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RECORDS 1961 No. 27

MAWSON GEOPHYSICAL OBSERVATORY WORK, ANTARCTICA 1957

by

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ABSTRACT

The author was geophysicist in charge of the magnetic and seismic observatories at Mawson during 1957. This Record describes the routine operation of these observatories and the installation of new equipment as part of the programme for the International Geophysical Year.

1. INTRODUCTION

Mawson is the principal base of the Australian National Antarctic Research Expedition (A.N.A.R.E.) in the Australian Antarctic Territory. The history of its establishment has been outlined by Oldham (1957;1958), who was responsible for the establishment of the magnetic observatory there during 1955.

P.M. McGregor (1959) continued the geophysical work in 1956, and extended the programme with the installation of a set of Leet-Blumberg seismographs. In February 1957 control of the observatory passed to the author, who maintained the routine magnetic and seismic work and, in addition, installed equipment for recording rapid pulsations in the earth's magnetic field. The latter was part of the International Geophysical Year programme for this station. Early in 1958 the author handed over control of the observatory to B.G. Cook, and returned to Melbourne.

2. THE VOYAGE TO MAWSON

The M.V. Kista Dan sailed from Melbourne on 17th December 1956. The voyage to Mawson was made via the Vestfold Hills area, where a small station called "Davis" was built; the party reached Mawson on 2nd February 1957. No magnetic observations were carried out during the voyage.

3. OBSERVATORY BUILDINGS

(a) Magnetic Observatory

Both the variometer and absolute huts were brought from Heard Island in 1955 and have been described by Ingall (1953). The erection of these huts was described by Oldham (1957). Only routine maintenance (viz. painting, guying, snow-proofing, and minor repair work after blizzards has been necessary.

(b) Seismic observatory

This building was erected in 1956, and was initially an ANARE-type prefabricated unlined hut. Owing to shortage of lining material at the time, the porch had to remain unlined, and the only material available to support the rockwool insulation in the ceiling was "caneite" sheeting. As might be expected, this sagged and eventually cracked beneath the weight. To detract further from the inferior finish of the hut, the plywood sheets lining the walls did not fit the distance between wall studs, and the improperly supported sheets warped badly.

During 1957, considerable time was spent on general improvement and maintenance of this hut. The exterior was re-painted and the roof was covered with flat iron sheeting. Inside, some attempt was made to provide more support for the plywood lining. The ceiling was relined with "masonite". The cold porch, which originally occupied one quarter of the hut, was reduced in size by moving a porch partitiion, and was then insulated with "caneite", and lined.

(c) General

None of the huts was seriously troubled by snow drifts, and the snow-proofing was generally quite good. The author's policy was to allow small drifts to accumulate at places where snow penetrated into the hut. These drifts sealed any small cracks that could not be sealed by other means. Additional heating was provided in the seismic hut to keep its temperature above freezing point in winter. Having a flat roof, this hut leaked badly during a wet snowfall in January 1958, but the leaks were reduced by "proofkote" applied along the joints between the iron sheets.

4. SEMI-ABSOLUTE MAGNETIC INSTRUMENTS

These comprised a set of three Quartz Horizontal Magnetometers (QHM's) and a Magnetometric Zero Balance (BMZ). QHM No. 300 only was used for declination observations, but all three QHM's were used for horizontal intensity measurements, except when temperatures exceeded the range of the thermometers on QHM's 301 and 302. For field D and H observations, only QHM 302 was used. All vertical intensity determinations were made with BMZ No. 62.

The QHM's functioned satisfactorily, except for the fact that for QHM 300 it was impossible to determine a consistent value of alpha, for use in D observations. Also, late in 1957 a small globule of mercury was found lodged in the upper bowl of the thermometer of QHM 301. At the end of the year, this instrument was returned to Australia for calibration and repair of the thermometer.

The BMZ also functioned satisfactorily; the only trouble experienced was through instability of levelling. This resulted mainly from the effect of temperature on the level bubble, together with differential temperature effects on the levelling feet. The "neutral division" was determined whenever magnetic conditions permitted, but variations in its value were quite small. A quarterly check of the disc zero seems necessary.

5. MAGNETIC VARIOMETERS

The normal-sensitivity La Cour-pattern magnetograph was the set operated at Heard Island until 1955 and transferred in that year to Mawson. The variometers themselves have given little trouble, and from December 1956, by which time all recorder troubles had been resolved, record loss was negligible.

(a) Declination Variometer

Orientation tests were made with the use of a Helmholtz-Gaugain coil by McGregor in January 1957. The following month, McGregor and the author adjusted the D magnet and re-evaluated the ex-orientation as 39.0 minutes east of the meridian. (Declination has been increasing westward at an estimated 10' per annum since 1955). In October 1957 an attempt was made to determine the scale value, using the torsion method. This was not entirely successful but gave a result of 0.86 ± 0.09 min/mm, with no account taken of the influence of the magnets in the H and Z variometers and a value of 200 ± 2 cm accepted for the distance from the D lens to the recording drum. A scale value of 0.86 min/mm was also determined with high reliability by the direct method (Olsen 1927), using a series of D observations made in February 1958 with an Askania declinometer, at $2\frac{1}{2}$-minute intervals during a disturbed period. Other determinations by the direct method, using ordinates at times of absolute observations throughout the year, have also been made, but are probably not so reliable, although they agree within 1 percent with the value of 0.86.

(b) Horizontal Intensity Variometer

The ex-orientation of the H magnet was determined by McGregor in January 1957 as 11 minutes, a very satisfactory figure.

During 1957 the temperature compensating strip was adjusted twice, the second time being to correct the earlier wrong adjustment. From 1st January until 24th April the baseline temperature relation was

$$(\text{H base})_{0^\circ C} = 17810 = (\text{H base})_{t^\circ C} - 0.85t$$

and the temperature trace calibration was given by

$$\text{temp. in } ^\circ C = 14.6 + 1.3(\text{temp. ord. in mm})$$

From 25th April to 10th June, after an adjustment of the length of the temperature compensating strip, the average temperature coefficient of the variometer was -2.0 gammas /°C. The adjustment had obviously been made in the wrong direction. Consequently, on 10th June, the bimetallic strip was adjusted to a length of 5.1 mm after which the temperature coefficient became + 0.46 gammas /°C. No further adjustments were made to the H variometer.

Scale values were determined whenever conditions permitted (on an average of once every 8 days) using the coil method. Intermittent wiping contact in the scale-value rheostats, lack of damping in the variometer, and the difficulty of selecting quiet days on which to make scale-value determinations, combined to give a scatter of about 2 percent.

(c) Vertical Intensity Variometer

The Z variometer was very stable until early in November when for an unknown reason the temperature coefficient changed from a negligible value to 1.1 gammas /°C, the change being apparently associated with a baseline jump of 6 gammas.

Z scale-value determinations by the coil method were more successful than the H determinations, because the Z magnet is more heavily damped than the H.

(d) Optical System and Recorder

On several occasions the cylindrical lenses had to be adjusted to maintain the correct trace thicknesses, but the optical system required no other attention.

The recorder functioned very satisfactorily and neither the clockwork drive not the escapement required any serviceing. Because the escapement ran fast, the record usually crossed the clamp bar at the end of each day. To avoid record loss at that time, sections of the clamp bar were removed, with no significant weakening of the bar, but allowing another 10 minutes of record.

(e) Battery supply and control panel

The battery supplying the lamp currents was a 6-volt wet-cell battery; it had been installed in 1957 to replace a similar one damaged by ice formation. Although difficult during the winter months, a weekly check should be kept on the level and specific gravity of the acid in the battery.

The control panel was altered slightly to allow either the main battery or a separate battery to be used to provide scale-value currents. Circuit resistance was reduced to allow greater currents to be used. The rheostats caused considerable trouble because of their intermittent wiping contact. Cleaning with "Servisol" would not improve them and they were replaced during the 1958 changeover.

(f) Observatory routine and photographic processing

Photographic processing at Mawson has always been a problem because of the poor water supply. The use of "Hypo Clearing Agent" following the fixer bath, reduced washing requirements by about 90 percent and so saved both water and time. It was thus possible to have the record hanging up to dry within an hour of the trace change.

In June 1957 a special camp time was introduced at Mawson. This was 2 hours ahead of local time and placed 0000 U.T. at 0700 hours. This meant that the magnetograph routine (at 0300 U.T.) would be carried out at 1000h camp time, but it was decided that it would be more convenient to do the magnetograph routine at 0000 U.T. despite the early rising that it entailed. This routine time was adopted from 1st July.

6. MAGNETIC BAR-FLUXMETER

This apparatus consisted of three mutually perpendicular "bars" which acted as "magnetic aerials", and three fluxmeter or integrating-type galvanometers whose deflections were recorded photographically. Each bar was formed of approximately 13,000 turns of copper wire on a core of alloy known as Anhyster D. The fluxmeters were Kipp Type A54 which have a natural period of 9 seconds, 2 coils of resistance 50 and 300 ohms respectively, and a current sensitivity attaining 0.25×10^{-9} amp/mm at 1 metre. It has been claimed that this bar-fluxmeter assembly has a flat response for periods from 2 seconds to 2 minutes but can record periods as short as 1/10 second.

(a) Bar-supporting framework (Plate 1)

Although E. Selzer's (1957) original paper on the apparatus stated that the 3 bars should be mounted a few metres apart, the French party in Adélie Land mounted them all on a compact single framework. This was prefabricated in France, and made mainly of the alloy duralumin. The Mawson framework was built after the same pattern as this, but unfortunately, instead of duralumin, timber had to be used. Rigidity was the most important requirement. All joints were angled butt-joints, braced on one side by 1/16" brass plate secured with wood-screws and on the other side by ¼" duralumin strip with bolts carried right through the timber.

The base section was mounted on 3 bolts, placed at the corners of the triangle, and cemented with melted sulphur into holes drilled in the rock. The section was laid down so that one H coil would be in the magnetic meridian (in this case, to within half a degree, although an accuracy of several degrees is sufficient). The section was also levelled, the height of each corner being adjustable with two nuts on each bolt, one above and the other below the timber. On investigating the rigidity of the framework, it was realised that the base section should have been supported at the points where the braces from the vertical section are attached to it. It was too late to put in more bolts, so timber blocks were placed beneath these points.

The engineer helped make the clamps to hold the bars. They were made from blocks of oregon about 9" x 10" x 2½" in the centre of which were cut holes of diameter 5⅝"; the blocks were then sawn in halves to make the 2 parts of each clamp. Coach bolts secured the clamps to the framework and the bars were mounted in the clamps. The coils comprising the bars were protected by fibre glass casings, and sponge rubber was used in the clamps, to prevent any friction caused by vibration.

The main trouble with the whole framework being made of timber was lack of rigidity. This was soon vividly illustrated when the vertical section was observed vibrating in the wind. At a later stage an attempt was made to brace further the vertical bar from the top of the rock in whose shelter the framework had been placed. However, this was still not satisfactory, owing to the possibility of the brace causing some constraint in the bar, which might change the permeability of the core.

(b) Connecting cable from bars to fluxmeters

For this purpose some 13-pair seismic cable was available. Most of this cable was laid in the cracks in the rock, so as to put it below wind level, and where this was not possible (viz. the final section before the bars, and the 50 or so feet near the seismic hut) it was placed in piping covered with stones.

The French party had warned of the trouble caused if even short lengths of this cable vibrated in the wind, and the care taken in laying the cable at Mawson was intended both to avoid vibration and to protect the cable from damage.

The resistance of the conductor from each bar to its corresponding fluxmeter has to be small compared with that of the fluxmeter. Each of the 26 conductors of the seismic cable was 7/.010". They were connected in six groups of four, giving each line a D.C. resistance of about 2 ohms. The six lines so formed were connected to 9-pin plugs on each end of the cable.

(c) Recording hut

Although it had been originally planned to build a new hut to house the fluxmeters and the recorder, it was later realised that it would be better to instal them in the existing seismic hut. To hold the instruments a wooden platform was built on the existing gravity pier (See Plate 2). This pier had 8 in. of earthenware pipe projecting above the floor with a slate slab 18 in. square resting on it. An attempt had apparently been made to cement the slab to the top but it had not been successful. As a firm base was required to support the platform, it was necessary first to secure this slab. A ram-set gun was used to try to drive bolts into the concrete which filled the earthenware pipe, but this only revealed the poor quality of the concrete, which shattered almost to sand. Therefore fresh concrete was made and four bolts were cemented into the top of the pipe. Four corresponding holes were drilled in the slate slab with a specially-made tungsten drill, and the slate slab was then bolted down. On top of this slate slab the timber framework was then built. It was clamped securely to the 18-in. square slab, and extends outwards and upwards from it to form a platform 5'1½" x 2' and 3ft high.

The three fluxmeters were placed at one end of this platform and the recording camera was placed one metre from them, at the other end. It soon became obvious that it had been a mistake to use unitary construction for this support. The bench was solidly constructed and well braced, but being of timber it allowed flexure. Any but the most gentle movement near the recorder set the fluxmeter coils swinging wildly. Nothing short of separating the two units on separate piers (as should have been done originally) will rectify this. For prolonged adjustments to the recorder the fluxmeters should be short-circuited, or preferably clamped; paper speed selection and record changes should be made as smoothly as possible.

Other work carried out in the seismic hut for the installation of the fluxmeters included the building of a small fixed table for the control box, improvements to the internal wiring, and the installation of new power points and lights. Also, in the hangar power line, which continues on from the seismic hut, separate fuses were installed so that there would be no loss of record if the staff in the hangar used sufficient power to blow a fuse.

(d) Fluxmeter control circuit (Plate 3)

This provided separate control of the sensitivity and damping of each coil of each fluxmeter. For the 50-ohm coils, control set B was used for each fluxmeter. The continuously adjustable resistances provided for critical damping were not used, except at an early testing stage, because the variable magnetic shunts on the fluxmeters were used for this purpose. Sensitivity was controlled with the 6-position switched shunt, which allowed 0,1,2,5,10, or 25 ohms to be shunted across the fluxmeter. Original records were made with full sensitivity (i.e. without shunt), but owing to the large deflections obtained during normal recording it proved better to have the 25-ohm shunt across the fluxmeter, giving approximately one third of full sensitivity. This was particularly necessary when it was desired to obtain 3 clearly defined traces on the same record.

At the control circuit too, the fluxmeters could be short-circuited for protection, and bars connected or disconnected as required.

(e) Optical system

Early in the year, preliminary optical tests were made on the equipment, but no sharp image of the lamp could be obtained. It was eventually discovered that the correct galvamometer lenses had not been sent. An attempt was made to grind some suitable lenses from optical perspex and mount them in front of the fluxmeters, but their optical quality was too poor. A spare 100-cm lens from the La Cour declinometer was found to give a good image with a galvanometer-to-recorder distance of 100 cm and the lamp placed very close to the recorder. Two ordinary camera "portrait" lenses, of focal length 100 cm, were obtained on loan, to make the full complement. A lens was mounted on a stand in front of each fluxmeter, and with these, three clear traces were finally obtained. Meanwhile, the correct lenses were ordered from Melbourne.

(f) Recording camera (Plate 2)

This was a Kipp manufacture and was driven by a small electric motor, consuming 25 watts.

Paper speeds of 5, 25, and 100 mm/min could be selected with a gear lever on the top of the recorder, but the speeds most used were 5 and 25 mm/min.

No trouble was experienced with the camera or driving motor. Only on one occasion did the paper jam, and this occurred when there were 20 metres of paper in the take-up chamber. On the indicator, new rolls indicate 35-38 metres, and the indicator reads 1 metre when the paper is all used.

(g) Fluxmeter galvanometers (Plates 2 and 4)

Only two of the three fluxmeters were working satisfactorily when they arrived at Mawson. The third did not react properly to torsion head adjustments and appeared to be less sensitive than the others, as though there were some constraint of the movement. Close inspection revealed no obvious cause for this until the galvanometer movement was removed completely from its case. The galvanometer coils are suspended on a single quartz fibre, and flexible connections are made to the coils by means of very fine gold strips. One of these strips had broken, presumably during transport from Holland to Australia (the instruments were loose in their boxes on arrival at Melbourne) and, having wound itself around the lower part of the coils' suspension, it impeded the free rotation of the coil. The strip had to be completely removed. Fortunately it was part of the 300-ohm coil circuit and its absence does not affect the present functioning of the fluxmeter, as only the 50-ohm coil is in use. However, this instrument, No. 9423, will be useless for any work for which the 300-ohm coil would be required.

The first record of 3 components was obtained on 27th January 1958, the instruments being connected as follows :-

Unit No:	I	II	III
Component	D	Z	H
Instrument No:	9423	9422	9424

As the fluxmeters exhibited some tendency to drift, torsion head adjustments had to be made quite frequently.

(h) Time marks

50-volt D.C. pulses, 2 seconds long, were supplied each minute from the cosmic ray recording equipment. Every fifth minute the pulse was shorter. These pulses were used to operate a relay which switched the 240-volt A.C. side of a bell transformer. This supplied 8 volts A.C. to the time-mark lamp which illuminated the slit in the camera.

(i) Recording programme

Most of the recordings made were at 25 mm/min, but a good deal of recording was done at 5 mm/min. This slower speed does not give a clear record or sufficient resolution of pulses, and most of the 5 mm/min records will be useless except perhaps for study of longer-period movements.* During the year, most recording was done during the international hours 02-03, 08-09 and 14-25 GMT, and on world days (regular or special). This rather un-ambitious programme was necessary because of lack of programming equipment and of facilities for processing large quantities of paper. Two sample records are shown in Plate 5.

7. SEISMOGRAPH

The equipment at Mawson comprised a set of 3 Leet-Blumberg seismometers, with electronic amplifiers, and a pen-and-ink recorder. Although the basic design was sound, their operation was most unsatisfactory owing to poor construction and difficulties of maintenance. Installed by McGregor during 1956, the seismograph had only two components in operation when the author arrived in 1957. A replacement galvanometer restored the third unit to operation, but shortly after this two amplifiers became defective. The remaining amplifier was maintained in operation, for some time on the east-west and for some time on the vertical seismometer, until June, when it also broke down. Lack of time prevented any more than a brief investigation of these troubles until November, when one amplifier was repaired; this operated for some time, but not very satisfactorily. In February 1958, Cook replaced the 3 amplifiers with units modified in the Bureau's laboratory at Footscray.

Some of the troubles experienced are listed :

(a) The A.C. power supply to the seismic hut was most unsatisfactory. In 1956, the power line had been extended from the seismic hut to the RAAF hangar. Variations in the hangar load produced large fluctuations in voltage at the seismic hut. Further, one side of the power line had been earthed at the hangar whereas both sides of the mains were intended to be floating. This caused excessive current to be drawn in one side of the line. No separate fuses had been included in the hangar line and overloads at the hangar caused major fuse breakdowns on several occasions, until separate fuses were installed.

(b) A Westinghouse "Stabilistor" had been installed in the seismic hut to stabilise the mains voltage. This unit proved to be frequency dependent and would produce a stable voltage only while the mains frequency was maintained between 49 and 51 c/s. As one of the station's two generators had very poor frequency stability, the voltage fluctuated considerably while this generator was being used. This fluctuation made the amplifiers very unstable because their final stage involves D.C. amplification.

* Editor's Note: It has since been found that the predominant vibrations recorded by Mr. Pinn were due to wind vibration of the bars. When this was eliminated, it was found that the speed of 5 mm/min was most suitable for geomagnetic pulsations.

(c) Particularly troublesome parts of the amplifiers were the oscillator stage and the servo amplifiers. Unbalanced capacitances in the tuning circuits of the former produced unbalanced signals when the seismometer mass was centrally placed. Unbalanced vacuum tubes in the servo amplifiers produced spurious servo signals, causing the servomotors to drive the mass off-centre. This sometimes caused "hunting" of the servomotors.

(d) Backlash in the centreing gears of the seismometers was another cause of "hunting". A few other troubles were traced to the seismometer units. In the N-S horizontal seismometer the mass was found to be jammed as the result of buckling of the small fibre-board blocks which support the fixed plates.

(e) The recorder was the direct cause of much record loss. Adjustment of the galvanometer pens was critical for a good trace. The paper was likely to jam at any time, despite careful attention to the loading and feed of the recorder.

(f) Because of the effect of temperature on the amplifiers and the fact that the winter temperature of the seismic hut fell below freezing point, improved temperature control was necessary. Only limited improvement of the inadequate heating was possible, however, owing to power restrictions.

The total number of teleseisms satisfactorily recorded during the year was only nine, but the total period over which any record was taken amounted to only about 5 months.

8. ACKNOWLEDGEMENTS

The author wishes to acknowledge the willing assistance given by members of the 1957 Mawson party, especially the engineers and the author's scientific colleagues.

He is also indebted to the staff of the Bureau's Observatory Group, especially Mr. C.A. van der Waal, for the encouragement and assistance given in the preparation of this Record.

9. REFERENCES

INGALL, L.N., 1953 Geophysical work at Heard Island 1952-53. Bur. Min. Resour. Aust. Rec. 1953/54.

McGREGOR, P.M., 1959 Magnetic results from Mawson, Antarctica, 1956. Bur. Min. Resour. Aust. Rep. 40

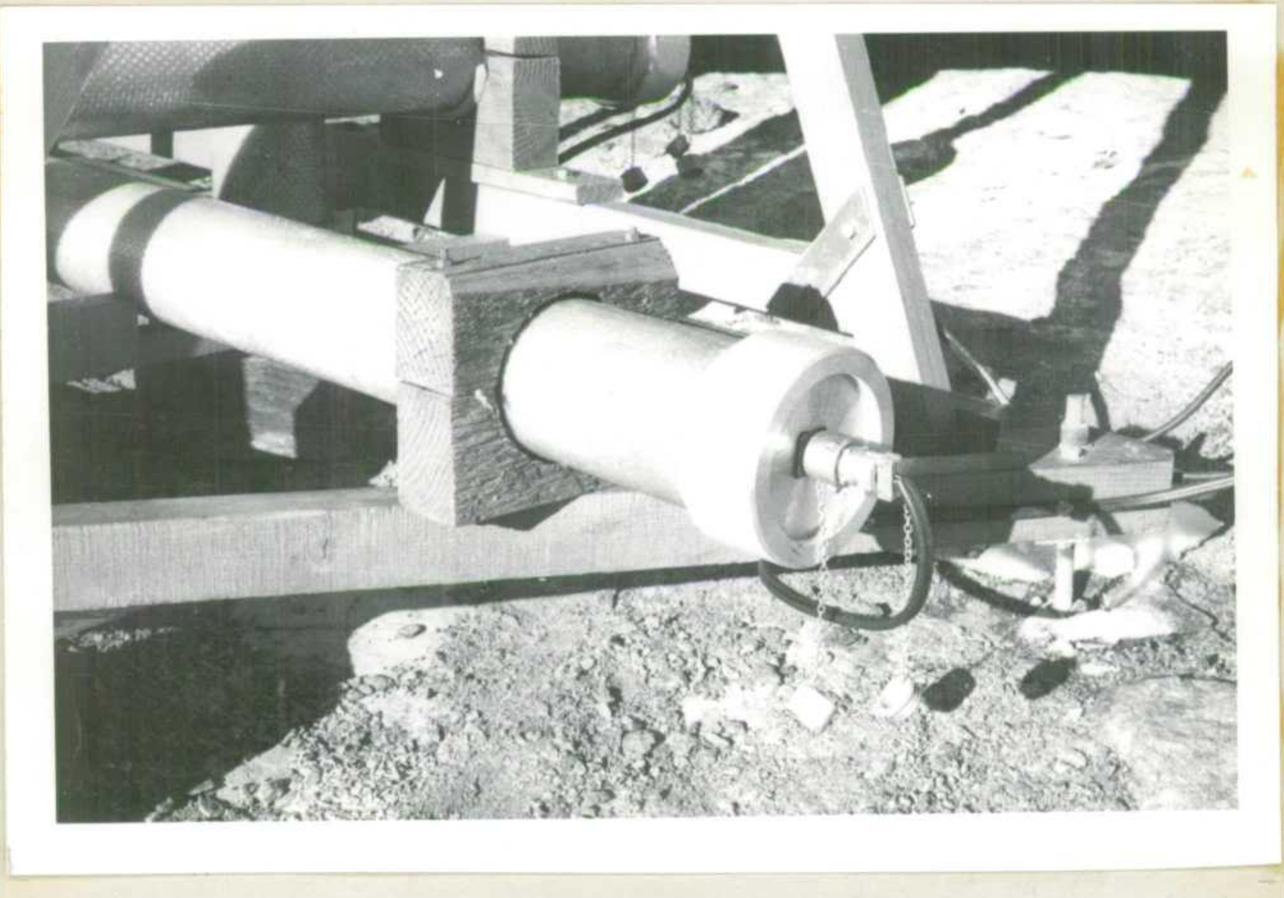
OLDHAM, W.H., 1957 Geophysical work at Mawson, Antarctica 1955-56 Bur. Min. Resour. Aust. Rec. 1957/79.

OLDHAM, W.H., 1958 Magnetic results from Mawson, Antarctica, 1955. Bur. Min. Resour. Aust. Rep. 39.

OLSEN, J., 1927 Direct determination of scale value at the magnetic observatory at Godhavn. Danish Metrological Institute, Communications Magnétiques 2.

SELZER, E., 1957 La méthode "Barre-fluxmètre" d'enrégisterment des variations magnétiques rapides. Annals of the I.G.Y. 4 (5), 287. Permagon Press, London.

(a) MAGNETIC FLUXMETER-FRAMEWORK AND BARS



(b) DETAIL OF FLUXMETER BAR AND FRAMEWORK

MAWSON, 1957

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G158-42

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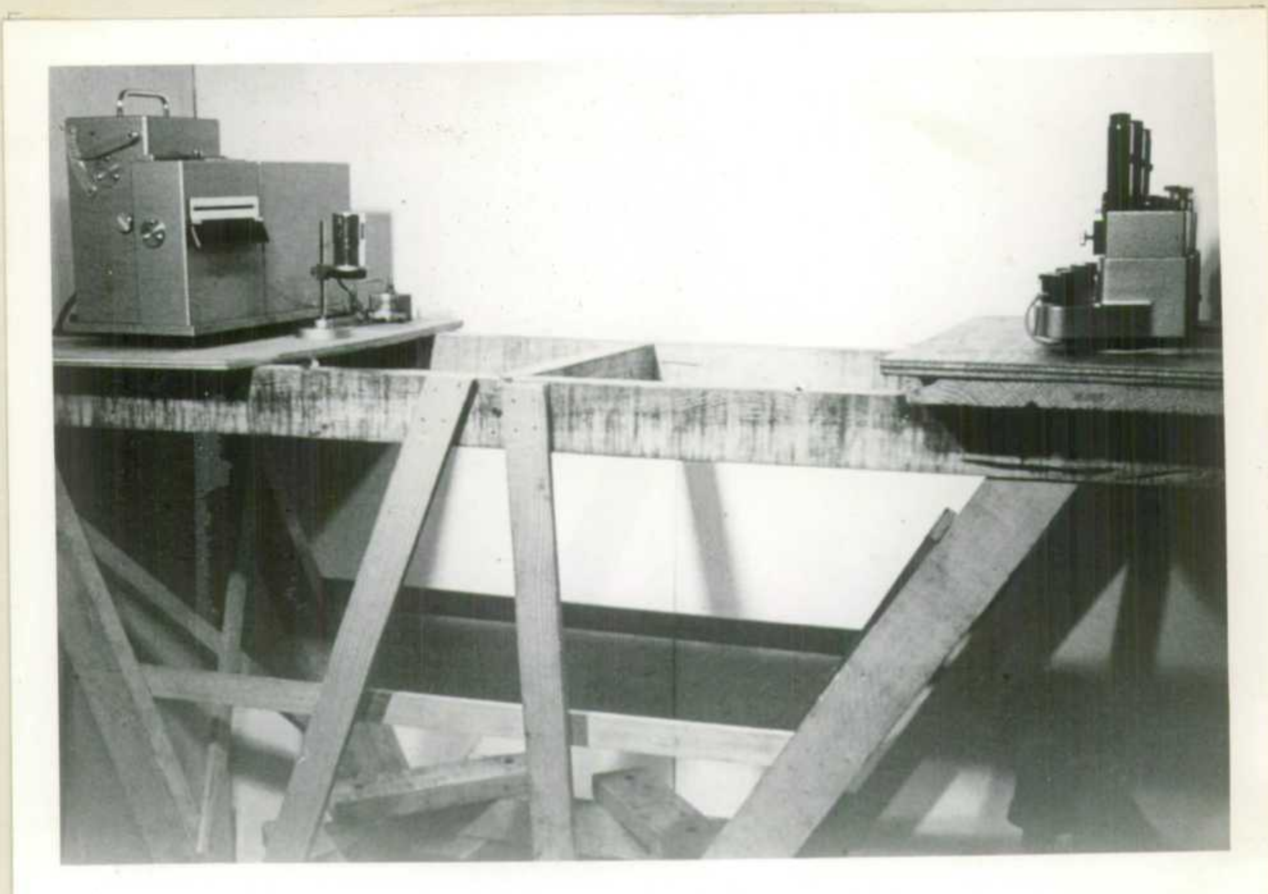
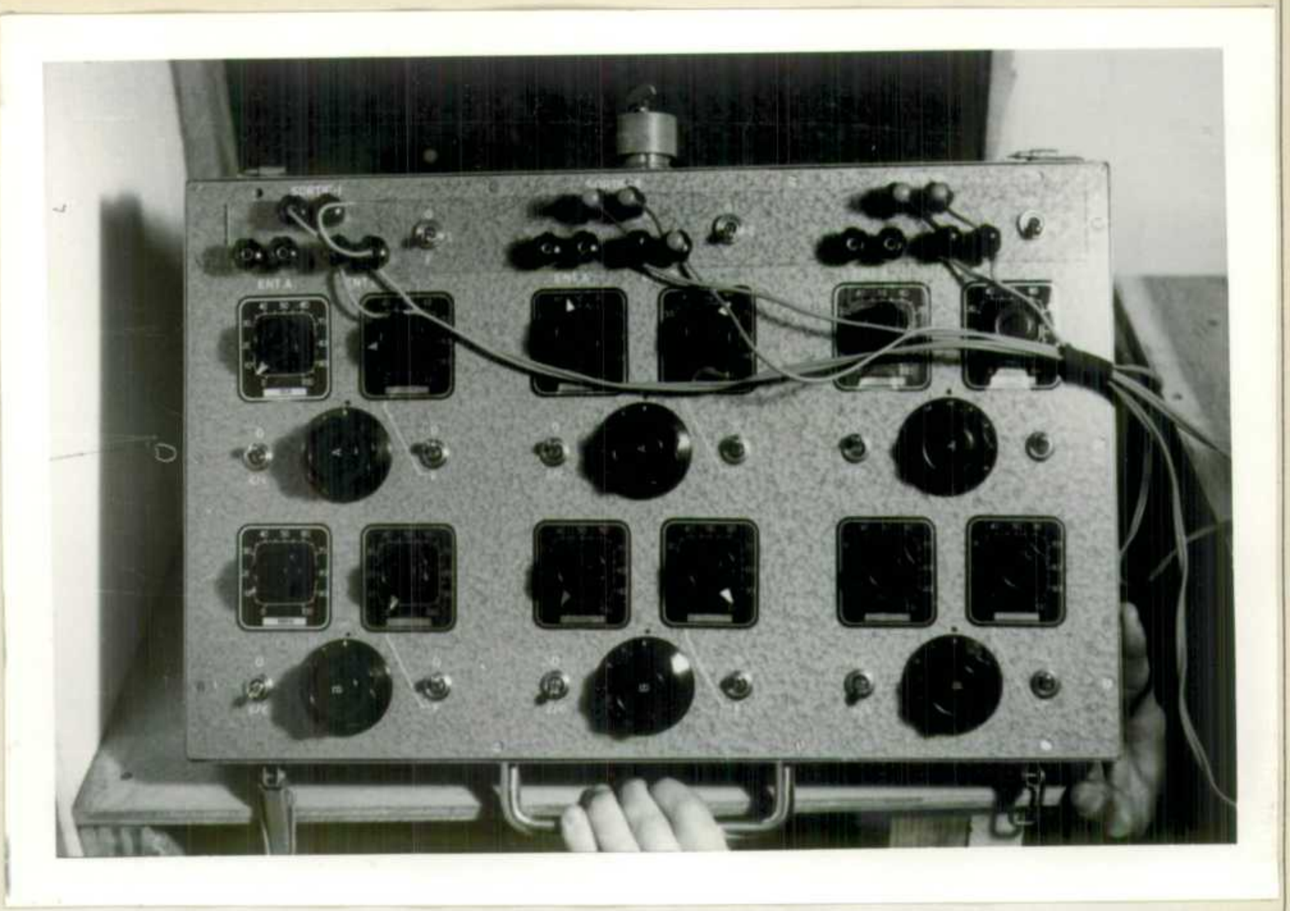


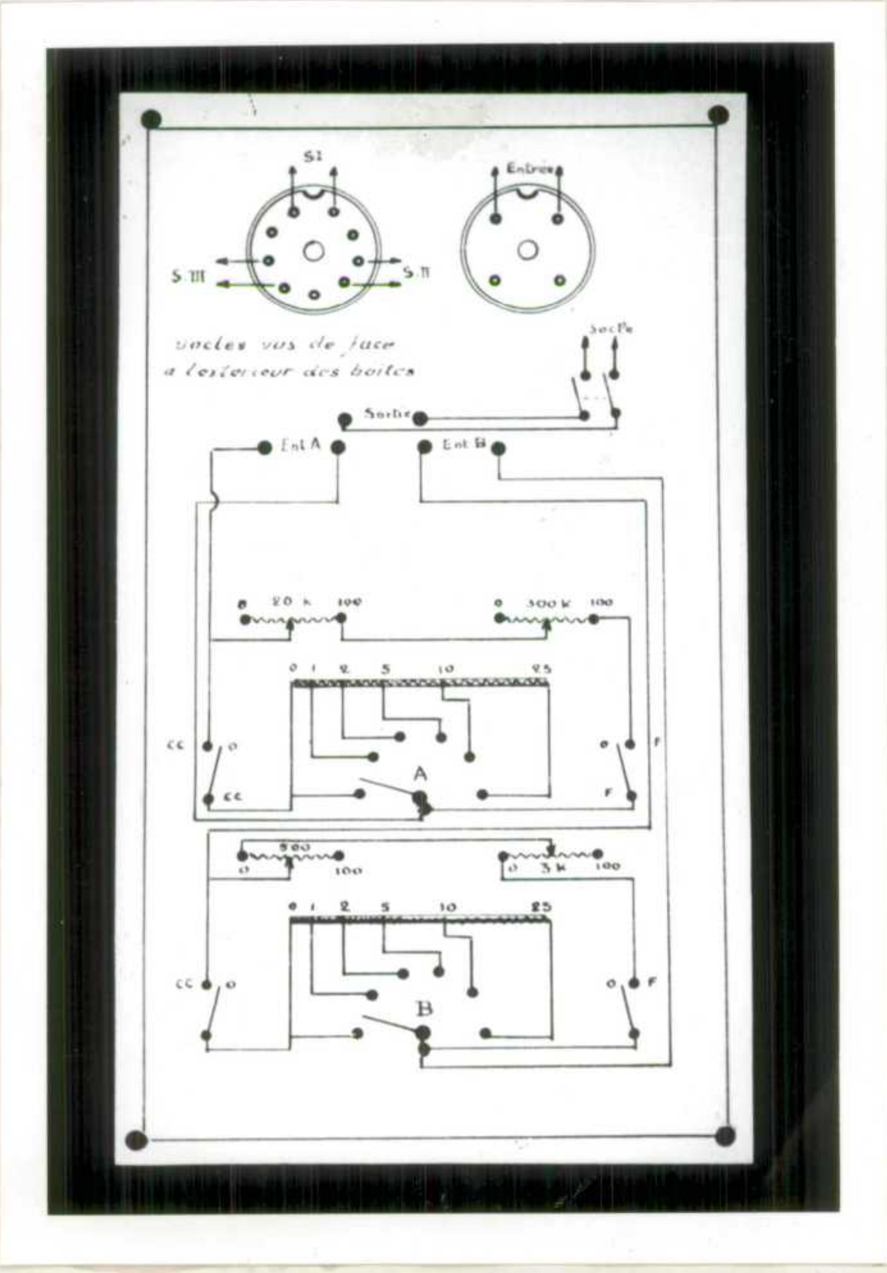
(a) FLUXMETER GALVANOMETERS AND RECORDING CAMERA

(b) DETAIL OF KIPP RECORDING CAMERA

MAWSON, 1957

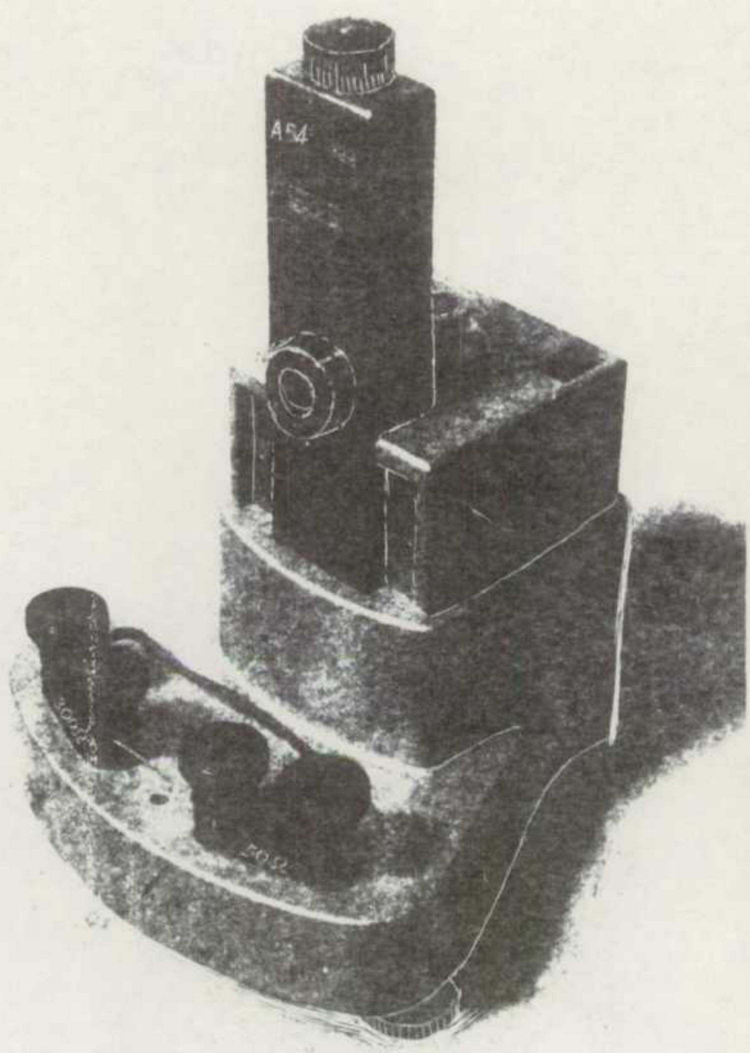


(a) FLUXMETER CONTROL PANEL



(b) FLUXMETER CONTROL CIRCUIT

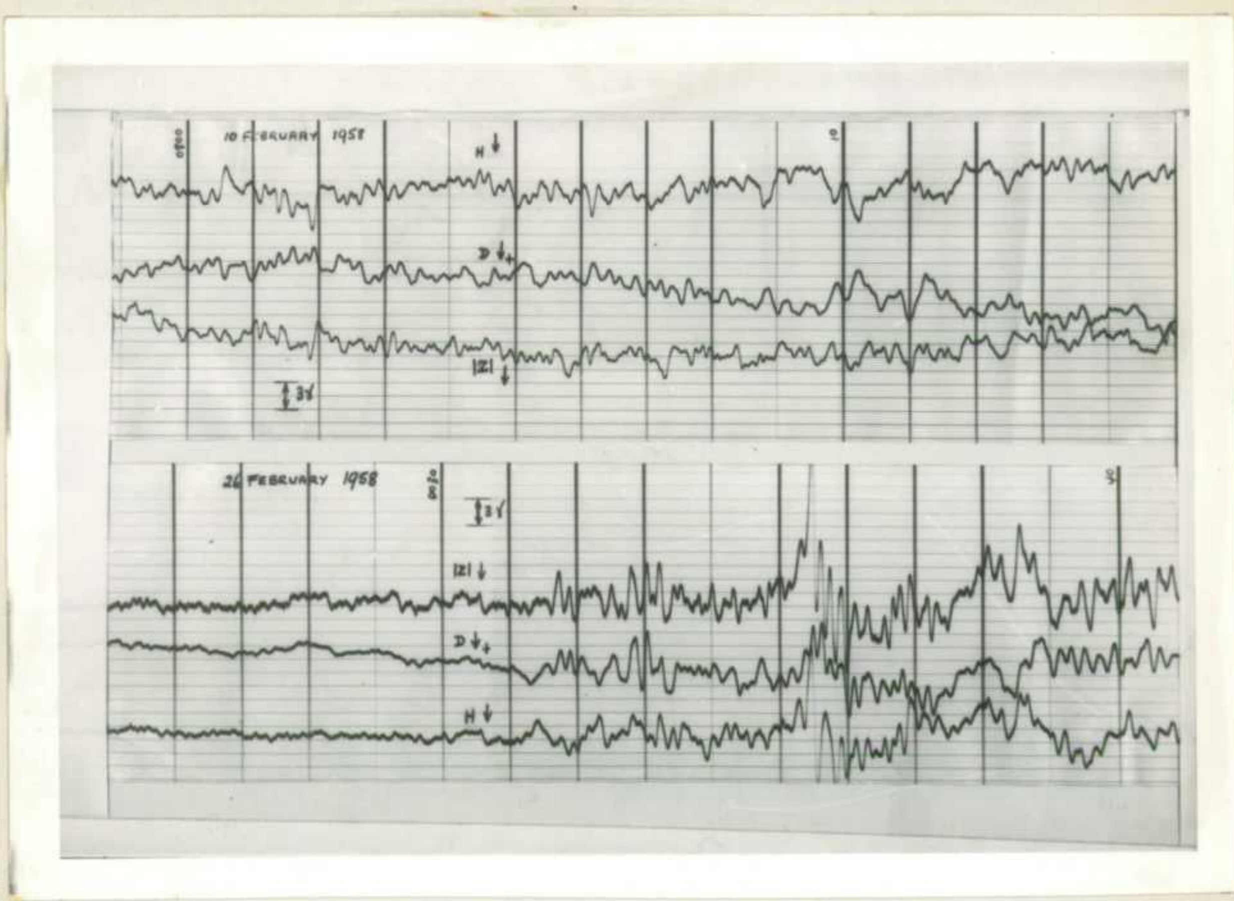
MAWSON, 1957



KIPP Fluxmeter Galvanometer, Type A54.

MAWSON, 1957

PLATE 5



TYPICAL MAGNETIC FLUXMETER RECORDS

MAWSON, 1957