060001

Bass Basin part XVI Vol I

OPERATIONS REPORT,
HB75A MARINE SEISMIC SURVEY,

BASS STRAIT

For

HEMATITE PETROLEUM PROPRIETARY LIMITED
B.H.P. HOUSE, 140 WILLIAM STREET
MELBOURNE, VICTORIA 3000 AUSTRALIA

Client Representative : Mr. E.Urschel

By

GEOPHYSICAL SERVICE INTERNATIONAL
P.O. BOX 437, CROWS NEST N.S.W. 2065

Party 2931 M.V. "EUGENE McDERMOTT II"
Operations Supervisor: G.Shilliday
Quality Control Seismologists T.O'Donnell, W.Grise

14th January-22nd January 1975

OR-016

GSI-709

060002

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# HEMATITE PETROLEUM PROPRIETARY LTD.

LOCATION OF PROSPECT

BASS STRAIT

GEOPHYSICAL SERVICE INTERNATIONAL

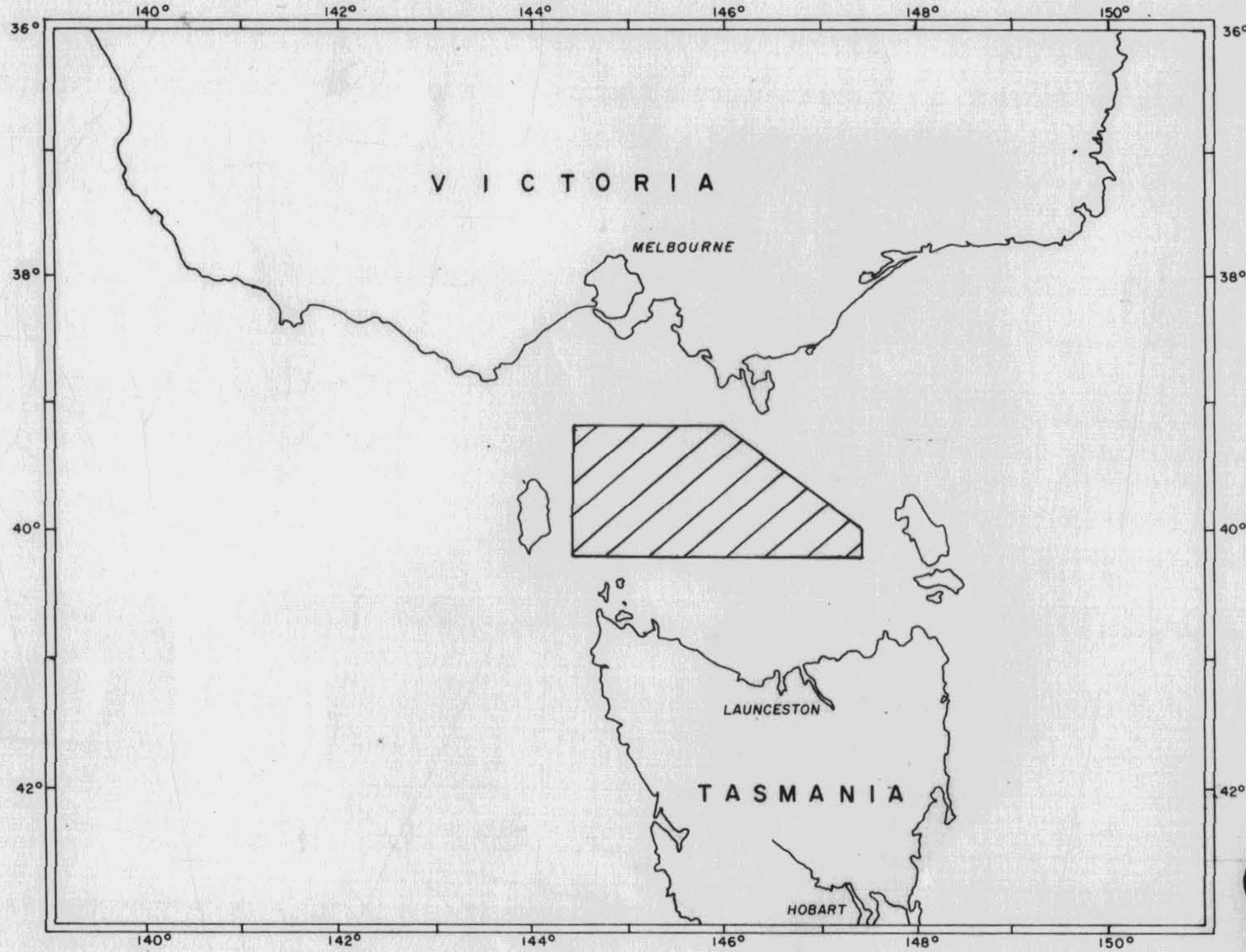
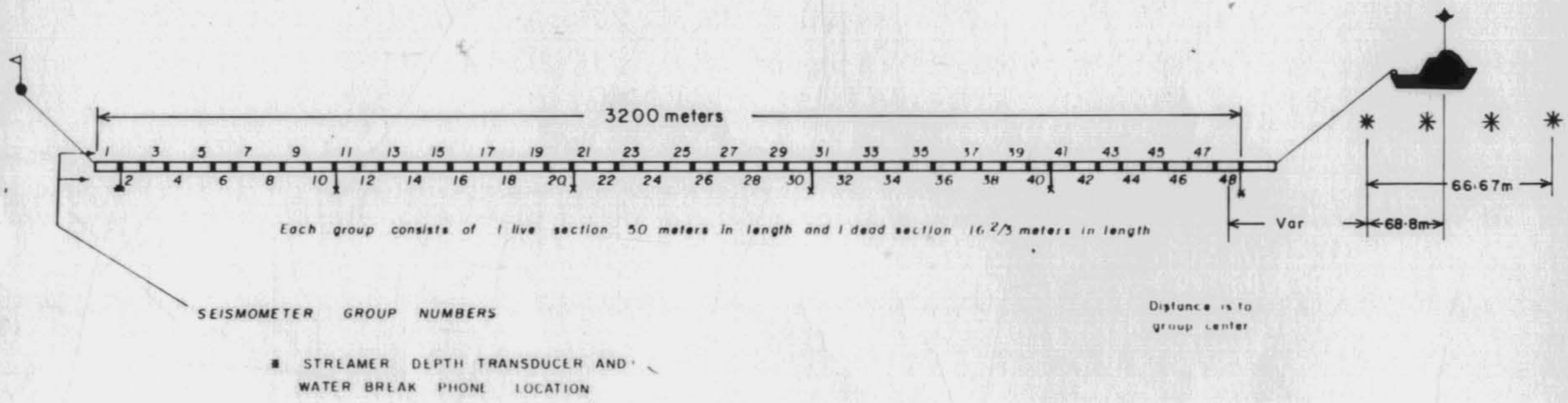
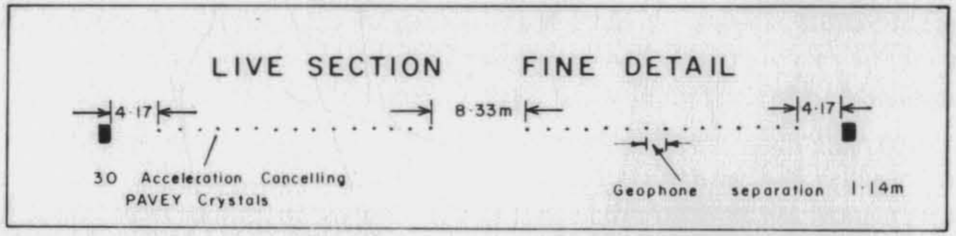



PLATE I

5 cm




| WATER BREAKS | DISPLAYED ON SEISMOGRAM TRACES | RECORDED ON TAPE CHANNELS |
|---|---|---|
| 1 | 25 & 49 | 31 |
| 2 | 48 | 28 |
| 3 | 50 | 29 |
| 4 | 49 | 31 |
| 5 | 50 | 27 |
| 6 | 48 | 28 |

5 cm

**MARINE CABLE DIAGRAM**
**3200 METER**
**(OFF END SPREAD – 48 GROUPS)**

G.S.I. Party: 931
Ship: M/V "EUGENE McDERMOTT II"
Client: HEMATITE
Area: BASS STRAIT
Date: 14 - 22 JAN. 1975

PLATE 2

600005

060C06

10·7m

| Port Gun N° | Port Gun Size | Distances | | Starboard Gun N° | Starboard Gun Size |
|---|---|---|---|---|---|
| 1 | 1·311 litres | 0m | | 17 | 1·639 litres |
| 2 | 1·311 | 0·46 | | 18 | 1·639 |
| 3 | 1·311 | 0·91 | | 19 | 1·639 |
| 4 | 1·311 | 1·37 | | 20 | 1·639 |
| 5 | 1·639 | 3·20 | 3·28 | 21 | 1·639 |
| 6 | 1·639 | 3·66 | 3·73 | 22 | 1·639 |
| 7 | 1·311 | 5·49 | 5·64 | 23 | 1·311 |
| 8 | 1·311 | 5·94 | 6·10 | 24 | 1·311 |
| 9 | 0·655 | 7·77 | 8·00 | 25 | 0·655 |
| 10 | 0·655 | 8·99 | 9·30 | 26 | 0·655 |
| 11 | 0·655 | 10·21 | 10·59 | 27 | 0·655 |
| 12 | 0·328 | 11·43 | 11·89 | 28 | 0·328 |
| 13 | 0·328 | 12·65 | 13·11 | 29 | 0·328 |
| 14 | 0·328 | 13·87 | 14·33 | 30 | 0·328 |
| 15 | 0·164 | 15·09 | 15·54 | 31 | 0·164 |
| 16 | 0·164 | 16·31 | 16·76 | 32 | 0·164 |
| PORT | | | | STARBOARD | |

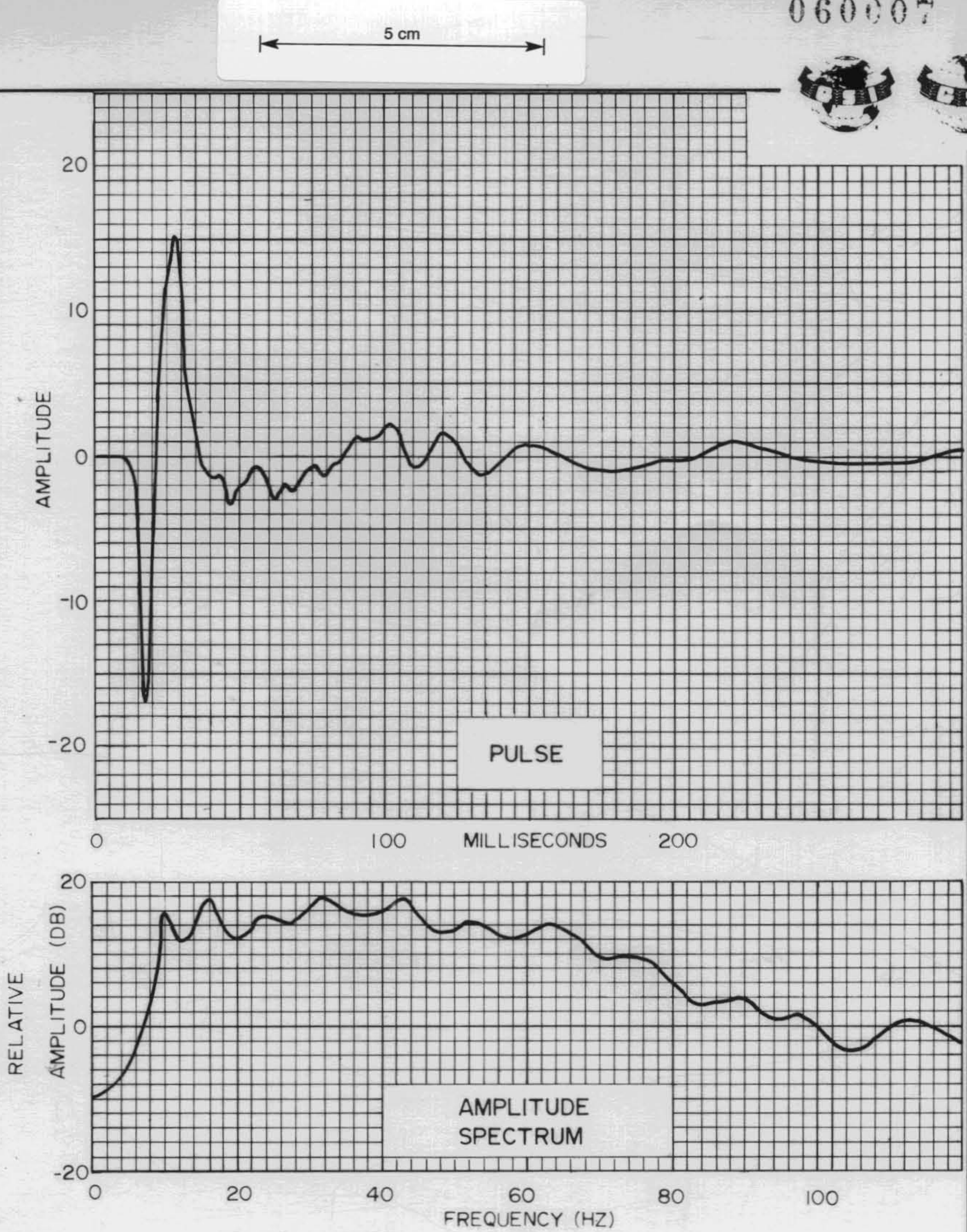
m/v EUGENE Mc DERMOTT II

AIR GUN ARRAY

5 cm

PLATE 3

060007




GUN SIZES

4 x 0·164 litres  2 x 1·311 litres

6 x 0·328 litres  2 x 1·639 litres

6 x 0·655 litres  1 x 3·278 litres

1 x 3·933 litres

AIRGUN ARRAY PULSE AND SPECTRUM

Vessel  M/V EUGENE McDERMOTT II

Array Capacity  19·665 litres

Recording Filter  0-248 Hz

Date  14 - 22 Jan. 1975.

PLATE 4

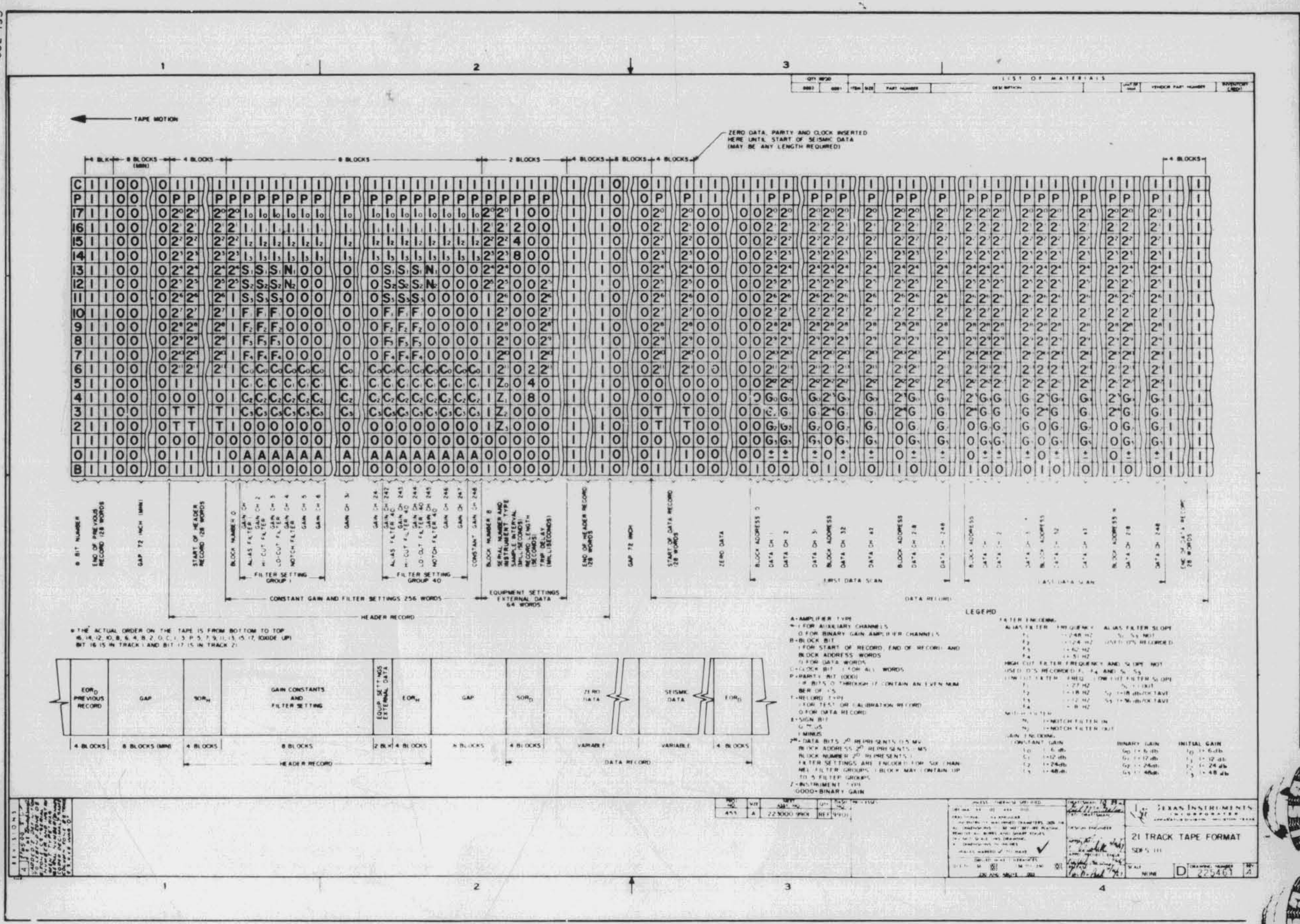



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PLATE 5

060008

5 cm

# SECTION I

## INTRODUCTION

A marine seismic reflection survey was conducted by the M.V. "Eugene McDermott II" in the Bass Strait for Hematite Petroleum Proprietary Limited between 14th January and 22nd January 1975.

Approximately 923 Kilometres of 72-fold reflection coverage were shot utilizing a 3200metre streamer under continuous tow in conjunction with a Pneumatic Acoustic Energy Source (Airguns), generally operating 24 hours per day.

Recordings were made using two sets of 24 trace DFS III's, with 3 tape transports recording on 25.4 mm magnetic tape in 21 track TIAC* Binary Gain Digital Format. Record length was 5 seconds and the sample rate was 4 milliseconds.

The ship's location was determined by Geonav II.

*Trademark of Texas Instruments Inc.

## SECTION II

## OPERATION PROCEDURES

A. RECORDING:

A Texas Instruments Digital Field System III (DFS III) with 3 tape transports was used for all recording. A Servo Writer Profiler was utilised to obtain 100% (Near Trace Gather) subsurface coverage (uncorrected section) of 4 second duration, directly from monitor recording.

Direct Read After Write (RAW) monitors were generated approximately every 20 shotpoints for quality control purposes.

B. STREAMER:

The 3200 metre, neutrally buoyant, continuous tow streamer consisted of 48 live sections each 50 metres in length and 47 dead sections each 16.67 metres in length. 6 Waterbreak/Depth Transducer sections each 1.83 metres in length, were placed in front of group 48 and between groups 40L and 40D, 30L and 30D, 20L and 20D, 10L and 10D, 1L and 1D.

Five nylon stretch sections were placed between group 48 and the recording vessel to attenuate ship generated noise. Four Condep** cable depth controllers were placed between

**Trademark of Continental Oil Company

the depth transducers on the streamer at the centre of dead sections 5D, 15D, 25D and 35D.

One nylon stretch section followed group 1 and was joined to the tailbuoy by 122 metres of nylon rope. Tailbuoy bearings were taken by radar every 40 pops to ensure that maximum feathering angle was not exceeded.

The average streamer depth was 16.6 metres.

C. ENERGY SOURCE (AIRGUNS):

An Electro-Pneumatic Acoustic Energy Source known as "Airguns" was used for all reflection work.

The airgun has basically two moving parts, the shuttle and the solenoid. Compressed air is supplied to this unit at a pressure of 13,780 kPa. The shuttle is forced to close on initial application of pressure. Compressed air fills the reservoir chamber through a central orifice in the shuttle. To discharge the gun an electrical current activates the solenoid and retracts a plunger, thus enabling compressed air to pass through a port hole to the underside of a flange at the top of the shuttle. The pressure difference above and below the shuttle then thrusts it open. The air from the chamber then escapes through four port holes near the centre of the gun and expands rapidly through the water, producing a single bubble and resultant shock wave. The air bubble collapses in a manner similar to that caused by explosives with one notable exception in that its period is controllable and is placed in the desired seismic frequency band.

There are three variables used to control the frequency content of the shock waves. These are:-

i) depth of the airgun in the water.

ii) pressure at which the gun is operated.

and

iii) size of the chambers used on the gun.

Using different guns of various chamber sizes broadens and flattens the frequency spectrum of the pulse (Plate 4).

The depth of the airguns was 7.8 metres and they were operated at a pressure of 12,400 kPa with the pressure never falling below this figure.

The individual airguns were arranged to produce an 19,665 litre array. This array consisted of:

i) 4 x 0.164 litre guns

ii) 6 x 0.328 litre guns

iii) 6 x 0.655 litre guns

iv) 2 x 1.311 litre guns

v) 2 x 1.639 litre guns

vi) 3 x 1.311 litre guns forming a
1 x 3.933 litre array

vii) 2 x 1.639 litre guns forming a
1 x 3.278 litre array

These arrays were arranged and spaced so as to operate as a tuned array which yields a flat frequency spectrum.

The time co-ordinator unit triggered the Digital Field System which in turn discharged the Texas Instrument Airgun Control Unit (Blaster), causing a current to flow simultaneously through all solenoids, resulting in the guns firing. The guns were fired every 22.22 metres giving 72-fold coverage. The airgun array was mounted on two Gun Strings, one port astern and the other starboard astern and towed behind the recording vessel at a distance of 27.4 metres from the stern to the centre of the array.

D. INSTRUMENTS AND NOISE TESTS:

Instrument tests were carried out prior to each day's operations and the results were examined in an analog form in the field. These tests consisted of Dynamic Range Determination, Amplifier Noise Test and Automatic Gain Control (AGC) Test. Frequent checks on tape speed and skew were made.

A set of monthly tests were carried out prior to commencement of operations. These tests included Harmonic Distortion, Gain Linearity, Periodic Calibration checks, skew checks and the above-mentioned tests.

The tests were analysed in the Sydney, Australia Processing Centre using TIAC routines.

A streamer noise analysis was made at the beginning of each line shot. Some of these tests were recorded on tape.

E. FATHOMETER:

A Ross Model 400A fathometer and an Elac Deneb, Model LAZ-17DDL, AGN8 fathometer were used.

The Ross fathometer operated at 50 KHz and the Elac fathometer at 15-20 KHz. Each fathogram was identified by line number, direction shot, time and date of first shotpoints and scale. The fathograms were marked every 60 pops and labelled every 120 pops. The zero line for the fathograms was not corrected for the ship's draught.

F. REFRACTION SURVEY:

Refraction data was collected on Lines HB75A-172 and HB75A-156 using Aquatronics SB68 Sonobuoys and operating at a depth of 18 metres with a twenty minute operate delay after release. The data was received aboard ship by an STR 70-2F receiver and displayed ten second records on the Servo Profiler every alternate pop.

This data appeared to be satisfactory.

G. NAVIGATION:

Positioning of the vessel and individual shotpoints throughout this prospect was controlled by Geonav, Texas Instruments satellite navigation system, a description of which is contained in Appendix E.

This system performed well in the periods of good weather but more critical attention had to be given to the data produced by the associate sensor equipment in heavy seas. There were no equipment problems with the system during this period.

H. MAPPING:

Shotpoint locations were computed and listed and maps drawn at scales of 1:100,000 and 1:250,000, using the Australian Mapping Grid parameters. This was organised by G.S.I. through Engineering Computer Services of Chandos Street, St. Leonards.

I. PERMITTING:

Permits to conduct the survey were obtained by Hematite Petroleum Pty Ltd. The Marine Operations Centre in Canberra was advised as to the ship's location throughout the survey to enable the necessary navigation warning to mariners to be issued.

# APPENDICES

APPENDIX A

KEY PERSONNEL

| | | |
|---|---|---|
| G.Shilliday | | Supervisor |
| A.Stirling | | Party Manager |
| J.Haigh | | Administrator |
| T.O'Donnell | ) | |
| W.Grise | ) | Quality Control Seismologists |
| J.Robinson | ) | |
| J.Stanton | ) | Instrument Engineers |
| R.Cowan-Lunn | ) | |
| S.Martin | ) | |
| R.Campbell | ) | Airgun Mechanics |
| C.Streeter | ) | |
| S.Simpson | ) | |
| M.Gusterson | ) | Captain |
| P.Holton | ) | |
| C.McGuinn | ) | Navigators-Geonav |
| E.Pickstone | ) | |

# APPENDIX B

## EQUIPMENT

a) Recording

i) 3200 Metre Streamer (Plate 2)

| | |
|---|---|
| Type Cable | :48 live group, neutrally buoyant, universal gland streamer 47 dead sections. |
| Length of Live Section | :50 metres |
| Length of Dead Section | :16.67 metres |
| Length of Depth Transducer Section | : 1.83 metres |
| Distance Group 1 to 48 (centres) | :3142.48 metres |
| Group Interval | :66.67 metres |
| Seismometer Type | :Pavey Acceleration Cancelling |
| Seismometers per Group | :30 |
| Seismometer Interval | :Linear, 1.14 metres except centre two which are 8.33 metres apart. |
| Sensitivity | :6.0 uV/uBar |

(ii) Recording Parameters

| | |
|---|---|
| Amplifiers | :TI DFS III Binary Gain |
| Gain Mode | :Binary Gain |
| Record Length | :Normal 5.0 seconds |
| Sample Rate | :4 Milliseconds |
| Gain Constant | :30 db. |
| Attack Rate | :1500 db/sec. |
| Final Gain | :120 db. |
| Trip | :As necessary |
| Initial Gain | :24-42 db. |
| Upper Set Limit | :62.5% and 50% |
| Lower Set Limit | :25% |
| Filter - | |
| Low Cut | : 8 Hz, 18 db/octave |
| High Cut | :62 Hz, 72 db/octave |
| Release Rate | :Fast 94 db/sec. |
| Delay time for RAW Monitors caused by displacement of RAW and record heads | :26.7 milliseconds |

iii) Data Channel Allocations - 3200 Metre Streamer

| Function | Monitor Trace No. | System | Tape Channel |
|---|---|---|---|
| Timing | - | Both | 0 |
| Streamer Odd Groups 1-47 | 1-24 | System I | 1-24 |
| Streamer Even Groups 2-48 | 31-54 | System II | 1-24 |
| Waterbreak 1 (between groups 1L & 1D) | 25&49 | Both | 31 |
| Waterbreak 2 (between groups 10L & 10D) | 48 | Both | 28 |
| Waterbreak 3 (between groups 20L & 20D) | 50 | Both | 29 |
| Waterbreak 4 (between groups 30L & 30D) | 49 | Both | 31 |
| Waterbreak 5 (between groups 40L & 40D) or Sonobuoy data | 50 | Both | 27 |
| Waterbreak 6 (in front of group 48) | 48 | Both | 28 |
| Field Timebreak | 4 | System I | - |
| Field Timebreak | 28 | System II | - |
| DFS Synthetic Timebreak | 8 | System I | - |
| DFS Synthetic Timebreak | 32 | System II | - |

B) Survey Vessel

M.V. "EUGENE McDERMOTT II"

| | |
|---|---|
| Flag | : Bahamas |
| Homeport | : Nassau |
| Trade | : Foreign Going-Seismic Exploration |
| Owners | : Worldwide Surveys Limited |
| Call Sign | : ZQA-2012 |
| Length | : 52.73 metres L.O.A. |
| Breadth | : 12.19 metres |
| Depth | : 4.27 metres |
| Draft | : 3.05 - 3.25 metres |
| Official Number | : 343728 |
| Gross Tonnage | : 929.89 tonnes |
| Net Tonnage | : 249.09 tonnes |
| Engine Power | : 2 x 839.25 KW engines |

## APPENDIX C

## OPERATION STATISTICS

| | |
|---|---|
| Prospect | : Bass Basin, HB75A |
| Operational period | : 14-22 Jan. 1975 |
| Time spent on recording | : 99 hrs 30 min |
| Time lost due to bad weather | : Nil |
| Time lost due to other reasons (includes supplies, equipment and survey failures) | : Nil |
| Field tapes used | : 215 |
| Water depth range | : 20 to 50 fathoms |
| Total production | : 933.16 Kms |
| Production shotpoints | : 13997 |
| Autofires | : - Nil |

## APPENDIX D

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Even |
|---|---|---|---|---|
| 14.1.75 | HB75-211 | 1A- 94C | | HB1 |
| | | 1A-140C | HB2 | |
| | | 95A-237C | | 3 |
| | | 141A-237C | 4 | |
| | | 238A-285C | | 4 |
| | | 238A-330C | 5 | |
| | | 286A-330C | | 6 |
| | HB75-212 | 1A- 51C | 5 | |
| | | 1A- 98B | | 6 |
| | | 52A- 60C | 7 | |
| | | 61A-209C | 8 | |
| | | 99A-104C | | 9 |
| | | 105A-253C | | 10 |
| | | 210A-293C | 11 | |
| | | 254A-293C | | 12 |
| | HB75-213 | 1A- 59C | 11 | |
| | | 1A-104C | | 12 |
| | | 60A-104C | 13 | |
| | | 105A-204C | | 13 |
| | | 105A-253C | 14 | |
| | | 205A-351C | | 15 |
| | | 254A-351C | 16 | |
| | | 352A-354B | | 16 |
| | | 352A-474C | 17 | |
| | | 355A-474C | | 18 |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Field Tape Numbers Even |
|---|---|---|---|---|
| 15.1.75 | HB75A-210 | 1A- 42C | HB20 | |
| | | 1A- 42C | | HB19 |
| | | 43A-109C | 19 | |
| | | 43A-184C | | 21 |
| | | 110A-256C | 22 | |
| | | 185A-189B | | 23 |
| | | 190A-330B | | 24 |
| | | 257A-330B | 25 | |
| | | 331A-333C | | 25 |
| | | 331A-352C | 26 | |
| | | 334B-352C | | 27 |
| | HB75A-209 | 1A- 81C | 26 | |
| | | 1A- 97C | | 27 |
| | | 82A- 97C | 28 | |
| | HB75-208 | 1A- 88C | | 28 |
| | | 1A- 88C | 29 | |
| | HB75-207 | 1C- 55C | 29 | |
| | | 1C-122C | | 30 |
| | | 56A-122C | 31 | |
| 16.1.75 | HB75-206 | 1A- 77B | | 31 |
| | | 1A-118C | 32 | |
| | | 77C-118C | | 33 |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Even |
|---|---|---|---|---|
| 16.1.75 | HB75-205 | 1A- 28C | HB32 | |
| | | 1A-104C | | HB33 |
| | | 29A-104C | 34 | |
| | | 105A-120C | | 34 |
| | | 105A-120C | 35 | |
| | HB75-204 | 1A- 54A | | 34 |
| | | 1A-134C | 35 | |
| | | 55A-134C | | 36 |
| | HB75A-193 | 1A- 55C | | 86 |
| | | 1A- 55C | 37 | |
| | | 56A-125C | | 37 |
| | | 56A-195C | 38 | |
| | | 126A-264C | | 39 |
| | | 196A-264C | 40 | |
| | | 265A-330C | | 40 |
| | | 265A-412C | 41 | |
| | | 331A-472C | | 42 |
| | | 413A-472C | 43 | |
| | | 473A-554C | | 43 |
| | | 473A-588C | 44 | |
| | | 555A-588C | | 45 |
| | HB75A-194 | 1A-106C | | 45 |
| | | 1A-106C | 46 | |
| | | 107A-126C | | 46 |
| | | 107A-126C | 47 | |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Field Tape Numbers Even |
|---|---|---|---|---|
| 16.1.75 | HB75A-195 | 1A-126C | HB47 | |
| | | 1A-131C | | HB48 |
| | | 127A-131C | 49 | |
| | HB75A-196 | 1A- 80C | | 49 |
| | | 1A-136C | 50 | |
| | | 81A-208C | | 51 |
| | | 137A-208C | 52 | |
| | | 209A-240C | | 52 |
| | | 209A-240C | 53 | |
| 17.1.75 | HB75-197 | 1A- 40C | | 52 |
| | | 1A-116C | 53 | |
| | | 41A-130C | | 54 |
| | | 117A-130C | 55 | |
| | HB75-198 | 1A- 55C | | 54 |
| | | 1A- 55C | 55 | |
| | | 56A-103C | | 55 |
| | | 56A-103C | 56 | |
| | HB75-199 | 1A- 96C | 56 | |
| | | 1A-145C | | 57 |
| | | 97A-145C | 58 | |
| | HB75-174 | 1A- 96C | | 58 |
| | | 1A-149C | 59 | |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Even |
|---|---|---|---|---|
| 17.1.75 | HB75-174 | 97A-240C | | HB60 |
| | | 150A-240C | HB61 | |
| | | 241A-288C | | 61 |
| | | 241A-384C | 62 | |
| | | 289A-436C | | 63 |
| | | 385A-436C | 64 | |
| | | 437A-528C | | 64 |
| | | 437A-577C | 65 | |
| | | 529A-577C | | 66 |
| | HB75-173 | 1A- 88C | | 66 |
| | | 1A- 88C | 67 | |
| | | 89A-144C | | 67 |
| | | 89A-232C | 68 | |
| | | 145A-288C | | 69 |
| | | 233A-288C | 70 | |
| | | 289A-295C | | 70 |
| | | 289A-295C | 71 | |
| | | 296A-376C | 70 | |
| | | 296A-392C | | 72 |
| | | 377A-392C | 73 | |
| | HB75-175 | 1A-119C | 73 | |
| | | 1A-119C | | 74 |
| | HB75-191 | 1A- 75C | 75 | |
| | | 1A- 75C | | 76 |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Even |
|---|---|---|---|---|
| 17.1.75 | HB75-190 | 1A- 64C | HB75 | |
| | | 1A-136C | | HB77 |
| | | 65A-136C | 78 | |
| | | 137A-208C | | 78 |
| | | 137A-285C | 79 | |
| | | 209A-344C | | 80 |
| | | 286A-344C | 81 | |
| | | 345A-424C | | 81 |
| | | 345A-493C | 82 | |
| | | 425A-568A | | 83 |
| | | 494A-568A | 84 | |
| | | 568B-605C | | 84 |
| | | 568B-605C | 85 | |
| 18.1.75 | HB75-186 | 1A- 32C | | 84 |
| | | 1A-108C | 85 | |
| | | 33A-179C | | 86 |
| | | 109A-179C | 87 | |
| | | 180A-256C | | 87 |
| | | 180A-328C | 88 | |
| | | 257A-404C | | 89 |
| | | 329A-404C | 90 | |
| | | 405A-477C | | 90 |
| | | 405A-555C | 91 | |
| | | 478A-624C | | 92 |
| | | 556A-624C | 93 | |
| | | 625A-704C | | 93 |
| | | 625A-719C | 94 | |
| | | 705A-719C | | 95 |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Field Tape Numbers Even |
|---|---|---|---|---|
| 18.1.75 | HB75-188 | 1A- 52C | HB94 | |
| | | 1A-134C | | HB95 |
| | | 53A-134C | 96 | |
| | | 135A-199C | | 96 |
| | | 135A-199C | 97 | |
| | HB75A-184 | 1A- 83B | 97 | |
| | | 1A-149C | | 98 |
| | | 84C-149C | 99 | |
| | | 150A-224C | | 99 |
| | | 150A-296C | 100 | |
| | | 225A-296C | | 101 |
| | HB75A- 84 | 1A- 64C | | 101 |
| | | 1A- 64C | 102 | |
| | | 65A-144C | | 102 |
| | | 65A-208C | 103 | |
| | | 145A-288C | | 104 |
| | | 209A-288C | 105 | |
| | | 289A-297C | | 105 |
| | | 289A-297C | 104 | |
| | HB75-180 | 1A- 48C | | 105 |
| | | 1A-128C | 106 | |
| | | 49A-192C | | 107 |
| | | 129A-192C | 108 | |
| | | 193A-273C | | 108 |
| | | 193A-333C | 109 | |
| | | 274A-333C | | 110 |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Even |
|---|---|---|---|---|
| 18.1.75 | HB75A-178 | 1A- 80C | | HB110 |
| | | 1A- 80C | HB111 | |
| | | 81A-145C | | 111 |
| | | 81A-224C | 112 | |
| | | 146A-288C | | 113 |
| | | 225A-288C | 114 | |
| | | 289A-310C | | 114 |
| | | 289A-310C | 115 | |
| 19.1.75 | HB75-172 | 1A- 50C | | 114 |
| | | 1A-103C | 115 | |
| | | 51A-176C | | 116 |
| | | 104A-176C | 117 | |
| | | 177A-248C | | 117 |
| | | 177A-326C | 118 | |
| | | 249A-399C | | 119 |
| | | 327A-399C | 120 | |
| | | 400A-475C | | 120 |
| | | 400A-549C | 121 | |
| | | 476A-624C | | 122 |
| | | 550A-624C | 123 | |
| | | 625A-696C | | 123 |
| | | 625A-771C | 124 | |
| | | 697A-793C | | 125 |
| | | 772A-793C | 126 | |
| | HB75A-156 | 1A- 50C | | 125 |
| | | 1A- 50C | 126 | |
| | | 51A-125C | | 126 |
| | | 51A-198C | 127 | |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Field Tape Numbers Even |
|---|---|---|---|---|
| 19.1.75 | HB75A-156 | 126A-271C | | HB128 |
| | | 199A-271C | HB129 | |
| | | 272A-345C | | 129 |
| | | 272A-413C | 130 | |
| | | 346A-464C | | 131 |
| | | 414A-464C | 132 | |
| | | 465A-512C | | 132 |
| | | 465A-584C | 133 | |
| | | 513A-656C | | 134 |
| | | 585A-656C | 135 | |
| | | 657A-677C | | 135 |
| | | 657A-677C | 136 | |
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| | HB75A-182 | 1A- 64C | | 137 |
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| | | 1A- 80C | 139 | |
| | | 17A-160C | | 140 |
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| | | 161A-224C | | 141 |
| | | 161A-305C | 142 | |
| | | 225A-365C | | 143 |
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| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Even |
|---|---|---|---|---|
| 20.1.75 | HB75A-201 | 1A- 20C | | HB144 |
| | | 1A- 20C | HB145 | |
| | HB75A-201 | 1A- 64C | | 144 |
| | | 1A-128C | 145 | |
| | | 65A-211C | | 146 |
| | | 129A-211C | 147 | |
| | | 212A-276C | | 147 |
| | | 212A-361C | 148 | |
| | | 277A-418C | | 149 |
| | | 362A-418C | 150 | |
| | HB75A-200 | 1A- 88C | | 150 |
| | | 1A-149C | 151 | |
| | | 89A-232C | | 152 |
| | | 150A-232C | 153 | |
| | | 233A-296C | | 153 |
| | | 233A-380C | 154 | |
| | | 297A-432C | | 155 |
| | | 381A-432C | 156 | |

| Date | Line Number | Shotpoints | Field Tape Numbers Nears | Fars |
|---|---|---|---|---|
| 20.1.75 | HB75A-192 | 1A- 88C | | HB156 |
| | | 1A-144C | HB157 | |
| | | 89A-207C | | 158 |
| | | 145A-207C | 159 | |
| | HB75-189 | 1A- 81C | | 159 |
| | | 1A-144C | 160 | |
| | | 82A-216C | | 161 |
| | | 145A-216C | 162 | |
| | | 217A-281C | | 162 |
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| | | 282A-372C | | 164 |
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| | HB75A-187 | 1A- 48C | | 164 |
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| | | 137A-151C | | 167 |
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| | | 1A-128C | | 167 |
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| | | 129A-184C | | 168 |
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| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Even |
|---|---|---|---|---|
| 21.1.75 | HB75A-172 A | 537A-600C | HB188 | |
| | | 537A-673C | | HB189 |
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| | | 745A-793C | | 192 |
| | HB75A-114 | 1A- 72C | | 192 |
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| | | 73A-136C | | 194 |
| | | 137A-208C | 194 | |
| | | 137A-280C | | 195 |
| | | 209A-352C | 196 | |
| | | 281A-307C | | 197 |
| | | 308A-448C | | 198 |
| | | 253A-357C | 199 | |
| | | 358B-496C | 200 | |
| | | 449A-451A | | 199 |
| | | 451B-597C | | 201 |
| | | 497A-498C | 199 | |
| | | 499A-648C | 202 | |
| | | 600A-749C | | 203 |
| | | 651A-799C | 204 | |
| | | 752A-899C | | 205 |
| | | 802A-928C | 206 | |
| | | 902A-928C | | 207 |

| Date | Line Number | Shotpoints | Field Tape Numbers Nears | Fars |
|---|---|---|---|---|
| 21.1.75 | HB75-177 | 1A- 56C | HB184 | |
| | | 1A-128C | | HB185 |
| | | 57A-128C | 186 | |
| | | 129A-173C | | 186 |
| | | 129A-173C | 187 | |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Even |
|---|---|---|---|---|
| 21.1.75 | HB75A-172 | 537A-600C | HB188 | |
| | | 537A-673C | | HB189 |
| | | 601A-744C | 190 | |
| | | 674A-744C | | 191 |
| | | 745A-793C | 191 | |
| | | 745A-793C | | 192 |
| | HB75A-114 | 1A- 72C | | 192 |
| | | 1A-136C | 193 | |
| | | 73A-136C | | 194 |
| | | 137A-208C | 194 | |
| | | 137A-280C | | 195 |
| | | 209A-352C | 196 | |
| | | 281A-307C | | 197 |
| | | 308A-448C | | 198 |
| | | 253A-357C | 199 | |
| | | 358B-496C | 200 | |
| | | 449A-451A | | 199 |
| | | 451B-597C | | 201 |
| | | 497A-498C | 199 | |
| | | 499A-648C | 202 | |
| | | 600A-749C | | 203 |
| | | 651A-799C | 204 | |
| | | 752A-899C | | 205 |
| | | 802A-928C | 206 | |
| | | 902A-928C | | 207 |

| Date | Line Number | Shotpoints | Field Tape Numbers Nears | Fars |
|---|---|---|---|---|
| 22.1.75 | HB75A-176 | 1A- 96C | | HB208 |
| | | 1A-147C | HB209 | |
| | | 97A-147C | | 210 |
| | | 148A-154C | 210 | |
| | | 148A-267C | | 211 |
| | | 155A-301C | 212 | |
| | | 268A-301C | | 213 |
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APPENDIX E

GEONAV POSITIONING SYSTEM

# APPENDIX E

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APPENDIX E*

GEONAV** POSITIONING SYSTEM

A. INTRODUCTION

The GeoNav integrated marine navigation system records and displays continuous position computed from U.S. Navy navigation satellite, doppler sonar, gyrocompass, attitude control, and velocimeter data. The system performs automatic line and shot control based on distance-measured equal shotpoint spacing along the great circle path between the end positions of a seismic line.

B. FIELD OPERATION

The GeoNav system computes the great-circle path for a seismic line based on end points input as geographical positions by the GeoNav operator. While on-line, the vessel's deviation from the great-circle path is plotted on a pair of track plotters to a preset scale (normally 200 m/in). One of these plotters is on the bridge, where the helmsman steers the vessel to minimize deviations as they are plotted.

Automatic shot control is obtained by measuring the distance traveled on the surface. Each time the required pop interval is traversed the digital field system and the shot relay for the seismic energy source are activated automatically. The required pop interval is computed from group and coverage information input by the operator.

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* This appendix is adapted from a paper entitled, "Self-contained Quality Control in Marine Satellite Navigation," by John M. Hughes and Rudolf Unger, presented at the 27th Annual Meeting of the Institute of Navigation, June 29, 1971 in Pasadena, California.

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The line and shot control module allows for extensions at either end of a line, line deflections (doglegs), and circling. In all these cases, continuity of shotpoint spacing along the great-circle path is preserved automatically. Subsurface coverage at the beginning and end of a line is guaranteed by taking into account possible position shifts due to satellite fix corrections and by computing the appropriate lead-in and lead-out. The track-plotters output a special lead-in display for each line and annotates line parameters, shotpoints, and satellite fixes.

All shotpoint positions, line parameters, position fixes, and other relevant navigation data are recorded on magnetic tape. Hardcopy redundancy of this recorded data is provided by teletype printout and track-plotter annotation.

## C. POST MISSION PROCESSING

The navigation accuracy obtainable in real time is improved in post mission processing by infinite time smoothing of the recorded navigation data. Shotpoint and satellite fix positions are weighted against "past" and "future" position information using statistical filtering parameters based on satellite variance estimates and velocity and heading calibration factors output at each satellite fix.

Post mission processing also computes the position shift from satellite receiver antenna position to any desired offset position (seismic source, common depth points, etc.), and the position shift due to conversion from the APL* satellite system reference ellipsoid to a given local datum.

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*Applied Physics Laboratory, Johns Hopkins University.

The post mission processing end product is the computerized map and listing of transverse Mercator projected positions.

D. SYSTEM DESCRIPTION

1. General

The GeoNav system establishes its absolute geographical location from information transmitted by satellites of the U.S. Navy Navigational Satellite System. The vessel's continuous path of travel is computed by a dead reckoning system consisting of a velocity measurement system (VMS) and an azimuth measurement system (AMS). The VMS derives its values from four-beam independent doppler sonar velocity measurements compensated for the ship's pitch and roll, and for variations in the sound propagation velocity. The AMS consists of a gyrocompass externally compensated for the ship's dynamics.

At intervals averaging approximately 1.5 hours at the equator and less at higher latitudes, the dead reckoned position is corrected by a satellite position fix. Each satellite fix printout contains an estimate of fix accuracy and provides calibration factors for the dead reckoning system. In this manner, a self-contained quality control is established.

The Navy currently has five satellites in non-synchronous, circular, polar orbits of about 600 mi. altitude. A core memory onboard the satellite contains its orbital position information which is updated approximately every 12 to 18 hours from ground tracking and injection stations. The satellite continuously transmits this data as its navigation message phase encoded onto two carrier frequencies.

The vessel's satellite receiver automatically locks onto the satellite signals when it appears in sight. A satellite pass may have a duration of up to 20 minutes during which period the satellite navigation message is redundantly received, and a number of integrated doppler frequency shift (doppler count) measurements are acquired. From the navigation message the satellite positions along its orbit are derived. The doppler counts yield measures of range difference between the vessel position and the satellite positions along its orbit. Comparing the doppler shifts of the two carrier frequencies permits elimination of the ionospheric refraction influence. Automatic data editing and an iterative process of fitting computed and measured range differences ultimately result in a correction to the dead reckoned position.

Besides the tasks of navigation and data quality control, the GeoNav computer performs the line and shot control as described in Section B.

2. Detailed Description

Figure 1 is a block diagram of the GeoNav system as configured for GSI. The system employs a Magnavox MX702CA satellite receiver configured for the transfer of doppler counts synchronized with the completion of each line of the satellite message (a line takes 4.6 sec of the 2-min cycle). This permits implementation of the so-called "short doppler" satellite solution whereby the doppler counts are integrated over segments corresponding to an integer multiple of satellite lines.

The satellite receiver also receives both of the two transmitted satellite frequencies, demodulates the signals, and organizes the demodulated bits into 12-bit data words for transfer to the computer. Each 12-bit data word is accompanied by three bits of code which identify the nature of the data being transferred. Also a part of the satellite receiver is a 5-MHz oven-stabilized crystal oscillator which is the reference oscillator for the

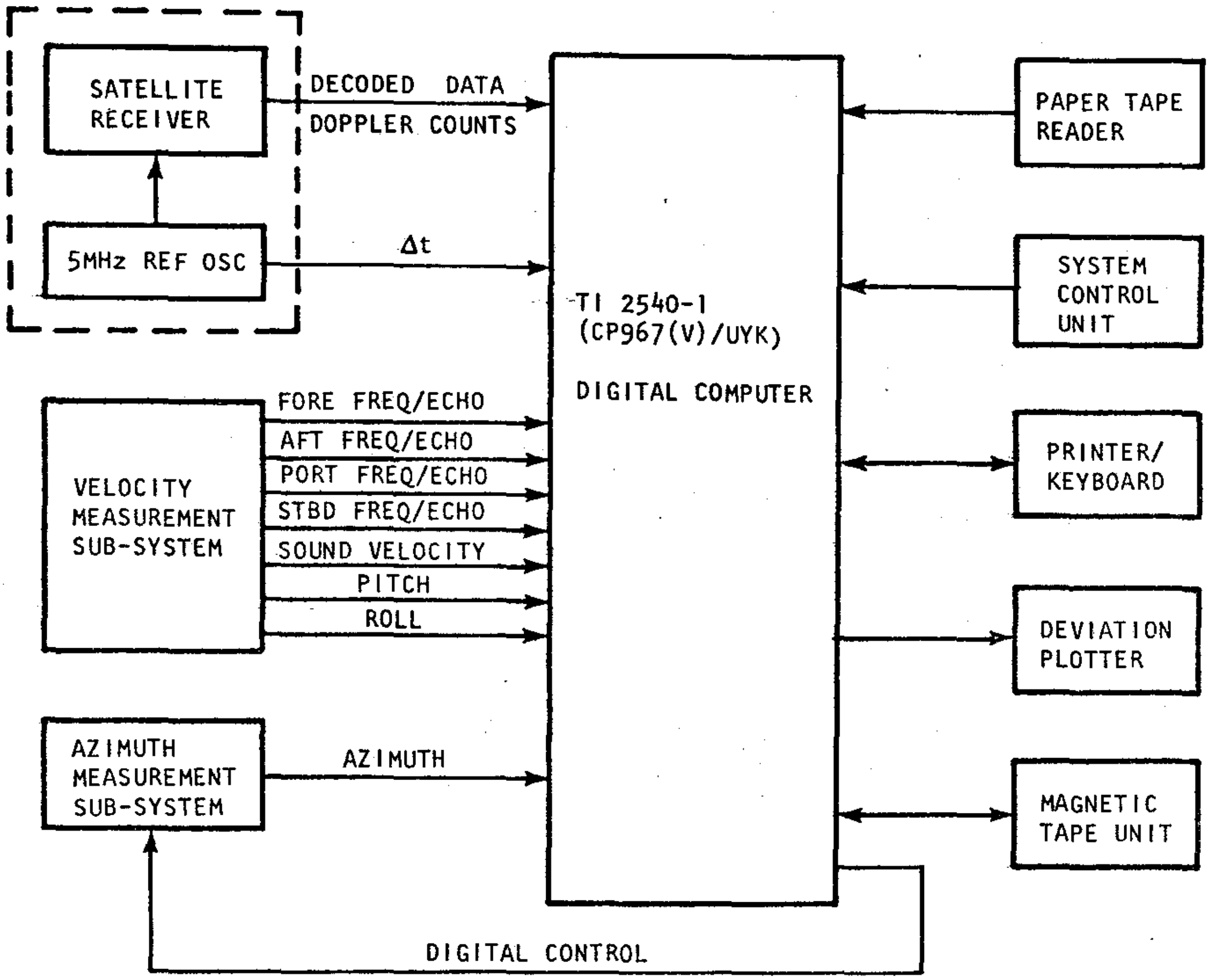


Fig. 1. GeoNav System Block Diagram.

satellite receiver in addition to being the relative time reference for the GeoNav system.

Figure 2 is a block diagram of the GeoNav velocity measurement subsystem. The sonar transducer and associated electronics are the Edo Western 435C pulse-frequency tracking system modified by Texas Instruments to yield only the frequencies of the four sonar beams (Figure 2 shows only one channel) and the time of arrival of their echoes.

The GeoNav velocity measurement subsystem provides parameters for computing the vessel's velocity in a plane tangent to the earth's surface. Components of this velocity are the projections of the ship's fore-aft and port-starboard axes on this tangent plane. To permit navigation from these data, these velocity vectors must be resolved into velocity components in northerly and easterly directions.

Figure 3 is a block diagram of the GeoNav azimuth measurement subsystem. Basic to it is the Sperry MK227-0 gyrocompass which provides X1 and X36 synchro outputs of vessel azimuth in addition to a 400-Hz reference, the amplitude of which is modulated by control from the computer, utilizing an amplitude modulator built by Texas Instruments. This external control from the computer is derived from an algorithm which compensates the gyrocompass for the effects of vessel dynamics on the compass.

A synchro-to-digital converter, Astrosystems A603-5-S149, translates the X1 and X36 information from the gyrocompass to digital form for transfer to the computer. Now available is the information necessary to resolve the data from the velocity measurement subsystem into components of velocity in northerly and easterly directions in the local earth-tangent plane. Basic instrument accuracies are shown in Table I.

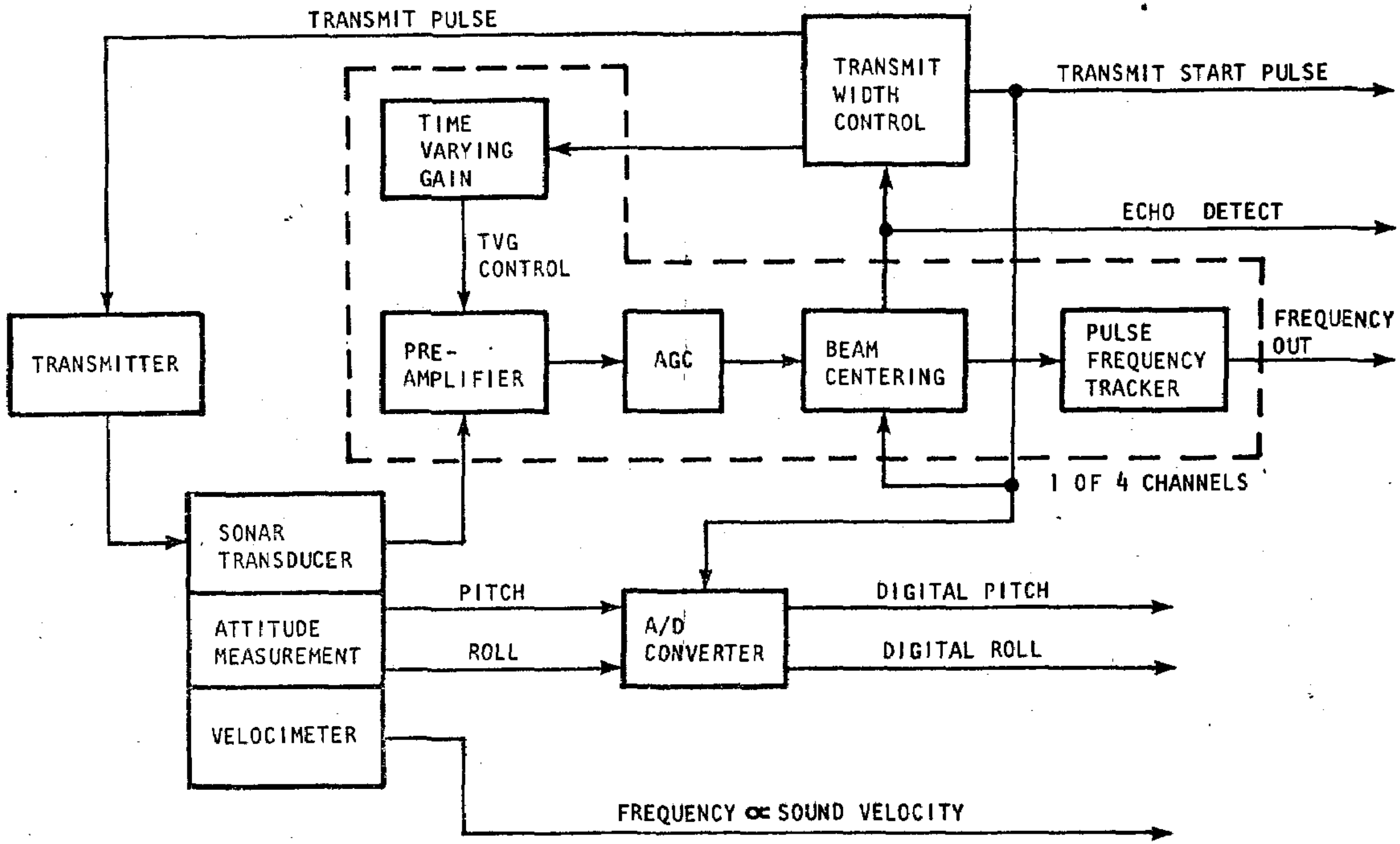


Fig. 2. Velocity Measurement Subsystem Block Diagram

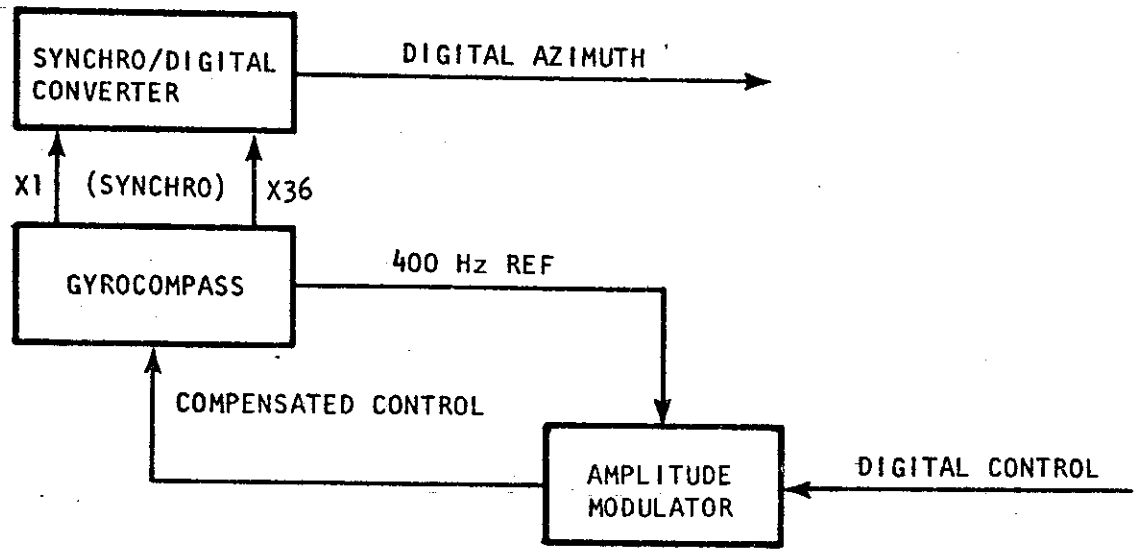


Fig. 3. Azimuth Measurement Subsystem Block Diagram.

Table I. Instrument Accuracy

| Unit | Accuracy |
|---|---|
| Gyrocompass (with compensation) | $0.2^{o}$ |
| Doppler Sonar | |
| <100 Ftm | 0.2% |
| 100-160 Ftm | 0.5% |
| Inclinometer | $0.1^{o}$ |
| Velocimeter | 0.01% |

Focal point of the GeoNav system is the TI 2540-3 (CP967(V)/UYK) digital computer; all sensor data must pass through the computer, and consequently, can be monitored by it. The GeoNav operating system software performs the satellite-fix solution and supplies velocity and azimuth measurement subsystem data to the dead reckoning system. The computer also performs position filtering, quality control of all sensors, and seismic-line and shot control. In this manner, data from all sensors are integrated to provide optimum continuous navigation, guidance, and shot control. In addition, data from the velocity measurement subsystem are used to compute the water depth for each sonar transmit/receive cycle. An extension of this technique permits using the system in bottom topography studies.

The system control panel, digital plotter, and printer/keyboard permit effectively using system outputs and system communications. A magnetic-tape unit is included for hardcopy data recording to permit post mission analysis.

The computer monitors the basic measurement processes of the various sensors. Anomalous measurements are noted and compensated for. The following paragraphs detail the techniques employed.

## E. GEONAV SELF CONTAINED QUALITY CONTROL

### 1. Continuous Sensor Quality Control

The doppler sonar and associated parameters necessary for velocity measurement are of foremost importance. The basic sonar measurement provides a component of frequency from each of the four sonar axes (fore, aft, port, and starboard. These measurements are relative to the plane to which the sonar transducer is attached. Since this plane is normally free to roll and pitch with the vessel, vessel attitude must be measured. For similar reasons, the velocity of the vessel must be measured normal to the sonar transducer mounting plane. These sonar frequency measurements must be corrected for the velocity of sound in water. To complete the data set, the frequency of the transmitted sonar energy is required to resolve the velocity component normal to the sonar mounting plane.

In all cases, the basic measurement data are examined by the computer for reasonableness and rate of change; if found anomalous, the GeoNav operating system alerts the operator to the error condition. This is the most basic level of system quality control.

Another ancillary item of data measured by GeoNav is the time of arrival of the echoes from the four sonar beams with respect to the transmitted energy pulse. These measurements permit extension of GeoNav sonar quality control to include reasonableness of the locale of the sonar echoes. When combined with sound velocity data, these measurements extend GeoNav's usefulness as a depth-controlling device. The four sonar echoes per transmitted pulse also provide a powerful tool for bottom topography studies.

Likewise, data from the azimuth measurement subsystem are examined for reasonableness of magnitude and rate of change. The operator is informed of anomalies.

The value of this method of quality control is limited, however, since the rate of change of the variables can legitimately vary over a large range depending on the vessel's design and sea conditions. Hence, a wide range of variation must be permitted. Similarly, individual anomalous values are useful only in detecting obvious hardware malfunctions. What is required is an alternative means of verifying a sensor's performance by comparing its data with data from another source. The following paragraphs describe how GeoNav does this.

2. Quality Control on Satellite Position Fixes

Digital data received from the orbiting satellites are independent of the velocity and azimuth measurement subsystems comprising the dead reckoning system. Since the vessel's velocity and azimuth do affect the doppler count, fixes derived from the decoded data and associated doppler counts are not independent of the dead reckoning system. The following describes the quality control that verifies incoming satellite data, quality assurance during computation, and interpretation of results, all of which permits use of satellite fixes as independent references.

All data received from a satellite observation are preserved in the computer's memory. At the end of a satellite pass, the software performs a validation sequence verifying the quality of incoming data. Since the same data is received several times during one pass of the satellite, one validity test is to see whether repeated data bits actually appear identical in the computer. This bit majority voting is performed on like bits of like parameters over the entire range of redundant satellite messages stored in memory. In the event the bit error rate is excessive, the entire satellite observation is invalidated and the operator informed of the excessive error rate. When this occurs, it is highly probable that there is a noisy receiver channel requiring repair or, less likely, a bad satellite being observed.

The two frequencies transmitted by the satellite are received by GeoNav, and the doppler counts received from the two receiver channels are preserved in memory. These data are reduced to refraction counts and compared against preset limits to insure reasonable refraction data. In case the refraction counts are not reasonable, the pass is rejected and the operator alerted that the receiver should be verified for proper operation of the doppler counters. All data are validated automatically in preparation for entering the satellite solution.

The bit majority voting scheme is altered when a satellite injection is detected. In this instance, the system attempts to utilize only data received following the injection to insure that the most current data and the best prediction of the satellite's orbit is used in the position-fix solution. Data received before the injection is ignored and replaced as necessary by extrapolating back based on parameters received after the injection, using curve-fitting techniques. Similar techniques are used to interpolate for parameters which may have been missed due to poor signal quality, fade, etc., or for parameter points at the short doppler intervals selected by the software system. The choice of whether to extrapolate is based on whether the following conditions (arranged in decreasing importance) can be achieved.

- A data set of valid fixed parameters
- A minimum range requiring extrapolation of variable parameters yet still coinciding with the maximum range of good doppler counts

- Maximum range of valid variable parameters
- Most recent data

This concludes the preprocessing of satellite data. The resulting data set is free of erroneous message data and invalid doppler counts.

Further quality control of satellite fixes is handled as an editing function. Inasmuch as satellite doppler and, more especially, the refraction count are known to degrade when the satellite is near the horizon, doppler counts received below 7.5$^{o}$ are rejected.

Another quality control tool available to GeoNav operators is a constant which specifies the minimum number of short doppler intervals on both sides of the satellite's closest approach which the software (GNSDOP) will demand before computing a fix. This constant insures symmetricity of the data (same number of short doppler counts on each side of closest approach) and is an indirect control of the minimum satellite elevation angle acceptable to the system. If, after checking the aforementioned editing criteria the system determines that there is the required symmetricity but not enough data above 7.5$^{o}$ (at least 10 short doppler intervals), the editing software will accept just enough short doppler segments below 7.5$^{o}$ (maintaining symmetricity) to meet minimum requirements.

Additional control permits rejection of an entire satellite observation if any portion of the data was collected while the observation angle exceeded some angle selected by the operator. This angle is typically 70$^{o}$ to 75$^{o}$ and is adjusted according to satellite alerts for the area of operation.

The preceding paragraphs describe some major elements of editing included in the GeoNav satellite software package. Together, all of these insure a high degree of quality for the data entering into a satellite-fix solution and intermediate to the solution. To use the resulting fix effectively as a measure of the quality of the GeoNav sensor subsystem data, the quality of a given fix solution must be measured. The GeoNav system does this with a unique, proprietary algorithm that estimates statistical variances north and east for the satellite fix. These estimates are not derived from *a priori* statistics of satellite fixes versus elevation angle but from only the incoming satellite data set. Figure 4 is a bull's-eye of satellite-fix distribution from a set of 100 fixes received in GSI's Dallas laboratory. These data were recorded with a minimum requirement of five short doppler segments on both sides of closest approach and with a maximum elevation angle of 75°.

The foregoing discussion covers the condition in which the satellite receiver is stationary. To obtain experimental data, a week of satellite observations were recorded on magnetic tape using a GeoNav system operating with the standard operating software. The resulting satellite fixes were tabulated, and known velocity and heading errors were introduced into the dead-reckoning or navigator's estimates. The satellite fixes were then recomputed and compared with the previously tabulated data and plotted. The resulting curves are those shown in Figures 5 and 6. It is noteworthy that the major component of satellite-fix error versus velocity error is that previously published in numerous journals. However, the smaller component of fix error shows a tendency to split, depending on the direction of satellite travel with respect to the observer, e.g., clockwise or counter-clockwise. These errors are as shown for 1 knot north in Figure 5 and 1 knot east in Figure 6 at latitude 32°N. These curves would converge to zero at the equator and be in reversed orientation in the southern hemisphere. In either

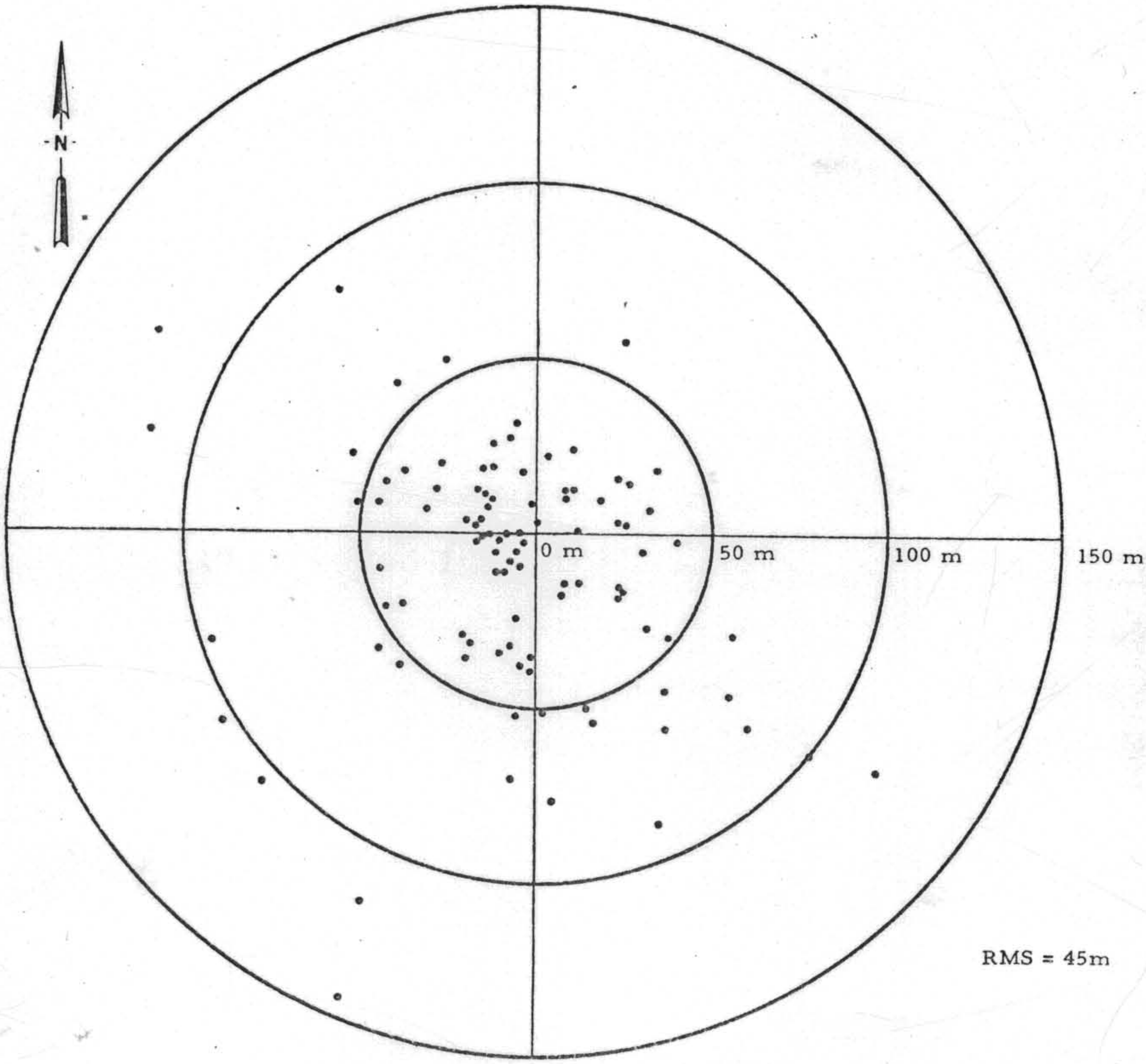


Fig. 4. Satellite-Fix Distribution.

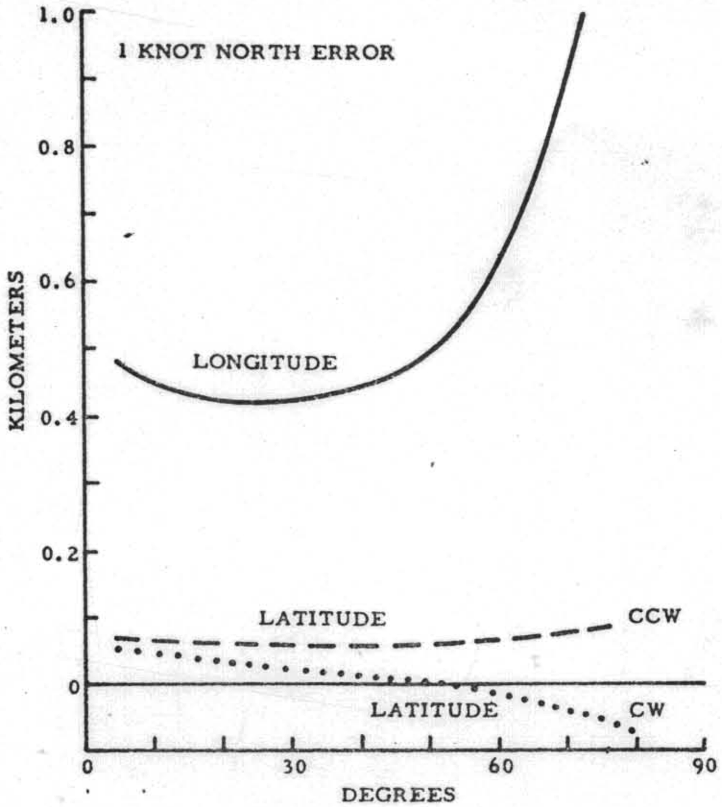


Fig. 5. Satellite Fix errors at Latitude 32°N, Due to Forced Dead Reckoning Errors.

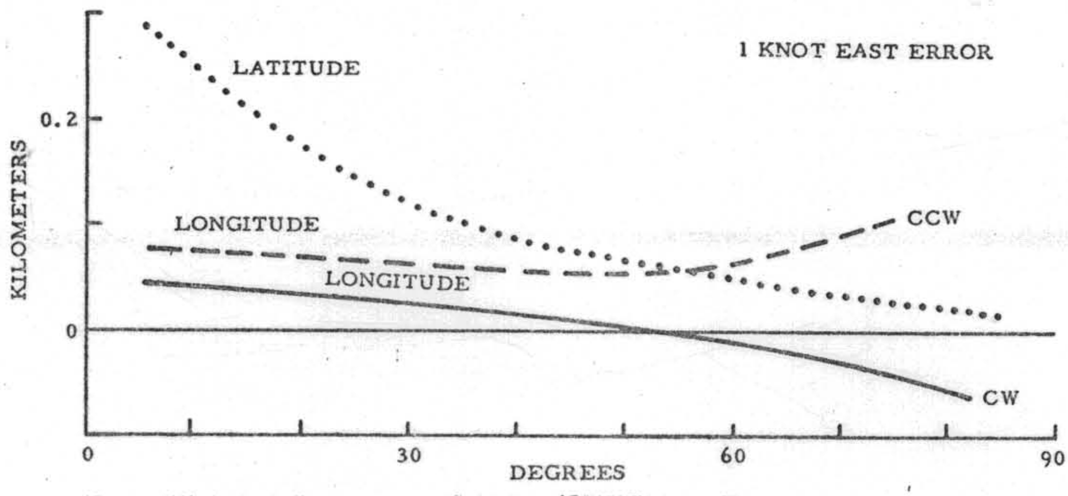


Fig. 6. Satellite Fix Errors at Latitude 32°N, Due to Forced Dead Reckoning Errors.

hemisphere, the magnitude of the error diverges as the pole is approached. In short, major satellite-fix errors are caused by dead-reckoning error, but the magnitude of these errors is such that they should be readily recognized. Hence, the problem reverts to one of identifying quality in a satellite-fix computation.

The previously described variances provided as part of the satellite-fix solution are independent of dead-reckoning error. To obtain a measure of the reliability of the variance computation, a set of satellite fixes was tabulated in the laboratory and each result and its variance estimates compared with the known antenna location. The curves shown in Figure 7 were obtained where the data were plotted as standard deviation versus satellite elevation angle. Figure 8 shows the same type of data recorded in the Far East while operating at approximately $40^{\circ}$S latitude. Figure 9 shows the difference between the variance estimate in the laboratory and the actual position error. This curve shows that the reliability of the variance estimate decreases at low elevation angles but that the estimate is reliable for satellites in the range $15^{\circ}$ to $70^{\circ}$. Note that the error estimate tends to exceed the actual error, thereby avoiding an over-dependence on the satellite fix results. Hence, we have a reference with a reliable estimate of its accuracy which we can now use as a tool for verifying the quality of the velocity and azimuth measurement subsystems.

3. <u>Velocity/Heading Quality Control</u>

Velocity and azimuth subsystem performance can be evaluated by relating the position correction resulting from a satellite position fix to the distance between fixes. See Figure 10.

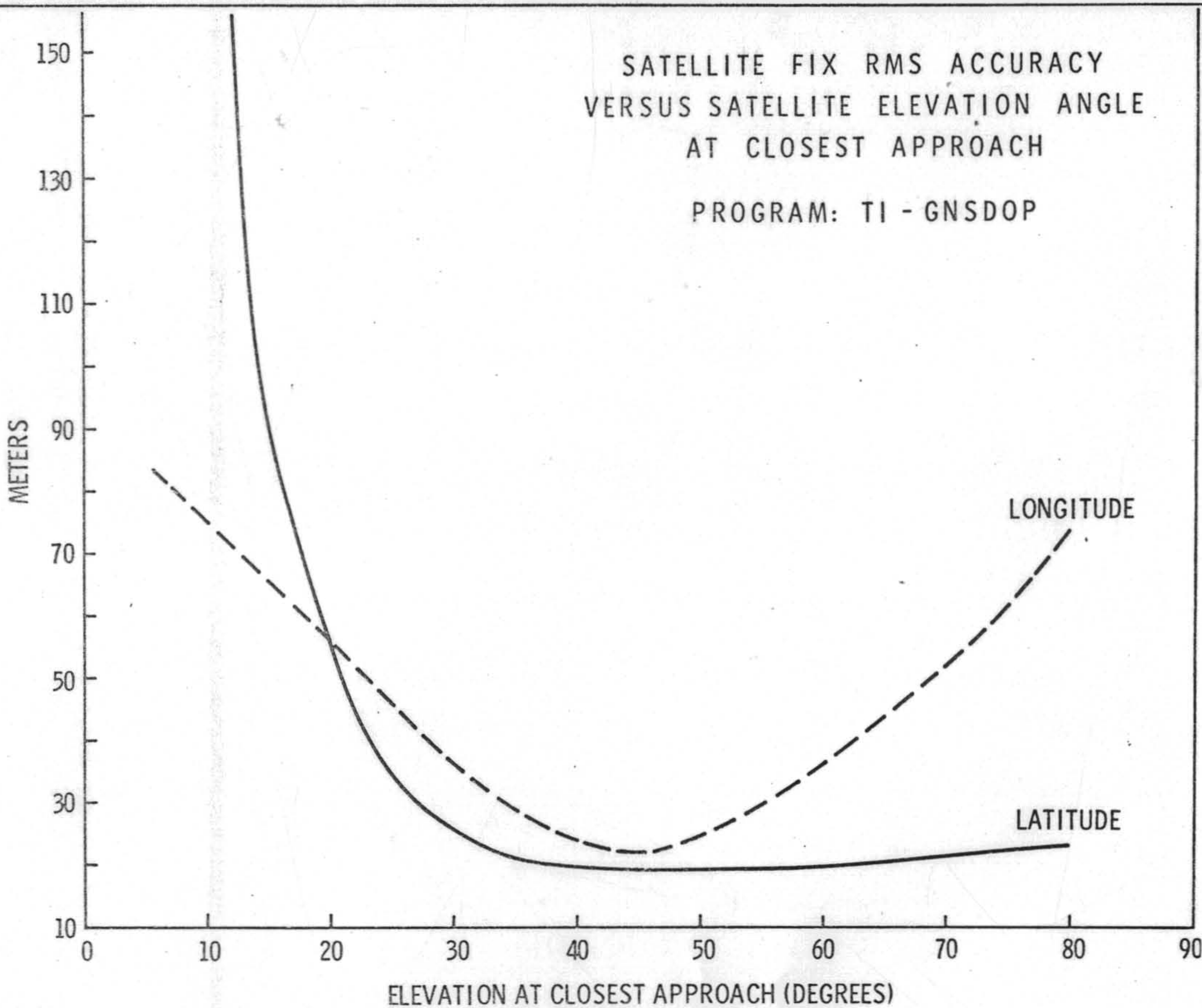


Fig. 7. Standard Deviation Versus Satellite Elevation Angle.

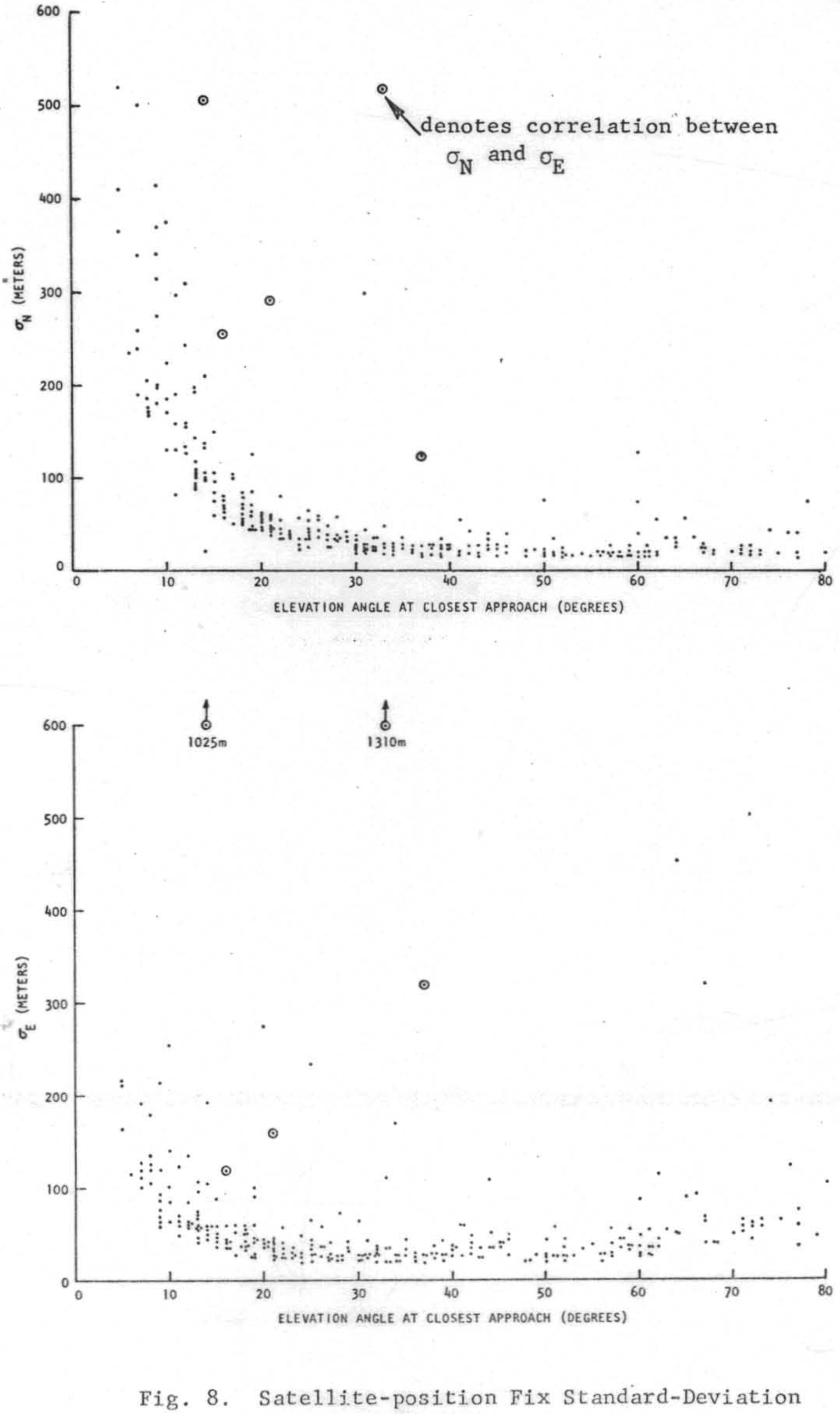


Fig. 8. Satellite-position Fix Standard-Deviation Estimate, Far East.





5 cm

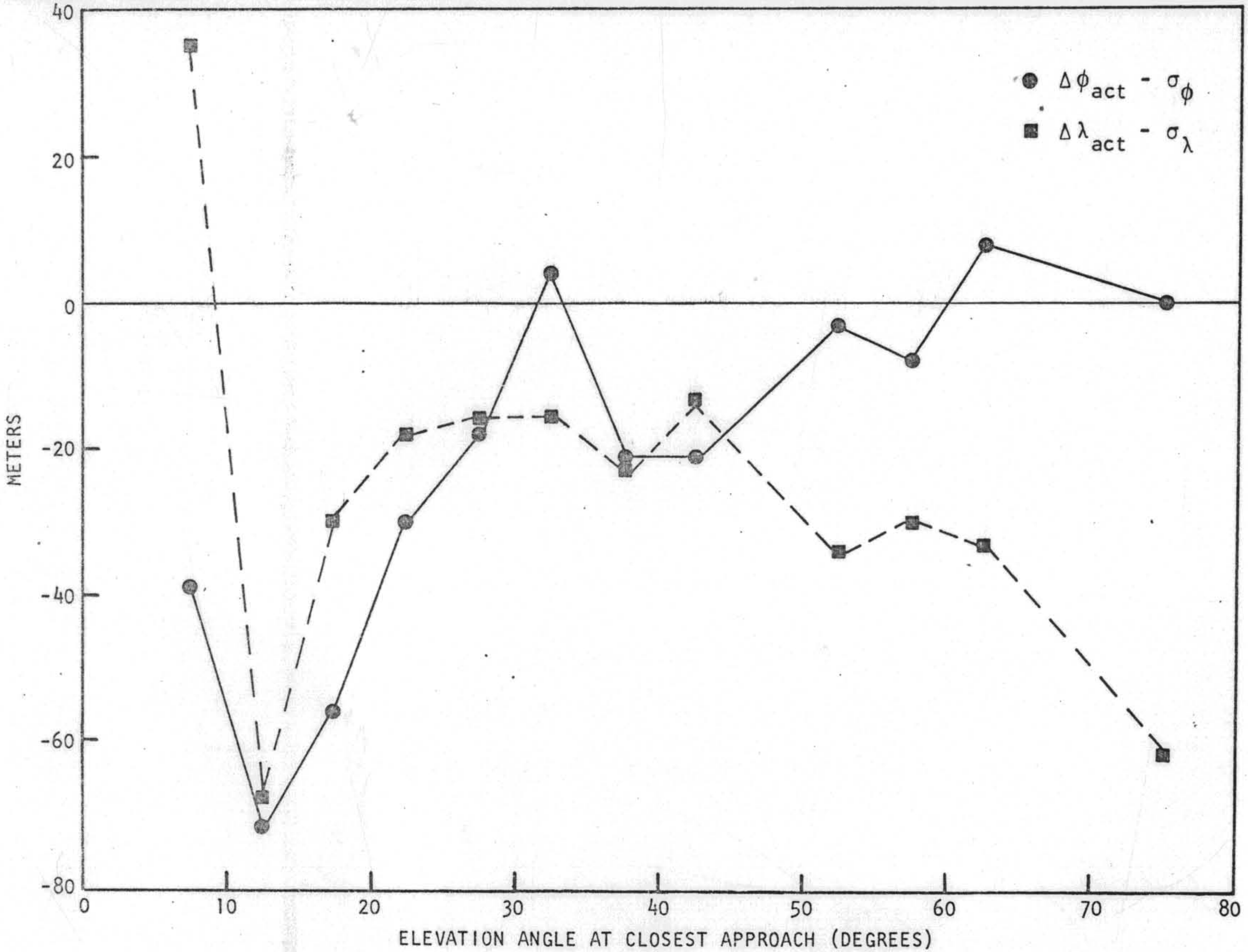


Fig. 9. Differences Between Variance Estimate In Laboratory and Actual Position Error.

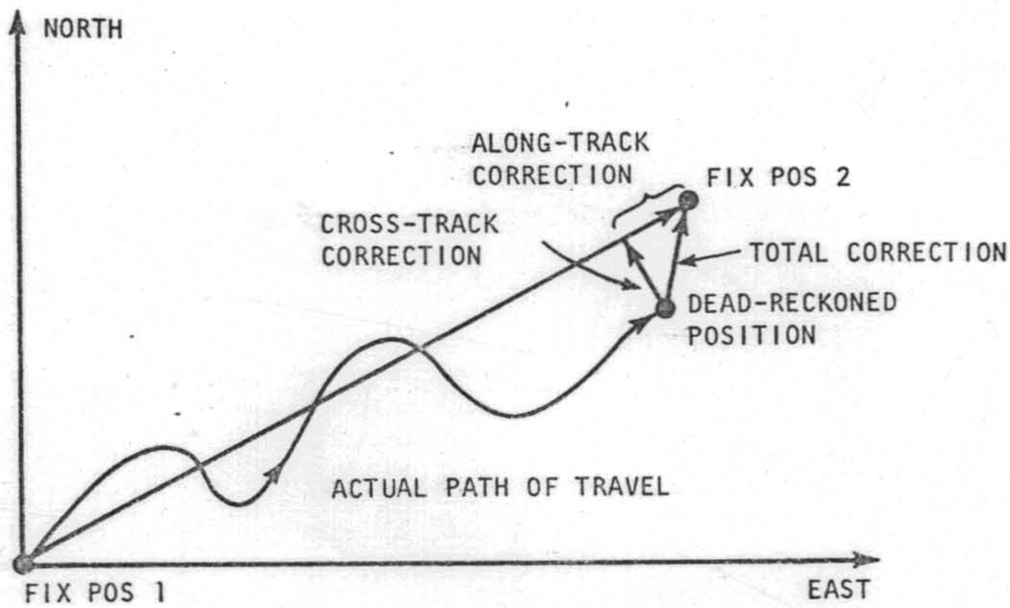


Fig. 10. Calibration Principle.

The total dead-reckoning error accumulated during the time between position fixes (fix interval) is a result of errors in along-track and cross-track velocity measurement and the error in azimuth measurement. Geometrically, this total error comprises two orthogonal error vectors. One vector is colinear with the direction of the shortest distance between each pair of position fixes. This component is basically the result of the error in the fore-aft or along-track velocity measurement. The orthogonal component combines the error in the port-starboard or cross-track velocity measurement and the error in measurement of the ship's azimuth. The heading error expresses any misalignment between the gyrocompass and the fore-aft direction as determined by the sonar beams. Thus, the error components are a direct and separate measure of average along-track and cross-track velocity errors. By prorating the vector magnitudes to the direct distance between fixes, we obtain relative or percent error factors.

Analytically, the total dead-reckoning error can be separated into total velocity error and heading error. In this, it is assumed that the relative errors in all velocity measurements are caused by the same sources, and higher-order cross-terms between velocity and heading error are ignored. The assumption is correct as far as the doppler sonar instrumentation is concerned and is plausible with respect to any environmental error sources.

Let

$K$ = relative error in velocity measurements

$\theta_e$ = absolute heading error

Then

$V_{true} = (1 - K)V_{meas}$, true velocity

$\theta_{true} = \theta_{meas} - \theta_e$, true heading

In dead reckoning, the fore-aft, port-starboard, and up-down velocities about the measured azimuth are resolved into velocity-north and velocity-east components, which are subsequently integrated over time:

$$\phi = \phi_o + \int_T \frac{VN}{R_N(\phi)} \, dt, \text{ latitude}$$

$$\lambda = \lambda_o + \int_T \frac{VE}{R_E(\phi)} \, dt, \text{ longitude}$$

where $(\phi_o, \lambda_o)$ is an initial position, VN and VE are the velocity-north and -east components, and $R_N$ and $R_E$ are the radii of the earth's curvature in north and east directions.

Each velocity component contains an error which is a function of both the relative velocity error, K, and the heading error, $\theta_e$. Therefore, dead-reckoned latitude and longitude also contain errors which are (different) functions of the error parameters, K, $\theta_e$:

$$\phi_e = f(K, \theta_e)$$

$$\lambda_e = g(K, \theta_e)$$

A position fix, if sufficiently accurate, immediately yields the position error $(\phi_e, \lambda_e)$. By neglecting second- and higher-order cross-terms as mentioned, the error parameters or "calibration factors" K and $\theta_e$ can be found directly.

Two requirements must be met for satisfactory calibration:

- The fixes at either end of the dead-reckoning interval must be sufficiently accurate
- The direct distance between fixes must be sufficiently large

For example, for a distance of 10 km between lines, a 100-m radial fix error causes an error of 1% in velocity calibration or 0.01 rad = $0.57^{o}$ in heading calibration.

The calibration method is independent of the actual travel path between fixes because deterministic errors compensate when traveling in opposite directions. In this respect, closed-loop navigation never reflects deterministic error, and the error at loop closure results from accumulated random errors. Thus, separate measurement of deterministic velocity and heading errors derived from position fixes of known accuracy have been established. At each satellite fix GeoNav prints out the estimated fix accuracy, the distance between fixes, and the calibration factors, plus all other necessary position update information, therefore providing continuous performance evaluation.

This velocity/heading calibration principle has been exercised extensively: first, in testing doppler sonar and gyrocompass instrument errors in the Gulf of Mexico in March 1970 by sailing between oil rigs, where the accurately known positions were substituted for satellite fixes; second, in the same period with a simulated seismic survey performed against electronic positioning; and third, by continuous data collection from actual worldwide field operations. Table II shows that the calibration factors obtained from the test run between known, fixed positions agree with the instrument errors specified.

Table II. Velocity-Heading Error Statistics

| Distance Traveled (km) | Heading Error (m) | Velocity Error (m) | Total Error RMS (m) |
|---|---|---|---|
| 24.1 (E→W) | -4.2 | 24 | 24 |
| 24.1 (W→E) | ≈0.0 | 0 | 0 |
| 24.1 (E→W) | 16.8 | -24 | 29 |
| 24.1 (W→E) | 29.4 | 0 | 29 |
| 24.1 (E→W) | 4.2 | -24 | 24 |
| 24.1 (W→E) | 16.8 | +48 | 51 |
| 44.5 (NE→SW) | 96.0 | -89 | 131 |
| 44.5 (SW→NE) | 8.0 | 0 | 8 |

060066

Bass Basin part XVI Vol II

# OPERATIONS REPORT

# HB75A MARINE SEISMIC SURVEY EXTENSION,

# BASS STRAIT

For

HEMATITE PETROLEUM PROPRIETARY LIMITED
BHP HOUSE, 140 WILLIAM STREET
MELBOURNE VICTORIA 3000 AUSTRALIA

Client representative: Mr. E.Urschel

By

GEOPHYSICAL SERVICE INTERNATIONAL
P.O. BOX 437, CROWS NEST N.S.W., 2065

| | |
|---|---|
| Party 2931 | M.V."Eugene McDermott II" |
| Operations Supervisor | G.Shilliday |
| Quality Control Seismologists | T.O'Donnell, W.Grise |

22nd January - 1st February 1975

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LIST OF APPENDICES



OR-016

# LIST OF PLATES

GSI-709

HEMATITE PETROLEUM PROPRIETARY LTD.

LOCATION OF PROSPECT
BASS STRAIT EXTENSION

GEOPHYSICAL SERVICE INTERNATIONAL

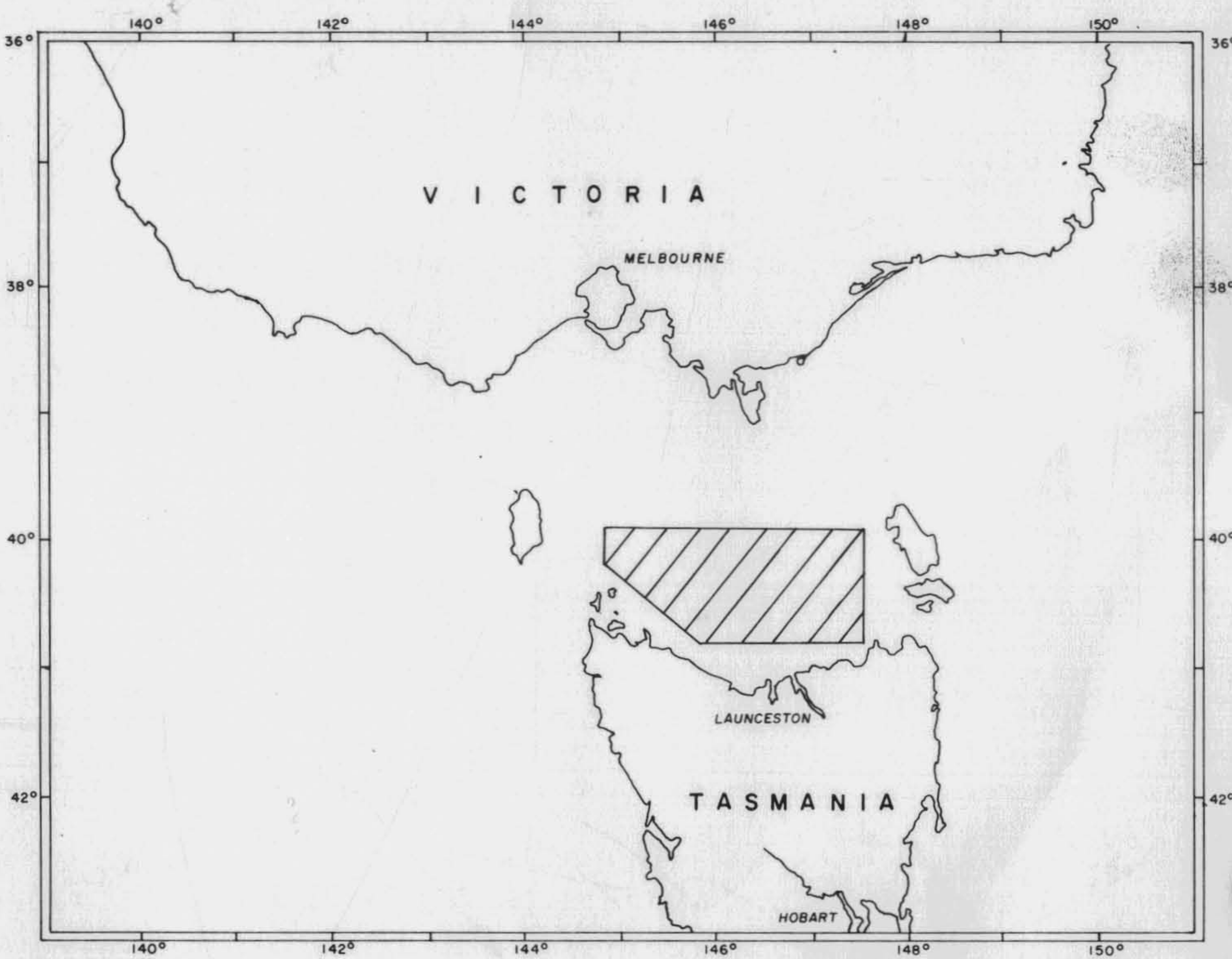
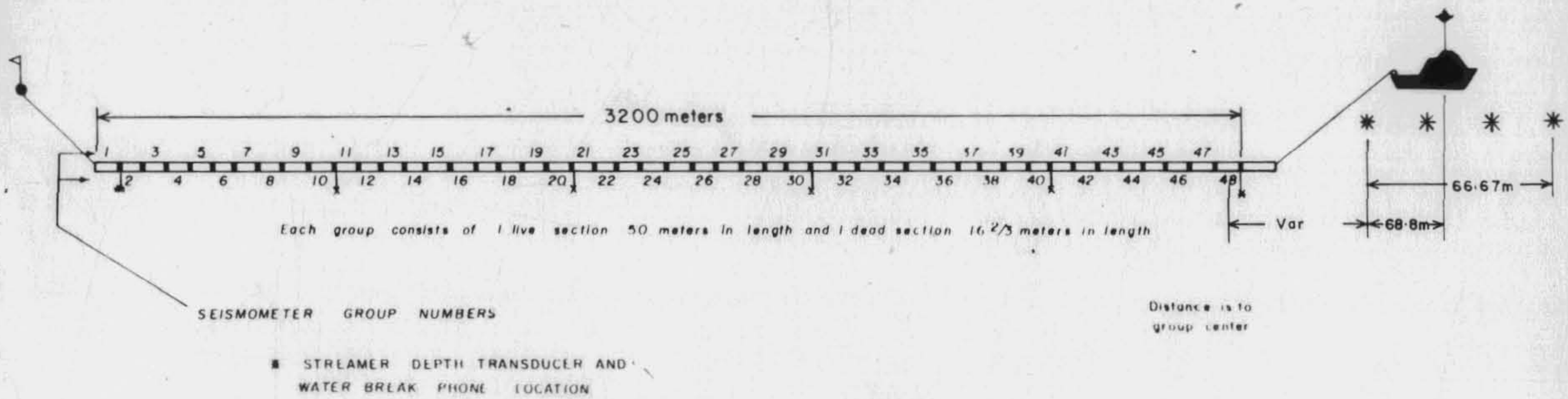
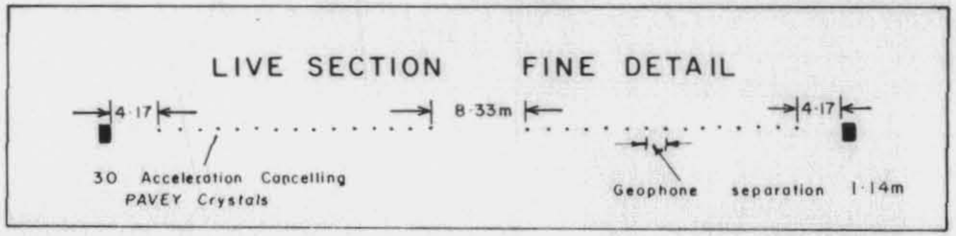



PLATE I



5 cm




| WATER BREAKS | DISPLAYED ON SEISMOGRAM TRACES | RECORDED ON TAPE CHANNELS |
|---|---|---|
| 1 | 25 & 49 | 31 |
| 2 | 48 | 28 |
| 3 | 50 | 29 |
| 4 | 49 | 31 |
| 5 | 50 | 27 |
| 6 | 48 | 28 |

5 cm

**MARINE CABLE DIAGRAM**
**3200 METER**
**(OFF END SPREAD – 48 GROUPS)**

G.S.I. Party 931
Ship M/V "EUGENE McDERMOTT II"
Client HEMATITE
Area BASS STRAIT
Date 22JAN - 1FEB.1975

PLATE 2

070090

060071

10·7 m

| N° | GUN | SIZE | Distances (Port) | Distances (Starboard) | N° | GUN | SIZE |
|---|---|---|---|---|---|---|---|
| 1 | ● | 1·311 litres | 0 m | | 17 | ● | 1·639 litres |
| 2 | ● | 1·311 | 0·46 | | 18 | ● | 1·639 |
| 3 | ● | 1·311 | 0·91 | | 19 | ● | 1·639 |
| 4 | ● | 1·311 | 1·37 | | 20 | ● | 1·639 |
| 5 | ● | 1·639 | 3·20 | 3·28 | 21 | ● | 1·639 |
| 6 | ● | 1·639 | 3·66 | 3·73 | 22 | ● | 1·639 |
| 7 | ● | 1·311 | 5·49 | 5·64 | 23 | ● | 1·311 |
| 8 | ● | 1·311 | 5·94 | 6·10 | 24 | ● | 1·311 |
| 9 | ● | 0·655 | 7·77 | 8·00 | 25 | ● | 0·655 |
| 10 | ● | 0·655 | 8·99 | 9·30 | 26 | ● | 0·655 |
| 11 | ● | 0·655 | 10·21 | 10·59 | 27 | ● | 0·655 |
| 12 | ● | 0·328 | 11·43 | 11·89 | 28 | ● | 0·328 |
| 13 | ● | 0·328 | 12·65 | 13·11 | 29 | ● | 0·328 |
| 14 | ● | 0·328 | 13·87 | 14·33 | 30 | ● | 0·328 |
| 15 | ● | 0·164 | 15·09 | 15·54 | 31 | ● | 0·164 |
| 16 | ● | 0·164 | 16·31 | 16·76 | 32 | ● | 0·164 |

PORT | STARBOARD

m/v EUGENE Mc DERMOTT II

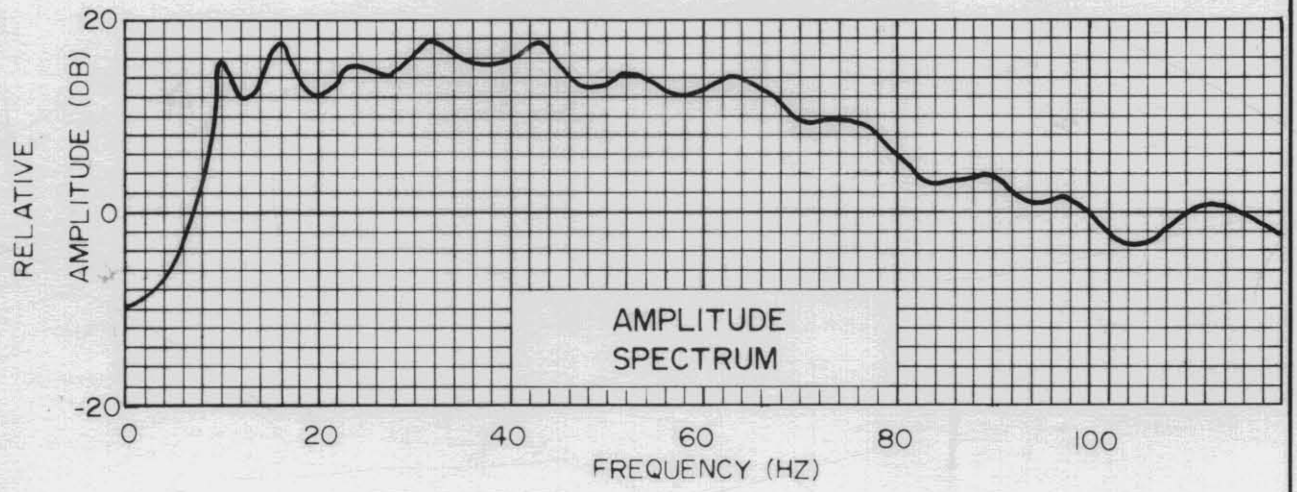
AIR GUN ARRAY

5 cm

PLATE 3

5 cm

060072


| GUN | SIZES |
|---|---|
| 4 x 0·164 litres | 2 x 1·311 litres |
| 6 x 0·328 litres | 2 x 1·639 litres |
| 6 x 0·655 litres | 1 x 3·278 litres |
| 1 x 3·933 litres | |

AIRGUN ARRAY PULSE AND SPECTRUM

Vessel M/V EUGENE M$^c$DERMOTT II
Array Capacity 19·665 litres
Recording Filter 0-248 Hz
Date 22JAN- 1FEB. 1975.

PLATE 4

GSI-709

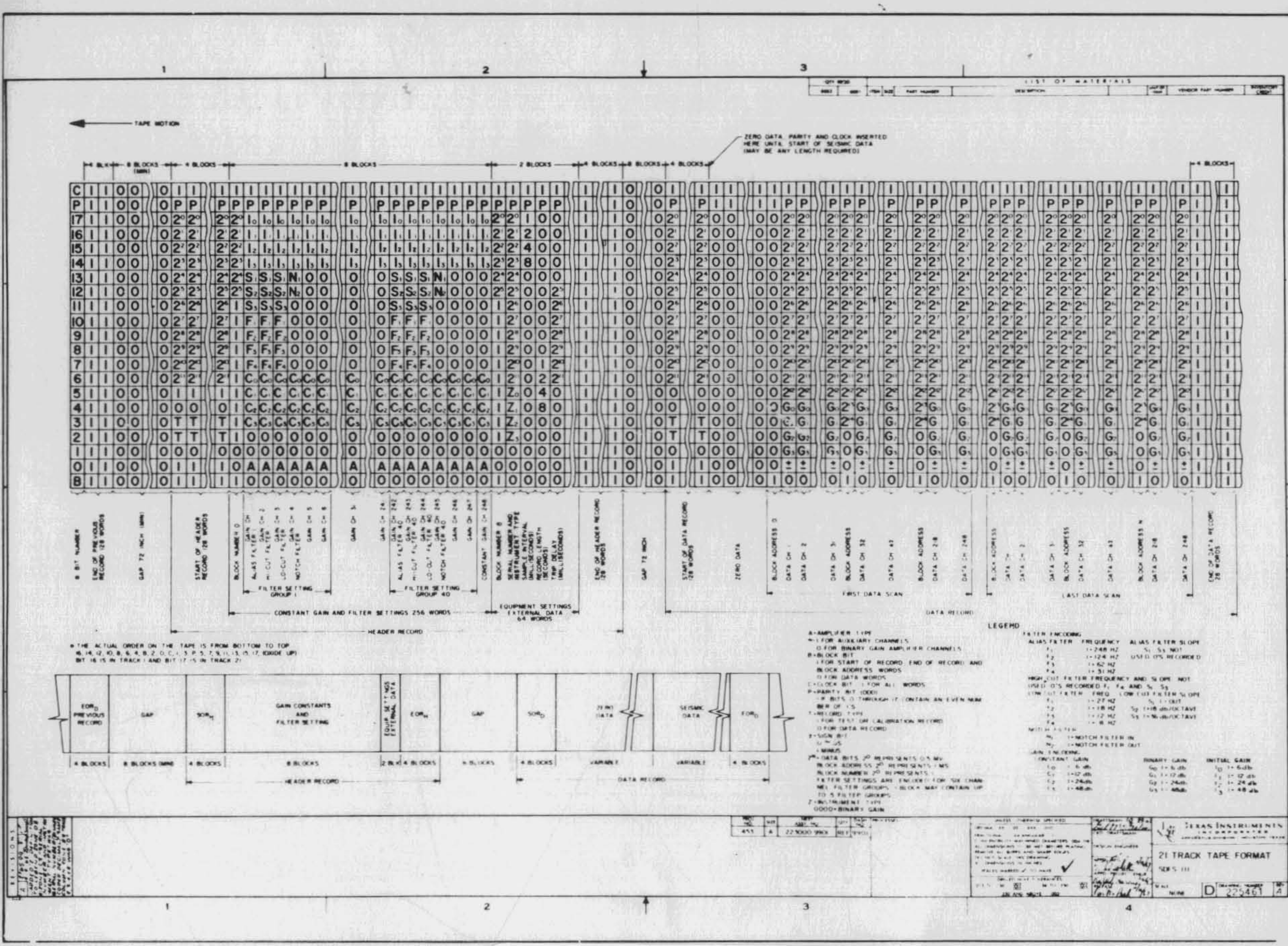



PLATE 5

5 cm

060073

# SECTION I

## INTRODUCTION

A marine seismic reflection survey was conducted by the M.V. "EUGENE McDERMOTT II" in the Bass Strait for Hematite Petroleum Proprietary Ltd between the 22nd January and 1st February 1975.

Approximately 1210 kilometres of 72-fold reflection coverage were shot utilizing a 3200 metre streamer under continuous tow in conjunction with a Pneumatic Acoustic Energy Source (Airguns), generally operating 24 hours per day.

Recordings were made using two sets of 24 trace DFS III's, with 3 tape transports recording on 25.4 mm magnetic tape in 21 track TIAC* Binary Gain Digital Format. Record length was 5 seconds and the sample rate was 4 milliseconds.

The ship's location was determined by Geonav II.

*Trademark of Texas Instruments Inc.

SECTION II

OPERATION PROCEDURES

A. RECORDING:

A Texas Instruments Digital Field System III (DFS III) with 3 tape transports was used for all recording. A Servo Writer Profiler was utilised to obtain 100% (Near Trace Gather) subsurface coverage (uncorrected section) of 4 second duration, directly from monitor recording.

Direct Read After Write (RAW) monitors were generated approximately every 20 shotpoints for quality control purposes.

B. STREAMER:

The 3200 metre, neutrally buoyant, continuous tow streamer consisted of 48 live sections each 50 metres in length and 47 dead sections each 16.67 metres in length, 6 Waterbreak/Depth Transducer sections each 1.83 metres in length, were placed in front of group 48 and between groups 40L and 40D, 30L and 30D, 20L and 20D, 10L and 10D, 1L and 1D.

Five nylon stretch sections were placed between group 48 and the recording vessel to attenuate ship generated noise. Four Condep** cable depth controllers were placed between

**Trademark of Continental Oil Company

the depth transducers on the streamer at the centre of dead sections 5D, 15D, 25D and 35D.

One nylon stretch section followed group 1 and was joined to the tailbuoy by 122 metres of nylon rope. Tailbuoy bearings were taken by radar every 40 pops to ensure that maximum feathering angle was not exceeded.

The average streamer depth was 16.6 metres.

C. ENERGY SOURCE (AIRGUNS):

An Electro-Pneumatic Acoustic Energy Source known as "Airguns" was used for all reflection work.

The airgun has basically two moving parts, the shuttle and the solenoid. Compressed air is supplied to this unit at a pressure of 13,780 kPa. The shuttle is forced to close on initial application of pressure. Compressed air fills the reservoir chamber through a central orifice in the shuttle. To discharge the gun an electrical current activates the solenoid and retracts a plunger, thus enabling compressed air to pass through a port hole to the underside of a flange at the top of the shuttle. The pressure difference above and below the shuttle then thrusts it open. The air from the chamber then escapes through four port holes near the centre of the gun and expands rapidly through the water, producing a single bubble and resultant shock wave. The air bubble collapses in a manner similar to that caused by explosives with one notable exception in that its period is controllable and is placed in the desired seismic frequency band.

There are three variables used to control the frequency content of the shock waves. These are:-

i) depth of the airgun in the water.

ii) pressure at which the gun is operated.

and

iii) size of the chambers used on the gun.

Using different guns of various chamber sizes broadens and flattens the frequency spectrum of the pulse (Plate 4).

The depth of the airguns was 7.8 metres and they were operated at a pressure of 12,400 kPa with the pressure never falling below this figure.

The individual airguns were arranged to produce an 19,665 litre array. This array consisted of:

i) 4 x 0.164 litre guns

ii) 6 x 0.328 litre guns

iii) 6 x 0.655 litre guns

iv) 2 x 1.311 litre guns

v) 2 x 1.639 litre guns

vi) 3 x 1.311 litre guns forming a
1 x 3.933 litre array

vii) 2 x 1.639 litre guns forming a
1 x 3.278 litre array

These arrays were arranged and spaced so as to operate as a tuned array which yields a flat frequency spectrum.

The time co-ordinator unit triggered the Digital Field System which in turn discharged the Texas Instrument Airgun Control Unit (Blaster), causing a current to flow simultaneously through all solenoids, resulting in the guns firing. The guns were fired every 22.22 metres giving 72-fold coverage. The airgun array was mounted on two Gun Strings, one port astern and the other starboard astern and towed behind the recording vessel at a distance of 27.4 metres from the stern to the centre of the array.

## D. INSTRUMENTS AND NOISE TESTS:

Instrument tests were carried out prior to each day's operations and the results were examined in an analog form in the field. These tests consisted of Dynamic Range Determination, Amplifier Noise Test and Automatic Gain Control (AGC) Test. Frequent checks on tape speed and skew were made.

A set of monthly tests were carried out prior to commencement of operations. These tests included Harmonic Distortion, Gain Linearity, Periodic Calibration checks, skew checks and the above-mentioned tests.

The tests were analysed in the Sydney, Australia Processing Centre using TIAC routines.

A streamer noise analysis was made at the beginning of each line shot. Some of these tests were recorded on tape.

E. FATHOMETER:

A Ross Model 400A fathometer and an Elac Deneb, Model LAZ-17DDL, AGN8 fathometer were used.

The Ross fathometer operated at 50 KHz and the Elac fathometer at 15-20 KHz. Each fathogram was identified by line number, direction shot, time and date of first shotpoints and scale. The fathograms were marked every 60 pops and labelled every 120 pops. The zero line for the fathograms was not corrected for the ship's draught.

F. NAVIGATION:

Positioning of the vessel and individual shotpoints throughout this prospect was controlled by Geonav, Texas Instruments satellite navigation system, a description of which is contained in Appendix E.

This system performed well in the periods of good weather but more critical attention had to be given to the data produced by the associate sensor equipment in heavy seas. There were no equipment problems with the system during this period.

G. MAPPING :

Shotpoint locations were computed and listed and maps drawn at scales of 1:100,000 and 1:250,000, using the Australian Mapping Grid parameters. This was organised by GSI through Engineering Computor Services of Chandos Street, St. Leonards.

H. PERMITTING:

Permits to conduct the survey were obtained by Hematite Petroleum Pty Ltd. The Marine Operations Centre in Canberra was advised as to the ship's location throughout the survey to enable the necessary navigation warning to mariners to be issued.

APPENDICES

## APPENDIX A

## KEY PERSONNEL

| | | |
|---|---|---|
| G.Shilliday | | Supervisor |
| A.Stirling | | Party Manager |
| J.Haigh | | Administrator |
| T.O'Donnell | ) | |
| W.Grise | ) | Quality Control Seismologists |
| J.Robinson | ) | |
| J.Stanton | ) | Instrument Engineers |
| R.Cowan-Lunn | ) | |
| S.Martin | ) | |
| R.Campbell | ) | |
| C.Streeter | ) | Airgun Mechanics |
| S.Simpson | ) | |
| M.Gusterson | ) | Captain |
| P.Holton | ) | |
| C.McGuinn | ) | Navigators-Geonav |
| E.Pickstone | ) | |

APPENDIX B

EQUIPMENT

a) Recording

i) 3200 Metre Streamer (Plate 2)

| | |
|---|---|
| Type Cable | :48 live group, neutrally buoyant, universal gland streamer 47 dead sections. |
| Length of Live Section | :50 metres |
| Length of Dead Section | :16.67 metres |
| Length of Depth Transducer Sectionm | : 1.83 metres |
| Distance Group 1 to 48 (centres) | :3142.48 metres |
| Group Interval | :66.67 metres |
| Seismometer Type | :Pavey Acceleration Cancelling |
| Seismometers per Group | :30 |
| Seismometer Interval | :Linear, 1.14 metres except centre two which are 8.33 metres apart. |
| Sensitivity | :6.0 uV/uBar |

(ii) Recording Parameters

| | |
|---|---|
| Amplifiers | :TI DFS III Binary Gain |
| Gain Mode | :Binary Gain |
| Record Length | :Normal 5.0 seconds |
| Sample Rate | :4 Milliseconds |
| Gain Constant | :30 db. |
| Attack Rate | :1500 db/sec. |
| Final Gain | :120 db. |
| Trip | :As necessary |
| Initial Gain | :24-42 db. |
| Upper Set Limit | :62.5% and 50% |
| Lower Set Limit | :25% |
| Filter - | |
| Low Cut | : 8 Hz, 18 db/octave |
| High Cut | :62 Hz, 72 db/octave |
| Release Rate | :Fast 94 db/sec. |
| Delay time for RAW Monitors caused by displacement of RAW and record heads | :26.7 milliseconds |

iii) Data Channel Allocations - 3200 Metre Streamer

| Function | Monitor Trace No. | System | Tape Channel |
|---|---|---|---|
| Timing | - | Both | 0 |
| Streamer Odd Groups 1-47 | 1-24 | System I | 1-24 |
| Streamer Even Groups 2-48 | 31-54 | System II | 1-24 |
| Waterbreak 1 (between groups 1L & 1D) | 25&49 | Both | 31 |
| Waterbreak 2 (between groups 10L & 10D) | 48 | Both | 28 |
| Waterbreak 3 (between groups 20L & 20D) | 50 | Both | 29 |
| Waterbreak 4 (between groups 30L & 30D) | 49 | Both | 31 |
| Waterbreak 5 (between groups 40L & 40D) or Sonobuoy data | 50 | Both | 27 |
| Waterbreak 6 (in front of group 48) | 48 | Both | 28 |
| Field Timebreak | 4 | System I | - |
| Field Timebreak | 28 | System II | - |
| DFS Synthetic Timebreak | 8 | System I | - |
| DFS Synthetic Timebreak | 32 | System II | - |

B) Survey Vessel

M.V. "EUGENE McDERMOTT II"

| | |
|---|---|
| Flag | : Bahamas |
| Homeport | : Nassau |
| Trade | : Foreign Going-Seismic Exploration |
| Owners | : Worldwide Surveys Limited |
| Call Sign | : ZQA-2012 |
| Length | : 52.73 metres L.O.A. |
| Breadth | : 12.19 metres |
| Depth | : 4.27 metres |
| Draft | : 3.05 - 3.25 metres |
| Official Number | : 343728 |
| Gross Tonnage | : 929.89 tonnes |
| Net Tonnage | : 249.09 tonnes |
| Engine Power | : 2 x 839.25 KW engines |

# APPENDIX C

## OPERATION STATISTICS

| | |
|---|---|
| Prospect | : Bass Strait Extension HB75A-A |
| Operational period | : 22nd Jan.-1st Feb. 1975 |
| Time spent on recording | : 117 hrs. 12 mins |
| Time lost due to bad weather | : 24 hrs. |
| Time lost due to other reasons (includes supplies, equipment and survey failures) | : Nil |
| Field tapes used | : 283 |
| Water depth range | : 20-50 fathoms |
| Total production | : 1209.94 Kms |
| Production shotpoints | : 18149 |
| Autofires | : 34 pops or 0.4% |

APPENDIX D

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Field Tape Numbers Even |
|---|---|---|---|---|
| 221.75 | HB75A-174A | 1A- 89C | | HB216 |
| | | 1A-148C | HB217 | |
| | | 90A-205C | | 218 |
| | | 149A-205C | 219 | |
| | HB75A-214A | 1A- 29C | | 218 |
| | | 1A- 29C | 219 | |
| | | 30A- 72C | | 219 |
| | | 30A-160C | 220 | |
| | | 73A-217C | | 221 |
| | | 161A-217C | 222 | |
| | | 218A-305C | | 222 |
| | | 218A-364C | 223 | |
| | | 306A-405C | | 224 |
| | | 365A-405C | 225 | |
| | HB75A-199A | 1A- 40C | | 224 |
| | | 1A- 40C | 225 | |
| | | 41A-104C | | 225 |
| | | 41A-189C | 226 | |
| | | 105A-251C | | 227 |
| | | 190A-251C | 228 | |
| | HB75A-196A | 1A- 80C | | 228 |
| | | 1A-131C | 229 | |
| | | 81A-131C | | 230 |

| Date | Line Number | Shotpoints | Field Tape Numbers Nears | Fars |
|---|---|---|---|---|
| 22.1.75 | HB75A- 93 | 1A- 80C | | HB231 |
| 23.1.75 | | 1A- 80C | HB232 | |
| | | 81A-144C | | 233 |
| | | 81A-224C | 233 | |
| | | 145A-289C | | 234 |
| | | 225A-289C | 235 | |
| | | 290A-368C | | 235 |
| | | 290A-436C | 236 | |
| | | 369A-447C | | 237 |
| | | 437A-447C | | |
| 23.1.75 | HB75A-2 7 | 1A- 67C | | 237 |
| | | 1A- 67C | 238 | |
| | | 68A- 97C | | 238 |
| | | 68A- 97C | 239 | |
| | | | Odd | Even |
| | HB75A-215 | 1A- 32C | | 238 |
| | | 1A-115C | 239 | |
| | | 33A-181C | | 240 |
| | | 116A-181C | 241 | |
| | | 182A-259C | | 241 |
| | | 182A-328C | 242 | |
| | | 260A-406C | | 243 |
| | | 329A-406C | 244 | |
| | | 407A-410C | | 244 |
| | | 407A-410C | 245 | |

| Date | Line Number | Shotpoints | Field Tape Numbers Nears | Fars |
|---|---|---|---|---|
| 23.1.75 | HB75A- 9 | 1A- 56C | | HB244 |
| | | 1A-136C | HB245 | |
| | | 57A-202C | | 246 |
| | | 137A-202C | 247 | |
| | | 203A-241C | | 247 |
| | | 203A-241C | 248 | |
| 24.1.75 | HB75A-232 | 1A- 40C | | 247 |
| | | 1A-109C | 248 | |
| | | 41A-188C | | 249 |
| 24.1.75 | | 110A-188C | 250 | |
| | | 189A-255C | | 250 |
| | | 189A-333C | 251 | |
| | | 256A-380C | | 252 |
| | | 334A-380C | 253 | |
| | | | Odd | Even |
| | HB75A-29 | 1A- 88C | | 254 |
| | | 1A-144C | 255 | |
| | | 89A-235C | | 256 |
| | | 145A-235C | 257 | |
| | | 236A-288C | | 257 |
| | | 236A-350C | 258 | |
| | | 289A-350C | | 259 |
| | | | Nears | Fars |
| | HB75A-93 | 448A-527C | | 260 |
| | | 448A-527C | 261 | |
| | | 528A-583C | | 261 |

| Date | Line Number | Shotpoints | Field Tape Numbers Nears | Fars |
|---|---|---|---|---|
| 24.1.75 | HB75A- 93 | 528A-670C | HB262 | |
| | | 584A-672C | | HB263 |
| | | 671A-672C | 264 | |
| | HB75A- 27 | 1A- 56C | 265 | |
| | | 1A- 56C | | 263 |
| | | 57A-144C | | 265 |
| | | 57A-200C | 266 | |
| | | 145A-288C | | 267 |
| | | 201A-288C | 268 | |
| | | 289A-344C | | 268 |
| | | 289A-432C | 269 | |
| | | 345A-443C | | 270 |
| | | 433A-443C | 271 | |
| | | | Odd | Even |
| 25.1.75 | HB75A-225 | 1A- 88C | | 272 |
| | | 1A- 88C | 273 | |
| | | 89A-142C | | 273 |
| | | 89A-235C | 274 | |
| | | 143A-291C | | 275 |
| | | 236A-291C | 276 | |
| | | 292A-381C | | 276 |
| | | 292A-439C | 277 | |
| | | 382A-435C | | 278 |
| | | 436A-439C | | 279 |
| | | 440A-444C | 279 | |
| | | 440A-444C | | 280 |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Even |
|---|---|---|---|---|
| 25.1.75 | HB75A-225 | 445A-540C | HB281 | |
| | | 445A-595C | | HB282 |
| | | 541A-595C | 283 | |
| | | 596A-685C | | 285 |
| | | 596A-738C | 284 | |
| | | 686A-828C | | 285 |
| | | 739A-828C | 286 | |
| | | 829A-884C | | 286 |
| | | 829A-914C | 287 | |
| | | 885A-914C | | 288 |
| | HB75A-224 | 1A- 56C | 287 | |
| | | 1A-118C | | 288 |
| | | 57A-118C | 289 | |
| | | 119A-200C | | 289 |
| | | 119A-264C | 290 | |
| | | 201A-308C | | 291 |
| | | 265A-308C | 292 | |
| | HB75A- 69 | 1A- 33C | | 291 |
| | | 1A- 33C | 292 | |
| | | 34A-103C | | 292 |
| | | 34A-176C | 293 | |
| | | 104A-244C | | 294 |
| | | 177A-244C | 295 | |
| | | 245A-317C | | 295 |
| | | 245A-393C | 296 | |
| | | 318A-460C | | 297 |
| | | 394A-460C | 298 | |
| | | 461A-537C | | 298 |
| | | 461A-559C | 299 | |

GSI-709

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Even |
|---|---|---|---|---|
| 25.1.75 | HB75A- 69 | 538A-559C | | HB300 |
| 26.1.75 | HB75A-223 | 1A- 42C | HB299 | |
| | | 1A-120C | | 300 |
| | | 43A-120C | 301 | |
| | | 121A-189C | | 301 |
| | | 121A-266C | 302 | |
| | | 190A-336C | | 303 |
| | | 267A-336C | 304 | |
| | | 337A-411C | | 304 |
| | | 337A-484C | 305 | |
| | | 412A-560C | | 306 |
| | | 485A-560C | 307 | |
| | | 561A-629C | | 307 |
| | | 561A-707C | 308 | |
| | | 630A-776C | | 309 |
| | | 708A-776C | 310 | |
| | | 777A-853C | | 310 |
| | | 777A-925C | 311 | |
| | | 854A-1001C | | 312 |
| | | 926A-1001C | 313 | |
| | | 1002A-1070C | | 313 |
| | | 1002A-1148C | 314 | |
| | | 1071A-1216C | | 315 |
| | | 1149A-1216C | 316 | |
| | | 1217A-1290C | | 317 |
| | | 1217A-1290C | 317 | |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Even |
|---|---|---|---|---|
| 26.1.75 | HB75A-231 | 1A- 64C | HB317 | |
| | | 1A-110C | | HB318 |
| | | 65A-110B | 319 | |
| | | 1A- 29C | | 318 |
| | | 1A- 29C | 319 | |
| | | 30A- 74C | | 319 |
| | | 30A- 74C | 320 | |
| 26.1.75 | HB75A-229 | 1A- 16C | | 319 |
| 27.1.75 | | 1A- 96C | 320 | |
| | | 17A-164C | | 321 |
| | | 97A-164C | 322 | |
| | | 165A-243C | | 322 |
| | | 165A-312C | 323 | |
| | | 244A-393C | | 324 |
| | | 313A-393C | 325 | |
| | | 394A-457C | | 325 |
| | | 394A-541C | 326 | |
| | | 458A-606C | | 327 |
| | | 542A-606C | 328 | |
| | | 607A-644C | | 328 |
| | | 607A-644C | 329 | |
| 27.1.75 | HB75A-228 | 1A- 45C | | 328 |
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| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Even |
|---|---|---|---|---|
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|---|---|---|---|---|
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| | | 887A-939C | | 375 |
| 29.1.75 | HB75A-222 | 1A- 89C | 376 | |
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| | | 521A-522C | 378 | |
| | | 523A-671C | 401 | |
| | | 598A-599C | | 378 |
| | | 600A-747C | | 402 |
| | | 672A-673C | 378 | |
| | | 674A-820C | 403 | |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Field Tape Numbers Even |
|---|---|---|---|---|
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| | | 1047A-1048C | | 378 |
| | | 1049A-1192C | | 408 |
| | | 1121A-1123C | 378 | |
| | | 1124A-1192C | 409 | |
| 30.1.75 | HB75A-220 | 1A- 78C | 409 | |
| | | 1A-146C | | 410 |
| | | 79A- 80C | 411 | |
| | | 81A-230C | 412 | |
| | | 147A-148C | | 411 |
| | | 149A-298C | | 413 |
| | | 231A-232C | 411 | |
| | | 233A-380C | 414 | |
| | | 299A-301C | | 411 |
| | | 302A-449C | | 415 |
| | | 381A-382C | 411 | |
| | | 383A-533C | 416 | |
| | | 450A-452C | | 411 |
| | | 453A-601C | | 417 |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Field Tape Numbers Even |
|---|---|---|---|---|
| 30.1.75 | HB75A-220 | 534A-535C | HB411 | |
| | | 536A-684C | 418 | |
| | | 602A-604C | | HB411 |
| | | 605A-755C | | 419 |
| | | 685A-686C | 411 | |
| | | 687A-835C | 420 | |
| | | 756A-758C | | 411 |
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| | | 838A-988C | 422 | |
| | | 909A-910C | | 411 |
| | | 911A-1060C | | 423 |
| | | 989A-994C | 411 | |
| | | 995A-1105C | 424 | |
| | | 1061A-1063C | | 411 |
| | | 1064A-1105C | | 425 |
| | HB75A-231 | 1A- 33C | 424 | |
| | | 1A-104C | | 425 |
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| | | 36A-185C | 427 | |
| | | 105A-106C | | 426 |
| | | 107A-256C | | 428 |
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| | | 492A-622C | 433 | |
| | | 560A-561C | | HB426 |
| | | 562A-622C | | 434 |
| 30.1.75 | HB75A-230 | 1A- 81C | | 434 |
| | | 1A-142C | 435 | |
| | | 82A- 83C | | 436 |
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| | | 581A-582A | 436 | |
| | | 582B-640C | 444 | |
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| | | 75A-221C | 447 | |
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| | | 530A-531C | 446 | |
| | | 532A-649C | 454 | |
| | | 596A-598C | | 446 |
| | | 599A-649C | | 455 |
| 31.1.75 | HB75A-229 | 645A-672C | 454 | |
| | | 645A-740C | | 455 |
| 31.1.75 | HB75A-229 | 673A-675C | 456 | |
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| | | 743A-891C | | 458 |
| | | 826A-827C | 456 | |
| | | 828A-975C | 459 | |
| | | 892A-893C | | 456 |
| | | 894A-1042C | | 460 |
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| | | 1024A-1122C | 462 | |
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| | | 301A-450C | 469 | |
| | HB75A-227 | 374A-375C | | 465 |
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| | | 605A-744C | 473 | |
| | | 673A-674C | | 465 |
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| | | 745A-746C | 465 | |
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| | | 817A-818C | | 465 |
| | | 819A-960C | | 476 |
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| | | 961A-962C | | 465 |
| | | 963A-1111C | | 478 |
| | | 1041A-1042C | 465 | |

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| 31.1.75 | HB75A-227 | 1043A-1194C | HB479 | |
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| | | 138A- 140C | | 483 |
| | | 141A- 282C | | 485 |
| | | 212A- 213C | 483 | |
| | | 214A- 362C | 486 | |
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| | | 285A- 431C | | 487 |
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| | | 579C- 580C | | 483 |
| | | 581A- 728C | | 491 |
| | | 667B- 671C | 483 | |
| | | 672A- 820C | 492 | |
| | | 729A- 731C | | 483 |

| Date | Line Number | Shotpoints | Field Tape Numbers Odd | Even |
|---|---|---|---|---|
| 31.1.75 | HB75 -226 | 732A- 879C | | HB493 |
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| | | 823A- 879C | 494 | |
| 1.2.75 | HB75A-228 | 1084A-1173C | 494 | |
| | | 1084A-1228C | | 495 |
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| | | 1176A-1325C | 497 | |
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APPENDIX E

GEONAV POSITIONING SYSTEM

APPENDIX E

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APPENDIX E*

GEONAV** POSITIONING SYSTEM

A. INTRODUCTION

The GeoNav integrated marine navigation system records and displays continuous position computed from U.S. Navy navigation satellite, doppler sonar, gyrocompass, attitude control, and velocimeter data. The system performs automatic line and shot control based on distance-measured equal shotpoint spacing along the great circle path between the end positions of a seismic line.

B. FIELD OPERATION

The GeoNav system computes the great-circle path for a seismic line based on end points input as geographical positions by the GeoNav operator. While on-line, the vessel's deviation from the great-circle path is plotted on a pair of track plotters to a preset scale (normally 200 m/in). One of these plotters is on the bridge, where the helmsman steers the vessel to minimize deviations as they are plotted.

Automatic shot control is obtained by measuring the distance traveled on the surface. Each time the required pop interval is traversed the digital field system and the shot relay for the seismic energy source are activated automatically. The required pop interval is computed from group and coverage information input by the operator.

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* This appendix is adapted from a paper entitled, "Self-contained Quality Control in Marine Satellite Navigation," by John M. Hughes and Rudolf Unger, presented at the 27th Annual Meeting of the Institute of Navigation, June 29, 1971 in Pasadena, California.

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The line and shot control module allows for extensions at either end of a line, line deflections (doglegs), and circling. In all these cases, continuity of shotpoint spacing along the great-circle path is preserved automatically. Subsurface coverage at the beginning and end of a line is guaranteed by taking into account possible position shifts due to satellite fix corrections and by computing the appropriate lead-in and lead-out. The track-plotters output a special lead-in display for each line and annotates line parameters, shotpoints, and satellite fixes.

All shotpoint positions, line parameters, position fixes, and other relevant navigation data are recorded on magnetic tape. Hardcopy redundancy of this recorded data is provided by teletype printout and track-plotter annotation.

## C. POST MISSION PROCESSING

The navigation accuracy obtainable in real time is improved in post mission processing by infinite time smoothing of the recorded navigation data. Shotpoint and satellite fix positions are weighted against "past" and "future" position information using statistical filtering parameters based on satellite variance estimates and velocity and heading calibration factors output at each satellite fix.

Post mission processing also computes the position shift from satellite receiver antenna position to any desired offset position (seismic source, common depth points, etc.), and the position shift due to conversion from the APL* satellite system reference ellipsoid to a given local datum.

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*Applied Physics Laboratory, Johns Hopkins University.

The post mission processing end product is the computerized map and listing of transverse Mercator projected positions.

D. SYSTEM DESCRIPTION

1. General

The GeoNav system establishes its absolute geographical location from information transmitted by satellites of the U.S. Navy Navigational Satellite System. The vessel's continuous path of travel is computed by a dead reckoning system consisting of a velocity measurement system (VMS) and an azimuth measurement system (AMS). The VMS derives its values from four-beam independent doppler sonar velocity measurements compensated for the ship's pitch and roll, and for variations in the sound propagation velocity. The AMS consists of a gyrocompass externally compensated for the ship's dynamics.

At intervals averaging approximately 1.5 hours at the equator and less at higher latitudes, the dead reckoned position is corrected by a satellite position fix. Each satellite fix printout contains an estimate of fix accuracy and provides calibration factors for the dead reckoning system. In this manner, a self-contained quality control is established.

The Navy currently has five satellites in non-synchronous, circular, polar orbits of about 600 mi. altitude. A core memory onboard the satellite contains its orbital position information which is updated approximately every 12 to 18 hours from ground tracking and injection stations. The satellite continuously transmits this data as its navigation message phase encoded onto two carrier frequencies.

The vessel's satellite receiver automatically locks onto the satellite signals when it appears in sight. A satellite pass may have a duration of up to 20 minutes during which period the satellite navigation message is redundantly received, and a number of integrated doppler frequency shift (doppler count) measurements are acquired. From the navigation message the satellite positions along its orbit are derived. The doppler counts yield measures of range difference between the vessel position and the satellite positions along its orbit. Comparing the doppler shifts of the two carrier frequencies permits elimination of the ionospheric refraction influence. Automatic data editing and an iterative process of fitting computed and measured range differences ultimately result in a correction to the dead reckoned position.

Besides the tasks of navigation and data quality control, the GeoNav computer performs the line and shot control as described in Section B.

2. Detailed Description

Figure 1 is a block diagram of the GeoNav system as configured for GSI. The system employs a Magnavox MX702CA satellite receiver configured for the transfer of doppler counts synchronized with the completion of each line of the satellite message (a line takes 4.6 sec of the 2-min cycle). This permits implementation of the so-called "short doppler" satellite solution whereby the doppler counts are integrated over segments corresponding to an integer multiple of satellite lines.

The satellite receiver also receives both of the two transmitted satellite frequencies, demodulates the signals, and organizes the demodulated bits into 12-bit data words for transfer to the computer. Each 12-bit data word is accompanied by three bits of code which identify the nature of the data being transferred. Also a part of the satellite receiver is a 5-MHz oven-stabilized crystal oscillator which is the reference oscillator for the

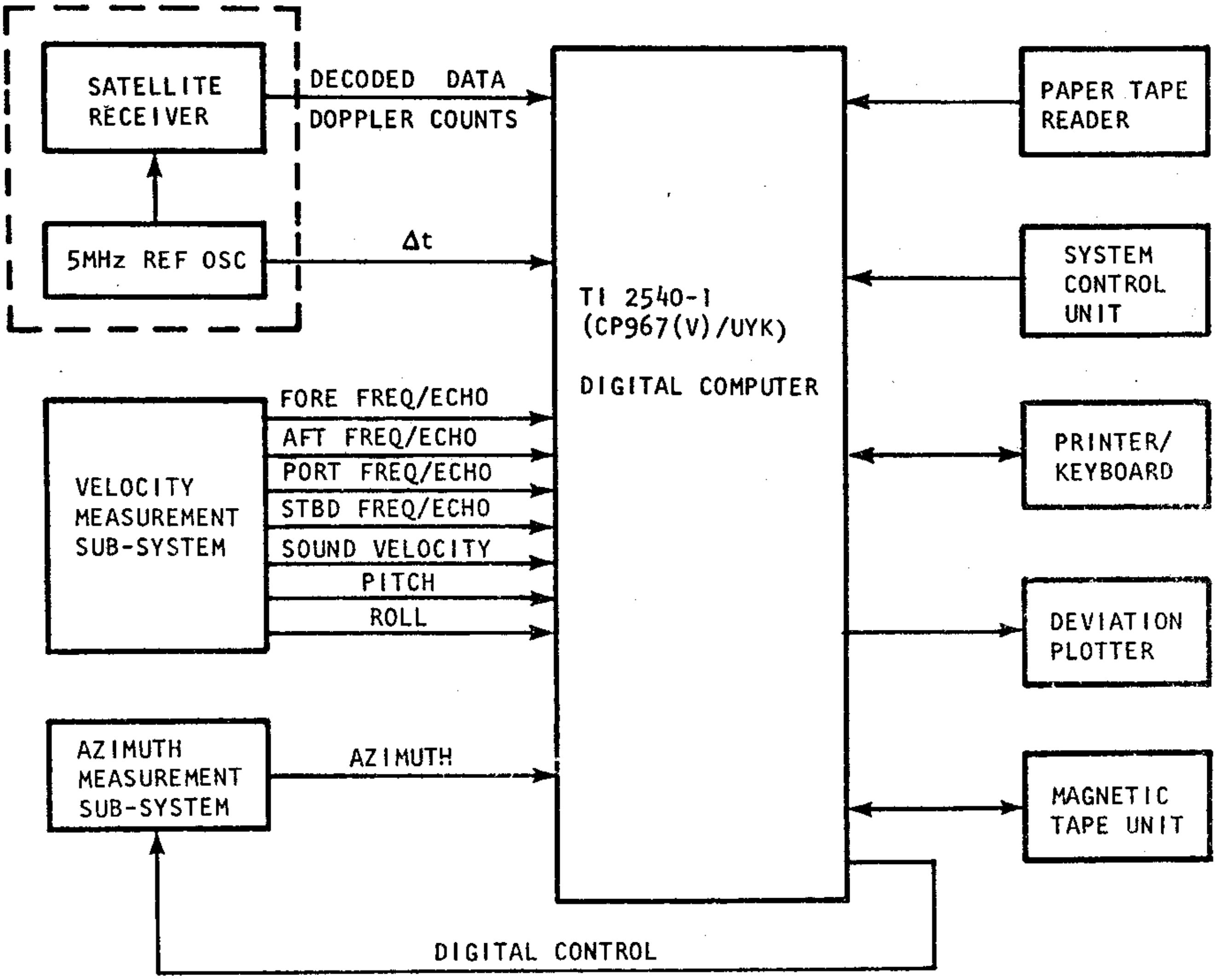


Fig. 1. GeoNav System Block Diagram.

satellite receiver in addition to being the relative time reference for the GeoNav system.

Figure 2 is a block diagram of the GeoNav velocity measurement subsystem. The sonar transducer and associated electronics are the Edo Western 435C pulse-frequency tracking system modified by Texas Instruments to yield only the frequencies of the four sonar beams (Figure 2 shows only one channel) and the time of arrival of their echoes.

The GeoNav velocity measurement subsystem provides parameters for computing the vessel's velocity in a plane tangent to the earth's surface. Components of this velocity are the projections of the ship's fore-aft and port-starboard axes on this tangent plane. To permit navigation from these data, these velocity vectors must be resolved into velocity components in northerly and easterly directions.

Figure 3 is a block diagram of the GeoNav azimuth measurement subsystem. Basic to it is the Sperry MK227-0 gyrocompass which provides X1 and X36 synchro outputs of vessel azimuth in addition to a 400-Hz reference, the amplitude of which is modulated by control from the computer, utilizing an amplitude modulator built by Texas Instruments. This external control from the computer is derived from an algorithm which compensates the gyrocompass for the effects of vessel dynamics on the compass.

A synchro-to-digital converter, Astrosystems A603-5-S149, translates the X1 and X36 information from the gyrocompass to digital form for transfer to the computer. Now available is the information necessary to resolve the data from the velocity measurement subsystem into components of velocity in northerly and easterly directions in the local earth-tangent plane. Basic instrument accuracies are shown in Table I.

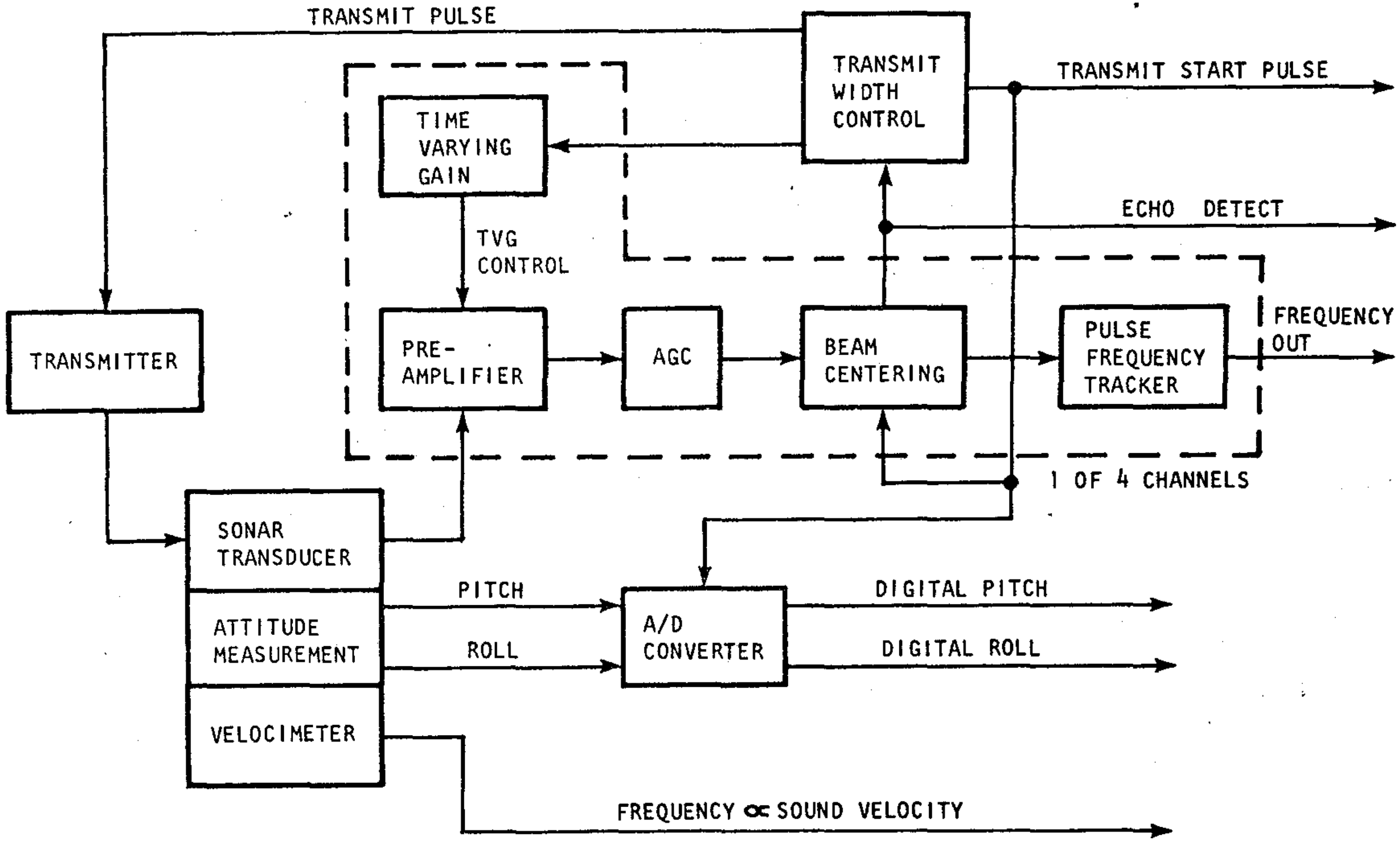


Fig. 2. Velocity Measurement Subsystem Block Diagram

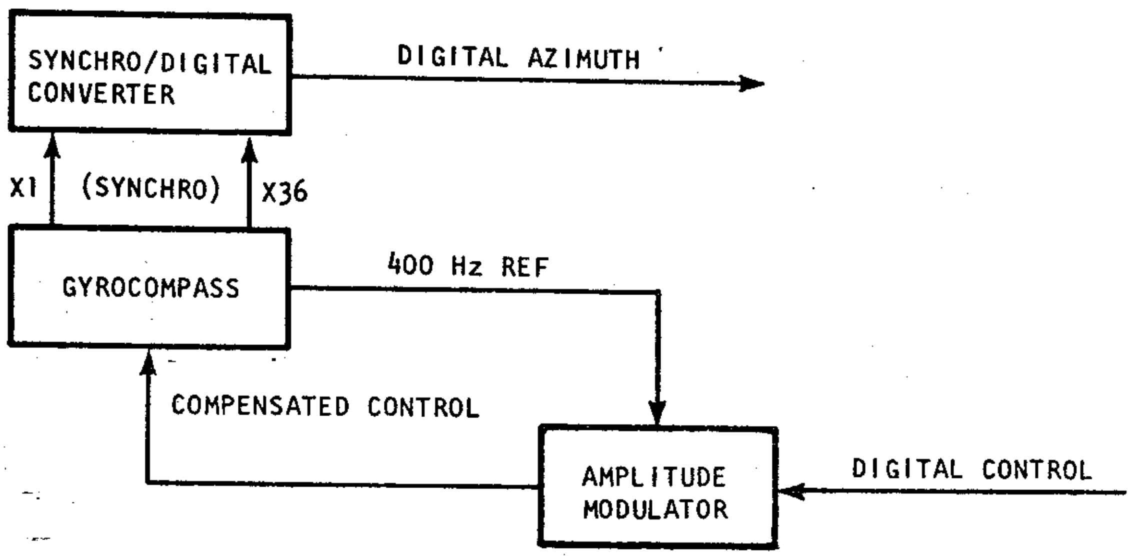


Fig. 3. Azimuth Measurement Subsystem Block Diagram.

Table I. Instrument Accuracy

| Unit | Accuracy |
|---|---|
| Gyrocompass (with compensation) | 0.2° |
| Doppler Sonar | |
| <100 Ftm | 0.2% |
| 100-160 Ftm | 0.5% |
| Inclinometer | 0.1° |
| Velocimeter | 0.01% |

Focal point of the GeoNav system is the TI 2540-3 (CP967(V)/UYK) digital computer; all sensor data must pass through the computer, and consequently, can be monitored by it. The GeoNav operating system software performs the satellite-fix solution and supplies velocity and azimuth measurement subsystem data to the dead reckoning system. The computer also performs position filtering, quality control of all sensors, and seismic-line and shot control. In this manner, data from all sensors are integrated to provide optimum continuous navigation, guidance, and shot control. In addition, data from the velocity measurement subsystem are used to compute the water depth for each sonar transmit/receive cycle. An extension of this technique permits using the system in bottom topography studies.

The system control panel, digital plotter, and printer/keyboard permit effectively using system outputs and system communications. A magnetic-tape unit is included for hardcopy data recording to permit post mission analysis.

The computer monitors the basic measurement processes of the various sensors. Anomalous measurements are noted and compensated for. The following paragraphs detail the techniques employed.

## E. GEONAV SELF CONTAINED QUALITY CONTROL

### 1. Continuous Sensor Quality Control

The doppler sonar and associated parameters necessary for velocity measurement are of foremost importance. The basic sonar measurement provides a component of frequency from each of the four sonar axes (fore, aft, port, and starboard. These measurements are relative to the plane to which the sonar transducer is attached. Since this plane is normally free to roll and pitch with the vessel, vessel attitude must be measured. For similar reasons, the velocity of the vessel must be measured normal to the sonar transducer mounting plane. These sonar frequency measurements must be corrected for the velocity of sound in water. To complete the data set, the frequency of the transmitted sonar energy is required to resolve the velocity component normal to the sonar mounting plane.

In all cases, the basic measurement data are examined by the computer for reasonableness and rate of change; if found anomalous, the GeoNav operating system alerts the operator to the error condition. This is the most basic level of system quality control.

Another ancillary item of data measured by GeoNav is the time of arrival of the echoes from the four sonar beams with respect to the transmitted energy pulse. These measurements permit extension of GeoNav sonar quality control to include reasonableness of the locale of the sonar echoes. When combined with sound velocity data, these measurements extend GeoNav's usefulness as a depth-controlling device. The four sonar echoes per transmitted pulse also provide a powerful tool for bottom topography studies.

Likewise, data from the azimuth measurement subsystem are examined for reasonableness of magnitude and rate of change. The operator is informed of anomalies.

The value of this method of quality control is limited, however, since the rate of change of the variables can legitimately vary over a large range depending on the vessel's design and sea conditions. Hence, a wide range of variation must be permitted. Similarly, individual anomalous values are useful only in detecting obvious hardware malfunctions. What is required is an alternative means of verifying a sensor's performance by comparing its data with data from another source. The following paragraphs describe how GeoNav does this.

2. Quality Control on Satellite Position Fixes

Digital data received from the orbiting satellites are independent of the velocity and azimuth measurement subsystems comprising the dead reckoning system. Since the vessel's velocity and azimuth do affect the doppler count, fixes derived from the decoded data and associated doppler counts are not independent of the dead reckoning system. The following describes the quality control that verifies incoming satellite data, quality assurance during computation, and interpretation of results, all of which permits use of satellite fixes as independent references.

All data received from a satellite observation are preserved in the computer's memory. At the end of a satellite pass, the software performs a validation sequence verifying the quality of incoming data. Since the same data is received several times during one pass of the satellite, one validity test is to see whether repeated data bits actually appear identical in the computer. This bit majority voting is performed on like bits of like parameters over the entire range of redundant satellite messages stored in memory. In the event the bit error rate is excessive, the entire satellite observation is invalidated and the operator informed of the excessive error rate. When this occurs, it is highly probable that there is a noisy receiver channel requiring repair or, less likely, a bad satellite being observed.

The two frequencies transmitted by the satellite are received by GeoNav, and the doppler counts received from the two receiver channels are preserved in memory. These data are reduced to refraction counts and compared against preset limits to insure reasonable refraction data. In case the refraction counts are not reasonable, the pass is rejected and the operator alerted that the receiver should be verified for proper operation of the doppler counters. All data are validated automatically in preparation for entering the satellite solution.

The bit majority voting scheme is altered when a satellite injection is detected. In this instance, the system attempts to utilize only data received following the injection to insure that the most current data and the best prediction of the satellite's orbit is used in the position-fix solution. Data received before the injection is ignored and replaced as necessary by extrapolating back based on parameters received after the injection, using curve-fitting techniques. Similar techniques are used to interpolate for parameters which may have been missed due to poor signal quality, fade, etc., or for parameter points at the short doppler intervals selected by the software system. The choice of whether to extrapolate is based on whether the following conditions (arranged in decreasing importance) can be achieved.

- A data set of valid fixed parameters
- A minimum range requiring extrapolation of variable parameters yet still coinciding with the maximum range of good doppler counts

- Maximum range of valid variable parameters
- Most recent data

This concludes the preprocessing of satellite data. The resulting data set is free of erroneous message data and invalid doppler counts.

Further quality control of satellite fixes is handled as an editing function. Inasmuch as satellite doppler and, more especially, the refraction count are known to degrade when the satellite is near the horizon, doppler counts received below 7.5$^{o}$ are rejected.

Another quality control tool available to GeoNav operators is a constant which specifies the minimum number of short doppler intervals on both sides of the satellite's closest approach which the software (GNSDOP) will demand before computing a fix. This constant insures symmetricity of the data (same number of short doppler counts on each side of closest approach) and is an indirect control of the minimum satellite elevation angle acceptable to the system. If, after checking the aforementioned editing criteria the system determines that there is the required symmetricity but not enough data above 7.5$^{o}$ (at least 10 short doppler intervals), the editing software will accept just enough short doppler segments below 7.5$^{o}$ (maintaining symmetricity) to meet minimum requirements.

Additional control permits rejection of an entire satellite observation if any portion of the data was collected while the observation angle exceeded some angle selected by the operator. This angle is typically 70$^{o}$ to 75$^{o}$ and is adjusted according to satellite alerts for the area of operation.

The preceding paragraphs describe some major elements of editing included in the GeoNav satellite software package. Together, all of these insure a high degree of quality for the data entering into a satellite-fix solution and intermediate to the solution. To use the resulting fix effectively as a measure of the quality of the GeoNav sensor subsystem data, the quality of a given fix solution must be measured. The GeoNav system does this with a unique, proprietary algorithm that estimates statistical variances north and east for the satellite fix. These estimates are not derived from a priori statistics of satellite fixes versus elevation angle but from only the incoming satellite data set. Figure 4 is a bull's-eye of satellite-fix distribution from a set of 100 fixes received in GSI's Dallas laboratory. These data were recorded with a minimum requirement of five short doppler segments on both sides of closest approach and with a maximum elevation angle of 75°.

The foregoing discussion covers the condition in which the satellite receiver is stationary. To obtain experimental data, a week of satellite observations were recorded on magnetic tape using a GeoNav system operating with the standard operating software. The resulting satellite fixes were tabulated, and known velocity and heading errors were introduced into the dead-reckoning or navigator's estimates. The satellite fixes were then recomputed and compared with the previously tabulated data and plotted. The resulting curves are those shown in Figures 5 and 6. It is noteworthy that the major component of satellite-fix error versus velocity error is that previously published in numerous journals. However, the smaller component of fix error shows a tendency to split, depending on the direction of satellite travel with respect to the observer, e.g., clockwise or counter-clockwise. These errors are as shown for 1 knot north in Figure 5 and 1 knot east in Figure 6 at latitude 32°N. These curves would converge to zero at the equator and be in reversed orientation in the southern hemisphere. In either

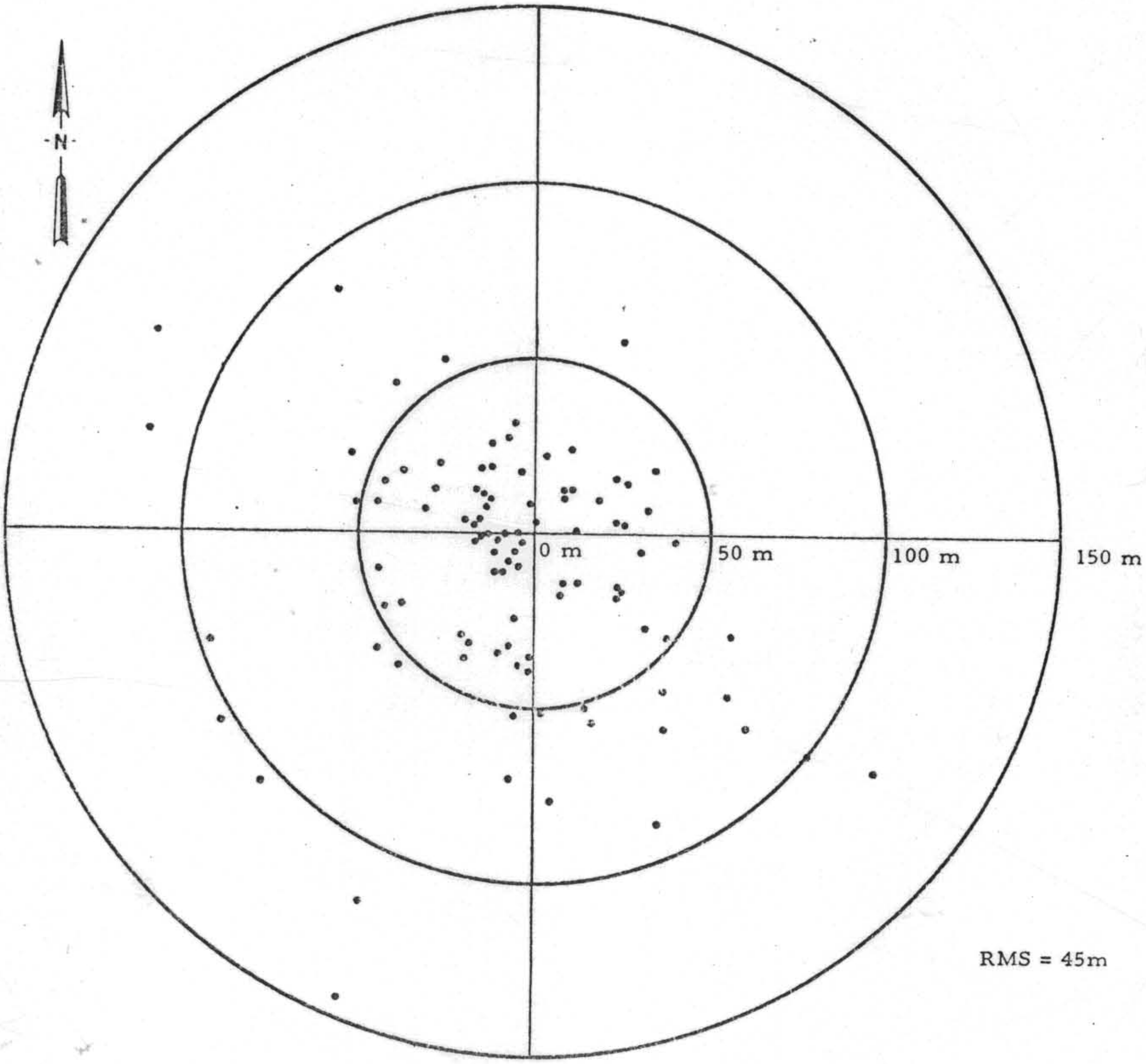


Fig. 4. Satellite-Fix Distribution.

5 cm

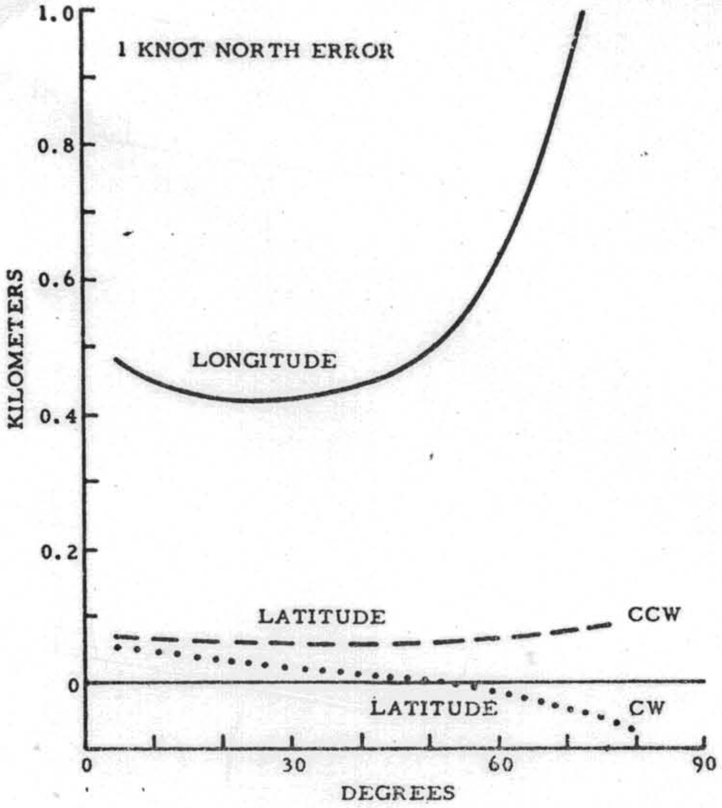


Fig. 5. Satellite Fix errors at Latitude 32°N, Due to Forced Dead Reckoning Errors.

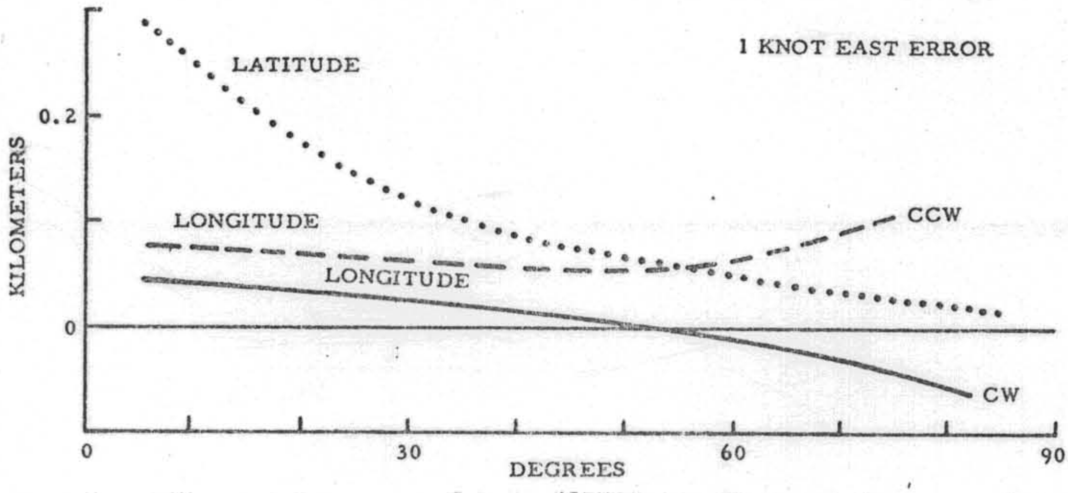


Fig. 6. Satellite Fix Errors at Latitude 32°N, Due to Forced Dead Reckoning Errors.

hemisphere, the magnitude of the error diverges as the pole is approached. In short, major satellite-fix errors are caused by dead-reckoning error, but the magnitude of these errors is such that they should be readily recognized. Hence, the problem reverts to one of identifying quality in a satellite-fix computation.

The previously described variances provided as part of the satellite-fix solution are independent of dead-reckoning error. To obtain a measure of the reliability of the variance computation, a set of satellite fixes was tabulated in the laboratory and each result and its variance estimates compared with the known antenna location. The curves shown in Figure 7 were obtained where the data were plotted as standard deviation versus satellite elevation angle. Figure 8 shows the same type of data recorded in the Far East while operating at approximately $40^{o}$S latitude. Figure 9 shows the difference between the variance estimate in the laboratory and the actual position error. This curve shows that the reliability of the variance estimate decreases at low elevation angles but that the estimate is reliable for satellites in the range $15^{o}$ to $70^{o}$. Note that the error estimate tends to exceed the actual error, thereby avoiding an over-dependence on the satellite fix results. Hence, we have a reference with a reliable estimate of its accuracy which we can now use as a tool for verifying the quality of the velocity and azimuth measurement subsystems.

3. Velocity/Heading Quality Control

Velocity and azimuth subsystem performance can be evaluated by relating the position correction resulting from a satellite position fix to the distance between fixes. See Figure 10.

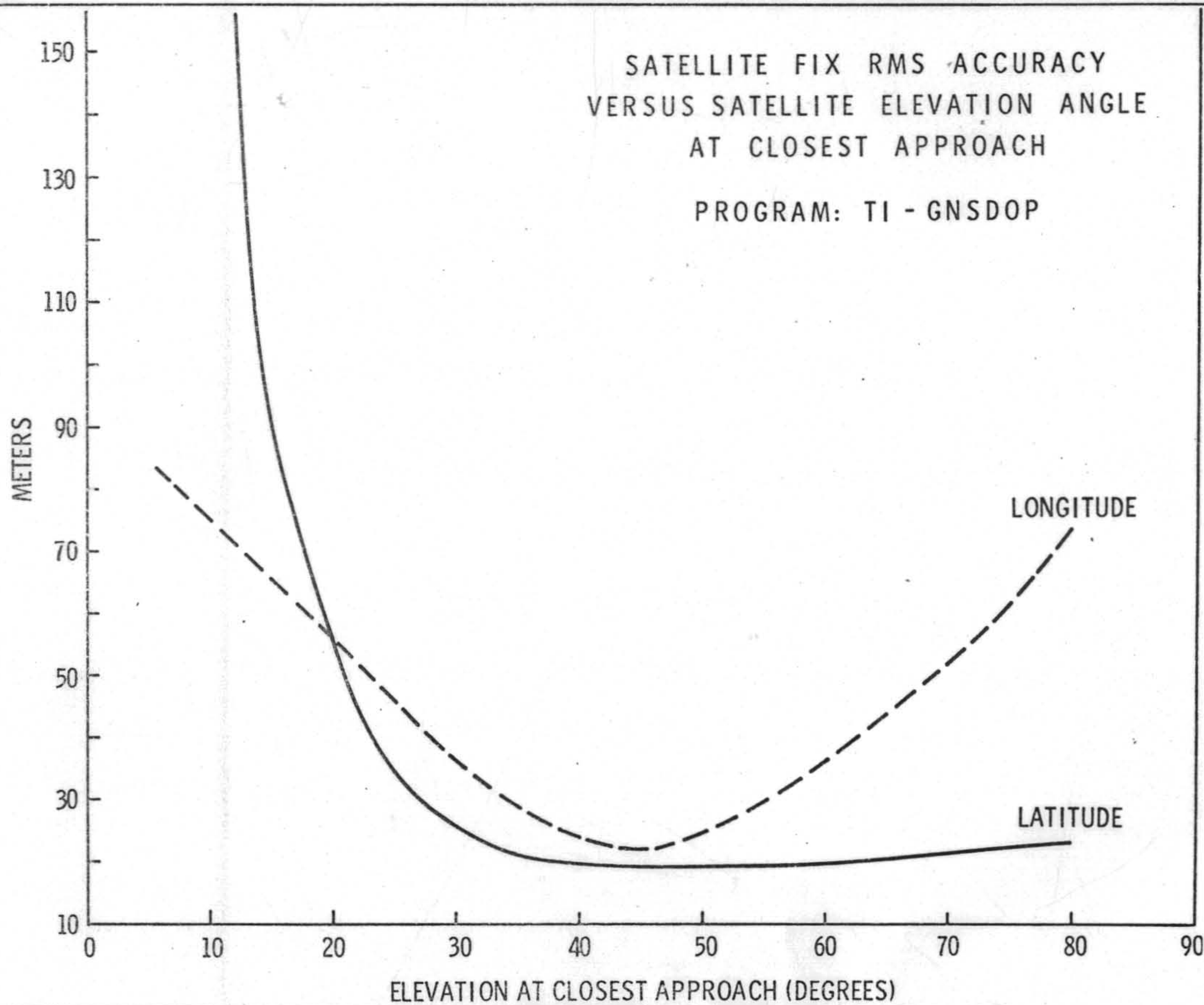


Fig. 7. Standard Deviation Versus Satellite Elevation Angle.

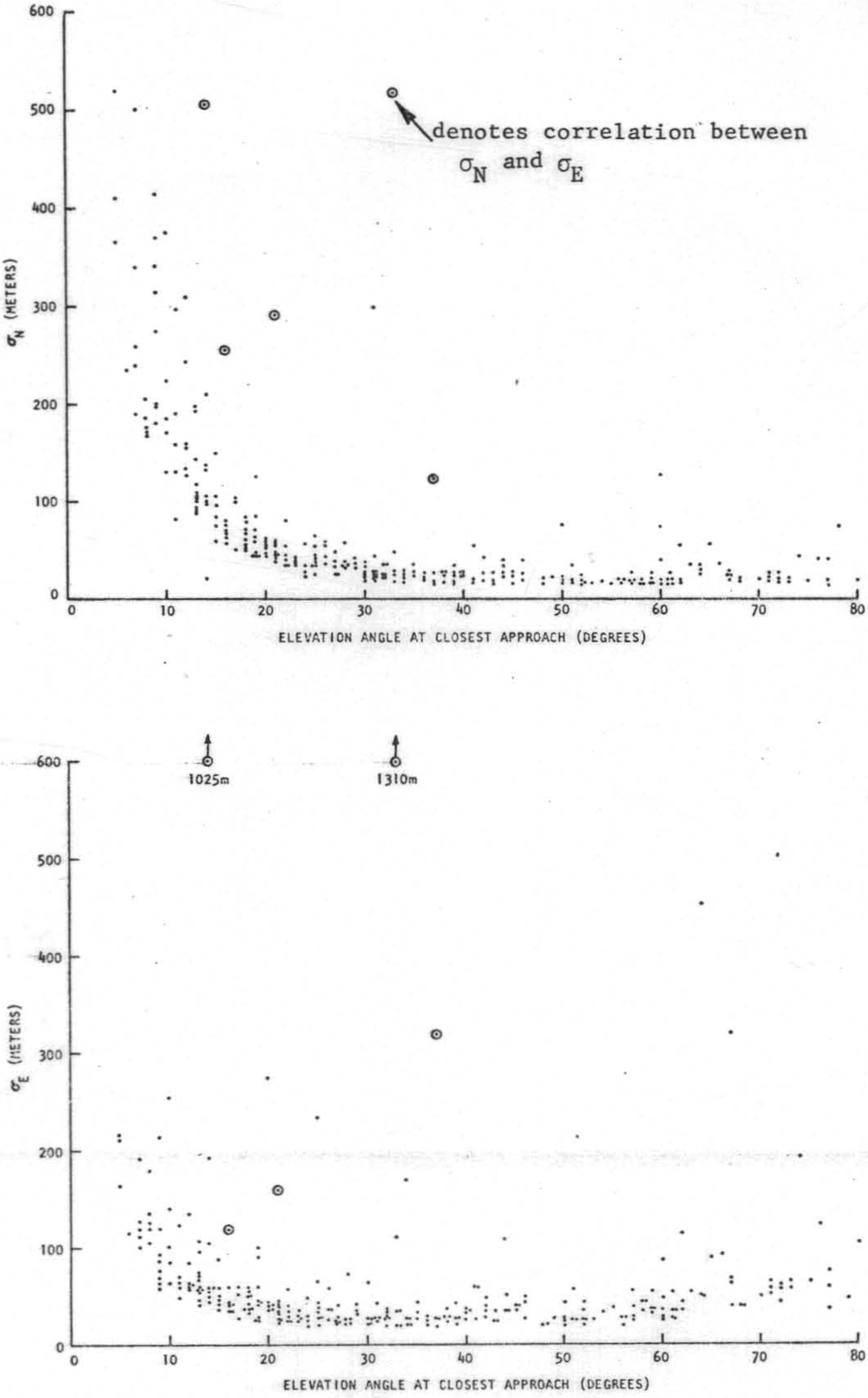


Fig. 8. Satellite-position Fix Standard-Deviation Estimate, Far East.

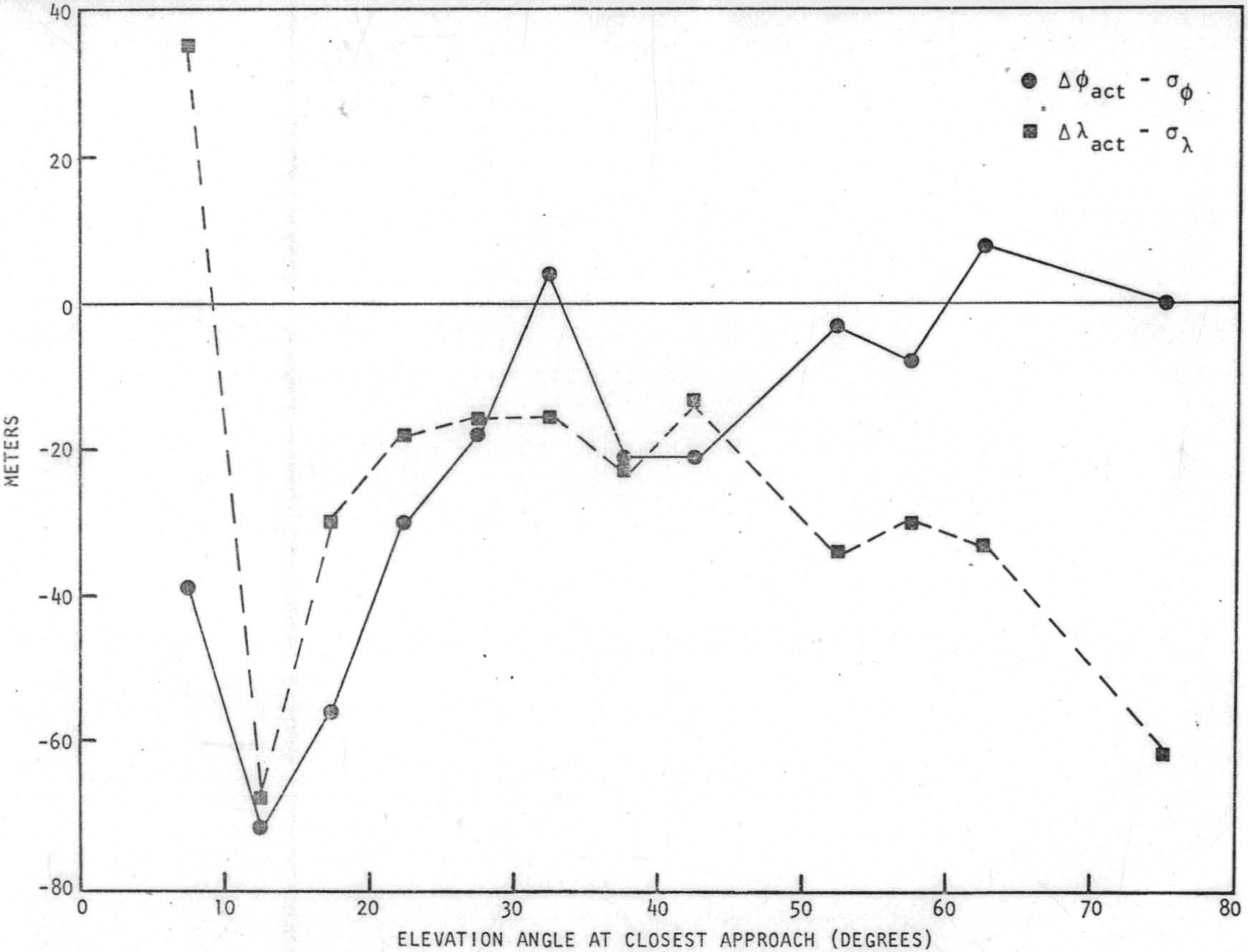


Fig. 9. Differences Between Variance Estimate In Laboratory and Actual Position Error.







5 cm

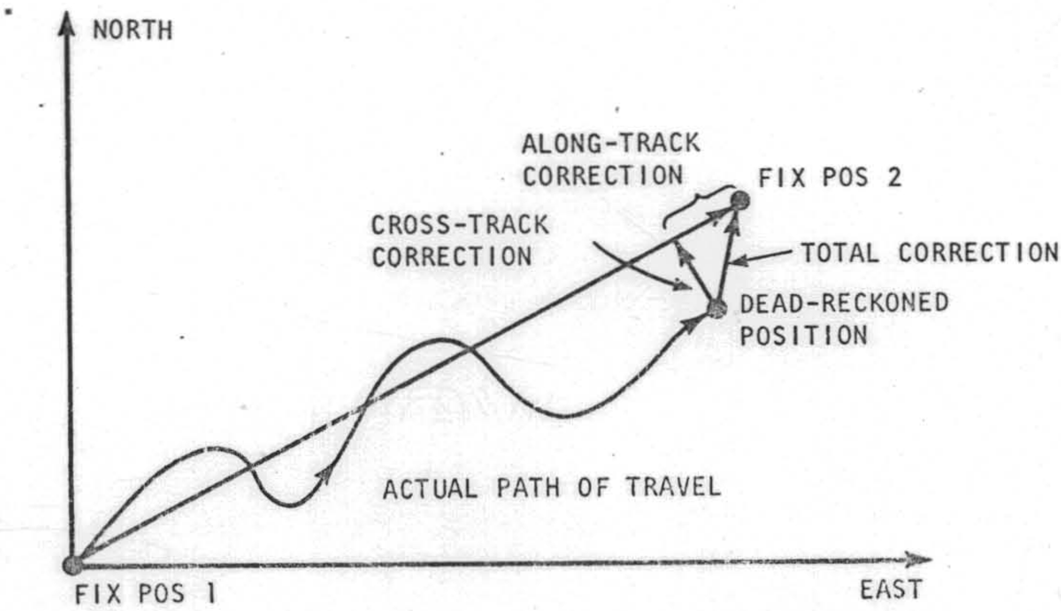


Fig. 10. Calibration Principle.

The total dead-reckoning error accumulated during the time between position fixes (fix interval) is a result of errors in along-track and cross-track velocity measurement and the error in azimuth measurement. Geometrically, this total error comprises two orthogonal error vectors. One vector is colinear with the direction of the shortest distance between each pair of position fixes. This component is basically the result of the error in the fore-aft or along-track velocity measurement. The orthogonal component combines the error in the port-starboard or cross-track velocity measurement and the error in measurement of the ship's azimuth. The heading error expresses any misalignment between the gyrocompass and the fore-aft direction as determined by the sonar beams. Thus, the error components are a direct and separate measure of average along-track and cross-track velocity errors. By prorating the vector magnitudes to the direct distance between fixes, we obtain relative or percent error factors.

Analytically, the total dead-reckoning error can be separated into total velocity error and heading error. In this, it is assumed that the relative errors in all velocity measurements are caused by the same sources, and higher-order cross-terms between velocity and heading error are ignored. The assumption is correct as far as the doppler sonar instrumentation is concerned and is plausible with respect to any environmental error sources.

Let

$K$ = relative error in velocity measurements

$\theta_e$ = absolute heading error

Then

$V_{true} = (1 - K)V_{meas}$, true velocity

$\theta_{true} = \theta_{meas} - \theta_e$, true heading

In dead reckoning, the fore-aft, port-starboard, and up-down velocities about the measured azimuth are resolved into velocity-north and velocity-east components, which are subsequently integrated over time:

$$\phi = \phi_o + \int_T \frac{VN}{R_N(\phi)} \, dt, \text{ latitude}$$

$$\lambda = \lambda_o + \int_T \frac{VE}{R_E(\phi)} \, dt, \text{ longitude}$$

where $(\phi_o, \lambda_o)$ is an initial position, VN and VE are the velocity-north and -east components, and $R_N$ and $R_E$ are the radii of the earth's curvature in north and east directions.

Each velocity component contains an error which is a function of both the relative velocity error, K, and the heading error, $\theta_e$. Therefore, dead-reckoned latitude and longitude also contain errors which are (different) functions of the error parameters, K, $\theta_e$:

$$\phi_e = f(K, \theta_e)$$

$$\lambda_e = g(K, \theta_e)$$

A position fix, if sufficiently accurate, immediately yields the position error $(\phi_e, \lambda_e)$. By neglecting second- and higher-order cross-terms as mentioned, the error parameters or "calibration factors" K and $\theta_e$ can be found directly.

Two requirements must be met for satisfactory calibration:

- The fixes at either end of the dead-reckoning interval must be sufficiently accurate
- The direct distance between fixes must be sufficiently large

For example, for a distance of 10 km between lines, a 100-m radial fix error causes an error of 1% in velocity calibration or 0.01 rad = 0.57° in heading calibration.

The calibration method is independent of the actual travel path between fixes because deterministic errors compensate when traveling in opposite directions. In this respect, closed-loop navigation never reflects deterministic error, and the error at loop closure results from accumulated random errors. Thus, separate measurement of deterministic velocity and heading errors derived from position fixes of known accuracy have been established. At each satellite fix GeoNav prints out the estimated fix accuracy, the distance between fixes, and the calibration factors, plus all other necessary position update information, therefore providing continuous performance evaluation.

This velocity/heading calibration principle has been exercised extensively: first, in testing doppler sonar and gyrocompass instrument errors in the Gulf of Mexico in March 1970 by sailing between oil rigs, where the accurately known positions were substituted for satellite fixes; second, in the same period with a simulated seismic survey performed against electronic positioning; and third, by continuous data collection from actual worldwide field operations. Table II shows that the calibration factors obtained from the test run between known, fixed positions agree with the instrument errors specified.

Table II. Velocity-Heading Error Statistics

| Distance Traveled (km) | Heading Error (m) | Velocity Error (m) | Total Error RMS (m) |
|---|---|---|---|
| 24.1 (E→W) | -4.2 | 24 | 24 |
| 24.1 (W→E) | ≈0.0 | 0 | 0 |
| 24.1 (E→W) | 16.8 | -24 | 29 |
| 24.1 (W→E) | 29.4 | 0 | 29 |
| 24.1 (E→W) | 4.2 | -24 | 24 |
| 24.1 (W→E) | 16.8 | +48 | 51 |
| 44.5 (NE→SW) | 96.0 | -89 | 131 |
| 44.5 (SW→NE) | 8.0 | 0 | 8 |

Bass Basin part XVI Vol III

# PROCESSING REPORT, MARINE SEISMIC SURVEY, BASS STRAIT, HB75A SEISMIC SURVEY.

HB75A EXT

1975

For

HEMATITE PETROLEUM PROPRIETARY LIMITED
140 WILLIAM STREET,
MELBOURNE VICTORIA 3000

By

GEOPHYSICAL SERVICE INTERNATIONAL
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PARTY 105-HEM-2,3
FEBRUARY/JULY, 1975.

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## LIST OF APPENDICES

## SECTION 1

## INTRODUCTION

A Marine Seismic Survey was conducted by the M.V. "Eugene McDermott II" in the Bass Strait for Hematite Petroleum Proprietary Limited between January 14 and February 2, 1975. The Survey can be broken down into three phases -

A) HB75A Survey

Approximately 923 Kilometres of "72-fold" reflection coverage were shot using a 48 trace, 3200 metre acceleration cancelling streamer under continuous tow. The acoustic energy source was a 19.655 litre tuned airgun array. The recording method was distributed between odd and even groups (approximately 754 Km.) and near and far groups (169 Km.).

B) HB75A Extension Survey

Utilising the same procedures as outlined above, approximately 1,109 Kilometres were recorded from odd and even groups, with a further 101 Kilometres from near and far groups.

C) Refraction

Two marine seismic refraction lines were included in the HB75A Survey. These lines were recorded at the same time as the reflection coverage. Telseis Sonobuoys were used to record and transmit the signals to an Aquatronics Sonobuoy onboard ship. The data was recorded using waterbreak channel 5 onto tape channel 27.

Field and survey operations reports are under separate covers.

Digital data processing was performed in the Sydney Office of Geophysical Service International. 1863 Kilometres of data were vertically stacked and processed as 24 fold CDP, 48 trace data. The remaining 270 Kilometres were processed with a vertical stack of the near 24 groups to give 12 fold, 24 trace, 1600 metre data.

Effectively then, all data recorded as odds and evens was processed 24 fold while of that data recorded nears and fars, only the nears were processed to give 12 fold coverage. Essentially, processing sequences for both types of data were the same.

# SECTION 11

## DIGITAL PROCESSING

The following processing sequence was applied to the data. All data were processed to a record time of 5.0 seconds at a sample period of 4 milliseconds.

A. SEQUENCE

1. Vertical Stack:

   a. True Amplitude Recovery.
   b. Vertical Stack

2. Pre-processing:

   a. Edit
   b. Pre-deconvolution Ramp Scaling
   c. Static Corrections
   d. Deconvolution
   e. Common Depth Point Gather
   f. Annotation of Water Depth and Offset Information
   g. Preliminary Stack.

3. Velocity Processing:

Full 700 Package Continuous Velocity Analysis on decimated depth points.

a. Moveout Scan, Dip Search and Reflection Identification.
b. Plot of picked events as a function of Time, Velocity, Amplitude and Dip.
c. Primary Segment Display.
d. Velocity File Tape.

4. Post-processing:

a. Normal Moveout Correction.
b. Single-fold Reproduction
c. Common Depth Point Stack
d. Time Variant Deconvolution (TVD)
e. Time Variant Filtering (TVF)
f. Cross Record Mix
g. Display

B. PROGRAM AND PARAMETER DETAILS

1. Vertical Stack:

a. True Amplitude Recovery (TAR)

TAR was applied to all field records. This process removed the gain imposed by the DFS III Binary Gain Control System and corrected for inelastic attenuation and spherical divergence losses.

b. 3 on 1 Vertical Stack

The "72-fold" shooting was reduced to 24-fold, 48 trace by stacking the 48 traces of three contiguous shots. This summing produces a depth point smear but maintains correct offsets. The main advantage of Vertical Stack is the cancellation of random noise and the reinforcing of primary data.

3 : 1 vertical stack of the nears only produced 12 fold, 24 trace data.

See Appendix A for line breakdown of processing method.

## 2. PRE-PROCESSING

### a. Edit

Edit at this stage does not refer to selected trace edit, but rather a record edit based on field Q.C. Reports and Daily Logs. Consequently, records known to contain autofires or excessively high parity counts were deleted from the processing.

### b. Pre-deconvolution Ramp Scaling

Pre-deconvolution ramp scaling was designed to suppress direct arrival energy. This was to prevent the high amplitude direct arrivals from being "blown-up" when the deconvolution operator was applied.

### c. Static Corrections

The total static applied was derived from three sources -

1. Static corrections of field multiplexing delays, shifting the traces to compensate for the difference in time of recording each individual trace.
2. Static correction to correct for sea level datum. A positive static correction was applied to compensate for the depth of the airgun array and streamer below sea level.



GSI-709

A water velocity of 4900 ft./sec., was assumed when making these corrections.

3. A correction for the airgun delay, which is the time lag between the firing commands and the actual gun pulse, was determined to be 13 milliseconds. This is a negative correction.

d. Deconvolution

The approximate deconvolution was accomplished by the application of a whitening filter designed from autocorrelation functions, which were derived from the trace to be deconvolved. Two filters were designed per trace and applied with a 50% overlap, such that the first filter tapered off while the second filter tapered on. The operators were designed as double section operators; i.e., to dereverberate the first and second water bottom reverberations.

e. Common Depth Point (CDP) Gather

All data output from the pre-processing stage is in a CDP format. Effectively, this means that each group of N traces (where N = fold) on these 24 trace output records is common to the same depth point. Within one depth point however, each trace represents a different offset location.

f. Annotation

The water depth and the offset to each trace in the gather is annotated in channel 25 for use in further processing.

g. Preliminary Stack

Velocities obtained from previous years' processing were applied to one system (usually evens) after CDP gather and the data stacked (24 fold 24 trace). This post-processing sequence omitted deconvolution. Similarly, data processed from near groups only generated a 12 fold preliminary stack. These stacks were output on CRT film frame and enlarged on paper.

3. VELOCITY ANALYSIS

The entire HB75A and HB75A Extension Surveys were processed through Full 700 Package Velocity Analysis, utilising decimated depth points, the latter depending on the fold of the data involved. 24 fold data was decimated 1 in 3 to give a 100 metre spacing while the 12 fold data utilised every second depth point to give a 66.7 metre interval. Note that in this description of 700 Package parameters, depth point numbering refers to decimated depth points.

a. Program 700-2 provides a continuous velocity analysis technique which was used to determine the complete velocity field along a line. Inputs to this program are pre-processed CDP gather records. On these CDP records the following processes were performed:-

1. Moveout and Dip Scan Building - A Moveout Scan is generated for each depth point and is formed by the application of a constant shift to each trace in proportion to the square of the offset of the trace and then stacking by mixing together all the traces in the gather to form a scan trace. The moveout applied is then incremented by a constant amount and the process repeated until the range of moveout applied exceeds the expected seismic range. Dip scans are built by stacking together series of moveout scans from consecutive depth points along linear planes of dip which are automatically incremented within a specified dip aperture designed to cover the expected range of dips on the seismic section. Dip apertures for each processing time gate were determined from the preliminary stack sections. The number of consecutive moveout scans stacked to form a dip scan is termed the SMASH rate and may also vary with the time gates.

2. Interpretation of Moveout/Dip Scans to detect valid events with time, amplitude and moveout, and dip information -

   The automatic interpretation is based on the fact that any coherent event on the gather record will stack at the optimum moveout value to a maximum (or minimum for negative values) in the two-dimensional time moveout plane of the scan. When stacking again takes place along the dip plane, which most approximates the true geological time-dip, maximum dip scan response will be achieved. The dip scan domain is a three-dimensional one in which every coherent event from the input gather records will be represented by a maximum or minimum at that time, moveout and dip which correctly describes the original seismic event.

   The resulting "TAMD picks" represent the mean time, amplitude, moveout and dip of the seismic event over a space gate of width SMASH depth points. The move-up rate is another important consideration. It refers to the number of depth points between the centre of each successive dip scan set. This information is listed in Appendix B.

3. Output to magnetic tape are the event files for each Space/Time gate -

   After the event detection is performed for all space points in each time gate the Event files are written on magnetic tape.

4. Extensions of the Event files in each time gate to produce Work files -

   Using search windows in time, amplitude, moveout and dip, the picked seismic events from neighbouring dip scan files can be correlated and those evolving from the same seismic horizon identified and connected. This process is called Extension and the set of connected seismic horizon events are termed Segments which are output as Work (Segment) files.

5. Summary Files and Consolidation Files -

After all time gates have been processed, the program outputs Summary and Consolidation files in the following manner.

- Hook-up of segments between time gates to allow continuous segments across time gates.
- Output Summary Files
- Consolidation of Summary files into continuous segments with time, amplitude and moveout at every depth point.
- Output of Consolidated Segment files on magnetic tape to be submitted for display on analysis routines.

b. Program 701 - Velocity Analysis Module - provides statistical displays (scattergrams) of velocity, amplitude and dip as a function of time over the entire space and also over specified space gates. The RMS velocities are computed from the segment times and moveouts averaged over each space gate and plotted as a coded symbol for each segment. The symbols are coded according to segment length within each space gate or according to the relative length in the entire Consolidated file. The highest amplitude segment within each 100 msec. gate is also shown by circling the rank or grading symbol. Dip and amplitude information is plotted on the right-hand side of the velocity versus time plot.

The inputs to this module are the Summary Files and the outputs are a series of CRT frames plus a listing. All outputs are generated for both the entire file and each individual space gate. The CRT frames were enlarged to a vertical scale of 1.875"/second and a horizontal scale of 1,000 ft/sec = 1 inch.

C. Program 602 - Segment Sort and Display - displays the Consolidated file in a fashion suitable for section overlay. Various sorting and annotation techniques are available to aid in the interpretation of the file.

Initially, the total file was displayed as a quality control measure. Only segments ≥ 24 depth points were plotted with segment numbers annotated on segments ≥ 24 depth points.

The final displays (segments ≥ 12 d.p.) were velocity sorted and consisted of -

a. Primary Peaks with RMS velocities averaged and annotated every 16 depth points.

b. Primary Troughs with RMS velocities averaged and annotated every 16 depth points.

Input to Program 602 was the Consolidated file and output was on 5" CRT frame. These were enlarged to a horizontal scale of the section to be overlaid (see "Display").

d. After interpretation of the scattergrams, the derived velocity functions were 'terminalised' and written out on one-inch magnetic tape. The latter was used as an input to the post-processing module.

4. Post-processing

The CDP gather records were input to the Post-processing Module and the following processes applied:-

a. Normal Moveout Correction

The Normal Moveout Correction was performed utilizing the velocity functions interpreted from the scattergrams. A velocity function was input at the location of each velocity module. A linear interpolation was performed between these functions and a velocity function calculated for and applied to each of the intermediate depth points. All velocity functions are referenced to the water top.

b. Single-fold Display

A single-fold section with the final stacking velocities applied was generated from the normal moveout program. This section was filtered with the final section TVF and displayed on paper.

c. Common Depth Point Stack

Common Depth Point Stack was performed with a scaling response equal to the reciprocal of the number of live traces contributing after first break supression. The first break supression ramps were derived from single-fold records, to remove unwanted water-borne energy, refractions and low frequencies due to stretching in the moveout process.

The stacked records were output on magnetic tapes which were purchased by Hematite.

d. Time Variant Deconvolution (TVD)

Time Variant Deconvolution is a multiple operator, whitening, deconvolution designed from and applied to each trace in a series of overlapping gates. Two operators were used on all lines. The TVD operators were designed from two 50% overlapping gates extending from 200 msecs. below the water bottom to 4900 msecs.

e. Time Variant Filtering (TVF)

A time variant, zero phase, digital filter was applied as shown on the side panel of each record section.

f. Cross Record Mix

This process does a weighted trace mix on the final output sections. This weighting used was 10%, 80%, 10%.

The first output trace of a record would have 10% contribution from input trace 1, 80% from input trace 2 and 10% from trace 3.

The second output trace would have 10% from input trace 2, 80% from trace 3 and 10% from trace 4. This process continues for the entire line.

This section was displayed on film.

g. Display

All plotter displays were in a wiggle trace/ variable area format at a horizontal scale of approximately .53 mile/inch and a vertical scale of 3.75 inches/second.

This resulted in a trace spacing of 10 traces/Cm.

## C. REFRACTION

Two refraction profiles were recorded in the HB75A Survey. These were :-

HB75A-156 SP 325-677

HB75A-172 SP 1-121

Due to a field error, on line HB75A-172 the Sonobuoy was dropped approximately one cable length (3200 metres) before SP.1.

The processing flow proceeded thus -

1. Single channel (27) gather from field tape.
2. Delay Time Profile. Each line was corrected with velocities of 13,500 ft/sec and 18,000 ft/sec.
3. Static corrections for source and receiver depth.
4. A 6 on 1 trace mix.
5. Filter, using a 15-30 Hz bandpass.

This was established on the basis of a filter analysis provided on HB75A 156, SP 469-563.

The profiles were displayed on film in the Variable area/wiggle trace mode with a vertical scale of 3.75"/sec and a horizontal scale of 8 traces per inch utilising 20% bias.

Side panels on final sections gives ready access to pertinent field and processing information.

Respectfully sumitted,
GEOPHYSICAL SERVICE INTERNATIONAL

K. Paine for

Steve Jeffrey
Party Chief

Ken Graybill
Data Processing Manager

APPENDIX A

LINE, PROCESSING, SHOTPOINT AND MILEAGE INDEX

| LINE | FOLD | SHOTPOINT RANGE | MILEAGE |
|---|---|---|---|
| HB75A 9 | 12 | 1 - 241 | 9.99 |
| 26 | 12 | 1 - 306 | 12.68 |
| 27 | 12 | 1 - 443 | 18.35 |
| 29 | 24 | 1 - 350 | 14.50 |
| 69 | 24 | 1 - 559 | 23.16 |
| 84 | 24 | 1 - 297 | 12.31 |
| 93 | 12 | 1 - 253<br>448 - 672 | 18.52 |
| 114 | 24 | 1 - 928 | 38.45 |
| 156 | 24 | 1 - 677 | 28.05 |
| 171 | 24 | 1 - 118 | 4.89 |
| 172 | 24 | 1 - 793 | 32.86 |
| 173 | 24 | 1 - 392 | 16.24 |
| 174 | 24 | 1 - 577 | 23.90 |
| 174A | 24 | 1 - 205 | 8.45 |
| 175 | 24 | 1 - 119 | 4.93 |
| 176 | 12 | 1 - 363 | 15.04 |
| 177 | 12 | 1 - 173 | 7.17 |

| LINE | FOLD | SHOTPOINT RANGE | MILEAGE |
|---|---|---|---|
| HB75A - 178 | 24 | 1 - 310 | 12.85 |
| 179 | 12 | 1 - 302 | 12.50 |
| 180 | 24 | 1 - 333 | 13.80 |
| 181 | 12 | 1 - 251 | 10.40 |
| 182 | 24 | 1 - 123 | 5.10 |
| 183 | 12 | 1 - 154 | 6.38 |
| 184 | 24 | 1 - 296 | 12.26 |
| 185 | 12 | 1 - 264 | 10.93 |
| 186 | 24 | 1 - 719 | 29.79 |
| 187 | 12 | 1 - 151 | 6.26 |
| 188 | 24 | 1 - 199 | 8.25 |
| 189 | 12 | 1 - 372 | 15.41 |
| 190 | 24 | 1 - 605 | 25.07 |
| 191 | 24 | 1 - 75 | 3.11 |
| 192 | 12 | 1 - 207 | 8.58 |
| 193 | 24 | 1 - 588 | 24.36 |
| 194 | 24 | 1 - 126 | 5.22 |
| 195 | 24 | 1 - 131 | 5.43 |
| 196 | 24 | 1 - 240 | 9.94 |
| 196A | 24 | 1 - 131 | 5.43 |
| 197 | 24 | 1 - 130 | 5.39 |
| 198 | 24 | 1 - 103 | 4.27 |

| LINE | | FOLD | SHOTPOINT RANGE | MILEAGE |
|---|---|---|---|---|
| HB75A - | 199 | 24 | 1 - 145 | 6.01 |
| | 199A | 24 | 1 - 251 | 10.40 |
| | 200 | 24 | 1 - 432 | 17.90 |
| | 201 | 24 | 1 - 418 | 17.32 |
| | 202 | 24 | 1 - 365 | 15.12 |
| | 204 | 24 | 1 - 134 | 5.55 |
| | 205 | 24 | 1 - 120 | 4.97 |
| | 206 | 24 | 1 - 118 | 4.89 |
| | 207 | 24 | 1 - 122 | 5.05 |
| | 208 | 24 | 1 - 88 | 3.65 |
| | 209 | 24 | 1 - 97 | 4.02 |
| | 210 | 24 | 1 - 352 | 14.59 |
| | 211 | 24 | 1 - 306 | 13.07 |
| | 212 | 24 | 1 - 269 | 11.14 |
| | 213 | 24 | 1 - 450 | 18.65 |
| | 213A | 24 | 1 - 649 | 26.89 |
| | 214 | 24 | 1 - 405 | 16.78 |
| | 215 | 24 | 1 - 410 | 16.99 |
| | 217 | 24 | 1 - 418 | 17.32 |
| | 218 | 24 | 1 - 812 | 33.64 |
| | 219 | 24 | 1 - 939 | 38.91 |
| | 220 | 24 | 1 - 1105 | 45.79 |
| | 221 | 24 | 1 - 1192 | 49.39 |
| | 222 | 24 | 1 - 1197 | 49.60 |
| | 223 | 24 | 1 - 1290 | 53.45 |
| | 224 | 24 | 1 - 308 | 12.76 |
| | 225 | 24 | 1 - 373<br>445 - 914 | 34.93 |
| | 226 | 24 | 1 - 879 | 36.42 |
| | 227 | 24 | 1 - 1277 | 51.91 |
| | 228 | 24 | 229 - 1382 | 44.87 |
| | 229 | 24 | 1 - 1122 | 45.50 |
| | 230 | 24 | 1 - 640 | 26.52 |
| | 231 | 24 | 1 - 622 | 25.77 |
| | 232 | 12 | 1 - 380 | 15.74 |

## APPENDIX B.

### PARAMETERS FOR 700 PACKAGE.

Both the Bass and Bass Extension Surveys utilised the following 700 Package parameters.

| Time Gates | Smash | Move-up |
|---|---|---|
| 0.0 - 0.1 | 0 | 0 |
| 0.1 - 1.0 | 4 | 4 |
| 1.0 - 2.5 | 4 | 3 |
| 2.5 - 3.8 | 6 | 6 |
| 3.8 - 5.0 | 8 | 8 |

Dip parameters are tabulated below, dip values being in sequence for the time gates as listed above.

Note that dip values refer to a measurement of time displacement (milliseconds) per horizontal unit.

For the 24 fold data, (See Appendix A), this is milliseconds per 3 traces, (as on final section), and for 12 fold data, milliseconds per 2 traces.

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 9 | 1 - 222 | 0 | 0 |
| | | -8 | 9 |
| | | -9 | 8 |
| | | -10 | 11 |
| | | -11 | 12 |
| 26 | 1 - 288 | 0 | 0 |
| | | -6 | 6 |
| | | -8 | 8 |
| | | -10 | 10 |
| | | -10 | 10 |
| 27 | 1 - 424 | 0 | 0 |
| | | -8 | 9 |
| | | -9 | 8 |
| | | -10 | 11 |
| | | -11 | 10 |
| 29 | 1 - 324 | 0 | 0 |
| | | -12 | 15 |
| | | -15 | 12 |
| | | -15 | 15 |
| | | -20 | 22 |
| 69 | 1 - 528 | 0 | 0 |
| | | -8 | 8 |
| | | -12 | 12 |
| | | -18 | 18 |
| | | -22 | 22 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 84 | 1 - 264 | 0 | 0 |
| | | -8 | 8 |
| | | -15 | 8 |
| | | -15 | 18 |
| | | -15 | 15 |
| 93 | 1 - 232 | 0 | 0 |
| | | -8 | 9 |
| | | -9 | 8 |
| | | -10 | 11 |
| | | -11 | 10 |
| | 451 - 654 | 0 | 0 |
| | | -6 | 6 |
| | | -12 | 12 |
| | | -15 | 15 |
| | | -15 | 15 |
| 114 | 1 - 504 | 0 | 0 |
| | | -11 | 11 |
| | | -15 | 15 |
| | | -15 | 11 |
| | | -15 | 12 |
| | 505 - 900 | 0 | 0 |
| | | -11 | 11 |
| | | -15 | 14 |
| | | -15 | 11 |
| | | -11 | 11 |
| 156 | 1 - 504 | 0 | 0 |
| | | -21 | 8 |
| | | -21 | 9 |
| | | -21 | 15 |
| | | -20 | 21 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 156 | 505 - 648 | 0 | 0 |
| | | -11 | 15 |
| | | -9 | 8 |
| | | -12 | 11 |
| | | -23 | 23 |
| 171 | 1 - 84 | 0 | 0 |
| | | -5 | 8 |
| | | -8 | 8 |
| | | -15 | 15 |
| | | -15 | 12 |
| 172 | 1 - 504 | 0 | 0 |
| | | -5 | 8 |
| | | -6 | 6 |
| | | -6 | 15 |
| | | -9 | 9 |
| | 505 - 537 | 0 | 0 |
| | | -9 | 4 |
| | | -8 | 4 |
| | | -9 | 9 |
| | | -15 | 4 |
| | 537 - 761 | 0 | 0 |
| | | -8 | 3 |
| | | -15 | 3 |
| | | -15 | 15 |
| | | -20 | 20 |
| 173 | 1 - 360 | 0 | 0 |
| | | -3 | 3 |
| | | -7 | 18 |
| | | -24 | 30 |
| | | -18 | 18 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 174 | 1 - 504 | 0 | 0 |
| | | -3 | 3 |
| | | -5 | 5 |
| | | -12 | 17 |
| | | -5 | 21 |
| | 505 - 549 | 0 | 0 |
| | | -3 | 3 |
| | | -8 | 16 |
| | | -15 | 15 |
| | | -15 | 15 |
| 174A | 1 - 177 | 0 | 0 |
| | | -9 | 9 |
| | | -12 | 12 |
| | | -18 | 15 |
| | | -22 | 18 |
| 175 | 1 - 85 | 0 | 0 |
| | | -9 | 6 |
| | | -15 | 15 |
| | | -12 | 15 |
| | | -20 | 18 |
| 176 | 1 - 344 | 0 | 0 |
| | | -5 | 5 |
| | | -5 | 5 |
| | | -10 | 5 |
| | | -10 | 10 |
| 177 | 1 - 152 | 0 | 0 |
| | | -9 | 10 |
| | | -10 | 9 |
| | | -16 | 15 |
| | | -15 | 16 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 178 | 1 - 276 | 0 | 0 |
| | | -3 | 3 |
| | | -14 | 6 |
| | | -25 | 25 |
| | | -22 | 16 |
| 179 | 1 - 294 | 0 | 0 |
| | | -8 | 6 |
| | | -12 | 11 |
| | | -11 | 11 |
| | | -12 | 10 |
| 180 | 1 - 300 | 0 | 0 |
| | | -6 | 10 |
| | | -9 | 9 |
| | | -24 | 15 |
| | | -12 | 21 |
| 181 | 1 - 232 | 0 | 0 |
| | | -6 | 6 |
| | | -8 | 8 |
| | | -10 | 10 |
| | | -10 | 10 |
| 182 | 1 - 96 | 0 | 0 |
| | | -4 | 6 |
| | | -9 | 9 |
| | | -12 | 15 |
| | | -8 | 15 |
| 183 | 1 - 136 | 0 | 0 |
| | | -6 | 6 |
| | | -8 | 8 |
| | | -10 | 10 |
| | | -10 | 10 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 184 | 1 - 264 | 0 | 0 |
| | | -11 | 11 |
| | | -15 | 6 |
| | | -15 | 5 |
| | | -10 | 15 |
| 185 | 1 - 246 | 0 | 0 |
| | | -5 | 3 |
| | | -10 | 8 |
| | | -10 | 10 |
| | | -12 | 10 |
| 186 | 1 - 684 | 0 | 0 |
| | | -6 | 9 |
| | | -19 | 15 |
| | | -20 | 19 |
| | | -21 | 20 |
| 187 | 1 - 132 | 0 | 0 |
| | | -6 | 6 |
| | | -6 | 6 |
| | | -10 | 10 |
| | | -10 | 10 |
| 188 | 1 - 168 | 0 | 0 |
| | | -12 | 12 |
| | | -15 | 12 |
| | | -18 | 15 |
| | | -20 | 20 |
| 189 | 1 - 352 | 0 | 0 |
| | | -6 | 6 |
| | | -6 | 6 |
| | | -10 | 10 |
| | | -10 | 10 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 190 | 1 - 504 | 0 | 0 |
| | | -10 | 5 |
| | | -15 | 10 |
| | | -15 | 15 |
| | | -18 | 15 |
| | 505 - 576 | 0 | 0 |
| | | -9 | 9 |
| | | -15 | 9 |
| | | -15 | 18 |
| | | -15 | 15 |
| 191 | 1 - 48 | 0 | 0 |
| | | -8 | 5 |
| | | -8 | 8 |
| | | -10 | 10 |
| | | -11 | 11 |
| 192 | 1 - 192 | 0 | 0 |
| | | -10 | 10 |
| | | -8 | 9 |
| | | -12 | 12 |
| | | -10 | 10 |
| 193 | 1 - 504 | 0 | 0 |
| | | -6 | 6 |
| | | -20 | 6 |
| | | -10 | 6 |
| | | -6 | 6 |
| | 505 - 558 | 0 | 0 |
| | | -3 | 6 |
| | | -12 | 6 |
| | | -9 | 9 |
| | | -17 | 6 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 194 | 1 - 96 | 0 | 0 |
| | | -9 | 6 |
| | | -21 | 21 |
| | | -8 | 8 |
| | | -8 | 8 |
| 195 | 1 - 96 | 0 | 0 |
| | | -3 | 3 |
| | | -9 | 12 |
| | | -25 | 24 |
| | | -21 | 24 |
| 196 | 1 - 213 | 0 | 0 |
| | | -6 | 5 |
| | | -8 | 15 |
| | | -5 | 5 |
| | | -6 | 6 |
| 196A | 1 - 105 | 0 | 0 |
| | | -10 | 11 |
| | | -15 | 20 |
| | | -15 | 20 |
| | | -20 | 21 |
| 197 | 1 - 96 | 0 | 0 |
| | | -3 | 3 |
| | | -8 | 8 |
| | | -13 | 5 |
| | | -13 | 5 |
| 198 | 1 - 60 | 0 | 0 |
| | | -6 | 3 |
| | | -15 | 5 |
| | | -22 | 5 |
| | | -22 | 5 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 199 | 1 - 117 | 0 | 0 |
| | | -4 | 3 |
| | | -5 | 4 |
| | | -25 | 9 |
| | | -18 | 4 |
| 199A | 1 - 225 | 0 | 0 |
| | | -8 | 8 |
| | | -18 | 10 |
| | | -15 | 15 |
| | | -18 | 15 |
| 200 | 1 - 405 | 0 | 0 |
| | | -9 | 12 |
| | | -15 | 15 |
| | | -15 | 12 |
| | | -21 | 21 |
| 201 | 1 - 384 | 0 | 0 |
| | | -5 | 6 |
| | | -8 | 9 |
| | | -15 | 9 |
| | | -15 | 15 |
| 202 | 1 - 333 | 0 | 0 |
| | | -10 | 10 |
| | | -10 | 14 |
| | | -10 | 14 |
| | | -10 | 14 |
| 204 | 1 - 105 | 0 | 0 |
| | | -5 | 10 |
| | | -8 | 10 |
| | | -15 | 12 |
| | | -9 | 15 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 205 | 1 - 90 | 0 | 0 |
| | | -11 | 11 |
| | | -8 | 8 |
| | | -15 | 12 |
| | | -15 | 15 |
| 206 | 1 - 90 | 0 | 0 |
| | | -3 | 3 |
| | | -6 | 8 |
| | | -6 | 8 |
| | | -6 | 8 |
| 207 | 1 - 90 | 0 | 0 |
| | | -5 | 5 |
| | | -8 | 8 |
| | | -5 | 8 |
| | | -5 | 8 |
| 208 | 1 - 60 | 0 | 0 |
| | | -5 | 8 |
| | | -12 | 6 |
| | | -5 | 8 |
| | | -8 | 5 |
| 209 | 1 - 69 | 0 | 0 |
| | | -3 | 3 |
| | | -8 | 5 |
| | | -5 | 8 |
| | | -8 | 16 |
| 210 | 1 - 324 | 0 | 0 |
| | | -8 | 3 |
| | | -15 | 8 |
| | | -15 | 5 |
| | | -15 | 5 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 211 | 1 - 300 | 0 | 0 |
| | | -2 | 5 |
| | | -4 | 18 |
| | | -5 | 23 |
| | | -18 | 23 |
| 212 | 1 - 261 | 0 | 0 |
| | | -2 | 3 |
| | | 1 | 15 |
| | | 0 | 24 |
| | | 7 | 24 |
| 213 | 1 - 444 | 0 | 0 |
| | | -6 | 8 |
| | | -17 | 11 |
| | | -17 | 6 |
| | | -23 | 6 |
| 213A | 1 - 621 | 0 | 0 |
| | | -10 | 10 |
| | | -15 | 15 |
| | | -20 | 20 |
| | | -25 | 25 |
| 214 | 1 - 372 | 0 | 0 |
| | | -8 | 9 |
| | | -10 | 11 |
| | | -20 | 21 |
| | | -18 | 19 |
| 215 | 1 - 384 | 0 | 0 |
| | | -12 | 9 |
| | | -15 | 22 |
| | | -18 | 15 |
| | | -18 | 15 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 217 | 1 - 384 | 0 | 0 |
| | | -10 | 10 |
| | | -15 | 15 |
| | | -20 | 20 |
| | | -25 | 25 |
| 218 | 1 - 504 | 0 | 0 |
| | | -8 | 8 |
| | | -9 | 15 |
| | | -12 | 22 |
| | | -15 | 25 |
| | 505 - 780 | 0 | 0 |
| | | -15 | 15 |
| | | -15 | 25 |
| | | -15 | 25 |
| | | -18 | 25 |
| 219 | 1 - 504 | 0 | 0 |
| | | -12 | 12 |
| | | -12 | 18 |
| | | -18 | 25 |
| | | -18 | 25 |
| | 505 - 909 | 0 | 0 |
| | | -12 | 12 |
| | | -15 | 15 |
| | | -15 | 15 |
| | | -18 | 15 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 220 | 1 - 504 | 0 | 0 |
| | | -10 | 10 |
| | | -12 | 12 |
| | | -15 | 20 |
| | | -18 | 20 |
| | 505 - 1008 | 0 | 0 |
| | | -10 | 10 |
| | | -15 | 20 |
| | | -15 | 20 |
| | | -20 | 22 |
| | 1009 - 1077 | 0 | 0 |
| | | -10 | 15 |
| | | -15 | 20 |
| | | -15 | 20 |
| | | -20 | 20 |
| 221 | 1 - 504 | 0 | 0 |
| | | -5 | 5 |
| | | -10 | 10 |
| | | -10 | 15 |
| | | -15 | 20 |
| | 505 - 1008 | 0 | 0 |
| | | -5 | 5 |
| | | -8 | 8 |
| | | -20 | 15 |
| | | -20 | 20 |
| | 1009 - 1161 | 0 | 0 |
| | | -5 | 5 |
| | | -10 | 10 |
| | | -15 | 15 |
| | | -15 | 18 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 222 | 1 - 504 | 0 | 0 |
| | | -8 | 11 |
| | | -8 | 9 |
| | | -8 | 15 |
| | | -8 | 23 |
| | 505 - 1008 | 0 | 0 |
| | | -3 | 9 |
| | | -11 | 15 |
| | | -11 | 25 |
| | | -6 | 25 |
| | 1009 - 1170 | 0 | 0 |
| | | -3 | 6 |
| | | -3 | 18 |
| | | -3 | 18 |
| | | -3 | 18 |
| 223 | 1 - 504 | 0 | 0 |
| | | -10 | 8 |
| | | -10 | 10 |
| | | -15 | 25 |
| | | -15 | 25 |
| | 505 - 1008 | 0 | 0 |
| | | -10 | 8 |
| | | -10 | 10 |
| | | -12 | 15 |
| | | -20 | 20 |
| | 1009 - 1260 | 0 | 0 |
| | | -10 | 10 |
| | | -10 | 20 |
| | | -20 | 20 |
| | | -20 | 20 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 224 | 1 - 276 | 0 | 0 |
| | | -5 | 5 |
| | | -10 | 15 |
| | | -15 | 15 |
| | | -20 | 18 |
| 225 | 1 - 369 | 0 | 0 |
| | 445 - 885 | -5 | 5 |
| | | -10 | 10 |
| | | -15 | 10 |
| | | -20 | 10 |
| 226 | 1 - 504 | 0 | 0 |
| | | -5 | 5 |
| | | -10 | 5 |
| | | -15 | 15 |
| | | -15 | 15 |
| | 505 - 852 | 0 | 0 |
| | | -5 | 5 |
| | | -20 | 10 |
| | | -20 | 20 |
| | | -20 | 20 |
| 227 | 1 - 504 | 0 | 0 |
| | | -8 | 8 |
| | | -12 | 12 |
| | | -18 | 18 |
| | | -22 | 22 |
| | 505 - 1008 | 0 | 0 |
| | | -8 | 8 |
| | | -12 | 12 |
| | | -18 | 18 |
| | | -20 | 20 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 227 | 1009 - 1248 | 0 | 0 |
| | | -8 | 8 |
| | | -12 | 12 |
| | | -18 | 18 |
| | | -22 | 22 |
| 228 | 229 - 732 | 0 | 0 |
| | | -5 | 5 |
| | | -5 | 8 |
| | | -10 | 10 |
| | | -15 | 20 |
| | 733 - 1056 | 0 | 0 |
| | | -5 | 5 |
| | | -5 | 5 |
| | | -18 | 15 |
| | | -18 | 18 |
| | 1087 - 1350 | 0 | 0 |
| | | -5 | 5 |
| | | -10 | 12 |
| | | -20 | 15 |
| | | -15 | 15 |
| 229 | 1 - 504 | 0 | 0 |
| | | -5 | 5 |
| | | -15 | 20 |
| | | -20 | 20 |
| | | -15 | 20 |
| | 505 - 612 | 0 | 0 |
| | | -5 | 10 |
| | | -18 | 20 |
| | | -18 | 25 |
| | | -30 | 25 |

| LINE | SHOTPOINT RANGE | DIPS | |
|---|---|---|---|
| 229 | 649 - 1092 | 0 | 0 |
| | | -5 | 10 |
| | | -18 | 10 |
| | | -18 | 20 |
| | | -18 | 20 |
| 230 | 1 - 504 | 0 | 0 |
| | | -5 | 6 |
| | | -15 | 16 |
| | | -15 | 20 |
| | | -15 | 16 |
| | 505 - 612 | 0 | 0 |
| | | -5 | 6 |
| | | -15 | 16 |
| | | -15 | 5 |
| | | -20 | 5 |
| 231 | 1 - 588 | 0 | 0 |
| | | -10 | 10 |
| | | -15 | 15 |
| | | -20 | 20 |
| | | -25 | 25 |
| 232 | 1 - 360 | 0 | 0 |
| | | -8 | 9 |
| | | -9 | 8 |
| | | -10 | 11 |
| | | -11 | 10 |

## APPENDIX C

## PURCHASE TAPE LOG INDEX

| Tape | Lines |
|---|---|
| 2380 | 212, 192, 181, 178, 84, 184, 186, 188, 190, 191, 196, 193, 201. |
| 2442 | 229, 223, 221, 69, 196A. |
| 2466 | 202, 198, 199, 200, 156, 114, 176, 204, 179, 177, 172 (SP.537-793), 26, 183. |
| 2624 | 189, 185, 187. |
| 2678 | 29, 215, 219, 199A, 222, 230, 232, 214. |
| 3432 | 227, 225 (SP.1-397), 226, 231, 228 (SP.229-1083), 93 (SP.1-253), 217. |
| 4932 | 213A, 9, 228 (SP.1084-1382), 93 (SP.448-672), 174A, 220, 218, 224, 225 (SP.445-914), 27. |
| 5032 | 172 (SP.1-564), 174, 182, 194, 195, 197, 210, 213, 171, 205, 207, 209, 175, 206, 208, 211, 173, 180. |

HEMATITE PETROLEUM PTY. LTD.

BASS HB75A MARINE SEISMIC SURVEY

GEOPHYSICAL SERVICE INTERNATIONAL PARTY 931

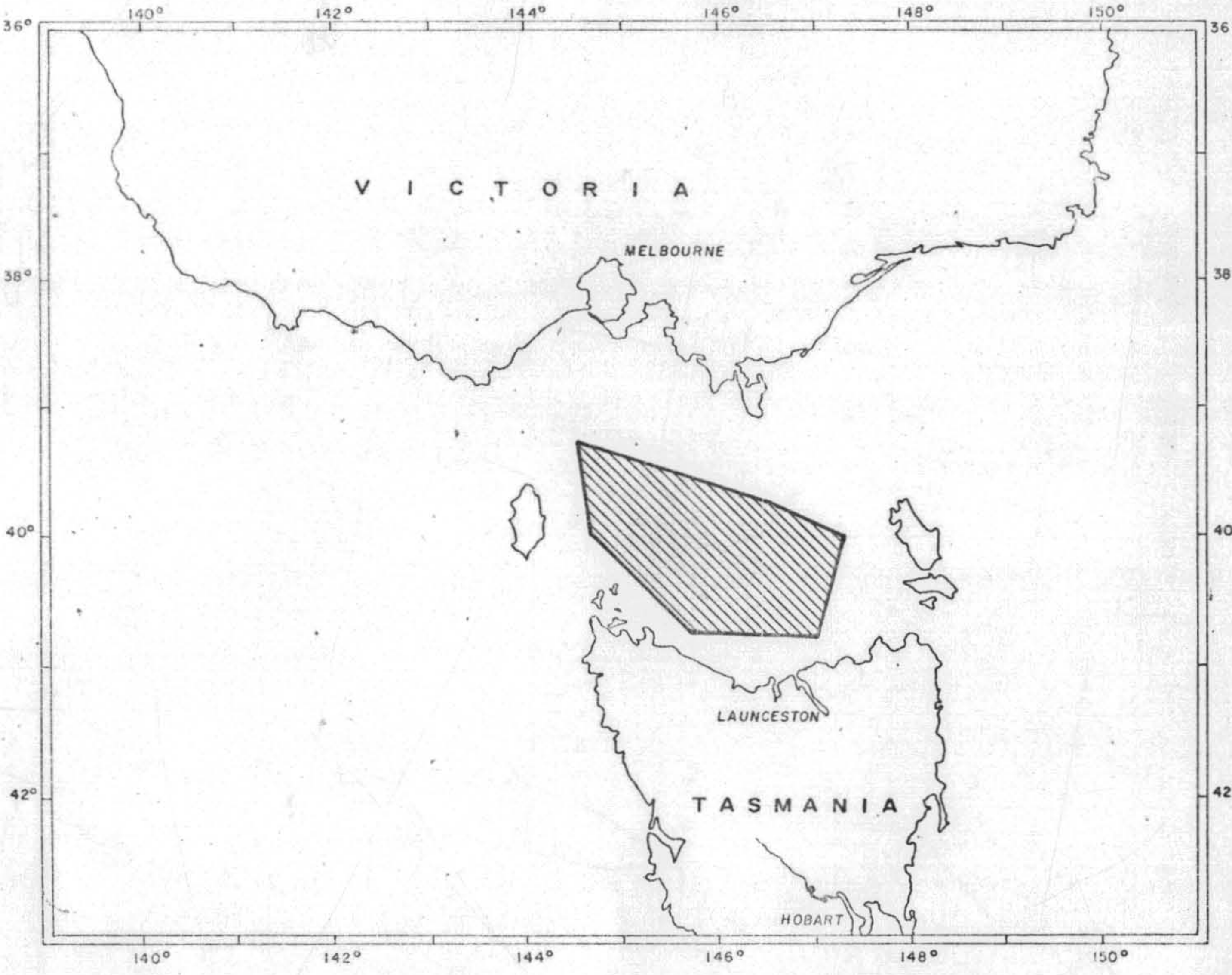



PLATE I

5 cm

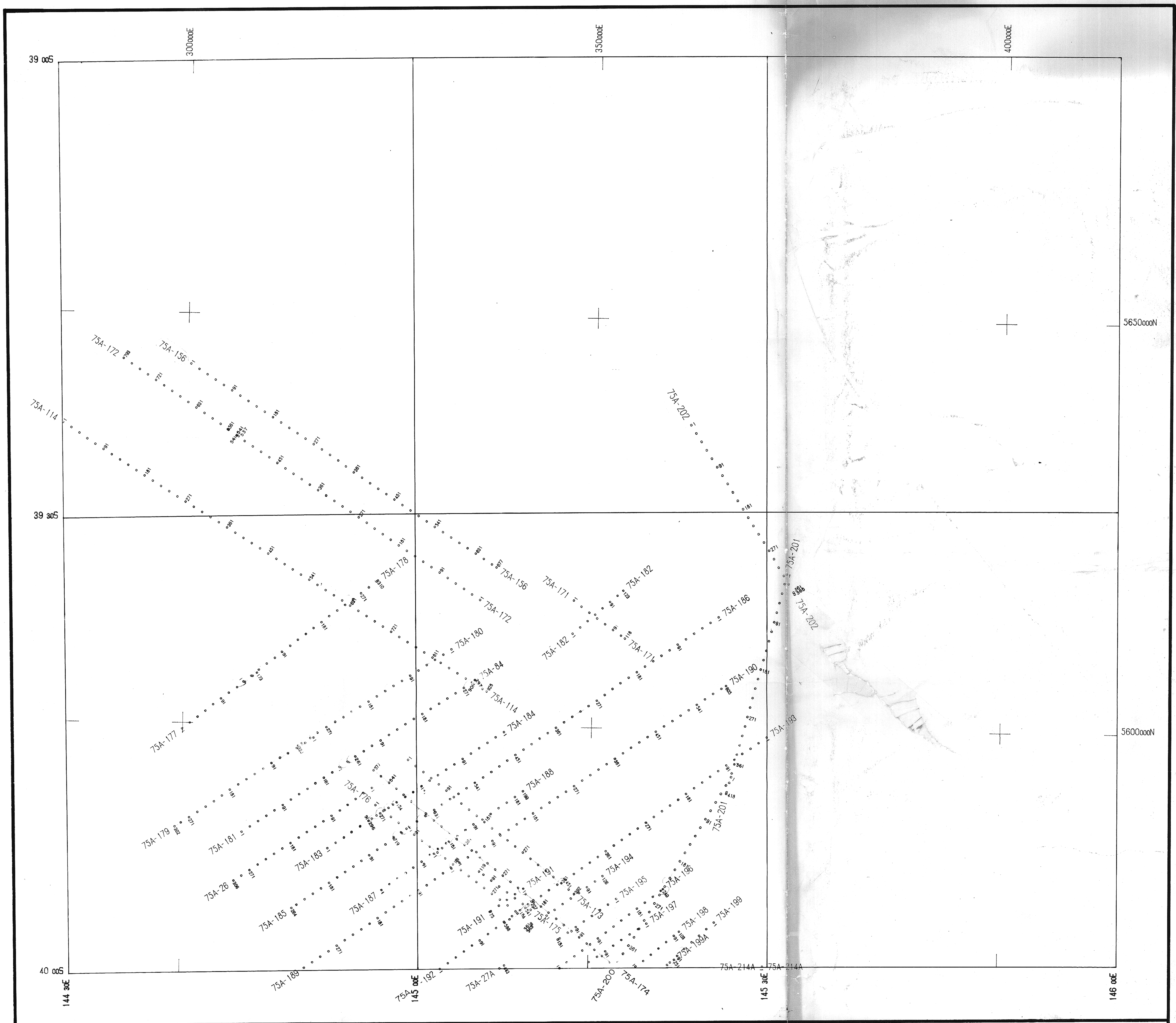
060179

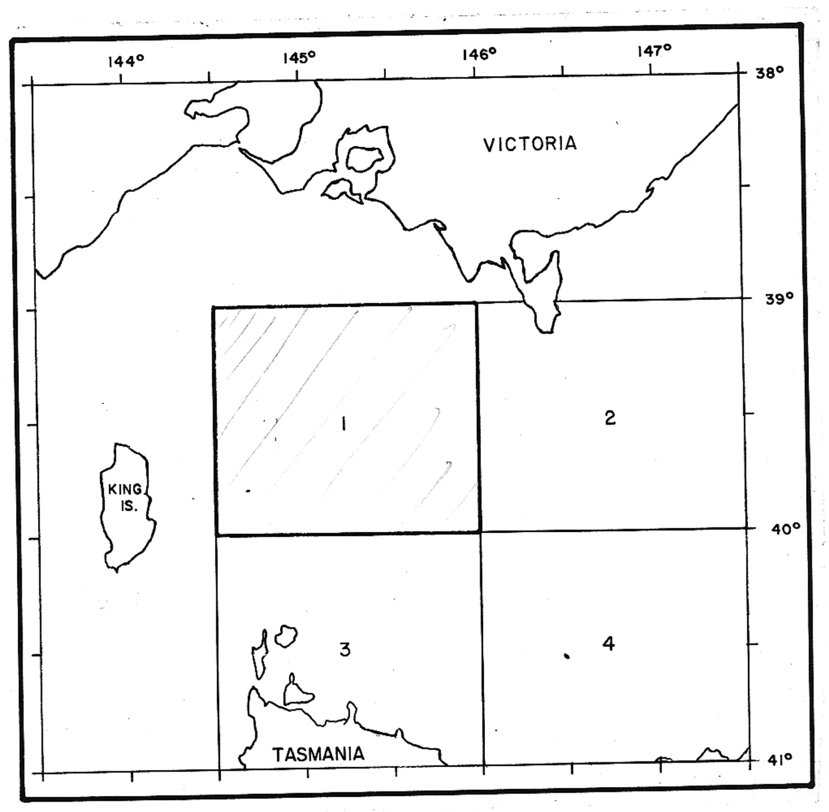
**BASS HB75A**

**MARINE SEISMIC SURVEY**

SHOT POINT LOCATION MAPS :

Sheet 1 / 4
Sheet 2 / 4
Sheet 3 / 4
Sheet 4 / 4




GEOPHYSICAL SERVICE INTERNATIONAL

HEMATITE PETROLEUM PTY. LTD.
HB75A

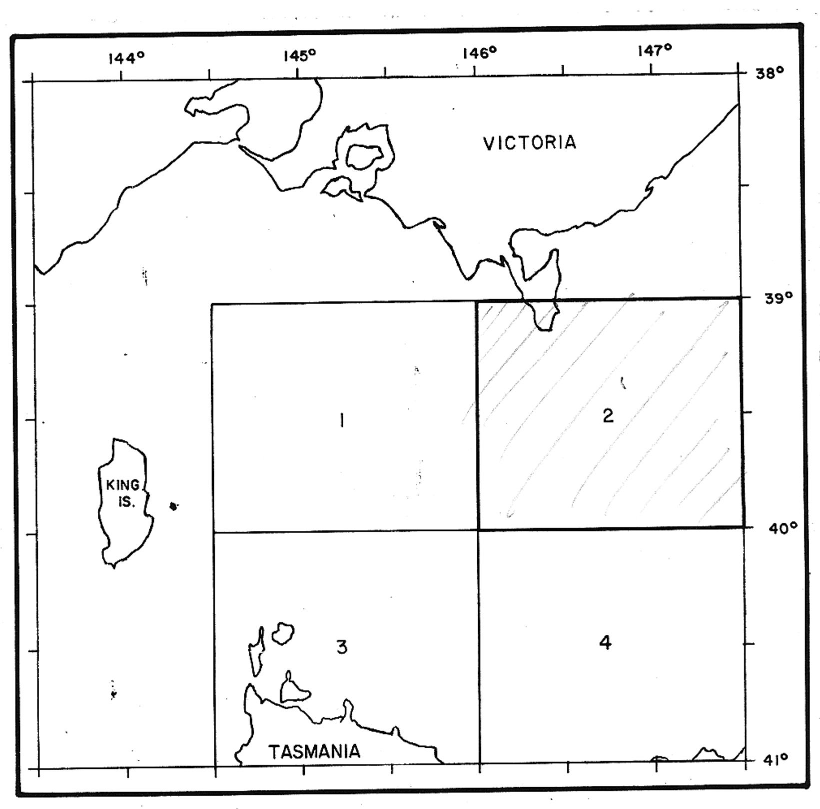
SHOT POINT LOCATION MAP
(POINT MAPPED = ℄ AIRGUNS)

| | |
|---|---|
| UNIVERSAL TRANSVERSE MERCATOR PROJECTION: AUST. NAT. SPHEROID | ZONE 55 |
| SCALE 1 : 250,000 | SHEET 1 OF 4 |
| SHOT BY M.V. EUGENE McDERMOTT II DATE JAN-FEB, 1975 | |

5 cm

060181

OR 016


**GEOPHYSICAL SERVICE INTERNATIONAL**

**HEMATITE PETROLEUM PTY. LTD.**
**HB75A**

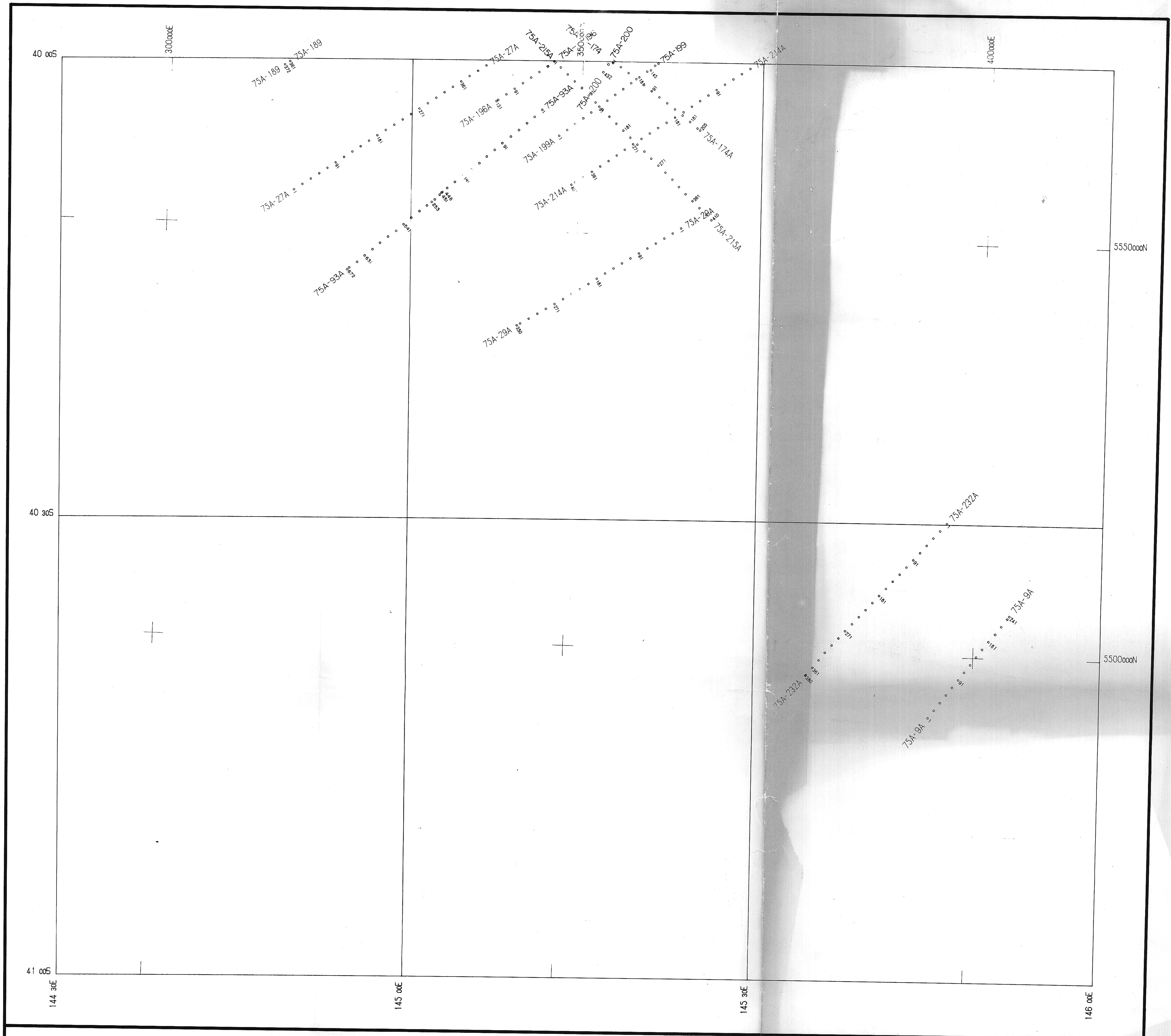
**SHOT POINT LOCATION MAP**
(POINT MAPPED = ℄ AIRGUNS)

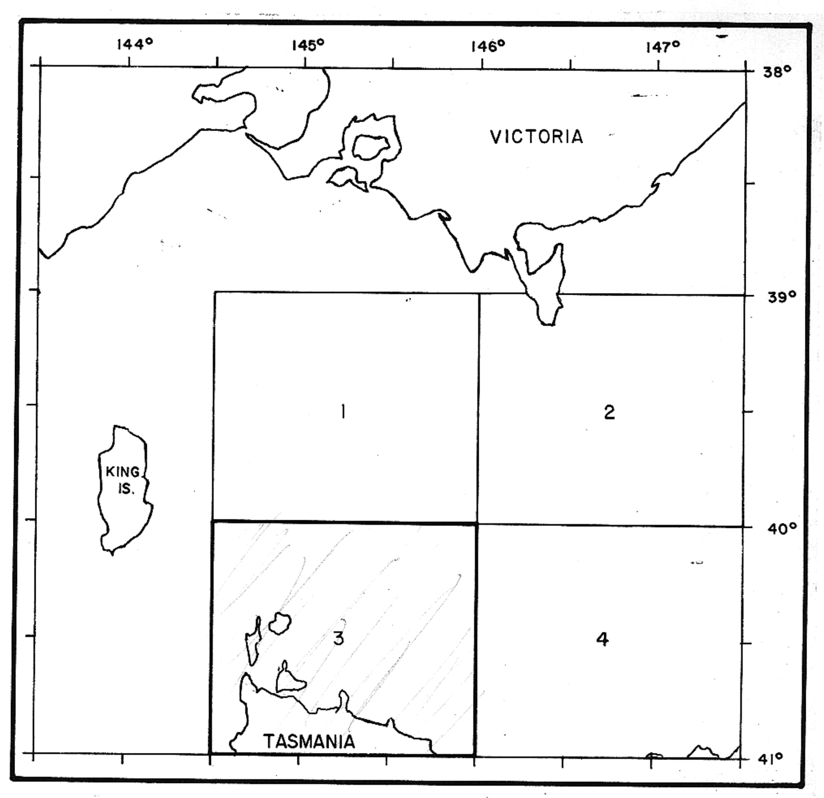
| | |
|---|---|
| UNIVERSAL TRANSVERSE MERCATOR PROJECTION: AUST. NAT. SPHEROID | ZONE 55 |
| SCALE 1 : 250,000 | SHEET 2 OF 4 |
| SHOT BY M.V. EUGENE McDERMOTT II DATE JAN-FEB, 1975 | |

5 cm

060182

OR 016




**GEOPHYSICAL SERVICE INTERNATIONAL**

**HEMATITE PETROLEUM PTY. LTD.**
**HB75A**

**SHOT POINT LOCATION MAP**
(POINT MAPPED = ℄ AIRGUNS)

UNIVERSAL TRANSVERSE MERCATOR PROJECTION: AUST. NAT. SPHEROID — ZONE 55

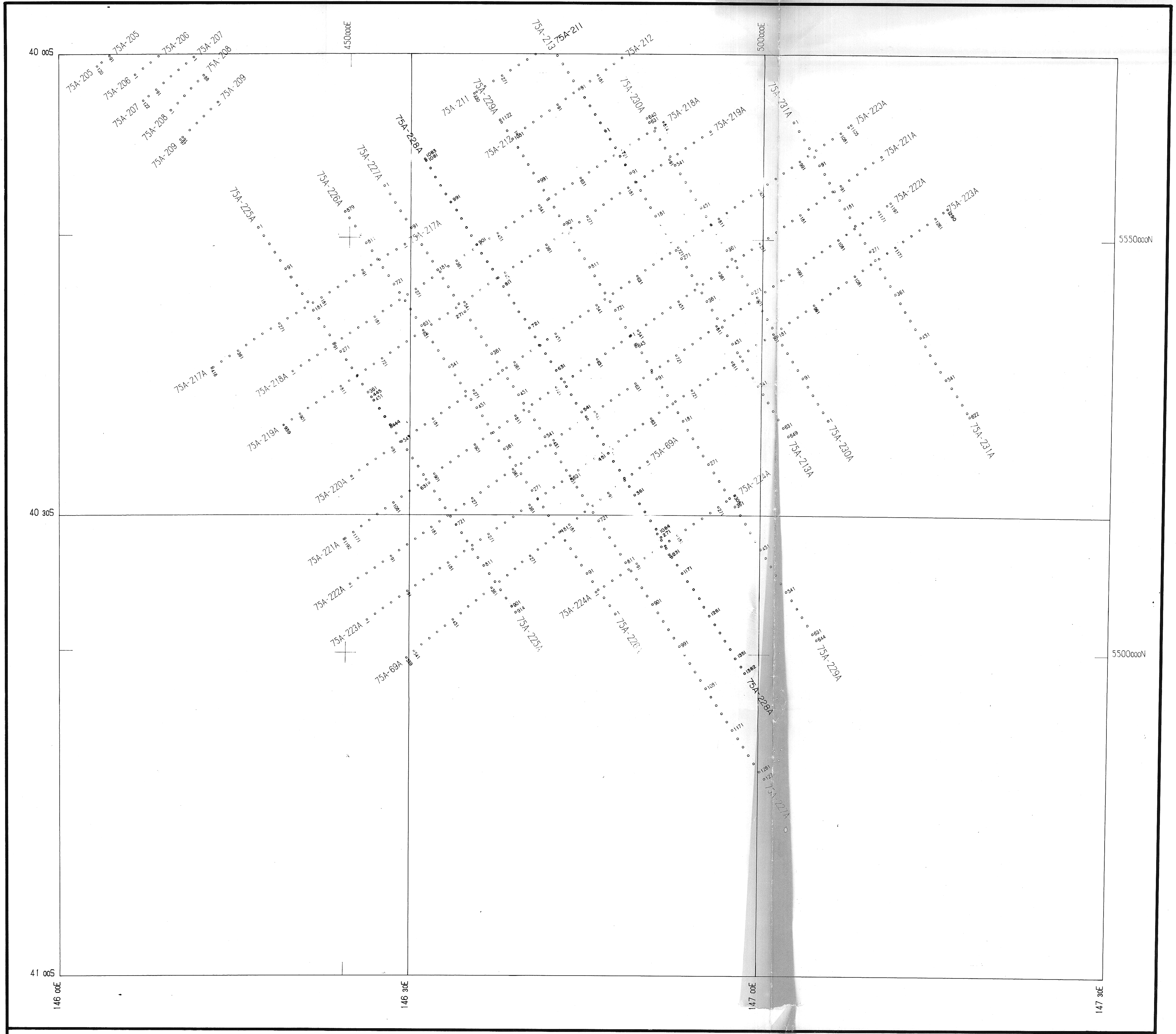
SCALE 1:250,000 — SHEET 3 OF 4

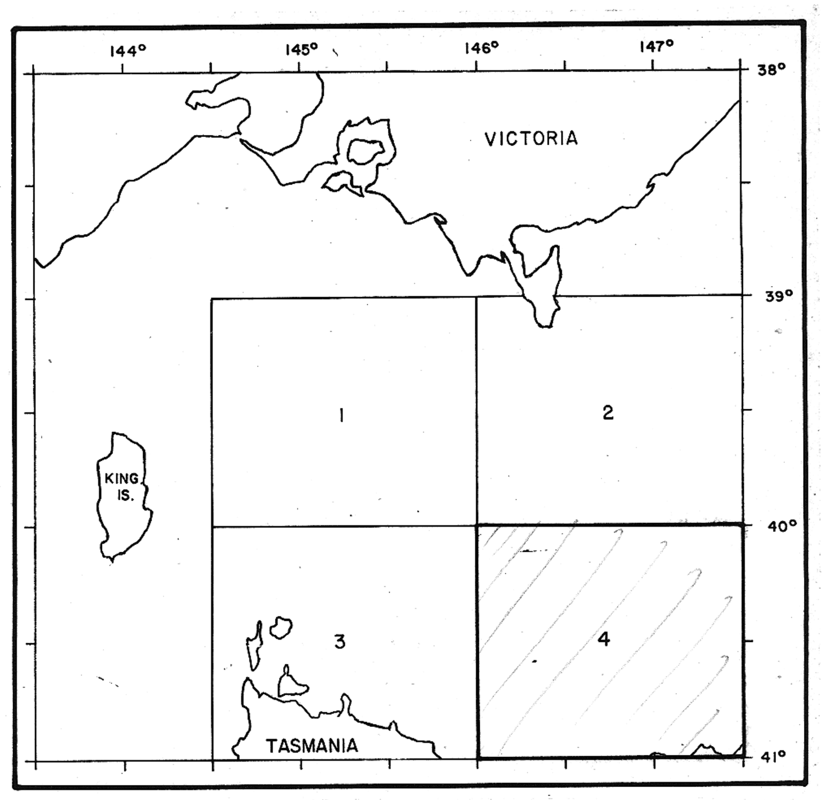
SHOT BY M.V. EUGENE. McDERMOTT II — DATE JAN-FEB, 1975

5 cm

060183

OR 016




GEOPHYSICAL SERVICE INTERNATIONAL

HEMATITE PETROLEUM PTY. LTD.
HB75A

SHOT POINT LOCATION MAP
(POINT MAPPED = ℄ AIRGUNS)

| | |
|---|---|
| UNIVERSAL TRANSVERSE MERCATOR PROJECTION: AUST. NAT. SPHEROID | ZONE 55 |
| SCALE 1:250,000 | SHEET 4 OF 4 |
| SHOT BY M.V. EUGENE McDERMOTT II DATE JAN-FEB, 1975 | |

5 cm

060184

OR 016