COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1966/35

MUNDARING GEOPHYSICAL OBSERVATORY,

ANNUAL REPORT 1962

by

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CONTENTS

TABLES

ILLUSTRATIONS

SUMMARY

The programme, organisation, and activities of the Mundaring Geophysical Observatory during 1962 are outlined. Instruments in operation are a normal magnetograph, an ionosonde, and seismographs; descriptions of the instruments, sites, and buildings are given, and appendixes summarise the observatory's history before 1962. In June 1962 the observatory became one in the World Network of Standardised Seismograph stations.

Regular scientific results are not included, as they were published currently or will be contained in separate reports.

1. INTRODUCTION

This Record describes activities at the Mundaring Geophysical Observatory during the calendar year 1962. Because it is the first in a series of such annual reports, descriptions of the observatory establishments, equipment, and operations are given in some detail. Appendixes 1 and 2 list main events in its history, and staff members to 1962. Instrumental data for the period before 1962 are included in tables showing current information.

The observatory replaced the Watheroo Magnetic Observatory on 18th March 1959 and is one of six now operated by the Geophysical Branch of the Bureau of Mineral Resources, Geology & Geophysics. Its function is to make basic investigations in the disciplines of geomagnetism, seismology, and ionospheric physics. In order that the site (and other) requirements for each discipline may be met the observatory comprises three establishments which are referred to as the "office", "weir", and "Gnangara" sites; the last has the separate and official title of "Gnangara Magnetic Observatory". Table 1 gives the site co-ordinates and other data, and Plate 1 shows their locations.

2. OBSERVATORY ESTABLISHMENTS

Office site

The office site is in Mundaring township where postal, telephone, and electrical power facilities are available. Located on Lots 73 and 74 are the office, garage, caretaker's residence, and laboratory, as shown in Plate 2A. Mundaring is 21 miles east of Perth, on the Great Eastern Highway. The site is one block south of the highway at the corner of Hodgson and Craig Streets.

Office. This is a brick and tile building providing 2400 square feet of floor space. It is divided into rooms whose functions are shown on the floor plan (Plate 2B). The processing of all photographic records (except ionograms) and the derivation of data from them are done in this building. A small workshop provides space for the repair or construction of equipment.

Laboratory. Constructed of silica bricks and asbestos, this building is non-magnetic. Its internal dimensions are 25 ft x 11 ft. It was completed in January 1962, and the floor plan is shown in Plate 2C. A plywood partition and curtained light trap were fitted during the year to provide observing and recording sections. Eight pier bases were provided in the building, six of them in the recording section; they are isolated from the concrete floor and are at floor level. This allows benches to be fixed in any desired layout for testing or short-term operation of recorders. A standard-height pier with BMZ-type top was secured to one of the bases in the observing section. This allows new observers to become familiar with the operation of magnetometers under supervision without having to travel to the Gnangara site. A combined reference mark and theodolite pillar was erected in the south-eastern corner of the site, to facilitate training in sun observation techniques.

During testing of seismometers and variometers it was found that the precaution of isolating the pier bases was unnecessary; instruments operated just as satisfactorily on the floor as on the bases. The construction of similar buildings could be simplified, and the cost reduced, by using a simple concrete floor.

Garage. This building measures 20 ft x 20 ft and has single-brick walls and an asbestos roof. It provides housing for the two official vehicles and some space for machine tools (lathe, circular and band saws, drill press, etc). Larger construction jobs have been done here but the arrangement is far from satisfactory - space is limited, lighting is bad, jobs cannot be left set up overnight, and summer and winter working conditions are poor. It was therefore planned to have the building extended by ten feet on the north side to provide a separate machine-shop, and the Department of Works estimate of cost was included in the Works proposals for 1963/64.

Weir site

Plate 3 shows the site plan. The site is about 6 miles (9 road miles) south-east of the office, in the Forest and Water Catchment reserve of the Mundaring Weir. The pumping station at the weir and the nearest public road are some three miles to the west. The site is a timbered area of ridges and gullies on a granitic section of the Precambrian Shield; the Darling fault, which is the western edge of the shield, is ten miles to the west.

Ionospheric house. Situated on a ridge which provides a reasonably level area for the antenna are this building and an associated store-lavatory structure. Plate 4A shows the floor plan of the house, which is of timber and asbestos-cement construction. It provides plenty of space for housing the ionosonde and test equipment and is amply provided with cupboards, benches, and shelves. The darkroom is adequate for handling the 35-mm ionograms, which are processed here each morning. Water is supplied from the 2000-gallon tank by an automatic pressure unit, and there are facilities for heating or cooling it. The water supply is not always sufficient to last through the summer but it can be replenished from a similar tank at the powerhouse.

Powerhouse. Because the site is some miles from the nearest commercial electricity mains, a power plant had to be provided. Details of the plant and power supplies are given in Chapter 8. The powerhouse is about 50 yards from the ionospheric house and about 500 yards from the seismograph vault. It is constructed of the same materials as the ionospheric house.

Seismograph vault. Plate 4B shows the floor plan of the vault, which is built into an excavation on the side of a ridge. The excavation penetrates into solid granite. The walls and arched roof consist of an inner shell of concrete, a waterproof membrane, and an outer covering of brick to a total thickness of 11 inches. The vault floor floats on a layer of rubble through which agricultural drains are laid, discharging on the surface below the excavation. The excavation is filled with gravel and the roof is covered with three feet of gravel. Concrete seismometer piers are isolated from the floor and bedded into the granite. Recorder and galvanometer piers rest on the floor and are built of brick with concrete slab tops. A plywood partition and door were placed between the seismometer and recording sections in June. The annexe, consisting of a porch and console room, provides a light and thermal barrier to the vault proper.

Gnangara site

The magnetic observatory is situated on a ten-acre block in the State Pine Plantation at Gnangara. It is 15 miles (24 by road) north-west of the office, on the Quaternary sands of the Perth Basin. The site shows no local or regional magnetic anomalies, and being over four miles from the Midland Railway Company's line and thirteen miles north-east of Perth, is not influenced by man-made disturbances. Buildings, as shown on the site plan (Plate 5) comprise a variometer vault, absolute house, auxiliary house, and store hut. All but the last are built of non-magnetic materials, as checked by magnetometer tests during construction.

Variometer vault. Plate 6A shows the floor plan. The vault is of un-reinforced concrete, all but the roof-arch being below ground level. The roof is covered with a foot or so of earth. No temperature regulating devices are used; the temperature range during 1962 was from 26.4°C in February to 13.5°C in August, and it is unlikely that the daily variation exceeded 0.3°C. The "control" room contains a time-marking pendulum clock (La Cour type), and control panels for adjusting recorder lamp currents and making scale-value and orientation measurements.

Absolute house. This is of jarrah timber and asbestos sheet construction and is lined with plasterboard. Plate 6C shows the floor plan. Piers are of sand-lime bricks resting on un-reinforced concrete footings and are capped with marble slabs. Illumination is provided by sky-lights and windows. The room is large enough to allow simultaneous use of magnetometers on north and south piers. In normal weekly control observations vertical intensity (Z) was measured on pier SM, and horizontal intensity (H) and declination (D) on pier NE. Differences between the piers are negligible.

At the base of each pier is fitted a footswitch allowing manual time marks to be recorded on the magnetogram, in place of normal time marks. These are applied at the instant of making a reading.

Auxiliary house. Formerly the temporary absolute observatory, this is used for housing the magnetograph power supplies. After connexion of the observatory to the S.E.C. 250-volt 50-c/s mains in September, a battery and charger were installed, eliminating the transport of batteries between Gnangara and the office. Underground cables link the building and vault.

Store. Until January this structure was situated near the centre of the site. It was moved to its present position near the turning area by the Department of Works. It is of timber and asbestos sheet construction, and is far enough from the vault to have no perturbing influence. It serves as the termination of the S.E.C. electric transmission line; observatory wiring proceeds from here in the form of copper-sheathed underground cables ("Pyrotech").

3. STAFF

During 1962 the staff consisted of:

Senior Geophysicist (Observer-in-Charge)	P.M. McGregor
Geophysicist Grade 3	I.B. Everingham
Geophysicist Grade 2	Vacant.
Geophysicist Grade 1	P.J. Gregson (until 16th September)
Technical Officer Grade 2	A. Parkes
Technical Officer Grade 1	G. Woad
Clerical Assistant Grade 1	Miss J.I. Luhrs (until 9th March) Miss D.M. Belcher (from 7th March).
Assistant Grade 1	N. Keating

Others employed at the observatory were:

Geophysicist Grade 1 (Antarctic trainee)	R. Whitworth 5th September to 28th October.
University Students	D. Andrich and V.P. St John (Vacation 1961/62). P.J. Browne-Cooper and S.S.W. Hui (vacation 1962/63.)
Gnangara Assistant	L.K. Eastcott.

Annual recreation leave was taken by all staff members. In addition, I.B. Everingham was on furlough from 2nd July to 14th September, and G. Woad was on military leave from 10th to 21st September.

Everingham was appointed as a Bureau delegate to the 36th Congress of the Australian and New Zealand Association for the Advancement of Science (Sydney, 20th to 24th August) where he presented a paper on local seismicity; following this he visited the Australian National University, Geophysical Branch Headquarters in Melbourne, and Hobart University seismological station, resuming furlough on 3rd September. McGregor was on duty at Melbourne headquarters and Macquarie Island from 26th November to 21st December.

Staff employed before 1962 are listed in Appendix 2.

Other visits made by professional or technical staff members were to:

No. 8 Tracking Station, Muchea

University Physics Department, official opening ceremony of new building.

Stanford v.l.f. Station, Gnangara.

P.M. McGregor addressed the W.A. Branch of the Institute of Physics and Physical Society on the Observatory's work, and I.B. Everingham the W.A. Branch of the Royal Society on local seismicity.

4. ORGANISATION AND OPERATIONS

Scientific programme

The scientific programme can be divided into the following main classifications:

(a) production of recordings and maintenance of equipment - Technical Officers and Geophysicists Grade 1;

(b) interpretation of recordings - Geophysicists and Technical Officer Grade 2.

Three "routines" based on this were followed. These were:

(a) General Routine, Monday through Sunday (Technical Officers, Geophysicist Grade 1). Daily inspections of "Weir" establishments at 10 a.m. and 4 p.m. Change, process, and label seismograms and ionograms; copy seismograms; check powerhouse; carry out adjustments, calibration, repairs, and maintenance of equipment.

(b) Magnetic Routine, Wednesday and Thursday (Geophysicists, Technical Officer Grade 2). Make control observations at Gnangara and computations; process weekly batch of magnetograms; derive K-indices, base values, and scale values.

(c) Monthly Routines

Senior Geophysicist - derive monthly magnetic data (control data, mean values, storms, and rapid variations); check all computations.

Geophysicist Grade 3 - make final seismological analysis (monthly Bulletin), prepare ISS mark-sense cards.

Geophysicists and Technical Officer Grade 2 - derive data published weekly or monthly in seismology or ionospherics.

Technical Officers, Clerical Assistant - reproduce data lists; microfilm magnetograms for distribution.

In all disciplines it was possible to keep up to date with routine data production, and the backlog in geomagnetism was greatly reduced. For the first time professional staff were able to spend a significant part of their time on non-routine projects, as described in the individual chapters. No serious equipment failures occurred and record losses were low. All these may be attributed to the satisfactory division of effort between professional and sub-professional officers, successful modifications to installations, and the possession of suitable test and auxiliary equipment.

Administration

Delegations. Operations and administration are the responsibility of the Senior Geophysicist. The Geophysicist Grade 3 assisted the Senior Geophysicist by supervising the seismological programme and the technical staff.

Stores accounting. Accountable stores comprised two groups: (a) Furniture and Office Equipment (controlled by the Department of Supply, Perth) and (b) Plant and Equipment (controlled by the Superintendent of Stores, Melbourne). The annual physical check and reconciliation of records was carried out with the assistance of Department of Supply in October. No serious discrepancies were found in either group.

Some thirty surplus items were sent to the Disposal authority after appropriate sentence by Boards of Survey; they were mostly minor plant items such as hand tools. A few other items were destroyed, being considered not worthy of auction. Boards in all cases comprised the Observer-in-Charge, a Department of Supply representative, and another permanent observatory officer.

Fire precautions. The Weir and Gnangara sites are unattended for most of the time, and in the absence of an automatic extinguishing system there is some risk of fire damage. However, they are both in Forests Department reserves where careful precautions and watching are observed, so the risk is considered to be slight. Numbers of extinguishers of all types are provided at each site. They were checked and refilled in October, when the spring growth of grass and scrub was removed from around all buildings and fences.

Library. Accessions to the library included thirty-two journals, six reference books, and several free publications of other institutions. All were registered and accounted for as required. Seventy-two volumes of journals were bound. Lists of all holdings and current receipts were supplied to the State Librarian for inclusion in the "Union List of Periodicals".

5. GEOMAGNETISM

Recording instruments

Magnetograph. The Eschenhagen normal-speed magnetograph operated throughout the year, except during electrical wiring of the vault (by contractors) from 10th to 14th September. The pier plan, Plate 6B, shows the disposition of the variometers and recorder.

The H magnetograph has a non-linear response. The value of the horizontal component is $H = H_o + S_o h + (a/2)h^2$ where H_o is the baseline value and h the ordinate from the baseline in mm. Characteristics of the magnetograms were:

Recording speed		20 mm/hour.
H scale value	S_o:	2.50 gammas per mm
	a:	0.0025 gammas per mm^2
D scale value		1.07 min/mm
Z scale value		5.36-5.26 gammas per mm
Temperature Coefficients (q)	q_H:	1.5 gammas per °C
	q_Z:	2.5 gammas per °C

Scale value determinations were made by the electrical method using Helmholtz-Gaugain coils and a first grade ammeter (Victorian Meter Laboratories No. 10923). No correction for temperature was made to the meter readings; the error introduced was, over the annual temperature range, less than the 1% accuracy of the meter. The H and D coils, and the Z orientation coil, were constructed in the BMR Geophysical Workshops to observatory specifications. The H and D coils may be rotated around a vertical axis; reference marks and one-degree verniers allow the coil axes to be oriented in the meridian or prime vertical to about 0.1 degree. The Z orientation coil encompasses and supports the scale-value coil.

No adjustments were made during 1962. H base values drifted by 7 gammas; D base values showed an apparent relation with temperature (of about 0.07 minutes per degree C) giving an annual variation of 0.8 minutes from summer to winter; Z base values changed, more or less in phase with scale-value changes, by 11 gammas. Standard errors of the mean and of the individual base values respectively were:

	D	H	Z
Mean	0.03'	0.3 gammas	0.5 gammas
Single	0.2'	2.2 gammas	3.1 gammas

No tests on the orientation of the variometer magnets were made. However, because the recording positions on the magnetogram are measures of the magnet direction, and the rate of change of D has been less than one minute per year (Plate 7), it is known from the initial (1960) orientation tests that the magnets are within half a degree of the required directions.

Visual recording variograph. For monitoring purposes an Askania visual recording variograph is installed at the office. The variometer with photocell attachment was housed in a temporary structure in the grounds until August, when it was transferred to the laboratory. The recording microammeter and scale value panel are located in the magnetic room in the office. Until August the instrument operated as a D variograph, thereafter as an H variograph. In this form it was fitted with temperature-compensating and sensitivity magnets. Its characteristics were: chart speed 20 mm/hour; scale-value about 3 gammas per mm (21 gammas per microamp).

Magnetometers

Horizontal Intensity. Askania magnetometer No. 508810 was used as the observatory standard until May. During this period it was used to determine two absolute values of H each week; these were supplemented by one value determined by a Quartz Horizontal-Force Magnetometer (QHM) after May. Instrument No. 293 has since served as the observatory "standard" because of its small correction and low rate of drift.

Declination. Askania magnetometer No. 508810 was used throughout to give absolute values of D.

Vertical Intensity. BMZ No. 120 (with supplementary magnet 120/2) was used throughout to give semi-absolute values of Z.

Comparisons and Standards. Comparisons with other instruments were made as follows:

May 15, 16: Observatory QHM and BMZ compared with Proton Vector Magnetometer MNZ 1.

September 4: Regional Field Party BMZ compared with observatory BMZ.

November 2: Regional Field Party BMZ (No. 211), Declinometer, and QHM (No. 306) compared with observatory instruments.

Of these, only the first was acceptable for standardisation of the observatory instruments. The results were:

(a) H standard = Proton Vector Magnetometer
= QHM 293 + 2 gammas

(b) Z standard = Proton Vector Magnetometer
= BMZ 120 + 323 gammas

Provisional corrections deduced from earlier comparisons were +1 gamma for QHM 293 and +323 gammas for BMZ 120.

Final corrections for all observatory instruments, applied in the derivation of the year's results, were:

Element	Instrument	Correction
H	Ask 508810	+5 gammas
	QHM 291	-11 "
	292	-16 "
	293	+1 "
D	Ask 508810	+0.5 min
Z	BMZ 120	+324 gammas

The comparisons listed above, and all others made since 1961, were made by the method of simultaneous observations. This eliminates errors involved in reference to magnetograms (scaling errors, scale-value uncertainty, temperature effects), and the time and labour required to derive base values.

Data and publications

Data were derived and distributed on weekly, monthly, quarterly, and annual schedules. The types of data and their distribution are shown in Table 3. In addition other organisations received the monthly

"Geophysical Observatory Report", which was issued by Branch Headquarters some months later. This contains (for Gnangara): K-indices, Preliminary Monthly Mean Values, Principal Magnetic Storms, and Normal Magnetogram events.

Apart from this regular publication programme, information was supplied on request to eleven research institutions within Australia and overseas. The requests were for magnetogram copies with complete reduction information, and covered intervals ranging from one day to two months. The institutions were located in Alaska, California, England, Germany, Japan, New South Wales, Poland, Tasmania, and Western Australia.

The demand for current data has increased in recent years, and can be met only by the provision of magnetogram copies with reliable reduction data. The good performance of the magnetograph and magnetometers has enabled such data to be given with confidence within a few weeks after the event. It is unlikely that values derived from this information will differ by more than a few gammas from final published values.

Secular variation

Since 1960, preliminary annual mean values have been derived from mean ordinates on the five quiet days each month. For 1962 they were:

H 23945 gammas

D $2^{o}52.8'$ W

Z -53490 gammas

These values confirm recent trends in the secular variation tendencies as shown in Plate 7. All three elements show a reduction in the annual rate of change since about 1957. H appears to have passed a peak and to be decreasing.

Projects

Induction loop. During the year, experiments were begun on the recording of micropulsations. A loop was designed and construction was almost completed by the end of the year. It is planned to record, without amplification, pulsations of one-tenth-gamma amplitude in the period range one to sixty seconds. To record horizontal components, whilst avoiding the effects of vibration (wind noise) and eliminating structural problems associated with burying large vertical coils, the loop is in the form of an octagon, with sides four feet long. The wooden coil former is four inches wide and one inch deep, allowing fifteen layers (each of 135 turns) of 21 B & S double enamelled wire to be accommodated. The loop will have a resistance of about 800 ohms and inductance of about 35 henries. It is intended to mount the coil vertically against the laboratory wall at the office site. It will be connected to a suitable nano-ampere galvanometer, recording on a seismograph-type drum with paper speed of at least 30 mm per minute.

Sq variability. Investigation of the solar quiet day variation (Sq) in H was commenced near the end of the year. As a first step each of the five quiet days for each month at Watheroo 1948 to 1958 was classified into one of three types E, P, or I. The first two are those of Hasegawa (Chapman & Bartels, 1940); the third is intermediate between them. Approximate percentages of occurrences were found to be: P - 60%, E - 10%, and I - 30%. Study of this phenomenon is proceeding.

Macquarie Island magnetograph. Following a headquarters decision to install the ex-Watheroo La Cour rapid-run magnetograph at Macquarie Island during the 1962 relief operation, the instrument was assembled by the officers involved (McGregor and Gregson). It was set up in the recorder section of the laboratory during July and August. Minor improvements made to the magnetograph included:

(a) Fitting of damping blocks to the variometers.

(b) Modification of the drum weight system to permit 24-hour operation on a single weight fall.

(c) Fitting of an Eschenhagen-type escapement.

(d) Provision of adjustable stands for the variometers.

(e) Fitting of an adjustable levelling magnet to the Z variometer.

A complete control panel and a time-pulse relay unit were constructed to facilitate connexion to existing units at the Island. The control panel included parallax-test and sense-indicator circuits.

Surveys. P.J. Gregson made a variometer survey of the Scott River iron ore deposit between 19th February and 16th March (Gregson, 1962).

A variometer survey was made at the University Physics Department by P.M. McGregor and P.J. Gregson. The purpose of this was to determine the uniformity, strength, and direction of the field at the site of electron diffraction apparatus in the new Physics Building.

Watheroo mean hourly values data

The adoption of magnetogram control data for Watheroo 1948 to 1958 was completed. Those for 1948 were sent to Headquarters in the form required for reduction of mean hourly values by digital computer. Hourly scalings for the complete period were edited to suit the reduction programme and despatched. Text to accompany the reduced values was written.

6. IONOSPHERIC PHYSICS

Ionosonde

The Cossor ionosonde type 7562C Mark II was used throughout the year. Soundings were initiated from the Landis pendulum clock and programme machine in the seismograph vault. The clock error was determined daily and kept within five seconds. Characteristics of the ionosonde are given in Table 4.

Until 22nd January quarter-hourly soundings were made, the first at 00 minutes. The receiver gain was adjusted at 10 a.m. and 4 p.m. for optimum day and night recording. On 22nd January a fifth sounding at 01 minutes was added; this was in the form of an expanded-height/fixed-gain display. The programme pulse operates a slow-release relay which remains closed for about forty seconds, i.e. longer than the sweep time. This in turn switches (via a second relay) the appropriate circuit elements in the "display" section. The range on this sweep is reduced from 1000 to 500 km.

The main cause of poor recordings, other than actual failures, was drift of the 30-Mc/s fixed frequency oscillator (f.f.o.). When its frequency alters, there is a detuning of the echoes in the receiver first i.f. stage. This was largely overcome by daily tuning of the f.f.o. coil from May onwards; E-layer echoes were made to peak while they were being observed on the test oscilloscope operating on A-type display. The oscilloscope was connected permanently and used as a monitor.

Power supplies

An external, regulated 250-V supply for the recorder circuits was constructed and installed in May to give a steadier C.R.O. brilliance and time base. In July an external high voltage (2.5 kV) supply for the power amplifier was constructed to a National Bureau of Standards design. This raised the peak-pulse-power to about 2 kW.

Data and publications

From the daily ionograms the parameters foF2, M(3000) F2, foF1, foE, foEs, f min, h'F and h'F1 were measured at each hour. The intermediate soundings were inspected for unusual absorption or fade-outs for correlation with magnetic effects. The standard data were forwarded monthly to the Ionospheric Prediction Service (NSW), which derived median values and published and distributed hourly values (except those of f min and h'F1) in booklet form.

Three overseas requests for ionogram copies or data were attended to during the year.

7. SEISMOLOGY

In May-June the original Benioff seismograph was replaced by World-wide Standardised Seismograph System No. 44, hereafter referred to as the Standard system. This proved disappointing insofar as the detection of short-period phases was concerned (the weekly number of reported teleseisms was reduced by a factor of three) so a more sensitive short-period instrument was added on 25th September. It is referred to as the "Benimore" seismograph. A brief description of the three systems is given below; operational constants and other data are given in Table 5.

Benioff system

Seismographs. Three Benioff variable-reluctance seismometers, each coupled to both a short-period and a long-period galvanometer, recorded on two triple-drum recorders.

Power. Drum motors were driven by the station's 50-c/s supply, which is frequency stable to better than 1 c/s. The voltage may vary between 230 and 260 volts.

Timing. A Landis pendulum clock and programme machine provided contacts at each minute, and each hour except the 11th and 23rd. The minute contacts were from 59 to 00 seconds until 5th December, and from 00 to 01 seconds afterwards; the hour contacts were about 5 seconds long, and started at the end of the minute contacts. Clock corrections were determined daily by comparison with WWV signals; when available, the hourly local signals (6 pips) were recorded directly on the seismogram. The automatic unit for this was operated by the programme machine. The

Landis clock is weight-driven and mercury compensated; the weight is electrically raised every fifteen minutes, the power for this and the programme machine being provided by a large-capacity 36-V battery bank in the powerhouse. By the use of small weights on the pendulum the daily rate was kept generally within 0.5 seconds. The pendulum clock drives secondary clocks in the recorder room, powerhouse, and ionosphere house.

Standard system

Short-period seismographs. Three Benioff-type seismometers were coupled to short-period galvanometers recording on a triple-drum recorder.

Long-period seismographs. Three Sprengnether-type seismometers were coupled to long-period galvanometers recording on a triple-drum recorder.

Power and timing. A console unit provides 60-c/s power for the drum motors, clock, and programmer. The unit is quartz-crystal controlled and is supposedly stable to 5 parts in 10^7 equivalent to 50 milliseconds per day. During 1962 it was not generally possible to achieve this performance; daily rates ranged from zero to several hundred milliseconds, with occasional values exceeding two seconds. It is not known whether this erratic behaviour was due to defects in the frequency standard or frequency divider modules (as seems most likely), or to some other obscure cause.

The console power is derived from a 28-V bank of nickel-cadmium batteries, charged from the station supply. This provides about twelve hours' standby power if the supply fails. In the event of failure of the frequency standard an electronic inverter provides regulated power for the drums and programmer.

Radio time signals are recorded on the short-period north-south seismogram, through the programmer, at six-hourly intervals. The clock correction was determined daily; until 8th December the comparison of clock and radio was made on a Phase Shifter module. This provided visual indication of the relation of the two time pulses, the phase-shift required to bring them to coincidence giving the correction. On 8th December during the visit of the first USCGS modification team this was replaced by the direct-reading stroboscope unit. The clock correction was reduced to zero each morning during the record change.

Magnification. A facility is provided on the console for determining the magnification of each seismograph. Standard forces are applied to the seismometers by an electromagnet system. The deflection on the record is a measure of the magnification, and also shows the sense of (ground) motion. These deflections were recorded at the beginning and end of each record. The attenuator trim adjustment was used to maintain correct magnifications.

Free periods. Seismometer and galvanometer periods were measured and adjusted as required to keep them within the allowed limits (Table 5).

Miscellaneous. Seismometer masses were inspected regularly and centred as required. Similarly galvanometers were adjusted to restore the light beams to a central position. A great deal of experimenting was done on the long-period N-S seismometer to reduce trace wandering. This was proved to be due to pressure effects on the seismometer and was largely overcome by careful sealing of the cases.

Benimore seismograph

The response of the Standard short-period system is less than that of the original Benioff at periods below one second (see Table 5). Therefore in order to record P phases better, particularly from local tremors, a vertical seismograph was added on 25th September. This consists of a Benioff vertical seismometer coupled to a Willmore galvanometer and recorder. Time-marks were provided by the Landis clock. From 5th December a Landis minute-pulse was impressed on the Standard seismogram each morning to give a record of the Landis correction.

Data and publications

A preliminary analysis of the seismograms was made to identify and determine the arrival time of those phases (P, pP, S; PKP, SKS) necessary for the location of earthquakes. This analysis was distributed each Wednesday to the institutions listed in Table 6. About 800 earthquakes were so reported during the year.

From 24th April, the observatory co-operated in the ISS machine card experiment for the determination of epicentres. The above preliminary data were transferred to IBM Mark Sense Cards and mailed in fortnightly batches. A second stage of the experiment was introduced from June. This required the re-analysis of seismograms when earthquake data (such as given by the USCGS Preliminary Determination of Epicentre cards) were available. This final analysis, which frequently includes phases not recognised at the preliminary stage, was made into the observatory's Bulletin and was distributed to the institutions given in Table 6.

Six requests for copies of seismograms or data were received from bodies within Australia and in the USA.

Projects

Local seismicity. A study of local seismicity, as indicated by Mundaring recordings from August 1959 to December 1961, was completed; it was the subject of Everingham's address to the ANZAAS Congress. The study is being extended to the end of 1962 and will be published.

Velocities of seismic waves. During final analyses data were accumulated for the study of the phases Pn, Sn, Pa, Sa, Lg and Rg, recorded as a result of earthquakes in the New Guinea and Banda Sea regions. Preliminary results gave these travel time equations:

Pn: $t = 5.6 \pm 2 + \Delta/8.21$ sec.

Sn: $t = 6.7 \pm 2 + \Delta/4.75$ sec.

where Δ is epicentral distance.

A Rayleigh wave group velocity dispersion curve was derived from New Guinea earthquakes. This was similar to that for South Africa (Press, Ewing, & Oliver, 1956). These studies are continuing and will be the subjects of Records.

Refraction studies. In December a co-operative venture was undertaken, with the oceanographic vessels Argo and Horizon of the Lamont Geological Observatory. On 3rd December four depth-charges were exploded on a line west of Rottnest Island and the waves were recorded at Mundaring and a Willmore outstation near Beverley. The distances between shot-points and recorders ranged from 65 to 135 kilometres. These results, together with those from the 1960 Vema survey and other geophysical surveys, were used to prepare a tentative model of the structure of the Perth Basin in this area. Further similar work is proposed for 1963 to provide more data.

Proposed field network. It is planned to establish in 1963 a network of three stations with a separation of roughly 100 km. These will be equipped with medium-period vertical and short-period horizontal seismographs to permit (a) the determination of Rayleigh-wave phase velocities, and (b) more reliable location of tremors in the south-west seismic zone. A start was made towards the end of the year on the construction of power supplies and radio-programmers, and on the testing of recorders and seismograph systems for these stations.

8. POWER PLANT AND VEHICLES

Power plant

Because of the distance from the nearest State Electricity Commission transmission line, power is provided at the weir site by a dual diesel-alternator plant. The two units are connected to an automatic change-over system which provides for starting the standby unit and putting it on load within a minute of: overheating, slow-running, or oil-pressure failure of the duty plant. Details of each unit are:

Diesel engine:	Lister, type FR2, twin-cyclinder, 16-hp, 1500-rev/min
Alternator-generator:	Petbow type HS 179/2C, 6-kVA, 240-V, 50-c/s; 28-V DC

The DC armature serves as a starter motor and as a generator for charging the starting batteries. The engines are mounted on rubber anti-vibration blocks to reduce their effect at the seismographs. A 1000-gallon tank contains the bulk fuel supply. From this, fuel is pumped to an overhead 90-gallon tank in the powerhouse by an automatic float switch and rotary pump. Fuel gravitates to the motors from this tank. Consumption averaged 75 gallons of diesel distillate per week.

A DC supply is provided by a bank of 18 two-volt lead-acid cells, which were charged weekly by a metal-rectifier charger. This is fed to the seismograph vault (36 V for the pendulum clock and programme machine) and to the ionosphere house (6 V emergency power for the transceiver and ionosonde programme unit).

A 30-A r.f. filter was inserted in the 250-V outlet to eliminate mains effects at the ionosonde. The supply to the ionosonde and to the seismograph (from October) was passed through Westinghouse Stabilistors to improve the voltage regulation.

The diesel engines were run alternately on a daily basis, and checked twice daily by the observer on weekly routine. Maintenance and servicing were done each week by a mechanic of the Stores and Transport Branch. No serious power failures occurred during the year.

Vehicles

One Holden Station Sedan and one Holden Sedan were hired from the Stores and Transport Branch on a weekly basis (S and T Hire Type 6). The Branch did the regular servicing of the vehicles.

9. WORKS PROGRAMME AND EQUIPMENT

Works programme

Jobs done under the Works programme were:

Job	Completed	Vote
Construction of Laboratory (Lot 74)	January	1961/62
Re-location of store (Gnangara)	January	1961/62
Painting interior of office (Part)	February	1961/62
Test bore, water supply (Gnangara)	May	1961/62
Road repairs (Weir site)	June	1961/62
Drainage repairs, darkroom plumbing additions (Office)	August	1962/63
Electrical wiring (Gnangara)	September	1961/62
Retaining wall raised (seismograph vault)	September	1961/62
Relacement of tungsten lamps by fluorescent fixtures, Office and Weir (powerhouse)	November	1962/63

Equipment

Purchases. Equipment items purchased during the year were:

(a) A 100-W, 12V-250V Inverter, for use in a proposed mains failure system at Gnangara.

(b) A 35-mm developing tank ("Rondinax") for microfilm processing.

(c) A 36-inch metal bending machine.

(d) A decade capacitance box.

(e) An 18-inch rotary mower.

(f) Various small hand tools and machine accessories.

Constructions. Several items of semi-consumable nature were purchased for installation in existing equipment or for new items constructed at the observatory. In this class were:

(a) A power timing unit for providing from AC mains one-minute pulses (30 V DC) to operate Landis secondary clocks in the office rooms.

(b) A Watts DC transistor chopper amplifier to drive a recording milliammeter from a Willmore (not completed).

(c) A 2.5-kV power supply for the Cossor ionosonde.

(d) Several transistor relay units for use on Mercer chronometers.

(e) Plug-in relay units, using 3000-type relays for the programme machine.

(f) A regulated 250-V DC supply for the ionosonde.

10. VISITORS

Visitors to the observatory included: Mr R.C. Finn (Texas Instruments, seismicity survey), Dr Parkinson and Messrs Prior, Condon, Taylor-Rogers, Williams, Vertigan, Herlihy, and Myers (BMR), Mr J. Jordan (USCGS, Network of Standard Seismographs), Messrs J.A. Mills and E. Edmiston (Department of Supply), Messrs F. Billingsley and E. Sparks (Standard Seismograph installation team), Messrs J. Hoffman and C. Morgan (Standard Seismograph inspection team), Mr P.W. Morrison (Texas Instruments, seismicity survey), Mr C. Reynolds (WAPET aeromagnetic survey), Mr F. Cook (IPS), and Messrs L. Jacksha and R. Labhart (Standard Seismograph modification team).

11. ACKNOWLEDGEMENT

The co-operation and assistance given by the State Controller and staff (Department of Supply) in such matters as procurement of stores, receipt and despatch of articles, stock-takes, and liaison with other departments is hereby acknowledged.

12. REFERENCES

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GREGSON, P.J. 1962 Scott River magnetic survey, WA 1962. Bur. Min. Resour. Aust. Rec. 1962/163 (unpubl.).

PRESS, F.M., EWING, M., and OLIVER, J. 1956 Crustal structure and surface-wave dispersion in Africa. Bull. seis. Soc. Amer. 46, 97-103.

APPENDIX 1

Summary of history to 1962.0

1952-1955	Testing, selection, and procurement of sites.
1956 April	Gnangara: vault, temporary absolute house, and store erected.
1957 May	Gnangara: La Cour normal magnetograph installation completed; regular operation from Watheroo commenced.
1958 August	Weir: seismograph vault location fixed after resistivity surveys and test drilling.
1959 February	Office: buildings completed.
March 18	Transfer from Watheroo effected.
April 3	Weir: Ionosonde (Type 2) in operation.
July 30	Weir: Benioff seismograph in operation.
December	Office: Lot 74 acquired.
1960 March to October	Weir: 5-kc/s Atmospheric Noise Recorder operated for Upper Atmosphere Section (CSIRO).
April 30	Gnangara: Eschenhagen normal magnetograph replaced La Cour.
May 1	Weir: Cossor ionosonde in operation. Office: Visual D variograph in operation.
June 22	Gnangara: Absolute House completed; pier differences determined.
Aug. 11	Gnangara: magnetic temperature compensation applied to H variometer.
October	Office and Weir: v.h.f. transceivers installed.
1961 January	Weir: automatic recording of hourly radio time signals on seismograms.
February 3	Gnangara: magnetic temperature compensation applied to Z variometer.
September 11 to 19	Weir: seismograph recorder and (one) seismometer pier modified to accept Standard seismographs.
November	Weir: Benioff system calibrated with Willmore Bridge equipment.

APPENDIX 2

Staff 1959 to 1962.0

Senior Geophysicist	P.M. McGregor.
Geophysicist Grade 3	I.B. Everingham (on furlough 29th May to 29th July 1961).
Geophysicist Grade 2	Vacant.
Geophysicist Grade 1	A. Parkes to 27th October 1960 A.D. Bowra 9th March to 21st August 1959.
Cadet Geophysicist	P.J. Gregson 21st November to 31st December 1961.
Technical Officer Grade 2	A. Parkes from 28th October 1960.
Technical Officer Grade 1	G. Woad from 27th July 1960.
Computing Assistant Grade 1	Miss D. Muhlmann 25th May to 18th December 1959 Miss C.M. Read 8th February 1960 to 2nd June 1961 Miss J.D. Rayner 19th June to 1st December 1961.
Clerical Assistant Grade 1	Miss L.E. Lee 25th May 1959 to 21st April 1961 Miss J.I. Luhrs from 19th April 1961.
Assistant Grade 1	N. Keating from 27th April 1959.
Antarctic Trainees	R.W. Merrick 19th May to 16th October 1959 C.H. van Erkelens 9th June to 16th October 1959 W.M. Burch 5th April to 27th October 1960 J.C. Branson 22nd November to 15th December 1961.
Vacation Students	C.G. Carton, D.A. McCallum, S. Jorna 1958/59 C.G. Carton, D.A. McCallum, M.J. Hodge 1959/60 B.G. Mullumby, V.P. St John 1960/61.
Gnangara Assistant	A. Malajczuk to 10th August 1960 L.K. Eastcott from 4th August 1960.

Mr. A.H.C. Farrell was employed as Clerk until 5th June 1959.

TABLE 1

OBSERVATORY SITE DATA

	Office	Weir	Gnangara
Latitude			
geographic	31°54.2'S	31°58.7'S	31°46.8'S
geomagnetic	-	-43.4°	-43.2°
Longitude			
geographic	116°09.9'E	116°12.5'E	115°56.8'E
geomagnetic	-	186.1°	185.8°
Height			
feet	950	771	195
metres	290	235	60
CSAGI No.	-	C 994	C 993
Distance from office			
miles	-	5.75	15.36
kilometres	-	9.27	24.78

TABLE 2

MAGNETOGRAPH DATA

Magnetograph	Applies from	Applies to	Trace speed (mm/h)	Scale value H: S_o* (γ/mm)	Scale value H: a* (γ/mm^2)	Scale value D (min/mm)	Scale value Z (γ/mm)	Temperature coefficient H ($\gamma/^\circ C$)	Temperature coefficient Z ($\gamma/^\circ C$)	Direction of numerical increase H	Direction of numerical increase D	Direction of numerical increase Z
La Cour	Jun 57	Jan 58	15	3.24 to 3.32	0	0.94	1.62	4.25	13.0	up	down	up
	Jan 58	Aug 58					3.53		10.5			
	Aug 58	Apr 60					4.80 to 6.20					
Eschenhagen	Apr 60	Aug 60	20	2.32 to 2.51	0.005	1.07	5.01 to 5.50	15.5	12.0	up	up	down
	Aug 60	Feb 61			0.0025			3.5				
	Feb 61	Dec 62						1.5	2.5			

* see page 6

TABLE 3

GEOMAGNETIC DATA DISTRIBUTION

Destination	Data	Frequency
BMR Melbourne	K-indices	Monthly
	Normal m/gram events	Monthly
	Prelim. monthly means	Monthly
	Principal mag. storms	Monthly
		Quarterly
BMR Port Moresby	K-indices	Weekly,
		Monthly
	Normal m/gram events	Monthly
Prof. Ellis, University of Tasmania	K-indices	Weekly
Adastra Hunting Geophysics, Mascot	K-indices,	
	Storm advice	Weekly
Director, IPS, Sydney	K-indices	Monthly
	Normal m/gram events	Monthly
D.S.B., Victoria Barracks, Melbourne	K-indices	Monthly
NSL, Chippendale	Mag. copies (2)	Monthly
	Principal mag. storms	Quarterly
USCGS, Washington, USA	K-indices	Monthly
	Annual means	Annually
	Magnetogram copies	Annually
H.F. Johnston, Maryland, USA	K-indices	Monthly
	Normal m/gram events	Monthly
NBS, Boulder, USA	Principal mag. storms	Quarterly
DTM, CIW, Washington, USA	Magnetogram copies	Monthly
Dr J. Veldkamp, De Bilt, Holland	K-indices	Monthly
Met. Institute, Charlottenlund, Denmark	K-indices	Monthly
	Normal m/gram events	
Dr M. Ota, Kyoto, Japan.	K-indices	Monthly
	Annual means	Annually

TABLE 4

IONOSONDE DATA

	CSIRO Type 2	Cossor 7562C Mk II
Sounding schedule	Hourly	Quarter-hourly **
Sweep duration	2 min	18 sec
Pulse rep. frequency	50 per sec	50 per sec
Pulse duration	80 microsec	60 microsec
Peak power	about 300 W	about 900 W to July 1962 about 2 kW after July 1962
Frequency sweep	1 to 16* Mc/s in four bands; logarithmic	1.6 to 20 Mc/s; logarithmic 1.6 to 12 Mc/s
Frequency marks	0.5 Mc/s to 5 Mc/s 1 Mc/s from 5 Mc/s	1 Mc/s
Height marks	50 km	100 km
Height range	1000 km	1000 km **
Tuning	Ganged condensers	Common oscillator
Display	A- or B-type	B-type
Antennae	Terminated vertical deltas (600-ohm)	Terminated vertical deltas (600-ohm)
Operational dates	3rd April 59 to 30th April 1960	from 1st May 1960

* In practice: 1 to 8.4 Mc/s, 4th Band in operative

** See Text

TABLE 5

SEISMOGRAPH DATA

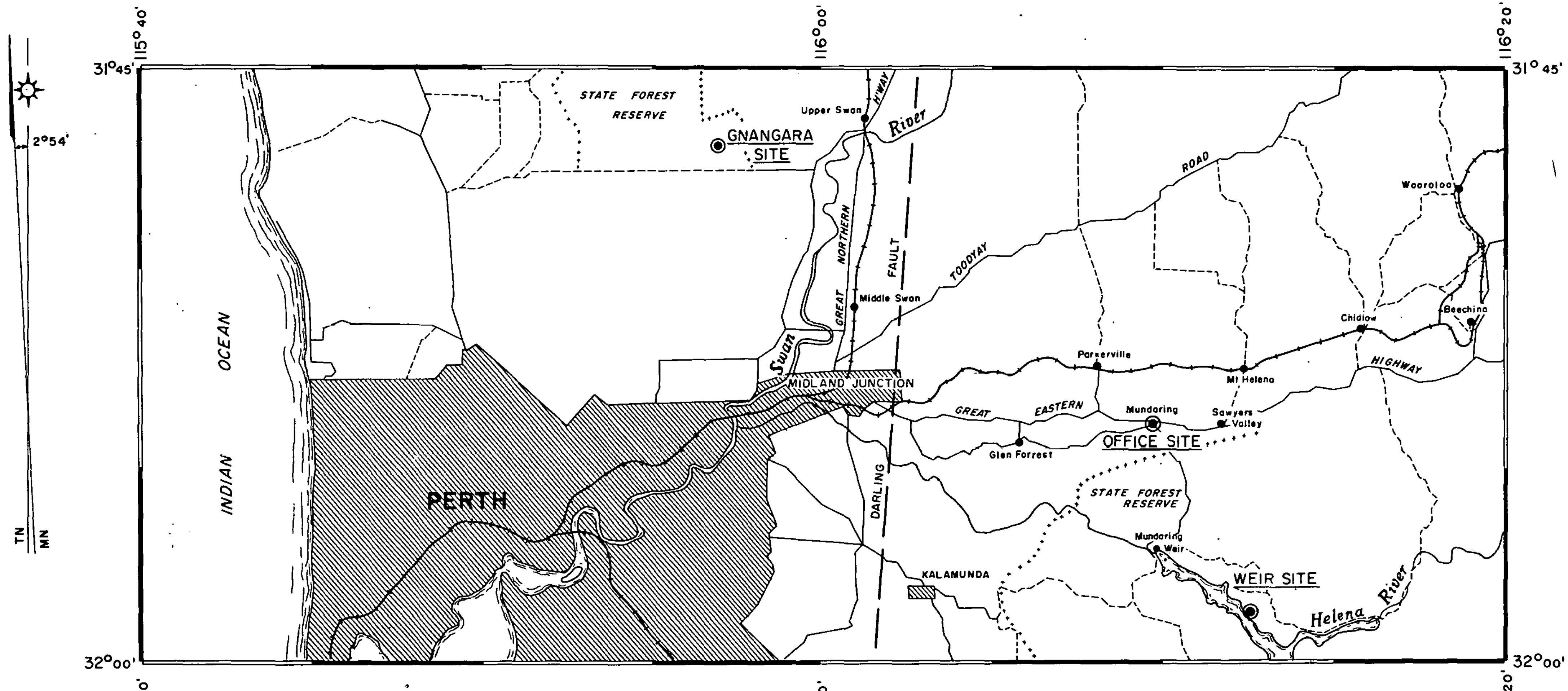
System	Seismo. Free Period	Galvo Free Period	Drum Speed	Magnification Peak	Magnification at	Operational Dates
	Seconds	Seconds	mm/min		secs	
BENIOFF Short Long	 1.0 1.0	 0.25 14	 60 30	 100K 800	 0.4 0.8	1st Aug. 1959 to 21st May 1962
STANDARD Short Long	 1.00 ±0.016 30.00 ±0.3	 0.75 ± 0.0375 100 ± 1	 60 30	 36K* ±2% 750 ±5%	 0.6 25	 From 26th June 1962
BENIMORE Short	 1.0	 0.25	 54	 100K	 0.4	 From 25th Sept 1962

* 25K ±2% at 1.00 seconds

TABLE 6

Seismological Data Distribution

Data and Frequency	Destination
Preliminary	Riverview Observatory, Sydney.
Analysis, Weekly	ANU, Canberra.
	University of Queensland.
	BMR, Port Moresby.
	Seismological Observatory, Adelaide.
	BMR, Rabaul.
	BMR, Melbourne.
	Observatory, Perth.
	University of Tasmania.
	BMR, Darwin.
	Seismological Observatory, Wellington N.Z.
	USCGS, Washington, USA.
Bulletin	ICSB, Strasbourg, France.
(Final Analysis)	Institute of Aeroclimatology, Moscow, USSR.
Monthly	Inst. fur Geophysik, Zurich
	Seism. Laboratory, Pasadena, USA.
	Seism. Station, Berkeley, USA,
	Apia Observatory, Western Samoa.
	Geophys. Inst., Sendai, Japan.
	Inst. de Geofisica, Ciudad, Mexico.
	University of British Columbia, Canada.
	Inst. Geofisico, Huancayo, Peru.
	Jesuit Seism. Assn, St Louis USA.
	ISS, Richmond, England.
	(Mark Sense Cards)



MUNDARING GEOPHYSICAL OBSERVATORY
LOCALITY MAP
OBSERVATORY ESTABLISHMENTS

MILES

4 2 0 4 8 12

LEGEND

- Main roads
- Other roads
- Railway
- Boundary State forest reserve

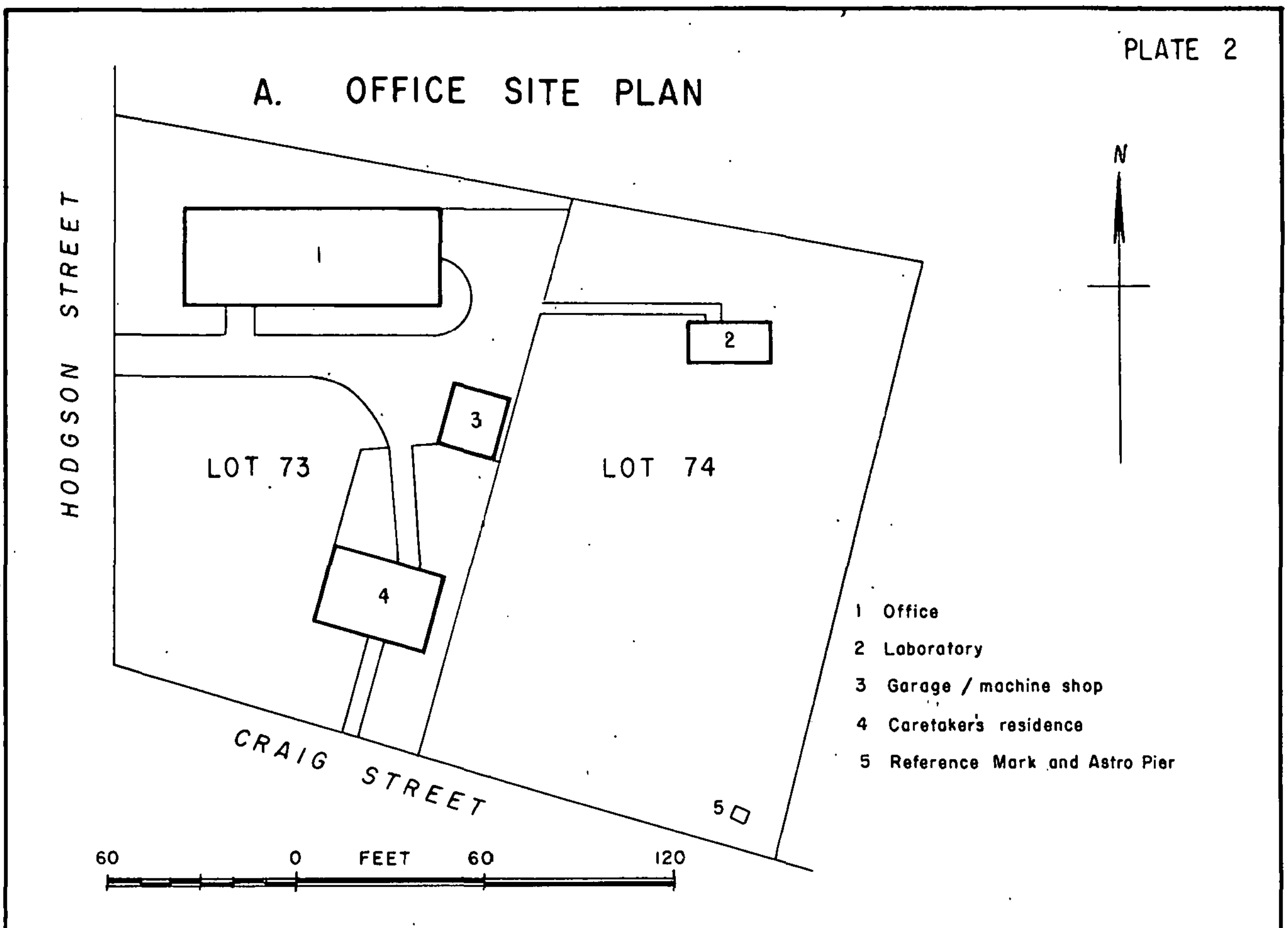
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

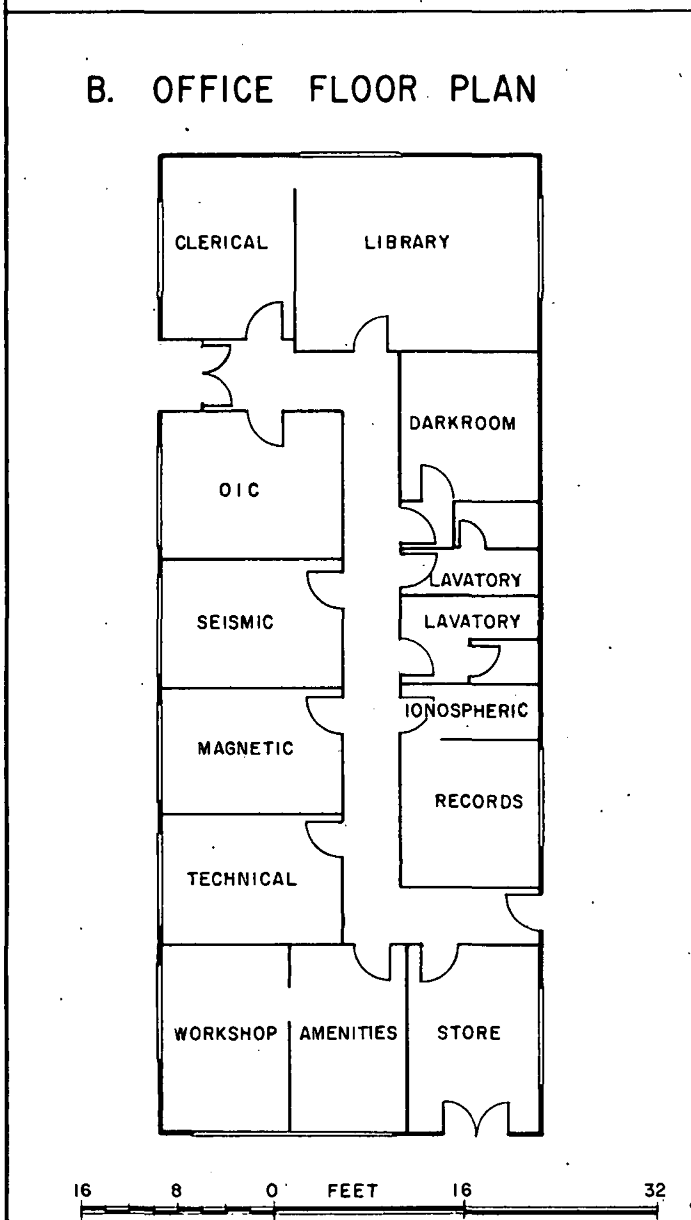
To Accompany Record No. 1966/35

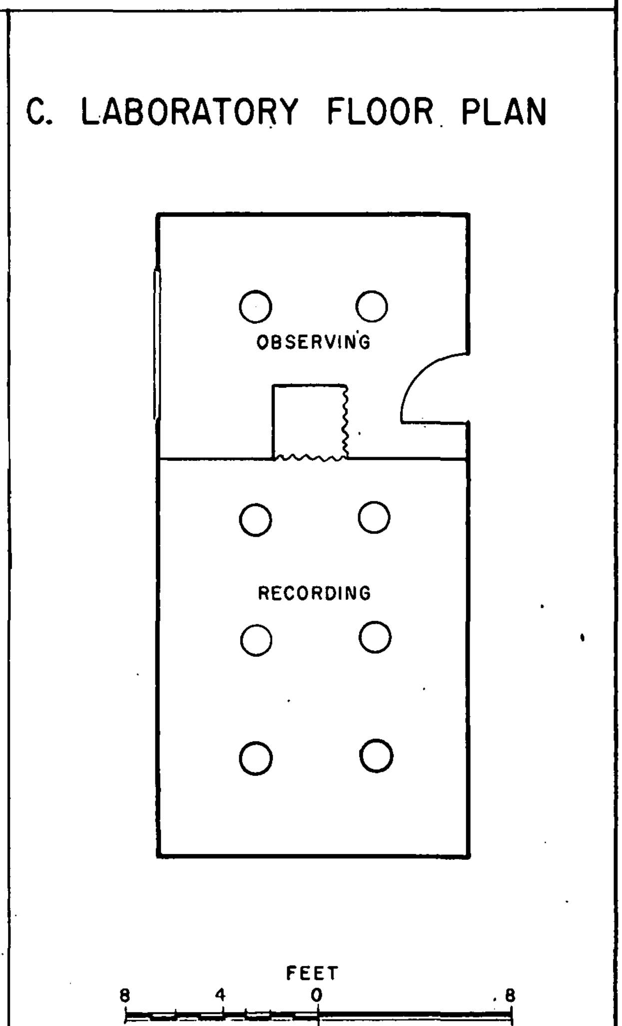
G82/3-11

PLATE I

PLATE 2







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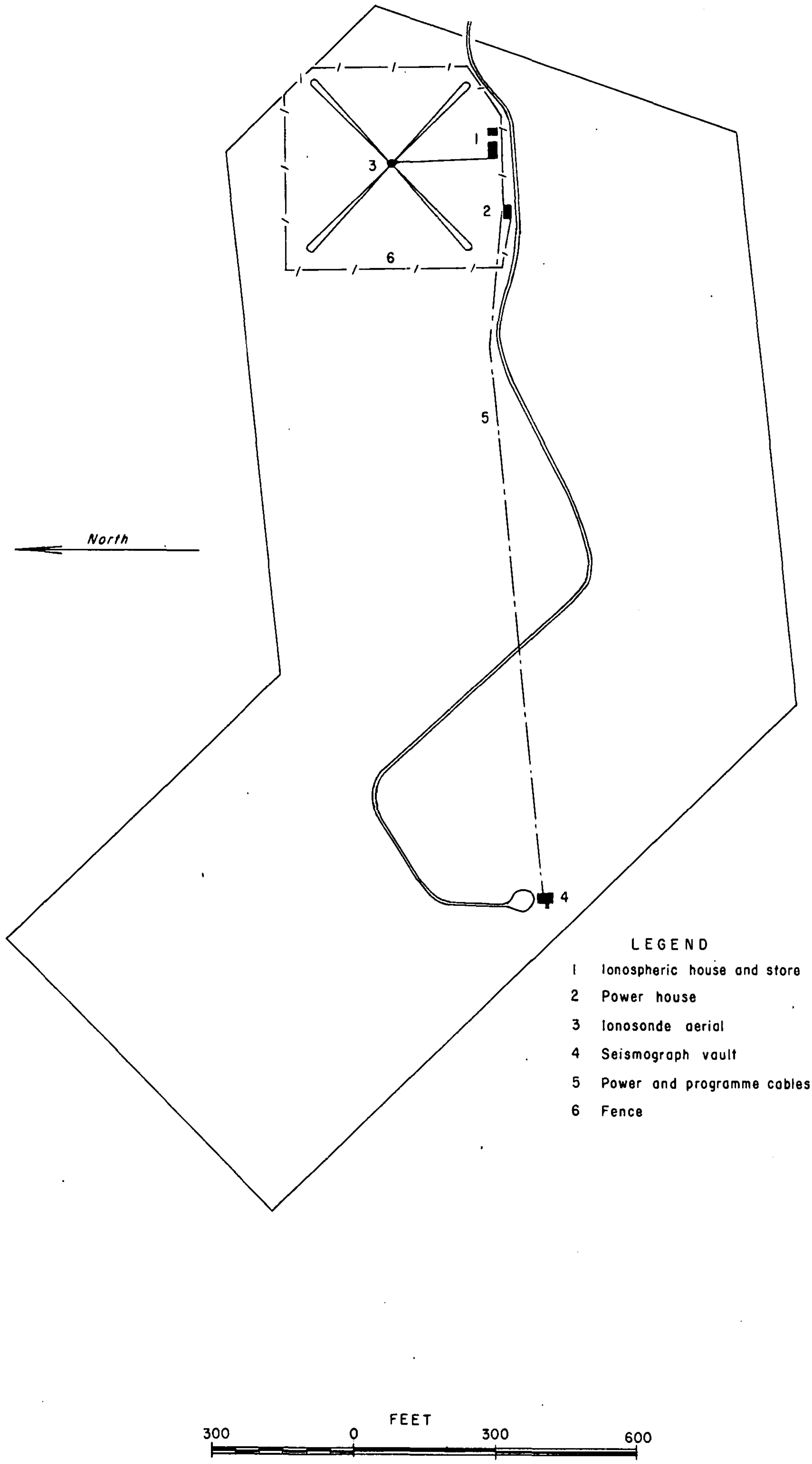
G 82/3-37

MUNDARING OBSERVATORY

PLATE 3

WEIR SITE PLAN



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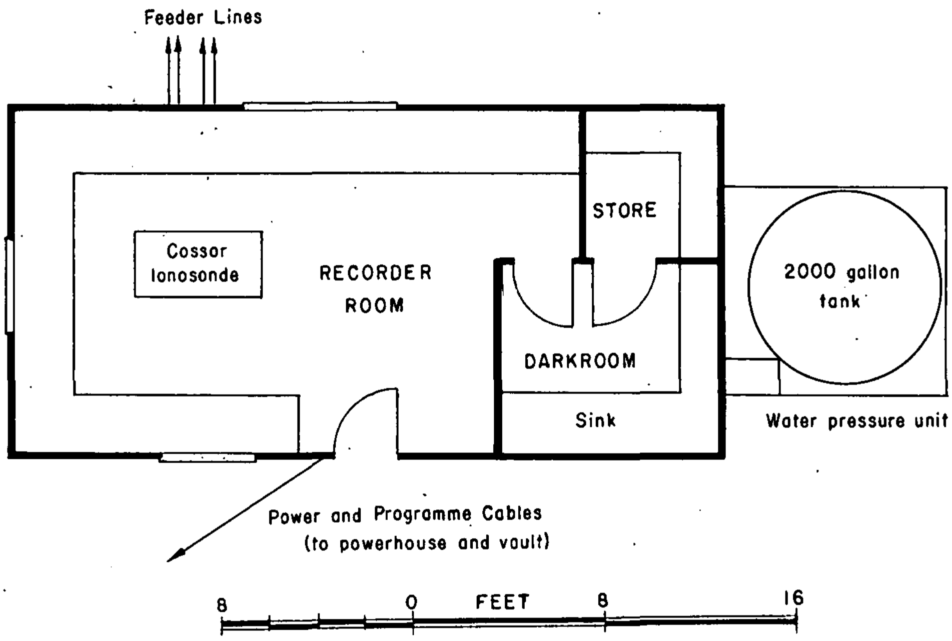
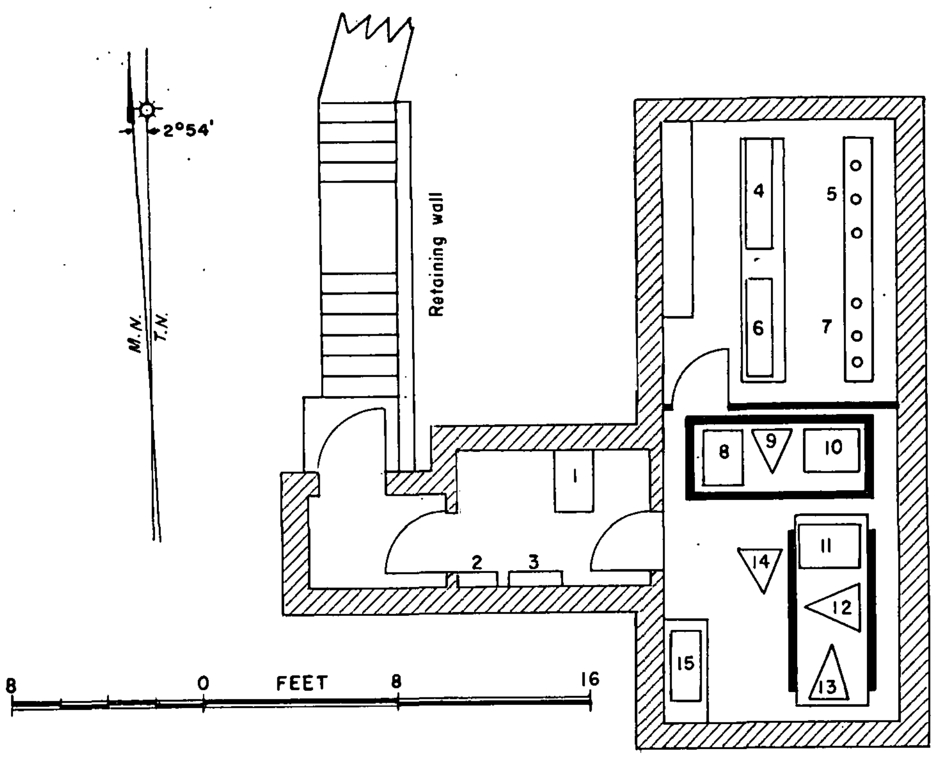
MUNDARING OBSERVATORY

PLATE 4

A. IONOSPHERIC HOUSE FLOOR PLAN



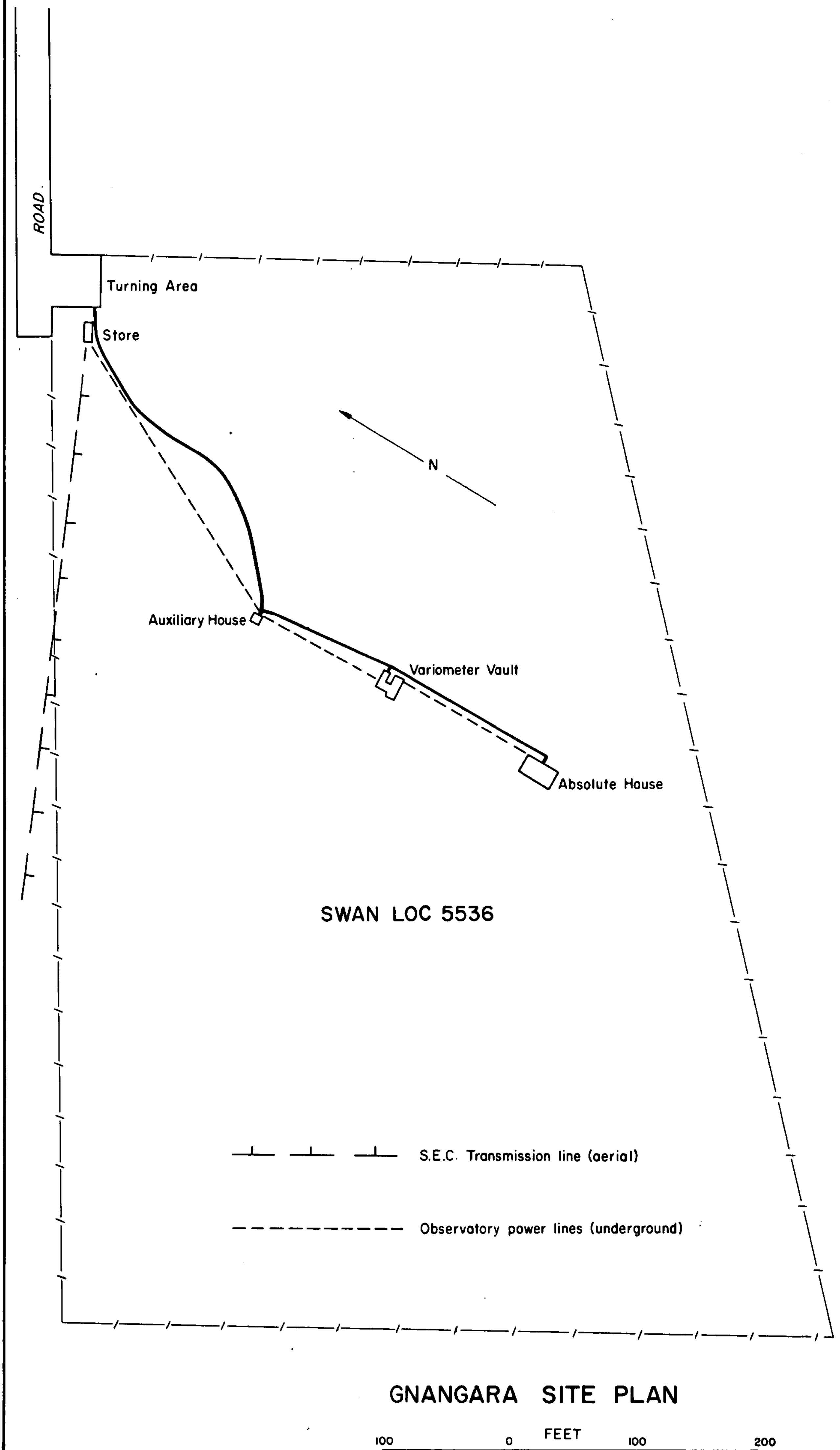
B. SEISMOGRAPH VAULT FLOOR PLAN



1 Standard Console
2 Landis pendulum
3 Landis programme
4 LP Recorder
5 LP Galvos
6 SP Recorder
7 LP Galvos
8 SP N-S
9 SP Z
10 SP E-W
11 LP Z
12 LP N-S
13 LP E-W
14 Benioff Z } Benimore
15 Willmore Recorder } Benimore

MUNDARING OBSERVATORY

To Accompany Record No. 1966/35 *Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics* G 82/3-39



GNANGARA SITE PLAN

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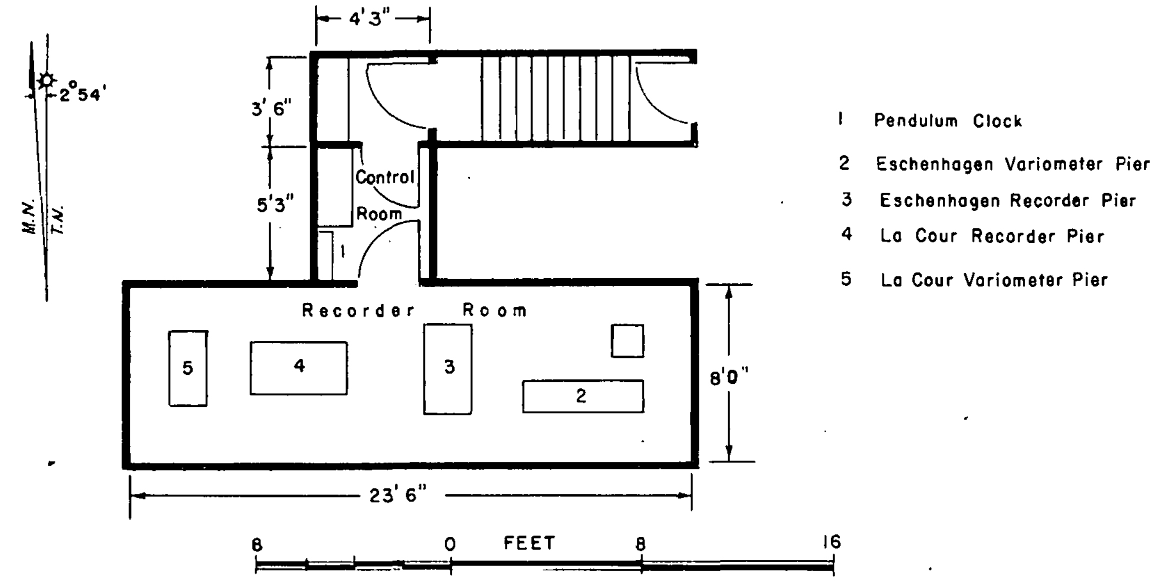
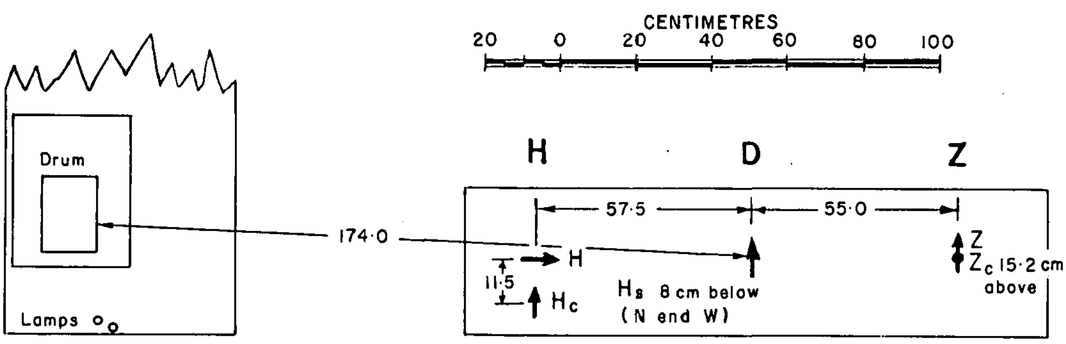
PLATE 6

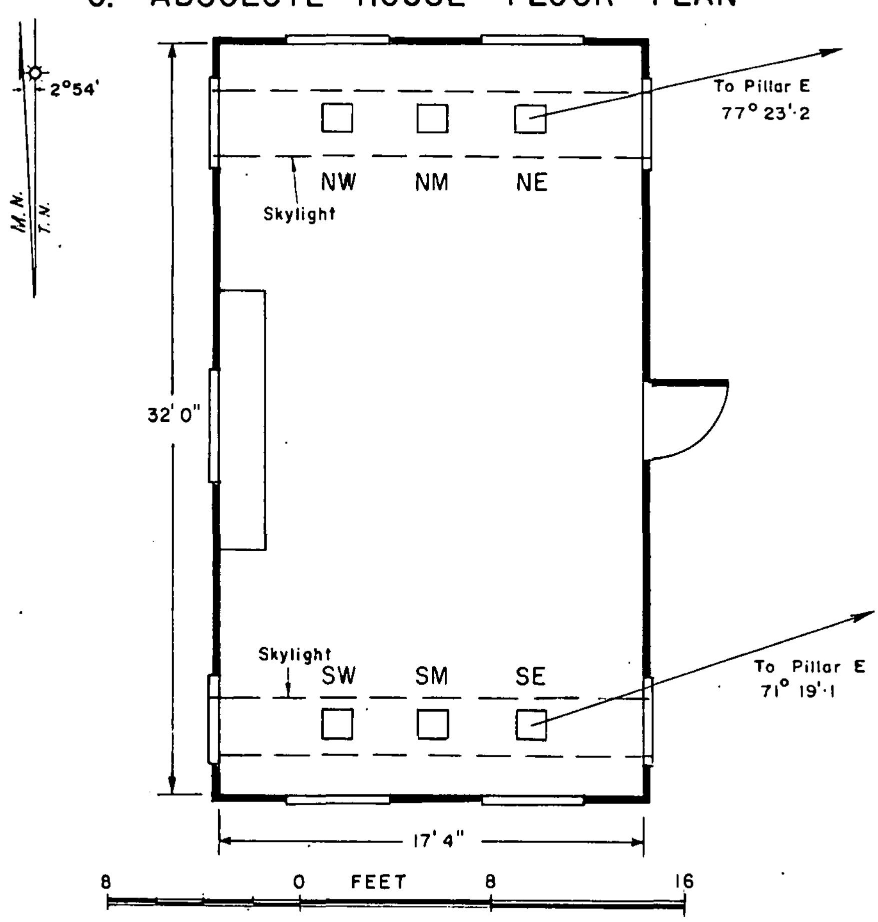
A. VARIATION VAULT FLOOR PLAN



B. ARRANGEMENT OF ESCHENHAGEN MAGNETOGRAPH



C. ABSOLUTE HOUSE FLOOR PLAN



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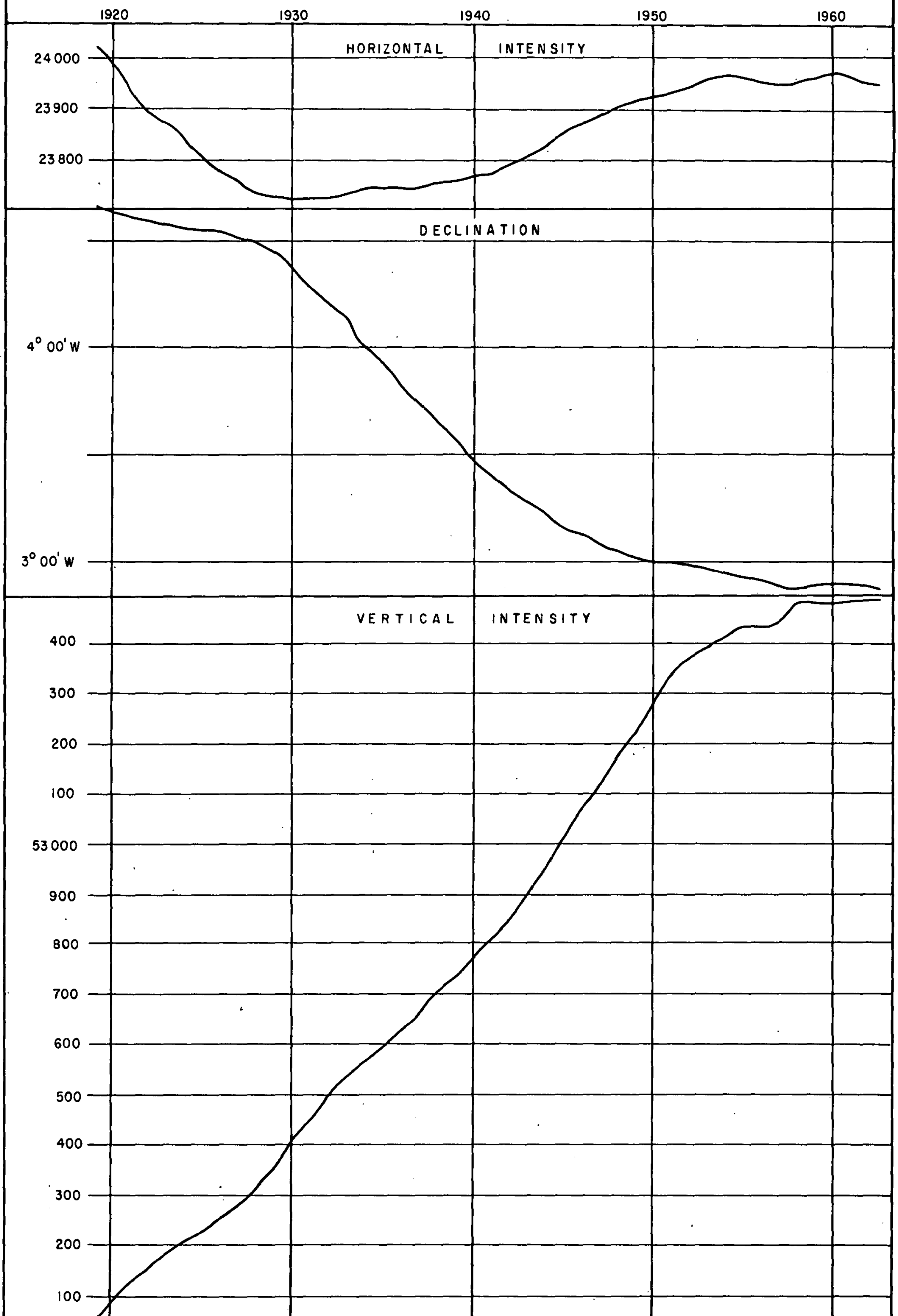
G 82/3-40

MUNDARING OBSERVATORY

PLATE 7

GEOMAGNETIC SECULAR VARIATION (Gn)



Values before 1959 are Watheroo Values adjusted to Gnangara by application of station differences observed in 1958

(D scale is equal to H and Z scales)

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MUNDARING OBSERVATORY