GS92/10

LOGISTICS REPORT

FOR AN

AIRBORNE MAGNETIC & RADIOMETRIC SURVEY

MILINGIMBI, N.T.

FOR

NT DEPARTMENT OF MINERALS AND ENERGY

GS92/10

JOB NO. 1-440

FEBRUARY 1993

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INTRODUCTION

From the 23rd July to 14th September 1992, Geoterrex Pty Ltd conducted an airborne magnetometer and spectrometer survey over the Milingimbi area (Figure 1) in the Northern Territory for NT Department of Minerals and Energy. This report summarises the logistics, survey parameters, calibration procedures and processing details of the survey.

The survey area lies on four 1:250,000 Map Sheets, namely Junction Bay (SC53-14), Milingimbi (SD53-2), Arnhem Bay (SD53-3), Mt Marumba (SD53-6), between 133°30'E,11°45'S and 135°30'E,13°30'S. A total of 55448 kilometres of airborne magnetic and 49031 kilometres of radiometric data was collected in 57 flights over the survey area. The difference in kilometres occurs as offshore kilometres were not included in the size of the spectrometer survey. A line spacing of 500 metres and flight line orientation of 90°/270° was used.

The base of operations was Jabiru, NT.

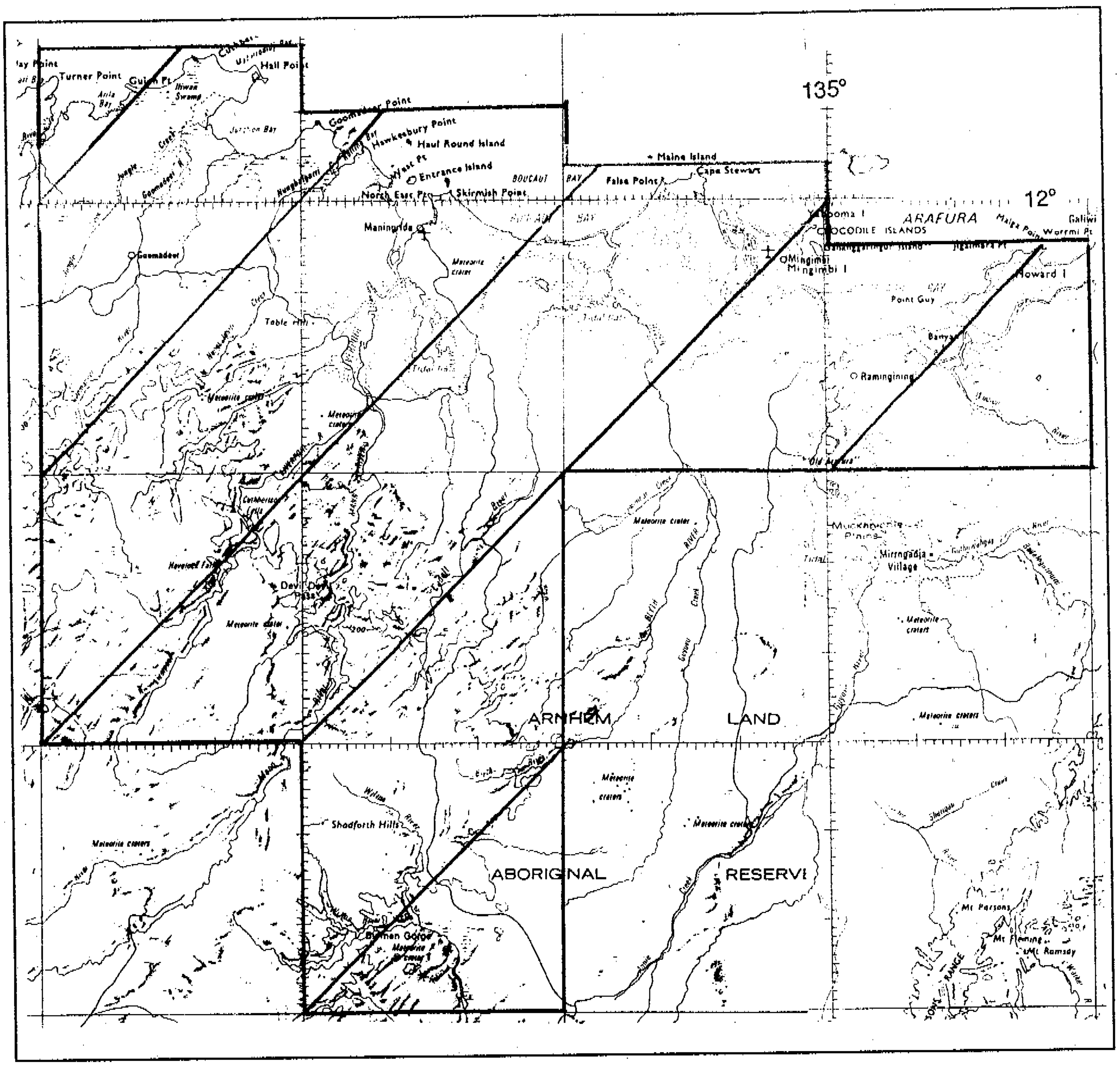
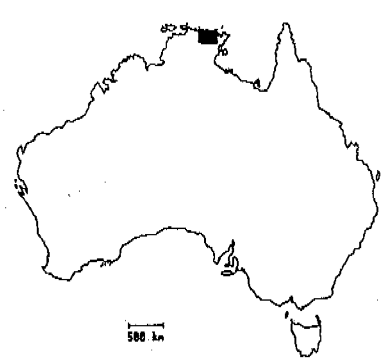


FIGURE 1. LOCATION MAP

SCALE: 1:1,500,000



1. SURVEY OPERATIONS SUMMARY

TABLE 1. SURVEY OPERATIONS SUMMARY

PARAMETER		SPECIFICATION
Type of survey		Magnetic and radiometric
Base of operations		Jabiru, NT
Aircraft		Rockwell Shrike Commander 500S. (VH-EXE).
Nominal aircraft terrain clearance		100 metres
Nominal aircraft speed		65 metres per second
Survey size		55,448 kilometres of magnetic data 49,031 kilometres of radiometric data
Traverse line direction		90°/270°
Traverse line spacing		500 metres
Tie line direction		Orthogonal to traverse lines
Tie line spacing		5 kilometres
Average line length		123 kilometres
Navigation		GPS/Doppler
Field Personnel	Pilot Electronics Technician Data Compiler Project Manager	J Floate, P Mosman, J Sparkman W Choate, D Lyus, P McGrath T Donnollan T Donnollan

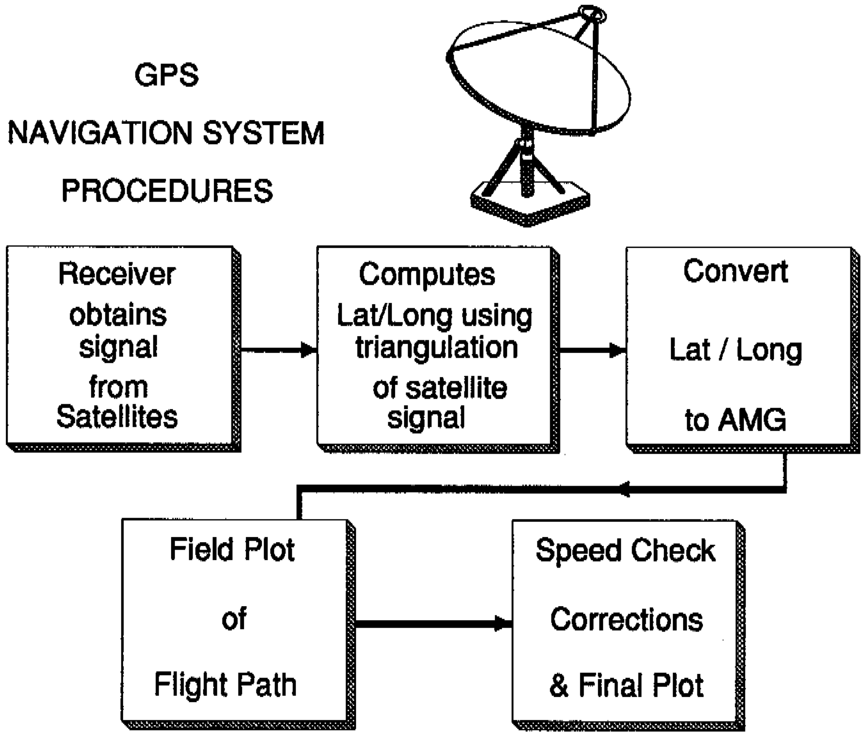
TABLE 2. SURVEY PROGRESS

Date	Flight	Progress	Tests/Calibrations	Weather
21/7		Mobilisation		
22/7	0	Calibrations	Cosmic Background, Altitude, Cloverleaf, FOM	Fine & Windy
23/7	1	Tie Lines & Traverse Lines		Fine & Windy
24/7	2	Tie Lines, Satellites inconsistent		Fine & Windy
25/7	3	Tie Lines & Traverse Lines		Fine
26/7	4	Tie Lines		Fine & Windy
28/7	5	Tie Lines		Fine & Windy
29/7	6	Tie Lines & Traverse Lines		Fine & Windy
30/7	7	Traverse Lines		Fine & Windy
31/7	8	Traverse Lines		Fine & Windy
1/8	9	Tie Lines		Fine & Windy
2/8	10	Traverse Lines		Fine & Windy
3/8	11	Traverse Lines		Fine
4/8	12	Traverse Lines		Fine
5/8	13	Traverse Lines		Fine
6/8	14	Traverse Lines		Fine
7/8	15	Traverse Lines		Fine
9/8	16	Traverse Lines		Fine
10/8	17	Traverse Lines		Fine
11/8	18 & 19	Traverse Lines		Fine
14/8	20	Traverse Lines		Fine & Windy
15/8	21	Traverse Lines		Fine
16/8	22	Traverse Lines		Fine & Windy
17/8	23	Traverse Lines		Fine & Windy
18/8	24	Traverse Lines		Fine & Windy
19/8	25	Traverse Lines		Fine & Windy
20/8	26	Traverse Lines		Fine & Windy
21/8	27	Traverse Lines		Fine & Windy
22/8	28	Traverse Lines		Fine & Windy

Date	Flight	Progress	Tests/Calibrations	Weather
23/8	29	Traverse Lines		Fine
24/8	30	Traverse Lines		Fine & Windy
25/8	31	Traverse Lines		Fine
26/8	32	Traverse Lines		Fine & Windy
27/8	33	Traverse Lines		Fine, Foggy in afternoon
28/8	34	Traverse Lines		Fine, Foggy in afternoon
29/8	35	Traverse Lines		Fine
30/8	36	Traverse Lines		Thick Smoke
31/8	37	Traverse Lines		Fine
2/9	38	Traverse Lines		Fine
3/9	39 & 40	Traverse Lines		Early Fog
4/9	41 & 42	Traverse Lines		Fine
5/9	43 & 44	Traverse Lines		Fine
6/9	45 & 46	Traverse Lines		Fine
7/9	47 & 48	Traverse Lines		Fine
8/9	49	Traverse Lines		Fine
9/9	50 & 51	Traverse Lines		Thick Smoke
10/9	52	Traverse Lines		Fine
11/9	53	Traverse Lines		Fine
12/9	54 & 55	Traverse Lines		Fine
13/9	56	Traverse Lines		Fine
14/9	57	Traverse Lines		Fine
	58	Calibrations	Cloverleaf & Compensation	Fine

2. FLIGHT PATH RECOVERY

FIGURE 2. FLIGHT PATH RECOVERY FLOW DIAGRAM



The GPS receiver mounted in the aircraft determined which satellites were in operation and used 3D triangulation of the satellite response to calculate its position in real time as well as providing the pilots with steering information. The GPS information was stored digitally as Latitudes and Longitudes (Lat / Longs) and later converted to Australian Map Grid (AMG) co-ordinates.

The GPS data is read into the field computer and plotted on a daily basis to ensure data quality control and to determine any necessary reflights.

The primary positioning data set used was the recorded GPS data which was updated during times of selective availability using base station data. Doppler data was used in-flight, updated to the GPS data.

The Doppler system is a radar velocity sensor that determines the three components of aircraft velocity from measurements of the Doppler frequency shift in radar energy transmitted toward, and received back from the ground. This velocity data considered with the heading data from the aircrafts compass was used to determine the aircraft position.

To maintain the necessary high level of accuracy, Doppler data was used in conjunction with GPS navigation and positioning. The Doppler data was corrected for drift by adjusting the Doppler flight path to intersect the recovered points from the GPS navigation system.

3. EQUIPMENT AND SPECIFICATIONS

3.1 AIRBORNE MAGNETOMETER

Model:	Scintrex cesium vapour optical absorption magnetometer
Mounting:	Tail stinger
Sample interval:	0.1 seconds
Sensitivity:	0.001 nT
Average Noise:	The average noise for the data is calculated from the fourth difference monitor using the equation: Fourth difference noise envelope/16 = Average Data Noise
Calibrations:	Test flights are conducted to determine effects of compensation, heading and system parallax. Descriptions and results of these calibrations can be found in Section 4 and Appendix A.

3.2 GAMMA RAY SPECTROMETER

Model:	Nuclear Data ADC/ND-560
Detectors:	8 Harshaw all viewing 4 pi NaI(Tl) crystals, totalling 33.5 litres. Crystals, photomultiplier tubes and preamplifiers are all mounted in temperature controlled, insulated compartments.
Sample interval:	1 second
Number of Channels:	256
Synchronisation:	The spectrometer sample is allocated to the time recorded at the end of the sample interval.

Window Definitions:	Total Count	-	Channel 68 to 255	
	Potassium	-	Channel 116 to 133	
	Uranium	-	Channel 141 to 158	
	Thorium	-	Channel 206 to 240	
	Cosmic	-	Channel 0	
Nominal Window MeV:	Total Count	-	0.4 to 3.0 MeV	
Ranges	Potassium	-	1.35 to 1.57 MeV	(K40, 1.46 MeV)
	Uranium	-	1.63 to 1.89 MeV	(Bi214, 176 MeV)
	Thorium	-	2.42 to 2.82 MeV	(Tl208, 2.615 MeV)
	Cosmic	-	above 3.0 MeV	

3.3 GROUND MAGNETOMETER BASE STATION

Sensor:	Caesium Vapour / Proton Precession
Magnetometer:	IFG / G856
Sample interval:	5 / 2 seconds
Sensitivity:	0.1 nT

The base station was used to monitor the diurnal field. The sensor was placed in a suitable position which minimises the effects of high magnetic gradients and man-made interference.

3.4 ALTIMETERS

Radar Altimeter

Model:	Sperry Stars AA200 radio altimeter system
Accuracy:	+/- 1.5% (+/- 1m at 60m)

Barometric Altimeter

Model:	Rosemount 8404 pressure altimeter
Sensitivity:	5 mv per foot
Sample interval:	1.0 second
Synchronisation:	The average of the output of the altimeter over each second is calculated and assigned to the time recorded at the end of each sample.

3.5 TRACKING CAMERA

Model:	Sony DXC101P Video Camera

The tracking camera is equipped with a 4mm wide-angle lens. The video tape is synchronised with the geophysical record by a digital fiducial display that increments every second. These fiducials are recorded on the video tape and displayed on the bottom left of the video screen. Times are recorded from the digital information provided by the MADACS system.

3.6 POSITIONING / NAVIGATION SYSTEMS

Doppler Model:	Singer Kearfott AN/ASN 128 mounted in aircraft and equipped with pilot steering indicators
Auxiliary Equipment	Sperry VG-14 Vertical Gyroscope Sperry C-12 Compass
GPS Equipment:	Sercel NR103 GPS receiver and antennae mounted in aircraft and equipped with pilot steering indicators
Base Station:	Sercel NR103 base station receiver with laptop data logger

3.7 DATA ACQUISITION SYSTEM

Model: Geoterrex Pty Ltd MADACS

The MADACS is a computer based software system that is used to control and command the operations of all the ancillary equipment. This includes the magnetometer, spectrometer, camera, altimeter, tape drive and analogue chart recorder. The system has the following features.

Communication system

The MADACS uses a lap top operating as a terminal for operator-system communication. Recorded spectrum are monitored via an oscilloscope trace during acquisition.

Software system

Program: AMS7

The key feature of this system is that all data collection, verification, buffering, and recording is software-controlled. Therefore, the acquisition system may be economically altered to fit almost any requirement. Critical parameters are automatically monitored during flight, with visual and aural alarms provided for the operator.

Survey parameters are displayed during flight in their correct physical units, simplifying operator analysis. The survey program operates on a request-response basis, with the system pre-empting the operator and rejecting all illegal responses.

Tape Drive

Model: Digi-Data 1639 magnetic tape drive

The tape drive has a feature which allows checking of the recording process as many times as the particular application permits.

Precision Clock

The system is controlled by a precision clock which allows data to be collected at any multiple of 0.1 seconds. Time is digitally recorded as a six-figure number called a "fiducial". A fiducial number equals the real time in tenths of seconds after midnight, for example, 000000 corresponds to midnight and 360000 corresponds to 10.00am. Fiducials are generated on digital tape, video or film and analogue charts at ten second intervals. The fiducial numbers are calculated from the clock time by the computer.

Computer

Model: Interdata 6/16 mini-computer.

Multiple buffers permit recording, processing and acquisition of data to be carried out simultaneously with no dead time. The computer has the following interfaces:

- **Digital Input/Output Bus** This bus is capable of recording from, writing to, testing and controlling 16 external digital devices.
- **ADC / DAC.** This interface is a caesium analogue to digital converter and a digital to analogue converter.
- **Magnetic Tape Controller** This interface/controller is capable of handling four 9-track NR21 tape transports. Tapes are written in an IBM compatible binary format with full parity, cyclic redundancy and longitudinal check characteristics.
- **Magnetometer Interface** This interface converts the signal from the high sensitivity caesium vapour magnetometer into a format acceptable to the MADACS.
- **Camera Controller** The interface allows the MADACS to control and monitor all aspects of the tracking camera's operation and can synchronise timing and navigation data to the video tape.
- **Operator's Console** This interface provides communication between the operator and the system. While on line during survey, all parameters are continuously displayed on the monitor unless the system senses an abnormal condition in which case a diagnostic message and the time sensed are displayed. The message remains until acknowledged by the operator.

Recorded Digital Data

Each second:
Flight number
Time
Radar Altitude
Barometric Altitude
Positioning data
Spectrometer windows
256 channels of radiometric data
Live time

Each 0.1 seconds: Total magnetic field

Tape formats are documented in Appendix C.

3.8 ANALOGUE CHART RECORDER

Model: RMS GR33 Thermal Dot Matrix Printer
Chart speed: 10 cm/minute; time increases from left to right
Chart width: 30 cm
Event marks: 10 second marks are recorded on both sides of the chart with the associated fiducial numbers being printed at the base of the chart.

TABLE 3. ANALOGUE CHART SCALES

Channels Recorded		Full Scale Values
Total Magnetic Field	Fine Scale	100 nt
	Coarse Scale	1000 nT
Magnetic Field 4th Difference		+/-20 nT
Terrain Clearance		200 metres
Total Count		4000 counts/sec
Potassium Count		500 counts/sec
Uranium Count		200 counts/sec
Thorium Count		200 counts/sec
Cosmic Count		500 counts/sec

All fields increase in value towards the top of the chart.

Zero Positions: These zero positions are annotated on the analogue sample. The zero position of each radiometric channel is calibrated automatically at the start of each line. Between lines each trace resides in its mid-range position.

Synchronisation: The only lag between traces is that between the magnetic field and its fourth difference.

Compton Effect: Corrections
The analogue radiometric channels have been Compton corrected using
Alpha (Thorium into Uranium) - 0.480
Beta (Thorium into Potassium) - 0.375
Gamma (Uranium into Potassium) - 0.700
The radiometric data recorded on the field tapes has not been corrected.

Cosmic Background correction: The analogue radiometric channels have been corrected in real time, for aircraft and cosmic background using the equations set out in Section 4.

A sample analogue record is shown in Figure 3.

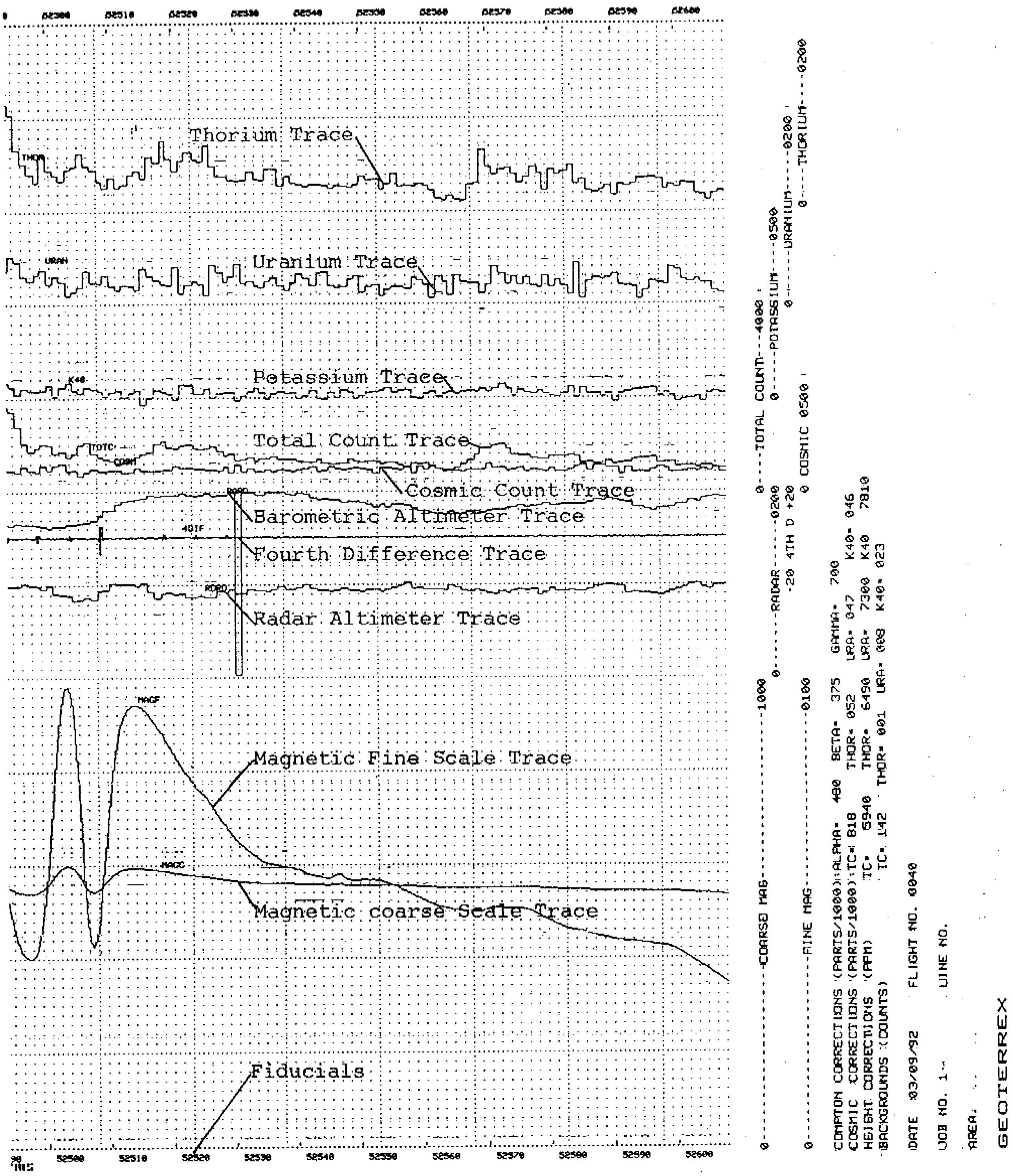


FIGURE 3. SAMPLE ANALOGUE RECORD

4. CALIBRATION PROCEDURES AND RESULTS

4.1 MAGNETOMETER

The following calibration tests were carried out on the magnetometer.

Manoeuvre test to determine Figure of Merit (FOM)

Figure Of Merit = sum of noise envelopes produced by ten degree roll, pitch and yaw manoeuvres heading N, S, E and W.

This test was carried out on 22 July 1992 and 14 September and is considered the most important of the magnetometer tests. The settings of the compensation coils determined from this test remain fixed during the heading effect test and during the survey. The Figure of Merit for this test was 1.6 nT and 2.95nT respectively. Copies of the Figure of Merit test analogues (Figure A1) and a Table of Results (Table A1) can be found in Appendix A.

Heading Effect Test

This test was conducted on 22 July and 14th September 1992. Test lines with bearings of 000, 090, 180 and 270 degrees were flown over a common point. These lines were flown, in a low gradient area, while the ground station was running and synchronised. It is necessary to use a low gradient area so that slight deviations in the test line navigation do not significantly affect the results of this test. The results of the heading tests can be found in Appendix A (Table A2 and Figure A3).

4.2 SPECTROMETER

The following checks and determinations were carried out for the radiometric data.

Pre and Post-flight Source Check Procedures

- Pre and post-flight U and Th source checks with samples in a standard position relative to the crystals and the aircraft in a standard parking position - recorded for 100 seconds.

- Pre and post-flight test line recorded at survey altitude.

The results of the pre and post-flight uranium and thorium source checks can be found in Appendix B, Table B1. A sample of the spectra plotted with each uranium and thorium source check is presented in Appendix B, Figure B1.

Compton Stripping Coefficients

These coefficients have been determined from source checks.They are:

Alpha	-	0.4585 +/- 0.015
Beta	-	0.4049 +/- 0.024
Gamma	-	0.7028 +/- 0.038
Delta	-	0.0446 +/- 0.017

Background Determination

This test was carried out in September 1991 to determine the relationship between cosmic events (energies greater than 3.0 MeV) and counts recorded in other channels. The test was flown overland with the spectrometer system correctly calibrated as for survey work. Data was recorded at 1000 foot intervals from 2000 feet to 12000 feet ASL.

The best fit linear equations for these tests are:-

Th	background	=	0.052 x Cosmic + 1.44
U	background	=	0.047 x Cosmic + 7.71
K	background	=	0.046 x Cosmic + 23.27
TC	background	=	0.818 x Cosmic + 142.12

where

cosmic = counts of energies greater than 3.0 MeV stored in channel 0.
# background = counts to be subtracted from window #.

Graphs of these equations are presented in Appendix B (Figure B2).

Height Attenuation Coefficients

Height attenuation coefficients were determined using the procedure outlined below:

a) An area with "homogeneous" radioactivity, high count rates and relatively flat terrain was selected.

b) An easily repeatable line was flown over this area at eight different altitudes: 200 feet, 250 feet, 300 feet, 400 feet, 500 feet, 600 feet, 700 feet and 800 feet. The spectrometer was correctly calibrated for this test flight.

c) Sections of each line sharing the most constant terrain clearance and count rate were selected for data processing.

d) The altitude data for each line section was corrected using the altitude calibrations recorded on the same flight, and averaged.

e) The radiometric data for each line section was background corrected using a height correction for alpha. The resultant data was averaged.

f) The resulting count rates in each channel were plotted and attenuation coefficients suitable for an air temperature of 18°C were determined.

Graphs of the results can be found in Appendix B (Figures B3).

The coefficients are:	Total count	0.00574 per metre
	Potassium count	0.00713 per metre
	Uranium count	0.00730 per metre
	Thorium count	0.00581 per metre

During all spectrometer tests the data used is the window data recorded on field tapes. The widths of these windows are specified in Section 3.

Resolution

The resolution of the spectrometer is defined as the full width of the Thorium peak at its half peak height position, expressed as a percentage of the peak MeV value. The spectrometer resolution was checked weekly during the survey. The results are presented in Table 4. Appendix B (Figure B4) is a copy of a sample source check.

TABLE 4. RESOLUTION CHECKS

Date of Test	Result (%)
22/7	6.1
31/7	6.1
7/8	6.1
14/8	6.1
21/8	6.2
22/8	6.1
5/9	6.0
12/9	6.2

4.3 ALTIMETER

The Sperry radio altimeter is a high quality instrument whose output is factory calibrated. It is fitted with a test function which checks the calibration of a terrain clearance of 100 feet and altitudes which are multiples of 100 feet. Calibration of the recorded terrain clearance, both analogue and digital, with respect to the altimeter reading is carried out using a potentiometer to vary the reading while recording the altimeter's output. The results of a recent altimeter calibration carried out in July 1992 are presented in Table 5.

TABLE 5. ALTIMETER CALIBRATION RESULTS

Indicated Alt (ft)	Recorded Alt (ft)
100	77
200	193
300	283
400	403
500	473
600	666
700	723
800	816
900	950
1000	1036

5. DATA PROCESSING

On receipt of all the data in Sydney, path recovery, analogue records and flight logs were checked for consistency of line numbering.

5.1 FIELD TAPES

These are recorded in binary format (see Appendix C for detailed description) Data recovered on the field tapes was verified each evening in the field and copied to the located data tape to ensure data security.

The 256 channels of radiometric data are not selected from the field tape unless there is some indication in the thorium and caesium peak positions that the radiometric channels have drifted away from the normal window settings. If it is necessary to re-construct radiometric data due to channel drift, summed spectral plots are produced for each survey line. These are examined to determine at what stage the drift began and which new channel positions define the principal radiometric windows.

Due to the difference in the sample interval between the magnetic and the radiometric data, the radiometric values are repeated for each magnetic sample interval between 1 second radiometric readings. All channels are checked and edited for single reading spikes and recording gaps, any single reading spikes are removed manually.

5.2 FLIGHT PATH PROCESSING

Processing of the flight path consisted of generating a speed report of the GPS/Doppler flight path that was checked for erroneous points by comparing the average aircraft speed between adjacent fixes (being real time values in seconds) and the average speed for the entire line. Significant speed changes over short intervals were noted and the GPS/Doppler data was checked for errors and corrected where necessary. The final flight path maps were then plotted at a scale of 1:100,000

5.3 MAGNETICS

<u>Corrections</u>

Levelling

The base station data is edited and checked for level shifts prior to synchronised to the airborne data for subtraction.

The aeromagnetic data is corrected for parallax error and then tie line levelled. The tie lines are levelled to a common datum first and then the traverse lines are levelled to the tie line network. The method involves the fitting of polynomials to the observed flight line/tie line intersection errors along each traverse line in the survey. These intersection locations are adjusted to give minimum intersection errors. The aircraft heading effect is eliminated by the levelling process and therefore is not subtracted as a separate process before levelling. Fine corrections to the gridded data were applied using the microlevelling technique developed by Geoterrex.

International Geomagnetic Reference Field
The International Geomagnetic Reference Field known as IGRF (1990, updated for secular variation to August 1992) is subtracted from the data and a datum of 2000 nanoteslas is then added to ensure that there are no negative magnetic values before contouring.

Product Specifications

Gridding and Contouring

Grid mesh size:	100 x 100 metres
Contour interval:	* 5nT (major intervals: 50 & 500 nT; scale 1:100,000) for the Junction Bay, Goomadeer, Liverpool, Cadell and Wilton River sheets * 2.5nT (major intervals: 25 & 250 nT; scale 1:100,000) for the Howard, Stewart, Rolling Bay, Milingimbi and Tomkinson sheets
Horizontal scale:	1:100,000 and 1:250,000

Stacked Profiles

Horizontal scale:	1:100,000
Vertical scale:	100 nT/cm.
Base Level:	1800 nT (The base level is a straight line joining the ends of the flight path at its intersections with the sheet boundaries)

5.4 RADIOMETRICS

Corrections

The radiometric data was corrected for:

Spectrometer dead time
"Dead time" is the fraction of 1 second when the spectrometer is actually counting the energy levels and not registering the incoming counts. A typical "dead time" is 15 msecs in a 1 second sample period.

Cosmic effect and aircraft background
Through test flying outlined in Section 4, Geoterrex Pty Ltd has established the coefficients for the linear relationship between the incoming cosmic counts (energies greater than 3 MeV) and their contribution to the background in each window.

Changes in ambient air temperatures
The effects of changing air temperature are incorporated in the notion of a temperature corrected altitude that will be used in other calculations. The field operator records the outside temperature at regular intervals throughout each flight while at survey altitudes.

Compton scattering
These coefficients were determined from the calibration procedures outlined in Section 4. It should be noted that alpha coefficient is height dependent under the linear relation:

true alpha = ground + 0.02 + 0.00025 x height

Height attenuation
The survey data was exponentially height attenuated to a common datum of the nominal survey altitude, using the coefficients determined in Section 4.

Product Specifications

Gridding and Contouring

Channel:	Total Count
Grid mesh size:	100 x 100 metres
Contour interval	5
Horizontal scale	1:100,000 & 1:250,000

5.5 ALTITUDE

Stacked Altimeter Profiles

Horizontal scale:	1:100,000
Vertical scale:	50 m/cm.
Base Level:	100m (The base level is a straight line joining the ends of the flight path at its intersections with the sheet boundaries)

5.6 DATA TAPES

Located Data Tape

Levelled located data tapes, containing raw data for all traverse lines and tie lines, final data per 1:100,000 sheet and calibration and test line data, were recorded in ASEG-GDF format, ASCII code, at a density of 6250 bpi.

Gridded Data Tape

A gridded data tape containing the magnetic, uranium, potassium, thorium and total count grids was recorded in ASCII code on 150Mb cartridge in an ER Mapper format.

5.7 1:250,000 SHEET LAYOUTS AND DATA MERGING

The entire survey consisted of coverage on ten standard 1:100,000 government map sheets, and colour maps of the Residual Magnetic and Total Count data were presented for the entire survey flown by Geoterrex at 1:250,000 scale.

The standard 1:250,000 Map Sheet entitled Milingimbi (SD 53-2) encompasses five of the 1:100,000 sheets surveyed and is fully covered by this survey, with the exception of the south-eastern corner. The NT DME agreed to produce an oversized 1:250,000 map sheet entitled Milingimbi that included the coastal strip immediately adjacent to the northern boundary of the standard Milingimbi Sheet (thus it included the on-shore area covered by the Junction Bay (SC 53-14) sheet). To complete the coverage of the Milingimbi Sheet, the survey data was enlarged to include data from the Blyth River 1:100,000 scale map sheet. Airborne geophysical data had been acquired over the Blyth River Sheet in 1990 by Kevron Geophysics and this data was provided in the form of located data on tape. The data acquired on the Blyth River Sheet (7,414 line km) is of similar survey specifications to that acquired during the Milingimbi survey, thus simplifying the merging process. The merged data consisted of the gridded Residual Magnetic Data and four channels of the gridded Radiometric Data.

This second 1:250,000 sheet layout was used to produce colour maps of the residual magnetic data and the Total Count data, as well as black line Contour Maps of the Residual Magnetic Data.

6. ITEMS DELIVERED

Product	Scale	Number
Flight Path	1:100,000	10
Stacked Altimeter Profile Maps	1:100,000	10
Residual Magnetic Contour Maps Including Blyth River Data but excluding Howard and Wilton River	1:100,000 1:250,000	10 1
Magnetic Colour Contour Map Including Blyth River Data but excluding Howard and Wilton River	1:250,000 1:250,000	2 x 1 2 x 1
Stacked Magnetic Profile Maps	1:100,000	10
Stacked Magnetic Profile Maps (every 4th line)	1:100,000	4 x 10
Total Count Colour Contour Maps Including Blyth River Data but excluding Howard and Wilton River	1:100,000 1:250,000 1:250,000	2 x 10 2 x 1 2 x 1
LDT (Raw Field Data) LDT (Final Data per 1:100,000 Sheet) LDT (Calibration & Test Line Data)	ASEG Format	3 x 10 3 x 10 3
GDT Mag/Spectro Data Including Blyth River Data	ER Mapper Format	1 1
Logistics Report		1
Analogues Videos Mileage Lists Flight Logs and Index		

APPENDIX A: MAGNETOMETER CALIBRATION DATA

TABLE A1. FIGURE OF MERIT TEST RESULTS

22nd July 1992

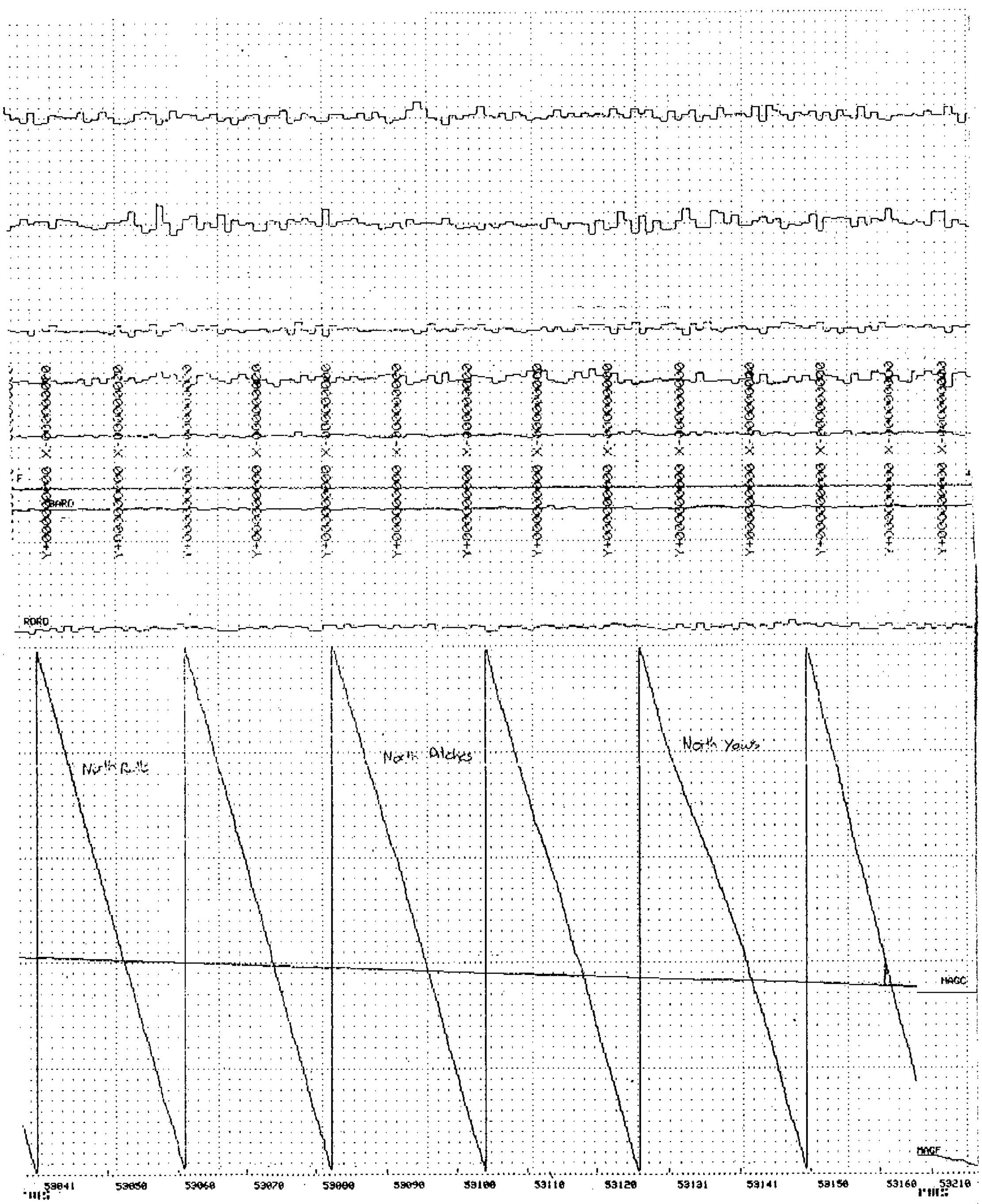
Heading	Rolls	Pitches	Yaws	Total
North	0.1	0.1	0.1	0.3
East	0.1	0.1	0.1	0.3
South	0.1	0.2	0.2	0.5
West	0.1	0.2	0.2	0.5
			F.O.M	1.6

14th September 1992

Heading	Rolls	Pitches	Yaws	Total
North	0.15	0.4	0.15	0.7
East	0.3	0.1	0.3	0.7
South	0.2	0.4	0.1	0.7
West	0.25	0.25	0.35	0.85
			F.O.M	2.95

FIGURE A1(1) COMPENSATION TEST - North
Pitches, Rolls, Yaws

July 22 1992



Pitches, Rolls, Yaws

Sept 14 1992

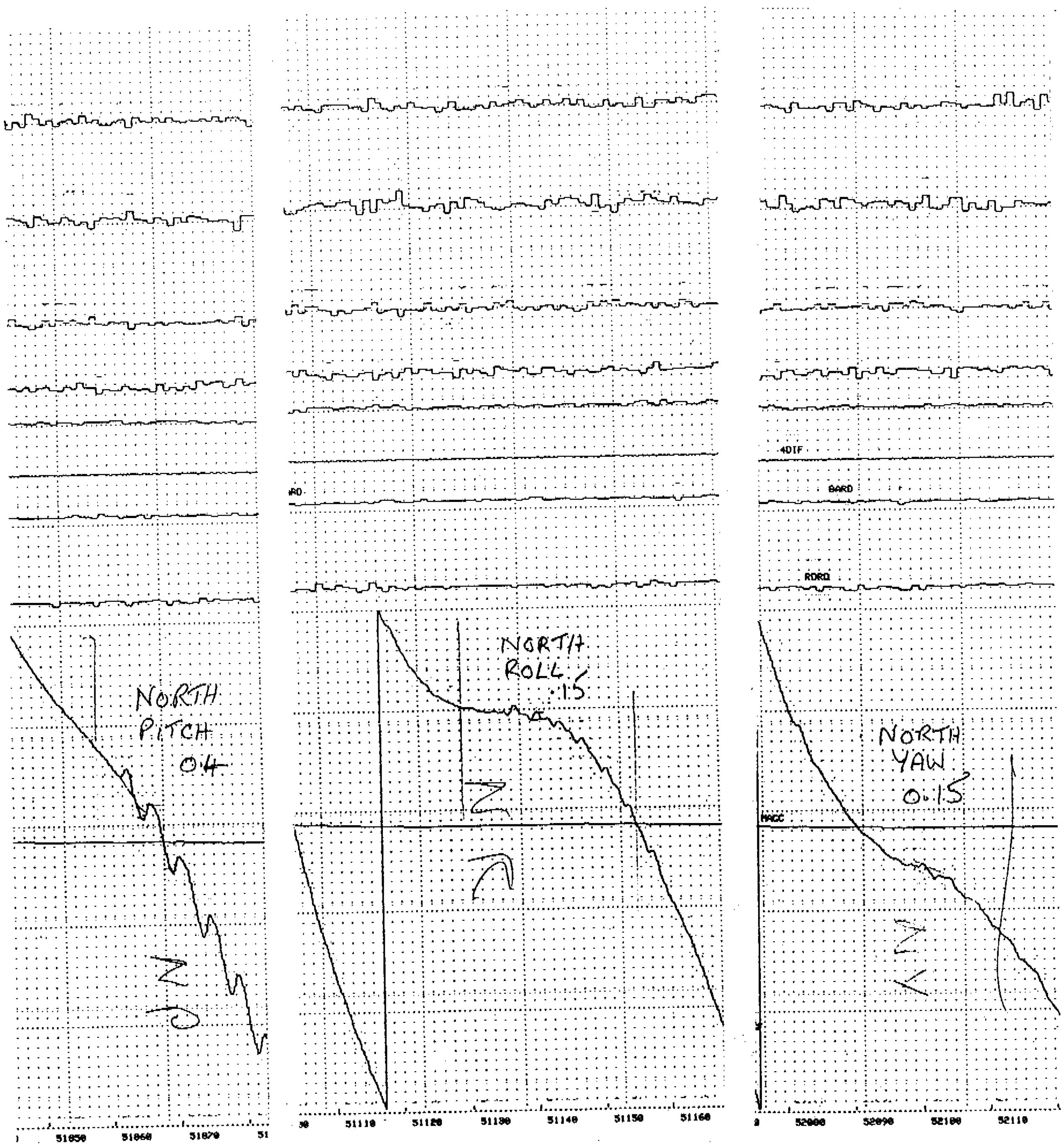
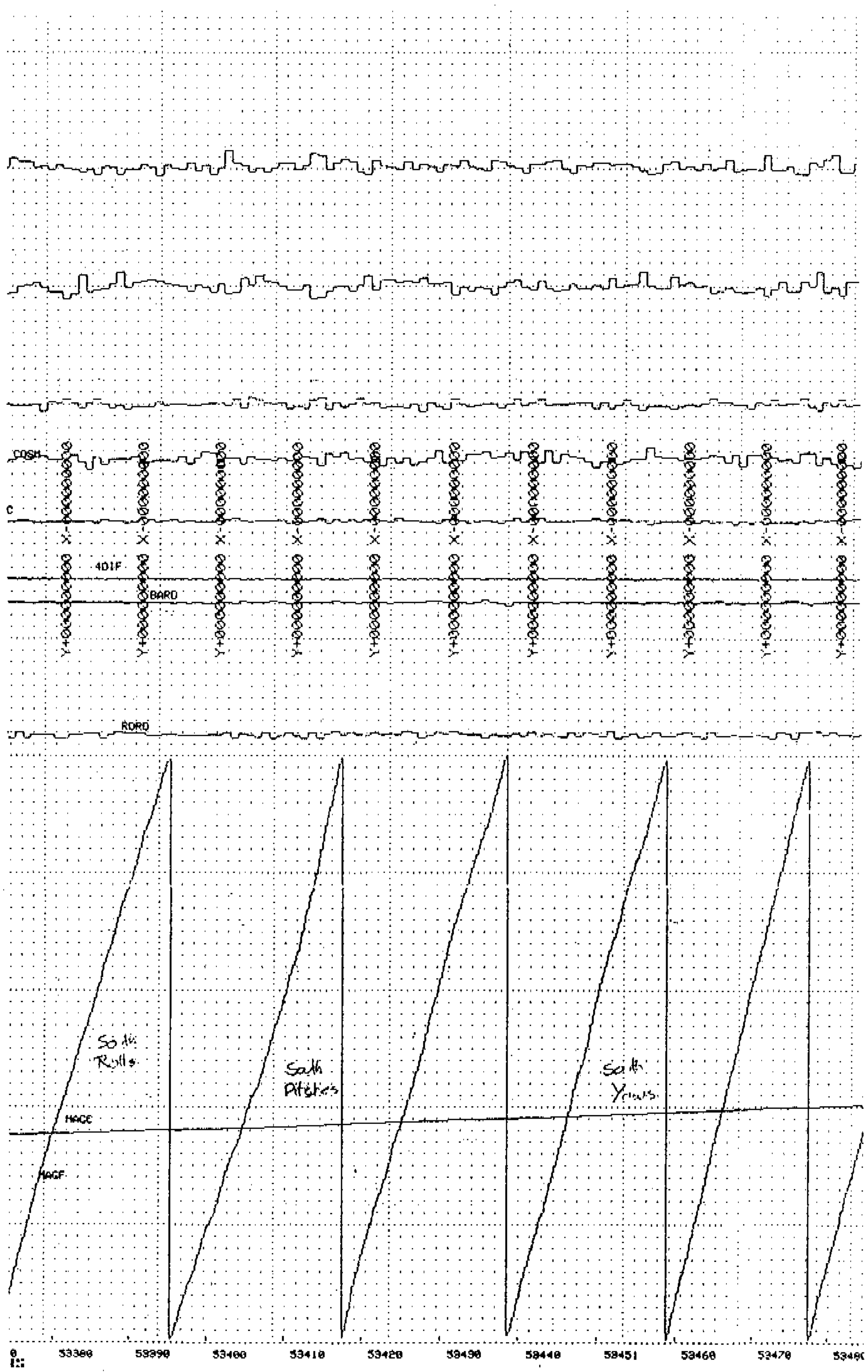


FIGURE A1(2) COMPENSTAION TEST - South

Pitches, Rolls, Yaws

July 22 1992



Pitches, Rolls, Yaws

Sept 14 1992

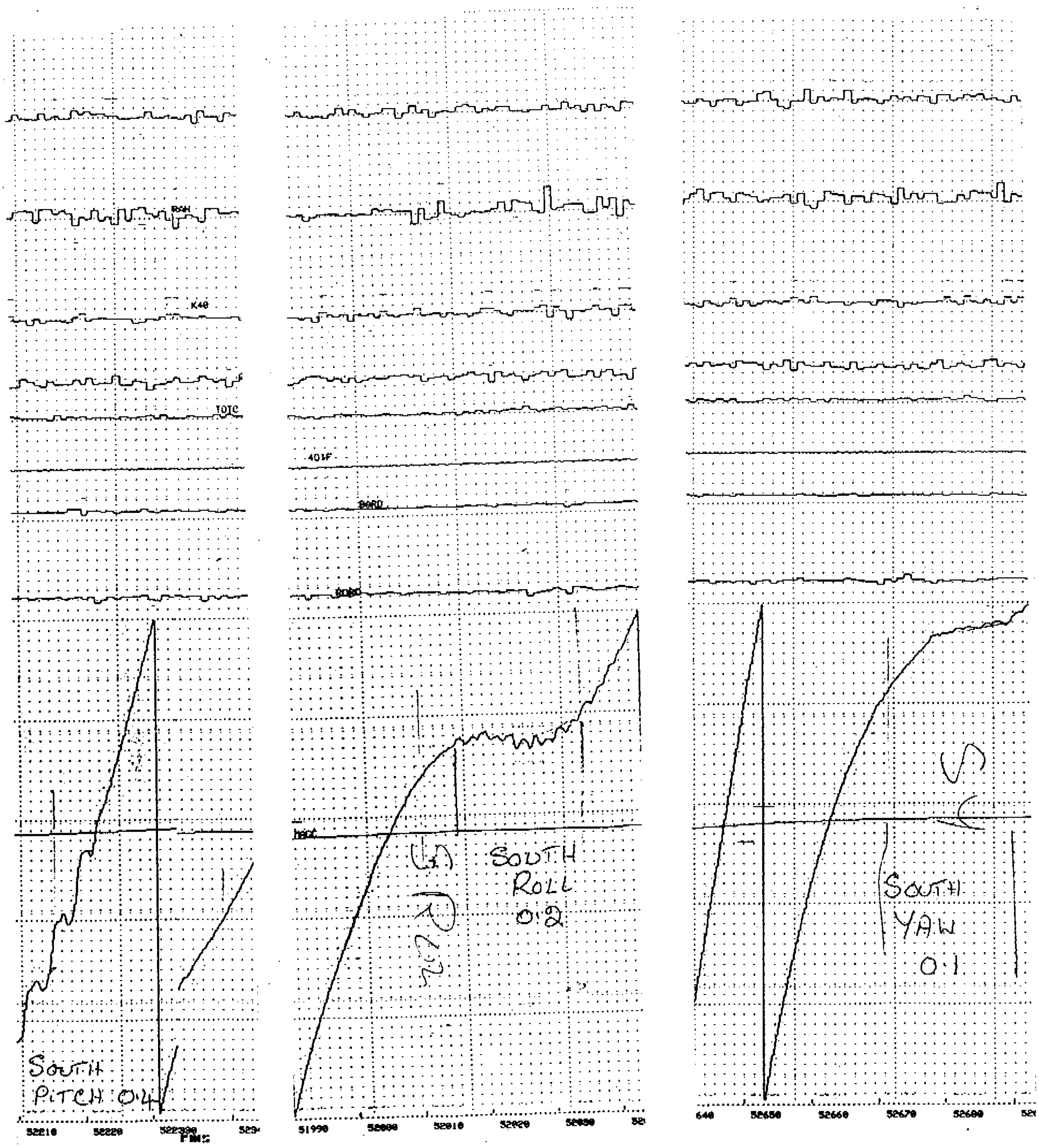
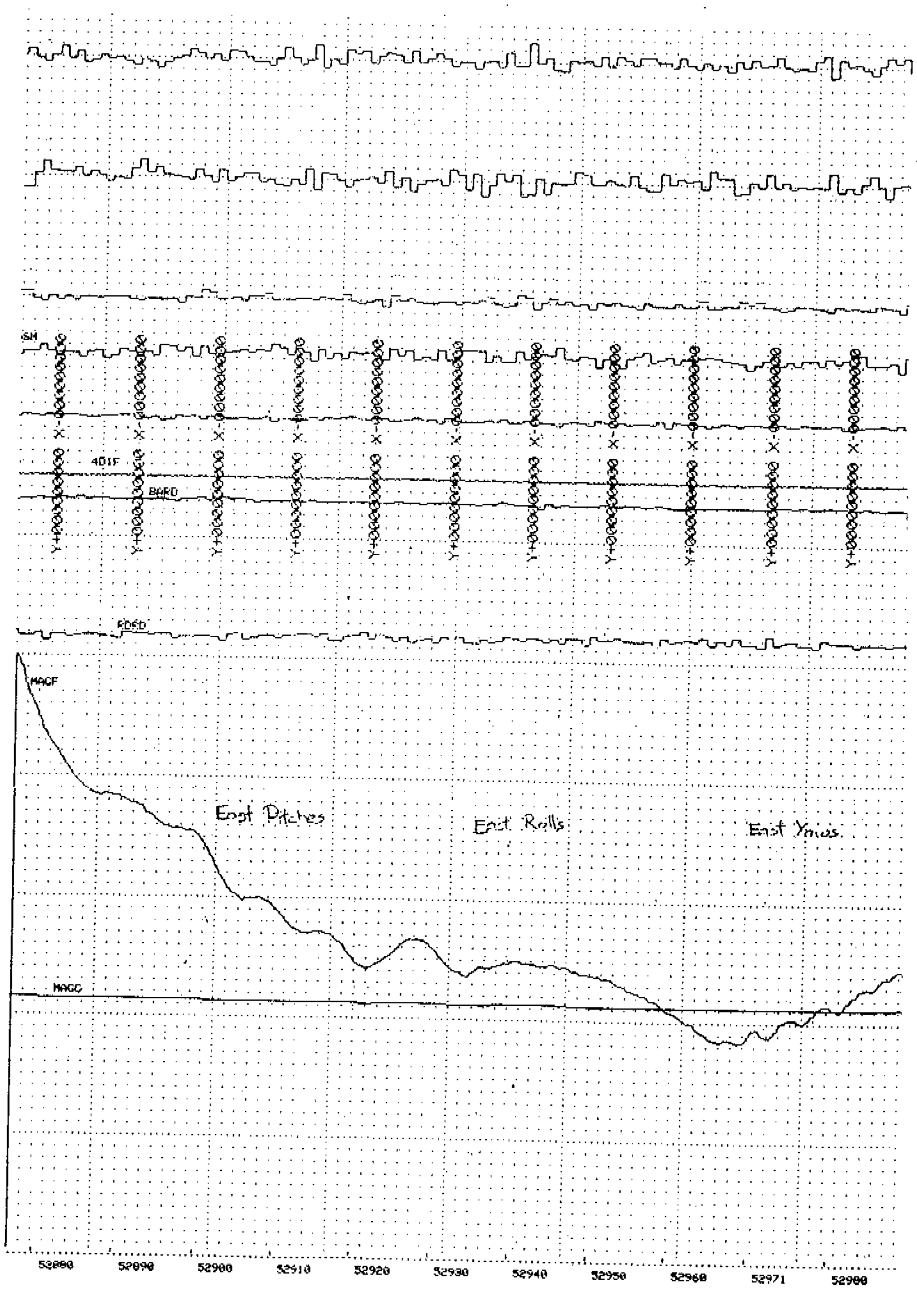


FIGURE A1(3) COMPENSATION TEST - East
Pitches, Rolls, Yaws

July 22 1992



Pitches, Rolls, Yaws

Sept 14 1992

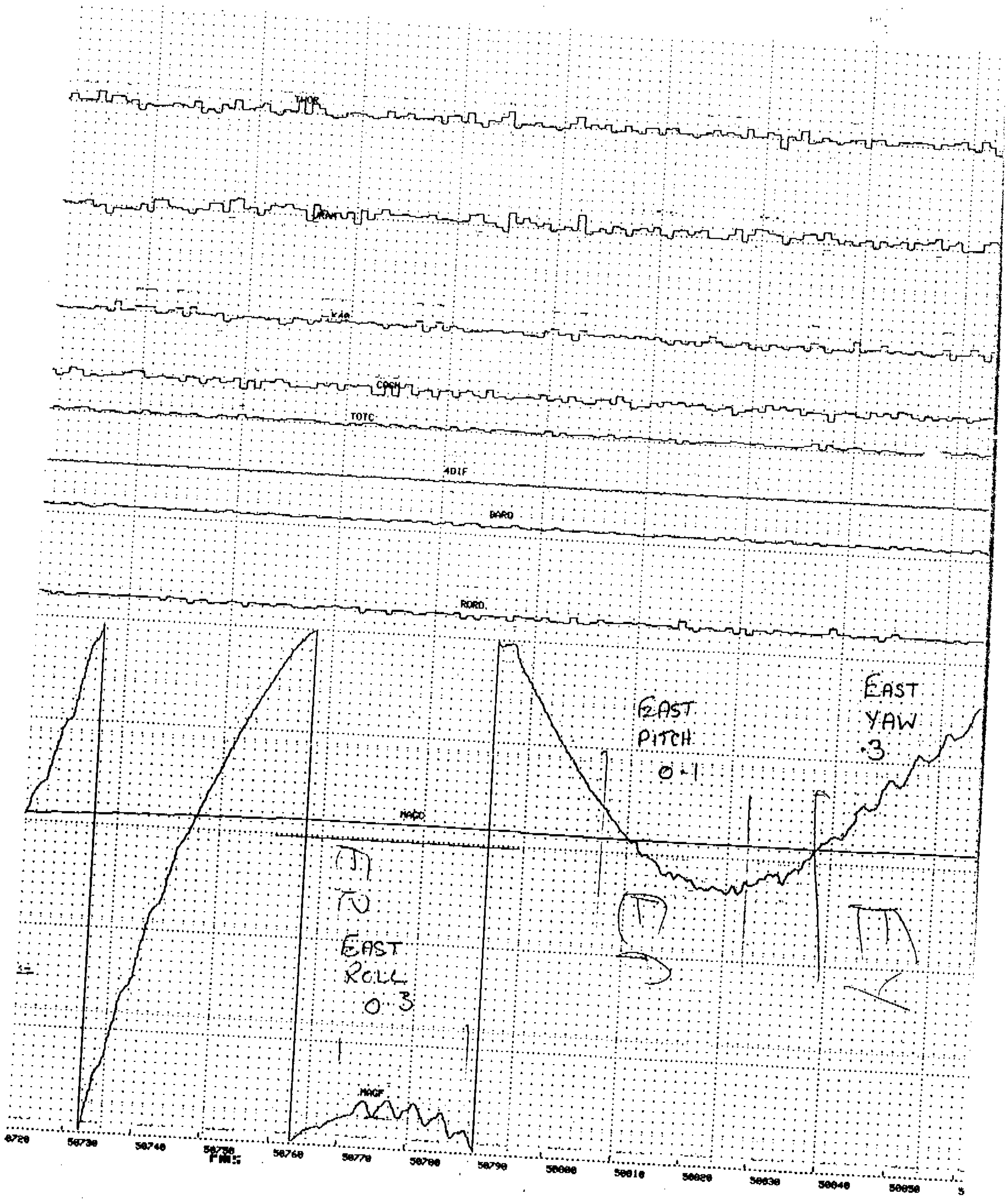
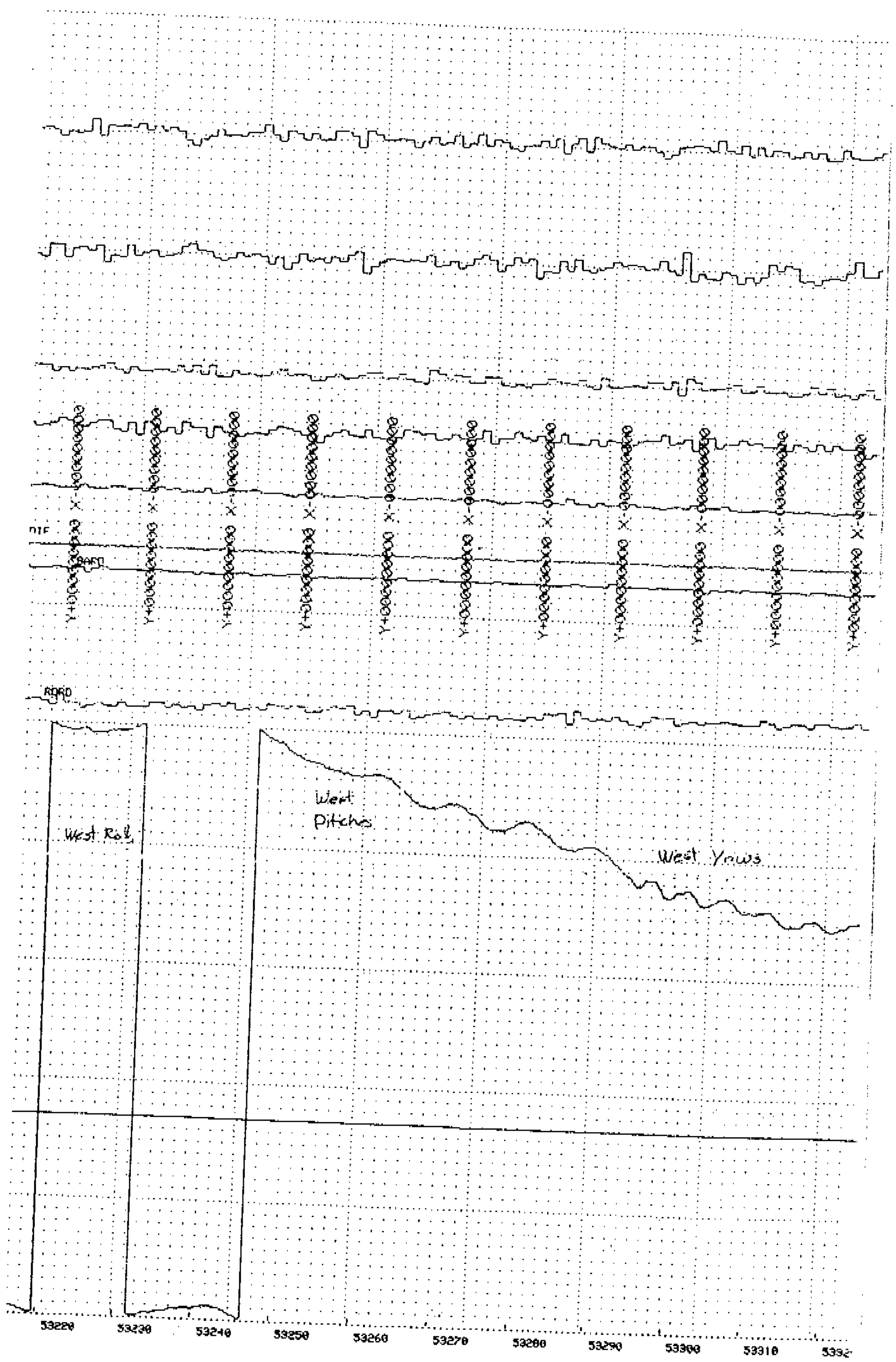


FIGURE A1(4) COMPENSATION TEST - West
Pitches, Rolls, Yaws

July 22 1992



Pitches, Rolls, Yaws

Sept 14 1992

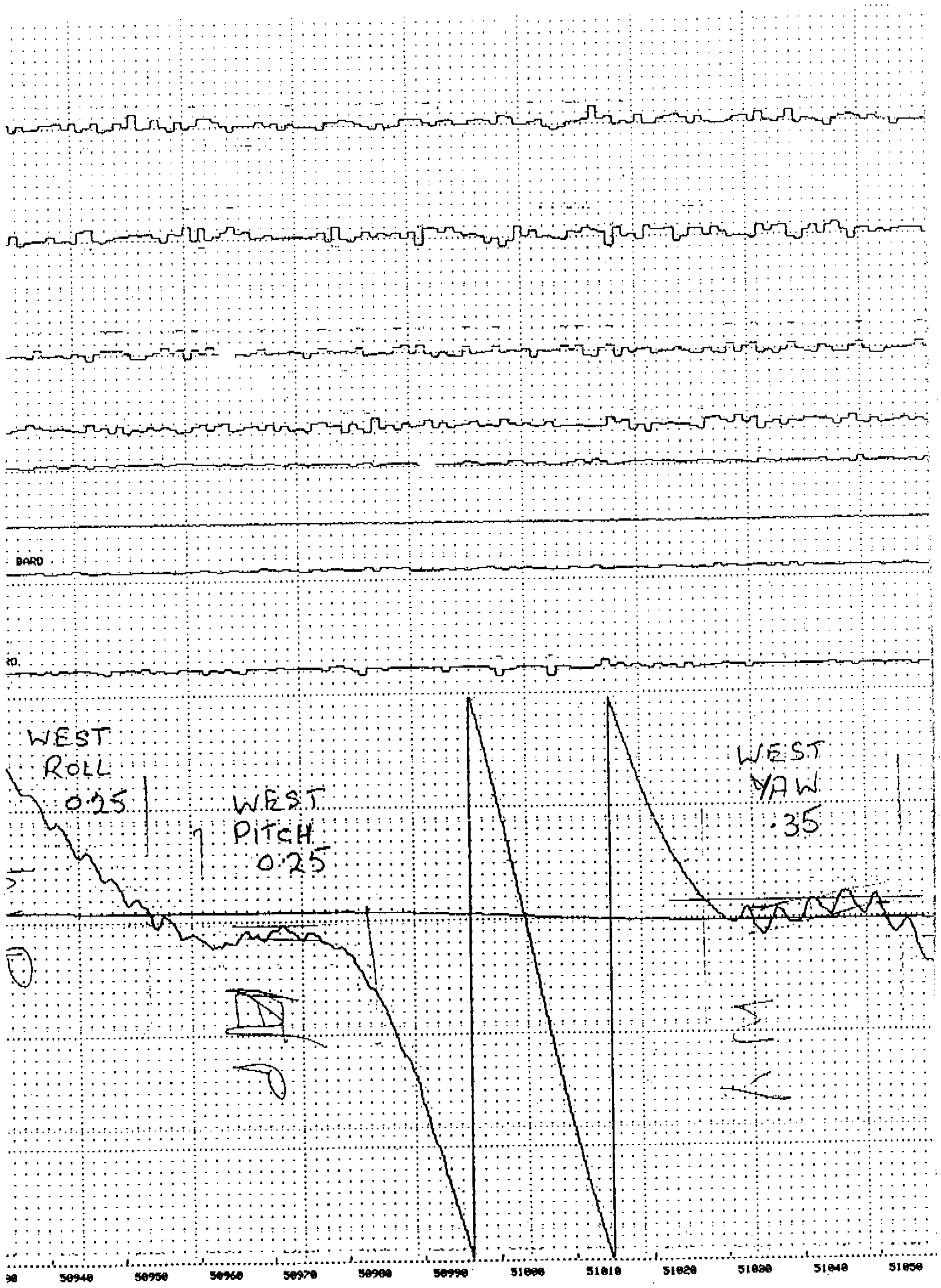


TABLE A2 CLOVERLEAF/HEADING TEST 22 July

Heading	Fiducial	Magnetic Value (nT)	Diurnal Correction (nT)	Altimeter Correction (nT)	Corrected Mag Value (nT)
North	57033.0 57964.8	77.8 85.3	4.3 -3.2	-0.2 -0.1	82.1
East	57188.4	84.1	0	-0.2	83.90
South	57306.2	82.5	-1	-0.17	81.33
West	57455.6	84.4	-1.7	-0.47	82.23
Heading Variation		North-South:		0.77	
		East-West:		1.63	
Total Variation				2.57	

FIGURE A3 HEADING TEST DIAGRAM 22 July

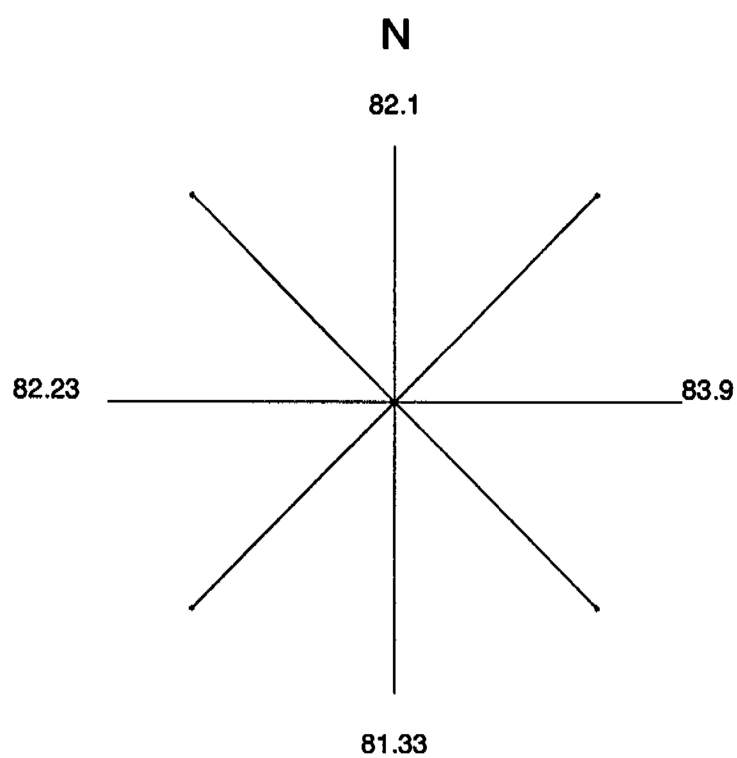
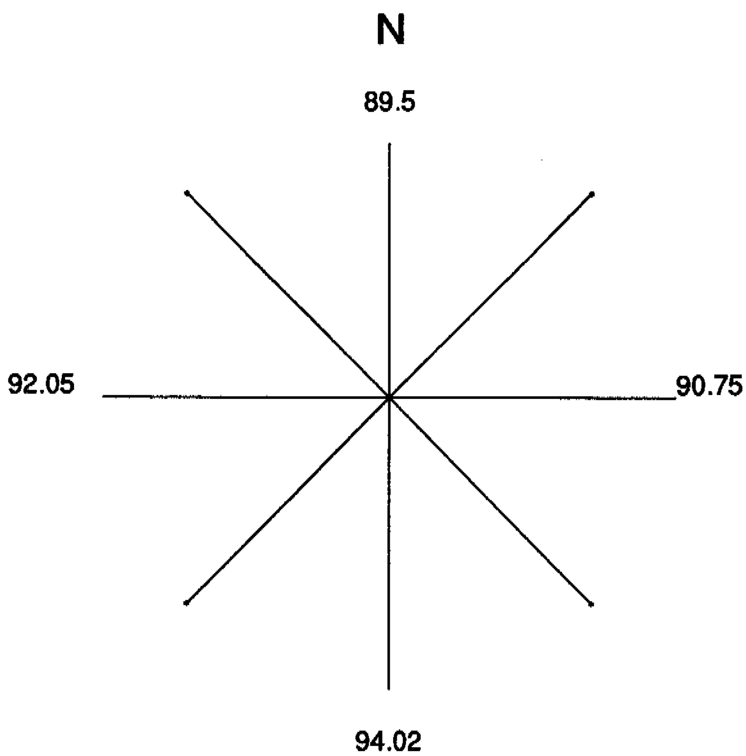


TABLE A2 CLOVERLEAF/HEADING TEST 14 September

Heading	Fiducial	Magnetic Value (nT)	Diurnal Correction (nT)	Altimeter Correction (nT)	Corrected Mag Value (nT)
North	49415.8	89.2	0.4	-0.1	89.50
East	49523.2	90.45	0.6	-0.3	90.75
South	49181.8 49631.2	94.05 93.50	0 0.5	0 0	94.03
West	49295.8	91.85	0.1	0.1	92.05
Heading Variation		North-South:		4.52	
		East-West:		1.30	
Total Variation				4.52	

FIGURE A3 HEADING TEST DIAGRAM 14 September



APPENDIX B: SPECTROMETER CALIBRATION DATA

TABLE B1. SOURCE CHECKS

Flight		Pre Flight		Post Flight	
		U Source	Th Source	U Source	Th Source
1	U count	27186	10435	28109	11031
	Th count	1156	22153	1410	21858
	K count	21706	10171	21800	9705
	Total count	293782	268611	300712	272784
2	U count	27919	10865	28151	10861
	Th count	136	22568	1325	22416
	K count	22024	9858	21532	10183
	Total count	300226	274194	298885	270861
3	U count	27828	10341	27860	11131
	Th count	1140	22483	1467	22771
	K count	22126	10405	21820	9710
	Total count	29647	27331	298297	274478
4	U count	27626	11086	27688	10249
	Th count	1341	22018	1408	22202
	K count	21575	9949	21190	9854
	Total count	295384	271779	297750	271165
5	U count	27235	10348	27895	10496
	Th count	1275	22752	1399	21885
	K count	21299	10068	21419	9915
	Total count	292674	270294	297856	271135
6	U count	27338	10348	27894	10422
	Th count	1378	21808	849	22113
	K count	21499	9798	21770	10334
	Total count	290978	263642	294541	269464
7	U count	27772	10538	28100	10963
	Th count	1307	21969	950	22016
	K count	21438	10033	21725	10006
	Total count	295853	267379	299526	272517
8	U count	28001	10315	28196	10829
	Th count	998	21980	1112	22223
	K count	21757	9667	21703	10258
	Total count	296154	267547	299194	272432
9	U count	27573	10930	27891	10394
	Th count	1115	22095	1177	21924
	K count	21355	9982	21724	10180
	Total count	293027	270336	296681	271939
10	U count	27802	9602	28258	10600
	Th count	1134	21921	960	21958
	K count	21996	10359	22110	10108
	Total count	296082	266847	298972	271118

Flight		Pre Flight		Post Flight	
		U Source	Th Source	U Source	Th Source
11	U count	27561	10753	28055	10510
	Th count	1142	21661	1123	22071
	K count	21322	9915	21752	10150
	Total count	292388	267182	296965	270948
12	U count	27668	9888	27765	10533
	Th count	839	21695	1157	22081
	K count	21452	9535	21764	9769
	Total count	294350	261714	297279	272306
13	U count	27687	10358	28081	10544
	Th count	1461	22424	1003	22204
	K count	20792	9974	21729	10038
	Total count	293706	270460	297856	272025
14	U count	27635	10420	27960	10621
	Th count	1132	22197	1214	22257
	K count	21379	9786	21484	10428
	Total count	295241	268775	297532	272852
15	U count	27325	10633	28355	10560
	Th count	1167	21754	1279	22418
	K count	21580	9874	21912	10363
	Total count	29333	265848	302715	274945
16	U count	28039	10536	27821	10661
	Th count	1150	22033	1151	21999
	K count	21654	10336	21474	10230
	Total count	295138	271698	297215	272522
17	U count	26687	10028	28329	10516
	Th count	1473	22153	986	22056
	K count	20971	9609	21520	10402
	Total count	287113	265793	296258	270256
18	U count	27201	10146		
	Th count	1203	22236		
	K count	21350	9728		
	Total count	289703	262114		
19	U count			28364	10177
	Th count			1114	21899
	K count			21952	10510
	Total count			301133	271214
20	U count	28024	10672	27502	9595
	Th count	1266	22343	925	21414
	K count	21955	9816	20288	11319
	Total count	300916	274350	295996	271661

Flight		Pre Flight		Post Flight	
		U Source	Th Source	U Source	Th Source
21	U count	2753	10767	27657	10711
	Th count	1116	22340	1161	22111
	K count	21864	9997	21140	10135
	Total count	294763	272569	295612	272547
22	U count	28047	11215	27577	10897
	Th count	1065	21947	1310	22218
	K count	21154	9502	22349	10010
	Total count	293878	270100	300066	272088
23	U count	27335	10129	27556	11028
	Th count	1362	21906	1389	21972
	K count	21631	9753	22268	10071
	Total count	292737	263644	299113	270047
24	U count	27948	11088	27015	10625
	Th count	1183	22460	1446	21940
	K count	21451	9549	21870	9953
	Total count	298735	273880	300063	274077
25	U count	27799	10687	27643	11404
	Th count	1351	22025	1552	22475
	K count	21797	15981	21972	9493
	Total count	295559	268543	299091	273127
26	U count	27844	10730	27675	10833
	Th count	1229	22438	1328	22018
	K count	21906	10016	21990	10315
	Total count	298056	272391	299692	274465
27	U count	27862	10630	27686	10632
	Th count	1353	22061	1339	22046
	K count	21504	10150	21851	10154
	Total count	295234	270739	299886	274800
28	U count	27606	10927	27834	11173
	Th count	1728	22505	1275	22114
	K count	21654	9841	22260	9900
	Total count	294477	270629	301626	275170
29	U count	27498	10585	27876	11211
	Th count	1175	22117	1104	22375
	K count	21943	9879	21823	10253
	Total count	295534	268480	299141	275890
30	U count	27483	10854	27604	11428
	Th count	1428	22611	1516	22355
	K count	21712	9689	22753	9957
	Total count	294872	270229	302901	276854

Flight		Pre Flight		Post Flight	
		U Source	Th Source	U Source	Th Source
31	U count	27359	10874	28453	10668
	Th count	1336	22674	1184	22411
	K count	21928	9672	21940	10189
	Total count	295300	269655	300877	273800
32	U count	27173	10793	27846	10863
	Th count	1599	22177	1217	22403
	K count	21225	9355	21888	9940
	Total count	292963	267757	299438	273418
33	U count	27501	10627	28359	10576
	Th count	1406	22393	1178	21800
	K count	21728	9929	21870	10326
	Total count	293946	270507	299153	273285
34	U count	27790	11115	27547	10879
	Th count	1275	22424	1314	22366
	K count	21845	9796	22147	9810
	Total count	296019	273685	301803	272933
35	U count	27810	10669	28051	10941
	Th count	1466	22367	1231	22198
	K count	21894	9501	22135	10407
	Total count	297465	271148	300083	275376
36	U count	27565	10475	28055	10582
	Th count	1424	22014	1084	22302
	K count	21961	9510	21964	10562
	Total count	295049	266484	299737	273714
37	U count	28191	11308	26883	10653
	Th count	1194	22494	1448	22451
	K count	22412	9655	21554	9390
	Total count	301090	274560	298050	274678
38	U count	28089	11137	28299	10989
	Th count	1403	22327	1224	22202
	K count	22093	9905	22335	10283
	Total count	298028	272885	298870	274848
39	U count	28248	10926		
	Th count	1201	22341		
	K count	21735	9918		
	Total count	295684	271163		
40	U count			28442	11090
	Th count			1072	22317
	K count			22278	10220
	Total count			299993	274524

Flight		Pre Flight		Post Flight	
		U Source	Th Source	U Source	Th Source
41	U count	27274	11202		
	Th count	1392	22277		
	K count	21462	9851		
	Total count	293814	270614		
42	U count			27929	10852
	Th count			1362	22373
	K count			21662	10146
	Total count			297404	275302
43	U count	28074	10928		
	Th count	1256	22231		
	K count	22243	9904		
	Total count	297286	271386		
44	U count			27950	10889
	Th count			1416	22326
	K count			21976	9600
	Total count			300219	273525
45	U count	27940	10993		
	Th count	1434	22140		
	K count	21811	9752		
	Total count	296310	271422		
46	U count			28311	11173
	Th count			1394	22746
	K count			22132	10007
	Total count			300092	276133
47	U count	27940	10957		
	Th count	1112	21740		
	K count	22267	9731		
	Total count	298041	265936		
48	U count			27853	11300
	Th count			1164	22292
	K count			22235	9777
	Total count			301656	275231
49	U count	27511	10923	27880	10885
	Th count	982	22100	1215	22570
	K count	21893	9750	22400	9961
	Total count	296117	271271	301243	276424
50	U count	27419	10846		
	Th count	1366	21989		
	K count	21509	9656		
	Total count	293836	268022		

Flight		Pre Flight		Post Flight	
		U Source	Th Source	U Source	Th Source
51	U count			28065	10895
	Th count			1305	22382
	K count			21668	10039
	Total count			300952	273618
52	U count	27280	10677		
	Th count	1428	22073		
	K count	22079	9550		
	Total count	294757	267568		
53	U count	27936	11311	28370	10893
	Th count	1439	22486	1190	22642
	K count	22425	10423	22102	10364
	Total count	298914	273600	301330	277169
54	U count	27783	10699		
	Th count	1107	21729		
	K count	22029	9636		
	Total count	297075	270661		
55	U count			28370	11058
	Th count			1251	22371
	K count			21952	10595
	Total count			299394	274856
56	U count	27704	10749	28109	11026
	Th count	1704	22123	1412	22536
	K count	21937	9907	2216	9978
	Total count	298009	266952	299894	274352
57	U count	27370	10800	28196	10404
	Th count	1140	22168	1049	21943
	K count	21545	9765	21573	9970
	Total count	293570	269887	299764	269232

FIGURE B1(1) SAMPLE SOURCE CHECK - URANIUM SOURCE

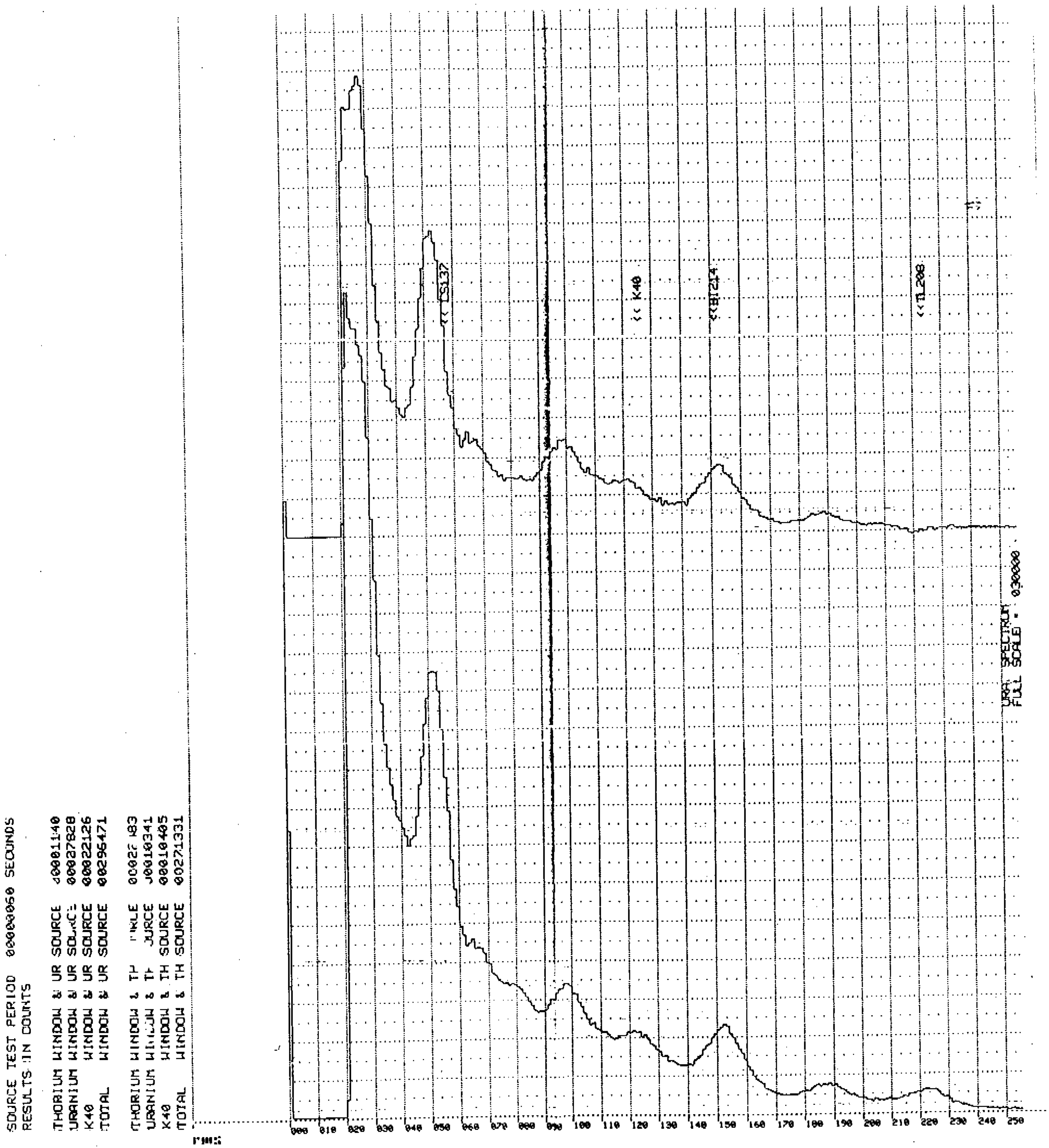


FIGURE B1(2) SOURCE CHECK - THORIUM SOURCE

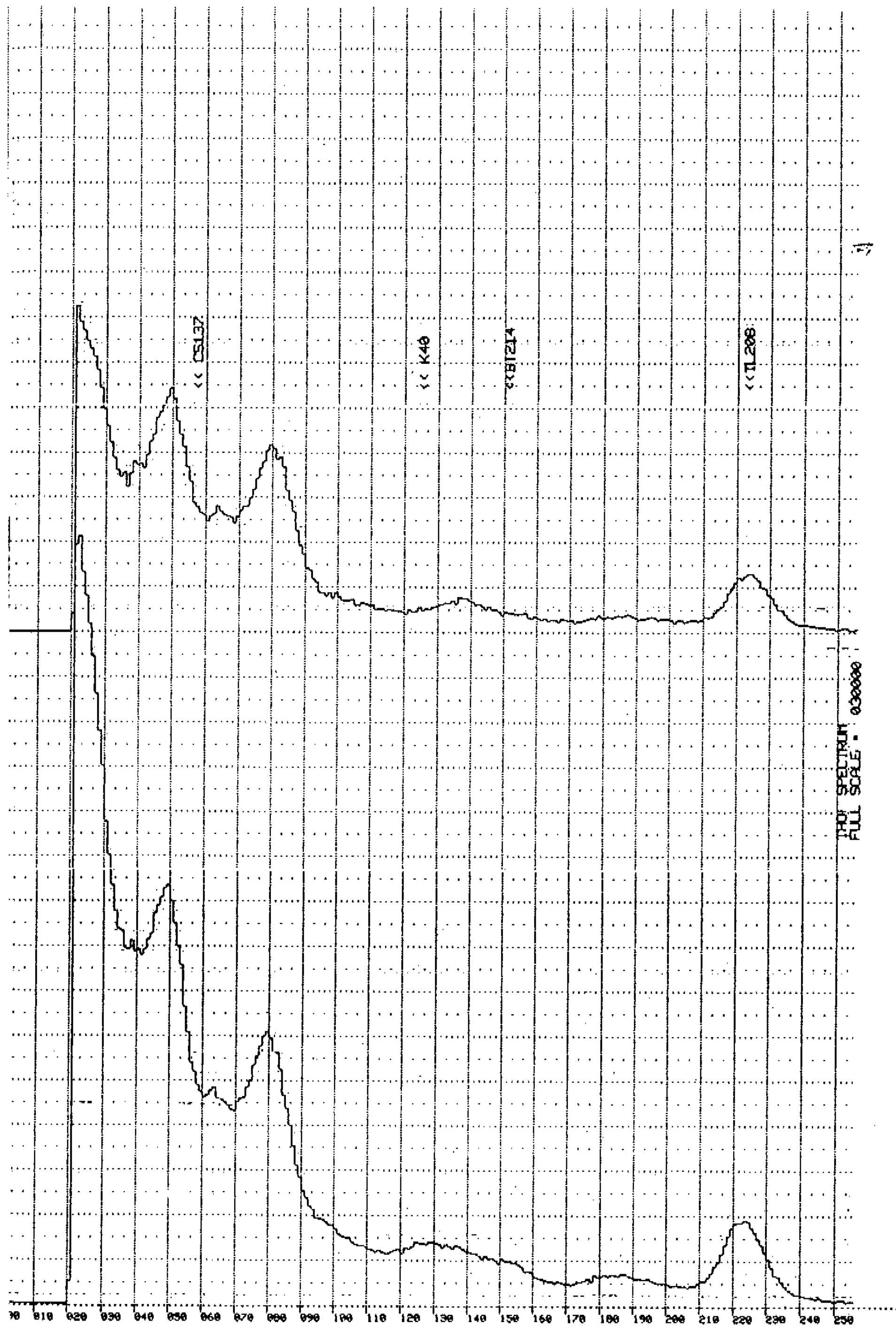
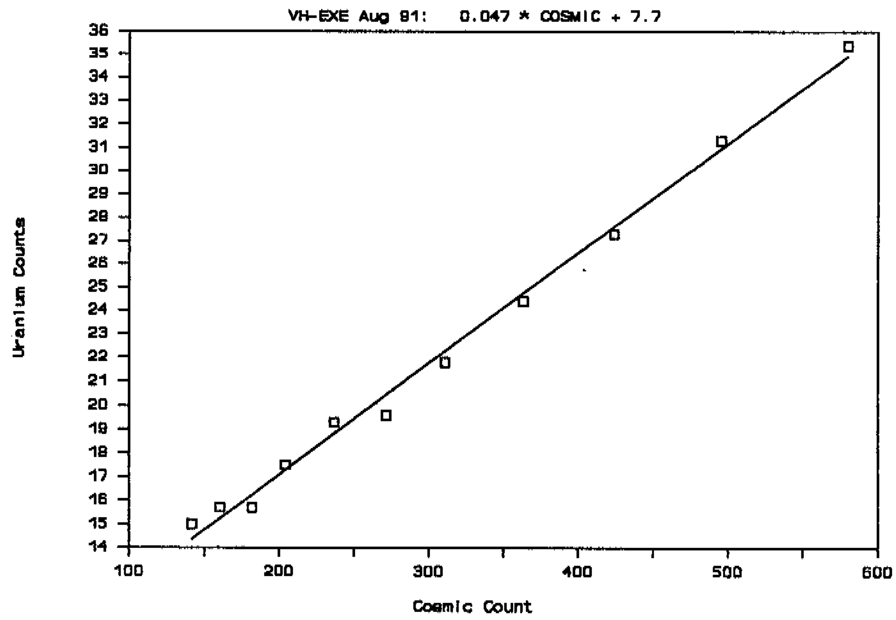


FIGURE B2 COSMIC BACKGROUND TESTS



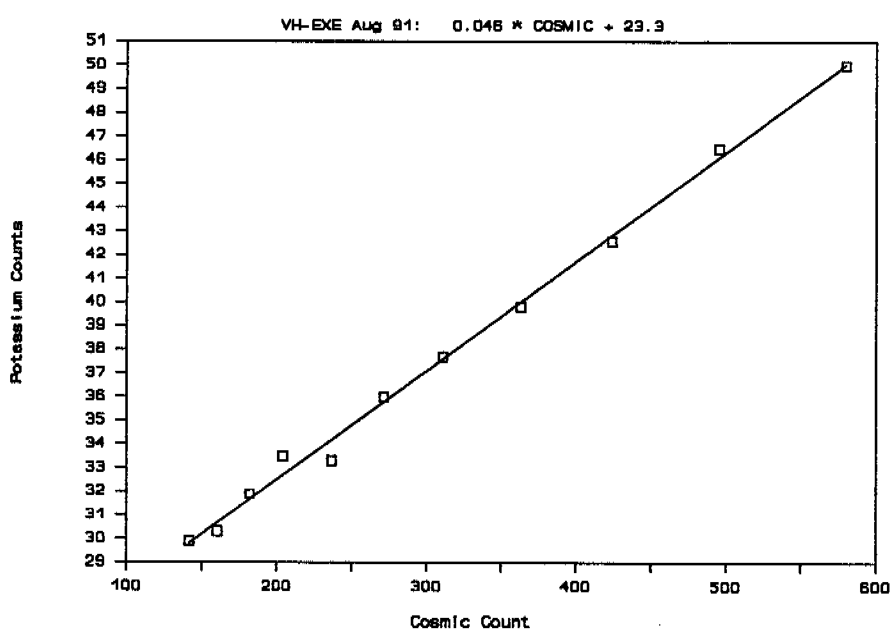
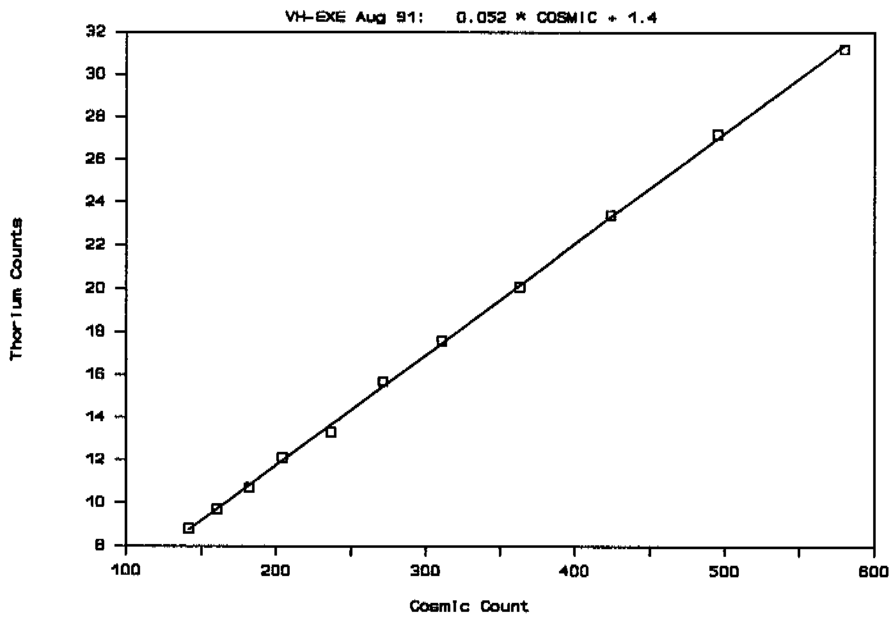


FIGURE B2 COSMIC BACKGROUND TESTS.



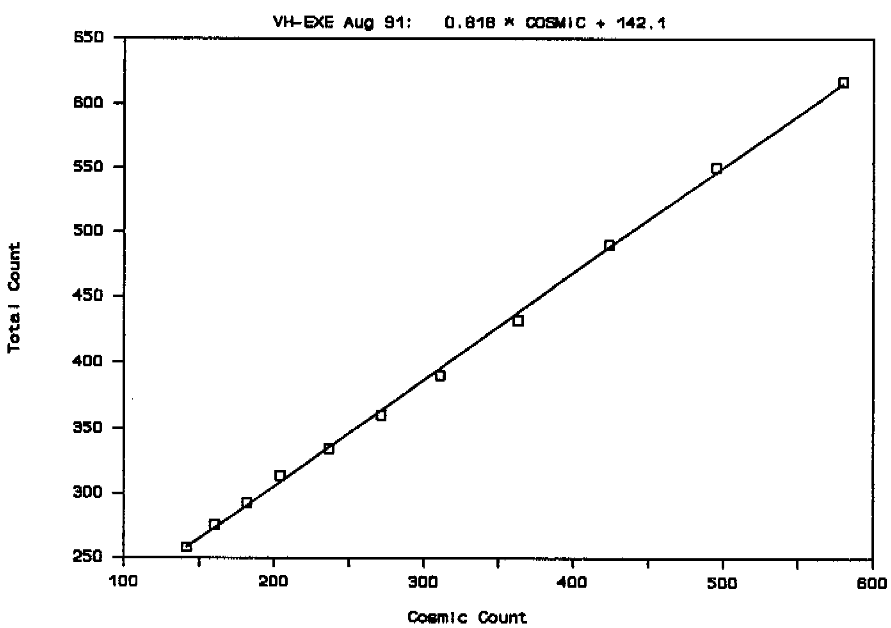
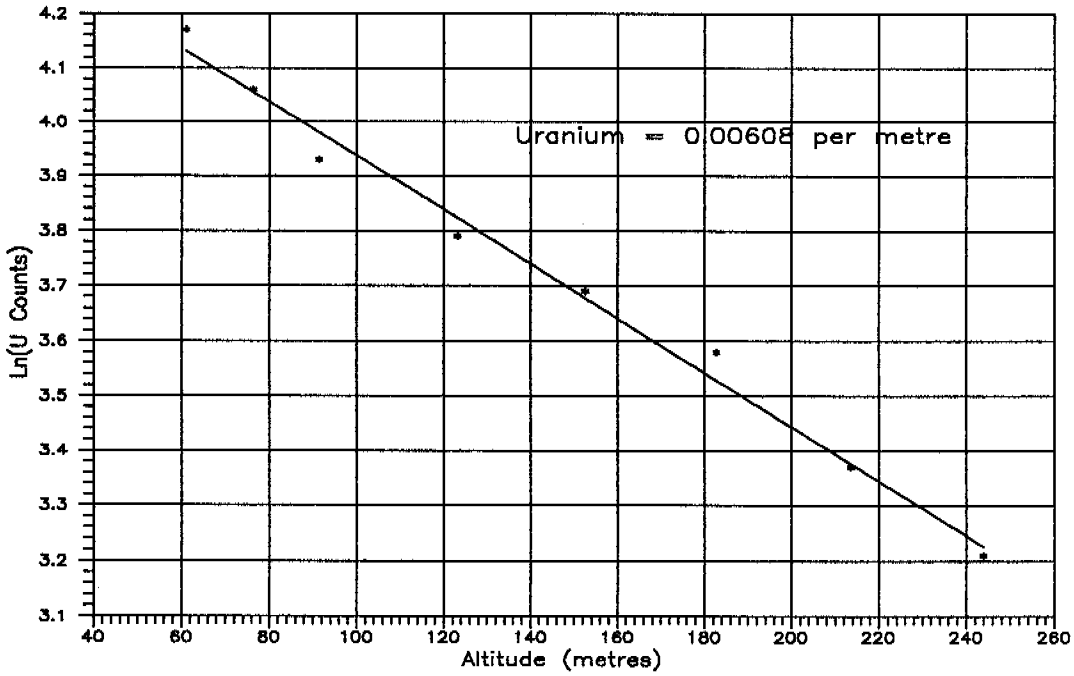


FIGURE B3 HEIGHT ATTENUATION TESTS



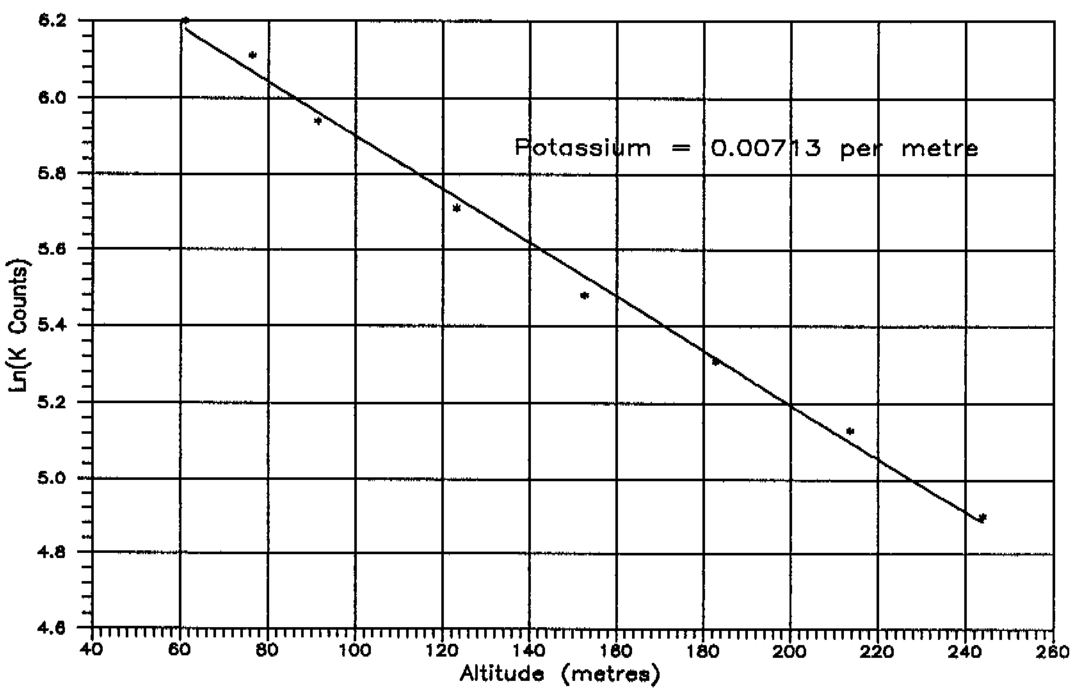
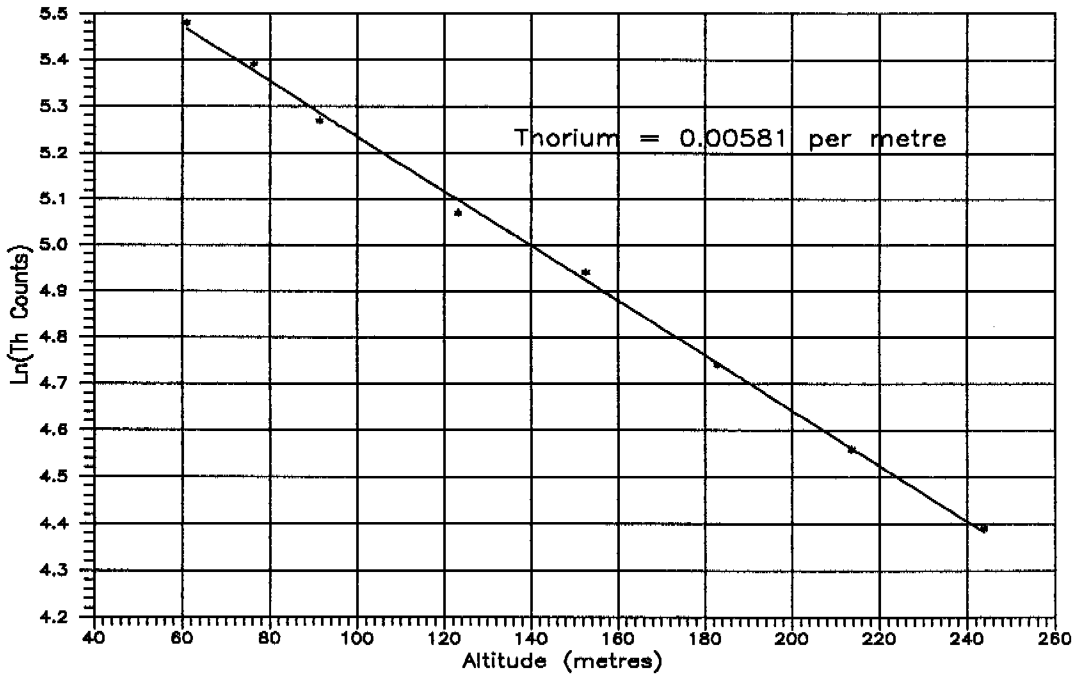


FIGURE B3 HEIGHT ATTENUATION TESTS



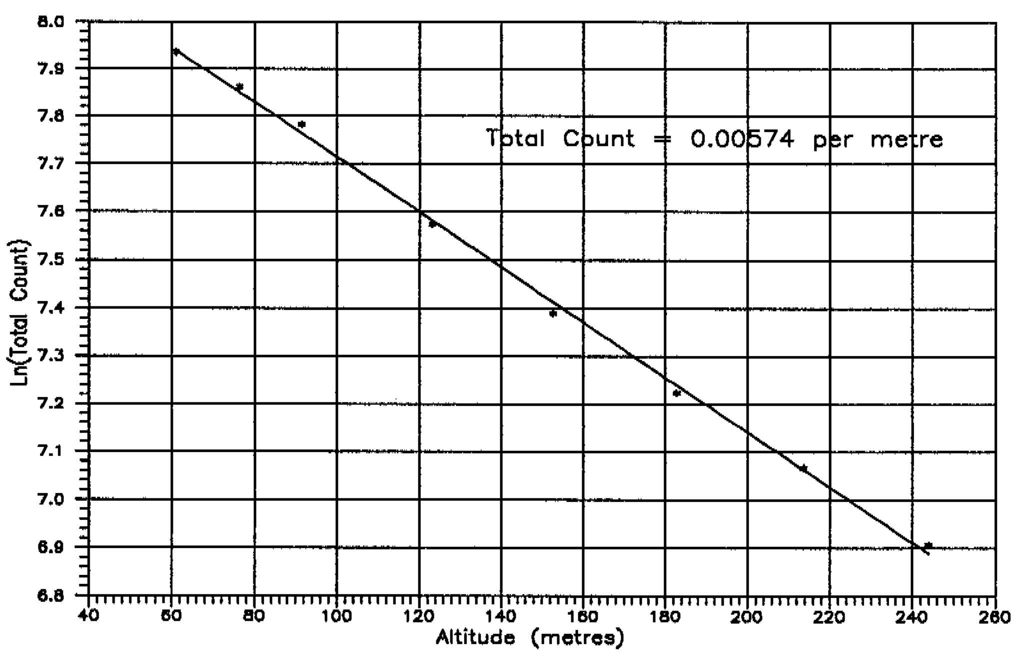


FIGURE B4. SPECTROMETER RESOLUTION CHECK

22 July 1992

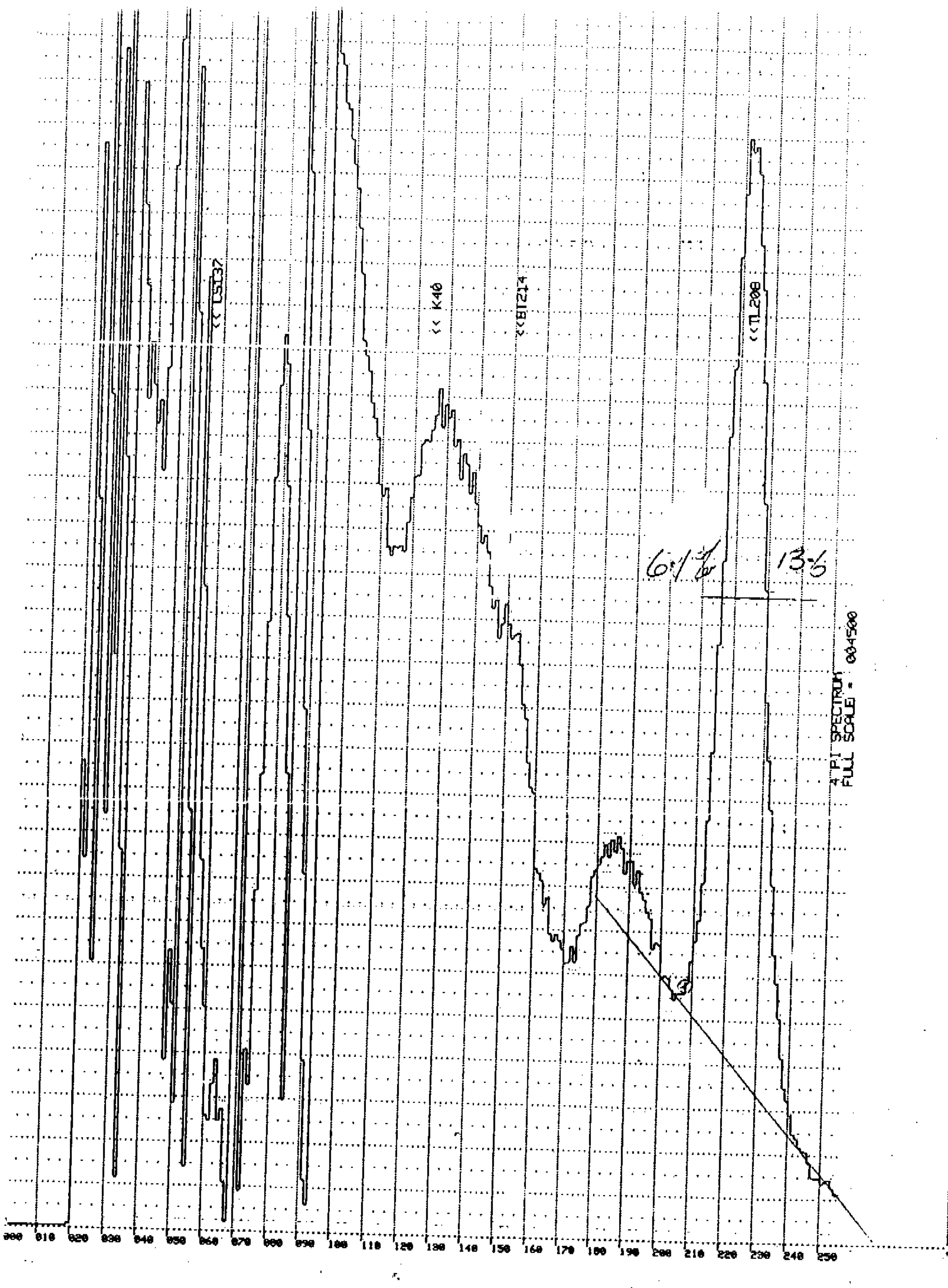


TABLE C FIELD DATA TAPE FORMAT

Byte Position	Used	Number	Description	General Information
0 - 1	*	2	Flight Number	
2 - 5	*	4	Fiducial Number	
6 - 21	*	16	Magnetometer @ t-0.0 seconds (see Note 1 below)	
22 - 37	*	16	Magnetometer @ t-0.1 seconds	
38 - 53	*	16	Magnetometer @ t-0.2 seconds	
54 - 69	*	16	Magnetometer @ t-0.3 seconds	
70 - 85	*	16	Magnetometer @ t-0.4 seconds	
86 - 101	*	16	Magnetometer @ t-0.5 seconds	
102 - 117	*	16	Magnetometer @ t-0.6 seconds	
118 - 132	*	16	Magnetometer @ t-0.7 seconds	
134 - 149	*	16	Magnetometer @ t-0.8 seconds	
150 - 165	*	16	Magnetometer @ t-0.9 seconds	
166 - 181	*	16	Spare	
182 - 183	*	2	Radar Altimeter	
184 - 185	*	2	Pressure Altimeter	
186 - 187	*	2	Temperature	
188 - 189		2	Relative Humidity	
190 - 191		2	For VLF Analogue Input	
192 - 193		2	For 2nd VLF Analogue Input	9 - Track Tape
194 - 199	*	6	Doppler Northing	
200 - 205	*	6	Doppler Easting	Record Length = 572 Bytes
206 - 211	*	6	For Zone Data	
212 - 217	*	6	For ID square Data	Block Size = 2068 Bytes
218 - 223	*	6	Doppler Ground Speed	Recording Mode = Binary
224 - 229	*	6	For Drift Velocity Data	(IBM Compatible)
230 - 235	*	6	For Heading Velocity Data	
236 - 239		4	STR4 Data Logged Time	
240 - 249		10	STR4 Y-Cooridnate	
250 - 259		10	STR4 X-Coordinate	
260 - 265		6	STR4 Quality of fix	
266 - 267		2	STR4 Measurement of Delay	
268 - 271	*	4	MADACS Acquire Time for GPS	
272 - 281	*	10	Satellite Time	
282 - 291	*	10	GPS Latitude	
292 - 301	*	10	GPS Longitude	
302 - 307	*	6	GPS Altitude ASL	
308 - 327	*	20	No. of Satellites Used	
328 - 329	*	2	Thorium	
330 - 331	*	2	Uranium	
332 - 333	*	2	Potassium	
334 - 335	*	2	Total Count	
336 - 337	*	2	Cosmic Count	
338 - 339	*	2	Live Time	
340 - 571	*	232	For Channels 24-255 inc. 1 byte each	

NOTE 1: Each Magnetic reading has four components, namely:

Magnetic Acquire Time
Raw Magnetics
Compensated Total Magnetic Field
Uncompensated Total Magnetic Field

APPENDIX D: RMS THERMAL PAPER STORAGE INSTRUCTIONS

PAPER STORAGE AND HANDLING, RMS 2030 THERMAL PAPER

STORAGE:

Ambient Temperature: Less than 25°C
Relative Humidity: Less than 65%
Storage Location: In darkness before and after exposure.

Under these conditions, the paper should retain its characteristics and the printed images will remain legible for at least 5 years, although in the case of blue image paper, there may be some slight fading.

TO ELIMINATE PREMATURE PAPER DEVELOPMENT:

- Colour development begins at temperatures between 70 to 100°C, and reaches saturation density between 80 and 120°C. Premature development of the paper may occur at lower temperatures, and particularly if the humidity is greater than 65%.
  eg. If the paper is stored for 24 hours at a temperature of 60°C, some development may occur. Or if the paper is stored for 24 hours at a temperature of 45°C when the relative humidity is 90%, development may also occur.

- Avoid use of solvent-type adhesives. Adhesives containing volatile organic solvents such as alcohol, ester, ketone, etc causes colour formation and therefore rubber-type adhesives etc should not be used. Starch, PVA and CMC type adhesives are recommended.

- Frictional heat generated by rubbing a finger nail or sharp object over the surface will cause images to develop.

- Thermal paper will develop colour if brought into contact with freshly processed Diazo copying paper.

TO ELIMINATE PAPER FADING:

- Thermal paper will turn yellow, and blue printed images will tend to fade if exposed to direct sunlight or to fluorescent lighting for long periods. File exposed paper in the dark immediately after exposure. Do not store paper near windows.

- Prolonged contact with PVC film containing plasticisers such as ester phthalate will reduce the image forming ability of the paper and cause printed images to fade. We recommend that files made of polyethylene, polypropylene, polyester, etc be used.

- Self-adhesive cellophane tapes containing an alcohol type plasticiser will cause the image to fade. Double-sided adhesive tape is recommended for use instead of paste.

- Handling thermal paper with dirty or sweaty fingers might cause images to fade.

- Do not store developed paper with the sensitised surfaces touching as images might be transferred from one sheet to another.