BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

RECORD 1986/12

MAWSON GEOPHYSICAL OBSERVATORY

ANNUAL REPORT, 1984

BY

Peter CROSTHWAITE

RECORD 1986/12

MAWSON GEOPHYSICAL OBSERVATORY

ANNUAL REPORT, 1984

BY

Peter CROSTHWAITE

Contents

Contents

TABLES

FIGURES

SUMMARY

The work described in this report was part of the BMR contribution to the 1984 Australian National Antarctic Research Expeditions at Mawson. This contribution consisted of continuous recording of seismic activity and the geomagnetic field.

The geomagnetic field was recorded using a normal La Cour magnetograph (recording H, D, and Z components photographically) for the entire year. In May, a two component (X and Y) Photo-electric Magnetometer (PEM) was connected to a digital recorder (an EDAS unit utilizing a magnetic cassette drive) and a visual multichannel chart recorder.

Seismic activity was recorded using a Benioff short period seismograph and a Press-Ewing long period seimograph onto two hot pen helicorders. In addition two Benioff short period horizontal seismometers recorded activity on a photographic drum recorder until the photographic system was disconnected in May 1984. The seismometers were relocated and connected to the visual recording system in February 1985.

Preliminary magnetic data were forwarded monthly to Australia. Preliminary seismic data were forwarded weekly to Australia and all Antarctic geophysical stations. In addition, special seismic data were forwarded daily to Australia and all other International Data Centres during the Group of Scientific Experts Technical Test (nuclear monitoring) from September to December.

CHAPTER 1: INTRODUCTION

Mawson Geophysical Observatory is operated by the Bureau of Mineral Resources (BMR), Division of Geophysics, as part of the Australian National Antarctic Research Expeditions (ANARE) at Mawson, Australian Antarctic Territory. Logistic support is provided by the Antarctic Division of the Department of Science and Technology. Station details are listed in Table 1.

The observatory commenced operation in 1955 with the installation of a three component La Cour magnetograph from Heard Island (Oldham, 1957). Since then numerous instrument changes have taken place (see Appendix A).

The author arrived at Mawson on 1st Februry 1984 on the M.V. Nella Dan, to relieve Bob Cechet, who departed on the 3rd February. The replacement geophysicist, Peta Kelsey, arrived on the Ice Bird on the 6th Febuary 1985, and after an extended changeover, the author departed on the 5th March on the Ice Bird.

BMZ comparisons were attempted at Davis in January 1984 with the assistance of Warwick Williams during a very brief stop. BMZ and QHM (H and D) comparisons were performed at Casey in March 1985 on the return voyage. A check of the automatic magnetic observatory at Macquarie Island was also made on the return voyage.

H, D and F comparisons were performed at Mawson both at the beginning and end of the author's term.

CHAPTER 2: MAWSON MAGNETIC OBSERVATORY

The H, D and Z components of the geomagnetic field were continuously recorded using a La Cour magnetograph accompanied by frequent baseline and scale value observations.

A two component (X and Y) horizontal PEM magnetometer was operated and recorded both digitally and on analogue charts from May 1984. The purpose of operating this system was to gain experience operating PEM's (which are relatively new and unique to BMR) and to determine the operating parameters of the magnetograph, which would soon replace the La Cour. The PEM was a very useful tool, and was used to calculate delta-D corrections to QHM observations, once its scale values were determined, and to calculate delta-D and delta-H corrections during instrument comparisons and measurements of the strengths of the magnets used for La Cour orientation tests.

A reference azimuth line was laid in the floor of the new variometer building, and a new mark for declination observations was installed to replace an old mark which has been obscured by the new variometer building. In conjunction with this, the azimuths of old marks were checked.

The geographic coordinates of the magnetic buildings were surveyed and determined more accurately than previously so that greater accuracy in sunshot calculations could be achieved. These are listed in Table 1.

2.1 Absolute Instruments

The instruments used were QHMs 300, 301, 302, using thermometers 2143, 1416 and 1401 respectively, Askania Declinometer 630332, Askania circle 611665, and BMZ 62 using thermometers 2501 and 2161 according to the prevailing temperature.

The proton precession magnetometer MNS2/1 had not worked since mid-1983 and was never used during 1984. All attempts to fix it early in 1984 failed. After a last attempt to fix it just before the 1985 changeover the instrument finally began to work with some small degree of reliability.

The BMZ required frequent cleaning and the telescope mounting was loose (leading to a very large variation in the neutral division). Otherwise it performed adequately.

The QHMs gave few problems. The clamping mechanism on QHM 301 is sticky and introduces nuisance vibrations at the beginning of an observation which take several minutes to damp out. The thermometer on QHM 301 is obviously inconsistent with other thermometers (Cechet, 1984), and an instrument correction discontinuity will be expected when it is eventually replaced.

The declinometer worked satisfactorily throughout the year. Unfortunately the observation procedure for using declinometers was incorrect. The base of the declinometer was left on the circle during the mark siting causing refraction errors. This led to a declination correction of 1.2'WEST. This error in technique relates to all D baseline reductions and preliminary mean values from February 1984 to January 1985 inclusive, and to the February 1984 D comparisons. In January 1985, mark sitings were made using the correct and incorrect technique to determine the above mentioned correction.

2.2 La Cour Magnetograph

The La Cour was operated continuously from 1st February 1984 until 31st January 1985 except for the following periods of record loss:

February	1984	17th	09-24 UT
		18th	00-03 UT
March	1984	15th	01-02 UT
April	1984	01st	03-06 UT, 12-24 UT
		02nd	00-06 UT
June	1984	11th	20-24 UT
		12th	00-09 UT, 11-13 UT

This was a total of 55 hours, or 0.6% of the total recording period. Data quality was reduced on several other occasions but the data was recoverable.

The primary reasons for data loss and degradation of data quality were:

1. failure of the 12V supply to the variometer building

2. jammed drum motor gears

3. failure of station power supply

4. loose/intermittent connections in the power supply and timing circuits and failures in the timing electronics in the variometer building

5. unable to perform chart change because of blizzards

6. overfixation of the photographic records

7. faint or off scale traces during active magnetic storms

8. adjustments to the variometers

9. magnetic interference from quarry vehicles

10. variometer malfunction caused by quarry blasts

Upon the author's arrival the following problems with the magnetograph existed:

1. there was no D timemark trace (Marks, 1982)

2. the Z trace was almost at the limit of its adjustment

3. D and Z reserve traces were either absent or out of adjustment

Following the failed attempts to rectify the D timemark and reserve trace problem by Silberstein and Cechet, no further attempts were made until the D and Z baselines were adjusted. However this attempt was also unsuccessful. The D trace was adjusted up the record on November 19th when data losses during large magnetic storms began to occur.

The H trace was considered to be acceptable and no adjustments were made to it throughout the year.

The Z trace eventually drifted upwards to the top of the record until data began to be lost during magnetic storms. On November 19th the Z traces were adjusted down the record.

Some baseline changes of unknown origin occurred during the year, not always to all traces at the same time. Some possible reasons are the deposition of magnetic building materials in the proximity of the variometer building on occasions, vibrations from machinery and quarry blasts and rearrangement of magnetic materials in the rock crusher/quarry site.

Other baseline changes were caused directly from quarry blasts less than 100 meters from the variometer building. One blast dislodged the Balance de Godhaven magnet and affected Z measurements for over a week until all of the associated problems were rectified. (The Z trace appeared almost normal even when the magnet was not resting on its agate, however baseline reductions and scale value observations were very scattered. Replacing the magnet failed to solve the problem until the magnet and agate were thoroughly cleaned.) It is suspected that the end result of the incident was to change the scale value of the Z variometer. Continuing observations by the 1985 geophysicist will be required to confirm this.

Other results of blasting included vibrating some of the very old wiring in the variometer hut to the point where a few critical connections broke and some timing relay driver circuits failed. Such problems were always very time consuming to fix as there were virtually no wiring diagrams of the old system left, and many modifications had been made in an ad hoc undocumented fashion.

The relay drivers in the variometer side of the timing circuitry caused many problems (relay chatter, transistor failures, etc.). They were eventually removed from the system and replaced by a reliable wire shunt. Apparently they had been installed when the Science Building end of the circuitry was not capable of driving the relays in the variometer building.

For about a month (around July) while the Advance Electronic Inverter was running, the entire recording system was virtually unaffected by station power failures. While relying on station power however, there were many short periods of data loss and the occasional day when the chart would not last for 24 hours as the station power frequency was exceptionally high.

2.2.1 Parallax Tests

Parallax tests were performed shortly before or after every set of absolute observations for baseline determination and instrument comparison. This was done to allow the event marks for the observations to be accurately transferred to the data traces using a parallel rule.

There is a small parallax between both the H and Z traces and their respective timemark traces. In both cases the data trace is one minute of time to the left of the corresponding timemark (i.e. the parallax corrections are +1.0 minutes). As mentioned above, there is no D timemark trace. Either the H or Z timemarks can be used. The D trace is five minutes to the right of the corresponding H timemark and eight minutes to the right of the corresponding Z timemark (i.e. the parallax corrections for the D trace are -5.0 minutes using the H timemarks and -8.0 minutes using the Z timemarks).

2.2.2 Orientation Tests

Orientation tests were carried out on the H and D variometers on the 18th September 1984. The orientation coils were assumed to be aligned at 296° True. The current for the test was derived from a BWD Minilab constant voltage source fed through a variable resistor. The currents used were 350mA. The results are consistent with previous years. (See Table 2.)

The Z variometer was tested on the 12th and 24th of November 1984. The deflector magnet was measured by the following method to be 484.2 nT/m3. (It was previously measured as 491.4 nT/m3. Wolter, 1981.)

1. the deflector magnet was positioned exactly magnetic east of Pier A in a magnetic East-West orientation at the same level as a QHM magnet resting on the pier, and levelled.

2. the field was measured without the presence of the deflector magnet, then with the magnet East-West, then West-East, and then with the magnet absent again.

3. the PEM data was used to correct for H and D variations

Before the Z tests, the holder for the deflector magnet was levelled and oriented correctly with respect to the Z variometer magnet. Both tests were consistent but differed markedly from 1982 and 1983 results.

The coil constants are given in Table 3.

2.2.3 Baseline Control

Absolute observations and scale value observations were performed on average seven times per month to determine H, D and Z baselines on the La Cour magnetograph, and X and Y baselines on the PEM. The observing schedule was:

1. BMZ62,BMZ62

2. DEC332,QHM300,QHM301,QHM302,DEC332

The BMZ was removed from the hut to its shelter in the cold after completion of Z observations so that the other measurements were not disturbed.

With the availability of the PEM analogue display, it was possible to select only very quiet periods during which to do absolutes. Emphasis was given to selecting quiet periods rather than rigidly doing absolutes twice per week. Hence, on occasions more than a week passed between sets of absolutes.

Additional observations were performed when baselines changed.

Before the 18th September, all QHM observations were corrected for declination variations measured from the La Cour magnetograms. Subsequently, the variations were calculated from PEM data.

In February 1984 and February 1985 instrument intercomparisons through baselines were performed with the travelling standards. These results are tabulated in Tables 4 and 5, and take into account residual torsion of all the QHMs. Baseline derivations in Table 6 use the standard QHM programs and do not include this correction. Table 7 lists the torsion corrections to all observatory QHMs and travelling standards.

The constants for the scale value coils for H, D, and Z variometers are listed in Table 3. During every scale value observation, the calibration current was monitored using a Fluke digital multimeter. The approximate calibration currents used were 60mA for H, 40mA for D, and 70mA for Z.

Temperature coefficients for the H and Z variometers were determined by a least squares analysis of baseline vs temperature data. The results for H were very speculative due to a large scatter in the data. However it is fairly certain that the temperature coefficients for the La Cour are quite small (but not negligible). See Table 8.

2.2.4 Temperature baseline and scale values

The temperature of the H and Z variometer thermometers was read every chart change and before and after every set of absolute observations. These measurements were related to scalings on the magnetograms, and a least squares analysis was used to determine the temperature scale values. An adopted scale value was then used to determine baselines. See Tables 6 and 8.

2.2.5 Data

Although the author was present from February 1984 until March 1985, only the data from February 1984 until January 1985 inclusive was processed. Discontinuities in the La Cour baselines and possible scale value changes to the Z variometer during January 1985, accompanied by a change in absolute observation procedure in February 1985 (i.e. the reintroduction of a PPM to measure F and hence determine Z baselines, and the abbreviation of the measurement of H by excluding QHMs 301 and 302 from normal observations), made it more appropriate for the data to be considered with the remainder of the 1985 data. My apology to my successor for the apparent shunning of responsibility.

The preliminary mean monthly field and K-index values for the months of data processed based on the preliminary instrument corrections and magnetograph parameters in Tables 8 and 9 are summarised in Table 10. The preliminary values of various field components over the last decade are summarised in Table 11.

2.3 Photo-electric Magnetograph

On the author's arrival the Y-PEM was not functioning. The PEMs had been recording on single channel HP chart recorders. The electronics in the Y-PEM was recalibrated (but not replaced) according to the description in the manual. The scale value coils of the X and Y PEMs were connected in series with the X scale value current output. A 24V backup power supply was installed in the PEM controller, and a faulty current monitor jack was replaced. The chart recorders were replaced by a Linseis recorder and a digital (EDAS cassette) recorder was installed.

During the alterations the X-PEM was knocked while replacing the thermal cover. It was reoriented.

The only deliberate discontinuity to the operation of the PEM that occurred following the initial changes was the relocation of the Doric thermistor from the X-PEM to the Y-PEM on the 17th June. Digital recording began on the 20th May.

There appeared to be no discontinuities in the data until 13th January 1985 when a quarry blast may have caused a base line jump.

2.3.1 Notes on installation and orientation

The PEM electronics were set up according to the manual. The only problem encountered arose from the photographic safelight positioned above the Y unit. Contrary to the 1983 report (Cechet, 1984) safelights do interfere with the operation of the PEM.

The orientation of the X unit was carried out using a theodolite. The orientation of the theodolite was determined from the standard wall markings and the orientation coils were aligned using the theodolite telescope. Difficulties were encountered because the floor of the building was not a sufficiently rigid base for the theodolite, and the depth of focus of the theodolite was shallow (less than the diameter of the coils). The unit was very easily moved when replacing the thermal covers due to the bulk of the cover and the small clearance around the PEM (necessitated by small piers). The thermal covers were slightly modified to help avoid the problem in future.

The installation of the Y-PEM was slightly different to the method described in early versions of the PEM manual, and to the method used by Cechet. The orientation coils were assumed to be aligned true East-West from the previous installation (this may not however have been the case as Cechet used a different installation technique). After the majority of the procedure recommended in the manual had been followed, the orientation of the QHM magnet was adjusted by moving the position of the photodiode until the application of a large orientation current produced no effect. The QHM fibre torsion was adjusted until the quiet field output of the QHM was 300 to 400 nT above the midpoint of the instrument output (0 volts) for X and a similar amount below for Y. (This was done as the depression in H caused by magnetic storms is equivalent to East and South variations to the field.) Care was taken to ensure that positive changes in voltages and currents corresponded to North and East variations of the field. It should also be noted that for Mawson (declination 63.5°West) that the X-QHM magnet needs to be rotated west and not east as described in the manual.

The scale value of the analogue records was adjusted to be as near to 15 nT/mm as possible.

In future installations it would be desirable to countersink a hole in the instrument pier for one of the levelling feet of the unit so that it can be repositioned if knocked. One of the other feet can be marked precisely so that it too can be repositioned to achieve the same orientation or differ by an exactly measurable angle (should reorientation be desirable).

2.3.2 PEM Baselines

An attempt was made to reduce the observations taken during the year to the PEM X and Y baselines. Only observations from the 17th June 1984 until the 13th January 1985 were considered as there appears to be discontinuities in the data outside of those times.

Both the X and Y PEMs exhibited relaxation of the QHM fibres in the form of a decaying term in the baselines, which one would intuitively feel to be exponential. Hence the aim of the baseline reductions was to find an expression which gave the asymptotic baseline, and to choose the constants in the expression to give the minimum scatter in the reductions.

The calculated preliminary QHM differences between individual observations within the same set throughout the year (after exclusion of some wild values) derived from the PEM data displayed a standard deviation of 1 to 2 nT (See Table 5). The EDAS exhibitted a drift corresponding to about 0.5nT in its analogue to digital conversion. The tolerences in the derived constants could not be expected to be any smaller than those that would lead to a scatter in the final reductions of at least a similar amount.

The expressions that were chosen to reflect the asymptotic baselines were:

X - sx * (x-xs) - qx * (t-ts) - ex * (Y - Ys) - Rx * exp(-d/Dx)

Y - sy * (y-ys) - qy * (t-ts) - ey * (X - Xs) - Ry * exp(-d/Dy)

where X,Y are the measured values of the NS and EW components of the field
sx,sy are the scale values of the X and Y PEMs
qx,qy are the temperature coefficients of the X and Y PEMs
ex,ey are the errors in alignment of the X and Y PEMs in radians
Rx,Ry are the terms arising from the relaxation of the QHM fibres
Dx,Dy are the time constants for relaxation of the X and Y QHM fibres
x,y are the EDAS values corresponding to the horizontal field X,Y
t is the temperature of the variometers
ts,Xs,Ys are arbitrarily assigned standard values for t,X and Y
xs,ys are arbitrarily assigned standard values for x and y
d is the number of days from an arbitrarily assigned time origin

The time origin was taken to be Julian day number 170 of 1984 (18th June), the standard temperature ts was taken to be 0°C, the standard values for the field, Xs and Ys, were taken to be 8200nT and -16500nT, and the standard values for the EDAS values, xs and ys, were taken to be 5000 (although the values for a null input to the EDAS were (for both x and y) 4991).

The observations were taken over a range in the field of 250nT for X, and 170nT for Y, although only a few observations actually fell outside of a range of 100nT in X and 65nT in Y. The range in X and Y at Mawson would be expected to be about 1000nT. Hence the errors in the derivation of misalignment effect the extremes of the data by an amount ten times as great as the effect on the baseline reductions.

The derived values of H from QHM observations used in processing the PEM data were made taking into consideration the effect of residual torsion. These derivations differed from the standard La Cour Data Processing Programs by a small amount. See Table 7.

No instrument corrections were made. In particular, no correction was made for the error in observation technique while using the declinometer (see Section 2.1 'Absolute Instruments').

The analysis procedure was as follows:

1. make a data file of all the QHM and declinometer results with the corresponding EDAS values of X and Y, and the value of the Doric temperature.

2. exclude any individual QHM observation which disagrees with the other QHM observations in the same set.

3. use the average declination and horizontal field strength during a set of observations taking into account the field variation in all calculations.

4. make the initial assumption that qx and qy can be calculated from the constants of the QHMs in the PEMs (see Appendix B), and that sx and sy are as measured by scale value tests throughout the year, and that ex, ey, Rx, Ry are zero.

5. determine graphically the initial estimates of Rx, Ry, Dx and Dy.

6. determine graphically the values of ex and ey.

7. redetermine, using linear regression analysis, better values for qx and qy.

8. redetermine the values of Rx, Ry, Dx and Dy by the following method:
(i) assuming a reasonable asymptotic baseline, perform a regression analysis of LOG(deviation from the asymptotic baseline) vs time.
(ii) repeat step (i) for a range of baselines either side of the estimated asymptotic baseline.
(iii) choose the baseline and associated constants which give the best correlation result in the step (ii).

9. redetermine sx and sy using regression analysis.

10. redetermine ex and ey using regression analysis.

11. repeat as many steps as necessary to refine the data.

The initial values chosen were:

qx = 3.02 nT/°C
qy =-7.97 nT/°C
sx = 0.1974 nT/count
sy = 0.2050 nT/count

After the analysis was complete the following values were accepted:

qx = 3.15 nT/Doric degree (see 'Temperature Coefficients' below)
qy =-8.53 nT/Doric degree (see 'Temperature Coefficients' below)
sx = 0.1968 nT/count
sy = 0.2065 nT/count
ex = 0.0041
ey = 0.051
Rx = 19 nT, Dx = 250 days
Ry =-58 nT, Dy = 500 days

It is questionable whether it was justifiable to adopt the above values of sx, sy, ex, and ey given the scatter in the data relative to the range in x, y, Y and X respectively, particularly for the Y component. Also, quite a range of Rx, Ry, Dx and Dy values can reduce the data to a reasonable straight line. Nevertheless, the above procedure gives an objective way of choosing reasonable values.

The accepted constants give asymptotic baseline values of:

7876.9 nT +/- 1.4 nT for X
-16090.2 nT +/- 1.6 nT for Y

To make these baselines comparable to the La Cour baselines in Table 6, it is necessary to apply a D correction of 1.2'WEST (for the error in observation technique using the declinometer - see Section 2.1 'Absolute Instruments') and an H correction of -1.3nT (as the PEM processing used an average QHM 300, 301, 302 value rather than just the QHM 300 value as in La Cour processing). This corresponds to a correction of -6.4nT to X and -1.7nT to Y.

In order to achieve more reliable estimates of the constants, it would be necessary to both reduce the scatter in the observations, and to extend the range of field values over which the observations are made. This means making observations during non-quiet periods, and reducing the sampling interval of the digital display.

See Appendix C for details of the computer programs used to perform the above analysis.

2.3.3 Temperature coefficients

The temperature response of the system depends on the QHM magnet coefficient, the response of the PEM electronics, and the response of the analogue to digital conversion electronics. These temperatures are not necessarily dependant. The primary component of the coefficient will be from the QHM magnet. See Appendix B for the justification of the following statement.
The temperature coefficient is the product of the QHM temperature coefficent and the PEM baseline value.

For X-PEM (using QHM 292) , q = 3.02 nT/°C.
For Y-PEM (using QHM 291) , q =-7.97 nT/°C.

The Doric temperature sensor used at Mawson in 1984 was never calibrated against a thermometer, but in adjusting the electronics it was found that the temperature corresponding to expected thermistor characteristics was beyond the range of adjustment of the Doric. The unit was slightly nonlinear, but over the range of measured temperature, the actual temperature should probably be increased by 5 per cent over the Doric readout. Hence the temperature coefficients derived from the observation data are actually:

For X-PEM, q = 2.99 nT/°C
For Y-PEM, q =-8.10 nT/°C

2.3.4 Orientation calculations

If the above accepted constants are reasonable, then the X PEM has an orientation error of 0.23° and the Y PEM has an orientation error of 2.9°.

2.3.5 PEM baseline drifts

The PEMs were installed in July 1983 (Cechet,1984). From the determined constants, the X PEM would enjoy a baseline drift of 1nT/month due to fibre relaxation about 18 months after installation, and 1nT/year after a further two years. The Y PEM would take three years to stabilise to 1nT/month, and six years to stabilise to 1nT/year.

2.3.6 Improvements to the digital recording system

The EDAS recording system performs well on the analogue/digital conversion side (having a short term drift of about 0.5 nT), but it records and displays the data in an inflexible manner, and provides no means of playing back the data for processing or verification. It is restrictive in that the display of data cannot occur at a different rate to the recording rate and the display format causes almost unacceptable levels of paper consumption. Also there have been a great many problems reading the EDAS cassettes - it is a time consuming error prone process.

It is desirable to be able to perform absolutes over the entire range of recorded data, then corrections that need to be applied to the data would be as obvious as they are important (eg. orientation errors in the PEM alignment). It is a fact of life that at the extremes of the data, the field is very active, and at such a level of activity very good variometer control of the observations is essential to reduce the baseline reduction scatter enough to determine the corrections. For this reason, a high display rate is desirable during absolutes.

There are two ways of improving the system

1. A cheap way.
   The EDAS could be reprogrammed to collect data at a fast rate (say every 10 seconds or faster), and to display and record at different rates. The recording could then carry on as ususal, and the display could occur at a much higher rate during calibrations (scale values and absolutes), and at a much lower rate all the time (to print out mean hourly ordinates). This would eliminate all analogue scaling, allow more accurate preliminary data to be produced at the observatory, greatly improve the results of calibrations, and provide the mean hourly ordinates as backup to the full digital recording.

2. An expensive way.
   Install a programmable micro or minicomputer to record the data. A multi-tasking system could concurrently acquire and record data at any rate and display or process current or noncurrent data, absolutes, etc., and be used as a general data analysis, graphics, report writing tool. This would improve the quality of the output data, reduce the amount of work to be done on RTA, and free the geophysicist to perform research or assist in other scientific duties.

   It is important to chose a multi-tasking computer for the acquisition system so that a modern, versatile and useful system capable of real time display and instant data recall can be developed - this would be far in advance of anything available at Mawson to date.

   The computer would either need its own analogue/digital conversion ability or an external device to perform the conversions. In the short term the EDAS itself could function as such a device, but in the long term a cheap micro-controlled unit such as the one developed in BMR for digital seismic acquisition or the relevant parts of the array magnetometer developed at Flinders University by Francois Chamalaun could be installed. The latter option could retain data in a buffer and be backed up with a low voltage power supply to avoid the more expensive power backup requirements of the computer. If it was designed such that information (such as mean hourly values) could be extracted using a printer terminal, it could also provide backup in the case of main computer failure or a cut cable, and run off the same emergency power supply as the PEM in the case of a mains power failure. Transmitting the information from the variometer hut to the Science Building in digital form via a modem interface along a single pair cable would reduce the noise introduced along the transmission path from radio transmissions etc. and reduce the requirements on the cable connecting the buildings.

   The Hewlett-Packard Integral Personal Computer operates under the UNIX multitasking operating system and provides graphics capability; it is an example of a microcomputer capable of performing the tasks required at the observatory, similar tasks in field surveys, and many other tasks in the office at BMR. Other possible computers are Convergent Technology machines using the CTOS operating system, and the IBM Personal Computer using Concurrent DOS.

2.4 Comparison of La Cour/PEM Data

The facilities for reading the EDAS cassettes at Canberra were occupied reading the cassettes from other observatories. As the PEM was not the primary magnetometer during 1984 at Mawson, only a small part of the data was processed. The lack of accurate temperature information on the PEM was a source of some uncertainty as to the meaning of the magnetic traces, but nevertheless a comparison between the mean hourly values of the PEM and La Cour variometers for certain periods was attempted.

Cassette MAW 84/008 was submitted to the computer room to be copied to disc. After several failed attempts to read the cassette, three of the eleven days data on the cassette were transferred to disc. The data began on 4th August 1985 at 1300UT (day 217) and ended on 7th August 1985 at 2000UT (day 220). The X PEM baseline at this time was 7885.5 nT (i.e. the asymptotic baseline of 7876.2 nT, a decay term of 15.7 nT, and an instrument correction term of -6.4 nT). The Y PEM baseline was -16144.6 nT (i.e. the asymptotic baseline of -16090.2 nT, a decay term of -52.7 nT, and an instrument correction of -1.7 nT). See subsection 2.3.2 'PEM Baselines' for the derivation of these baselines (at standard temperature).

The uncertainties in the X and Y baselines are equivalent to uncertainties in the derived values of H and D of 2.1 nT and 0.4' respectively. The uncertainties in the La Cour H and D baselines during the above period are 2.1 nT and 0.5' respectively. The tolerence in the scaling of La Cour mean hourly values is 0.4mm or 8.5 nT for H and 1.0' for D. Hence one may expect a PEM/La Cour difference of about 12 nT for H and 2' for D for any particular hour interval, and an average difference for a large number of hours of 4 nT for H and 1' for D.

The temperature coefficients of the derived values of H and D from the PEM data are +9.0 nT/°C and -0.2 '/°C (calculated from qx and qy). The temperature trace for the PEM was extremely insensitive, and the actual temperature can only be estimated from spot checks taken daily at record changes.

The adopted temperatures and the hourly La Cour-PEM differences are shown in Table 12.

The average differences between the mean hourly values from the two magnetographs for the 78 hours considered were 0.5' (+/- 1.3') for D, and -1.0 nT (+/- 9.5 nT) for H. After exclusion of a few wild values, the differences were 0.6' (+/- 0.7') for D, and -0.4 nT (+/- 7.9 nT) for H.

The comparison results are well within the expected tolerences, although the sample size is not large enough to be thoroughly convincing.

2.5 Temperature Control

The variometer building is heated by four bar heaters controlled by a PZC-1 thermistor control unit. The temperature sensor is located on the ceiling above the La Cour magnetograph. It failed only once during the year when the temperature in the hut began to be controlled at about -8°C. The cause was never discovered as the unit recovered of its own accord. Only three heaters were connected to the PZC-1, and the fourth was only used during the failure of another heater. As far as possible the same set of heaters was used to try and keep the huts isotherms fixed, and therefore make temperature corrections more meaningful. (Note that the temperature of all La Cour variometers is measured from the one thermograph, and the temperature of both the X and Y PEMs is measured by the same thermocouple.)

The PZC-1 unit restricted the daily temperature variation in the hut to 1 or 2 °C.

During summer the temperature of the hut rose to well above 5°C, but nothing could be done about this. All of the heater elements required replacing during the year.

The electronics room in the variometer building is not heated. This caused several problems with some of the PEM electronics which is only rated down to 0°C. In the new building it will be desirable to keep all of the electronics at above 0°C.

The temperature in the variometer building varies by 5°C between floor and instrument level, and several degrees at the same level at different distances from the heaters. It also varies by 3°C at the PEM location in response to the thermostat cycle period. (In winter it is about a forty minute cycle). This cycle was very apparent during the operation of the Doric thermistor which was recorded on chart paper. It is not however apparent on the La Cour records, which leads to some degree of mistrust in the correlation between the temperature traces and the measured temperatures in the hut. The new variometer building is far better insulated than the old one, and heating requirements would be expected to be much less. A circulating air heating system to maintain a much more even temperature through the new hut was suggested.

The Absolute Hut is heated by a twin bar heater. During winter, the temperature at instrument height can be -5°C and nearly out of range of the QHM thermometers. Also there is a considerable temperature differential between the pier position and the bench where the magnetomers are kept - this leads to temperature stabilisation problems. A better heating system could be installed. The heaters from the old variometer building will soon be available.

2.6 Surveyed Reference Marks

See Figure 1 for details of reference marks. See Major (1971) for other versions of azimuths and reference marks in the Old Variometer Building.

2.6.1 New Variometer Building

A primary mark, N1, and a reference mark, R1, were embedded in the floor of the building to provide a reference azimuth for installation of the Photo-electric Magnetograph. The marks consist of hexagonal brass plugs (25mm diameter, 25mm long) with turned raised centre marks surrounded by blue tinted epoxy resin, coated with a clear layer of epoxy. N1 is located in the northeast corner of the building (i.e. the instrument room) and R1 is located in the southeast corner (i.e. the electronics room). R1 is visible from N1 through the doorways of the two rooms. The azimuth of R1 from N1 was measured by sunshots using the Department of Housing and Construction's Sokkisha Theodolite before the erection of the walls to be 131° 49' 10" +/- 10".

2.6.2 Declination Marks

The N1-R1 azimuth line was transferred to Pier A to measure the azimuth of the brass peg installed by J.A. Major (1971) and the 1983 reference mark SOH reinstalled by Cechet (1984).

The measured azimuths from Pier A were:

1. brass peg - 355° 25.3' (cf Major's result 355° 24.9')
2. Mark SOH - 274° 14.8' (cf Cechet's result 274° 14.4')

The brass peg actually subtends a significant angle from the pier and so surveyed angles may vary a little. It is also tall and a little bent. There is no definite point on the peg to refer to. The mark is now obscured from view from the pier by the New Variometer building.

The mark SOH is near the quarry site, and with future extensions to the quarry planned, it is in danger of being damaged or destroyed.

A new declination reference mark engraved 'BMR 1985/2' was installed as a backup mark following the loss of the brass peg. It is a hexagonal brass rod extending some 15cm from the ground south southwest of the pier. It is coloured with blue and yellow tinted epoxy and conical at the top to provide a definite reference mark. The top of the peg is also turned with a raised centre so that a theodolite can be exactly positioned over the reference mark. Hence the mark can be used as a sunshot station. It is suggested that sunshots from the mark be used to determine its azimuth from Pier A in the near future. Its approximate azimuth determined by measuring the angle between SOH and BMR 1985/2 from Pier A is 241° 03.7'.

2.7 Comparisons for QHM302 as a field declinometer

In preparation for an expected opportunity to measure the field at Scullin Monolith, comparisons between QHM302/circle 49 (the field declinometer), Askania declinometer 630332/circle 611665 and QHM300 were carried out on the 15th December 1984. Two sets of comparisons sandwiching QHM302 (H and D obs) between Dec332 and QHM300 were made.

The D comparisons showed that QHM302 had a correction of +26.0' (i.e. an eastwards correction) relative to the standard 630332. This correction was made up of a collimation correction of +26.4' and an alpha (residual torsion) correction of -0.4'.

The H comparisons showed that QHM302 had a correction of -4.4nT (compared to the annual average of -4.9nT) relative to the standard QHM300.

2.8 Data Communications

Data was frequently transmitted to Canberra via handwritten telexes passed to the radio operators, but whenever the UAP or IPS computing facilities were available, the telex tapes were generated from computer files. This reduced the workload on the operators and provided the opportunity to check the final telexed data immediately before transmission to remove transcription errors. A few computer programs would have been useful to perform standard report processing (calculating K-indices from H and D indices for example) and eliminate other sources of errors in the monthly reports.

CHAPTER 3: OTHER ANTARCTIC OBSERVATORIES

3.1 Davis

BMZ comparisons were carried out on the voyage to Mawson in January 1984 with the assistance of Warwick Williams. The observing conditions were far from ideal, and the observations were necessarily rushed due to the brevity of the stopover. The comparisons were performed by simultaneous observation, and the results are listed in Table 13.

They were not very successful. Only two observations of each BMZ was made at each of the two stations (eight observations in all). The two derived station differences differed by 60nT.

3.2 Casey

QHM (H and D) and BMZ comparisons were carried out on the return voyage from Mawson in March 1985. Consecutive observations were made according to the following schedule:

1. BMZ and QHM comparisons
   instruments QHM172, PPM1023, BMZ64, BMZ236
   order H172,F1023,Z236,Z64,Z64,Z236,F1023,H172,H172,H493,H493,H172,H172
   three sets of observations were performed

   In addition one set of observations
   order H172,F1023,Z64,Z64,Z236,Z236,Z64,F1023,H172
   was performed.

2. Declination comparisons
   instruments Askania declinometer 640505/circle 508813, QHM493
   order D505,H493,H493,D505
   three sets of observations were performed

   The following problems were encountered.

1. The field was, not unexpectedly, active, and in the absence of both variometer control and a second observer to perform simultaneous observations, there was a large scatter in the derived field values.

2. The observation procedure recommended was very slow, particularly where BMZs were used. The BMZs could either be moved from the warm hut to the cold outside storage pier and back again resulting in large temperature stabilisation problems and condensation problems, lengthening the time between observations and increasing scatter, or dismantled and stored in insulated boxes again lengthening the time between observations (but avoiding the condensation problems).

3. The hut temperature could not be reduced to the external temperature even with the door open and the heating off because of the thermal absorbtion on sunny days. Cloudy days were better.

4. Performing pairs of observations under the circumstances was worse than useless. For example the last QHM 172 observation in each set was never used in any of the calculations. Under these conditions, where the major source of error (in the 1985 comparisons, this was 10 - 50nT) is the field variation, the prime concern is to reduce the time between observations with different instruments.

A suggested alternative schedule is:

H172,F1023,Z64,Z236,F1023,H172,H493,H493,H172 using only the first zero pi and +n pi readings for all H observations (and ommitting subsequent +/- n pi readings).

D505,H493,H493,D505 using only zero pi readings for QHM (i.e. omitting the +n pi and -n pi readings).

The correction for QHM torsion in D and H calculations, and the estimation of the average phi value from the 'plus' phi value in H calculations can be made from a knowledge of the instrument parameters determined from the accumulation of recent observatons using the particular instruments (i.e. a knowledge of alpha and the average asymetry of the +/- n pi readings).

The results of the comparisons are listed in Table 14.

It appears that the Casey observer was not properly briefed on the importance of maintaining a magnetically clean environment in the Absolute Hut, and that there were no suitable non-magnetic tools that could be used in repairing magnetometers. Ordinary screw drivers etc. were probably used instead, possibly altering the magnetometer constants.

3.3 Macquarie Island

A brief examination in passing of the Maquarie Island observatory was made. All equipment appeared to be working correctly, the installation was impressively neat and tidy, all personnel assisting BMR in running the observatory appeared keen and capable, and it was a beautiful warm sunny day and the absence of any problems was much appreciated.

3.4 Remote Automatic Observatories

These observatories do not exist as yet, but the power supplies and communications facilities of Automatic Weather Stations that have been deployed around Antarctica and other places by the Bureau of Meteorology could be used to provide otherwise unobtainable continuous recordings of the field from very remote locations. The movement of icebound stations would be a source of baseline drift, but it may be worthwhile looking into building gimbled F, Z, D magnetometers which would have to be corrected for D during possible rotations of the magnetometer along with the surrounding ice. (The British have a full magnetic observatory on a moving rotating ice shelf at Halley in the Weddell Sea.)

CHAPTER 4: SEISMOLOGICAL OBSERVATORY

Mawson seismic observatory consists of a four component seismograph system. (see Table 1 for details of seismograph locations)

Vertical seismometers

a Press-Ewing long period seismometer
a Benioff short period seismometer

Horizontal seismometers

two Benioff short period seismometers

The vertical seismometers were in operation throughout 1984 and were located in the Cosray vault 13m underground, and recorded on Geotech Helicorder hot-pen recorders.

The horizontal seismometers were in operation until 7th May in the Old Seismic Vault and were recorded on a Benioff three drum photographic recorder. On the 23rd June, with the help of several other expeditioners, they were moved to the BMR seismometer room in the Cosray vault.

During changeover in February 1985, the SPZ seismometer was moved to make room on the seismometer platform for the two horizontal seismometers, and the horizontal seismometers were orientated and connected to a separate pre-amplifier rack. The Helicorders were converted to dual pen operation and all four seismometers were subsequently recorded on the visual system, with the LPZ and SPN seismometers on one recorder set at 30 mm/min, and the SPZ and SPE seismometers on the other set at 60 mm/min.

See Tables 15, 16 and 17 for the seismograph parameters in the various configurations.

See Figure 2 for the layout of the Seismometer Room in the Cosray Vault.

4.1 Operation

The horizontal seismometer photographic recording system suffered the same noise problems as previous years, and required occasional adjustment to the time mark mirrors and lamp intensities. As the system is no longer in operation, it will not be described in this report. See Silberstein (1984) and Cechet (1984) for details of the system. No changes were made in 1984 other than essential maintenance.

On the author's arrival, the SPZ system was working satisfactorily. The LPZ system was unsatisfactory in many respects - the TAM5 preamplifier was separated from its rack and attached to its own mains-fed transformer power supply (and hence not backed up by battery power during station power failures), the calibration circuitry was disconnected, the temperature compensating circuitry was disconnected, and the seismometer was completely undamped. This situation had persisted for some time according to previous reports. The following action was taken.

1. The temperature compensating ciruit board was removed and RTA'd.

2. The TAM5 amplifier was returned to the equipment rack and powered from the battery-fed PP2 power supply.

3. The output from the rack to the calibration coil was located.

4. A 5.1K damping resistor was installed (on the 24th September 1984).

Many problems then occurred, and no problems (principally noise problems) were solved. In particular, there was an interaction between the LPZ and SPZ systems, causing, for example, the SPZ calibration pulse responses to be superimposed on the LPZ record. There was no suitable Cannon plug available to tap the calibration output from the rack and ad hoc alligator clips had to be used. The two systems were found to be wired differently (the rack wiring used the LOW gain output form the TAM5 while the ad hoc wiring used the HIGH gain output). The detailed rack wiring diagram was not to be found, and although it appeared that the seismometers and seismometer to TAM5 cable shields were not connected to the appropriate TAM5 pins, any problems with the rack could not be located without shutting down the seismic system and rebuilding the circuit. Rather than doing this, the LPZ amplifier was returned to the top of the baked bean box from whence it came and a combined SPZ, LPZ, SPN, and SPE circuit rack (or parts) was ordered for the following year. Unfortunately it was never supplied and the unsatisfactory arrangement persisted at the author's departure.

The vertical seismometer system suffered many problems, most of which are described in earlier reports. A high frequency noise problem which was expected to be solved by the installation of a new shielded multi-twisted pair cable and balanced AR-320 helicorder amplifiers persisted. The noise was observed to come from two distinct sources. One was the Stabilac voltage stabiliser (see Chapter 5 'CONTROL EQUIPMENT'), and the other was radio transmissions (in particular, ARQ radio transmissions to Casey). Various attempts to fix the problem by earthing various parts of the system failed, and the 'dirty contacts rectification phenomenom' described in previous reports was investigated without success. The effects of the problem were minimised by maintaining a high attenuation in the recorder amplifiers and a high gain in the TAM5 preamplifiers. This caused some problems during isolated noisy days (principally during blizzards) as the attenuation at the recorders could not be increased enough, but as the likelihood of recording an event against a high noise level was minute, no further action was taken. The gearing and transmission in the LPZ helicorder gave several problems and caused the loss of data on several occasions until all the necessary adjustments and repairs were located and performed.

A temporary rack for the horizontal seismometer amplifiers was assembled (see Figure 3), and with the help of Peta Kelsey the helicorders were converted to dual pen operation, the SPZ seismometer was moved and the SPH seismometers were prepared for installation by connecting their eight (nominally 125 ohm) coils in series and orienting them north-south and east-west on the seismometer platform. The horizontal system was merged with the vertical system and suffered the same radio interference noise problem. The noise problem occurred on only two of the four signals, and occurred on only one signal on each recorder, one signal on each of the two AR320 racks and one signal of the two horizontals installed in the same rack using the same PP2 power supply - in short the problem was traceable to no specific common component between any pair of seismic signals. During the initial power up of the new AR320 amplifiers for the Horizontals, the negative voltage regulators in the AR320s vapourized - it was disappointing that the equipment had never been tested before being sent to Mawson (and apparently not since its construction in the factory).

The general lack of detailed circuit descriptions and lack of rack building hardware at the observatory seems to be the cause of the persistence of the untidy and less than fully reliable system.

4.2 Calibrations

The polarity of the horizontal system was checked soon after arrival in February 1984 and found to be: South is up, East is up.
Daily calibration pulses were applied at the beginning and end of each chart. No complete calibration was performed before the seismometers were moved to the Cosray vault. The last calibration of the seismometers appears to have been in 1982 (see Silberstein, 1984).

The polarity of the vertical seismometers was checked whenever system connections were altered, and daily calibration pulses were applied at the start and end of each SPZ chart, but not the LPZ chart. As far as possible, the recording polarities of the seismometers were kept to the standards (Up, North, East are all up). These polarities, and any brief anomalies are recorded on the seismograms. Complete calibrations were carried out on the SPZ system on the 14th October 1984 and the 21st January 1985. See Tables 18 and 19, and Figures 4 and 5. A complete LPZ calibration was carried out on the 24th January 1985. See Table 20 and Figure 6.

The calibrations were performed using the BWD minilab function generator and the Fluke digital multimeter to monitor the input signals. The minilab frequency settings were found to be very inaccurate and had to be precalibrated (the final signal periods were measured directly from the seimograms). The multimeter was used to obtain the positive and negative peak voltages by reversing the leads of the meter, and the overall peak to peak voltage derived by addition. An attempt was made to perform the calibrations remotely from the Science Building, but it was found that high frequency noise in the cable made it difficult to measure the peak current values and so the usual seismometer-site calibrations were performed.

On the departure of the author, following reinstallation of all seismometers and installation of new AR320 amplifiers, the entire system was uncalibrated.

4.3 Data

During the Group of Scientific Experts Technical Test (GSETT) from October 15th 1984 until December 15th 1984, special effort was taken to report all events, including very weak events that would normally not have been considered. The information scaled from the seismograms (principally the SPZ, and to a very limited extent the LPZ seismograms) was telexed to all International Data Centres. In all, 550 events were reported during the test, and they were described by 2924 parameters. Of these reported events, 145 were actually used in epicentre determination - this was 13 per cent of all of the global events recorded by all stations participating in the test.

During the entire year, P, and occasionally other phase arrival times were reported to Canberra weekly, and the data was relayed to US Geological Survey, National Earthquake Information Service, Denver, Colorado. In all, 1600 events were reported from February 1984 to January 1985. Of these, 1183 occurred between August and December. During the months when there was no sea-ice (February and March 1984, and January 1985) fewer than 50 events per month were reported, and on about half of the days, no events at all were reported.

Reported SPZ amplitudes were incorrect following the October calibrations due to an incorrect determination of G. See Table 18. LPZ amplitudes have been reported incorrectly since the installation of the seismometer as the seismometer mass has always been assumed to be 11.2 kg. Manufacturer's specifications indicate that the actual seismometer mass is 6.9 kg. The system magnification should have been reduced by 6.9/11.2 in past calibrations. It is still quite likely that the assumed distance to the centre of gravity of the boom/mass system is not 308mm as has been assumed in 1984 and previous calibrations, and so the determined magnifications are probably still incorrect.

One significant ice breakout was recorded only a few kilometers from the station. Details of the breakout are described in Appendix F.

CHAPTER 5: CONTROL EQUIPMENT

On arrival at the observatory the author was faced with a terminal board that collected and redistributed all of the 240V, backup 240V, 115V, 24V, 12V supplies and in addition the data signals and timing signals. The high voltage and timing signals passed through the PPT-1 board (power and timing control) and a power monitor board. Most of the high voltage was put through exposed terminals, and none of the wiring was relocatable with ease as it was all terminated in screw terminal boards.

This wiring was not only untidy and incomprehensible (being undocumented), but also extremely dangerous to anyone who needed access to the rack.

This board was gradually dismantled. The 240V devices were fitted with standard 240V plugs and the power was supplied through standard wall sockets. The 110V system was similarly treated, although it was not required after the shutdown of the photographic seismic system and was removed. The 24V devices were fitted with low voltage two pin plugs and power was distributed through power sockets. The 12V system was converted to a 6 pin Jones plug setup - not ideal, but the only other type of plug available. The original system no doubt originated from the lack of general hardware available to Mawson geophysicists.

The power monitor board was removed from service for safety reasons. Switchover power relay boxes were ordered so that the PPT-1 could be removed also for safety reasons.

5.1 Power Supply

The primary sources of power are station mains (240V 50Hz), a battery 24V supply, and a battery 12V supply.

The 240V system drives most of the equipment. Station power was not totally reliable and suffered from poor frequency regulation and variations in supply voltage. The new power house is a vast improvement on the old, but still suffers from reliablity problems. Station power was regulated by a Stabilac voltage stabiliser, and was for a time used only as a secondary supply as backup to inverter power.

The low voltage devices are the Time Mark Unit, the GED clocks (24V backup power), the magnetic photographic recording lamps, and the timing circuitry. The remote equipment rack in the Cosray vault also has its own 12V battery supply. Low voltages were supplied from standard car batteries charged by Boss chargers.

5.1.1 Stabilac voltage stabiliser

The Stabilac was of questionable use. It was not capable of providing noise free power at 240V and was turned down to under 210V to prevent induced noise in the seismic recorders. At one stage the voltage output surged to 300V and melted the seismic recorder pens. Another similar surge nicely toasted a couple of seismic charts (i.e. if you like your charts crisp). It was unsatisfactory when used as backup to inverter supply as there was too great a voltage difference between the output of the two devices. These problems occurred both before and after all of the valves in the unit were replaced. The installation of a line filter on the output of the unit did not solve the noise problem. It was retained in use as the station power voltage variations caused fadeouts on the seismic charts.

5.1.2 Advance Electronic Inverter

The inverter functioned very well for about a month providing reliable and high quality power. Initial problems were caused by its very high synchronising load which could not be supplied by the clock's 50Hz output. Its characteristics seemed to change, and fuses began blowing more and more frequently until it completely failed. This was very disappointing as it provided a means of making the entire system totally unaffected by brief power failures.

5.2 Timing Control

5.2.1 Time Signals

A Labtronics radio receiver connected to a borrowed long wire antenna was used to receive time signals from various time services. The quality of reception was extremely poor, and at times no time signal was received for 15 or 20 days. This was mainly due to the radio receiver, although one Polar Cap Absorption event obliterated all HF radio reception for one week. A borrowed HF communications receiver (available during the worst reception period, midwinter, courtesy of IPS) performed manyfold better than the BMR counterpart, even though it did not have any notch filters to select the audio time signal.

Generally, VNG (Lyndhurst, Victoria) was used to provide accurate time corrections for the GED crystal oven clock. Occasionally, WWV was used although it was sometimes difficult to be certain whether the time signal originated from WWVH Hawaii or WWV Colorado, or indeed ZUO Olifantsfontein (South Africa) which transmits on the same frequencies.

See Table 21 for stations, frequencies, and propagation delays to Mawson.

Advice from physicists at Macquarie Island suggests that a more reliable method of receiving the time signals may be via an Omega very low frequency receiver. It may be well worthwhile looking into this possibility in the future if the performance of the HF receivers and antennae continue to be unreliable.

5.2.2 GED digital crystal oven clock

The GED clock was used to provide timemarks to the seismic system and to the La Cour recording system.

The inverter card on one of the clocks malfunctioned early in the year depriving the clock of a display. The clock was still usable, albeit with difficulty and was not used subsequently.

The comparator display digits on the other clock failed at a later time. This was not considered significant as connecting the radio output to the clock comparator was a difficult method of performing clock corrections owing to the many spurious pips received. An alternative method of comparing the clock and the time pips was used - the (filtered) audio output of the radio and the one second pulses from the clock were fed into a dual channel CRO and the time difference was measured. (This required the construction of a delay circuit to trigger the CRO approximately 950ms after a second mark from the GED clock so that all of the second mark and time pip could be seen whether the clock was fast or slow. See Figure 7.) This method allowed the observer to use judgement in detecting the start of a time pip and the quality of reception of individual pips, and also to disregard spurious pips, and distinguish between multiple pips on the same frequency.

The timemarks from the clock drove the seismic system via a relay board and the La Cour system via the same relay board and the Programmable Time Mark Unit (TMU-1). The end result was to supply 12V pulses to the seismic recorders and closures to the La Cour system.

During the 1985 changeover the relay board and the Time Mark Unit were removed from circuit and replaced with a relay driver (see Figure 7) which directly drove the seismic system and drove the magnetics via a single relay. This was done to avoid the alternative of introducing a string of relays with multiple relay action delays into the timemark circuitry of the seismic system, and to reduce the load on the GED timemark transistors. Unfortunately, the clock derived timemarks are not as clear as the TMU timemarks, and occur only every 10 minutes, with an emphasised mark every hour (compared to the TMU marks every 5 minutes and also on the 59th and 01st minutes).

The relay driver box contained a delayed triggering circuit to drive a CRO and a one second pulse output that could be monitored on the CRO to make time corrections.

The clock was also used to synchronise the Advance Electronic Inverter. This gave problems as the clock was not capable of driving the 50 ohm load at a sufficient voltage to synchronise the inverter. Consequently an impedance buffer and transistor drive were connected to the 50Hz clock output.

The rate of the clock was carefully adjusted throughout the year so that the required 50ms accuracy was maintained during long periods of poor radio reception. Most of the time it was kept within 5 ms/day. At one stage the clock hiccoughed and went from a nice 1 ms/day rate to a 100 ms/day rate. No reason was obvious and the clock eventually settled down again and resumed being nice.

5.2.3 Timemark Programming Unit (TMU-1)

The TMU was used until the 1985 changeover. It gave few problems during the year other than:

1. occasional minute jumps from static or while altering the instrument rack wiring

2. twice when the unit failed (although it worked again when it was reset)

3. an occassion when it completely lost track of the time

The TMU is antiquated and there is little need for it now. It will no longer be used once the La Cour is withdrawn from service.

5.2.4 PEM / Linseis Clock

This cheap and nasty little clock was used to provide hour marks to the Linseis chart recorder for the PEM analogue system. It suffered from static related time increments, and failed to provide any timemarks from 2000 to 2359. It is due to be made redundant by the GED clock (which can directly drive a W & W recorder, but not a Linseis) and retired.

This clock annotated the analogue charts via a multichannel split output relay box; the digital recorder was not sent time mark signals.

5.3 Cables

The following cables were superseded and removed:

1. the pyrotenax cable from the Cosray building to the Science Building.
2. the multi-core shielded cable from the Cosray building to the Science Building.
3. the multi-core shielded cable from the Old Seismic Vault to Science Building.
4. a variety of cables originating in the office, magnetic and seismic buildings and leading nowhere in particular.
5. a variety of cables within the Cosray and Science buildings which were not in use.

The removal of these cables cleared up a great deal of confusion about how data got into and control out of the Science Building. Very little of the cable was retrievable in sufficient lengths to be reusable - most of the plastic covering of the shielded cable had been cracked by the cold, and some cables had been cut by vehicles.

In addition, the pyrotanex cable from the Science Building to the Old Seismic Vault was not in use and was offered to the Bureau of Meteorology for their use.

This left the following cables, other than station power services, which are of relevance to BMR:

for long term usage ..

1. the 10 twisted pair shielded cable from the Cosray vault to the Science building carrying seismic information and control signals. This cable was damaged near the Pump House, and had a new section spliced into it. It was laid in February 1984.
2. the 10 twisted pair shielded cable from the New Variometer Building to the Science Building carrying magnetic information and control signals. This cable was partially laid in February 1985 during changeover, and completed during 1985 by Peta Kelsey.
3. the cable carrying 12V from the Cosrologists office to the Cosray vault.

for short term usage ..

4. the 7 core pyrotanex cable from the Science Building to the Old Variometer Building carrying 240V for the recorder drum motor, timemark closures, and 12V for the recorder lamps.
   CAUTION: This cable has an unusable 7th core which is shorted to the 240V pair.

5. the multichannel shielded cable from the Science Building to the Old Variometer Building carrying PEM information and control signals. This cable was cut numerous times during the year, and has some discontinuous pairs, and some pairs which are shorted to each other. It is not in good condition.

6. the cable from the Science Building to the PPM box that used to carry PPM data, a heater relay switch drive, and maybe other things. This cable had at least three cuts, only two of which could be found, at the author's departure. It was left in an unusable condition.

7. the cable between the Absolute Hut and the Old Variometer Building which carries event mark signals to the La Cour recorder.

All of those cables between the Science Building and the Old Variometer Building run through the quarry site, via several underground road crossings. They are all in grave danger of being damaged, and indeed frequently were during 1984. The cable route is no longer viable. No new cables should follow this route, and it is doubtful that any of the cables could be recovered in usable lengths. These cables will not be required when the Old Variometer Building is shutdown.

The 10 pair cables for the magnetic and seismic systems are 10 twisted pairs of insulated solid conductors. It was found that the most suitable joining method employed Scotchlock crimping connectors. In summer the join should be encased in epoxy resin, but in winter when it is difficult to prevent the resin from freezing, the join should be covered with heavy duty heat shrink tubing. The shield material cannot be soldered, and it was suggested that automotive coolant system hose clamps be used to make physical and electrical connections in the join.

CHAPTER 6: BUILDINGS AND BUILDING MAINTENANCE

The buildings used in the operation of the BMR observatories are

1) Magnetic Absolute Building
2) Magnetic Variometer Building
3) New Magnetic Variometer Building
4) Micropulsations Building (or Variometer Power Supply Building)
5) Old Seismic Vault
6) Cosray Building
7) Science Building (or Wombat)

The Magnetic Absolute Building is blasted by snow and ice particles carried by the prevailing winds. It is in moderately good condition. The only maintenance carried out was painting the windward wall with one coat of undercoat and two layers of silver topcoat. In addition, another hole with internal and external sliding covers was made in the southern wall to observe a new mark from Pier A.

The Magnetic Variometer Building will cease to be used some time in 1985. No problems were encountered with this building other than an occasional buildup of drift around the instrument piers during blizzards.

The New Magnetic Variometer Building was completed in Autumn 1985, after the departure of the author. It will be fitted out during 1985 with the four component PEM/PPM system.

The Variometer Power Supply Building resides in the midst of the quarry. It is very vulnerable to damage from vehicles and flying boulders, and indeed was damaged on several occassions by quarrying activities. The hut originally housed the 12V power supply for the La Cour lamps, but this was moved in April 1984 to the Science Building. Its only function now is to house a switchboard for the station power supply to the variometer building. With the transfer to the New Variometer Building, it will no longer be required by BMR.

The Old Seismic Vault once housed the seismometers. Since May 1984 it has not been used for any specific reason. The only reason for retaining it is the presence of a GRAVITY STATION on the instrument pier. Advice from Dr. P. Wellman of the BMR was that the station was not vital; alternative gravity stations exist at Mawson. It is currently used as a store room by BMR and the Antarctic Division. If it is to remain in service, it will require painting in the near future.

The Cosray Building houses all of the seismometers and a preamplifier/calibration rack deep in its mine shaft, and a 12V power supply in the office. I suggest that a ceiling be added to the BMR side of the shaft to stop dust from being washed down onto the instruments during the summer melt, and that shelving be installed into the cavities in the rock walls to improve working conditions in the vault. At frequent intervals during the melt the sump in the shaft has to be emptied by hauling buckets of water up on a pulley system. This has been so since the sump pump ceased operation. It would be worthwhile persuading the Antarctic Division to install a new pump.

In the Science Building, affectionately known as Wombat, BMR has possession of a workroom, an office, and a darkroom. A very time consuming part of a geophysicists life at Mawson is spent working out what is in Wombat, where it is stored, how it works and what to do with it. On the author's arrival, the workroom was unwalkable and unusable. As appears to be the case with my predecessor, a great deal of time was spent discarding or preparing for RTA as much old junk as possible to make room for as much new junk as possible, as it appears that out of the way places such as Antarctic Observatories are the last resting ground for such things. Of course the geophysics rooms were totally reorganised to suit the occupant, and no doubt they have already been reorganised by the new occupant. There is more than enough furniture in the office, and an excess of archaic equipment. It could be hoped that only useful and reliable equipment will be allowed to clutter the halls of Mawson science in the future. By the way, Wombat is at the end of all of those cables originating from the out-buildings and houses the PEM digital and analogue recorders, the seismic recorders and most of the control equipment and low voltage and backup power supplies.

CHAPTER 7: OTHER DUTIES

The author was the Sea Ice Observer for 1984. This involved taking measurements of the depth of the sea ice either weekly or monthly at various sample points in the Mawson area, and noting the formation and decay pattern of the ice. It also involved at times reconnaisance of the ice to judge its safety regarding travel and recreation. The author was also the iceberg watcher, counter and measurer on the voyage from Australia to Antarctica.

The usual station duties were performed. This included one night per month nightwatch, 14 days full time kitchen duties, Saturday afternoon council duties (garbage disposal, etc.).

Some assistance was given to the Ionospheric Prediction Service in performing daily routines during the absence of their observer.

ACKNOWLEDGEMENTS

The author wishes to express his thanks to the Mawson 1984 and 1985 wintering and summering parties for their assistance and co-operation. In particular, special thanks are due to Grant Lamont for his frequent and helpful advice on electronic matters, and assistance in performing the daily routine during the author's absence, to Robin Thomas for his assistance in performing the daily routine during the author's absence, to Neil Christie for paying meticulous attention to the quality of the output of the new power house (and improving the appearance and readability of the seismic charts immensely), and to the DHC foremen, Mike Hartnett and Danny O'Reilly, for doing all in their power to minimise the disruption caused by the rebuilding program and for their assistance in surveying the observatory sites. A word of praise to Tim Sandford, who operated a rock crusher and quarry only 50 meters (and on occasions much less) from the variometer building, for never causing direct damage to the building.

Many thanks also to all those people and their sponsoring organisations who knowingly or otherwise contributed to BMR's inadequate supply of electronic parts and hardware.

REFERENCES

Cechet, R.P., 1984 - Mawson Geophysical Observatory Annual Report, 1983. *Bureau of Mineral Resources, Australia, Record* 1984/36.

Draper and Smith - Applied Regression Analysis. *Wiley Series in Probability and Mathematical Statistics*

Major, J.A., 1971 - Mawson Geophysical Observatory Annual Report, 1969. *Bureau of Mineral Resouces, Australia, Record* 1957/79

Marks, A.S., 1982 - Mawson Geophysical Observatory Annual Report, 1981. *Bureau of Mineral Resources, Australia, Record* 1982/28.

McGregor, P.M., Notes on the use of the QHM magnetometer in the measurement of horizontal intensity and declination. *Bureau of Mineral Resources, Australia, Record* 1967/140.

Oldham, W.H., 1957 - Magnetic Work at Mawson Antarctica 1955/56. *Bureau of Mineral Resources, Australia, Record* 1957/79.

QHM The Quartz Horizontal-Force Magnetometer. User Manual. *Danish Meteorological Institute, DK-2100 Copenhagen* February 1978.

Silberstein, R.P., 1984 - Mawson Geophysical Observatory Annual Report, 1982. *Bureau of Mineral Resources, Australia, Record* 1984/35.

Wolter, P.J., 1981 - Mawson Geophysical Observatory Annual Report, 1976. *Bureau of Mineral Resources, Australia, Record* 1981/7.

APPENDIX A: HISTORY OF INSTRUMENTATION UP TO 1985

A brief summary of the development of Mawson Geophysical Observatory in terms of instrumentation until 1985 is presented below.

Geomagnetic

May 1955	:	Absolute instruments used for regular observations of H, D & Z (Oldham, 1957).
Jul 1955	:	Continuous recording commenced by three-component normal La Cour magnetograph (Oldham, 1957).
1957	:	Bar-fluxmeter magnetograph installed (Pinn, 1961).
Jan 1961	:	Three-component insensitive La Cour magnetograph installed and recording commenced (Merrick, 1961).
Dec 1967	:	Bar-fluxmeter magnetograph withdrawn (Dent, 1971).
Sep 1968	:	Insensitive La Cour magnetograph converted to medium sensitivity and renamed normal magnetograph. The normal La Cour magnetograph was renamed sensitive magnetograph (Smith, 1971).
Feb 1975	:	15 mm/hr normal recorder replaced by 20 mm/hr recorder (Hill, 1978).
Dec 1975	:	15 mm/hr sensitive recorder replaced by 20 mm/hr recorder.
Mar 1981	:	MNS2 proton precession magnetometer installed for absolute measurements.
Aug 1982	:	Sensitive recorder removed.
Jul 1983	:	Photo-electric magnetometer (PEM) X and Y components installed.
Jul 1983	:	MNS2/1 Proton precession magnetometer ceased operation.
May 1984	:	Digital recording of PEM X and Y component data began.

Seismological

Jul 1956	:	Three-component Leet-Blumberg seismograph (Pen-and-ink recorder) installed.
1960	:	Three-component seismograph installed consisting of Benioff

seismometers (free period 1.0 s) and three- channel BMR single drum recorder. Z galvanometer 0.2 s free period, horizontal galvanometers free period 70 s (Merrick, 1961).

Feb 1963	:	BMR recorder replaced by Benioff 60 mm/min three- channel recorder. 14 s free period horizontal galvanometers installed (Black, 1965).
Sep 1970	:	14 s free period horizontal galvanbometers replaced by short period (0.2 s) galvanometers (Robertson, 1972).
Dec 1973	:	Z seismometer transferred to vault beneath Cosray building (Almond, 1975).
Apr 1977	:	Transfer of Geophysics office, including power and timing to Wombat (Science Block).
1978	:	Recording of SP-N Benioff seismometer discontinued (Petkovic in prep.).
Jul 1981	:	Helicorder hot-pen recorder installed for SP-Z and LP-Z; and SP-N Benioff restored.
Mar 1983	:	Vault beneath Cosray building fully concreted in readiness for movement of SP-N and SP-E. Thermostatically controlled heating introduced to stabilise LPZ.
Aug 1983	:	Four Teledyne-Geotech seismic amplifiers (AR320) installed for connection to two twin hot pen recorders.
May 1984	:	Horizontal seismometers and the Benioff photographic recorder disconnected.
Feb 1985	:	Horizontal seismometers connected to visual hot pen recorders after reinstallation in Cosray vault and conversion of recorders to dual channel.

APPENDIX B: P-P-PEN'N'PAPER PEM PARAMETERS

Temperature coefficients

It should be possible to calculate a good approximation to the horizontal PEM temperature coefficients given that the magnets in the QHMs have been calibrated at the Rude Skov Observatory accurately enough for absolute observations.

The equation of equilibrium of a QHM magnet in a PEM is :

$$M.(C+F) = T.D$$

where M = moment of the magnet
MO= moment of the magnet at 0°C
C = component of the field the PEM is measuring
F = feedback field produced by the PEM
T = torsion constant of the QHM fibre
D = torsion in the QHM fibre introduced during the PEM installation

M can be written as MO.(1-k1.t) where k1 is the QHM temperature coefficient and t is the temperature (in degrees centigrade). Consequently, the above equation can be written as :

$$C+F = R.(1 + k1.t)$$

for a constant R = T.D/MO (assuming that T, D, and MO are constant, which is valid over a short time period, and that k1 is small, as it is).

Let Bt be the baseline at temperature t, Bts be the baseline at standard temperature ts corresponding to a reference PEM feedback field (which is the measure of the field variation) of Fr.

Then Bt + Fr = R.(1 + k1.t)
and Bts + Fr = R.(1 + k1.ts)
hence Bt - Bts = R.k1.(t - ts) i.e. *q = R.k1*

As Fr is small (often zero) compared to Bt, and k1 is small, R is very nearly the value of the baseline. Hence the temperature coefficient is the product of the baseline and the QHM constant k1.

Exorientation angles

The geometry of a PEM system is very simple as the feedback system keeps the magnet steady. The analysis is therefore simple compared to a La Cour system.

Assuming a PEM has a true baseline Bt for the component of the field C it is measuring, then

$$Bt = H.\cos(b-e) - s.c$$

where H = horizontal field
b = angle between the horizontal field and the nominal PEM

alignment
e = error in PEM alignment
s = scale value of the PEM
c = output of the PEM measuring the field variation

hence Bt = H.(cos(b).cos(e) + sin(b).sin(e)) - s.c
= H.cos(b).cos(e) - s.c + H.sin(b).sin(e)
= Bt'.cos(e) + D.sin(e)

where Bt' = calculated baseline assuming the nominal orientation
D = complementary component of the one measured by the PEM

For small values of e this translates to :

true X-PEM baseline = apparent X-PEM baseline - e.Y
true Y-PEM baseline = apparent Y-PEM baseline + e.X

where the sign of e may be confusing!

APPENDIX C: FUTURE PROCESSING OF PEM DATA

The computer programs available for processing data on the CSIRONET are not well documented, not particularly reliable, and not completely relevant to the PEM data. The plotting facilities both on CSIRONET and the BMR computers do not provide fast enough turnaround to enable processing of data to proceed with reasonable speed (and minimal loss of enthusiasm). Consequently there is a need for new computer processing software for the Antarctic data.

Of course, there is nothing special about Antarctic data, so the processing would overlap to a large extent with Canberra, Gnangara, etc. data processing. Several ad hoc programs written by the author to process 1984 PEM data would be useful if rewritten in a more leisurely, better documented and more generalised fashion. Programs that are transportable between the BMR HP system, CSIRONET, and small personal computers (hopefully, to be installed at the remote observatories and for possible use in field surveys) are highly desirable. Also interactive plotting facilities that can be woven into statistical analysis programs on personal computers (and possibly on mainframes as well) would greatly increase the speed of parameter determinations and increase the depth to which the data can be studied.

The following programs on the BMR HP system were found necessary:

1. a QHM observation reduction program

2. an Askania declinometer reduction program

3. a program to process *sets of Askania declinometer and QHM observations* using the PEM data as control to find PEM baselines.

4. a linear regression program to calculate temperature coefficients, scale values, exorientation angles, etc

5. a data editting program to reject data that lies too far off a given straight line as a preprocessor for the above regression program

6. a semi-logarithmic regression program to calculate the exponential decay of PEM fibre torque

7. a quick and nasty plot program (using Dr. Hopgoods basic subroutine) to get a variety of data plots from input text data with a minimum of effort.

Many of these programs could be combined into larger more general programs. For example, the QHM and Declinometer reduction programs could be combined into a program to process any absolute instrument observation recorded on any observation schedule form supplemented by any relevant data (such as variometer data). Another program could process *sets of absolute observations* (supplemented by variometer data) to produce lists of all seven basic components (F, H, Z, D, I, X and Y) at a standard time with the relevant variometer outputs. The regression/plotting programs could be combined to a multilinear regression analysis and plotting package, with builtin data editing and data rejection facilities. It is likely that much of the statistical programs could be aquired from software vendors. Alternatively, Draper and Smith describe in detail methods in both multilinear and nonlinear regression.

I suggest that future QHM reduction programs, particularly when used on Antarctic observations or on observations made during times of high field activity, use the procedures outlined in Appendix D to compensate for field and temperature variations during the observation to reduce scatter in the calculated value of alpha (and hence H) and to simplify the correlation of variometer output to measured field values. Similar procedures can be developed for any other instrument which relies on more than one instantaneous measurement. When QHMs are used in the odd pi mode, I suggest that they be thoroughly tested for angularity of the QHM mirror according to the tests outlined in Appendix E.

APPENDIX D: QHMs AND VARIOMETER CONTROL

A variety of techniques have been proposed for the use of the QHM, either alone or combined with the use of a Declinometer, to control the horizontal components of a variometer, be it a PEM or some other device. What follows is a suggested method of calculating the value of H from a quiet-field QHM observation (which differs from the method BMR has until now used) and a method of reducing an active field to an apparent quiet field in order to relate the circle readings of a QHM observation to a single output from a multicomponent variometer.

Calculation of a QHM's H

The formula given in a number of publications, such as the QHM User's Manual, Danish Meteorological Institute, gives the full QHM formula as :

H = K.n / (1-k1.t).(1+k2.H.cos(phi)).sin(phi).cos(b)

where H = horizontal field strength
K = QHM constant
n = number of pi rotations used
k1 = QHM temperature coefficient
k2 = QHM induction coefficient
t = QHM temperature
phi = average +/- n pi circle deviation from the zero pi reading
b = a + (phi+ - phi-)/2
phi+ = +n pi circle deviation from the zero reading
phi- = -n pi circle deviation from the zero reading
a = alpha, as usual the residual deviation
(tan a= (sin(phi+) - sin(phi-)) / (2 - (cos(phi+)+cos(phi-)))

The effect of the final term, cos(b), is often only a few tenths of a nanotesla and can be ignored. However it is not *always* safe to assume that the QHM is so well adjusted that the neglection of this term is justified. Although the correction that arises from the term can be accounted for in comparisons when the QHM is used in the same field strength as the one it is compared in, the correction will vary if the field strength changes (from Australia to Antarctica, say). In one case (QHM305), the residual deviation was about 200' in Canberra, and about 130' in Papua New Guinea, leading to a correction of many tens of nanoteslas in both locations, and a final error, after extrapolating the Canberra comparisons to the PNG field, of many tens of nanoteslas.

It is advisable in future to include this term in all computer QHM reduction programs, and to determine a standard correction for each QHM in the field in which it is used for hand calculations. A table of such corrections for instruments used at Mawson is included in this report. See Table 7.

It should be noted that the change in method of calculation may cause apparent discontinuities in the long term comparison graphs.

<u>Quiet-ing a noisy field</u>

The availability of digital data and computer processing of observations makes it more desirable to reduce a QHM observation to a single moment in time (.. a moment can be redefined these days as a digital aquisition period). The advantages are :

1. all circle readings then refer to the digital output of the variometer at a single moment. Otherwise, averages of several moments must be taken, and the moments chosen for looking at the H observation are different from the moments chosen for looking at the D side of a QHM observation, which leads to a few complications in keeping track of the data.

2. since all circle readings then become relative to the same field both zero readings, both +n pi readings, and both -n pi readings should be identical, and the +n pi and -n pi deviations from the zero reading should differ by a predictable amount. This makes quality checking of the combination of an observation and the variometer very simple, and highlights errors in each part of the observation.

The analysis that follows ignores the effect of induction, and commences by differentiating the equation of equilibrium of a QHM magnet :

M.H.sin(p) = T.Q ....(1)

where M = moment of the QHM magnet
= M0.(1-k1.t) ... ignoring induction
k1= QHM temperature coefficient
H = horizontal field strength
T = QHM fibre torsion constant
Q = torsion in the QHM fibre
p = angle between the magnet and the horizontal field
t = QHM temperature

dH/H - k1.dt/(1-k1.t) + cot(p)dp = dQ/Q

i.e. dp =-tan(p).[dH/H - k1.dt/(1-k1.t) - dQ/Q] ....(2)

First consider the zero reading. Then :

p = a (i.e. alpha)
Q = B (the residual torsion in the fibre)
dp=-dQ
=-dB
= da

from (1)
B = M.H.sin(a)/T ....(3)
from (2)
dp =-tan(a).[dH/H - k1.dt/(1-k1.t) + dp/B]
i.e. dp =-tan(a).[dH/H - k1.dt/(1-k1.t)] / (1 + tan(a)/B) ....(4)

Next consider the +n pi reading. Then :

p = phi+ + a
Q = n.pi + B

from (1)
n.pi + B = M.H.sin(phi+ + a)/T ....(5)

from (2)

$$dp = -\tan(phi+ + a).[dH/H - k1.dt/(1-k1.t) - dB/(n.pi+B)] \quad ....(6)$$

Next consider the -n pi reading. Then :

$$p = -phi- + a$$
$$Q = -n.pi + B$$

from (1)

$$-n.pi + B = M.H.\sin(-phi- + a)/T \quad ....(7)$$

from (2)

$$dp = -\tan(-phi- + a).[dH/H - k1.dt/(1-k1.t) - dB/(-n.pi+B)] \quad ....(8)$$

Substituting for dB from (4) into (6):

$$dp = -\tan(phi+ + a).[dH/H - k1.dt/(1-k1.t)] .[1 - \tan(a)/((1 + \tan(a)/B).(n.pi + B))] \quad ....(9)$$

Substituting for dB from (4) into (8):

$$dp = -\tan(-phi- + a).[dH/H - k1.dt/(1-k1.t)] .[1 - \tan(a)/((1 + \tan(a)/B).(-n.pi + B))] \quad ....(10)$$

From (3), (5) and (7):

$$T/(M.H) = \sin(a) / (B) = \sin(phi+ + a) /(+n.pi + B) = \sin(-phi- + a)/(-n.pi + B)$$

From the standard formula for a QHM calculation:

$$T/(M.H) = K / (H . pi)$$

This quantity is typically of the order 0.1, and at most it may be 0.32 (i.e. 1/pi).

Equations (4), (9) and (10) can be therefore approximated (very roughly in the case of (4)) to:

$$dp = -\tan(p).(dH/H - k1.dt/(1 - k1.t))$$

for whatever value of p is relevant.

If the actual circle reading 'c' is now considered, then:

$$dc = dD + dp$$

where D is the declination.

Hence the effect of field changes on the circle readings can finally be written as :

$$dc = dD - \tan(p).(dH/H - k1.dt/(1-k1.t))$$

Substituting $dD = -(\sin(D)/H).dX + (\cos(D)/H).dY$
and $dH = \cos(D) .dX + \sin(D) .dY$
(and remembering to take into account the unit of angle is the radian)

for zero readings:

$$
\begin{aligned}
dc = {} & \tan(a).k1.dt \\
& + (-\tan(a).\cos(D) - \sin(D)).dX/H \\
& + (-\tan(a).\sin(D) + \cos(D)).dY/H
\end{aligned}
$$

for plus readings:

$$
\begin{aligned}
dc = {} & \tan(phi+ + a).k1.dt \\
& + (-\tan(phi+ + a).\cos(D) - \sin(D)).dX/H \\
& + (-\tan(phi+ + a).\sin(D) + \sin(D)).dX/H
\end{aligned}
$$

for minus readings:

$$
\begin{aligned}
dc = {} & \tan(-phi- + a).k1.dt \\
& + (-\tan(-phi- + a).\cos(D) - \sin(D)).dX/H \\
& + (-\tan(-phi- + a).\sin(D) + \cos(D)).dY/H
\end{aligned}
$$

Not all of the terms are relevant all of the time. Taking an extreme case with phi = 60°, dt = 2°C, dH = 50nT, H = 8000nT, and a = 3° (with k1 = .00005),

tan(phi).dH/H	is about	35'
tan(a) .dH/H	...	1'
k1.tan(phi).dt	...	0.6'
k1.tan(a) .dt	...	0.2'

In this example the calculated value of H varies by about 1nT for a variation in phi of 1'. The temperature correction for the zero readings is not therefore very significant, and the H correction for the zero reading is required only for a very badly adjusted QHM.

The quiet-ing coefficients could be calculated accurately enough assuming that a = 0° and phi+ and phi- are an average value for phi for most cases. However, if computers are going to do all of the work, then why bother approximating anyway?

The above technique was applied to a very limited set of observations from Macquarie Island. The observations were not made in such a manner that the circle readings coincided with the midpoint of the EDAS sampling interval, so the variometer corrections were not as good as they could have been. The H and D values derived from the observations processed in this manner were compared to the values derived from the usual processing after being reduced to the same point in time (by averaging the four EDAS ouputs at the + and - readings for the H observation and calculating the relevant delta-H, and by averaging the two EDAS outputs at the zero readings and calculating the relevant delta-D). The H calculations were virtually identical, and the D calculations differed only in the term involving the residual torsion angle (alpha). The value of alpha calculated by the above method displayed a reduced scatter when compared to the usual processing method. (The scatter reduced from 0.9' to 0.5', equivalent to a reduction in the scatter the derived X and Y values of about 1nT.) The improvement would be expected to be better with better variometer control. (The corrections outlined in this appendix are equivalent, insofaras the calculation of alpha, to the correction given in the QHM User's Manual, Danish Meteorological Institute, for the calculation of alpha in a varying field.)

Another application of this processing technique would be to investigate the importance of QHM observation schedules referred to by McGregor (1967) by observing the minute by minute creep in the QHM fibre in the torsioned position after correcting for all field variations. The time period of the creep displayed by QHMs installed in PEMs is of the order of hundreds of days, which indicates that the creep during an observation should be unimportant. (See Section 2.3 'PEM Baselines'.) This is inconsistent with McGregor's report and the assumption in this report that the fibre relaxation decays exponentially.

APPENDIX E: USING THE QHM IN 'ODD PI' MODE

QHMs are used in 1 pi, 2 pi, 3 pi, ... modes making the assumption that 1 pi = 1 pi, 2 pi = 2 pi, etc.. While it is obvious that 2 pi = 2 pi, it is not quite so obvious that 1 pi = 1 pi. What this means is that it may not be true that the front and back mirrors of a QHM are exactly parallel. For instruments that are used in odd pi modes, it is worthwhile confirming that the mirrors are close enough to parallel, or if not, determining the error. Of course it may not be possible to compare some 1 pi instruments to the 2 pi mode unless they are taken to a place of high field by natural or artificial means, so Antarctic QHMs should be tested in Australia.

Let
- m = an odd integer
- e = the angle between the back and front mirrors of the QHM
- a = the residual deviation angle, alpha
- phi+' = apparent deviation of the magnet in the +m pi position from the zero position
- phi-' = apparent deviation of the magnet in the -m pi position from the zero position
- phi' = average of phi+' and phi-'.
- phi+ = actual deviation of the magnet in the +m pi position from the zero position
- phi- = actual deviation of the magnet in the -m pi position from the zero position
- phi = average of phi+ and phi- .
- M = moment of the QHM magnet.
- H = horizontal field strength.
- T = QHM fibre torsion constant.
- B = residual torsion in the fibre.

Then
phi+' = phi+ + e
phi-' = phi- - e
phi+' - phi-' = phi+ - phi- + 2e
phi+' + phi-' = phi+ + phi-
phi' = phi.

During a 'plus odd pi' rotation, the QHM head rotates through [m.pi + phi+'], and the QHM magnet rotates through phi+. Hence the twist developed in the fibre is m.pi + phi+' - phi+ = m.pi + e.

During a 'minus odd pi' rotation, the QHM head rotates through [-m.pi - phi-'], and the QHM magnet rotates through -phi-. Hence the twist developed in the fibre is -m.pi - phi-' + phi- =-m.pi + e.

See Figure 8 for some help in visualising the geometry of the situation.

So the equations of equilibrium in the zero, +n.pi and -n.pi positions become:

M.H.sin(a) = T.B
M.H.sin(phi+ + a) = T.(B + m.pi + e)
M.H.sin(-phi- + a) = T.(B - m.pi + e)

and so:
M.H.[sin(phi+ + a) + sin(-phi- + a)] = 2.T.B + 2.T.e
= 2.M.H.sin(a) + 2.T.e ....(1)

and

M.H.[sin(phi+ + a) - sin(-phi- + a)] = 2.m.pi.T ....(2)

From (2)

M.H.[sin(phi).cos(b)] = m.pi.T

i.e. H = m.(T.pi/M) / (sin(phi).cos(b))
= K.m / ((1-kl.t).sin(phi).cos(b)) ....(3)

where b = a + (phi+ - phi-)/2

which is very much like the standard QHM formula; in fact it is the same. The only difference is that phi+ and phi- are not directly measureable angles. Only phi+' and phi-' are directly measurable.

So it is only reasonable to express b in terms of these quantities. Thus :

b = a - e + (phi+' - phi-')/2 ....(4)

and e must be determined. This can be done by comparing 'even pi' and 'odd pi' observations.

From equation (1),

M.H.sin(a).(2-cos(phi+)-cos(phi-)) = M.H.cos(a).(sin(phi+)-sin(phi-))
- 2.T.e

i.e.

tan(a).(2-cos(phi+)-cos(phi-)) = (sin(phi+)-sin(phi-))
- 2.e.T/(M.H.cos(a))

Substituting sin(phi).cos(b)/(m.pi) for T/(M.H) (see (3) above)

tan(a) = (sin(phi+)-sin(phi-))/(2-cos(phi+)-cos(phi-))
- 2.e.sin(phi).cos(b)/(m.pi.cos(a).(2-cos(phi+)-cos(phi-))

approximating, this becomes:

a = (phi+ - phi-).cos(phi)/(2.(1 - cos(phi))
- 2.e.sin(phi)/(m.pi.2.(1-cos(phi)))

= (phi+' - phi-').cos(phi')/(2.(1-cos(phi'))
- 2.e.cos(phi')/(2.(1-cos(phi'))
- 2.e.sin(phi')/(2.(1-cos(phi').m.pi)

= (phi+' - phi-').cos(phi')/(2.(1-cos(phi'))
- e.[cos(phi') + sin(phi')/(m.pi)]/(1-cos(phi')) ....(5)

Equation (5) gives *a* as it is normally approximated plus a term in *e* and a measurable angle *phi'*. Hence comparing *a* as derived by standard formulae for odd and even observations can yield the term in *e* and therefore *e* itself. The effect on the H calculations can then be determined from (4).

APPENDIX F: EAST BAY ICEFALL, JULY 1984

A moderate icefall occurred in East Bay on 10th July and made a great impression on the seismic charts between 0300 and 0400 UT. The amount of ice involved in the fall was surveyed using theodolite and sextant. The largest icebergs were measured and positioned and the extent of the effects of the fall were mapped. Figure 9 shows the positions of the icebergs, and Figure 10 shows the seismic recording of the event. The following data was recorded.

The area south of Rouse Islands extending from the coast to Jocelyn Islands and Teyssier Island (an area 1800m by 1500m) was effected by upheaval and ridging of the plates of seaice along the perimeter and between the islands. The area extending 800m out from the 1800m of coast was completely shattered by the movement of the icebergs breaking away from the icecliffs.

There was a water wave associated the fall - the shores of Horseshoe Harbour were very broken up by the wave and pools of water were left behind higher than usual in the rocks.

Some seaice was seen on some of the small bergs at the north of the breakout, but it was not possible to examine the larger bergs.

The bergs remained virtually fixed by the seaice until summer but after the breakout of the seaice, they rapidly and freely floated away passing to the north of Petersen Island and through Jocelyn Islands.

Some bergs obviously rolled, some tipped partially, but many of the larger bergs (if not all) seemed to just drift out without tipping or rolling.

There were four large bergs whose nonsubmarine portions measured:

1. 159m by 238m in area, with a maximum height of 50m

2. 378m by 401m in area, with a maximum height of 58m

3. 315m by 211m in area, with a maximum height of 25m

4. 212m by 262m in area, with a maximum height of 57m

The accumulation of drift and icelitter at the base of the bergs could lead to an error of up to 6m in the apparent height of the bergs and cliffs. The average height of the bergs was estimated to be 70% of the maximum height for the major bergs. The height of the remaining icecliffs were 3m to 50m.

The size and location of the bergs were measured by the angles subtended by them at the Cosray Building (using a theodolite) and Petersen Island (using a sextant) and their angular displacement from Welch Island and the trig station on Rouse Islands from the same locations. The locations of the bergs may seem odd when related to the Mawson map, but the shape of the coast has changed considerably since the map was made.

1 STATION DATA FOR MAWSON 1984

Magnetic Absolute Hut - Pier A (instrument level)
Geographic coordinates 67°36'14.2"S 62°52'45.4"E
Geomagnetic coordinates 73.1 S 102.9 E (as stated in previous reports)
Geomagnetic coordinates 73.34S 105.86E (from IGRF 1980,pole 78.80S 109.24E)
Geomagnetic coordinates 73.35S 106.44E (from IGRF 1980 extrapolated to 1984, pole 78.91S 109.03E)

Elevation (m) 12
Foundation Precambrian Granite

Magnetic Variometer Building - NEW, Mark N1.
Geographic coordinates 67°36'11.4"S 62°52'44.5"E
Elevation (m) 09
Foundation Precambrian Granite

Magnetic Variometer Building - OLD
Geographic coordinates 67°36'13.0"S 62°52'38.5"E
Foundation Precambrian Granite

Cosray building, Seismometer platform
Geographic coordinates 67°36'16.6"S 62°52'16.6"E
Elevation (m) 17
Foundation Precambrian Granite

Old Seismic Vault, location of SPH seismometers until May 1984.
Geographic coordinates 67°36'04.2"S 62°52'24.1"E
Elevation (m) 08
Foundation Precambrian Granite

The co-ordinates of Pier A, Mark N1, and the Cosray building seismometer platform were measured by the author using ISTS 51 as a reference location. This reference is a satellite trig station positioned by the road near the Old Seimic Vault and the Bureau of Meteorology buildings. Its location is 67°36'04.95"S 62°52'23.66"E, its height above mean sea level is 9.79m, and its spheroidal height is 39.37m.

The co-ordinates of all buildings were measured by Australian Survey Office surveyors, and the WGS 72 co-ordinates provided by ASO agree within 0.2" of latitude and longitude with the instrument pier co-ordinates measured by the author.

Elevations quoted are Height Above Mean Sea Level. The elevations of Pier A, Mark N1, and the top of the Cosray shaft were measured relative to ISTS 51. The quoted elevation of the seismometer platform assumes the shaft to be 13m deep. The elevation of the Old Seismometer Vault was taken from the 1983 Mawson report.)

Tables

2 RESULTS OF ORIENTATION TESTS ON La Cour MAGNETOGRAPH

Component /Date	Reference Field	Magnet N	Ex Orientation degrees	N-Pole
H 18Sep84	18450	E	0.9	South
D 18Sep84	63°34.0' West	N	0.4	West
Z 12Nov84	-46388 nT	N	2.3	Down

3 SCALE VALUE AND ORIENTATION COIL CONSTANTS 1984

Component	Scale Value Constant nT/mA	Orientation Constant nT/mA
X	8.03	8.03
Y	8.03	8.03
H	8.07	8.07
D	8.07	8.07
Z	7.49	-

Date	Instrument A	Instrument B	Difference (A-B) at H = 18500 nT
Feb 19/23 84	HTM 570704	QHM 300	-6.2 +/- 0.8 nT =-0.00034H
Feb 19/23 84	QHM 174	QHM 300	35.4 +/- 0.5 nT = 0.00191H
Feb 15/16 84	Dec 640505	Dec 630332)	-0.9'+/- 0.3'
	Cir 508813	Cir 611665)	

The values of the residual torsion deviation (alpha) for these observations were:

HTM 704	0.8' +/- 2.0'
QHM 174	15.5' +/- 1.2'
QHM 300	-2.5' +/- 1.0'

Values are given with no instrument corrections applied. La Cour data were used to reduce all observations to baselines. Four sets of H comparisons (HTM704, QHM174, QHM300, QHM300, QHM174, HTM704) were made. Four sets of D comparisons (640505, 630332, 630332, 640505) were made.

Declination observations were made using an improper procedure - the declinometer base was left on the circle while siting the reference mark. This will introduce a refraction error into the comparison results. No attempt was made to correct these results as the refraction error for 640505/508813 was not known.

As a quality check on observer performance/variometer sensitivity, and absolute instrument reliability, one may note the following observation scatters:

Instrument	Difference between observations in the SAME set: Average	Maximum
HTM 570704	7.3 nT	12.0 nT
QHM 174	2.1 nT	4.1 nT
QHM 300	1.6 nT	3.5 nT
DEC 640505	0.2 '	0.8 '
DEC 630332	0.3 '	0.5 '

The results quoted for the HTM 704 / QHM 300 comparisons in Cechet (1984) are incorrect.

Tables

5 INTERCOMPARISONS OF MAGNETOMETERS, Mawson February 1985

Date	Instrument A	Instrument B	Difference (A-B) at H = 18500 nT
Feb 13/16 85	HTM 570704	QHM 300	-3.9 +/- 1.3 nT =-0.00021H
Feb 13/16 85	QHM 172	QHM 300	40.9 +/- 0.8 nT = 0.00221H
Feb 15/16 85	Dec 640505	Dec 630332)	-0.4'+/- 0.3'
	Cir 508813	Cir 611665)	
Feb 21 85	Geometrics 816	MNS2/2	-9.2 +/- 3.1 nT

The values of the residual torsion deviation (alpha) for these observations were:

HTM 704 1.1' +/- 1.0'
QHM 172 -5.3' +/- 0.5'
QHM 300 -3.0' +/- 0.8'

Values are given with no instrument corrections applied. PEM/EDAS data were used to calculate delta-H and delta-D to reduce all H comparisons and all D comparisons to a common time for each set. Four sets of H comparisons (HTM704, QHM172, QHM300, QHM300, QHM172, HTM704) were made. Four sets of D comparisons (640505, 630332, 630332, 640505) were made.

F comparisons were performed by alternating F measurements on Pier A until the average instrument difference ceased to vary appreciably. 15 pairs of F measurements were made.

Declination observations were made in the proper way. (see Feb 84 comparison comments)

Through routine baseline determinations from February 1984 to January 1985 using reductions from La Cour variometer magnetograms :

QHM 300 - QHM 301 = 1.7 nT +/- 0.6 nT
QHM 300 - QHM 302 = -5.4 nT +/- 0.5 nT

The above calculations are not subject to torsion correction, see Table 7. Standard Deviations are those of the various baselines calculated between baseline discontinuities. Statistically grouping the observations in this way would be expected to reduce the standard deviation by a factor of four or five.

Through routine baseline determinations from June 1984 to January 1985 using reductions from PEM/EDAS digital recordings :

QHM 300 - QHM 301 = 0.7 nT +/- 1.6 nT
QHM 300 - QHM 302 = -4.9 nT +/- 1.8 nT

The above calculations are subject to torsion correction, see Table 7. Standard Deviations are those of the individual observations; the results compare more favourably than would appear with the La Cour results.)

As a quality check on observer performance, variometer sensitivity, and absolute instrument reliability, one may note the following observation scatters:

Instrument	Difference between observations in the SAME set	
	Average	Maximum
HTM 570704	0.7 nT	1.3 nT
QHM 172	1.0 nT	1.7 nT
QHM 300	0.6 nT	1.1 nT
DEC 640505	0.4 '	0.8 '
DEC 630332	0.2 '	0.5 '

This is a considerable improvement on February 1984 results due to an observer with one year's more experience and a much better variometer to control the comparisons (namely, the PEM/EDAS).

6 OBSERVED BASELINE VALUES FOR LA COUR MAGNETOGRAPH, 1984

Date	Baseline	Remarks
Horizontal Intensity		
1984		
Feb 01 0000UT - Mar 10 1800UT		new observer
	17435.0nT +/-3.3nT	QHM 300
	17432.7nT +/-3.5nT	QHM 301
	17433.2nT +/-3.4nT	QHM 302
+Mar 10 1800UT - May 07 0900UT		unknown
	17428.1nT +/-2.3nT	QHM 300
	17425.5nT +/-1.8nT	QHM 301
	17433.2nT +/-2.4nT	QHM 302
+May 07 0900UT - Nov 19 2000UT		unknown
	17421.5nT +/-2.1nT	QHM 300
	17419.9nT +/-1.8nT	QHM 301
	17426.6nT +/-1.9nT	QHM 302
Nov 19 2000UT - Jan 03 1330UT		Tz baseline change
	17421.9nT +/-3.6nT	QHM 300
	17420.8nT +/-2.6nT	QHM 301
	17426.7nT +/-3.6nT	QHM 302
1985		
Jan 03 1330UT - Jan 12 1320UT		quarry blast
	17418.2nT	QHM 300
	17416.9nT	QHM 301
	17424.0nT	QHM 302
Jan 12 1320UT - Jan 31 2400UT		quarry blast
	17396.5nT +/-1.9nT	QHM 300
	17395.0nT +/-1.3nT	QHM 301
	17402.6nT +/-3.3nT	QHM 302
Declination		
1984		
Feb 01 0000UT - May 18 1800UT	-61°44.3' +/-0.5'	new observer
+May 18 1800UT - Nov 19 0900UT	-61°43.3' +/-0.5'	unknown
Nov 19 0900UT - Jan 03 1330UT	-61°42.7' +/-0.5'	optics adjustment
1985		
Jan 03 1330UT - Jan 14 1020UT	-61°39.8' +/-0.5'	quarry blast
Jan 14 1020UT - Jan 31 2400UT	-61°40.4' +/-0.4'	quarry blast

Vertical Intensity

1984			
Feb 01 0000UT - Nov 19 2000UT	-46428.7nT	+/-3.0nT	new observer
Nov 19 2000UT - Jan 03 1330UT	-46192.2nT	+/-1.9nT	optics adjustment
1985			
Jan 03 1330UT - Jan 12 1320UT	-46159.2nT	+/-4.1nT	quarry blast
++Jan 12 1320UT - Jan 14 1029UT	-46226.7nT		quarry blast
*Jan 14 1020UT - Jan 16 1900UT	-46254.1nT		quarry blast
Jan 16 1900UT - Jan 20 0535UT	-46183.6nT	+/-0.8nT	Z magnet repositioned
++Jan 20 0535UT - Jan 31 2400UT	-46165.6nT	+/-2.8nT	Z magnet/agate cleaned

Temperature - Vertical Thermograph

1984			
Feb 01 0000UT - Nov 19 2000UT	-84.17 °C	+/- 0.22 °C	new observer
Nov 19 2000UT - Jan 31 2400UT	-102.67°C	+/- 0.42 °C	optics adjustment

Temperature - Horizontal Thermograph

1984			
Feb 01 0000UT - Jan 31 2400UT	-35.98 °C	+/- 0.35 °C	new observer

---

See Table 7 for residual torsion corrections to the H baselines which have not been applied to the data in this table.

The baselines for declination measured using declinometer 630332 have been adjusted for an error in observation technique**. This correction is completely independent of the instrument correction which should be applied additionally in the final derivation of mean hourly values.

** the error in technique involved leaving the base of the declinometer on the circle while siting the mark. This required a declination correction of 1.2'WEST.

+ these times for baseline changes are approximate. The baseline shift could only be definitely ascertained to a period between observations.

* the baseline for this period was derived from the measured baseline shift on the magnetogram as no observations were made during this period.

++ the Z baselines during the period January 12th to 20th 1985 are uncertain due to a malfunction in the variometer during this period. See comments in section 2.2 'La Cour Magnetograph'.

---

7 QHM RESIDUAL TORSION CORRECTIONS (at Mawson)

Instrument	phi (°)	phi (°) difference	derived (') alpha	residual torsion (nT) correction	
QHM 300	58.25	-0.11	- 3.7	0.0	
QHM 301	63.46	-0.67	-16.1	1.0	* significant
QHM 302	56.69	-0.23	- 8.4	0.2	
QHM 172	59.47	-0.17	- 5.3	0.1	
QHM 174	57.77	0.45	15.5	0.7	* significant
HTM 704	40.87	0.01	1.0	0.0	

8 LA COUR MAGNETOGRAPH PARAMETERS 1984

Component	Preliminary Scale Value	Preliminary Temperature Coefficient	Adopted Scale Value	Adopted Temperature Coefficient
H	21.2 nT/mm	+0.8 nT/°C	21.21 +/- 0.02 nT/mm	+0.6 nT/°C
D	2.43 '/mm	-	2.423+/- 0.004 '/mm	
Z	22.8 nT/mm	-1.0 nT/°C	22.65 +/- 0.08 nT/mm	-1.1 nT/°C
Tz	1.73 °C/mm	-	1.738 °C/mm	-
Th	2.48 °C/mm	-	2.36 °C/mm	-

9 PRELIMINARY INSTRUMENT CORRECTIONS, 1984

Instrument	Correction at H = 18433 nT	Correction
QHM 300	- 5 nT	-.000271H
QHM 301	- 3 nT	-.000163H
QHM 302	- 8 nT	-.000434H
Askania Dec 630332	0	-
BMZ 62	0	-

10 PRELIMINARY MEAN MONTHLY AND K-INDEX VALUES 1984/5

	H nT	D(W) ° '	Z nT	F ** nT	K-INDEX av.	med	max
1984 (Cechet)							
January	18437	-63 29.7	-46426	49953	3.8		
1984 (Crosthwaite)							
February	18445	-63 29.2	-46438	49967	3.9	3	8
March	18448	-63 32.0	-46424	49955	4.0	5	8
April	18448	-63 32.3	-46426	49957	3.8	3	9
May	18445	-63 31.5	-46412	49943	3.8	3	8
June	18436	-63 33.8	-46410	49938	3.8	4	8
July	18430	-63 34.4	-46393	49920	4.1	3	8
August	18451	-63 34.2	-46386	49921	3.8	4	7
September	18443	-63 35.1	-46390	49922	4.1	3	8
October	18450	-63 35.6	-46388	49922	4.0	3	7
November	18458	-63 34.4	-46387	49924	4.1	4	8
December	18458	-63 35.0	-46371	49910	4.2	4	8
1985							
January	18466	-63 35.0	-46368	49910	3.8	3	7
Mean 1984	18446	-63 33.1	-46404	49936	4.0		
Feb84 - Jan85	18448	-63 33.5	-46399	49932	4.0		

** F values are derived from H and Z data. No PPM measurements were made.

11 GEOMAGNETIC ANNUAL MEAN VALUES, 1974-1984

YEAR	D(W) °	D(W) '	I °	I '	H nT	X nT	Y nT	Z nT	F nT
1974	-62	24.8	-68	47.2	18390	8516	-16298	-47380	50824
1975	-62	31.4	-68	44.0	18397	8488	-16321	-47269	50723
1976	-62	37.3	-68	40.0	18418	8470	-16354	-47157	50626
1977	-62	43.9	-68	36.9	18525	8442	-16376	-47051	50530
1978	-62	51.9	-68	35.5	18421	8402	-16392	-46986	50468
1979	-62	57.9	-68	32.9	18425	8375	-16411	-46890	50380
1980	-63	05.8	-68	29.8	18432	8340	-16436	-46784	50284
1981	-63	14.6	-68	27.1	18443	8303	-16467	-46705	50215
1982	-63	21.2	-68	25.5	18433	8267	-16475	-46616	50128
1983	-63	26.6	-68	22.3	18439	8245	-16493	-46503	50025
1984 **	-63	33.1	-68	19.2	18446	8216	-16515	-46398	49930

Mean annual changes

	D(W) '	I '	H nT	X nT	Y nT	Z nT	F nT
1974-1984	-6.8	2.8	5.6	-30.0	-21.7	98.2	-89.4
1974-1979	-6.6	2.9	7.0	-28.2	-22.6	98.0	-88.8
1979-1984	-7.0	2.7	4.2	-31.8	-20.8	98.4	-90.0

** 1984 results have a Z correction of +6nT applied to the annual average as the preliminary means used a correction of 0nT for BMZ62. This correction is applied nowhere else in this record.

Date	04			05			06			07		
Hour	K	H-dif nT	D-dif '	K	H-dif nT	D-dif '	K	H-dif nT	D-dif '	K	H-dif nT	D-dif '
01				6	-48	-8.1	4	1	0.7	3	-6	0.9
02					3	0.7		-9	0.6		-5	0.1
03					13	0.2		1	-0.3		-4	0.2
04				4	1	-0.1	4	-3	1.0	3	3	-0.4
05					-5	0.3		1	0.6		5	0.2
06					0	0.6		-4	0.8		2	0.2
07				4	1	0.4	3	-6	0.4	2	-3	0.9
08					-3	1.8		-1	-0.1		2	0.1
09					5	2.0		-6	0.8		-1	0.0
10				4	-1	1.1	2	1	0.9	1	0	0.5
11					14	1.5		2	1.3		-4	0.6
12					-3	0.8		5	1.1		-6	0.2
13	3		-	2	7	0.8	2	3	0.9	1	-1	0.3
14		12	2.0		17	1.4		-6	1.1		-7	0.0
15		-6	0.9		12	1.2		1	0.4		0	0.5
16	4	2	0.6	2	11	1.8	3	-7	1.5	1	-2	-0.1
17		-8	1.0		9	1.0		-1	1.6		1	-0.2
18		-7	-0.8		9	1.3		-2	1.5		8	-0.1
19	3	5	0.4	4	9	0.9	4	-14	1.3	1	7	-0.5
20		-4	0.4		19	1.3		-7	0.8		-1	-0.2
21		-5	0.3		3	0.8		-11	1.0			
22	7	-26	0.0	4	7	1.0	5	-10	-0.4			
23		-19	0.7		4	0.9		-13	-1.6			
24		-	-		8	1.2		-15	-3.6			
av		-6	0.6		4	0.6		-4	0.5		-1	0.2

This table lists the difference between La Cour and PEM H and D data from the 4th to the 7th August 1984. The corresponding K indices are also provided.

The adopted temperatures for the PEM were taken from spot readings during chart changes and are not fully-indicative of the temperature variations. Hence some temperature correction errors will exist in the PEM data. The temperatures were 2°C on the 4th, 1°C on the 5th, 1.5°C on the 6th, and 0.5°C on the 7th.

The differences are in the sense La Cour value - PEM value (eastwards declinations reckoned positive).

13 INTERCOMPARISONS OF MAGNETOMETERS, Davis January 1984

Date	Instrument A	Instrument B	Difference (A-B)
Jan 15 1984	BMZ 121	BMZ 115	358.5 nT

Values are given with no instrument corrections applied. Thermometer corrections were not available and assumed to be zero. BMZ 121 was used with long range magnet A set at division 16. BMZ 115 was used with magnet A set at division 17, however the BMZ constants only give divisions 16 and 18. Cubic interpolation was used to estimate the nominal division 17 calibration.

14 INTERCOMPARISONS OF MAGNETOMETERS, Casey March 1985

Date	Instrument A	Instrument B	Difference (A-B) at H = 9600 nT
Mar 13/14 85	QHM 172	QHM 493	40.8 +/-13.3 nT = 0.00425H
Mar 13/14 85	QHM 172+PPM 1023	BMZ 236	-105.6 +/-44.7 nT
Mar 13/14 85	BMZ 64	BMZ 236	-77.8 +/-33.7 nT
Mar 15 85	DEC 640505 +CIR 508813	QHM 493 **	91.6'+/- 6.5'

** alpha = -15.8' +/- 5.9', collimation angle = 75.8' +/- 5.7'.

The values of the residual torsion deviation (alpha) for these observations were:
QHM 172 -38.5' +/- 2.8'
QHM 493 -15.3' +/- 4.2'

Values are given with no instrument corrections applied.

15 HORIZONTAL SEISMOGRAPH PARAMETERS, 1983 - May 1984

Component	SP-NS	SP-EW
Seismometer		
Type	Benioff	Benioff
Free Periods	1.0	1.0
Mass (kg)	107.5	107.5
Galvanometer		
Type	Geotech	Lehner-Griffith
Free Period(s)	0.2	0.2
Recorder		
Type	Benioff	Benioff
Model	Photographic	Photographic
Chart Rate	60 mm/min	60 mm/min
Calibrator		
Motor constant(N/A)	1.27	1.25
Coil Resistance(ohm)	249	258
System		
Damping	8:1	8:1
Magnification at 1 sec	25.5K	21.8K
Peak Magnification (Period)	157K (0.2)	49K (0.5)
Polarity	South-up	East-up

The contents of this table are taken directly from Silberstein (1984). No later calibrations or system changes have been made. The magnification settings on the system until May 1984 are identical to that reported by Cechet (1984).

16 VERTICAL SEISMOGRAPH PARAMETERS, pre-February 1985

Component	SP-Z	LP-Z
Seismometer		
Type	Benioff	Press-Ewing
Free Periods	1.0	12.0
Mass (kg)	107.5	6.9
Power supply	PP2	ad hoc
Preamplifier		
Type	TAM5	TAM5
Gain setting	96dB	72dB
Attenuator setting	(gain - attenuation recorded on seismogram)	
Bandpass filter	.1-10 Hz	.01-20 Hz
Recorder Amplifier		
Type	Geotech.	Geotech
Model	AR320	AR320
Attenuator setting	..Recorded on seismogram..	
Recorder		
Type	Geotech.	Geotech.
Model	RV-301	RV-301
Chart Rate	60 mm/min	15 mm/min
Calibrator		
Motor constant(N/A)	1.50	0.21
Coil Resistance(ohm)	(247)	3.3
System		
Polarity	Up-up	Up-up

Bracketted values () are those taken from previous reports.

17 SEISMOGRAPH PARAMETERS, post-February 1985

Component	SP-Z	SP-NS	SP-EW	LP-Z
Seismometer				
Type	Benioff	Benioff	Benioff	Press-Ewing
Free Periods	1.0	1.0	1.0	12.0
Mass (kg)	107.5	107.5	107.5	6.9
Coil Resistance	1000 ohms	1000 ohms	1000 ohms	500 ohms ++
Power supply	PP2	PP2	PP2	ad hoc
Preamplifier				
Type	TAM5	TAM5	TAM5	TAM5
Gain setting	96dB	-	-	72dB
Attenuator setting (gain - attenuation recorded on seismogram)				
Bandpass filter	.1-10 Hz	-	-	.01-20 Hz
Recorder Amplifier				
Type	Geotech.	Geotech	Geotech	Geotech
Model	AR320	AR320	AR320	AR320
Attenuator setting	..........Recorded on seismograms...................			
Recorder				
Type	Geotech.	Geotech	Geotech	Geotech
Model	RV-301	RV-301	RV-301	RV-301
Chart Rate	60 mm/min	30 mm/min	60 mm/min	30 mm/min
Calibrator				
Motor constant(N/A)	1.50	not measured	not measured	0.21
Coil Resistance(ohm)	(247)	(249)	(258)	3.3
System				
Polarity	Up-up	North-up	East-up	Up-up

Bracketted values () are taken from previous reports.
++ The coil values are nominal values only. The actual values are slightly less than the nominal values.

Period (secs)	Magnification (measured)	Magnification (corrected)	
0.2	23.4 x 1000	20.1 x 1000	
0.25	41.0	35.3	
0.3	65.7	56.5	
0.4	102.3	88.0	
0.5	135.0	116.1	
0.6	168.5	144.9	
0.7	192.6	165.6	) maximum
0.8	195.6	168.2	) magnification
0.9	180.5	155.2	
1.0	151.2	130.0	
1.1	115.2	99.1	
1.2	90.8	78.1	
1.3	72.0	61.9	
1.5	45.6	39.2	
2.0	18.4	15.8	
3.0	5.4	4.6	
4.0	2.2	1.9	
5.1	1.1	1.0	

Magnifications are given at TAM5 set to 96db gain
0db attenuation
0.1-10Hz passband
AR320 -24db attenuation
Seismometer Free Period 0.96 secs
Damping Resistor 386 ohms

			currents used : 500 microamps (approx p-p value)
Weight lift tests	0.141	mm/mg	masses used : 100mg
Current pulse tests	18.6	mm/mA	currents used : 1mA, 2mA.
Motor Constant, G	1.29	N/A	

The results of weight lift tests are certainly incorrect due to a certified 100mg mass used in the tests being other than its stamped mass. The results of the weight lift test are inconsistent with subsequent tests and the derived motor constant is similarly inconsistent. The first column of magnifications has been corrected by a factor of 1.29/1.50 (the ratio of the derived motor constants in the calibrations in October 84 and January 85) to give the second column of magnifications.

19 SPZ SEISMOGRAPH CALIBRATION, January 1985

Period (secs)	Magnification	
0.31	8.23 x 1000	
0.41	11.1	
0.51	16.5	
0.62	19.6	
0.72	22.1	) maximum
0.82	21.5	) magnification
0.93	18.5	
1.02	15.4	
1.12	11.8	
1.19	9.88	
1.31	7.28	
1.53	4.53	
2.03	1.88	
3.03	0.56	
4.08	0.22	
5.10	0.11	

Magnifications are given at TAM5 set to 96db gain
-12db attenuation
0.1-10Hz passband
AR320 -30db attenuation

Seismometer Free Period 0.96 secs (from Oct 84 results)
Damping Resistor 386 ohms

			currents used : 3mA - 6mA (approx p-p value)
Weight lift tests	0.015	mm/mg	masses used : 100mg - 1000mg
Current pulse tests	2.29	mm/mA	currents used : 1mA - 5mA
Motor Constant, G	1.50	N/A	

Magnification Conversion Tables

TAM5 Attenuation	0 db	-6 db	-12db	-18db
0 db	1	0.504	0.255	0.127
-6 db	1.98	1	0.506	0.251
-12 db	3.92	1.98	1	0.497
-18 db	7.89	3.98	2.01	1

AR320 Attenuation	-18 db	-24 db	-30db	-36db
-18 db	1	0.518	0.264	0.127
-24 db	1.93	1	0.510	0.245
-30 db	3.79	1.96	1	0.480
-36 db	7.89	4.09	2.08	1

Period (secs)	Magnification
5.90	440
7.93	380
8.97	373
10.06	355
11.78	300
11.87	301
11.95	300
12.23	288
12.98	254
13.33	232
14.62	177
15.60	137
17.08	100
18.07	81
19.44	62
20.76	48
21.85	41
24.30	27
27.27	18
30.24	14
35.07	8.6
39.76	5.4
49.80	2.8
62.53	1.3

Magnifications are given at	TAM5 set to	72db gain
		-24db attenuation
		0.01-20Hz passband
	AR320	-30db attenuation
Seismometer Free Period		12.0 secs
Damping Resistor		5110 ohms

			currents used : 600 microamps (approx p-p value)
Weight lift tests	613	mm/mg	masses used : 31mg, 62mg
Current pulse tests	10.88	mm/mA	currents used : 0.2 to 0.5 mA
Motor Constant, G	0.21	N/A	

The pivot to weight lift point for the tests was 370mm. The calculations assume that the pivot to centre of gravity of the mass is 308mm (see Silberstein(1984)). The seismometer mass used in calculations was 6.9 kg. This is different from the assumed mass of 11.2 kg used in previous reports.

See Cechet(1984) for Magnification Conversion Tables for TAM5 and AR320.

21 TIME SERVICES, FREQUENCIES, PROPAGATION DELAYS

Station	Location	Frequency (kHz)	Schedule	Delay (ms)	Bearing
VNG	Lyndhurst Australia - 38° 3' -145°16'	1500 7500 12000	9h45m - 21h30m 22h45m - 22h30m 21h15m - 9h30m	22	101°
WWV	Fort Collins USA + 40°41' +105° 2'	2500 5000 10000 15000 20000 25000	continuous	60	201°
WWVB	Fort Collins USA + 40°40' +105° 3'	60	continuous		
WWVH	Kauai USA + 21°59' +159°46'	2500 5000 10000 15000 20000	continuous	50	128°
YVTO	Caracas Venezuaela + 10°30' + 66°56'	6100	12h00m - 20h00m 0h30m - 1h30m	45	236°
ZUO	Olifantsfontein South Africa - 25°58' - 28°14'	2500 5000 10000	18h00m - 01h00m continuous continuous	20	316°

VNG second markers of 50 cycles of 1kHz modulation; 5 cycles only for second markers 55 to 58. Seconds marker 59 is omitted. 500 cycles for minute markers. During the 5th, 10th, 15th, ... minutes, 5 cycles for seconds markers 50 to 58. Identification by voice announcement during the 15th, 30th, 45th and 60th minutes.

DUT1: CCIR code 45 cycles of 900 Hz modulation immediately following the normal second markers.

WWV pulses of 5 cycles of 1kHz modulation. 59th and 29th second pulse omitted. Hour is identified by 0.8s long 1500Hz tone. Beginning of each minute identified by 0.8s long 1000Hz tone.

DUT1: CCIR code by double pulse. Additional information on corrections.

WWVB second pulses given by reduction of the amplitude of the carrier. Coded announcement of the date and time and of the correction to obtain UT1. No CCIR code.

WWVH pulses of 6 cycles of 1200Hz modulation. 59th and 29th second pulse omitted. Hour is identified by 0.8s long 1500Hz tone. Beginning of each minute identified by 0.8s long 1200Hz tone.

DUT1: CCIR code by double pulse. Additional information on UT1 corrections.

YVTO second pulses of 1kHz modulation with 0.1s duration. The minute is identified by a 800Hz tone of 0.5s duration. Between seconds 52 and 57 of each minute, voice announcement of hour, minute, and second.

ZUO pulses of 5 cycles of 1kHz modulation. Second 0 is prolonged.

DUT1: CCIR code by lengthening.

For VNG, WWV and WWVH, DUT1 is defined as UT1 - UTC. The sign of DUT1 is positive if the first emphasised marker of a group is seconds marker 1. The sign of DUT1 is negative if the first emphasised marker of a group is seconds marker 9. The magnitude of DUT1 is given by the number of consecutive emphasised seconds markers, each one representing 0.1 second.

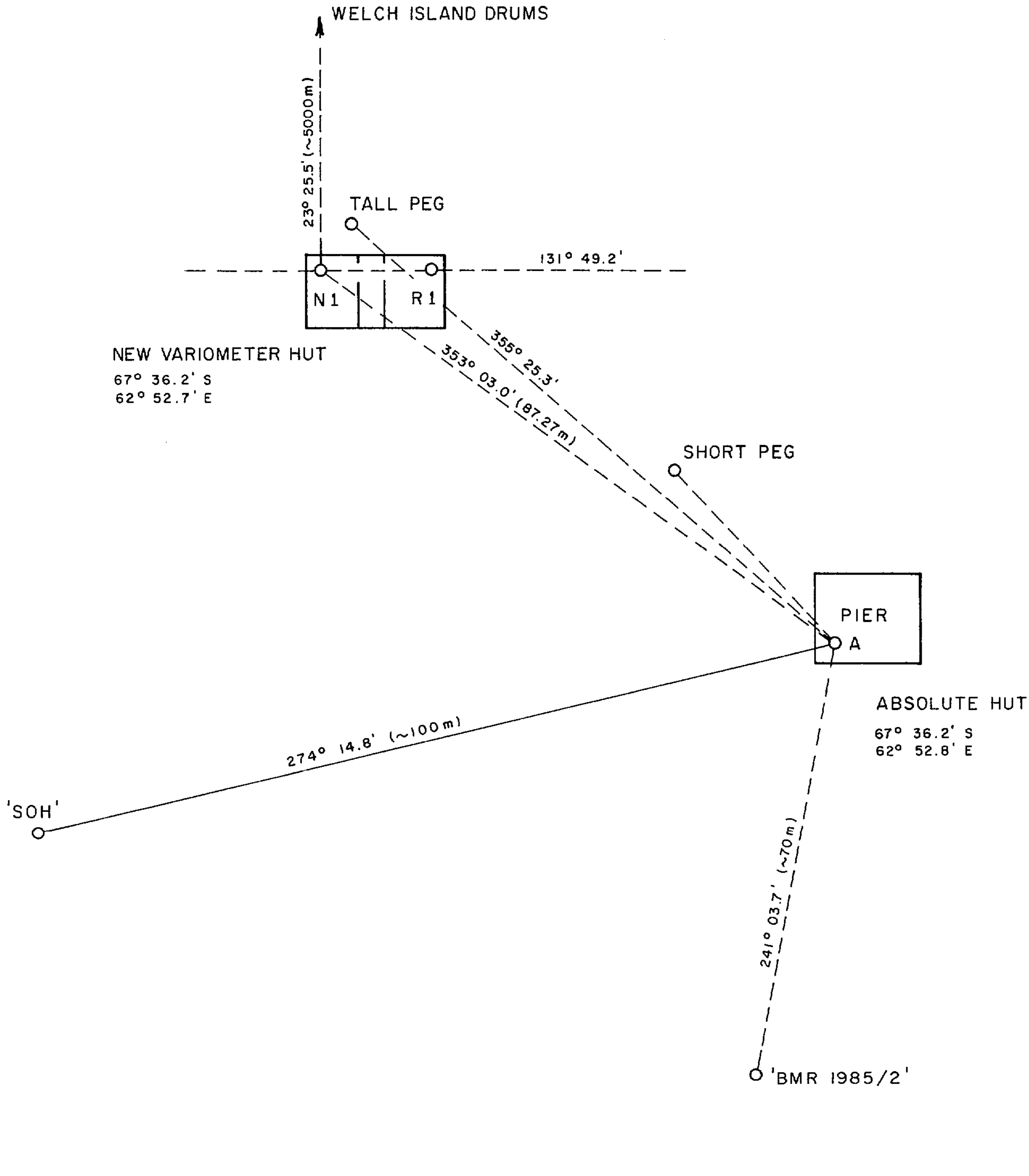

Fig. 1 Reference Marks and Azimuths

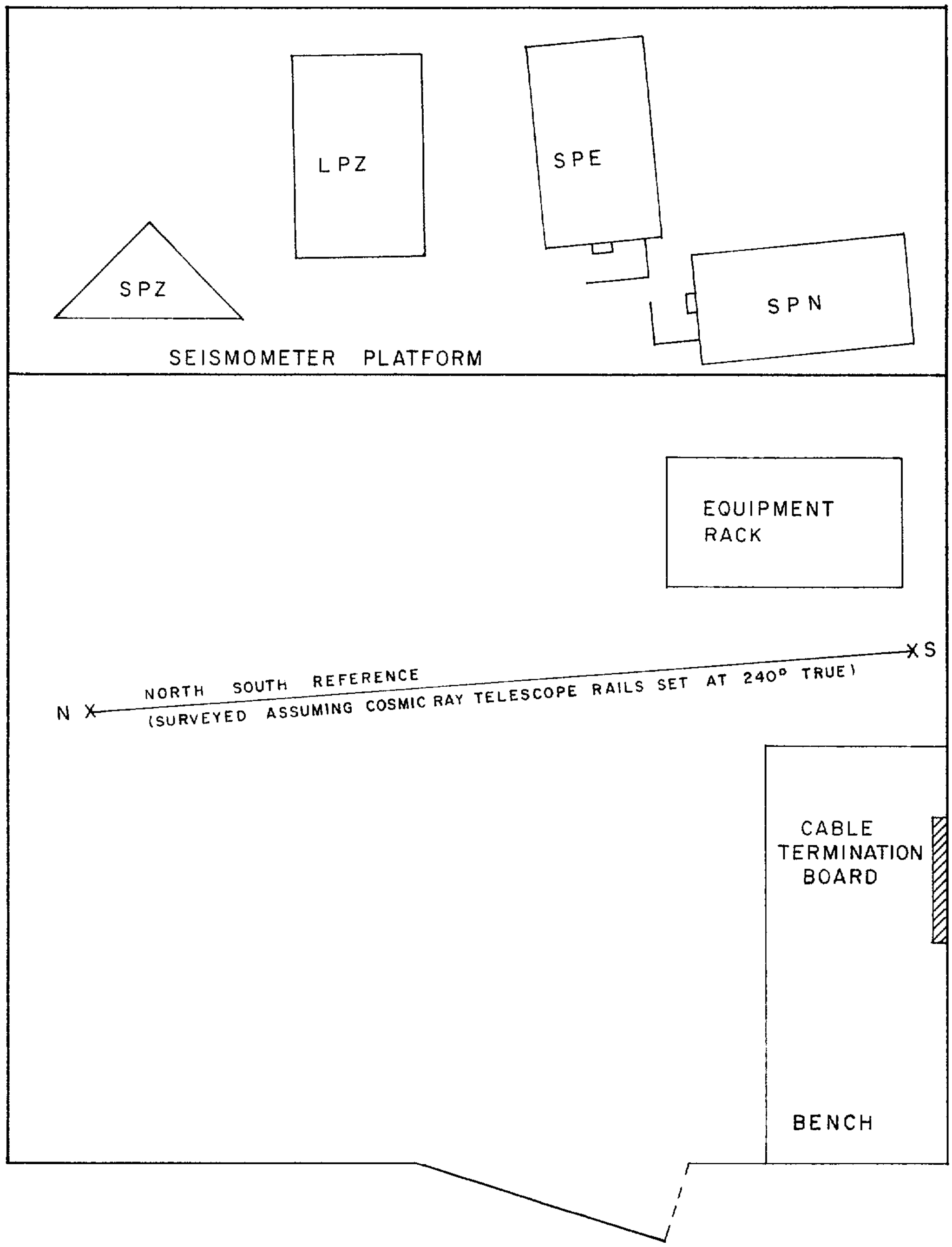

Fig. 2 Seismic Vault layout

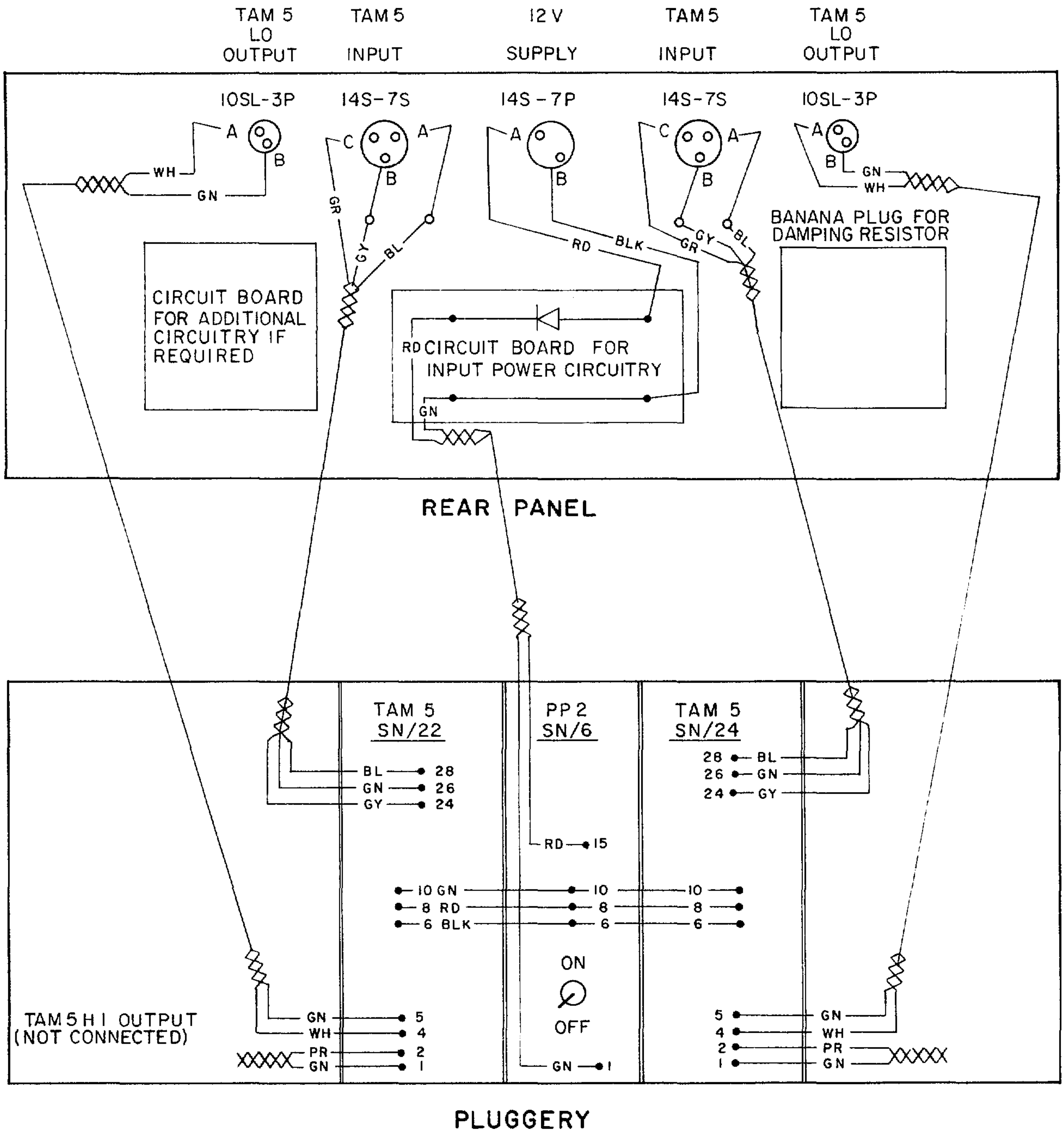

Fig. 3 SPH electronics rack wiring diagram

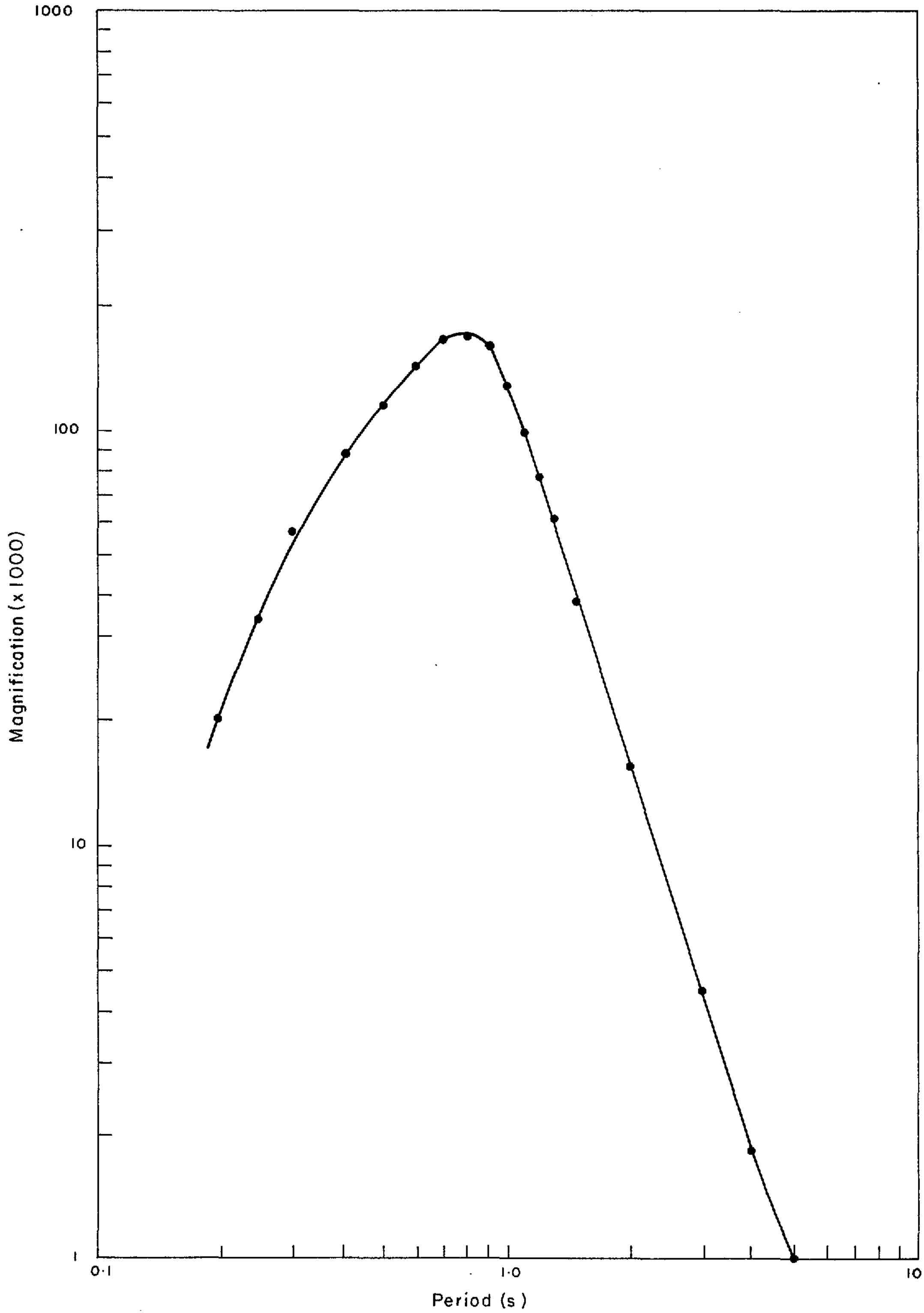

Fig.4 SPZ Calibration curve, October 1984

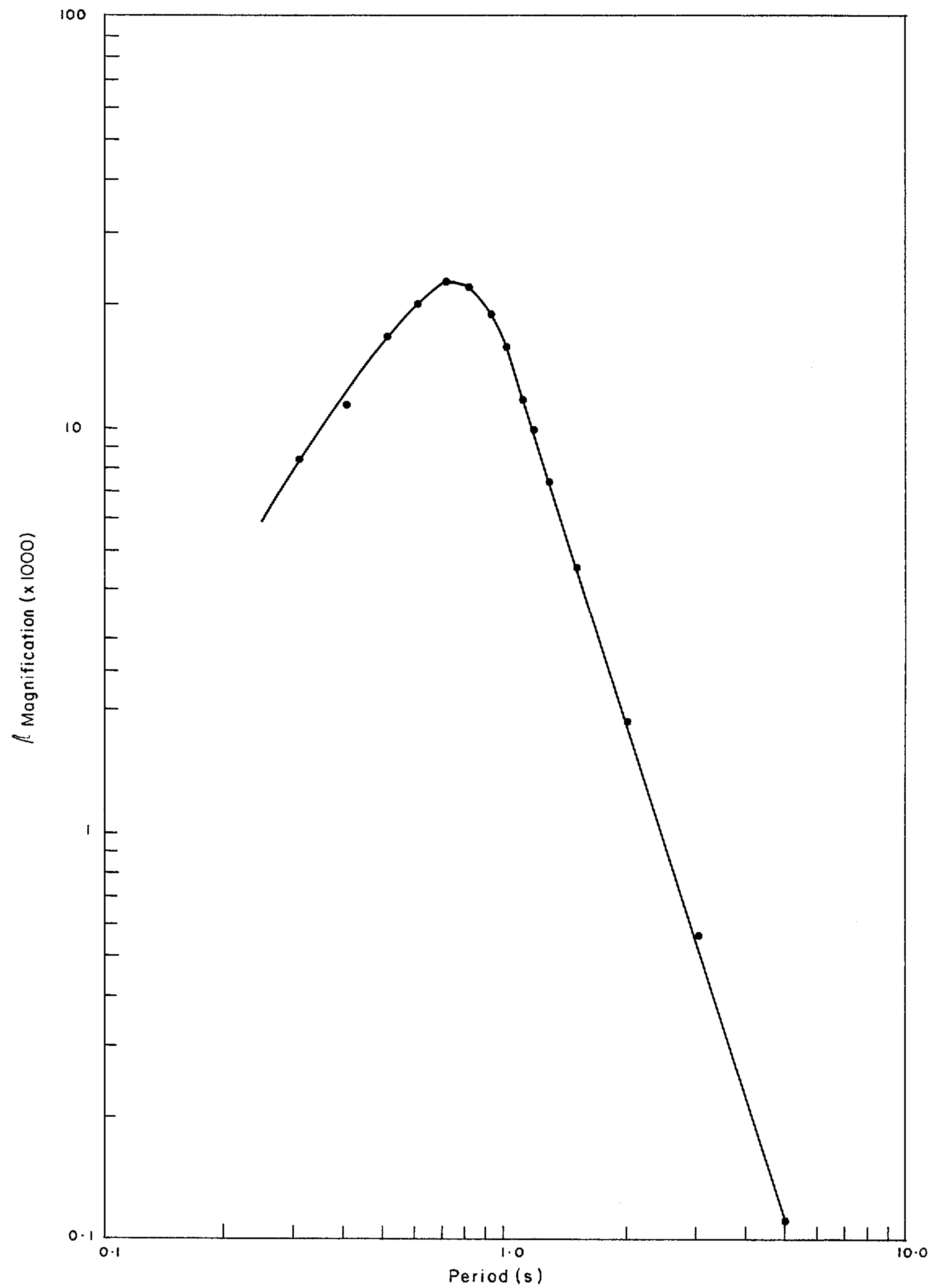

Fig.5 SPZ Calibration curve, January 1985

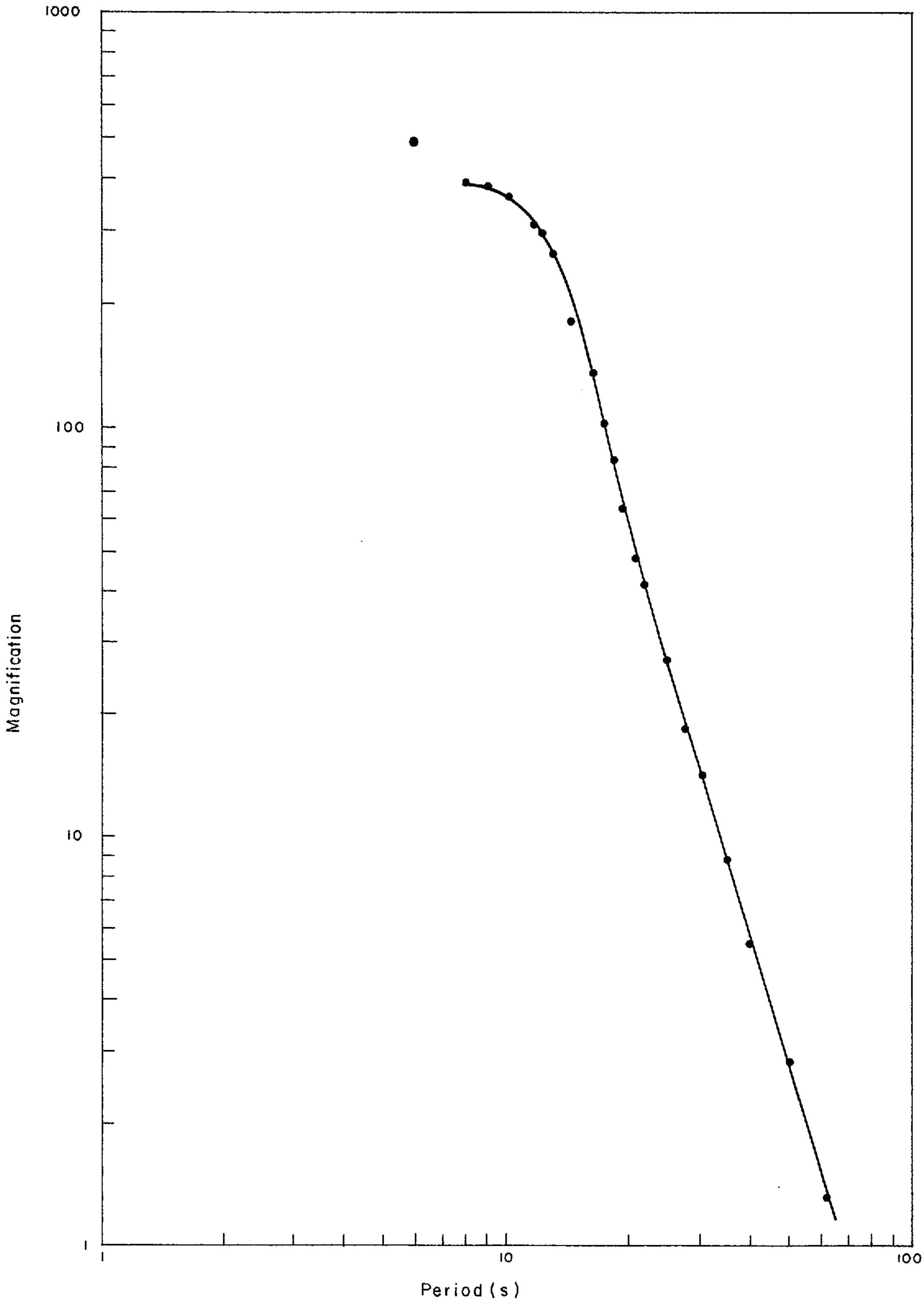

Fig.6 LPZ Calibration curve, January 1985

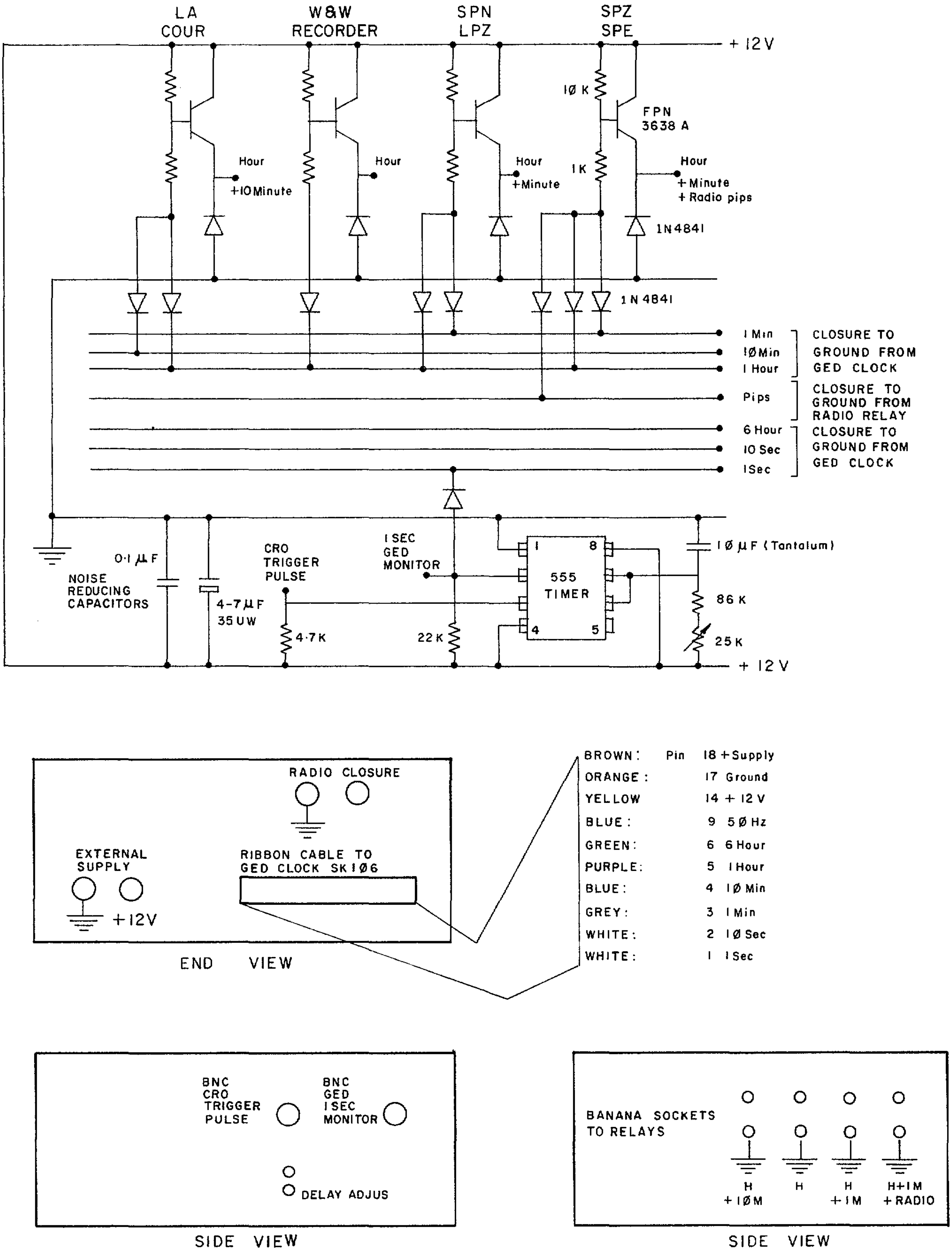

Fig. 7 Time-mark relay driver box circuit

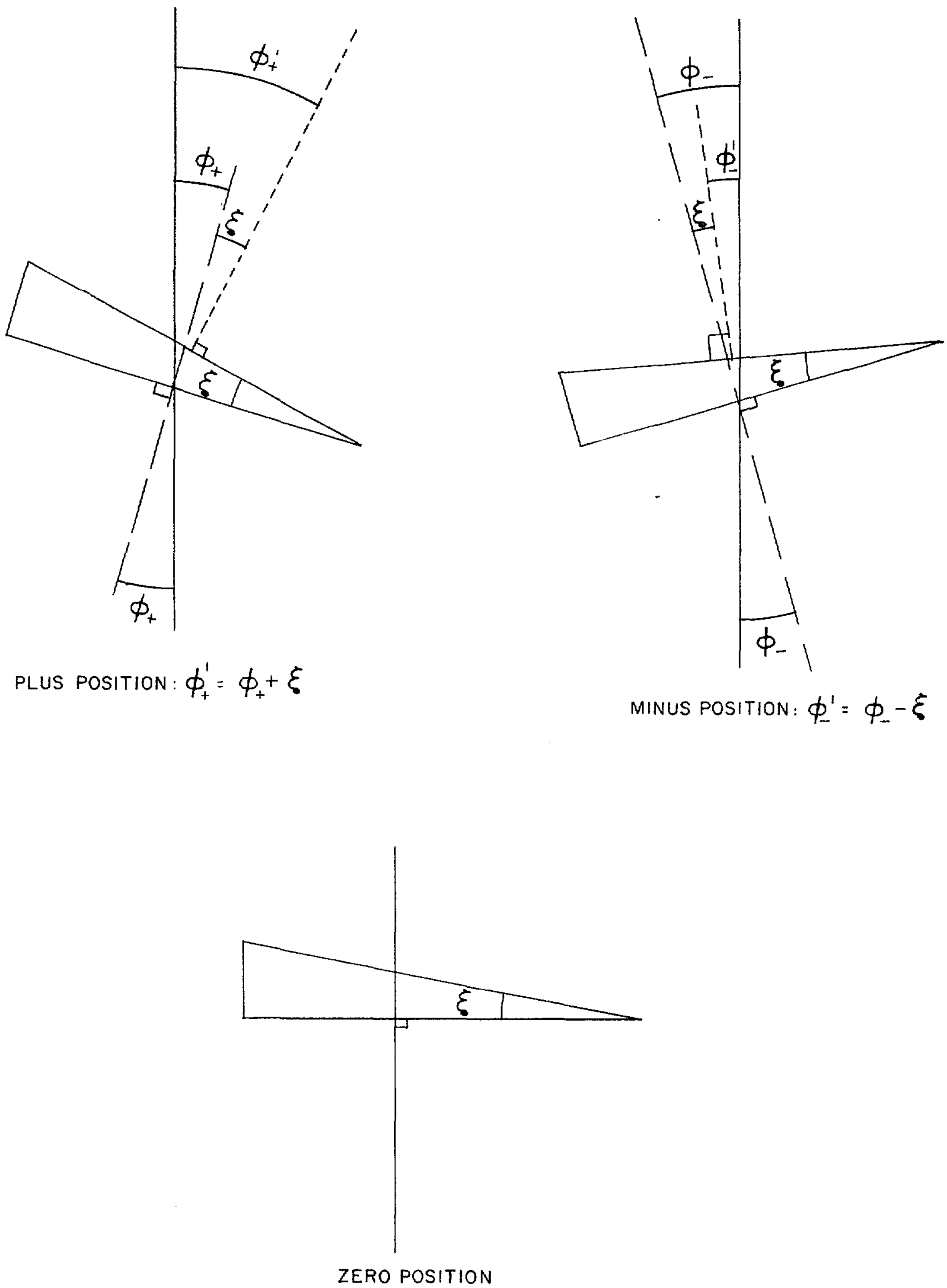

Fig. 8 QHM odd pi mode geometry

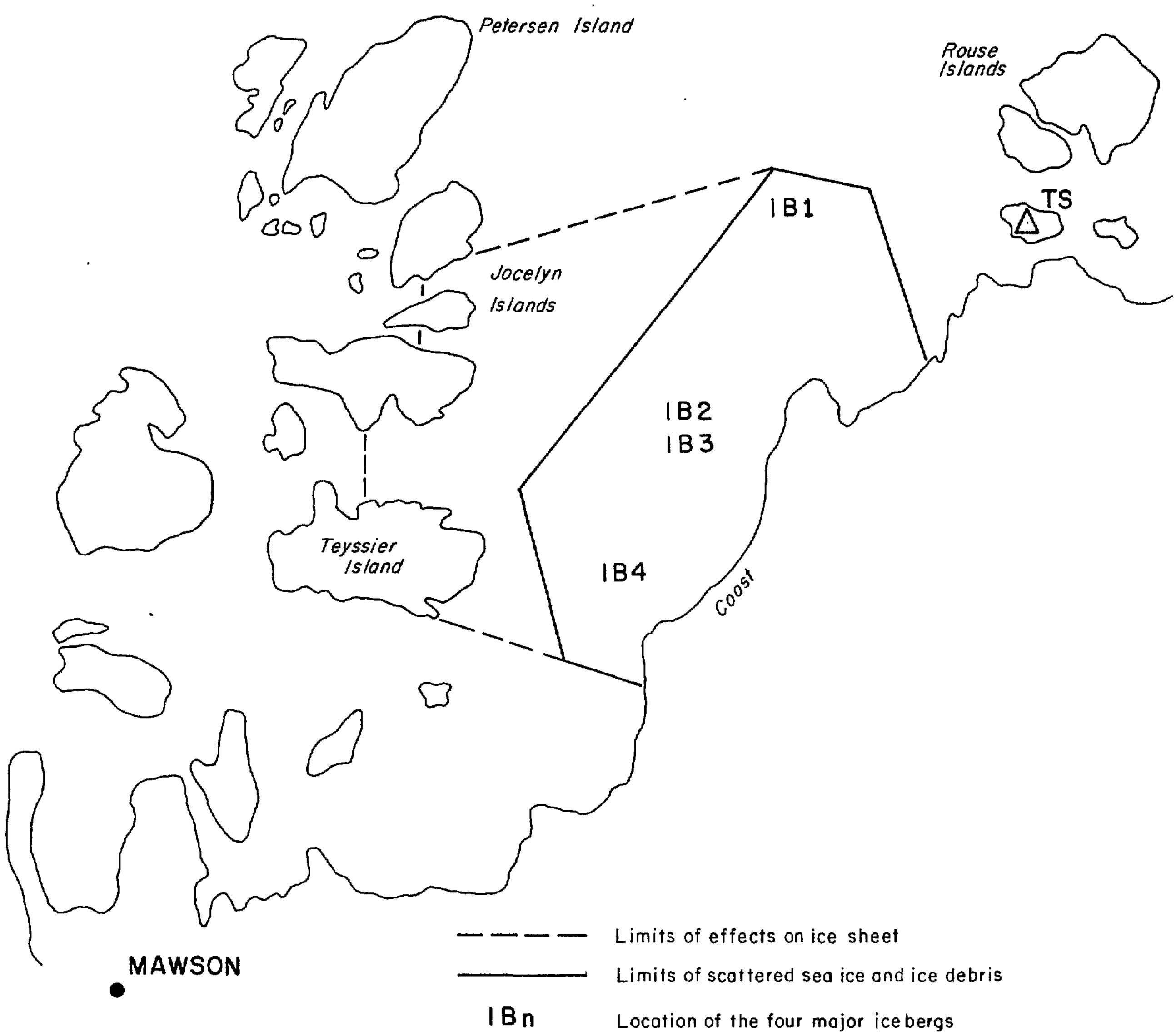

Fig. 9 East Bay icefall map

Fig. 10 East Bay icefall seismograph, 10 July 1984