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REPORT ON THE
COMBINED HELICOPTER-BORNE
MAGNETIC AND ELECTROMAGNETIC SURVEY
IN THE
MOUNT LEE AREA OF WESTERN TASMANIA
FOR
UNION OIL DEVELOPMENT CORPORATION

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1. INTRODUCTION

At the request of Mr. J. McGregor Dawson of Union Oil Development Corporation, a one day helicopter-borne combined magnetic and electromagnetic survey was conducted in the Mount Lee area of Western Tasmania. The purpose of the survey was to map any anomalous magnetic or electromagnetic response which may indicate sulphide mineralisation.

Mount Lee is situated approximately 60 kilometres south of Queenstown in Western Tasmania.

2. SURVEY DETAILS

The survey was flown from Strahan, Western Tasmania, because the crew was already based there for other work.

Flight lines were spaced at 300 metre interval throughout the area, wherever possible. The lines were 5 kilometres long and flown either east or west. Subject to the discretion of the pilot over the rugged terrain, a minimum terrain clearance of 140 metres was maintained.

A total of 120 line kilometres was flown in the area. Navigation was by visual means from photomosaics, at a scale of approximately 1:16,000, supplied by Union Oil Development Corporation. The actual flight path was recovered on to the photomosaics from 16 mm. tracking film.

Instrumentation employed during this survey is described in the notes attached to this report.

3. PRESENTATION OF RESULTS

The results of the combined magnetic and electromagnetic survey are shown on the accompanying map, Dwg. Number AEM 75/06. The map has been prepared as an overlay from the photomosaic, and because the photomosaic is uncontrolled, the marked direction of north is only approximate.

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The results are shown in the standard manner described by the map legend and the notes attached to this report. Wherever possible a line to line correlation of the anomalies are shown.

As requested by the client the magnetic data is shown in analogue form.

A magnetic contour map has not been prepared but such a map of this area may be of assistance in mapping and interpretation of the geological structure of the area.

Magnetic highs are shown on the anomaly map only where they coincide with the electromagnetic anomalous zones.

4. DISCUSSION OF RESULTS

Detailed geological information of the area is not available, but a rough geological sketch provided by the client was referred to in the interpretation.

It should be noted that in areas of rugged terrain, especially those of Western Tasmania, it is not usually possible to fly at a constant height above the ground. With this in mind, a series of tests were performed over known anomalies to determine the effect of altitude. These show that although the amplitude of the anomaly decreases with increase in height, the more important conductivity ratio remains substantially constant. The anomaly expected from a normal massive sulphide body is usually detectable to a height of about 750 feet and areas

where the altitude exceeds this figure should be regarded as not fully investigated.

Zone 1:

Zone 1 consists of an isolated 'D' category anomaly with an average conductivity ratio of 0.5 and is located approximately on the contact between the Owen conglomerate and the Thirkel Group of sediments. The conductivity ratio coupled with the poor shape of the anomaly suggests that the zone may be associated with a swamp, or minor conductivity variations due to surface weathering. Ground followup of the zone should be regarded as low priority.

Zone 2:

This zone consists of a 'C' category anomaly on Line 22 associated with a possible anomaly on Line 23. Although low in amplitude, the anomaly has a good conductivity ratio of 1.1 and an associated magnetic high. The location is approximately on the contact of the Thirkel Group of sediments and the Lewis River volcanics. Ground followup should be carried out to determine the nature of the source.

Zone 3:

This zone consists of an isolated possible anomaly on Line 21. Ground followup is not recommended.

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Zone 4:

Zone 4 consists of possible anomalies on two adjacent lines. A rather rapid change of altitude occurs in this area and the anomalies seem likely to be related to this cause. No ground followup is recommended.

Zone 5:

A possible anomaly in an area of higher apparent conductivity makes up Zone 5. In areas of higher conductivity altitude changes are often reflected as weak anomalous responses. This is suggested to be the source of this anomaly. No ground followup is recommended.

Zone 6:

Zone 6 consists of a series of anomalies in an area of high apparent conductivity. They make up a possible conductor axis which may reflect the contact between the sediments and the volcanics. Ground followup is recommended for this zone using either ground electromagnetic methods or Induced Polarisation. This should start on Line 6 and Line 8 where there are 'D' category anomalies with conductivity ratios of 0.5.

Zone 7:

This possible conductivity zone consists of an isolated 'D' anomaly on Line 2. The anomaly is out of the area of higher conductivity and the source of the zone is possibly a swamp. Ground followup is not recommended.

Zone 8:

This zone can be recognised on three flight lines. The anomalies are of reasonable amplitude and moderate conductivity ratios, ranging from 1.0 to 0.4, with a coincident magnetic high. The zone appears to lie on the Precambrian sediments. Ground followup is recommended using either electromagnetic methods or Induced Polarisation. This zone is considered to be of high priority.

Zone 9 and Zone 10:

These two zones consist of possible anomalies and flank both sides of Zone 8. Ground followup on Zone 8 should include Zone 9 and Zone 10.

Zone 11:

Zone 11 is made up of two possible anomalies in an area of low conductivity. Altitude changes in this area could be the cause. No ground followup is recommended.

Further Recommendations:

A number of isolated possible anomalies have been shown on the map but not discussed. These are probably due to surface conductivity changes caused by weathering.

A few zones of higher conductivity have been shown on the map and may assist geological interpretation.

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5. CONCLUSIONS AND RECOMMENDATIONS

Eleven zones of anomalous electromagnetic responses have been mapped from the combined helicopter-borne magnetic and electromagnetic survey.

Zone 8 is the most important zone and should have priority in the ground followup work. Zone 6 and Zone 2, which could be located on the contact of the sediments with the volcanics should also be investigated.

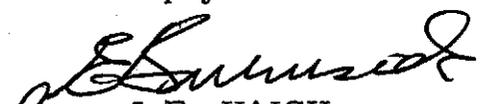
The priority anomalies should first be located and confirmed using a vertical coil electromagnetic system and magnetometer traverses. Since electromagnetic anomalies can be caused by non-mineralised solution-filled shears, faults and contacts, the confirmed anomalies should be tested with Induced Polarisation traverses before drilling, in order to establish the presence of metallic sulphides.

The analogue magnetic data shows a considerable amount of detail and the preparation of an airborne magnetic contour map should be carried out. This will assist the geological mapping and interpretation of the ground geophysics.

As the results of ground exploration become available it may be possible to re-evaluate zones to be possible sources of sulphide mineralisation.

GEOEX PTY. LTD.


C.G. WEBSTER
Geophysicist


for J.E. HAIGH
Geophysicist

12th June, 1975.

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THE McPHAR 400 SERIES DUAL FREQUENCY AIRBORNE ELECTROMAGNETIC SYSTEM

by

David K. Fountain, P.Eng.

— and —

Frank B. Bottos

INTRODUCTION

In the last twenty years the airborne electromagnetic method of surveying has become the accepted form of "first look" in the search for conductive sulphide deposits in Canada and in other similar environments. The list of "ore discoveries" that may be attributed to this method is extensive and, in itself, is indicative of its effectiveness.

The first truly successful airborne EM system was flown in 1950 by INCO. This system was pioneered by McPhar Engineering Limited which began work on this concept of mineral exploration in 1948, and with the technical staff of INCO developed the operational system.

Figure #1 is a photograph of one of the earliest systems mounted on an Anson aircraft. The photograph was taken at North Bay Airport in July 1948 when a series of tests were being flown in the Sudbury area. Although only partially successful, this particular system indicated that the idea of airborne EM surveys was sound and led to the development of the INCO system.

The same McPhar engineers developed the "towed beam" helicopter system for the American Metal Company which first flew survey with it in 1955. Following this development, several other "towed beam" helicopter systems have been produced that are similar in concept.

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FIG.-1 EARLY AIRBORNE EM SYSTEM, NORTH BAY AIRPORT - JULY 1948

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Since 1967 McPhar Geophysics has actively worked on the development of a complete line of airborne geophysical instruments. Combining the latest electronic developments with this background of practical experience, systems have been designed that are adaptable for use on light aircraft, both fixed wing and helicopter. Ease of installation and removal of the equipment has been a prime consideration so that full utilization of aircraft can be realized. The systems presently manufactured by McPhar and in use throughout the world include the AV-4 four threshold *Scintillometer, the AF-4 airborne AFMAG unit, the KEM airborne VLF-EM unit and the 400 Series dual frequency airborne electromagnetic unit. The latter system will be described in detail in this paper.

ELECTROMAGNETIC SYSTEM

The electromagnetic system basic to the 400 Series (F-400 fixed wing and H-400 helicopter) is a two frequency, out-of-phase, "towed bird", maximum coupled system. The axis of the transmitting dipole is horizontal while the axis of the receiver dipole is vertical. The receiver bird is positioned, during survey, such that there is maximum coupling with the transmitted field. This is illustrated in Figure #2, a schematic drawing indicating the relative location of the aircraft, transmitting coils (horizontal dipole), field lines, and receiver coil or loop (vertical dipole). In the illustration the transmitting coils are shown mounted on a Beaver aircraft (F-400). The diagram is also valid for the helicopter system (H-400).

The specifications for the McPhar 400 Series airborne EM system are given in the Appendix. The symmetrically mounted iron-cored transmitting coils are connected in series to form a single transmitting dipole. The two operating frequencies, 340 Hz and 1070 Hz, are transmitted on a time share basis in normal operation. The horizontal axis, iron-cored, transmitting coil has been selected for ease of mounting on the aircraft and the splitting of the coil into two halves introduces a symmetry necessary for minimizing system noise due to airfoil or airframe flexure. A vertical axis was chosen for the receiving coil since the vertical component of atmospheric noise (AFMAG fields) is typically of an order of magnitude lower than the horizontal component.

There exists controversy in the geophysical industry regarding the relative merits of the various types of airborne EM systems available today. Due to the very nature of the problem, the design of an airborne EM system involves consideration of a large number of parameters, some directly interrelated and some diverse. There are the basic parameters of electromagnetic theory and also the very important practical parameters of exploration theory. A feasible system must be a compromise between these not always complementary parameters.

*Trademark

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Tx. COILS (HORIZONTAL DIPOLE)

5 cm

55°

TOW CABLE

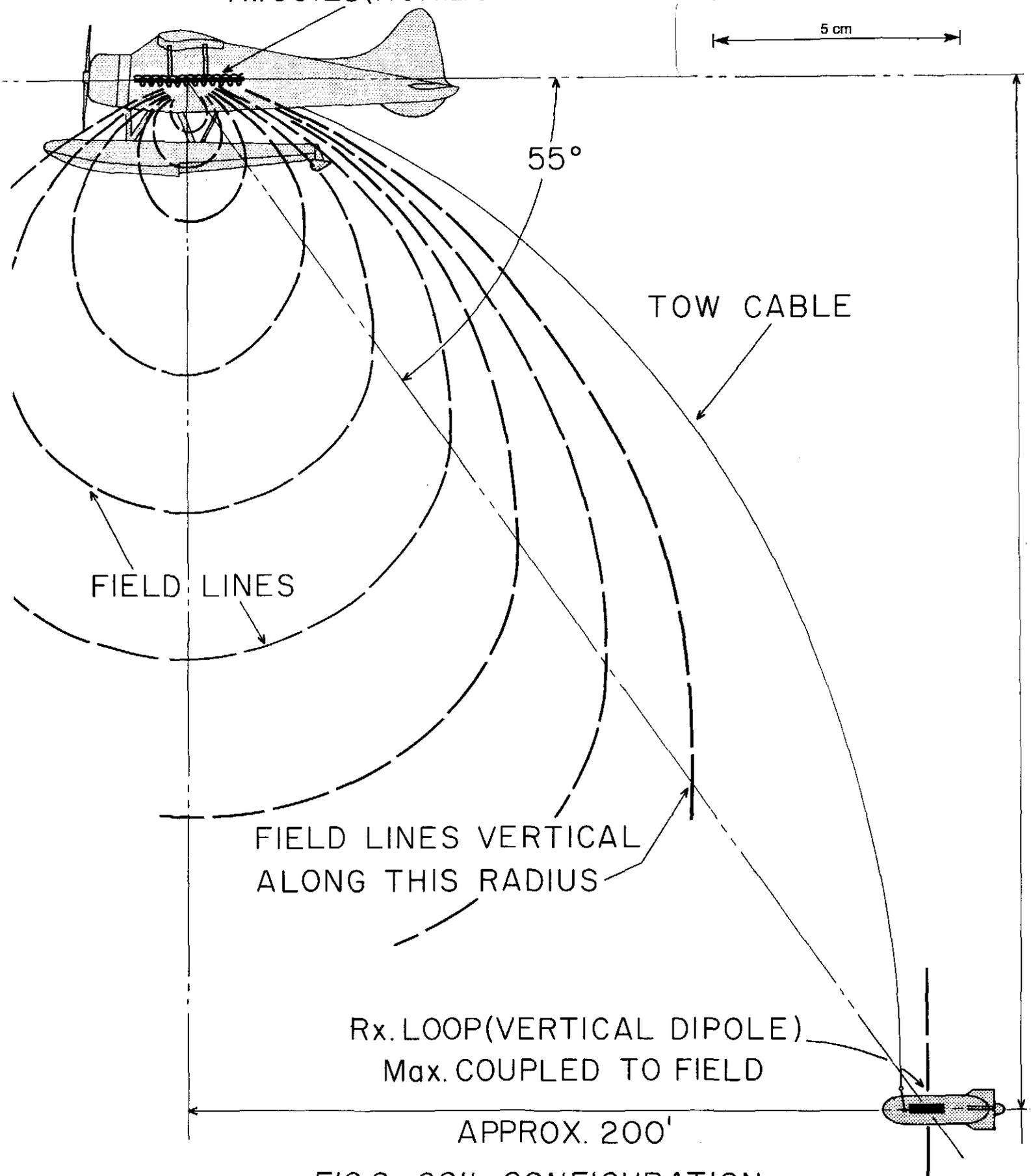
FIELD LINES

FIELD LINES VERTICAL
ALONG THIS RADIUS

Rx. LOOP (VERTICAL DIPOLE)
Max. COUPLED TO FIELD

APPROX. 200'

FIG.2- COIL CONFIGURATION
McPHAR "400" SERIES AIRBORNE E.M.



The McPhar 400 Series airborne EM system has been designed with stress on the following factors:

a) Versatility of Aircraft:—

Equally adaptable to fixed-wing or helicopter installation, the system has been flown in conjunction with magnetics; magnetics and radiometrics; magnetics and VLF-EM; and magnetics, radiometrics and VLF-EM; in float, ski, and wheel mounted light fixed-wing aircraft as well as helicopters.

b) Compatibility with Other Airborne Geophysical Systems.

c) Ease of Installation and Removal from Aircraft:—

The fact that the system can be installed on a suitable fixed-wing aircraft or helicopter in less than two days (in some cases one half day) saves on aircraft costs and allows maximum utilization of aircraft for other than survey purposes.

d) Efficiency of Survey Coverage:—

The large separation "towed bird" configuration gives maximum depth and lateral coverage. Adaptability for both fixed-wing and helicopter installation allows realization of the economy of fixed-wing surveying in areas of moderate terrain and the manouverability of helicopter surveying in areas of rugged terrain.

A basic division exists in airborne EM between rigid transmitter and receiver coils, "rigid boom", systems and rigid transmitter coil towed receiving coil, "towed bird" systems. There are distinct advantages and disadvantages to each system with regard to both the electromagnetic parameters and the practical exploration parameters mentioned above.

If the in-phase component of the secondary field is to be measured, the transmitter coil and receiver coil must be rigidly fixed relative to each other since any relative movement will create a spurious anomalous response. It is therefore obvious that the measurement of the in-phase component is not practical with a "towed bird" system. Also there is a limit to the amount of separation between transmitter and receiver coil that can be realized with the "rigid boom" system. This limit being the wing span or length of the fixed-wing aircraft used (including possible extensions) or the length of the boom that a helicopter can practically tow or can be mounted on the helicopter. Since the coil separation is limited, the "rigid boom" must be flown close to the ground and be very sensitive in order to obtain effective depth penetration. The requirement is an inverse cube decrease in noise level with reduction in coil separation. In order to obtain this sensitivity there must be elaborate compensation for airframe flexure and the effect of the metal aircraft. This renders "rigid boom" EM systems impractical as a system which can be easily installed or removed from a standard fixed-wing aircraft since significant modifications are usually required to the aircraft.

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The two frequency quadrature system does not measure an in-phase component and therefore does not require a rigid relationship between transmitter and receiver coils. This permits use of the "towed bird" configuration allowing greater coil separation and removing the receiver from effects of the aircraft. This eliminates the need for elaborate compensation systems and allows the versatility of aircraft use and ease of installation which is an important aspect of the McPhar 400 Series EM systems. A unique patented method of eliminating the electromagnetic response of the aircraft is incorporated into the 400 Series EM systems which further reduces the need for compensation systems.

AIRCRAFT INSTALLATION

BASIC COMPONENTS

The 400 Series Airborne EM System has been installed and flown in several different types of aircraft, both fixed-wing and helicopter. The basic components of the system are illustrated in Figure #3 and Figure #4. Transmitter coil mounts and instrument racks will vary with the aircraft and the other geophysical systems included in the installation. Figure #3 illustrates the following basic components: (dimensions and weights of the various components are given in the Appendix).

- "A" — These are the two iron-core transmitting coils which are electrically connected in series to form a single horizontal axis transmitting dipole. On one of the coils illustrated, the mounting brackets for attachment to the wing mounts are on the coil.
- "B" — This is the EM transmitter console normally mounted on the instrument rack and easily accessible to the operator.
- "C" — Also mounted on the instrument rack is the EM receiver console.
- "D" — The receiver bird containing the receiving coil (vertical dipole axis) is towed during survey at the end of the 450 foot cable.
- "E" — Illustrated here is the light-weight, hand-powered winch and drum containing 450 feet of shielded conductor tow cable. Power driven winches are also available and normally used when weight restrictions allow.
- "F" — Included in Figure #3, is the Century 444 six channel permanent trace recorder. This recorder is normally used for combined EM and magnetic surveys recording all the data; EM, magnetic, altimeter and fiducials; on one chart record. Depending upon the other geophysical systems included in the installation, as well as the amount of geophysical data to be recorded, twelve, fourteen and eighteen channel recorders have been utilized.

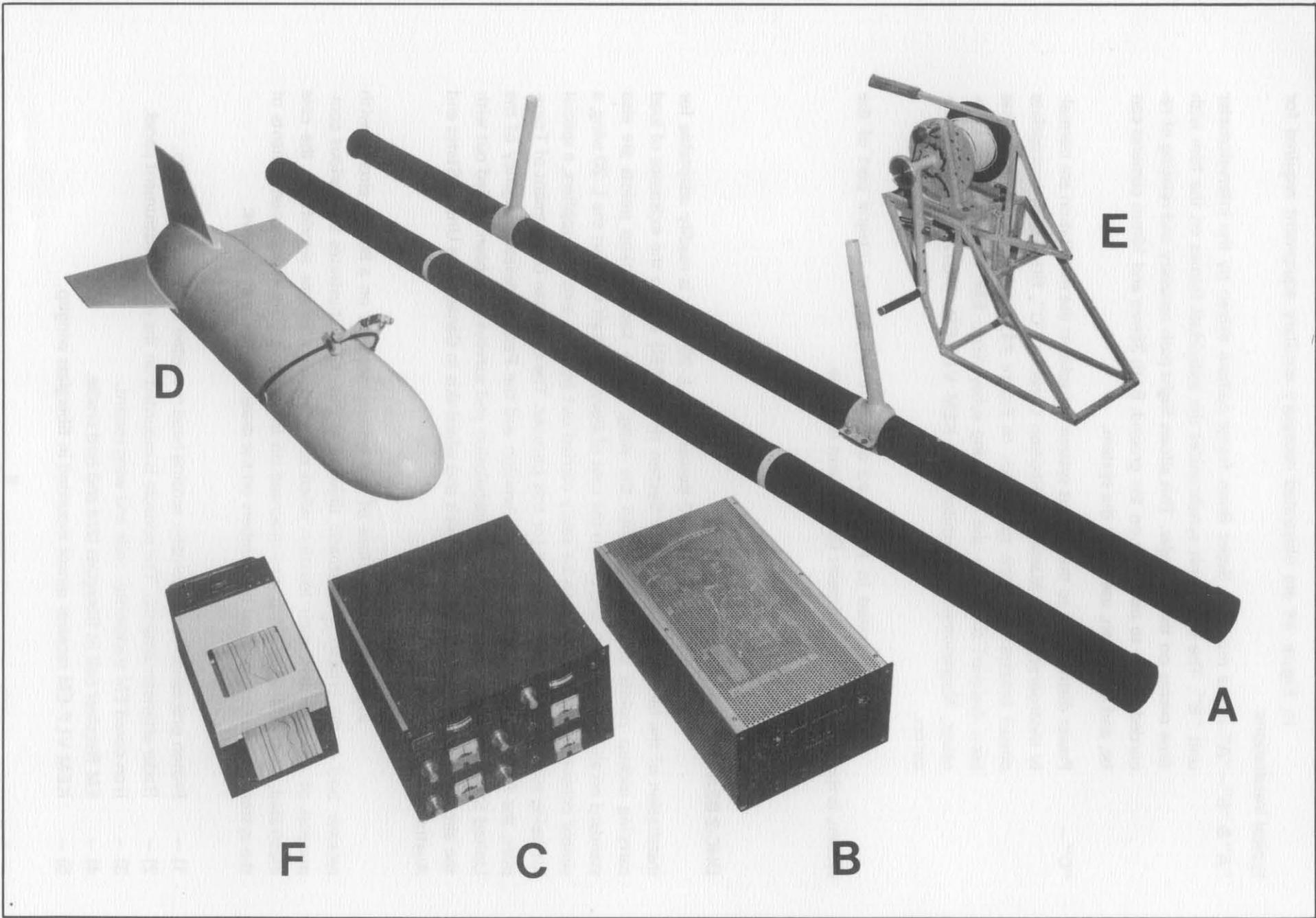


FIG. 3- BASIC COMPONENTS OF "400" SERIES AIRBORNE EM

In Figure #4 are illustrated necessary ancillary equipment required for typical installations:

“A” & “B”—“A” is the modified Super 8mm frame camera driven by the intervalometer unit “B”. The latter unit synchronizes the individual frames on the film with time events on the recorder. This allows flight path recovery and relating of recorded events to positions on the ground. Both 35mm and 16mm cameras can be, and have been, used with the system.

“C” — Power distribution to the various system consoles in the installation are normally incorporated in a Master Distribution Console, “C”, fitted with appropriate circuit breakers for each subsystem. In Figure #4, the console illustrated has been designed to handle the following subsystems: EM Transmitter, EM Receiver, Magnetometer, Scintillometer, KEM VLF-EM, Intervalometer and Recorder.

Not illustrated in Figure #3 or Figure #4, but an integral part of the system, is the Bonzer Radar Altimeter Console and Antenna.

DHC-2 BEAVER AIRCRAFT

The De Havilland DHC-2 Beaver with L-20 wing is readily adaptable for installation of the McPhar 400 Series EM System (F-400 EM) due to the existence of load carrying pickup points already built into the wing. These same pickup points are also standard on all Turbo Beaver aircraft. In the case of Beaver aircraft without the L-20 wing, a simple conversion of the wing can be easily carried out by most aircraft suppliers, a special kit being available from De Havilland for this purpose. The Canadian Department of Transport, the Australian Department of Civil Aviation and the Federal Aviation Agency of the United States have approved the Beaver installation and surveys have been carried out with the aircraft mounted on wheels, floats, skis and wheel-skis in Canada, the United States and Australia.

Figure #5 is a picture of the system mounted on a Beaver aircraft with receiver bird in the cradle. A schematic drawing in Figure #6 illustrates the various components of a system and their location when mounted on a Beaver aircraft. In the case illustrated, the KEM VLF-EM is also mounted on the aircraft. The various components of the system have been identified by numbers on the drawing and are as follows:

- 1) — Proton precession magnetometer sensing head mounted in fiberglass wingtip.
- 2) — Radar altimeter antenna. The console is mounted on the pilot’s instrument panel.
- 3) — Iron-cored EM transmitter coils and wing mount.
- 4) — EM Receiver coil in fiberglass bird and bird cradle.
- 5) — KEM VLF-EM receiver sensor mounted in fiberglass wingtip.



C



B



A

FIG.4 — ANCILLARY EQUIPMENT FOR AIRBORNE SYSTEM

- 017
- 6) – Instrument rack containing:
 - a) EM Transmitter Console
 - b) EM Receiver Console
 - c) KEM VLF-EM Receiver Console
 - d) Magnetometer Console
 - e) Recorder
 - f) Intervalometer Console
 - g) Power Distribution Console
 - 7) – Winch assembly and drum containing 450 foot tow cable.
 - 8) – Camera.

In the Beaver installation a specially designed floor plate fits around the camera hatch and accommodates the combined winch-cradle assembly. The tracking camera slides into the camera hatch after the receiver bird has been lowered in flight. The instrument rack is attached to existing tie points on the cabin floor.

Since Beaver aircraft are readily available, survey costs can be reduced by carrying out equipment installation near the survey site and thus saving on aircraft ferry costs. The versatility and ruggedness of the Beaver, floats, wheels or skis, permits landing on lakes within the survey area reducing unproductive ferry time.

CESSNA TU206D AIRCRAFT

The McPhar 400 Series EM System has been installed in Cessna TU206D aircraft with Robertson STOL conversion. The Cessna Turbo 206 is a versatile single engine, light weight aircraft which is capable of carrying out high-level photography as well as being a comfortable passenger aircraft. The Canadian Department of Transport and the United States Federal Aviation Agency have approved the installation.

Figure #7 is a picture of the system mounted in a Cessna TU206D. This particular installation was carried out for a major mining company for use in their exploration programme in Africa. It was designed so that all equipment mounted within the aircraft, such as instrument rack and scintillometer crystal, as well as the exterior mountings, could be easily removed allowing the aircraft to be used for other purposes when not required for airborne surveys. The schematic drawing, Figure #8, illustrates the various components of the system and their location. The geophysical systems included in this installation are the 400 Series EM (F-400), a proton precession magnetometer, a KEM airborne VLF-EM, and an AV-4 four threshold scintillometer with one 4" x 6" crystal. Figure #9 is a picture of the instrument rack illustrating the various consoles.



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FIG.5 - "400" SERIES EM (F-400) MOUNTED ON DHC-2 BEAVER AIRCRAFT.

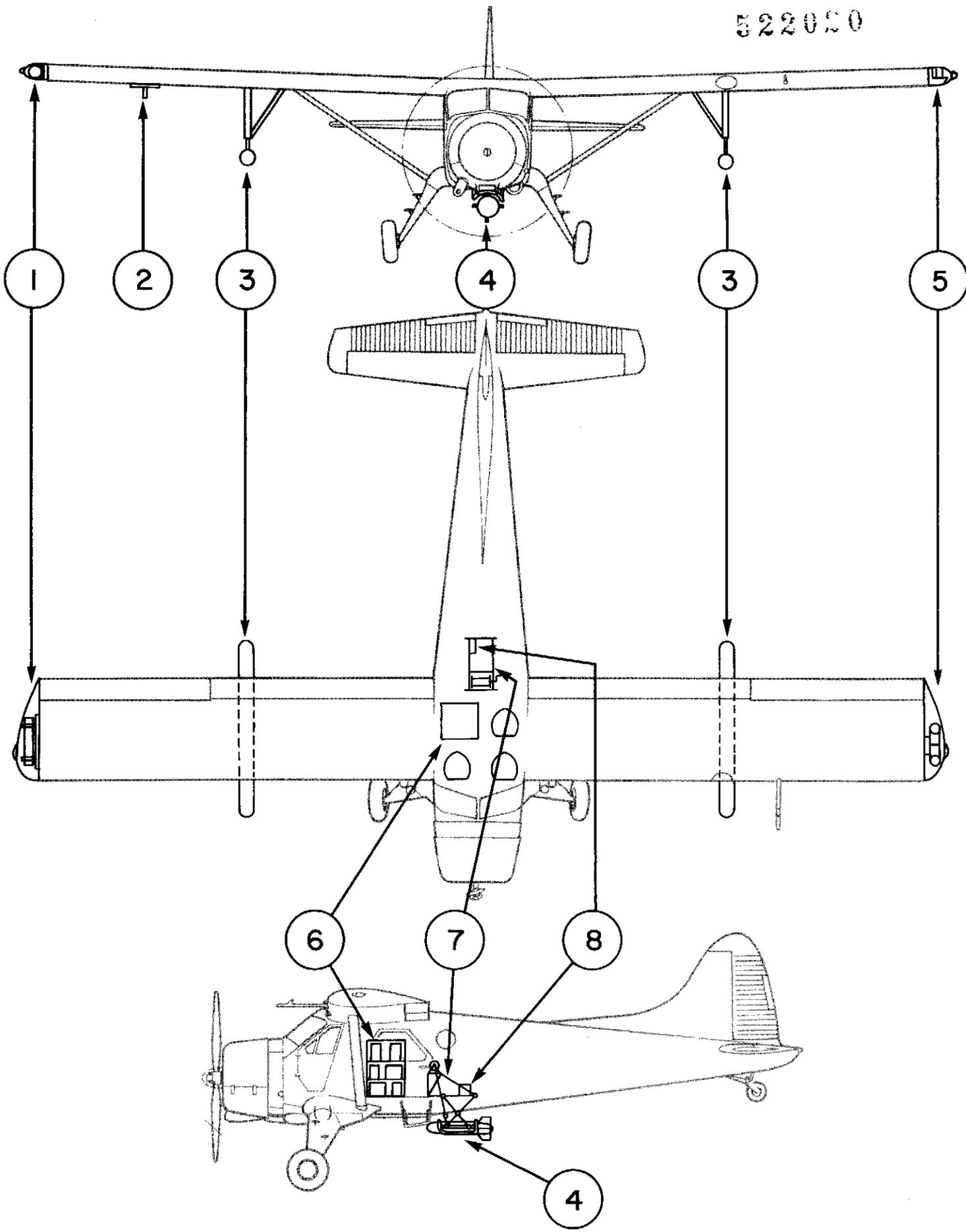


FIG. 6- SCHEMATIC OF INSTALLATION ON A DHC-2 BEAVER AIRCRAFT.

The various components of the system have been identified in Figure #8 by numbers, and are as follows:

- 1) – KEM VLF-EM receiver sensor mounted in fiberglass wingtip.
- 2) – Radar altimeter antenna. The console is mounted on the pilot's instrument panel.
- 3) – Iron-cored EM transmitter coils and wing mounts.
- 4) – Winch assembly and drum containing 450 foot tow cable. The tracking camera slides into the camera hatch after the receiver bird is lowered.
- 5) – Instrument rack (for details see Figure #9).
- 6) – Protective canister containing 4" x 6" americium doped NaI crystal.
- 7) – EM receiver coil in fiberglass bird and bird cradle.
- 8) – Proton precession magnetometer sensing head mounted in fiberglass pod under the wing.

The individual consoles are numbered in Figure #9 and are as follows:

- 1) – This is a portion of the hand powered winch for extending and retracting the EM receiver bird. The winch is mounted on a frame which is attached to the sliding seat rail so that it can be easily removed.
- 2) – In the lower left hand portion of the rack is the EM transmitter console.
- 3) – This is the AV-4 four threshold scintillometer console.
- 4) – This is the proton precession magnetometer console.
- 5) – Mounted in the upper left of the rack is the EM receiver console.
- 6) – The 18 channel permanent trace recorder is mounted in the upper right of the rack.
- 7) – This is the intervalometer which synchronizes the pulse camera and recorded traces.
- 8) – This is the power distribution console for the entire system.
- 9) – In the lower right is the KEM VLF-EM console.

BELL JET RANGER 206A HELICOPTER

In areas of moderate terrain surveying with fixed-wing aircraft is the most efficient and economical procedure. However, in areas of rugged terrain the greater manoeuvrability of a helicopter mounted system is necessary to properly conduct surveys. The McPhar 400 Series EM System can be installed in helicopters in which case it is referred to as the H-400 system. Figure #10 is a picture of the H-400 system installed in a Bell Jet Ranger 206A helicopter. As with the F-400 system, the bird containing the receiver coil is towed at the end of a 450 foot cable which is extended or retracted by a winch. The two iron-core transmitting coils, electrically connected in series to form a single transmitting dipole, are mounted within specially designed fiberglass landing skids which replace the standard metal skids. Because of this unique installation, there is only minimal effect on the flying characteristics of the helicopter, a factor which experienced survey pilots consider significant. In this installation the proton precession magnetometer sensing head is mounted in a second small bird which during survey is towed about twenty feet beneath the helicopter. The schematic drawing, Figure #11, illustrates the various components of the system and their location on the helicopter. The components are identified by numbers on the drawing and are as follows:



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FIG.7 - "400" SERIES EM (F-400) MOUNTED ON CESSNA TU206D AIRCRAFT.

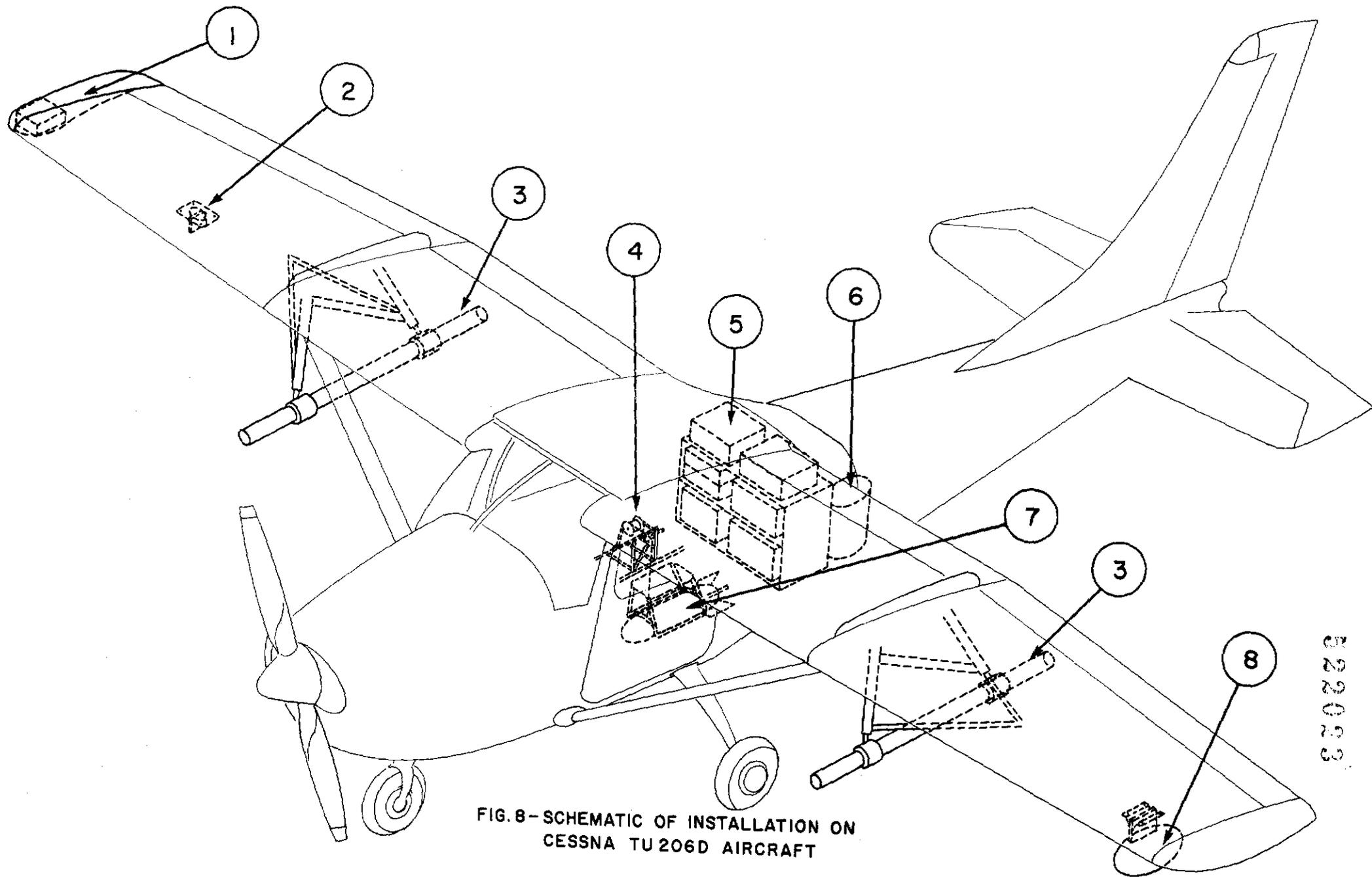


FIG. 8 - SCHEMATIC OF INSTALLATION ON
CESSNA TU206D AIRCRAFT

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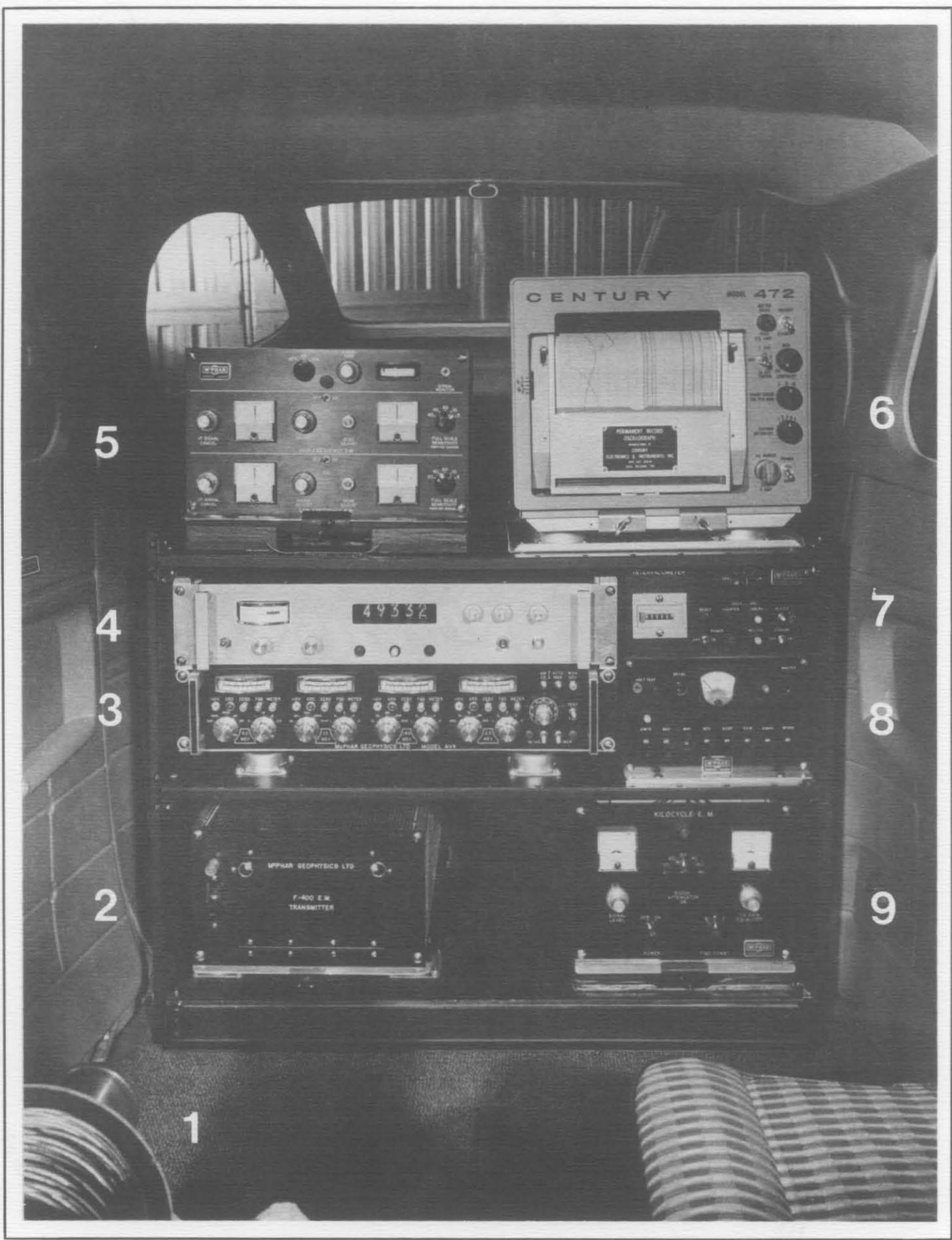


FIG.9-INSTRUMENT RACK CESSNA TU206D INSTALLATION.

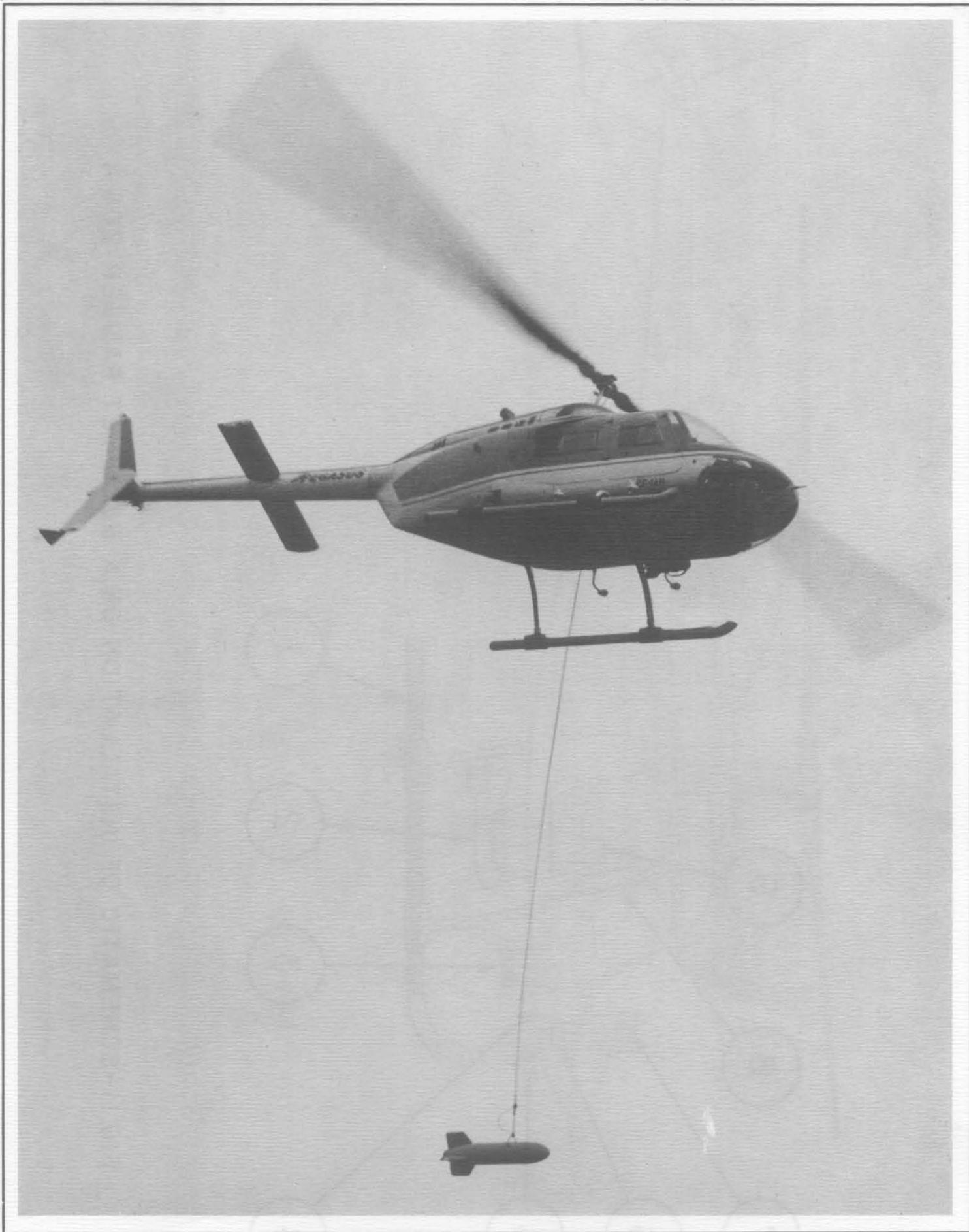


FIG. 10- "400" SERIES EM (H-400)
MOUNTED IN JET RANGER 206A HELICOPTER.

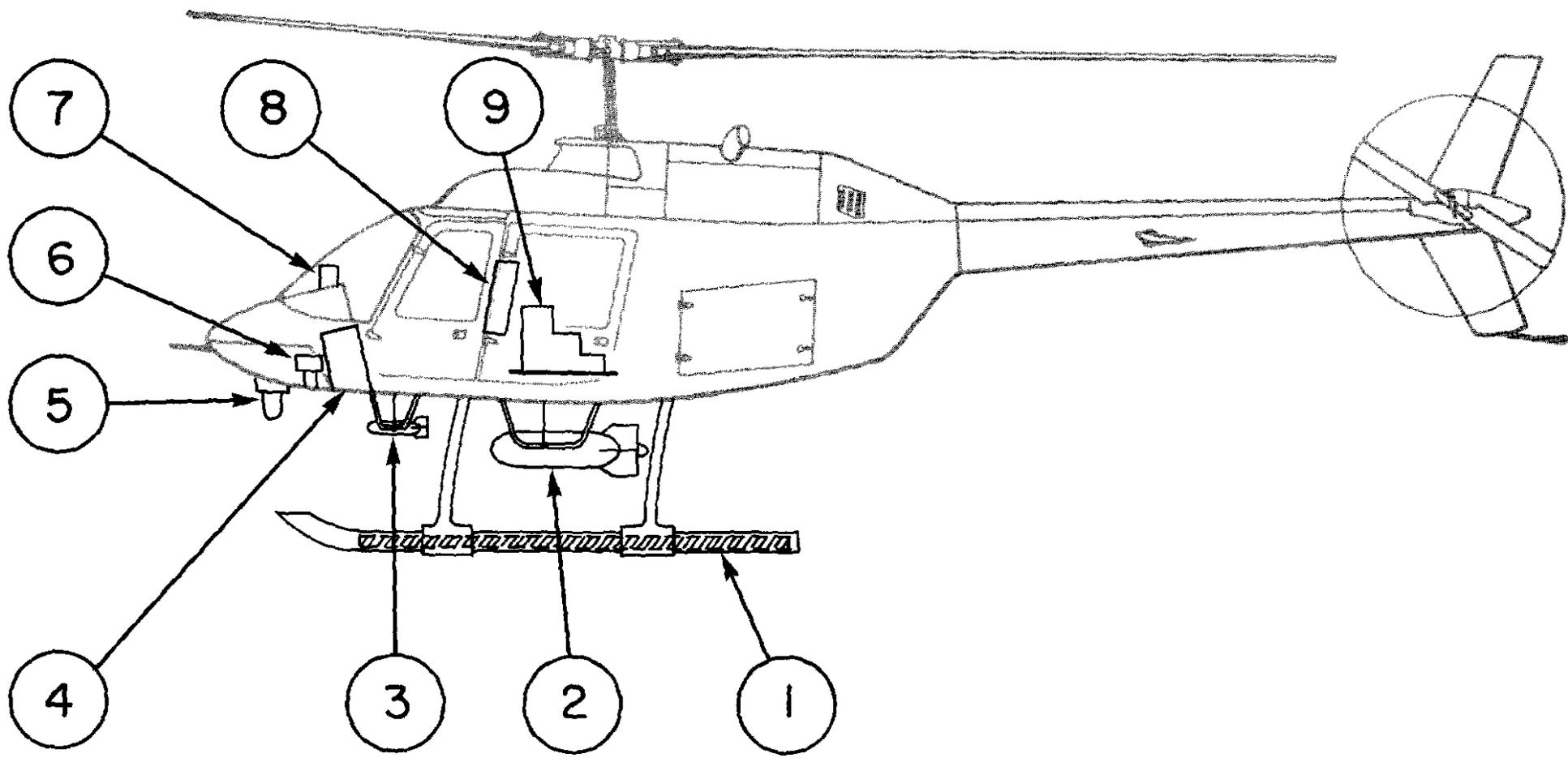


FIG. 11-SCHEMATIC OF INSTALLATION ON A BELL JET RANGER 206 A

- 026
- 1) — Iron-core EM transmitter coils mounted in special fiberglass landing skids.
 - 2) — Bird cradle and fiberglass bird containing EM receiver coil.
 - 3) — Bird cradle and fiberglass bird containing magnetometer sensor.
 - 4) — Front instrument rack containing EM receiver console and recorder.
 - 5) — Radar altimeter antenna.
 - 6) — Tracking camera.
 - 7) — Altimeter console.
 - 8) — Magnetometer console.
 - 9) — Rear instrument rack containing EM transmitter console, intervalometer, power distribution console, winch and tow cable.

DATA RECORDED & PRESENTATION

The EM transmitting coils in the 400 Series EM System are operated at two frequencies, 340 Hz and 1070 HZ, on a time share basis. A double tuned receiving coil mounted in the towed receiver bird detects both frequencies. The quadrature or out-of-phase response detected at each frequency is recorded on the analogue strip chart and positive out-of-phase response, normally indicative of the presence of a conductor, is indicated by an upward excursion of the trace.

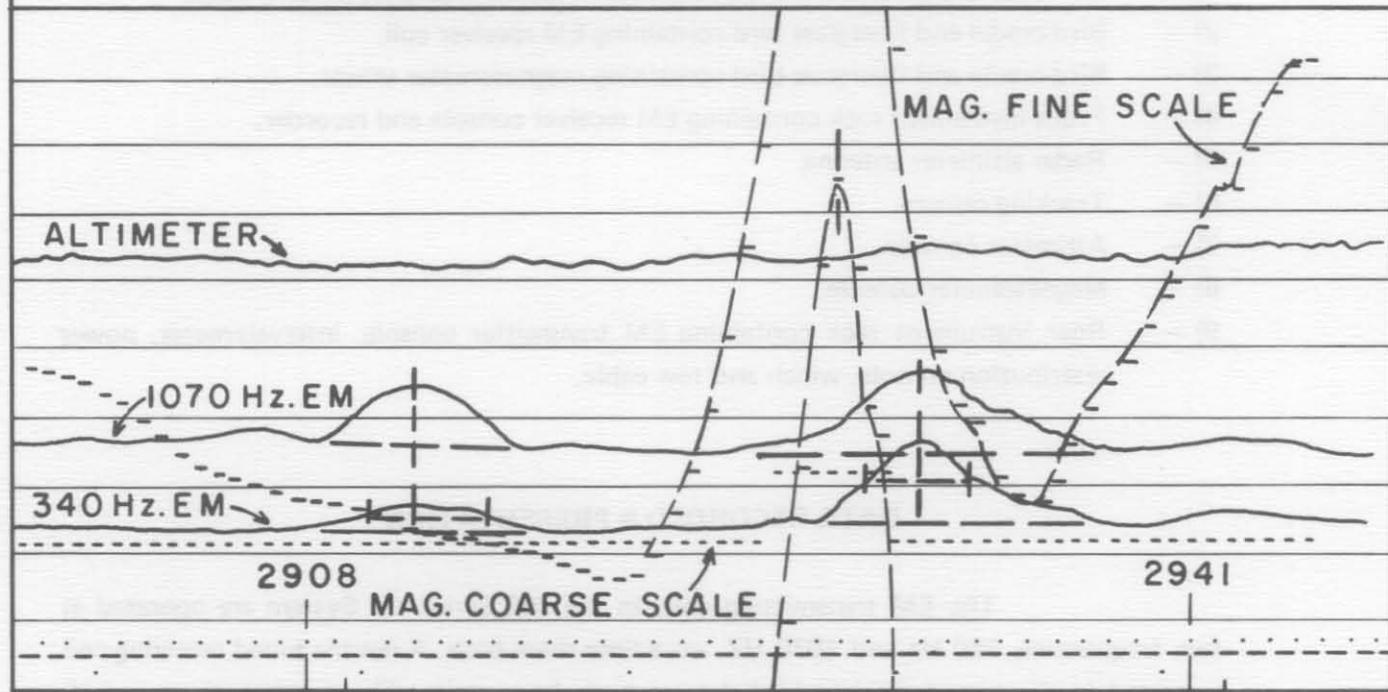
The analogue recorder normally used to record the EM data is the Century 444 six channel unit illustrated in Figure #3. It is a light-beam recorder employing a photo-sensitive paper chart. High sensitivity galvanometers give almost instantaneous response to incoming signals, and the recorder time lag is essentially zero. Fiducial marks are also indicated on the chart record which synchronize the events recorded on the strip chart with the topographic features indicated by the tracking camera. By comparing the film from the camera with photo mosaics of the area flown, the accurate location of the survey flight line can be plotted and the geophysically anomalous events recorded on the strip chart can be located on the ground. An altimeter trace is also included which gives a continuous record of the mean terrain clearance during the course of the survey. This information is utilized in the interpretation of the geophysical data since the mean terrain clearance will affect the geophysical response measured.

It is normal practice to combine electromagnetic and magnetic surveys. Two traces of the recorder chart are utilized to record the data from the proton precession magnetometer which measures the absolute value of the total magnetic field. The absolute value of this field is a five digit number; the first three digits are set on the zero line of the recorder chart and are recorded by the operator at the beginning of each flight. One of the traces assigned to the magnetic data measures the coarse scale, usually 2000 gammas recorded in ten steps of 200 gammas covering the width of the chart. The other trace records the fine scale, usually 200 gammas recorded in ten steps of 20 gammas covering the width of the chart. This is illustrated in Figure #12.

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RECORDER DATA CHART - LINE 32



EM RESPONSE LAG

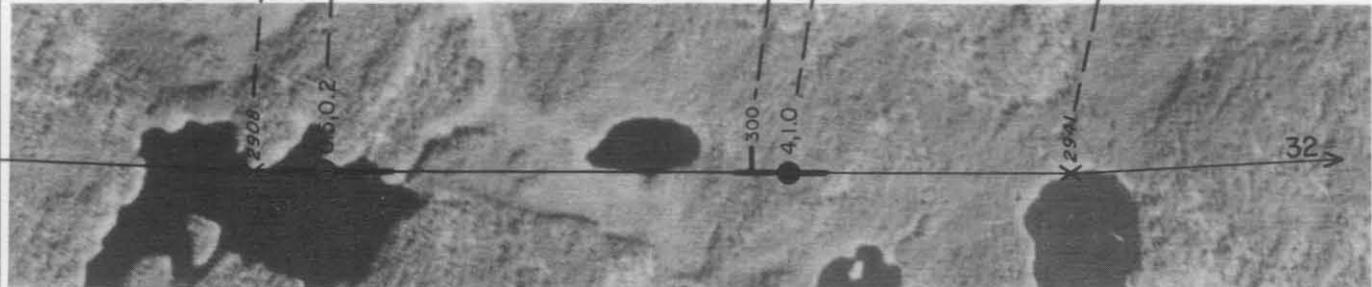


PHOTO MOSAIC BASE MAP

E.M. SYMBOLS

- A  SYMBOLS SHOW LENGTH, SHAPE AND PEAK OF ANOMALY
- B  340 Hz AMPLITUDE ANOMALY SHAPE
- C  RATIO - 340/1070Hz
- D 

MAGNETIC CORRELATION

-  DIRECT CORRELATION
-  FLANK CORRELATION
-  FIDUCIAL MARK



FIG.12 - SAMPLE RECORD SECTION AND BASE MAP

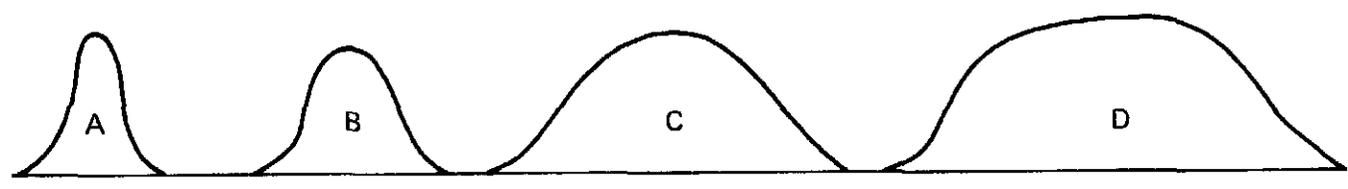
The values of the out-of-phase EM response at the two frequencies is recorded in parts per thousand (ppt) of the primary field at the receiver. Anomalies of 1000 ppm (parts per million) or 1 ppt are easily recognized in most conditions. The amount of deflection on the recorder chart which corresponds to 1 ppt is dependent upon the sensitivity setting of the receiver. Sensitivity settings of 5 ppt, 10 ppt, 20 ppt and 40 ppt can be employed depending upon the "geologic noise" in the area surveyed. In most survey operations, a sensitivity of 10 ppt is used. The higher sensitivity setting, 5 ppt, may be used under low noise conditions where relatively small anomalous responses may be significant. Less sensitive settings, 20 ppt or 40 ppt, can be used where the opposite conditions are anticipated.

The survey data obtained is usually presented in a manner similar to that illustrated in Figure #12, an idealized record section and plan map. The sample record indicates the various traces and the data obtained, while immediately below, the sample plan map illustrates how this data is presented. The fiducials are the frame of reference relating the events on the record to the plan map. Topographic features such as lakes, streams or highways are located on the tracking camera film and related to the appropriate fiducial number (2908 and 2941). Joining these points indicates the path of the survey aircraft. By appropriate scaling between these points on the record and the plan map the various geophysical features can be located. Due to the fact that the EM receiver bird trails the aircraft containing the camera and magnetometer sensor, a lag must be applied to the EM trace as is indicated in Figure #12.

The presentation used on the plan maps for the EM data has been developed to show the three primary characteristics of each individual response. This is accomplished by the numerals and letters adjacent to each anomaly symbol. For most purposes these characteristics are sufficient to describe the anomaly but for detailed interpretation it is best to study the actual flight trace.

a) Width, Shape and Peak

The letters "A", "B", "C" and "D" are used to indicate the recorded shape of the EM response which approximates on the following curve types. The bar coinciding with the flight line represents the half-height width of the EM response on the 340 Hz trace and the circle symbol represents the position of the anomaly peak. The symbols used are illustrated in Figure #12.



b) Amplitude

The amplitude of the peak response at 340 Hz is shown in parts per thousand (ppt). Although various sensitivity settings may be used, resulting in various amounts of deflection on the trace representing 1 ppt, the amplitude indicated on the map is always in units of parts per thousand.

c) Apparent Conductivity Ratio

The ratio of the response at 340 Hz compared to the response at 1070 Hz is shown as the third parameter. Generally ratios less than 0.5 indicate poor conductivity while those equal to or greater than 1.0 indicate good to excellent conductivity. However, it should be noted that this ratio is a measure of the "Apparent conductivity" and varies with the product of the size and conductivity. The significance of the calculated ratio is obviously dependent upon the amplitude of the response, with the reliability decreasing with very low amplitude.

In the standard presentation of the combined electromagnetic and magnetic survey results, the location and amplitude of magnetic highs which appear to be related to electromagnetic features are indicated on the plan map as illustrated in Figure #12. This is usually done in the form of a cross line which indicates the location of the peak (direct correlation or flank correlation) and the value of the amplitude of the response in gammas.

In some cases, it may be of value to present all the magnetic data in contour form. These contours represent lines of equal intensity of the earth's magnetic field and are termed "isograms". This is usually carried out on a separate map.

INTERPRETATION OF DATA AND CASE HISTORIES

An effective airborne electromagnetic system must record accurately, and with high sensitivity, the presence and location of a conductor and also give some criteria for estimating the conductivity, size, depth and attitude of the conductive source. There are various schools of thought as to the best procedures to achieve this. The variable factors are: operating frequency or frequencies, coil configuration, the number of transmitting and receiving coils, and measurement of inphase and quadrature at one frequency or quadrature at two frequencies. No one system can be optimal in all these respects, and optimizing one variable may have the opposite effect on another variable. A practical airborne system represents a compromise of the best of each of the above geophysical variables as well as the other practical variables such as enhancement of message to noise ratio, cost of design, engineering, manufacture and operation of the system, and the geological and topographic environment in which the system is to be used.

In an earlier section of this paper the reasons for choosing the "towed bird" dual frequency quadrature electromagnetic system for the McPhar 400 Series were given; namely, versatility of aircraft, compatibility with other airborne geophysical systems, ease of installation and removal from aircraft, and efficiency and effectiveness of survey coverage. The mode of presentation of the EM data has also been described. The width and shape of the anomalous EM response curve is indicative of the attitude and geometry of the

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source. The amplitude of the EM response gives some idea of the size and depth of burial of the source and the ratio of the amplitude of the response at two frequencies is a measure of the conductivity and width of the source.

Ward, et al, in various papers have outlined the basis of quantitative interpretation of airborne electromagnetic data utilizing model studies and characteristic diagrams. While serving as very useful guide lines, it is very important to be aware of the assumptions involved in the preparation of these curves and the limitations in their use. Because of the large number of parameters that can influence the EM response, the data must be evaluated in light of all available geological, geophysical and physiographical information as well as utilizing past experience in similar areas and previous case histories.

**BASE METAL DISCOVERY
MATTAGAMI LAKE MINES LIMITED,
STURGEON LAKE AREA, ONTARIO, CANADA**

This discovery was the direct result of an airborne electromagnetic survey. During the winter and early spring of 1969 airborne geophysical surveys were carried out in the Sturgeon Lake Area by Questor Surveys for Mattagami Lake Mines Limited. That summer, ground followup was carried out based upon the results of the airborne survey and diamond drilling commenced. In the fall of 1969 the discovery hole was drilled and production from the mine should commence by 1972.

Figure #13 illustrates the results obtained with the F-400 EM system over the ore zone. Illustrated are results from a line flown from south to north and a line flown north to south. The F-400 EM system was mounted in a Beaver aircraft in conjunction with a proton precession magnetometer. The results were obtained at a standard survey mean terrain clearance of 425 feet.

In order to obtain the same spacial relationship it is necessary to invert one of the data charts in Figure #13. The lower data chart is Line 3.5N flown from south to north while the upper and inverted data chart is line 3.5S flown from north to south. Three anomalous electromagnetic responses are indicated on the section of chart illustrated, "A", "B" and "C". Anomaly "A" is the response over the Mattagami Lake Mines Limited discovery. It correlates directly with a magnetic response of about 275 gammas and has good shape characteristics ("B" category). The ratio of low frequency to high frequency response indicates moderate to good conductivity (ratio 0.8) and the amplitude of the low frequency response is approximately 5 ppt. On the basis of the airborne data this would be a high priority target for further ground followup. Anomaly "B" is a very low amplitude, relatively good ratio anomalous EM response located immediately to the north of the ore zone. Its amplitude is only of the order of 1 to 2 ppt. However, it has been indicated on all test surveys as well as the original survey and would warrant further investigation. Anomaly "C" correlates with a lake, and its low ratio of low frequency response to high frequency response (ratio 0.3) suggests a poor conductor such as conductive lake bottom sediments.

**WHISTLE MINE,
SUDBURY, ONTARIO, CANADA**

The Whistle Mine is one of the favoured test sites for airborne electromagnetic systems. Data is available for most electromagnetic systems over this deposit so that comparisons can be made. Located on the northeast rim of the Sudbury Basin, this well known sulphide body is both magnetic and conductive. Although the mineralization is reported to be massive, its apparent conductivity is lower than many other sulphide bodies. The results from two test lines across the deposit are illustrated in Figure #14. Both survey lines (Line "A" and Line "B") were flown in a direction from south to north at a standard survey mean terrain clearance of about 450 feet. A distinct anomalous EM response is indicated over the ore zone on both lines. On Line "A" the 340 Hz response is 9.5 ppt and the 1070 Hz response is 15 ppt resulting in a ratio of 0.6 which would indicate moderate conductivity. On Line "B" the 340 Hz response is 7.5 ppt while the 1070 Hz response is 15 ppt resulting in a ratio of 0.5 again indicating moderate conductivity. The anomalous response shape is good and there is a directly correlating magnetic response on both lines (Line "A" - 840 gammas; Line "B" - 825 gammas). An anomaly of this type would definitely warrant further investigation on the ground.

COMBINED GEOPHYSICAL INSTALLATION DATA

Figure #15 illustrates the results from a test flight over the Whistle Mine with the combined geophysical system installation in the Cessna TU206D aircraft described earlier. A total of 12 channels of data are recorded with this system and are illustrated in Figure #15. In this particular test flight the AV-4 gamma ray spectrometer and the intervalometer were not turned on so that the four radiometric channels and the fiducial marker channel show as continuous straight lines. The results for the F-400 EM (second and third trace from the bottom) as well as the magnetometer correlate very well with the results illustrated in Figure #14. It is interesting to note the distinct anomalous response obtained with the KEM VLF-EM over the mineralized zone and the relatively uniform background response. The KEM data indicates a distinct tilt angle crossover and a distinct increase in field strength correlating with the zone of mineralization.

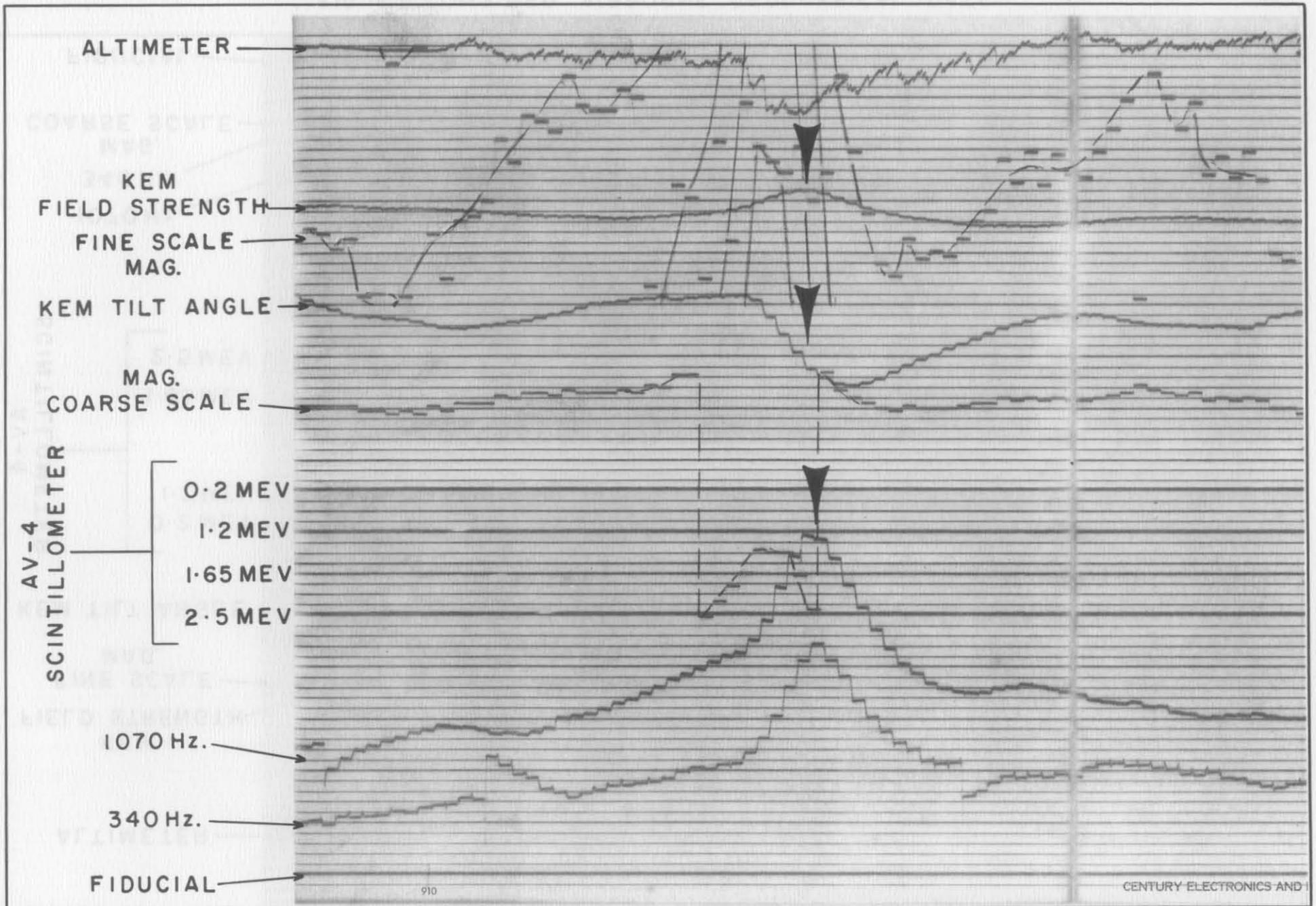
Figure #16 is another typical data record from the Cessna TU206D installation in which all the equipment is operating. The various channels of data are labelled in the figure and are self-explanatory.



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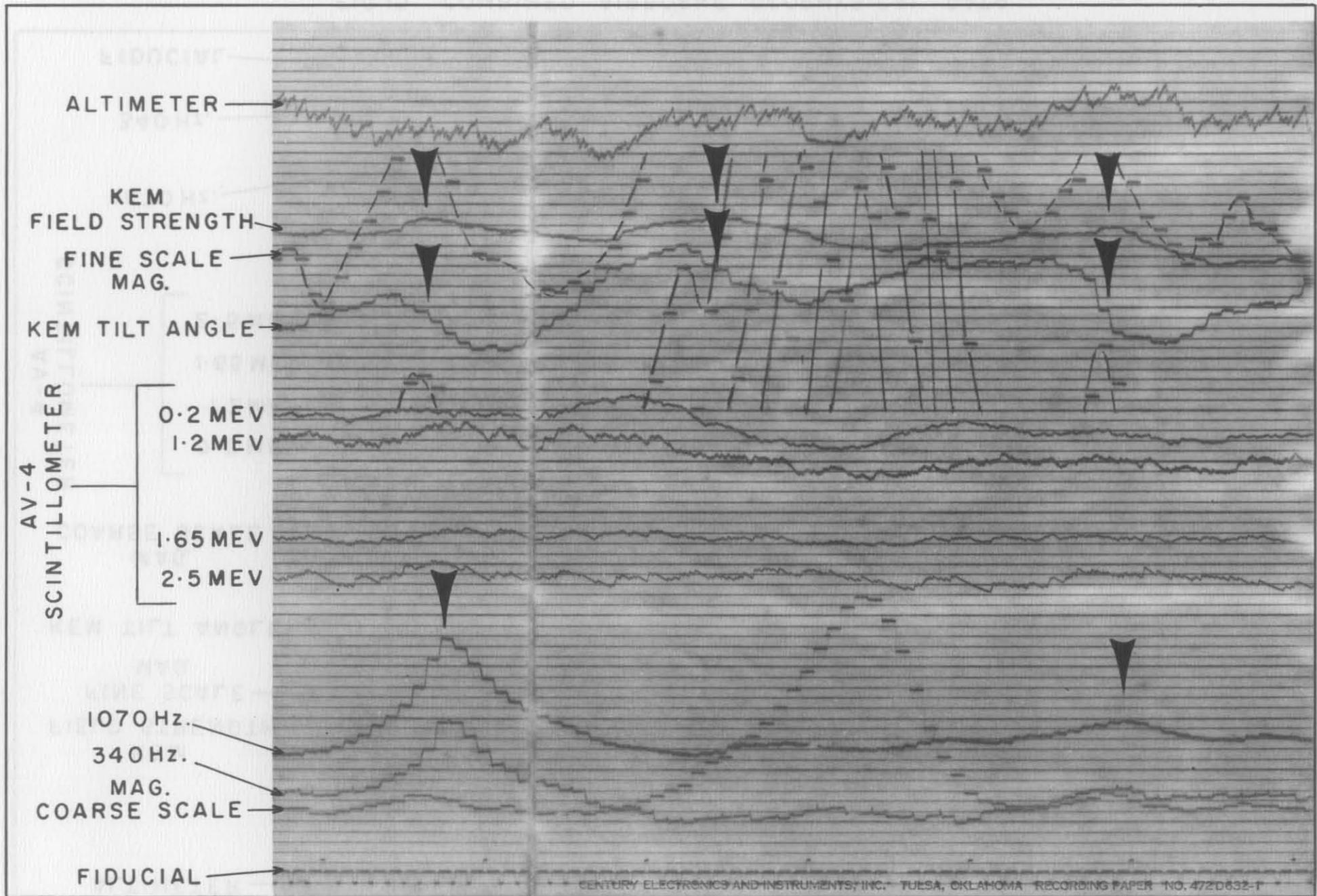
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FIG.14- WHISTLE MINE , SUDBURY- CANADA.



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FIG.15 COMBINED AIRBORNE GEOPHYSICAL DATA WHISTLE MINE, SUDBURY-CANADA.



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FIG.16 - COMBINED AIRBORNE GEOPHYSICAL DATA
CESSNA TU206D INSTALLATION

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ACKNOWLEDGEMENTS

The drawings and illustrations in this paper were prepared by Mr. Roy Peer of McPhar Geophysics Limited.

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APPENDIX

SPECIFICATIONS

McPHAR 400 SERIES AIRBORNE EM

A) Operating Frequencies:—

High	1070 Hz
Low	340 Hz

B) Operating Modes:—

High Frequency =	Continuous
Low Frequency =	Continuous
High Frequency – Low Frequency =	Time Share
High – Low – Mag =	Time Share

C) Transmitter – Receiver Coil Separation:— 400 feet.

D) Receiver Sensitivity:— 5 ranges – 5000 ppm (max. – Full Scale)

E) Receiver Noise:— 500 ppm

F) Analogue Outputs:— High and Low Frequency Quadrature Response

G) Power Requirements:—

Transmitter – 250 Watts	24-32 VDC
Receiver – 15 Watts	24-32 VDC

H) Weight and Dimensions:—

Transmitter Console	23 lbs.	10" x 6" x 17"
Receiver Console	20 lbs.	12" x 7" x 15"
Transmitter Coils	55 lbs. (each)	3" D x 98"
Bird Sensor	22 lbs.	8" D x 42"
Tow Cable	5 lbs.	450 ft. x .08" D

UNION OIL DEVELOPMENT CORPORATIONE.L. 9/74 - BIRCH INLET GEOPHYSICAL INTERPRETATION

More recent geophysical surveys of the Cambrian Lucas Volcanic belt covered by E.L. 9/74 include the following:

February, 1973 - A Scintrex conducted Turair survey for Australasian Minerals

March, 1975 - A U.O.D.C. conducted I.P. survey for U.O.D.C.

April, 1975 - A Geox conducted M-400 E.M. survey for U.O.D.C.

Magnetic observations made concomitantly with the electromagnetic surveys

The Turair survey covered the northern third of the area with lines spread at 500 foot intervals. The central portions of the belt have been surveyed with gradient I.P. methods along lines spaced at 800 meter intervals. The lower third of the area was surveyed using the McPhar-400 electromagnetic system on 300 meter line spacing. No coverage of the belt exists for an area just east of Innes Peak, but this is a relatively small portion of the length of the volcanic belt. Substantial overlap exists for the I.P. survey and the airborne electromagnetic survey flown by Geox.

Reports of all three surveys exist on file. This report is intended as a means of tying the three data sets together and is therefore only supplemental. Important anomalies of all three surveys are grouped as to their apparent geologic associations, and all anomalies are shown on one Geophysical Anomaly Synthesis Map. Magnetic highs shown on the electromagnetic profile data are traced on this map. A description of some of the magnetic features is herein provided.

Conductive or Chargeable Sources

Responses reflecting anomalous conductivity or chargeability were obtained on these geophysical surveys. Such anomalies generally lack the stronger characteristics which might be anticipated from major sulphide accumulations in an environment lacking overburden masking. However, orebody anomalies are rarely first order features, and the following anomalies might warrant further study.

Pre-Cambrian and D'Aguilar Anomalies

Each of the geophysical surveys discovered some of its highest amplitude anomalies east of last mapped Cambrian Lucas Volcanics. Some of these anomalies appear related to Cambrian D'Aguilar Group rocks, the others to the Pre-Cambrian sequence.

More interesting D'Aguilar anomalies are:

Turair Conductor E, Anomalies 20 and 30
Turair Conductor K, Anomaly 40
I.P. Anomalies 8, 9 and 10
M-400 Conductor 4

Stronger Pre-Cambrian anomalies are:

Turair Conductor C, Anomaly 22
Turair Conductor M, Anomaly 39
M-400 Conductor 8, with a magnetic coincidence.

Lucas Volcanic Anomalies

Relatively few anomalies were detected in the Lucas Volcanics, and most of these have very poor amplitude characteristics. The following are the better of the Lucas Volcanic anomalies:

Turair Conductor J, Anomaly 5
Turair Conductor L, Anomaly 43
Turair Anomaly 47
I.P. Anomaly 11
I.P. Anomaly 22 (D'Aguilar related ?)
M-400 Conductor 2 on Line 22

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Birch Inlet Geophysical
Interpretation contd.

-3-

Thirkell Anomalies

Numerous anomalies were discovered along the trend of the Thirkell Group rocks. Some of these anomalies are quite close to the Thirkell-Lucas contact, while others are higher in the Thirkell section.

Thirkell-Lucas contact anomalies are:

Turair Conductor H, Anomaly 50

Turair Conductor G, Anomalies 29 and 36

I.P. Anomalies 1 and 2

M-400 Conductor 5, Anomalies on Lines 8 and 6

Internal Thirkell anomalies are:

I.P. Anomaly 3

I.P. Anomalies 5 and 7

I.P. Anomalies 4 and 6 (on Thirkell-Owen contact)

Owen Anomalies

Owen coverage is minimal and no interesting Owen anomalies have been defined.

Magnetic Sources

Profile by profile examination of magnetic traces obtained on the electromagnetic surveys reveals that most of the source magnetic bodies are thin (< 200 meters); shallowly buried, if at all; and linear, persisting as identifiable features on several adjoining flight lines. To some degree, amplitude appears relatable to width, perhaps suggesting fairly consistent magnetite (specularite?) concentrations

A higher amplitude, long anomaly observed in the southwestern portion of the Lucas Volcanic lends itself to more detailed study. This feature begins as a steeply dipping, thinner unit at the lower end of the survey block, apparently thickening and beginning to dip quite shallowly to the west by the vicinity of I.P. grid Line 128N. Westerly dip is maintained to the northern limit of these data; however, the body may thin in this direction. Assuming this

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Interpretation contd.

-4-

magnetic body has approximately its estimated 400-meter thickness (at its maximum), its magnetic susceptibility would be in the 1000×10^6 cgs. realm, equivalent to some half percent magnetite concentration.

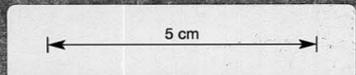
Although there may be correlation of some magnetic features with rocks mapped as "rhyolite flows, abundant chloritized biotite", most source lithologies are unknown. Anomalies are noted in both the Pre-Cambrian and Cambrian Lucas Volcanic environments. Only three cases of reasonable magnetic high association with conductors are noted. These are Anomaly 8 of the Geoex survey and Anomalies 23 and 47 of the Turair survey.

No magnetic anomalies are noted over D'Aguilar group outcrops where the writer has seen hematite fracture fillings which he thought were weathered specularite. This may be important in considering possible sources for I.P. anomalies associated with D'Aguilar group rocks.

There are no indications of "blind" magnetic bodies in the survey area. All features have shallowly derived gradients.


Blair K. Salisbury

June 25, 1975



ELECTROMAGNETIC AND MAGNETIC SURVEY

FOR
UNION OIL DEVELOPMENT CORPORATION

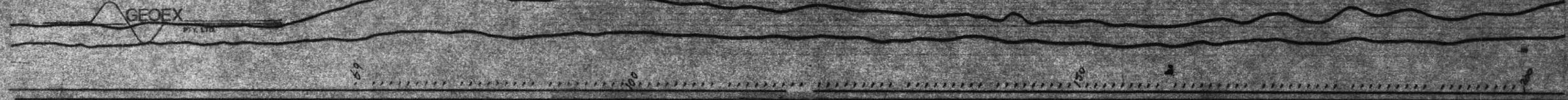
MOUNT LEE AREA

SURVEY SPECIFICATIONS

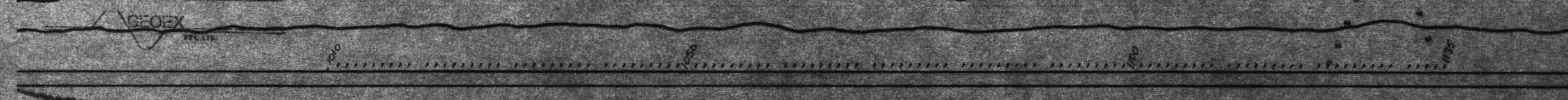
- HELICOPTER: Bell Jet Ranger 206B VH-BLR
- E.M. SYSTEM: Geox H400 dual frequency sequential transmission 340 Hz and 1070 Hz
- MAGNETOMETER: Geometrics G803 proton precession (reading accuracy ±1 gamma)
- DIURNAL RECORDER: Geometrics G806 proton precession magnetometer with Rustrak recorder and crystal clock
- ALTIMETER: Bonzer radar
- ANCILLARY EQUIPMENT: Geox intervalometer
Century 444 analogue light beam recorder
Geox film digital recorder
Vinten 16 mm ground tracking camera
- READING INTERVAL: 1.025 seconds
- NOMINAL AIRCRAFT SPEED: 90 knots (mean reading spacing 47 metres)
- NOMINAL AIRCRAFT SURVEY ALTITUDE: 140 metres (E.M. bird 50 metres, Mag. bird 120 metres)

E.M. response lags tracking fiducial by approx. 1.5 fiducial intervals

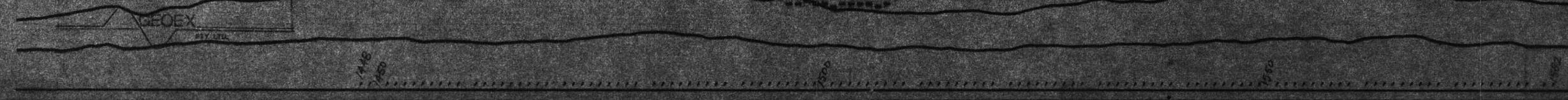
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 LINE NUMBER 1E
 START FIDUCIAL 69
 END FIDUCIAL 200

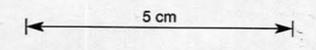


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 LINE NUMBER 2E
 START FIDUCIAL 1010
 END FIDUCIAL 1135



LIGHT NUMBER #1
 DATE FLOWN 20/4/75
 LINE NUMBER 3E
 START FIDUCIAL 1448
 END FIDUCIAL 1582





**ELECTROMAGNETIC
AND MAGNETIC
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FOR

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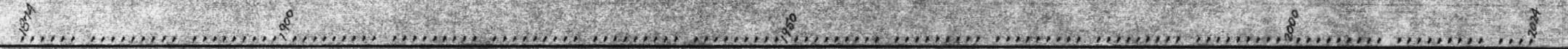
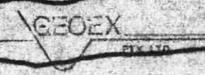
MOUNT LEE AREA

SURVEY SPECIFICATIONS

- HELICOPTER: Bell Jet Ranger 206B VH-BLR
- E.M. SYSTEM: Geox H400 dual frequency sequential transmission 340 Hz and 1070 Hz
- MAGNETOMETER: Geometrics G805 proton precession (reading accuracy ± 1 gamma)
- DIURNAL RECORDER: Geometrics G806 proton precession magnetometer with Russtrak recorder and crystal clock
- ALTIMETER: Bonzer radar
- ANCLLIARY EQUIPMENT: Geox intervalometer
Century 444 analogue light beam recorder
Geox film digital recorder
Vinten 16mm ground tracking camera
- READING INTERVAL: 1.023 seconds
- NOMINAL AIRCRAFT SPEED: 90 knots (mean reading spacing 47 metres)
- NOMINAL AIRCRAFT SURVEY ALTITUDE: 140 metres (E.M. bird 50 metres, Mag. bird 120 metres)

E.M. response lags tracking fiducial by approx. 1.5 fiducial intervals

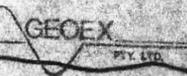
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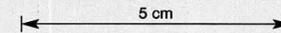


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DATE FLOWN 20/4/75
LINE NUMBER 5E
START FIDUCIAL 2350
END FIDUCIAL 2511



FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 6E
START FIDUCIAL 2839
END FIDUCIAL 2973





**ELECTROMAGNETIC
AND MAGNETIC
SURVEY**

FOR

UNION OIL DEVELOPMENT CORPORATION

MOUNT LEE AREA

SURVEY SPECIFICATIONS

HELICOPTER	Bell Jet Ranger 208B VH-BLR
E.M. SYSTEM	Geox H400 dual frequency sequential transmission 340 Hz and 1070 Hz
MAGNETOMETER	Geometrics G803 proton precession (reading accuracy 21 gamma)
DIURNAL RECORDER	Geometrics G806 proton precession magnetometer with Rustrak recorder and crystal clock
ALTIMETER	Bonzer radar
ANCILLIARY EQUIPMENT	Geox intervalometer Century 444 analogue light beam recorder Geox film digital recorder Vinten 16 mm ground tracking camera
READING INTERVAL	0.023 seconds
NOMINAL AIRCRAFT SPEED	90 knots (mean reading spacing 47 metres)
NOMINAL AIRCRAFT SURVEY ALTITUDE	140 metres (E.M. bird 50 metres, Mag. bird 120 metres)

E.M. response logs tracking fiducial by approx. 1.5 fiducial intervals

FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 7E
START FIDUCIAL 3304
END FIDUCIAL 3452

GEOEX
PTY. LTD.

3304 3360 3420 3480 3492

FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 8E
START FIDUCIAL 3783
END FIDUCIAL 3932

GEOEX
PTY. LTD.

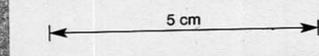
3783 3800 3850 3900 3932

FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 9E
START FIDUCIAL 4266
END FIDUCIAL 4418

GEOEX

4266 4300 4350 4400 4418

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**ELECTROMAGNETIC
AND MAGNETIC
SURVEY**

FOR

UNION OIL DEVELOPMENT CORPORATION

MOUNT LEE AREA

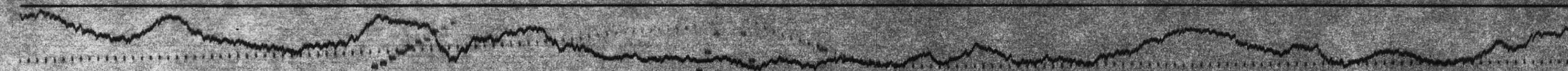
SURVEY SPECIFICATIONS

- HELICOPTER: Bell Jetranger 208B VH-BLR
- E.M. SYSTEM: Geox H 300 dual frequency sequential transmission 340 Hz and 1070 Hz
- MAGNETOMETER: Geometrics G803 proton precession (reading accuracy 1.1 gamma)
- JOURNAL RECORDER: Geometrics G806 proton precession magnetometer with Ruelrak recorder and crystal clock
- ALTIMETER: Benzer rader
- ANCILLARY EQUIPMENT: Geox intervalometer
Century 440 analogue light beam recorder
Geox film digital recorder
Vinten 16 mm ground tracking camera
- READING INTERVAL: 1.023 seconds
- NOMINAL AIRCRAFT SPEED: 50 knots (mean reading spacing 47 metres)
- NOMINAL AIRCRAFT SURVEY ALTITUDE: 140 metres (E.M. bird 50 metres, Mag. bird 120 metres)

E.M. response logs tracking fiducial by approx 1.5 fiducial intervals

FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 10E
START FIDUCIAL 4145
END FIDUCIAL 4878

GEOEX



FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 11E
START FIDUCIAL 5204
END FIDUCIAL 5334

GEOEX

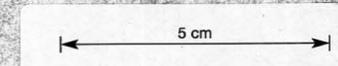


FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 12W
START FIDUCIAL 766
END FIDUCIAL 896

GEOEX



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ELECTROMAGNETIC AND MAGNETIC SURVEY

FOR

UNION OIL DEVELOPMENT CORPORATION

MOUNT LEE AREA

SURVEY SPECIFICATIONS

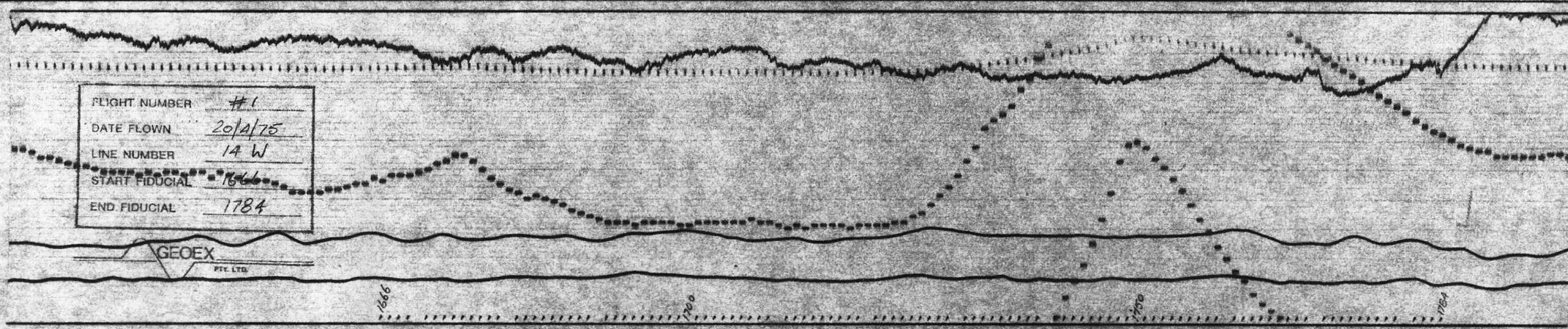
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- E.M. SYSTEM: Geox M400 dual frequency sequential transmission 340 Hz and 1070 Hz
- MAGNETOMETER: Geometrics G803 proton precession (reading accuracy ± 1 gamma)
- DIURNAL RECORDER: Geometrics G805 proton precession magnetometer with Austrak recorder and crystal clock
- ALTIMETER: Bonzer radar
- ANCILLARY EQUIPMENT: Geox intervalometer
Century 444 analogue light beam recorder
Geox film digital recorder
Vinten 16 mm ground tracking camera
- READING INTERVAL: 1.025 seconds
- NOMINAL AIRCRAFT SPEED: 90 knots (mean reading spacing 47 metres)
- NOMINAL AIRCRAFT SURVEY ALTITUDE: 140 metres (E.M. bird 50 metres, Mag. bird 120 metres)

E.M. response logs tracking fiducial by approx. 1.5 fiducial intervals.

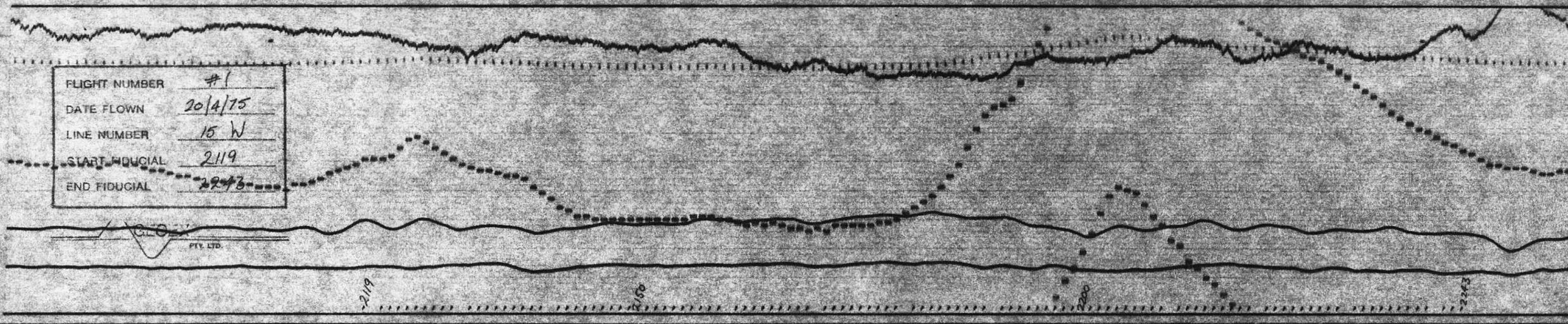
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LINE NUMBER 13 W
START FIDUCIAL 1222
END FIDUCIAL 1352



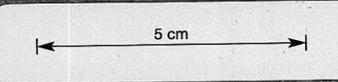
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LINE NUMBER 14 W
START FIDUCIAL 1666
END FIDUCIAL 1784



FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 15 W
START FIDUCIAL 2119
END FIDUCIAL 2243



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**ELECTROMAGNETIC
AND MAGNETIC
SURVEY**

FOR

UNION OIL DEVELOPMENT CORPORATION

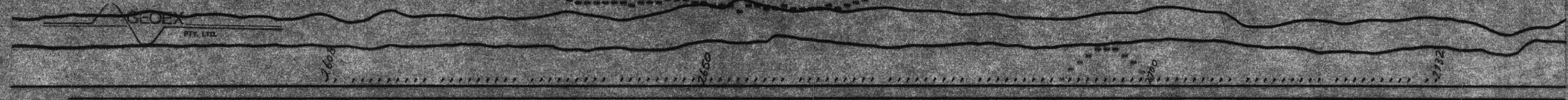
MOUNT LEE AREA

SURVEY SPECIFICATIONS

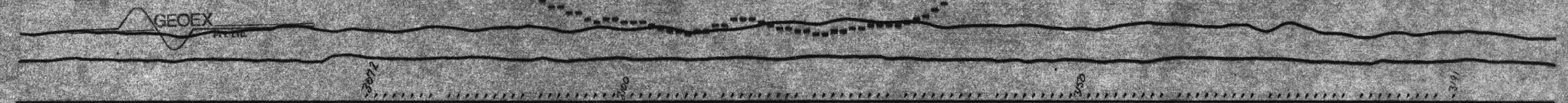
HELICOPTER	Bell Jet Ranger 206B VH-BLN
E.M. SYSTEM	Geox H400 dual frequency sequential transmission 340 Hz and 1070 Hz
MAGNETOMETER	Geometrics G803 proton precession (reading accuracy ± 1 gamma)
JOURNAL RECORDER	Geometrics G806 proton precession magnetometer with Rustrak recorder and crystal clock
ALTIMETER	Boozar radar
ANCILLIARY EQUIPMENT	Geox intervalometer Century 444 analogue light beam recorder Geox film digital recorder Vinten 16 mm ground tracking camera
READING INTERVAL	1.023 seconds
NOMINAL AIRCRAFT SPEED	90 knots (mean reading spacing 47 metres)
NOMINAL AIRCRAFT SURVEY ALTITUDE	140 metres (E.M. bird 50 metres, Mag. bird 120 metres)

E.M. response logs tracking fiducial by approx 1.5 fiducial intervals

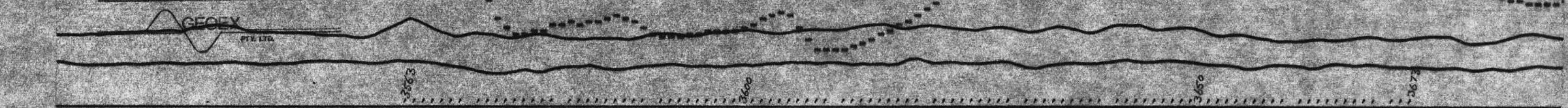
FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 16W
START FIDUCIAL 2608
END FIDUCIAL 2732



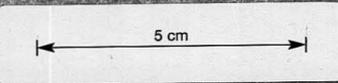
FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 17W
START FIDUCIAL 3072
END FIDUCIAL 3191



FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 18W
START FIDUCIAL 3563
END FIDUCIAL 3673



522049



**ELECTROMAGNETIC
AND MAGNETIC
SURVEY**

FOR

UNION OIL DEVELOPMENT CORPORATION

MOUNT LEE AREA

SURVEY SPECIFICATIONS

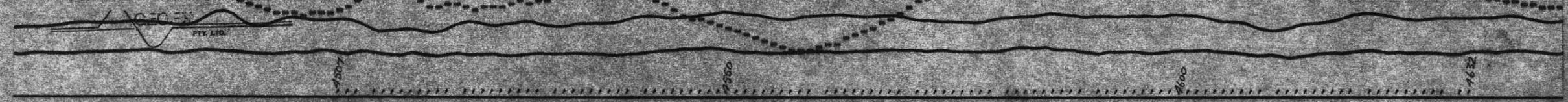
HELICOPTER	Bell Jet Ranger 206B VH-BLR
E.M. SYSTEM	Geox H-400 dual frequency sequential transmission 340 Hz and 1070 Hz
MAGNETOMETER	Geometrics G803 proton precession (reading accuracy ±1 gamma)
DIURNAL RECORDER	Geometrics G806 proton precession magnetometer with Rustrak recorder and crystal clock
ALTIMETER	Bonzer radar
ANCILLARY EQUIPMENT	Geox intervalometer Century 444 analogue light beam recorder Geox film digital recorder Vinten 16 mm ground tracking camera
READING INTERVAL	1.023 seconds
NOMINAL AIRCRAFT SPEED	90 knots (mean reading spacing 47 metres)
NOMINAL AIRCRAFT SURVEY ALTITUDE	140 metres (E.M. bird 50 metres Mag. bird 120 metres)

E.M. response lags tracking fiducial by approx. 1.5 fiducial intervals

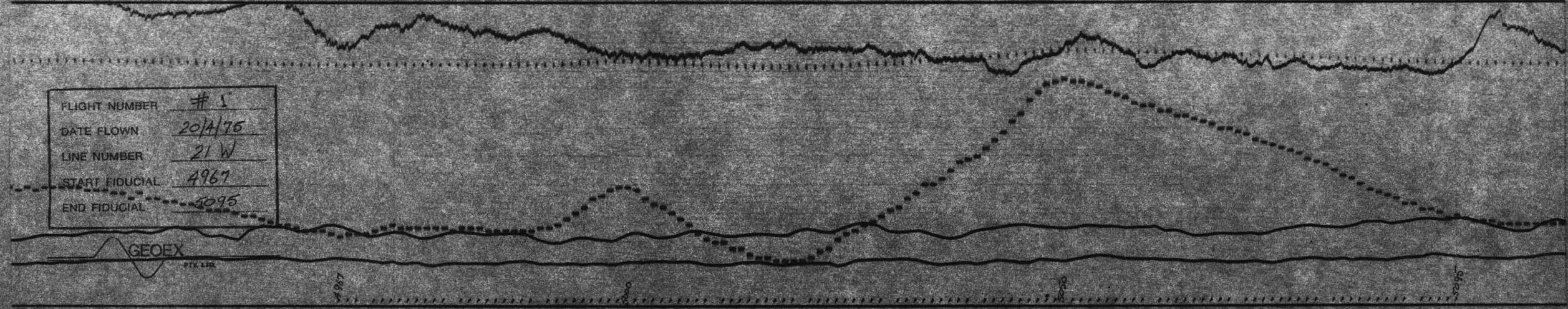
FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 19 W
START FIDUCIAL 4032
END FIDUCIAL 4161



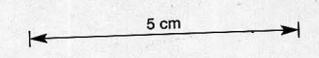
FLIGHT NUMBER #2
DATE FLOWN 20/4/75
LINE NUMBER 20 W
START FIDUCIAL 4507
END FIDUCIAL 4632



FLIGHT NUMBER #3
DATE FLOWN 20/4/75
LINE NUMBER 21 W
START FIDUCIAL 4967
END FIDUCIAL 5095



522050



ELECTROMAGNETIC AND MAGNETIC SURVEY

FOR

UNION OIL DEVELOPMENT CORPORATION

MOUNT LEE AREA

SURVEY SPECIFICATIONS

HELICOPTER	Bell Jet Ranger 206B VH-BLR
E.M. SYSTEM	Geopex H-400 dual frequency sequential transmission 340 Hz and 1070 Hz
MAGNETOMETER	Geometrics G803 proton precession (reading accuracy 24 gamma)
DIURNAL RECORDER	Geometrics G806 proton precession magnetometer with Rustrak recorder and crystal clock
ALTIMETER	Benzel radar
ANCILLIARY EQUIPMENT	Geopex intervalometer Century 444 analogue light beam recorder Geopex film digital recorder Vinten 16 mm ground tracking camera
READING INTERVAL	1.023 seconds
NOMINAL AIRCRAFT SPEED	90 knots (mean reading spacing 47 metres)
NOMINAL AIRCRAFT SURVEY ALTITUDE	140 metres (E.M. bird 50 metres, Mag. bird 120 metres)

E.M. response logs tracking fiducial by approx. 1-5 fiducial intervals

FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 22 W
START FIDUCIAL 5423
END FIDUCIAL 5535

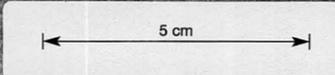


FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 23 E
START FIDUCIAL 5647
END FIDUCIAL 5797



FLIGHT NUMBER #1
DATE FLOWN 20/4/75
LINE NUMBER 24 W
START FIDUCIAL 5876
END FIDUCIAL 5991





ELECTROMAGNETIC AND MAGNETIC SURVEY

FOR

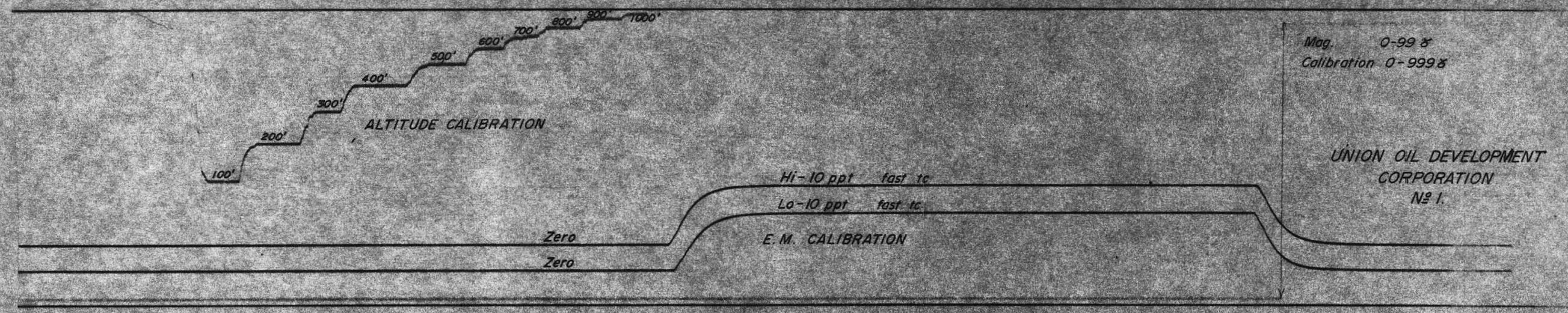
UNION OIL DEVELOPMENT CORPORATION

MOUNT LEE AREA

SURVEY SPECIFICATIONS

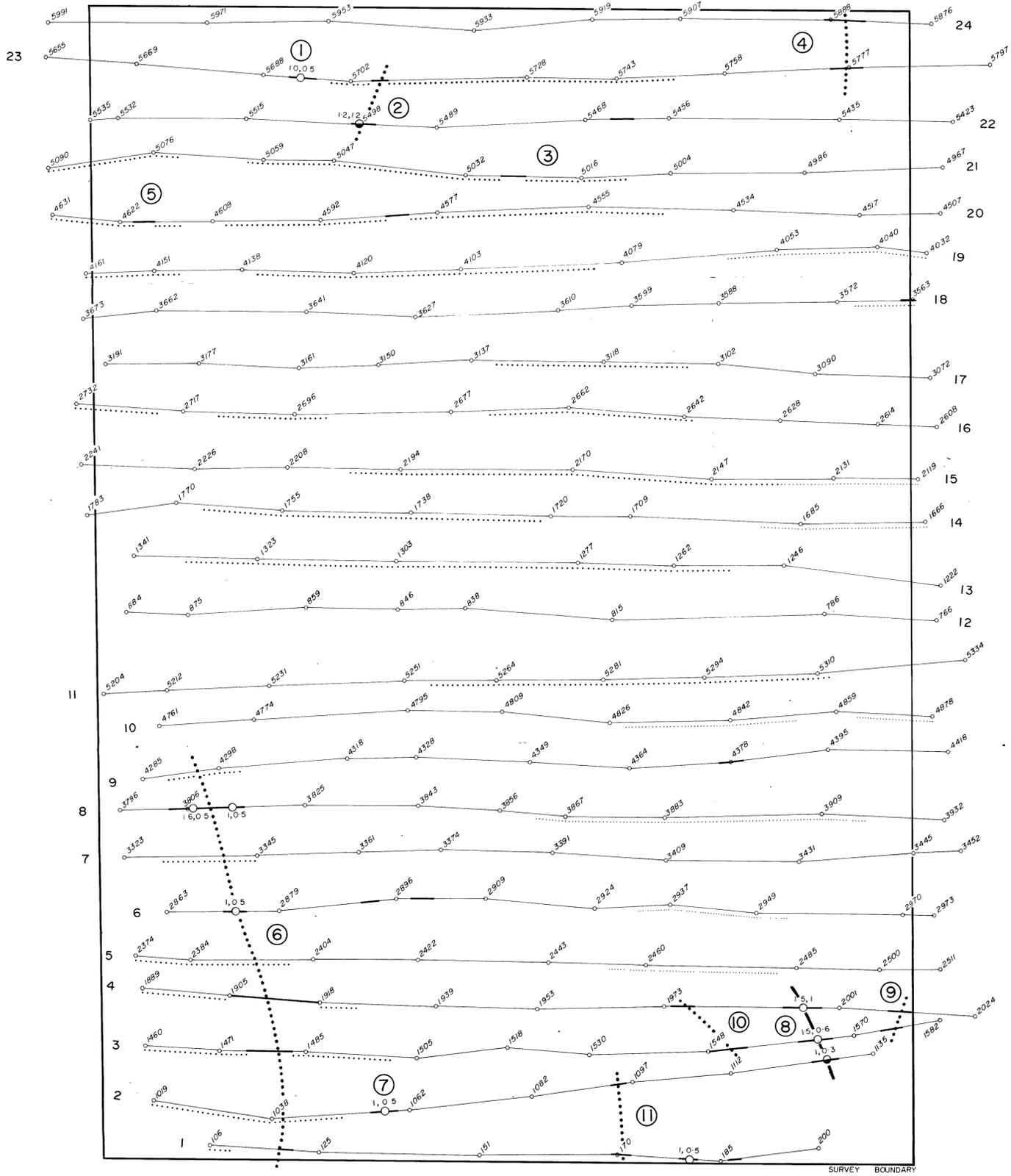
HELICOPTER	Bell Jet Ranger 206B VH-BLR
E.M. SYSTEM	Geox H400 dual frequency sequential transmission 340 Hz and 1070 Hz
MAGNETOMETER	Geometrics G803 proton precession magnetometer (reading accuracy ± 1 gamma)
DIURNAL RECORDER	Geometrics G806 proton precession magnetometer with Rustrak recorder and crystal clock
ALTIMETER	Bonzer radar
ANCILLIARY EQUIPMENT	Geox intervalometer Century 444 analogue light beam recorder Geox film digital recorder Vinten 16 mm ground tracking camera
READING INTERVAL	1.023 seconds
NOMINAL AIRCRAFT SPEED	90 knots (mean reading spacing 47 metres)
NOMINAL AIRCRAFT SURVEY ALTITUDE	140 metres (E.M. bird 50 metres, Mag. bird 120 metres)

E.M. response lags tracking fiducial by approx. 1.5 fiducial intervals

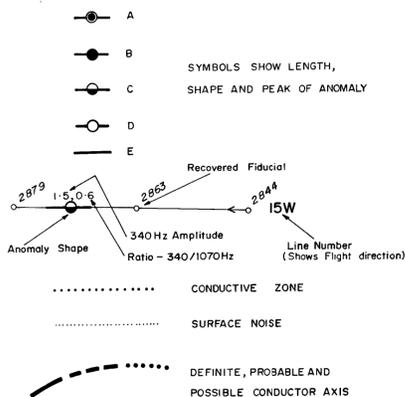


Mag. 0-99 %
 Calibration 0-999 %

UNION OIL DEVELOPMENT CORPORATION
 No 1.



REFERENCE



SURVEY SPECIFICATIONS

HELICOPTER	Bell Jet Ranger 206B VH-BLR
E.M. SYSTEM	Geocex H400 dual frequency sequential transmission. 340 Hz and 1070 Hz.
MAGNETOMETER	Geometrics G803 proton precession (reading accuracy ± 1 gamma)
DIURNAL RECORDER	Geometrics G806 proton precession magnetometer with Rustack recorder and crystal clock.
ALTIMETER	Bonzer radar
ANCILLIARY EQUIPMENT	Geocex intervalometer Century 444 analogue light beam recorder Geocex film digital recorder Vinten 16 mm ground tracking camera
READING INTERVAL	1-023 seconds
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NOMINAL AIRCRAFT SURVEY ALTITUDE	140 metres (E.M. bird 50 metres, Mag. bird 120 metres)

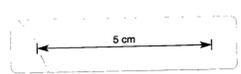
FOR LOCATION SEE
U.O.D.C. GEOPHYSICAL ANOMALY
LOCATION SYNTHESIS SHEET 2

GEOEX 522052
PTY. LTD. 001

UNION OIL DEVELOPMENT CORPORATION
MOUNT LEE AREA
AIRBORNE ELECTROMAGNETIC ANOMALY MAP
SCALE 1:16000

METRES 400 0 400 800 1200

SURVEYED: APRIL 1975 APPROVED: C. G. WEBSTER
DRAWN BY: N. B. PROJECT NO: AEM 75/06





ORDOVICIAN QUATERNARY

CAMBRIAN

CAMBRIAN

PRE CAMBRIAN

LEGEND

- Alluvial fans, mud flows, outwash
- Detritus coarse to fine talus, glacial debris
- Alluvium, river bed and fluvio-glacial sands and silts
- Undifferentiated oligomictic quartz conglomerate, Conglomeratic quartz-mica sandstone, pyritic sandstone, limestone, Rare shale and siltstone horizons, Coarse conglomerate
- THIRKELL GROUP
Volcanic rich polymictic conglomerate, epiclastic sandstones, siltstones calcareous siltstones and carbonaceous shales, pyritic in part, Chlorite schists and phyllitic schists
- micaceous sandstone, chloritic and phyllitic schists, carbonaceous shale, Volcanic conglomerate
- LUCAS VOLCANICS
Undifferentiated acidic volcanics, dominantly ignimbrites and ash fall pyroclastics, Rhyolite domes and flows, Intrusive (?) trachy-andesites, Clastic and chemical sediments, Chert, Epiclastic tuff, sandstone and shale, rhyolite flows and domes, no ferro magnesium minerals, Rhyolite flows, abundant chloritized biotite, Ignimbritic rocks, some coarse agglomerate and fragmental rhyolite, Ash fall tuffs with occasional ignimbrite and rhyolite flows, Lapilli tuff, Trachy-andesite and coarse grained intrusive (?) rhyolites
- D'ACULAR GROUP
Poorly sorted polymictic conglomerate, cross bedded green and grey shale, epiclastic sandstone and siltstone, Occasional lenses of massive and sheared keratophyre, Generally strongly sheared, Keratophyre, Conglomerate
- PRE CAMBRIAN
Undifferentiated quartzite, quartz-mica schist, tourmaline-quartz schist, silicified dolomite, graphitic schist and chlorite schist

- Unconformity
- Fault (observed or inferred)
- Photo lineament (mostly joints)
- Approximate geological boundary
- Intra formational boundary
- Strike and dip of stratum
- Prevailing strike and dip of stratum
- Vertical stratum
- Strike and dip of foliation
- Prevailing strike and dip of foliation
- Vertical foliation
- Watercourse

NOTE: Unconformity between Quaternary and older formations not shown.

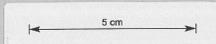
- SCINTREX E.M. Anomalies
Stronger
- Weaker
- UQDC IP Anomalies
Stronger
- Weaker
- Magnetic body trace
- Turair survey boundary

UNION OIL DEVELOPMENT CORP.

TASMANIA E.L. 9/74
(formerly E.L. 2/72)

GEOPHYSICAL ANOMALY LOCATION SYNTHESIS

June 75



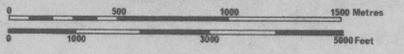
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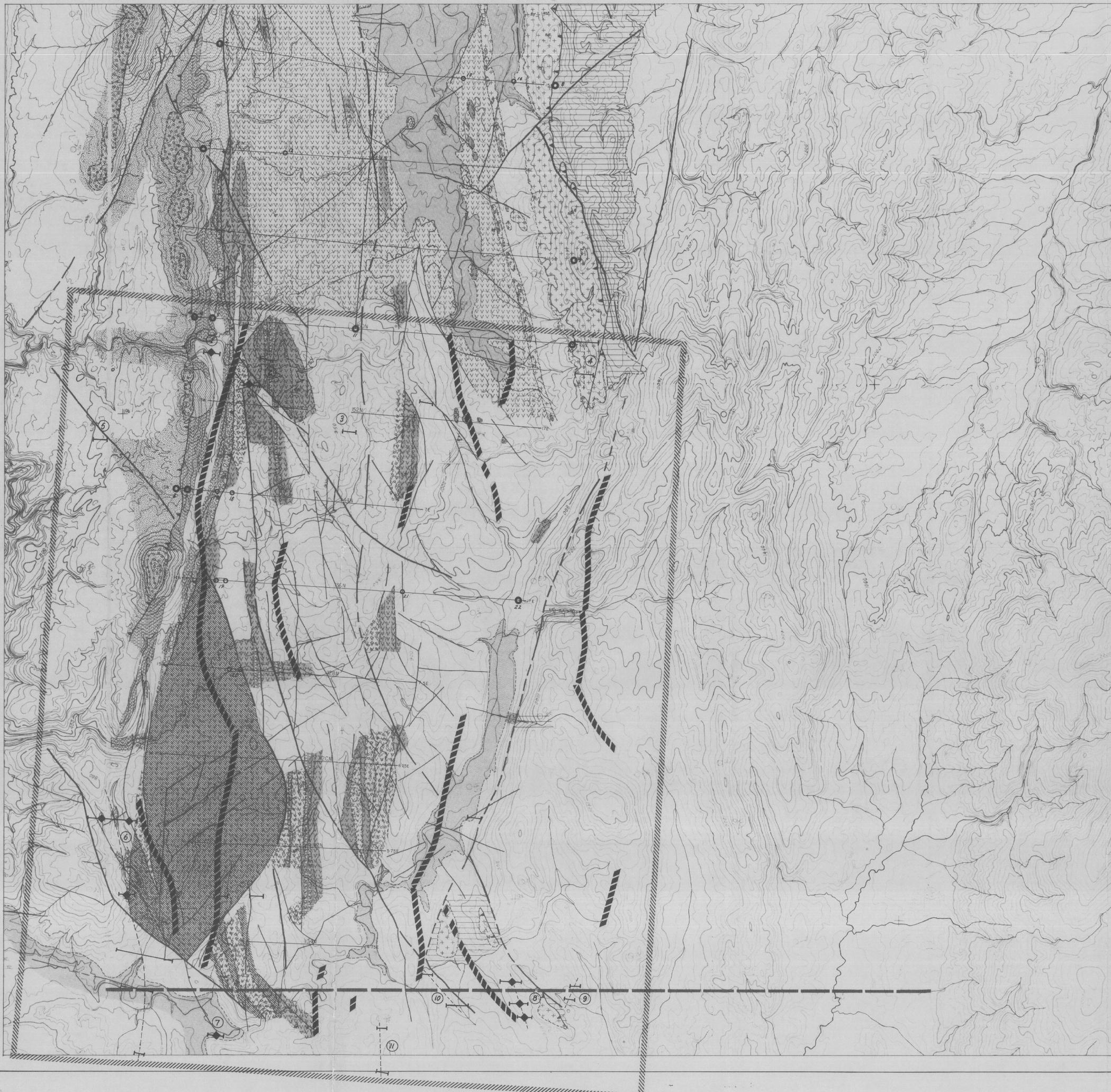
522053

002

GEOLOGY after Australasian Minerals

Scale 1:15 840





LEGEND

- QUATERNARY**
 - Alluvial fans, mud flows, outwash
 - Detritus, coarse to fine talus, glacial debris
 - Alluvium, river bed and fluvio-glacial sands and silts
- ORDOVICIAN**
 - Undifferentiated oligomictic quartz conglomerate, Conglomeratic quartz-mica sandstone, pyritic sandstone, limestone, Rare shale and siltstone horizons, Coarse conglomerate
- THIRKELL GROUP**
 - Volcanic rich polymictic conglomerate, epiclastic sandstones, siltstones calcareous siltstones and carbonaceous shales, pyritic in part, Chlorite schists and phyllitic schists
 - micaceous sandstone, chloritic and phyllitic schists, carbonaceous shale
 - Volcanic conglomerate
- CAMBRIAN**
 - LUCAS VOLCANICS**
 - Undifferentiated acidic volcanics, dominantly ignimbrites and ash fall pyroclastics, Rhyolite domes and flows, Intrusive (?) trachy-andesites, Clastic and chemical sediments, Chert
 - Epiclastic tuff, sandstone and shale
 - rhyolite flows and domes, no ferro magnesian minerals, Rhyolite flows, abundant chloritized biotite, Ignimbritic rocks, some coarse agglomerate and fragmental rhyolite
 - Ash fall tuffs with occasional ignimbrite and rhyolite flows, Lapilli tuff, Trachy-andesite and coarse grained intrusive (?) rhyolites
 - D AGUILAR GROUP**
 - Poorly sorted polymictic conglomerate, cross bedded green and grey shale, epiclastic sandstone and siltstone, Occasional lenses of massive and sheared keratophyre, Generally strongly sheared, Keratophyre, Conglomerate
- PRE CAMBRIAN**
 - Undifferentiated quartzite, quartz-mica schist, tourmaline-quartz schist, silicified dolomite, graphitic schist and chlorite schist

- Unconformity
- Fault (observed or inferred)
- Photo lineament (mostly joints)
- Approximate geological boundary
- Intra formation boundary
- Strike and dip of stratum
- Prevailing strike and dip of stratum
- Vertical stratum
- Strike and dip of foliation
- Prevailing strike and dip of foliation
- Vertical foliation
- Watercourse

NOTE: Unconformity between Quaternary and older formations not shown.

- UOOC IP Anomalies
- Stronger
- Weaker
- GEOEX E.M. Anomalies
- Stronger
- Weaker
- Anomaly number
- E.M. survey boundary
- Magnetic body trace

UNION OIL DEVELOPMENT CORP.
TASMANIA E.L. 9/74
 (formerly E.L. 2/72)

GEOPHYSICAL ANOMALY LOCATION SYNTHESIS

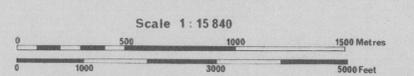
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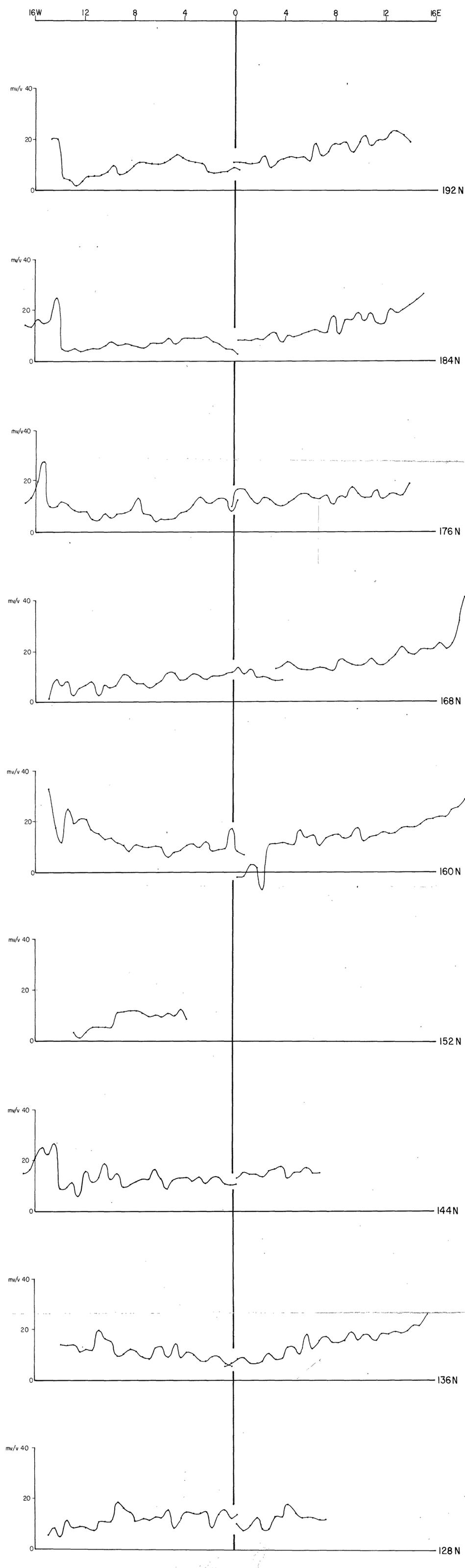
June 75

Sheet 2

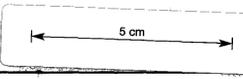


GEOLOGY after Australasian Minerals





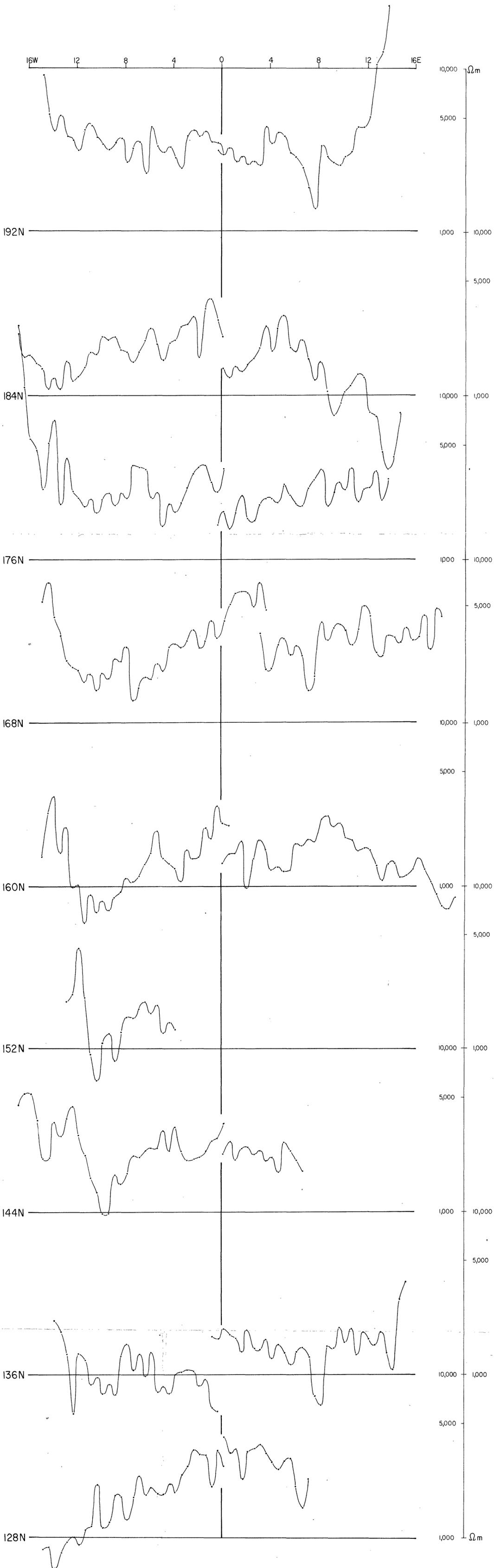
Union Oil Development Corporation
BIRCH'S INLET (EL.9/74)
 TASMANIA
 CHARGEABILITY PROFILES



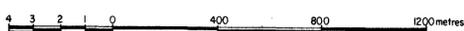
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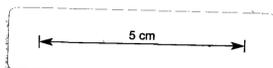
75-1097



Union Oil Development Corporation
BIRCH'S INLET (EL.9/74)
 TASMANIA
 APPARENT RESISTIVITY PROFILES



005



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