DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD 1975/50

STEPHENS CREEK SEISMOGRAPH INSTALLATION

by

G.R. Small and L. Zeitlhofer

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SUMMARY

A short-period vertical-component seismograph was installed at Stephens Creek reservoir near Broken Hill, NSW, in March 1974; the siesmograph will supplement those in South Australia operated by the University of Adelaide, and those in Victoria operated by BMR.

The seismograph is of the visible recording type, with a 1-second seismometer and filter/amplifier designed to peak the response at about 0.6 s.

The station is operated jointly with the Broken Hill Water Board which attends to the seismograph; recordings are analysed by the Toolangi Geophysical Observatory Group, BMR.

1. INTRODUCTION

The Bureau of Mineral Resources' long-term program to improve the location of earthquakes in eastern Australia included the installation of seismographs near Broken Hill in 1973, and Armidale and Mount Isa in 1975.

The Broken Hill station was proposed to supplement the South Australian network operated by the University of Adelaide and the BMR's Victorian stations at Bellfield and Toolangi. The distribution of stations in Australia at 1 April 1974 is shown in Plate 1.

In March 1973 several sites were tested in the Broken Hill area by Messrs P.M. McGregor of BMR and K. Vost of the Physics Department of the University of NSW at Broken Hill. Subsequent attempts to obtain the preferred site (in an abandoned mine at the Pinnacles, southwest of Broken Hill) were unsuccessful. The site finally selected was at the Stephens Creek Reservoir of the Broken Hill Water Board (Plate 2). The Board offered a room in the pumping station building to house the recorder, and assistance in operating the station. This Record describes the installation and calibration of the station, which were carried out by the authors; Appendix 3 describes alterations made by Mr. E.P. Paull in December 1974. Basic information on the station is given in Table 1.

The opening of Broken Hill station was delayed until March 1974 because of late delivery of components.

The seismograms are analysed by staff of the BMR Toolangi Geophysical Observatory Group, who are also responsible for maintenance and repair of the equipment.

2. SEISMOMETER AND RECORDER SITES

The recording rack is housed in a room in the Pumping Station buildings and the seismometer and preamplifier are situated about 200 m SSW of the recording site. The positions of the buildings, seismometer, radio aerial and cable route are shown in Plate 3. The seismometer and recording sites are connected by a 6-core shielded cable buried in plastic conduit about 25 cm deep.

A 20 000 V power line to the pump motors passes under the recording room floor, but even at full load it has no effect on recordings. A nearby radio transmitter caused a single pulse of about 5 mm on the recording trace but did not otherwise affect recording. The room is partly below ground level so it stays at a fairly stable temperature throughout the day. As the 240-V mains power at the site has a frequency of 40 Hz, the 50-Hz equipment generates more heat than usual, so the rear door of the rack was left off to improve the ventilation.

The seismometer and preamplifier are buried in a galvanized rubbish bin which was cemented to solid rock foundations (Plate 4). A few days after the installation was completed the preamplifier ceased to operate because moisture entered it owing to high humidity in the bin (water was probably still coming out of the concrete). The fault was corrected by drying out the amplifier. Water entering the bin continued to be a problem and the vault and amplifier had to be dried out on several occasions. Moisture in the amplifier was the most likely cause of the change in gain of the system that was found at the visit in December 1974. A drain and vent were added to the bin at this visit (see Appendix 3).

3. EQUIPMENT

A block diagram of the system is shown in Plate 5. The system comprises:

(a) At the seismometer site:

(i) A Willmore Mk II seismometer with BMR calibration coil and magnet

(ii) TAM5 amplifier

(b) At the recording site:

(i) Power supply for the TAM5

(ii) Helicorder recorder RV301 and amplifier AR311

(iii) EMI clock and standby Mercer chronometer

(iv) DC Electronics inverter, Boss battery charger and batteries

(v) Labtronics radio

(vi) Power and timing monitor and distribution panel

(vii) Calibration current control (BMR type SSC) and 30-second timer.

The 50-Hz synchronous motors of the recorder would not operate from the 40-Hz mains power. Therefore the automatic changeover to mains in the event of inverted failure was disconnected by removing the mains supply cable between the Power Distribution panel and the Power and Timing Monitor panel. The radio receiver, battery charger, and EMI clock all operated satisfactorily from the mains.

4. SYSTEM TESTS

After several tests with various gain and filter combinations the final settings were decided and complete system tests were carried out. The TAM5 amplifier alternator was set at 84 dB and the filter switch set to 3 (0.01 Hz to 10 Hz); the AR311 amplifier attenuator was set at 12 dB.

Seismometer free period.

The strip chart recorder taken to measure the seismometer free period broke down, so the period was checked by timing the oscillations with a stop watch and checking them on the Helicorder records. The results gave a seismometer free period of 1.00 $\pm$ 0.01 s, and no adjustment to its period was required.

Seismometer damping

This was determined by using a portable cathode ray oscilloscope which measured the output from the seismometer before the signal was amplified. The value of the shunt damping resistor was determined experimentally by means of a decade resistance box in the seismometer-preamplifier circuit. The overshoot ratios were difficult to measure but with a 2800-ohm damping resistor the final damping ratio was about 14:1 (damping factor about 0.6 critical).

Calibrator constants

The parameters G and K were determined as described by McGregor and Zeitlhofer (in prep.). The weight-lift test was made by removing the calibrating coil and placing the weight on the indicator rod. At normal recording levels a weight of 25 mg would have to be used; however, this is not very practicable as the weight of the thread used to lift the weight would be significant. Instead a weight of 200 mg was used and the AR311 amplifier attenuator was turned down to 30 dB. The corresponding calibrator current for deflections of the same amplitude was 4mA. The results are shown in Table 2.

Frequency response

Relative frequency-response tests were recorded on the Helicorder. A check of the Waretek oscillator used showed that its frequency settings were in error, so the frequency values used in obtaining the response curve were scaled from the recordings.

The absolute magnification at 1Hz was measured by using the setting of 10 on the x0.1 range of the oscillator (Table 3).

The details of the frequency-response test are given in Table 4 and the system response curve is shown in Plate 6.

Recording level

The Helicorder amplifier was set at 12 dB and the daily calibration pulse of 0.25 mA gave a trace deflection of 20.9 mm.

Battery charge rates

The battery load for normal operation is 2.4 A; the nominal charging current is about 2.5 A.

If there is a mains failure the battery drain is 3.9 A and so with the 125 ampere-hour batteries the station can operate for up to 32 hours on the batteries alone.

5. OPERATIONS AND DATA PROCESSING

The maintenance of the Stephens Creek seismograph station and the processing of data from it are carried out by the Toolangi Geophysical Observatory Group, based in Melbourne. The daily routines are carried out by a member of the staff of the Broken Hill Water Board. The duties and responsibilities of the daily seismograph attendant are described in Appendices 1 and 2.

Preliminary data are telegraphed daily to the US Geological Survey and sent monthly to HQ Canberra for producing bulletins. Final data are prepared by the Toolangi Group and sent to HQ Canberra for despatching to the International Seismological Centre in Edinburgh.

6. MAINTENANCE

The following should be attended to on maintenance visits:

(a) Inspect seismometer; replace drying agent; check that mass is centred correctly. Clean out the seismometer pit if necessary.

(b) Replace the calibrator dry cells when due (about every 12 months).

(c) Record seismometer free period; reset if not in the range 0.98 to 1.02 s.

(d) Record 5-10 weight-lift tests and current pulses to redetermine G.

(e) Record a 1-Hz calibration test to compute magnification at 1 Hz. Full frequency-response tests should be made annually or when a change is suspected.

(f) Carry out the maintenance as described in the Helicorder and Amplifier handbooks.

(g) Check operation of standby power and timing systems by simulating a mains failure and a clock failure.

A Manual containing the manufacturer's handbooks and details of BMR-designed and built components has been prepared by L. Zeitlhofer, and is kept at the Recorder site.

There is no tool kit for the Willmore seismometer or mass for the weight-lift tests at the site.

7. ACKNOWLEDGEMENTS

The authors acknowledge the help given by the co-operating authorities; the Broken Hill Water Board through its secretary Mr P. Rout; and the University of New South Wales at Broken Hill through Mr K. Vost of the Physics Department.

Particular thanks go to Mr R. Knapp, the resident employee of the BHWB in charge of the Stephens Creek Reservoir, and to Mr F. Hooper, also resident at the site, and their staff.

Messrs Knapp and Hooper were trained as seismograph attendants.

8. REFERENCE

McGREGOR, P.M. & ZEITLHOFER, L., (in prep.) - Manton seismograph. Bur. Miner. Resour. Aust. Rec.

APPENDIX 1

STEPHENS CREEK SEISMOGRAPH STATION PROCEDURES

1. Introduction

Each chart accommodates about 25 hours of record at a chart rate of 60 mm/min. Therefore the chart needs to be changed daily at about the same time, plus or minus 30 minutes.

The nominal time of changing the chart may be chosen to suit yourself; at other stations the early morning is the most popular time because it leaves the rest of the day free.

The daily "routine" comprises:

(a) check clock correction and reset if necessary

(b) record calibration pulses

(c) record a chronometer time-mark

(d) change and mail chart

Details of the operation of the Helicorder recorder and amplifier and the Labtronics radio are given in the handbooks. The following is a summary of the steps involved in changing the chart and checking for satisfactory operation. Note that the heat-sensitive charts are also pressure sensitive so they should not be folded (except where necessary for mailing), creased, or scratched.

2. Daily routine

(a) Switch-on calibration unit and allow time for it to stabilize.

(b) Switch-on radio, and record clock correction on log sheet. Reset clock if correction more than 20 ms (If radio reception is poor do not try to reset)
Refer to notes on Labtronics radio-time check (Appendix 2.).

(c) Record a minute time-mark from the Mercer chronometer. Press the CHRON 1 MIN button in until the chronometer second hand has gone through 60 and a time mark is seen to record.

Record on log sheet the hour and minute reading of the Mercer.

(d) Record calibration pulse; hold in push button for 10 seconds

(e) <u>Change chart</u>

(i) Prepare a fresh chart by pencilling on one end the calendar DAY and DATE, Central Standard Time

(ii) Raise the stylus by means of the LIFT CONTROL

(iii) Stop the drum by pulling out the CARRIAGE RESET CONTROL

(iv) Release the previous chart by turning the PAPER RELEASE LEVERS anti clockwise, and remove the chart

(v) Enter in "End" position on log sheet the hour and minute (UT) of the last recorded time mark

(vi) Load the new chart (emulsion side out!) as detailed in the handbook sections 4.2.2. b-d (p.9); ensure that the chart is tight on the drum

(vii) Move the stylus to the start position by rotating the CARRIAGE RESET CONTROL anti clockwise; the start position is where the stylus is about 1 inch in from the left side of the chart

(viii) Set the drum in the correct start position by reference to the indicators on the right hand side of the drum. These give 1-minute intervals throughout the hour; the one nearest to the actual time should be set at the top

(ix) Commence recording by pushing in the CARRIAGE RESET CONTROL to the centre position

(f) Fill out a new log sheet and enter in the "Beginning" position the hour and minute (UT) of the first recorded time-mark.

(g) Record calibration pulse; hold in push button for 10 seconds, switch off unit

(h) Wind Mercer chronometer

(i) Mail chart, and log sheet daily to BMR Melbourne.

3. System check

When working correctly the chart should show

(a) Wavy lines of background noise not more than about 1 mm amplitude spaced uniformly 2.5 mm apart.

(b) Even intensity across the chart, strong enough to show the stylus trace during most earthquakes

(c) Time-marks every minute, progressing in line across the chart

(d) Adequate but not excessive stylus pressure; this can be judged where the stylus crosses the gap

4. System failures

If a breakdown occurs notify the BMR Melbourne office by phone (reverse charges) 6693037. If necessary switch recorder off and AR311 amplifier to   or OFF.

5. Supplies

Keep a check on your supply of recording paper, stamps, envelopes etc., and advise Melbourne (a note on the log sheet is OK) well before supplies are exhausted.

6. Battery check

Once a week check the charge of each cell of the batteries, using the hydrometer. Top-up the cells with distilled water if needed. If necessary change the battery charger current to keep the batteries fully charged.

The normal load is 2.4 A so a charger current of at least this is necessary to maintain the batteries in a fully charged condition.

APPENDIX 2

LABTRONICS RADIO - TIME CHECK

1. Switch on
2. Watch for consistent (within 2 or 3 ms) readouts of EMI correction
3. If reception is OK but correction readouts are not consistent it may be necessary to change the relay level control. To do this turn the control fully anticlockwise, then turn slowly clockwise until you can see the correction indicators triggering with consistent readouts.
4. If reception is OK but correction readouts are indicating + or - 99 release the error button (push in and let go). Unit will now register up to 990 ms correction. A zero for the units lights up when error button is released. Readouts now give correction to nearest 10 ms.
5. To reset correction, to 0 $\pm$ 5 ms switch EMI clock to CAL, push advance button if correction is +, and retard button if correction is - (correction will change 5 ms per second while advance/retard button is held in). When the correction is less than 100 ms push in error button to make display read 0-99. Record on log sheet the time the clock was reset.
6. Switch EMI clock back to CLOCK
7. Switch Radio OFF

NOTES

1. The clock is set on Universal Time (UT)
2. Normal settings for Labtronics radio are Selected Audio: 1000; Mode: AM; Out Level: full anticlockwise (not used); Channel: 2; Relay level: as above
3. When EMI SWITCH is in CLOCK position all push buttons except the error will not work.

APPENDIX 3.

ALTERATIONS MADE IN DECEMBER 1974

The station was visited during 10-13 December 1974 for the purpose of modifying the frequency response and investigating a drop in sensitivity. Ten centimetres of water was found in the bottom of the seismometer vaultlet and it is likely that moisture affected the TAM5 preamplifier, which is situated in the same enclosure.

The following adjustments or modifications were made:

1. A drain and vent pipe were fitted to the seismometer vaultlet.
2. The helicorder pen was adjusted for uniform height across its travel.
3. The radio time-mark push-button switch was bridged so that radio time-marks record whenever the radio is on.
4. The 0-20 mA calibration current meter was replaced with a 0-1 mA meter. The calibration current is now 0.5 mA for a trace deflection of 35.5 mm.
5. A TAM5 preamplifier with a modified frequency response was installed and the syetem was recalibrated. The higher magnification at shorter periods gives improved detection of local and regional earthquakes.

The magnification at 1-second period was 40 000 before the change and 55 000 after it. The peak magnification changed from 54 000 at 0.6s to 220 000 at 0.2 s. The relative magnification curves are shown in Plate 6.

TABLE 1

STEPHENS CREEK SEISMOGRAPH STATION

Name:	STEPHENS CREEK	Code:	STK
Latitude:	31°52.9'S	Longitude	141°35.5'E
Foundation:	Precambrian metamorphics	Elevation	213 m
Seismometer:	Free period: 1.0 s	Damping factor:	0.6

TABLE 2

DETERMINATION OF MOTOR CONSTANT (G)

Weight lift X_{1w} = 39.5 mm

Calibration pulse X_{1p} = 41.9 mA

$g = 9.8\ m/s^2$

W = 200 mg ip = 4 mA

$G = (X_{1p}/X_{1w}).\ (Wg/ip) = 0.46\ N/A$

TABLE 3

MAGNIFICATION AT 1.0 Hz

Seismometer mass M = 4.75 kg

$1/K = 4\pi^2 M/G = 407.6$

1.0 Hz sine wave, 0.325 volts, 1 K ohms line resistance; $is = 0.325.10^{-3}$ A

Trace amplitude A = 47.5 mm

Magnification $V = Af^2/K.is = 59600$

i.e. Nominal magnification at 1 Hz = 60 000

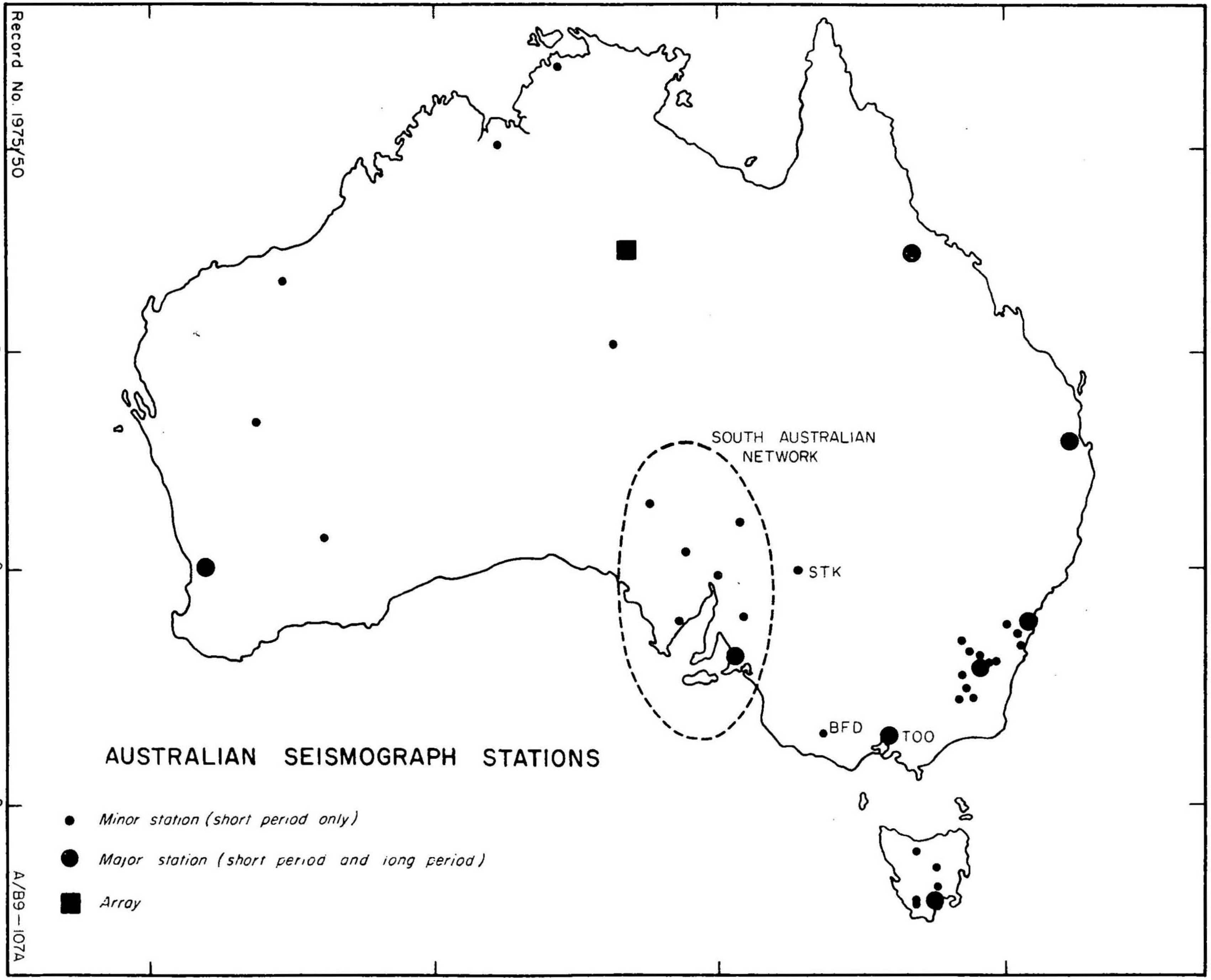
TABLE 4

FREQUENCY RESPONSE TESTS

April 1974

Osc. Range	Frequency (f) Hz Nominal	Actual	A mm	Af^2	t s	Magnification (x 1000)
X1.0	5.00	(4.50)	0.7	(14)	(0.22)	(18.5)
	3.33	2.89	3.8	32	0.35	42.4
	2.50	2.35	9.3	51	0.43	67.5
	2.00	1.88	17.4	62	0.53	82.1
	1.67	1.56	25.8	63	0.64	83.4
	1.25	1.16	40.0	54	0.86	71.5
	1.00	0.92	46.2	39	1.1	51.7
X0.1	1.00	1.00	44.9	45	1.0	59.6
	0.80	0.80	46.8	30	1.25	39.7
	0.67	0.68	43.8	20	1.5	26.5
	0.50	0.50	36.2	9	2.0	11.9
	0.40	0.40	29.7	5	2.5	6.6
	0.33	0.32	24.4	3	3.1	4.0
	0.30	0.29	21.8	2	3.4	2.6

A = trace amplitude for current of 0.32 mA; AR311 setting 12 dB.



Record No. 1975/50
16°
24°
32°
40°
114°
126°
138°
150°
SOUTH AUSTRALIAN
NETWORK
STK
BFD
TOO
AUSTRALIAN SEISMOGRAPH STATIONS
Minor station (short period only)
Major station (short period and long period)
Array
A/B9-107A

PLATE 1

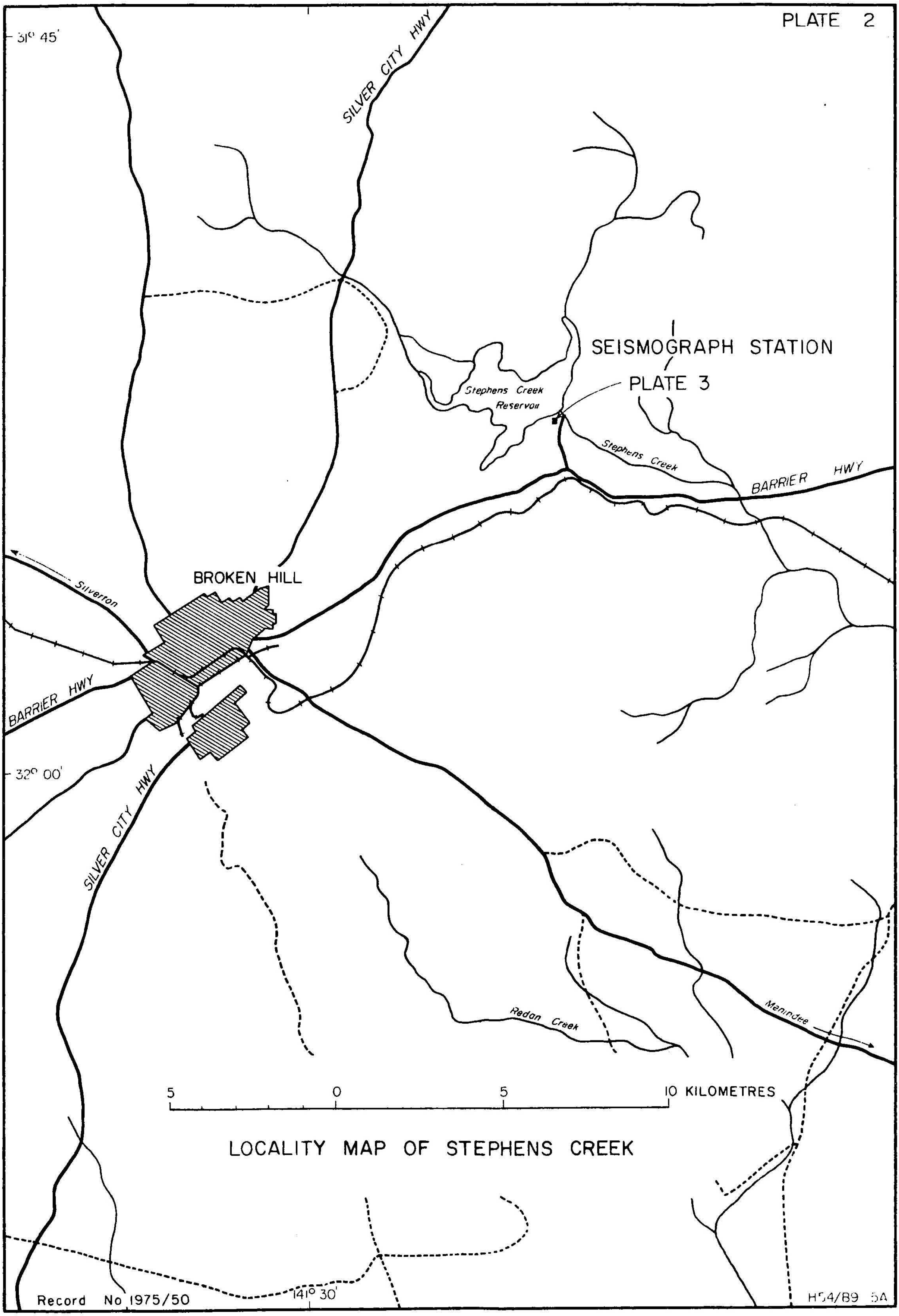
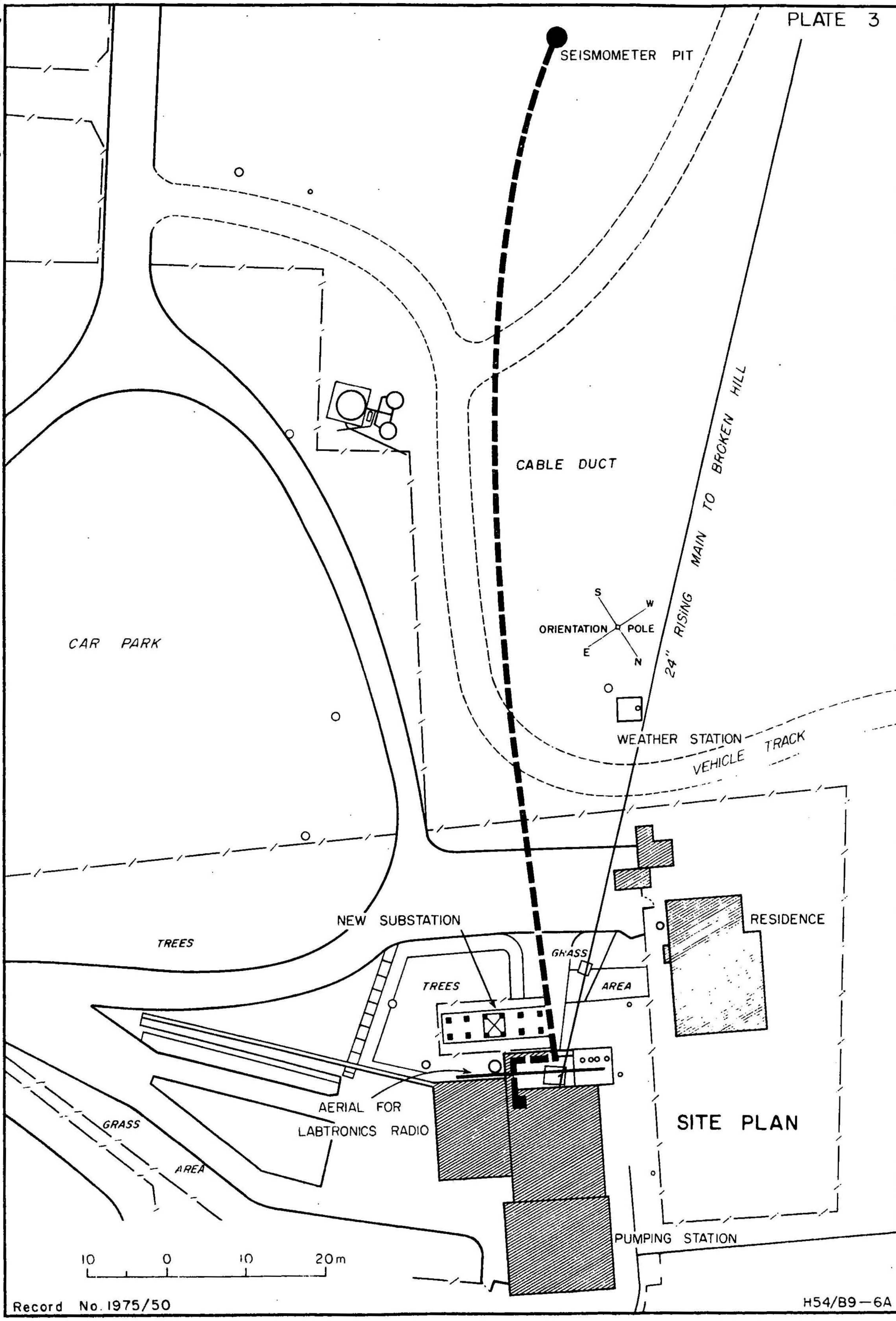
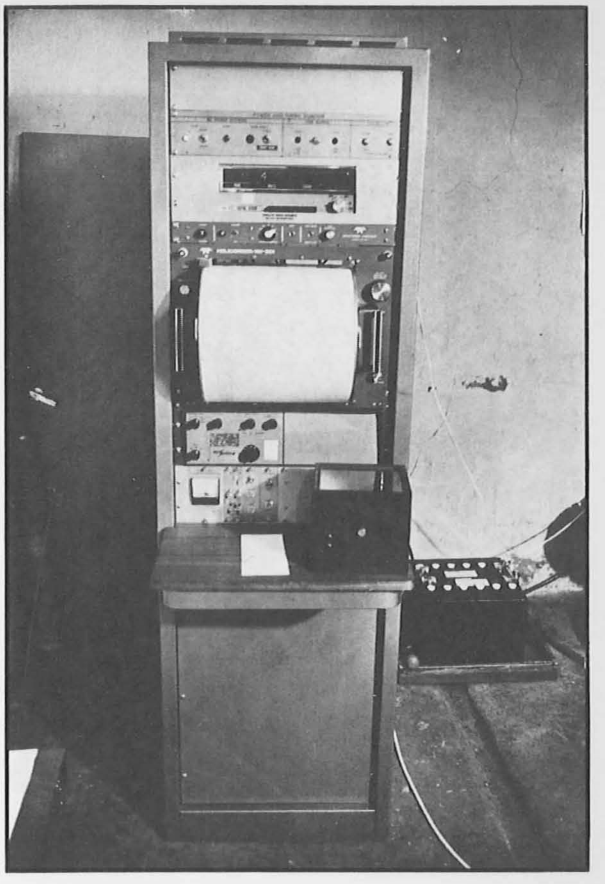


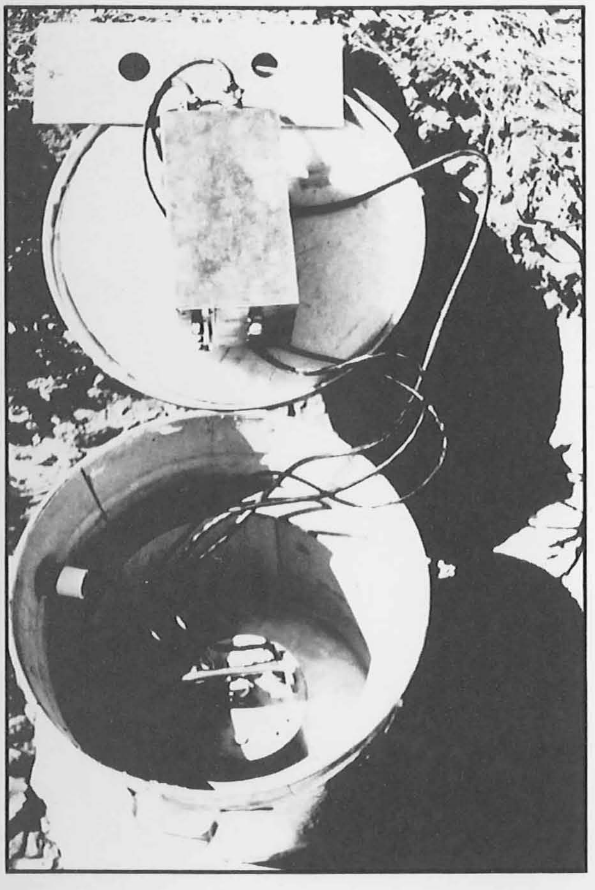
PLATE 2
31° 45'
SILVER CITY HWY
SEISMOGRAPH STATION
PLATE 3
Stephens Creek
Reservoir
Stephens Creek
BARRIER HWY
Silverton
BROKEN HILL
BARRIER HWY
32° 00'
SILVER CITY HWY
Redan Creek
Menindee
5
0
5
10 KILOMETRES
LOCALITY MAP OF STEPHENS CREEK
Record No 1975/50
141° 30'
H54/B9 5A


SEISMOMETER PIT
CABLE DUCT
24" RISING MAIN TO BROKEN HILL
S
W
ORIENTATION POLE
E
N
CAR PARK
WEATHER STATION
VEHICLE TRACK
NEW SUBSTATION
RESIDENCE
TREES
GRASS
AREA
TREES
AERIAL FOR
LABTRONICS RADIO
GRASS
AREA
PUMPING STATION
10 0 10 20m

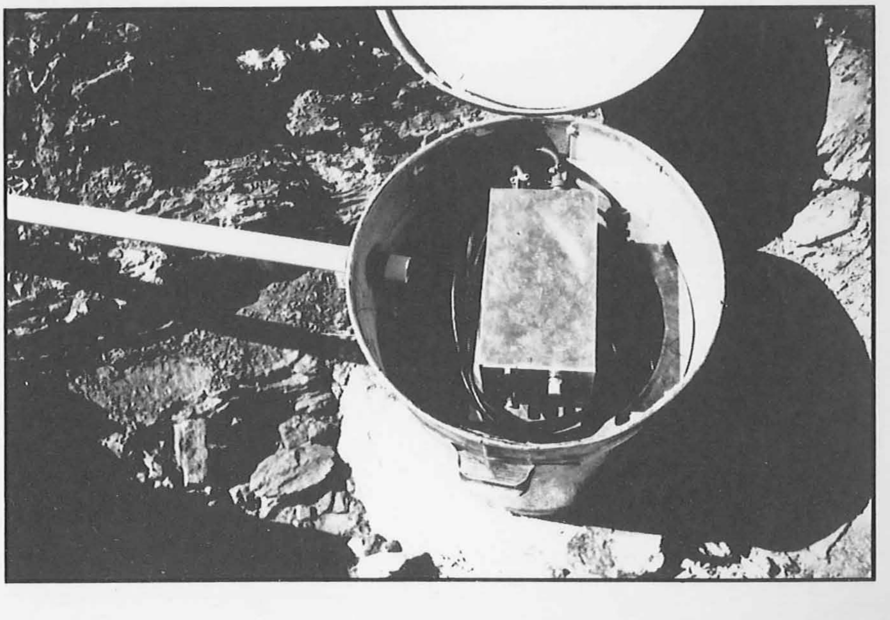
SITE PLAN

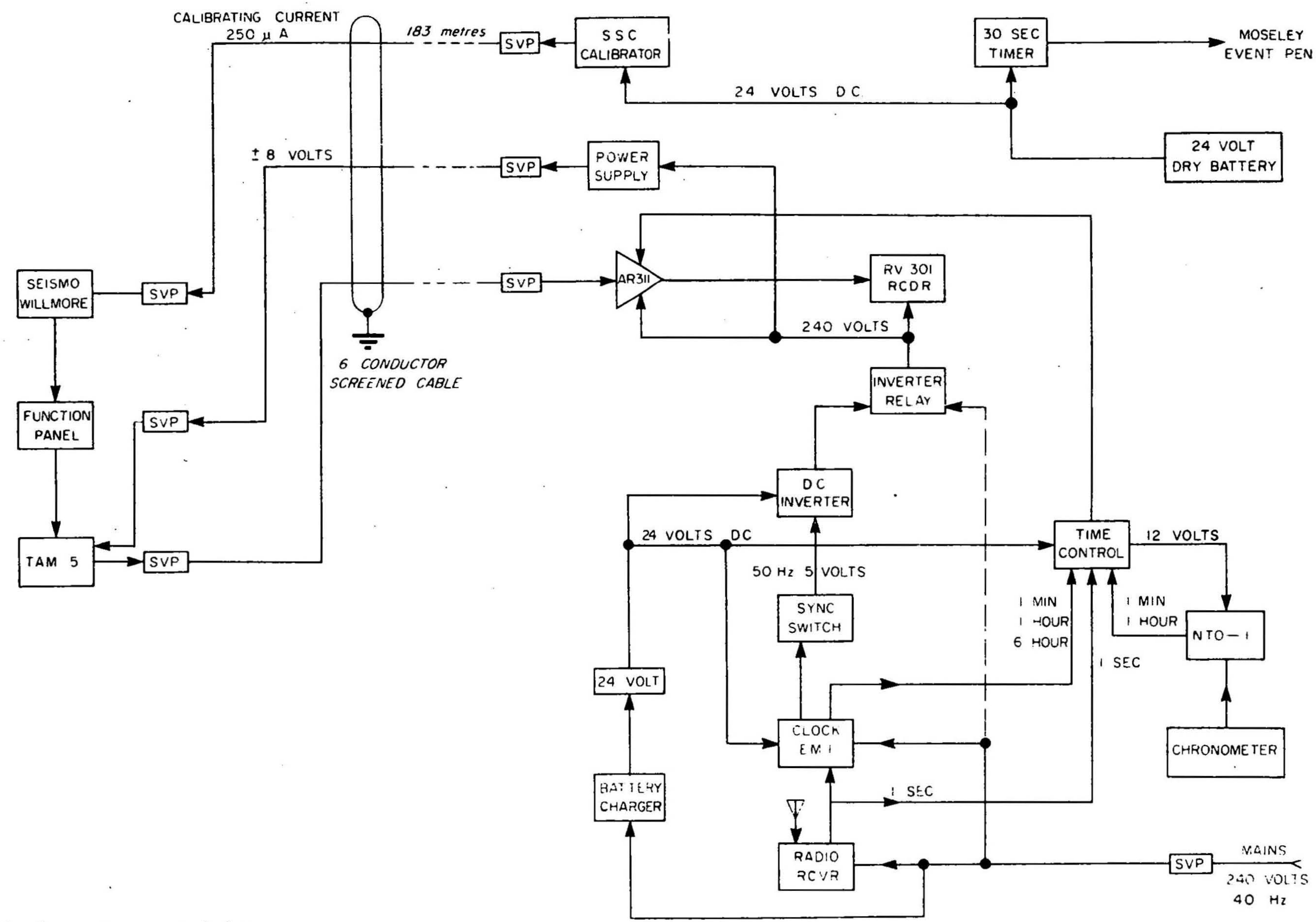


RECORDER



SEISMOMETER SITE

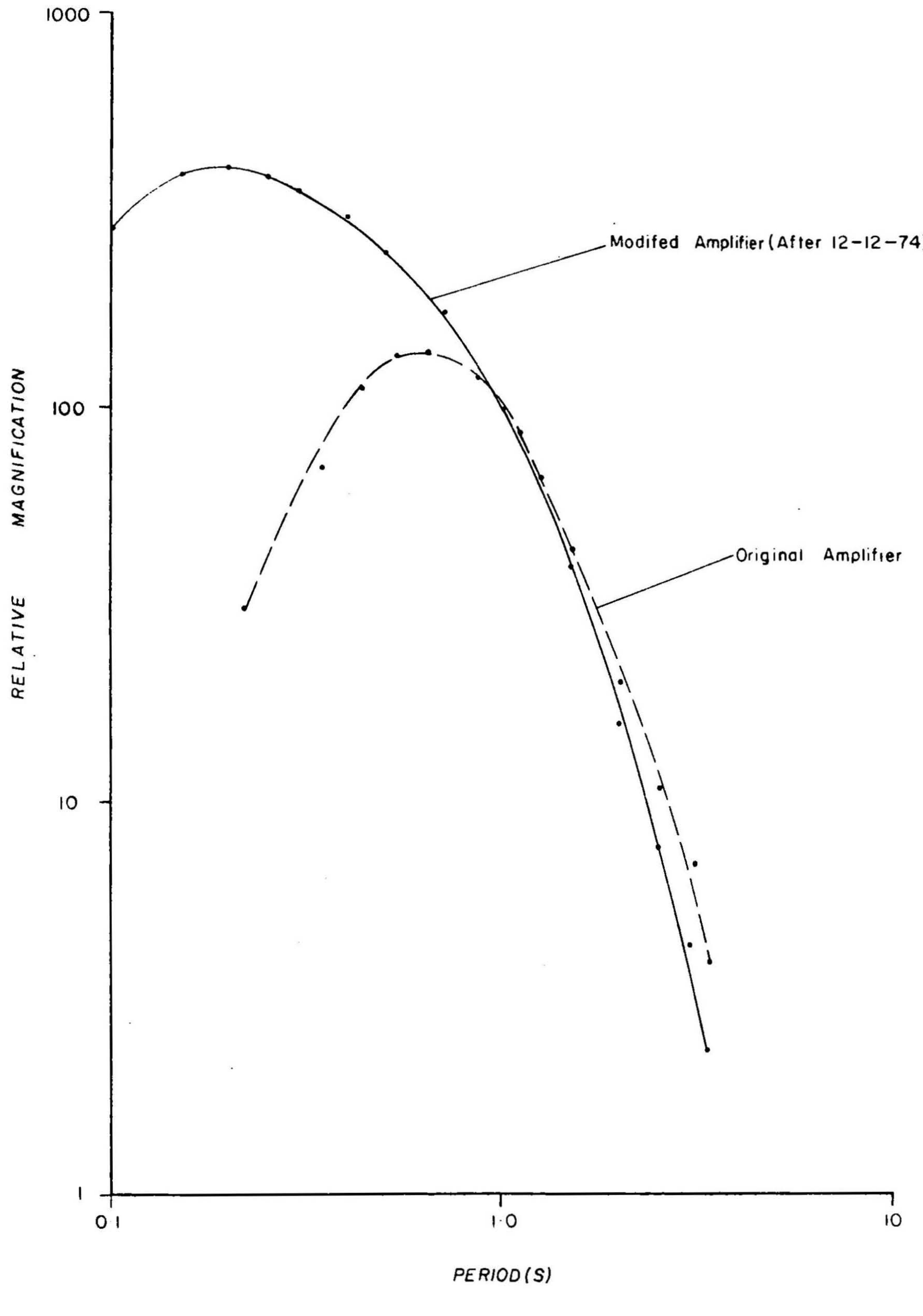




— — This line not connected for 40 Hz mains operation

H54/B9-8A

PLATE 5



STEPHENS CREEK SEISMOGRAPH

RELATIVE MAGNIFICATION