Department of Supply (Perth), and of Mr D. Eggleston at the Kalgoorlie outstation is hereby acknowledged. The information on seismicity was compiled by I.B. Everingham and P.J. Gregson.

6. REFERENCES

EVERINGHAM, I.B. 1966 Seismicity of Western Australia. Bur. Min. Resour. Aust. Rec. 1966/127.

GREGSON, P.J. Seismograph calibrations, Mundaring and Kalgoorlie, WA 1965-66. Bur. Min. Resour. Aust. Rec. (in preparation).

MCGREGOR, P.M. 1966 Mundaring Geophysical Observatory, annual report 1964. Bur. Min. Resourc. Aust. Rec. 1966/37.

RICHTER, C.F. 1958 ELEMENTARY SEISMOLOGY. San Francisco, W.H. Freeman p. 366.

TABLE 1

Observatory staff 1965

Officer	Designation
P.M. McGregor	Geophysicist Cl. 3 (Observer-in-Charge)
I.B. Everingham	Geophysicist Cl. 2
P.J. Gregson	Geophysicist Cl. 1
A. Parkes	Technical Officer Gr. 2
G. Woad	Technical Officer Gr. 1
T.D. Dunning (Miss)	Clerical Assistant Gr. 1
N. Keating	Assistant Gr. 1

TABLE 2

Associated personnel

Name	Designation or services rendered
L.F. Quin (Miss)	University student, vacation 1964/65
V.N.E. Robinson	University student, vacation 1964/65 and 1965/66
D.J. Edmiston	University student, vacation 1965/66
F.J. Taylor	Geophysicist Cl. 1, Antarctic trainee (13th September to 22nd October)
P. Towson	Geophysicist Cl. 1, Antarctic trainee (9th September to 22nd October)
D.H. Eggleston	Daily attendant, Kalgoorlie seismograph
R. Gaskell	Daily attendant, Gnangara magnetograph
A. Wormall	Daily attendant, Gnangara magnetograph (relieving from September)

TABLE 3

Observatory staff absences

Nature of absence	No. of man-days
Sick, special, repatriation, leave	24
Military leave	25
Attendance at outstations	33
Conferences and interstate travel	67
Total	149

TABLE 4

Corrections to magnetometers, 1965

Instrument	Element	Correction
Askania 508810	D	+0.5 minute
QHM 291	H	-13 gammas
QHM 292	H	-19 gammas
QHM 293	H	+ 1 gamma
BMZ 120	Z	+305 gammas

TABLE 5

BMZ pier corrections, 1957-1965

Interval	Station	Correction to pier Nw (gammas)
1957 June - 1960 June 15	Aux	+5
1960 June 22 - 1965 July 14	Sm.1	+12
1965 July 20 -	Sm	+0.2

TABLE 6

Western Australian earthquakes ($M_L \geqslant 3.3$), 1965

No.	Date	H	Lat. °S	Long °E	Distance (MUN) (km)	M_L (m_L)	M_S (m_S)	m_b	Unified m	Remarks
45	May 18	10 17 52	17.5	121.0	1690	4.5		4.6	4.6	Rec. DAR, KLG
46*	May 19	02 13 48	25.0 h = 33 km	112.1	900	6.1	5.0 (5.6)	6.0 5.6X	5.6	Felt Carnarvon
47*	Jun. 15	06 16 01	19.6 h = 33km	106.3	1700	5.3		4.8	4.8	Indian Ocean
48	Jul. 14	13 05 34	25.1	112.0	860	3.8		4.5	4.5	Rec. KLG
49	Jul. 14	23 07 05	26.6	117.3	600	3.3 (4.3)		4.4	4.4	Rec. KLG
50	Sep. 10	12 24 01	18.1	122.2	1670	5.1		4.7	4.7	Rec. DAR, KLG
51	Oct. 4	00 44 12	28.1	123.3	780	4.1		4.5	4.5	Rec. KLG (M_L 3.6) Felt Cosmo Newbery
52	Oct. 11	04 07 27	26.9	110.5	780	4.5		5.6	5.6	Rec. KLG

Notes:

DAR - Darwin

M_L, m_b Determined from MUN records unless designated

M_S Mean value determined from all suitable recording stations

m Weighted mean from all listed magnitude values

* Determined by USCGS

X Mean for W.W.S.S. stations, MUN excluded

TABLE 7

Western Australian minor earthquakes ($M_L < 3.3$), 1965

Date	P - arrival (G.M.T.)	M_L	Distance (km)	Bearing ^oT
Feb. 2	22 55 37	2.2	92	108
Mar. 13	20 20 33	1.8	95	108
Mar. 14	00 29 20	1.8	95	108
Jul. 4	06 48 29	1.7	106	000
Jul. 13	06 07 32	1.5	84	120±
Jul. 16	20 05 23	1.0	88	090
Jul. 22	18 35 48	2.0	90	125

TABLE 8

Larger Australian Earthquakes for 1965

Date	H			Lat °S	Long °E	m_B	P.D.E. Card	h
Jan. 17	02	48	32.8	28.1	135.7		13/65	33R
25	20	22	56	32.2	138.6	4.9	13/65	33R
Mar. 2	15	18	53.2	30.5	138.4	5.1	28/65	33R
14	12	47	42.2	31.9	138.8	5.0	27/65	26
18	18	09	31.1	40.2	149.6		33/65	33R
May 19	02	13	47	25.0	112.1	5.7	51/65	33R
Jun. 3	21	59	58.5	28.1	150.1		52/65	33R
4	10	45	13	30.8	138.5	(Aust. data)		
15	06	16	01	19.6	106.3	4.3	64/65	33R
Aug. 28	00	26	38.1	32.3	138.1	4.9	74/65	33R
Sep. 14	12	53	13	38.7	144.3	5.0	74/65	33R
14	12	34	36.3	38.7	144.2		75/65	33R

TABLE 9

Seismic Events at Kalgoorlie

7th November 1964 - 31st December 1965

Date	W.S.T.		Relative Amplitude	Approximate* Bearing	Remarks **
1964 November					
7	17	10	1.0		Blast?
12	15	16	1.5		Blast?
18	06	03	14.0		GB, LVS, strong, no damage.
19	15	19	1.5		Blast?
21	18	29	4.5		LVS, strong, no damage
23	18	39	3.5		
30	00	49	4.0		GB, strong, no damage
December					
2	13	33	60		GB, LVS, strong, no damage - recorded at Mundaring(M_L = 2.5)
8	04	23	0.9		
8	20	00	5.0		
9	20	20	1.2		Blast N?
10	15	24	1.0		Blast N?
11	15	49	1.2		
14	12	28	6.0		GB, Slight damage - LVS medium, no damage.
14	15	20	1.0		Blast?
18	15	11	0.9		Blast?
21	02	45			Reported GB - not recorded
24	14	57	1.3		Blast?
29	11	49	1.6		Blast?
31	15	31	1.9		Blast?
1965 January					
4	15	18	1.3		Blast?
6	16	14	2.1		LVS, slight, no damage.

Date	W.S.T.		Relative Amplitude	Approximate * Bearing	Remarks **
1965					
January					
6	16	15	9.7		GB, LVS, moderate, no damage.
9	15	02	1.4		Blast?
16	15	17	2.1		Blast?
21	09	06	6.2		
21	09	07	7.1		
23	15	03	1.0		Blast?
February					
6	16	56	1.0		
9	15	15	1.5		Blast?
10	15	12	0.9		Blast?
12	15	17	0.6		Blast?
16	15	12	0.6		Blast?
22	19	31	1.0		Blast?
22	20	12	1.3		
27	08	59	1.5		GMK - Blast, Kalgoorlie Enterprise shaft.
March					
4	03	57	0.9		Blast?
4	04	20			Reported GMK - no recorded
4	06	31	4.5		GMK - felt no damage
6	00	26	3.2		GMK Stopeblast.
10	11	50	Instrument adjustments		Reported GB
11			Instrument adjustments		GMK rock fall
15	15	03	1.7		Blast?
17	15	23	1.1		Blast?
17	21	32	5.0	085	GMK, LVS, GB, weak, no damage
17	21	33	4.0	088	GMK, LVS, GB, weak no damage
20	10	52	0.8		Blast?
22	00	34	0.5		Blast?
25	22	39	3.0	083	GMK, no damage

Date	W.S.T.		Relative Amplitude	Approximate * Bearing	Remarks **
1965 March					
25	23	32	16.0	077	GB, NK, GMK. Severe, no damage.
26	15	39	1.5		GMK, NK, - stope blast Paringa.
27	10	30			Reported GB - not recorded
27	12	08	1.2		Blast?
29	15	20			Reported LVS - not recorded
29	15	28	1.5	025	Blast?
April 5	07	19	12.5	076½	GMK, rock fall - GB, NK, felt.
7	15	10			Reported LVS
7	15	39	1.0		Blast?
8	15	12	1.2		Blast?
13	05	49	2.3		LVS, weak, no damage.
14	15	21	1.7		Blast?
20	17	20	1.5		Blast? - felt NK
20	18	40			Reported NK
22	15	20	1.1		Blast?
22	20	35	11.0	084	LVS, strong, damage - felt GB
27	14	50			Reported LVS, slight.
27	Seismograph not operating				
28	Seismograph not operating				
29	12	06	1.9		NE Quarry blast?
30	20	36	6.5	(086)	
30	21	35			Reported LVS
May 1	15	16	1.5		Blast?
3	12	22	1.2		Blast?
4	15	11	1.2		Blast?

Date	W.S.T.	Relative Amplitude	Approximate * Bearing	Remarks **
1965 May				
5	00 38	2.6	(074½)	
8	09 45			Reported NK
9	10 46	11.0	093	GB, severe damage - NK, GMK, LVS, medium, no damage.
11	15 17	1.0		Blast?
14	19 23	1.0		Blast?
19	23 26	5.0		Blast? (Mt. Charlotte?)
21	22 03	21.0	090½	GMK, damage - LVS, NK, GB, severe no damage.
27	21 30	2.0		LVS, damage - GB, NK, medium to strong, no damage.
June				
2	20 01	0.6		Blast?
3	14 45			Reported GB
8	01 31	3.0		
10	17 21	43	(073½)	LVS, GB, NK, strong no damage - recorded at Mundaring (M_L = 2.3)
10	17 23	22	073½	ditto (very weak)
17	00 10	6.8	(068)	GB, slight
18	15 14	0.8		Blast?
19	15 (24)	1.2		Blast?
22	12 25	2.0		LVS, very strong, damage.
25	18 09	6.7	(081)	
26	13 46			Reported NK
26	15 03	1.0		Blast?

Date	W.S.T.	Relative Amplitude	Approximate * Bearing	Remarks **
July				
3	00 06	2.5	(093)	
5	15 00	4.5	(088)	
6	15 20	1.4		Blast?
9	00 02			Blast GMK, not recorded.
12	12 20			Reported GB, slight bump, no damage.
21	15 39	2.2		Blast?
25	(17 58)	2.4		GB, medium
26	15 39	1.2		Blast?
29	15 27	1.5		Blast?
August				
3	15 17	2.5		Blast?
4	15 15	0.9		Blast?
5	15 17	0.9		Blast?
12	14 38			Reported NK
18	14 32	14.0		Felt GB minor damage - GMK, NK, LVS, felt but no damage.
19	15 16	0.4		Blast
25	06 40	(270)	(081½)	GB, heavy tremor, severe damage 820 ft from Hamilton shaft azimuth 41°-69°. GMK, no major damage - LVS, NK, felt, no damage. Recorded Mundaring (M_L = 3.3)
25	06 42	5.2	081½	GB, sharp snaps 2 - 3 minutes after above - NK, felt.
26	10 30			Reported GB, two slight bumps location as above.
26	17 57	6.8	079½	GB, damage 600 ft from main shaft, azimuth 352°. LVS, slight, no damage.

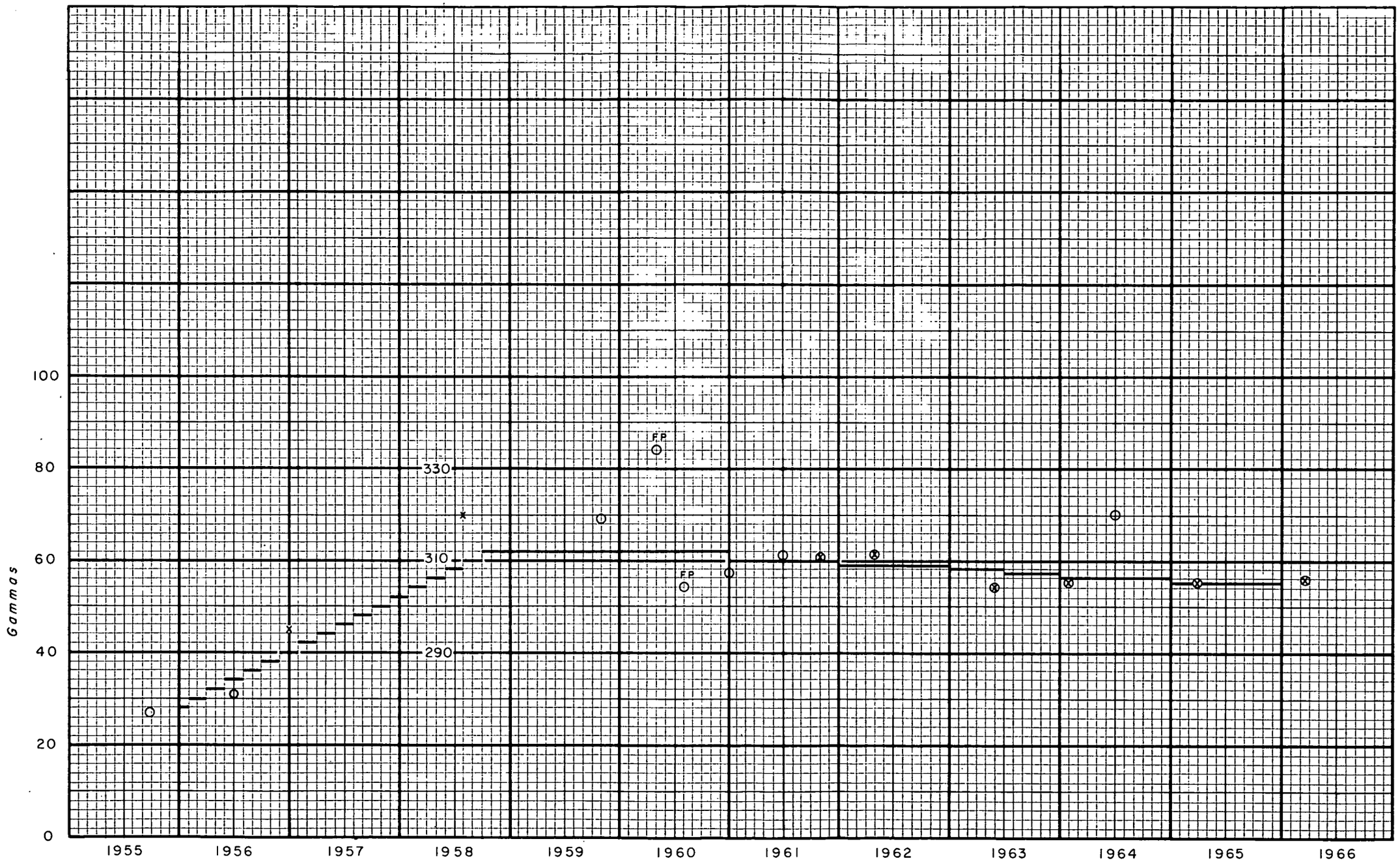
Date	W.S.T.		Relative Amplitude	Aproximate * Bearing	Remarks **
September 2	05	38	1.0		LVS, two slight tremors damage - GB, two slight bumps, no damage.
9	17	37	1.9		
10	15	15	0.4		Blast?
22	15	07	3.0	102½	
22	15	10	13.5	198	GB, slight bump minor damage - LVS, medium, no damage - NK, slight at surface
23	18	49	1.1		GB, slight bump, no damage
24	12	08	1.0		
October 10	09	55	2.0	(084)	LVS, medium, no damage.
12	01	43	2.0	(074)	NK, moderate on surface, no damage
28	15	22	1.3		Blast?
31	15	30			Reported LVS, minor fall.
November 2	15	51	1.5		Blast?
13	11	32	18.0	096	LVS, sharp medium tremor, slight damage. Position - 0 - 20 chains south of Chaffers shaft.
18	23	10	1.2		
22	14	44	1.1		Blast?
24	21	20	1.1		NK, slight bump, no damage.
26	15	22	1.0		Blast?
December 3	15	36	0.8		Blast?
8	15	29	1.4		Blast?
14	15	23	1.1		Blast?
21	15	27	1.6		Blast?
24	15	13	1.7		Blast?
28	15	26	1.4		Blast?

* Bearings are from the seismograph at the airport entrance.

** Reports of events felt were given by the following mines:

GB	Great Boulder Gold Mines Ltd.
LVS	Lake View and Star Ltd.
NK	North Kalgoorlie (1912) Ltd.
GMK	Gold Mines of Kalgoorlie (Aust). Ltd.

PLATE 1



O B M Z

x Earth inductor

⊗ Proton procession magnetometer

O FP Field party B M Z

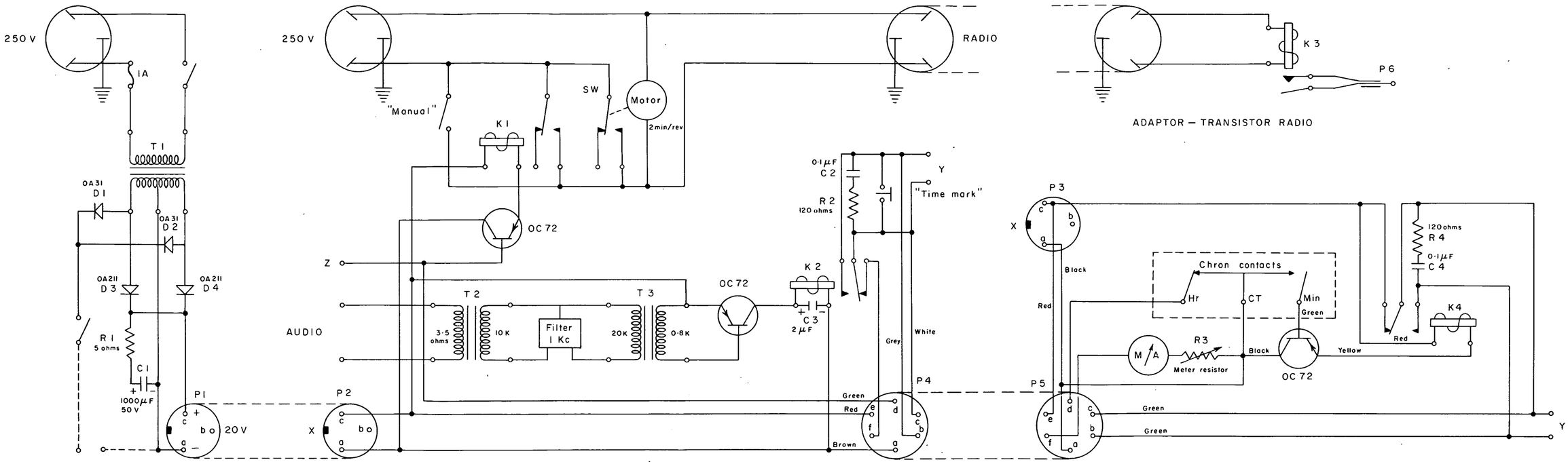
MUNDARING GEOPHYSICAL OBSERVATORY ANNUAL REPORT 1965

BMZ 120 CORRECTIONS, 1956 – 1965

(BASED ON G 82–134)

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G 82/2–58

TO ACCOMPANY RECORD 1967/29



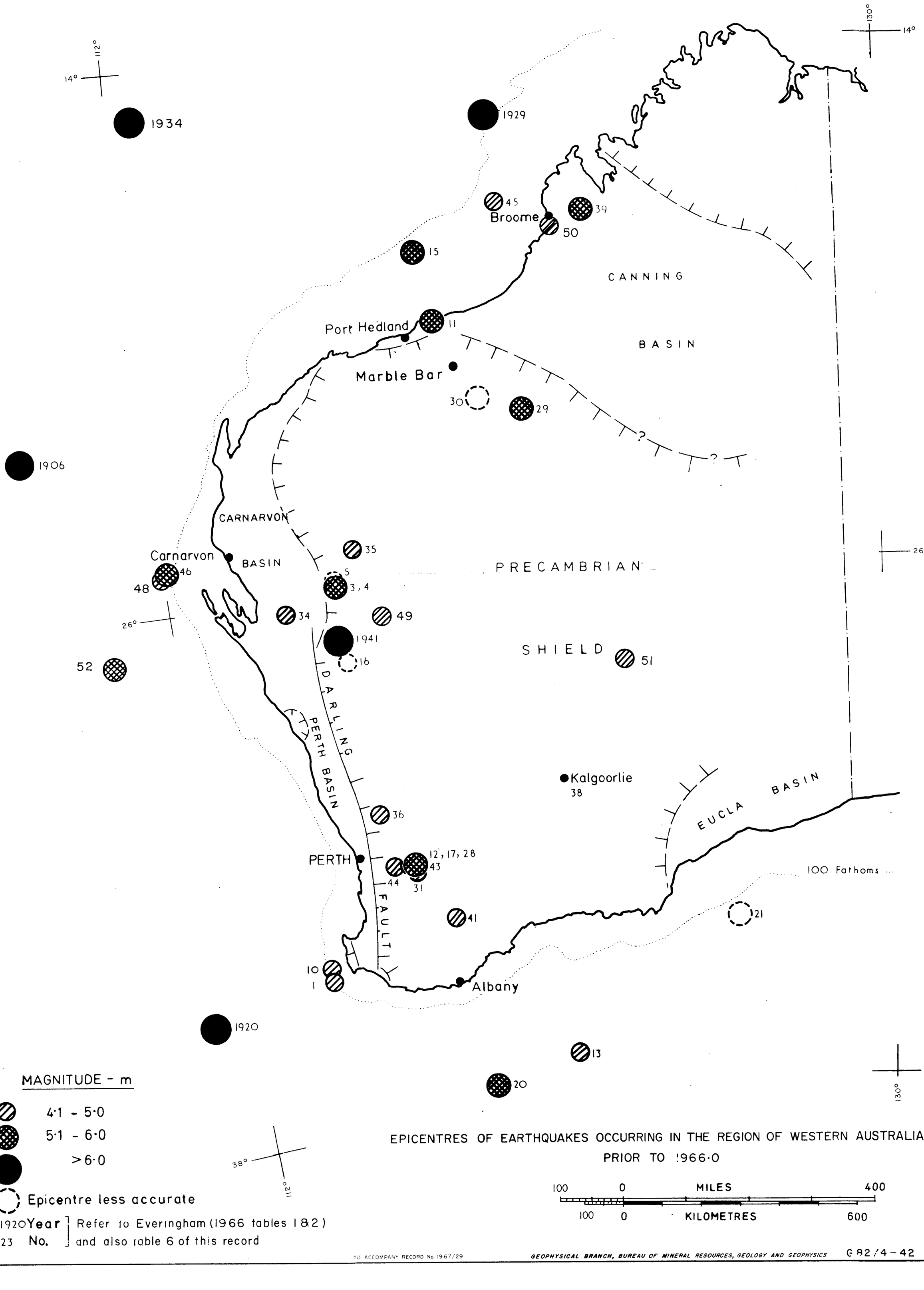
Alternative connections: X, X — 20V input (P/S or dry battery)
Y, Y — to Recorder
Z — from Hr contact

RADIO TIME-MARK SYSTEM

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G 82/3-80

TO ACCOMPANY RECORD No. 1967/29

PLATE 3



MAGNITUDE - m

- 4·1 - 5·0
- 5·1 - 6·0
- >6·0

Epicentre less accurate

1920 Year
23 No.
Refer to Everingham (1966 tables 1&2) and also table 6 of this record

EPICENTRES OF EARTHQUAKES OCCURRING IN THE REGION OF WESTERN AUSTRALIA PRIOR TO 1966·0

100 0 MILES 400

100 0 KILOMETRES 600

TO ACCOMPANY RECORD No. 1967/29

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

G 82/4-42

KALGOORLIE SEISMIC EVENTS
CUMULATIVE STRAIN RELEASE 1965

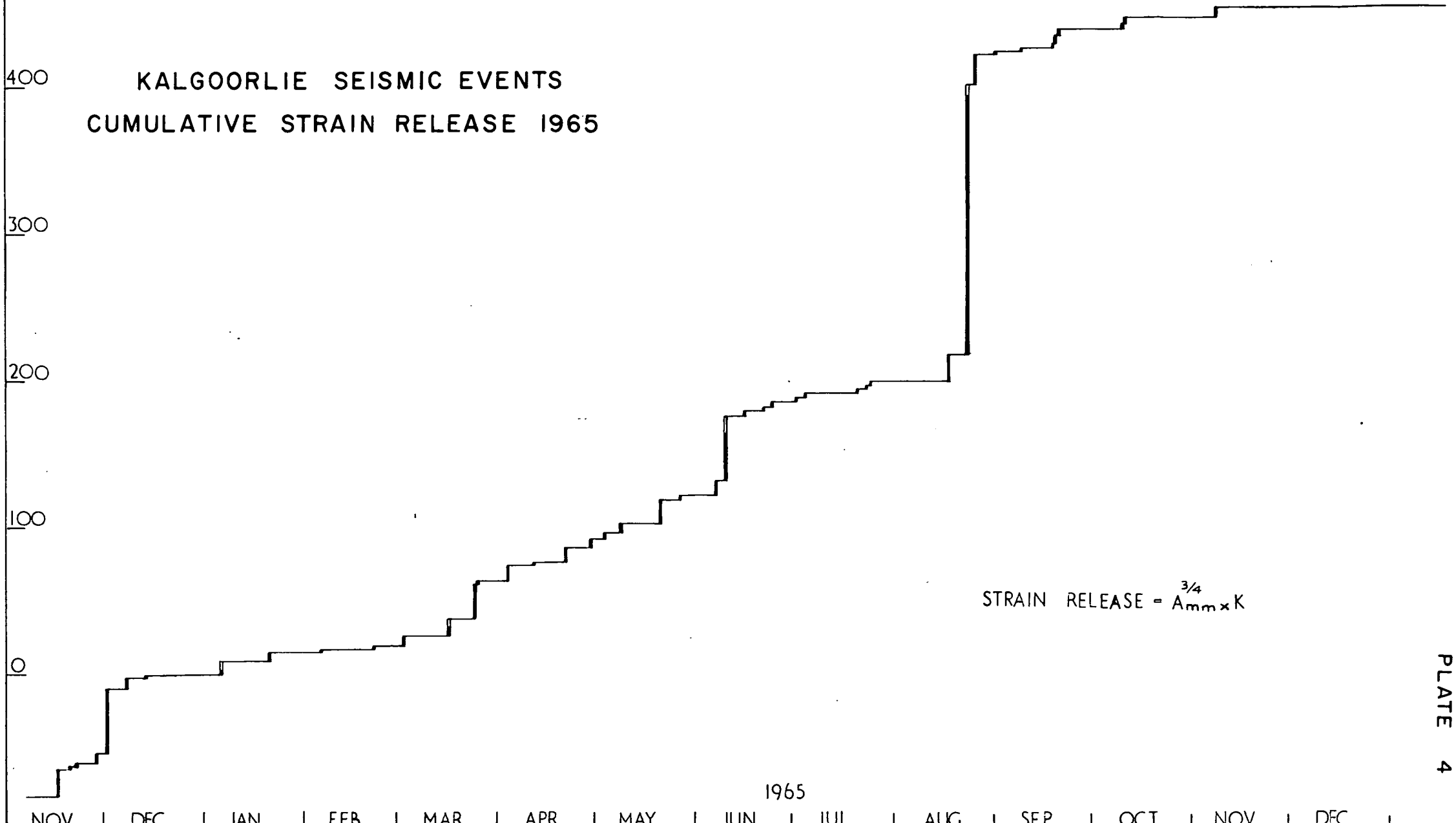


PLATE 4

TO ACCOMPANY RECORD No. 1967/29

G82/4 - 43