Kim Frankcombe

SIROTEM MK II

OPERATIONAL MANUAL

GEOEX

SIROTEM* II

TRANSIENT EM SYSTEM

OPERATION MANUAL

GEOEX PTY. LTD.

50 MARY STREET,

UNLEY, S.A. 5041,

AUSTRALIA.

CAUTION

BATTERY PACK

THE BATTERIES ARE SHIPPED DRY CHARGED AND SEALED. READ CAREFULLY THE ENCLOSED INSTRUCTIONS (SECT. 4.4). CHARGE AS PER INSTRUCTIONS BEFORE OPERATING.

18th December, 1980.

NOTICE

OPERATING PRECAUTIONS

1. Sferics Rejection in Presence of Power Line Noise

A slight problem has been noticed with sferics rejection in the presence of power line (50Hz or 60Hz) noise. This is related to the way in which power line rejection is performed and slight out of phase noise can be seen as sferics.

This can cause the measurement to abort either because it cannot obtain an average or too many readings are rejected.

In this case it is best to switch sferics rejection (2) OFF. (To cure this problem would require major hardware and software changes).

2. Sferics Rejection in Presence of Negatives

When large negatives are observed*and when sferics rejection is also ON, the error will likely be printed as zero.

The reason for this is still under investigation but in the meantime, we suggest you take at least one reading with sferics limit (2) OFF, if errors are required.

*Either with separated loop geometry or in some cases, with coincident loop negatives can be genuine.

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P R E A M B L E

This Operation Manual is principally meant to contain sufficient information to enable the operator to obtain results in the field and to recognise these results as valid. It does not include details of the electronics function or how to repair the instrument. Nor does it include details of quantitative interpretation.

WARRANTY

GEOEX PTY. LTD. warrants that instruments manufactured by it are free from defect in material and factory workmanship for a period of six months, and agree to repair such instruments operating under normal use and service that are disclosed to be defective and the fault of manufacturing.

This warranty shall not apply to any instrument which has been:

1) repaired or altered by persons not authorised by GEOEX PTY. LTD. so as in their sole judgement such work affected the reliability of such instrument.

2) subjected to misuse, negligence, or accident, and

3) connected, installed, used, or adjusted otherwise than in accordance with good practice as outlined in the herein contained instructions.

This warranty is in lieu of any other warranty expressed or implied and GEOEX PTY. LTD. shall not in any event be liable for consequential damages or for breach of any warranty except as herein stated. GEOEX's liability and the buyers exclusive remedies under this agreement shall be limited to the repair of any instrument alleged to be defective and which upon examination proves to be defective when returned to the factory. All freight charges arising from claims resulting under this warranty are for the client's account.

GEOEX PTY. LTD. reserves the right to make any changes in the design or construction of its instruments at any time without incurring any obligation to make any change whatsoever in units previously delivered.

DISCLOSURE

The contents of this operating and service manual with all attendant drawings and schematics contain information considered proprietary to GEOEX PTY. LTD. This information is furnished for the sole purpose of allowing the buyer of the instrument to understand, operate, maintain, and repair said instrument. Any reproduction, disclosure, or other use of the contents of this manual with attendant drawings and schematics is expressly prohibited except as GEOEX PTY. LTD. may otherwise agree in writing.

REPLACEMENT OF PARTS

In the event that any part of any instrument herein described shall become defective after the expiration of the warranty period, such part shall be replaced by GEOEX PTY. LTD. and the buyer shall pay the reasonable value of such parts and the reasonable cost of installation thereof.

CERTIFICATION

GEOEX PTY. LTD. certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications at the time the unit was shipped from the factory.

1. INTRODUCTION

1.1 Principle of Transient E.M.

The principle of the Transient E.M. (TEM) method of geophysical prospecting, very briefly, is that current flowing in a transmitter loop sets up a magnetic field which induces eddy currents to flow in any good electrical conductor in the ground. These eddy currents set up a secondary magnetic field which can be detected by a receiver loop. (See Figure 1.1)

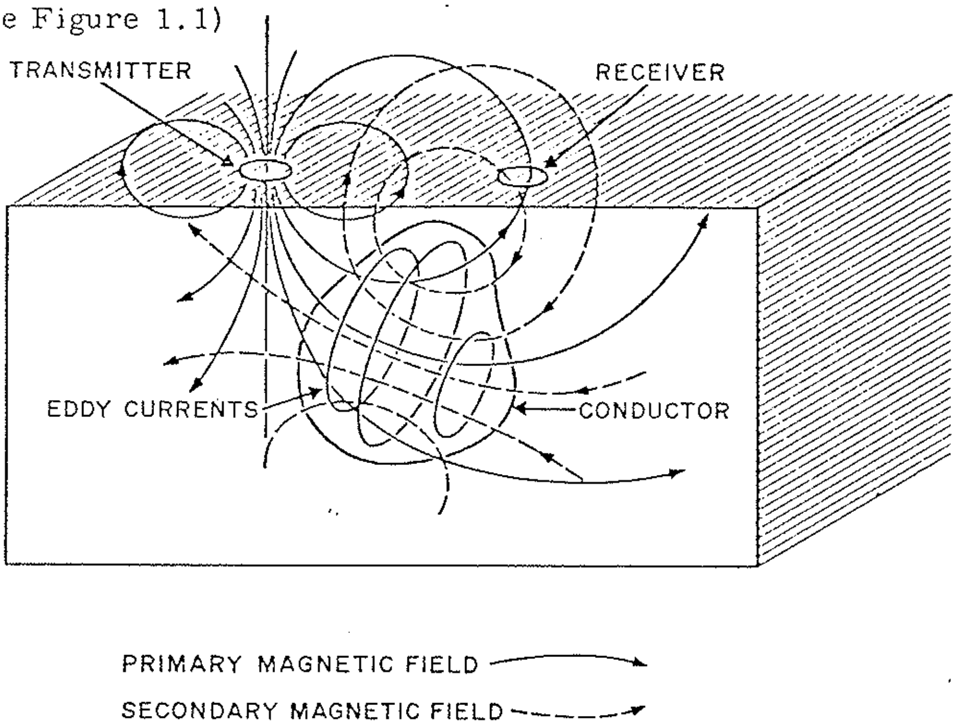


Figure 1.1 Induction of Eddy Currents in a Subsurface Conductor

Since the eddy currents do not cease flowing instantly when the transmitted current is switched off but decay gradually, their presence is indicated by the decaying or transient voltages that they induce in the receiver loop. Hence the recording of these "transients" is a means of detecting conductors in the ground. The better the conductor, the longer the transients persist.
The decaying transient can be described by a number of measurement channels recording the voltage at various delay times. (See Figure 1.2).

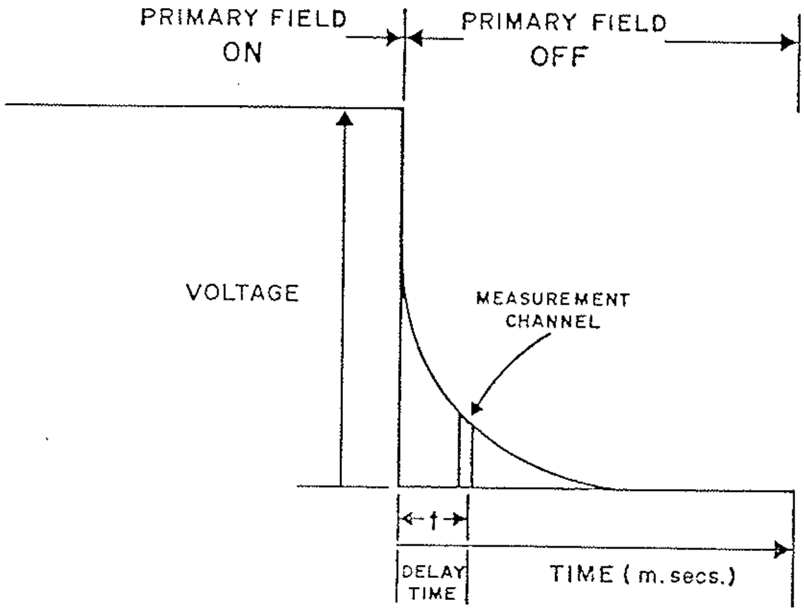


Figure 1.2 TEM Transient Measurement

The character of this decay depends on the conductivity, shape and size of the conductor and its position with respect to the receiver loop.

A particular advantage of transient EM systems over continuous waves systems is the fact that the measurements are taken when the transmitted fields are switched off. This means that the sensitivity of the receiver can be at a maximum to record the transient voltages only without having to cope with the much greater signal strength of the transmission field. It also means that a greater variety of loop configurations can be used including having the receiver loop in the same place as the transmitter loop for maximum signal reception (See section 5.2).

1.2 General Operating Principle of SIROTEM

SIROTEM has been designed to measure the transient decay over a larger number of channels than other instruments of this type, and to later time delays than ever previously possible. The particular advantage of later times is the ability to record conductors underlying highly conductive overburden and/or highly conductive surrounding hosts. SIROTEM records the transient over 32 contiguous channels out to a maximum time delay of 165 milliseconds. Table 1 gives the full details of the positions and widths of each channel in milliseconds from the current switch-OFF.

SIROTEM has also been designed to be:

- simple to operate (as automatic as possible),
- light weight and easy to transport,
- versatile in terms of its ability to use various types of loop configurations.

The instrument is very sensitive, in being able to resolve one nanovolt (10^{-9}) volt per amp. and has a low inherent noise of a few hundred nanovolts per amp or less depending on number of stacks, etc. It has a high degree of ambient noise rejection capability due to its ability to stack up to 4096 (2^{12}) separate readings to obtain the output average. This is performed simultaneously over all channels so that the background noise is common to all channels at the time of measurement. The readings corrected by the output current are produced automatically on a printer and can also be loaded onto cassette. As opposed to dial readings, they are thereby objective, operator independent and in ready hard-copy form. The instrument also has a significant amount of in-built data processing capability due to the incorporation of a micro-processor, and calculates apparent resistivity data in the field.

The microprocessor performs the full automatic sequencing of the instrument including operating the transmitter, storing and averaging the data, controlling the measurement and output sequence, and finally transforming the data to apparent resistivity or other parameters as is appropriate. The microprocessor is programmed by a set of programmable read-only memories (PROMs) and hence the operation of SIROTEM may be altered by the preparation of a new set of proms. Figure 1.3 is a simplified block diagram of the circuitry.

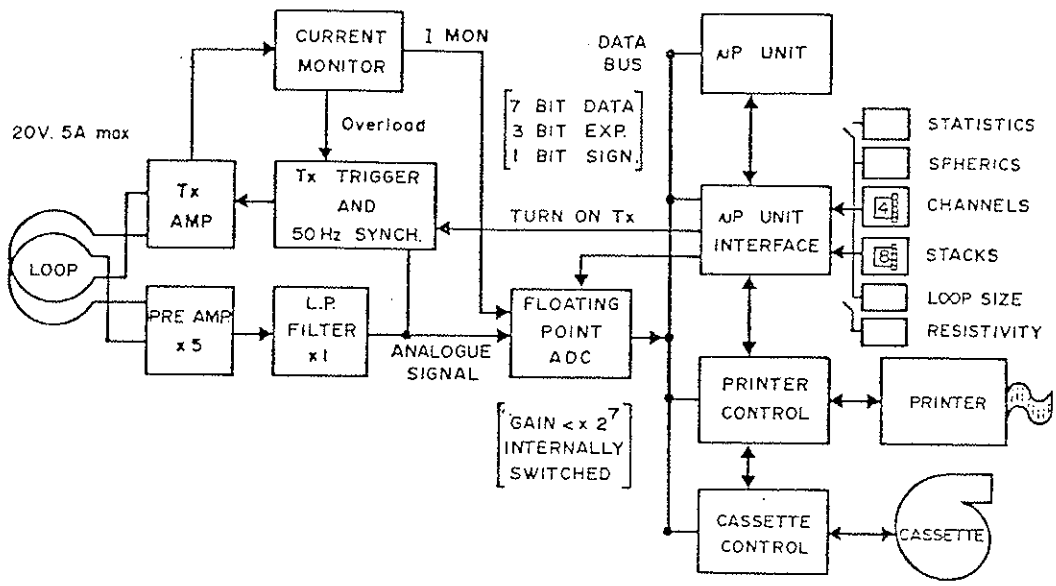


Figure 1.3 Simplified block diagram of SIROTEM

Strict economy in power consumption has been used throughout SIROTEM in order that the battery weight may be reduced and its life increased. As a result, 80% of the battery current is used in the transmitter loop; only 20% being needed to run the instrument itself. To achieve this performance, a CMOS microprocessor is used and the PROMs are powered only when they are being read.

TABLE I

CHANNEL DELAY TIMES AND INTEGRATION WIDTHS

Channel No.	Nominal Mean Delay (msecs)	Nominal Width (msecs)	Actual Integration Window (msecs)	
1	0.4	0.4	0.25 - 0.6	1666
2	0.8	0.4	0.65 - 1.0	1000
3	1.2	0.4	1.05 - 1.4	714
4	1.6	0.4	1.45 - 1.8	
5	2.0	0.4	1.85 - 2.2	
6	2.6	0.8	2.25 - 3.0	
7	3.4	0.8	3.05 - 3.8	
8	4.2	0.8	3.85 - 4.6	
9	5.0	0.8	4.65 - 5.4	
→10	5.8	0.8	5.45 - 6.2	161
11	7.0	1.6	6.25 - 7.8	
12	8.6	1.6	7.85 - 9.4	
13	10.2	1.6	9.45 - 11.0	
14	11.8	1.6	11.05 - 12.6	
15	13.4	1.6	12.65 - 14.2	
16	15.8	3.2	14.25 - 17.4	57.5
17	19.0	3.2	17.45 - 20.6	
18	22.2	3.2	20.65 - 23.8	
19	25.4	3.2	23.85 - 27.0	
20	28.6	3.2	27.05 - 30.2	33
21	33.4	6.4	30.25 - 36.6	
22	39.8	6.4	36.65 - 43.0	
23	46.2	6.4	43.05 - 49.4	
24	52.6	6.4	49.45 - 55.8	18 Hz
25	59.0	6.4	55.85 - 62.2	
26	68.6	12.8	62.25 - 75.0	
27	81.4	12.8	75.05 - 87.8	
28	94.2	12.8	87.85 - 100.6	
29	107.0	12.8	100.65 - 113.4	
30	119.8	12.8	113.45 - 126.2	
31	139.0	25.6	126.25 - 151.8	
32	164.6	25.6	151.85 - 177.4	5.7 Hz

2. UNPACKING AND INSPECTION

Carefully unpack the equipment and inspect for shipping damage. If the instrument or accessories were damaged during transit, the carrier should be notified immediately, so he can arrange for repair or replacement.

The contents of your shipment should be as follows:

1	SIROTEM Console
1	Battery Pack
2	Battery Chargers
1	Calibration Unit (in lid of Console case)
1	Console - Battery Pack Connecting Cable
1	Console - Loop Connecting Cables
5	Spare Fuses for Battery Pack and Console
1	Calibration Sample Printout
1	Operation Manual
1	Set of Circuit diagrams

3. SYSTEM DESCRIPTION

3.1 CONSOLE FRONT PANEL

Figure 3.1 is an illustration of the SIROTEM console front panel. A description of each of the features numbered is given below. If any of the features do not behave as described, refer to the Fault Finding Procedure (Sect. 9).

Transmitter (Tx) Loop Size (1)

This switch is used in conjunction with the Resistivity Calculation switch (4). It should be set to the appropriate side length being used for the resistivity calculation to be correct. Should a side length be used that is not one of the 4 settings available, the switch should be set at the "100 metre" position. The values then calculated can be corrected for the loop size being used by multiplying the values printed by $(\text{side length}/100)^{8/3}$. For example for a side length of 80 metres, the printout value should be multiplied by approximately one half.

Sferics Limit (2)

This switch in one of the 'on' positions 1, 2 or 3 will provide a means of rejecting odd voltage spikes such as are caused by sferics. The criteria for rejection is determined as a percentage of the mean reading. The positions 1, 2 and 3 provide three different percentages of decreasing magnitude and hence increased rejection. The operator should determine by trial in each area which of the three positions is most effective in rejecting spurious bad readings. If more than half the number of stacks set (6) are rejected no reading will be obtained.

Sferics Hi/Lo (3)

This switch selects 3 "high" or 3 "low" levels of sferic rejection. Currently these are 800%, 400% and 200% on 'HI' and 100%, 50% and 25% on 'LO'. The value will be indicated on the printout (see Fig. 4.1).

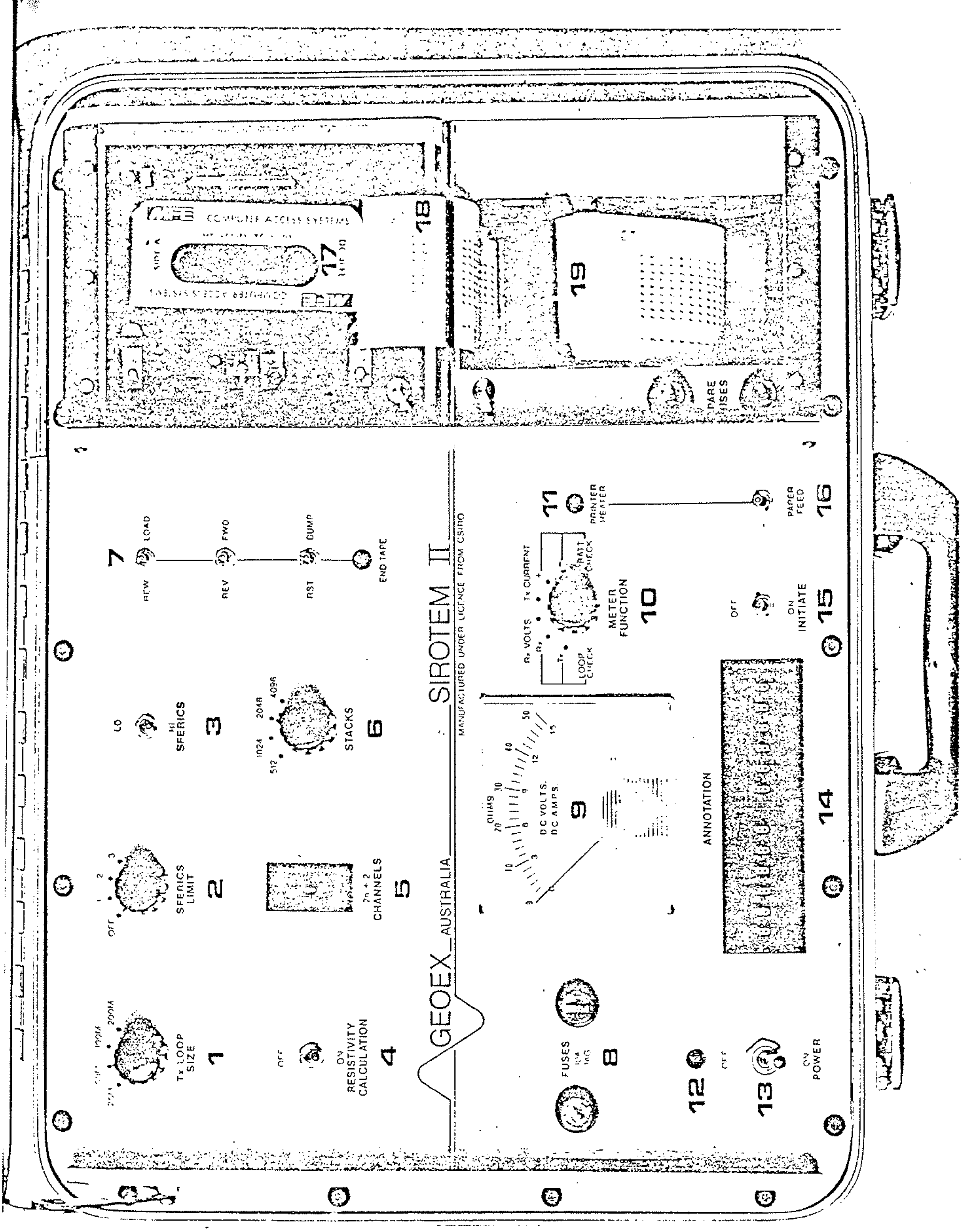


Figure 3.1 SIROTEM Front Panel

Resistivity Calculation (4)

Turning this switch on causes resistivities to be calculated for the particular side length determined by the position of Transmitter Loop switch (1). The values printed will be apparent resistivities assuming a uniform half space and a single turn coincident loop. For multiturn loops multiply the value printed by (Tx turns x Rx turns)$^{2/3}$.

Channels (5)

This thumb-wheel switch sets the number of channels to be measured. The number appearing represents the value of "n" in the expression "2n + 2". The range of selection is from 10 channels (n = 4) to 32 channels (n = 15).

Note:

The position n = 0 is used to carry out a fast reading of low stack (64) number for check purposes. Positions n = 1, 2, 3 are not used. It should be noted at this point that the number of channels selected determines the repitition rate of the instrument as the measurement time is always just slightly longer than the completion time of the last channel window selected. This also equals the transmit on time.

Stacks (6)

This switch selects the number of pulses to be stacked or averaged. There are 4 positions as indicated, providing for stacking of 512, 1024, 2048 or 4096 individual readings. (One positive plus one negative pulse).

Cassette Controls (7)

All these switches are momentary action.

REW - This switch causes the tape to rewind at 120 IPS and then move forward to the load point ready for recording data. When inserting a new tape the rewind switch should be activated to correctly position the tape.

LOAD - Activation of this switch moves the tape to the end of the last recorded data block. The tape should be at or past the load point before LOAD is selected.

REV - This switch reverses the cassette tape by one record each time it is impulsed.

FWD - This switch takes the tape forward one record each time.

RST - This position is used to reset the cassette player, cancelling any previous cassette controls. It can be used for example, when the tape is inserted back to front or when it breaks, jams or runs out.

DUMP - This position is used to dump data from the cassette to the printer one record at a time.

END TAPE - This L.E.D., when flashing, indicates that the end of tape has been reached. The data being recorded will not be lost as long as the cassette is not on the clear leader when it has finished writing. The L.E.D. flasher is turned off by the RST switch.

Fuses (8)

These two 10 amp fuses protect the power input supply. Should they be fused, spares are located inside the printer compartment.

Multi Function Meter (9)

This meter is used in conjunction with the meter function switch (10). It is calibrated to read:

(i) 0 - 50 ohms for the transmitter (Tx) and receiver (Rx) Loop check.

(ii) 0 for "Rx volts" zero check.

(iii) 0 - 15 amps for "Tx current".

(iv) 0 - 15 volts for "Battery check".

Meter Function (10)

This switch selects the function to be read on the meter (9).

(a) "Loop check Tx" checks the continuity of the transmitter loop by registering the amount of resistance in the loop. The correct value of this will be determined by the size of the loop, and hence the length of cable used times the resistance per unit length of the cable. A reading of zero indicates 'no circuit' and a full scale deflection indicates a probable 'open-circuit'. The unit will not initiate while the meter select switch is in either the Tx or Rx loop test positions. These positions should not be selected while transmitting. If this is done transmission will halt until another meter position is chosen. The program will then continue without loss of data.

(b) "Loop check Rx" checks the receiver loop in the same manner as Loop check Tx described above.

(c) "Rx volts". This position is only used as part of the laboratory test procedure.

(d) "Tx current" monitors the peak current transmitted.

(e) "Battery check $\mp$" checks the power supply voltage which should read greater than 11 volts in each position.

Printer Heater (11)

The printer heater circuit has an ON/OFF switch mounted inside the unit at the top of the partition between the p.c. card compartment and the printer compartment. On delivery this switch will be in the OFF position.
When switched ON the printer heater is controlled by a thermostat which will switch on when the console temperature drops below $0^{\circ}C$ and off when the temperature reaches $15^{\circ}C$. The printer heater L.E.D. on the front panel will come on while the heater is on. The cycling of the heater should not affect operation of the SIROTEM unless battery voltage is low.

Power On Indicator (12)

This L.E.D. flashes when the Power switch (13) is on. For a well charged battery pack the L.E.D. flashes at approximately two times per second. A slower rate indicates a low state of battery charge, no light at all indicates that the battery voltage is below usable level (20 volts).

Power Switch (13).

In the 'on' position of this switch, the battery voltage is provided to the instrument.

Annotation (14).

These 12 thumb-wheel switches provide numbers which will be written on the cassette tape and the paper printout to indicate line number, station number or any other identifier that may be desired.

Note:

The no. of stacks, current value, sferics rejection percentage, and number of rejected readings will be written automatically in addition to this annotation.

Initiate (15)

Activation of this impulse or momentary action switch to the 'on' position when the Power switch (13) is on, starts the measurement cycle. Initially the instrument will read all the other settings of switches numbered 1, 2, 3, 4, 5, 6 and 14 and begin automatically transmitting current and measuring the transient voltages over the range of channels and stacks selected. On completion it will automatically switch off and print results on the printer and, if required, the cassette.

Paper Feed Switch (16)

This switch when held in the 'on' position feeds paper through the printer and out the paper feed slot (18).

Cassette Tape Transport (17)

When data is required to be recorded on cassette, the cassette tape should be inserted here. Access is gained to this compartment by raising the clear plastic lid with the handle provided. For the specifications of this tape transport refer to Appendix II.

Printer Paper Feed Slot (18)

On the completion of a transmit cycle the Printer paper will automatically feed out through this slot. In order to prevent bunching of the paper it should be assured that some paper is protruding through this slot before initiation. The bevelled edge of this slot can be used to tear off print-outs when required.

Printer Paper Chamber (19)

Access to this chamber is obtained by raising the clear plastic lid with the handle provided. Printer paper is placed in this chamber and loaded according to the instructions given in Section 4.4

3.2 CONSOLE EXTERIOR CONNECTIONS

Power In Put Socket (20)

This socket is used, with the appropriate cable, to connect the console to the Battery Pack as shown in Figure 3.2. The three pins are assigned as follows:

Pin 1	+ 12 volts
Pin 2	- 12 volts
Pin 3	Ground

Loop Socket (21)

Connection is made through this socket with the appropriate cable to the receiver and transmitter loops, or to the Calibration Unit in the lid of the console case as illustrated in Figure 3.2.

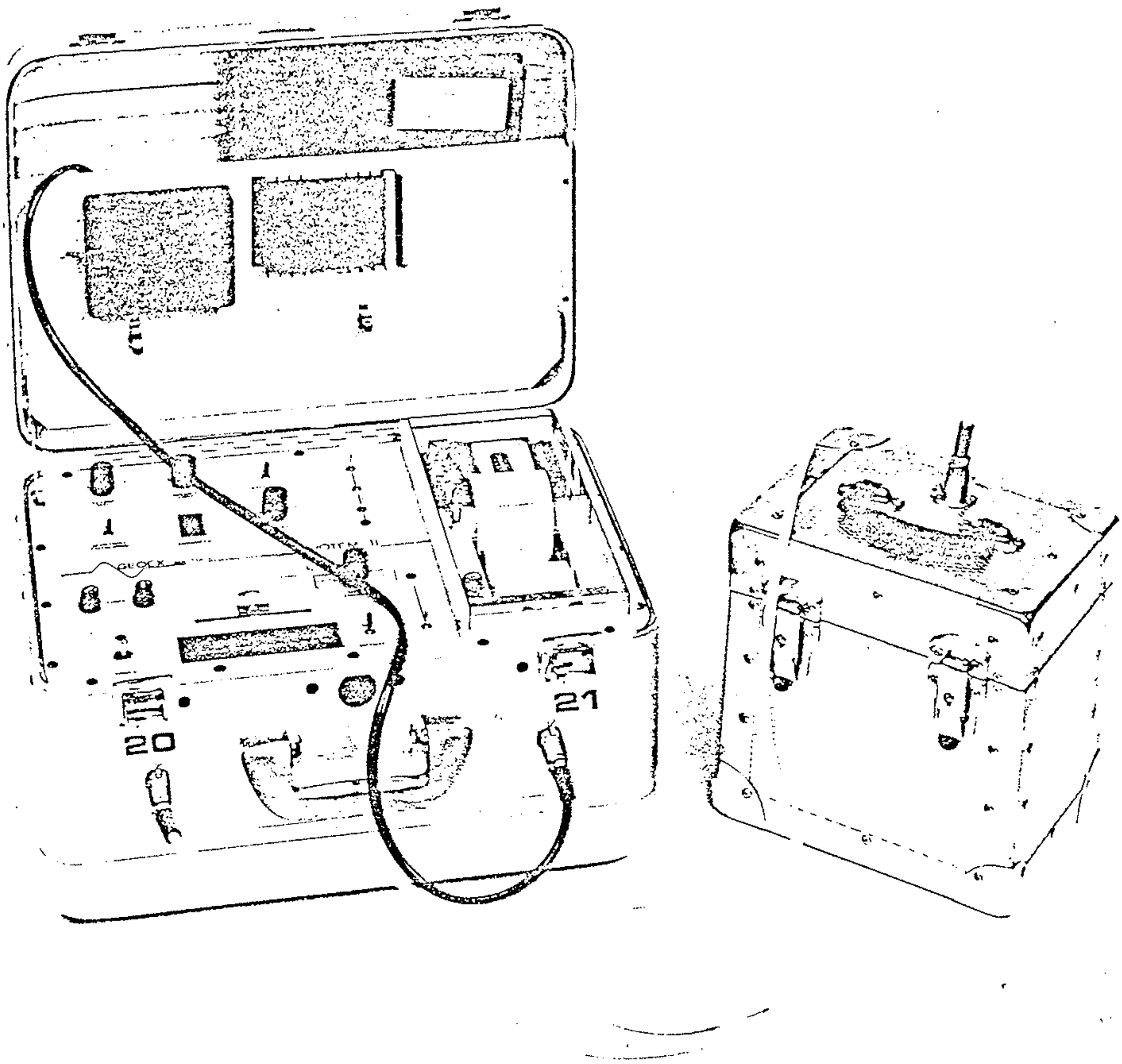


Figure 3.2 External View

Note:

The above two connections are external to the console so that operations in heavy rain or dusty conditions, can be made with the console lid closed.

3.3 BATTERY PACK

Figure 3.3 is an illustration of the typical Battery Pack supplied when motorcycle batteries are used as a power source. The socket (22) in the lid is used to connect the power to the console through socket (20) (Fig. 3.2).

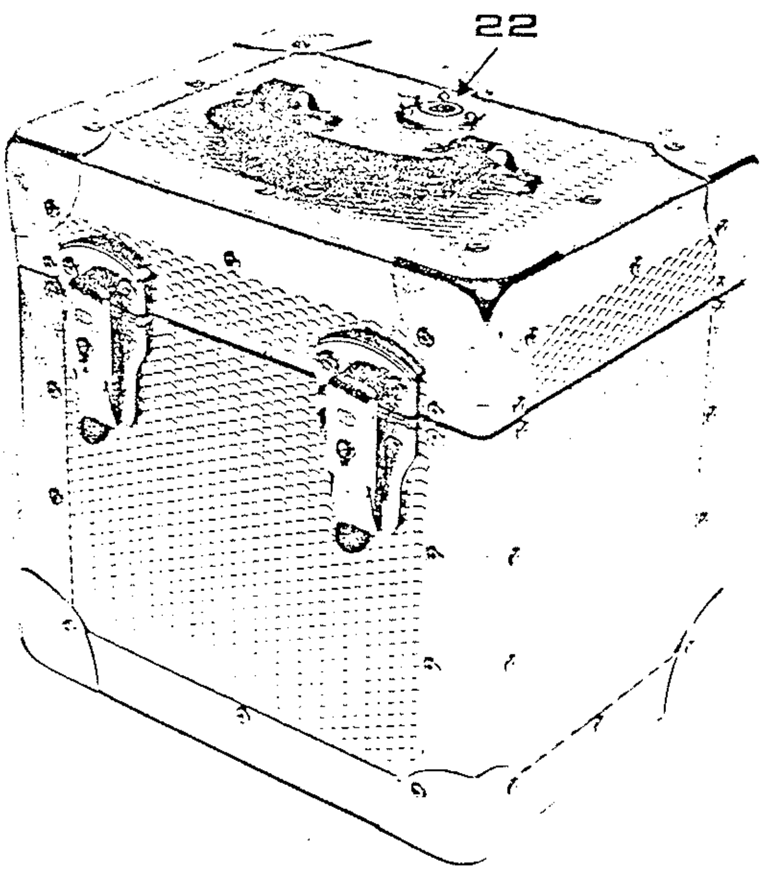


Figure 3.3 Battery Pack

4. GENERAL OPERATION PROCEDURES

(For Field Measurement Procedure see Sect. 7.4)

4.1 PUTTING BATTERIES INTO SERVICE FOR FIRST TIME

Each battery is charged-and-dry, which means that it may be put into service immediately after filling with acid. However, to insure good battery performance and long life, 5 hours' freshening charge is recommended after acid filling.

(1) Before filling electrolyte, take off the sealed short tube on the battery and connect the long exhaust tube to the battery.

(2) Remove filling plugs and fill cells to HIGHEST line with electrolyte (diluted sulphuric acid) having a specific gravity as follows:

Cold or Temperate Climate	1.28 at 20°C	(68°F)
Tropical Climate	1.24 at 20°C	(68°F)

When filling the electrolyte temperature must not be lower than 15°C (59°F) nor higher than 30°C (86°F).

(3) Allow battery to stand for some time after filling before placing on charge.

If electrolyte level has dropped, add more electrolyte until HIGHEST is reached.

(4) Place on charge at 1.2 amp. Charge until all cells gas freely, and the voltage and specific gravity are constant over three successive readings taken at 30 minutes intervals. The total charging time required will be about 5 hours.

(5) After completion of charge, adjust the electrolyte level to HIGHEST.

(6) Replace the filling plugs tightly, and wash off any electrolyte which is spilled on the battery. Battery is then ready for service.

4.2 CALIBRATION PROCEDURE

SIROTEM can be operated "on the bench" by using the Calibration Unit and this is best done before proceeding to the field to ensure that all operations are functioning correctly.

Step 1. Connect the Console to the Battery Power source (through power socket 20) using the appropriate connecting cable provided.

Step 2. Connect the Calibration Unit to the loop socket (21) of the console, using the cable attached to the Calibration Unit.

Step 3. Turn the power switch (13) to 'ON'. The indicator light (12) should commence to flash.
If it does not, check that the battery pack is correctly charged (above 20V) by turning meter function switch (10) to "BATT CHECK" + and - and observing the panel meter (9). If the D.C. volts is below 10 volts in each case, charge the Battery Pack according to procedure in sect. 4.5 If it is more than 10V, something else is at fault and Section 9.4 should be consulted.

Step 4. Set the channels thumbwheel switch (5) to "0" and the "stacks" thumbwheel switch (6) to "512" for a fast check.

Step 5. Turn the INITIATE switch (15) 'ON'. After about 15 seconds, the printer should commence to print a record. If it does not print, refer to Section 9. If it does print, the system is basically functioning correctly, and a full calibration can then be obtained as follows.

Step 6. Set the channels thumbwheel (5) to "15" and the stacks switch (6) to 2048. This will take about 25 minutes and should be done before proceeding to the field.

Such a calibration will indicate:

- instrument malfunction (by comparison against a standard output - see sample supplied)
- an insufficiently charged Battery Pack if the battery voltage has fallen markedly after the run is completed.

4.3 TYPICAL PRINTER OUTPUT DESCRIPTION

Figure 4.1 is an explanation of the various outputs from the printer. The units of measurement are nanovolts per amp and milliohm-metres.

Asterisks will appear instead of voltages if:

(i) a suitable average cannot be obtained for the mean error (indicating excessive variation of readings).

(ii) More than half the required stacks are rejected by the sferic rejection level selected.

In either of these cases, the current reading will be zero.

Asterisks will be printed instead of resistivities if the voltages are negative, zero or the resistivity value is outside the range 1.0 to 5×10^{7} milliohm-metres.

In general, the values should decrease monotonically with increasing channel number. Noisy or incorrect measurements are indicated by values in one channel being greater than those in the proceeding channel, or not being repeatable in successive measurements. Since the combined inherent instrument noise and normal geomagnetic noise, etc. can be of the order of 100 - 200 nanovolts per amp, the readings are usually plotted in microvolts per amp (μV/A) rounded to the nearest 1/10 or a μV/A.

4.4 PRINTER PAPER CHANGE PROCEDURE

Raise the lid of the Printer Paper Chamber (19 in Figure 3.1). With Power ON, press Paper Feed (16 in Figure 3.1) to feed through any remaining paper in the printer.

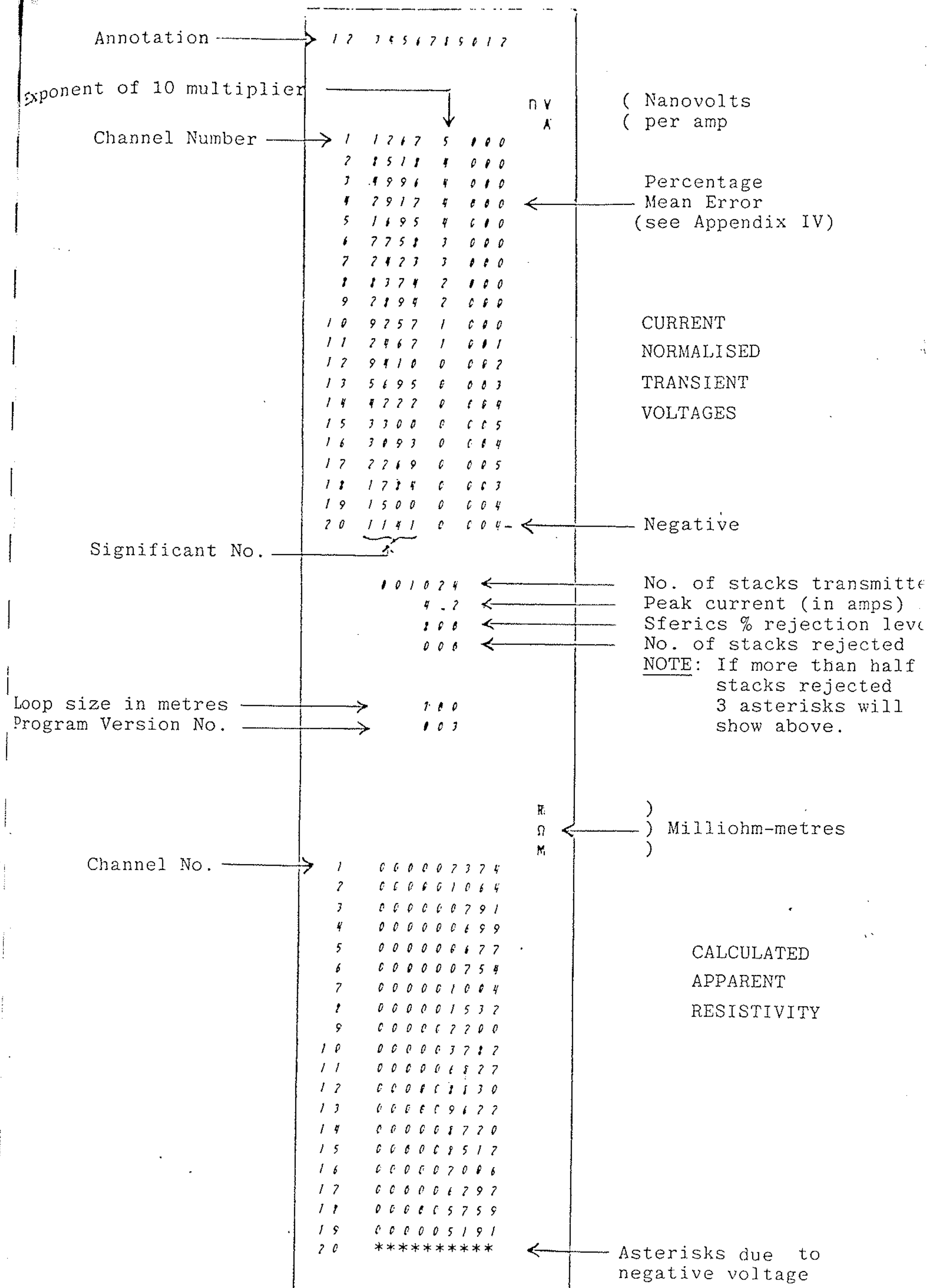


Figure 4.1 Explanation of Printout Format

4.4 PRINTER PAPER CHANGE PROCEDURE (cont.)

The new roll of paper is placed in the printer paper chamber and the end inserted in the slit as indicated in Figure 4.2.

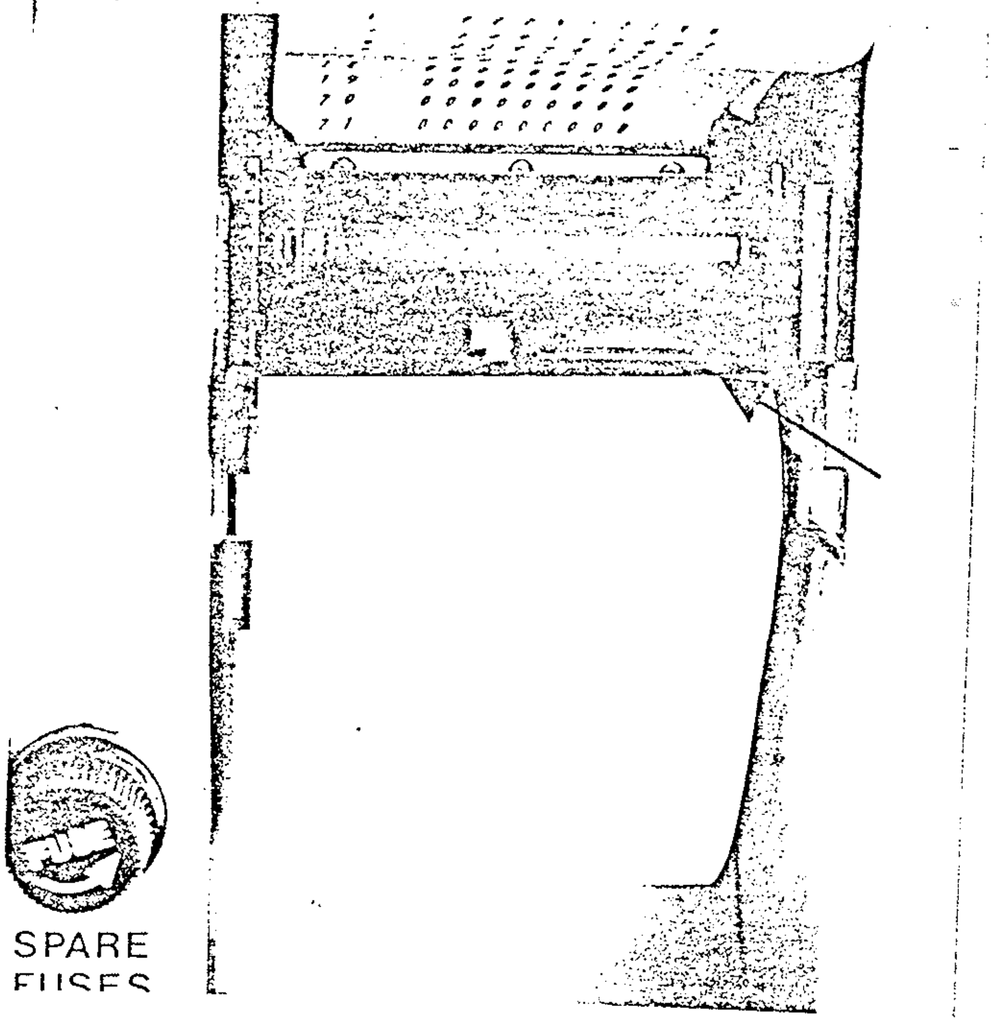


Figure 4.2 Paper Feed Slot and Ink Roller (Arrowed

Paper is then fed through the printer using the Paper Feed switch (16 in Figure 3.1). In order for it to feed correctly, the paper should not be crumpled or torn and it may be necessary to prepare a straight edge with a knife or a pair of scissors before inserting it in the printer. Feed the paper until 2-3 cms. protrudes through the slit (18 in Figure 3.1).

4.5 BATTERY CHARGING PROCEDURE

4.51 Use of Battery Chargers

1. Unplug the power lead between the Console and the Battery Pack.
2. Open the lid of the Battery Pack and connect one charger to each battery, plus to plus, minus to minus. It is unnecessary to disconnect any internal battery case wiring.
3. Set chargers to "12 volt" and "Low".
4. Batteries are fully charged when ammeters read approximately 1 (one) Amp.

4.52 General

1. Charge battery fully as soon as it becomes discharged.
2. Don't clog exhaust tube.
3. The battery should be kept warm and the charged state should be maintained in order to keep electrolyte from freezing in the cold.
4. If installed battery is to be left standing for a long time, disconnect the ground terminal.
5. The battery should not be in contact with petroleum or vinyl chloride.

4.6 PRINTER INK ROLLER CHANGE PROCEDURE

When the printing becomes faint, the printer ink roller has probably become worn (after 6 months or more of steady use). To replace the roller (illustrated in figure 4.2) remove the existing one by pulling it away from the paper slot until 2 spring clips on either side release it. Place the new roller in with the ink pad in contact with the print drum (face down) and the axis ends underneath the spring clips.

5. TYPES OF LOOP CONFIGURATIONS

5.1 General

There are a number of different loop configurations possible for TEM measurements, some being better than others for specific geological situations. SIROTEM is not restricted to any particular configuration. Figure 5.1 illustrates three of the most common loop configurations.

Note: In theory the loops are circular but it is more practical to lay square loops with the sides formed by cables along and at right angles to the traverse direction.

The particular advantages and disadvantages of the various configurations, especially as they apply to SIROTEM, are given below.

5.2 Coincident Loops (See Figure 5.1 (a))

In this configuration, the Tx and Rx loops have no physical separation but are separate electrically. Common sizes are 50, 100 or 200 m. on the side. Smaller loops require more than one turn to give effective dipole moments which are time consuming to lay. Depth of penetration increases with increasing loop size and is of the order of the loop size or more.

Advantages

- highest signal levels of any configuration because Rx is in place of strongest transmission, and therefore best when transmission field attenuated such as is caused by conductive overburden.
- also ensures good practical depth of penetration.
- twin flex or figure-eight cable can be used (see Section 7.3).

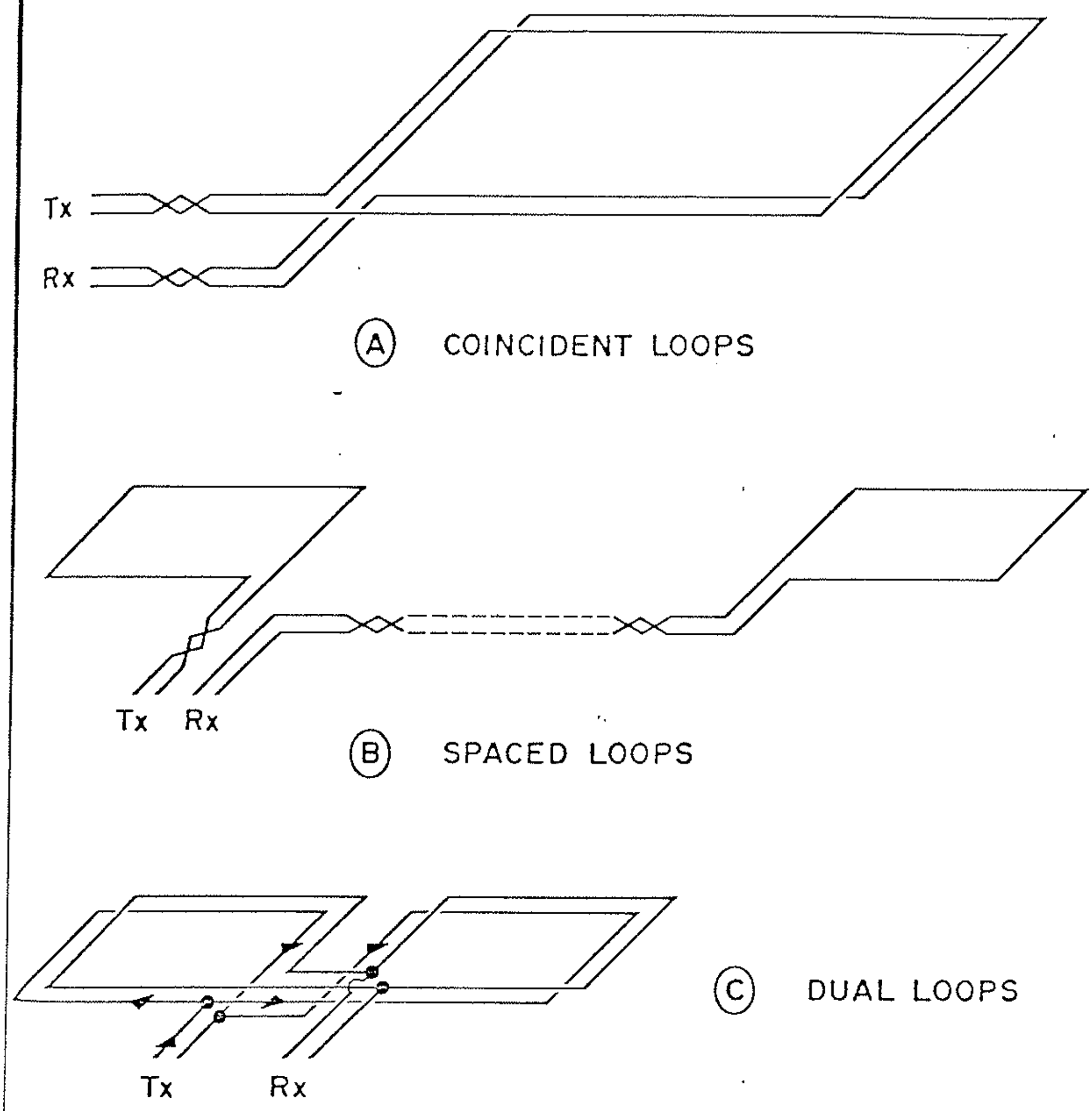


Figure 5.1 Loop Configurations

Disadvantages

- poor coupling to steeply dipping, thin conductors due to the magnetic field being predominantly vertical, producing a minimum response directly over them (see figure 8.1).

5.3 Common Tx and Rx Loop

This is a special case of the coincident loop when a single loop is used for both Rx and Tx.

Advantages

- same as 5.2 above, also
- requires least amount, or weight, of cable, particularly useful for loops greater than 200 m. on the side.

Disadvantages

- same as 5.2 above,

Note - can only be used with SIROTEM if special circuitry installed. Contact Geoex for clarification.

5.4 Spatially Separated Tx and Rx Loops (See figure 5.1 (b))

In this configuration, the two loops are separated by typically 100 m. or 150 m. and are usually 50 m. or 25 m. on the side. Depth of penetration, in theory, is dependent on the separation of the loops, increasing with increasing separation.

Advantages

- good coupling to steeply dipping, especially thin, conductors.

Disadvantages

- more complex to lay in field (see section 6.4).
- lower signal levels, hence poorer depth of penetration in practice than theoretically expected.

5.5 Dual Loop (after Spies 1975)

In this configuration two loops are adjoined in a figure 8 (see figure 5.1 (c)) so that current flow in the adjacent central wires is in the same direction, producing an especially strong field which is horizontal beneath them. Rx and Tx are spatially coincident.

Advantages

- good coupling to vertical conductors
- less masking due to conductive overburden
- peak response directly over conductor (see figure 8.11)

Disadvantages

- complex to lay out
- produces 3 peaks for each conductor (see figure 8.11) which could cause confusion with multiple conductors

5.6 Small Multi-turn Rx Loop

A variant on 5.2 and 5.4, depending on whether it is placed inside or outside the Tx loop, is a physically small Rx coil (2 m. or less) with hundreds of turns (300 - 500) in order to retain adequate signal levels.

Advantages

- best possible resolution of conductor position
- more portable

Disdavantages

- requires special Rx cable
- may require special winding on a metal core in order to overcome some electronic problems

6. LOOP LAYING PROCEDURES

6.1 Introduction

As indicated in section 5, there are a number of different types of loop configurations and correspondingly there are many ways of laying them out. Some of what are considered the most efficient procedures will be described below.

The user may devise his own procedures or adapt those described to suit his own special requirements. Obviously those procedures which are quickest and require the least amount of effort are preferred.

Remember The plotting point of all measurements is in the centre of coincident loops or midway between separate loops. If measurements are required on a particular line, the loops will need to straddle this line. It is advisable to have pegs at the corners of the proposed loops.

The best way of forming a loop is to use separate lengths of cable for the sides and joined at the corners (such as by twisting wires) so that they can be pulled apart easily on moving to the next station.

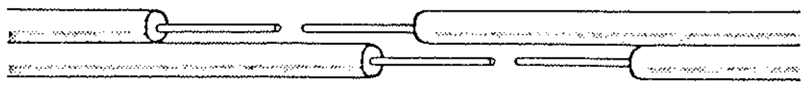
6.2 General Procedures and Precautions

The following general procedures and precautions should be observed at all times with all types of loops:

(i) Keep bare (uninsulated) cables off the ground (TEM loops are purely inductive and must not be earthed).

(ii) Never have a completely connected loop near one which is recording data - always make sure such loops are open-circuit so that currents are not incuded in them so causing spurious transients.

(iii) When using twin-flex (figure 8) cable ensure that the Tx wires do not short with adjacent Rx wires. This can be avoided by cutting one wire to a different length than the other so that the Rx and Tx joins are not side by side (see below).



(iv) Ensure that with any loop size or configuration and type of cable chosen, the resistance in the Tx loop is less than 20 ohms, so that at least 1 amp of current can be transmitted from the battery; (22 volts gives 1.1 amps into 20 ohms) and greater than 2 ohms, so that the current does not exceed the maximum permissable 10 amps output.

(v) Do not leave reels of cable or vehicles near the loop cable. Vehicles should be at least 2 vehicle lengths distant from the nearest part of the loop and preferably never inside the loop especially when the loop area is not more than 100 times that of the vehicle area.

(vi) Avoid where possible, laying loops near large metal objects, such as sheds, drill pipe, core boxes, etc. as these could give spurious results, particularly in the case of small loop areas (less than 100 m^2). If they are unavoidable their presence should be noted.

Drill casing in the ground and wire fences could give a spurious disturbance especially if within 1 m. the loop cable. A loop cable crossing a steel fence post can give a response equal to that due to an ore-body.

(vii) Accuracy of loop area

It is important for consistency and to comply with theoretical assumptions that the area of the loop does not vary from station to station and that it is as near as possible equal to the (side length)^2. To ensure this,

(a) lengths should be as accurate as possible.
(b) sides should be as straight as possible.
(c) sides should form right angles.

(viii) Height of loop off ground

It has been shown (Lee, 1978) that a large loop ($\gtrsim$ 50 m) can be 1 to 2 m. off the ground without introducing a significant error into the amplitude of the transient. This means that it does not matter if the loop is strung over low scrub and across culverts, etc.

6.3 Coincident Loops

6.3.1 General

As loop side lengths are most commonly multiples of 100 m., cables are best cut to this length. Loops of greater than 100 m. can be made up by joining 100 m. lengths and 50 m. loops can be made by using two 100 m. lengths each forming 2 sides of the loop.

The following descriptions will apply to any length of side.

The set-up now has the same relationships as at the start (except for B and C having exchanged positions) and this cycle is repeated over and over.

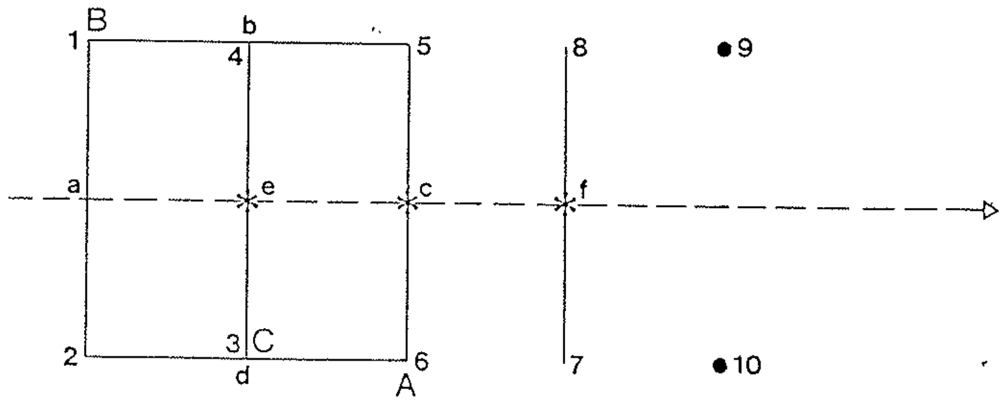
By alternating roles, B and C share the unequal tasks.

At each change, the operator walks one side length L and the assistants 1 L and 5 L, respectively.

6.3.3 50% Overlap

In this case the measurement point interval is half the loop side length.

Figure 6.2 illustrates the initial set-up and the designation of the symbols used.



* Measurement Point

Figure 6.2

The first loop 1-2-6-5 is formed by joining cables a, b, c and d. Additional cables e and f are laid at 3-4 and 7-8, respectively, but not joined. Distances 1-4 and 5-8 are equal and half that of 1-5. Operator A has the instrument at 6. Assistants B and C are at 1 and 3, respectively.

Upon completion of the first reading, A moves to 7. pulling d with him. At the same time, B pulls a to 5, where he also pulls b to 8 and carries on with a to leave at 9 - 10. Meanwhile C connects d to e at 3 and walks to 4 where he connects b to e.

While the new loop 3-4-8-7 is being read, B walks to 6. The configuration is now the same as at the start and this cycle continues with B and C interchanging roles. At each change, A walks $\frac{1}{2}$ L, and the assistants 1L and 4L, respectively.

<u>A variation</u> on the above, which may be faster but requires more walking and more cable is to have a second complete loop 3-4-8-7 laid in advance (see figure 6.3).

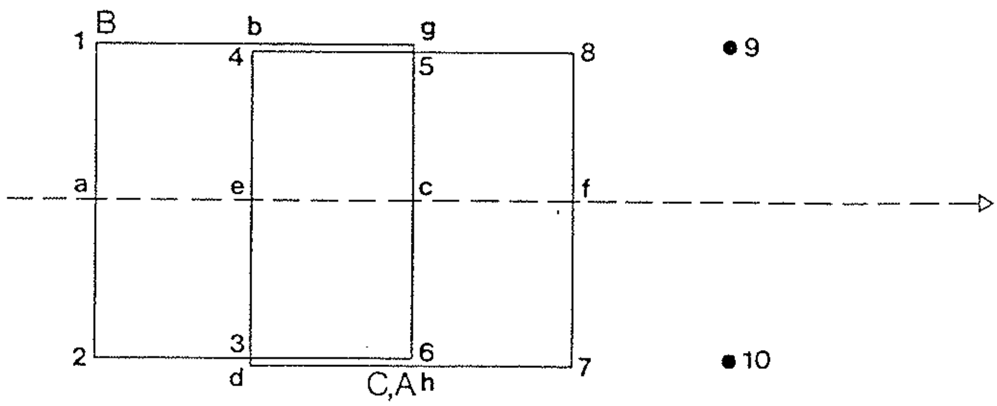


Figure 6.3

On completion of the reading on loop 1-2-6-5, A moves to 7 pulling d where he connects the instrument to loop 3-4-8-7 which is ready for measurement. During the measurement he pulls d on to 10. Meanwhile B pulls a via 5, picking up b to leave at 9 and continuing on to 10 with b. He then walks to 7. C connects d to c and walks to 5 to connect b to c and then walks to 4.

In this method, A walks $1\frac{1}{2}L$, and the assistants $1\frac{1}{2}L$ and $3\frac{1}{2}L$, alternatively.

6.4 Separated Tx and Rx Loops

When separated transmitter and receiver loops are used it is more efficient to lay out a series of loops on the ground and record two different spacings at each location. Simple layouts that allow minimum time between equipment locations are essential and many different methods can be designed. As an example, described below are details of a survey using 50 metre loops with spacings of 2 and 3 times the loopside length. The loops are laid as shown in Figure 6.4 and a total of twelve 100 metre cables are needed.

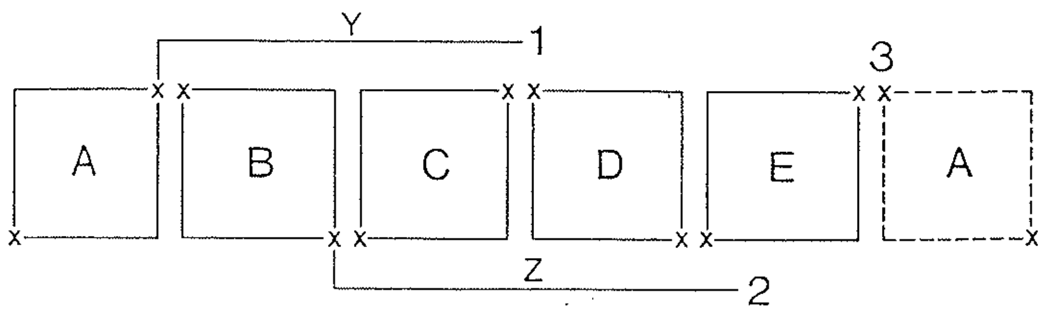


Figure 6.4

SIROTEM is placed at position 1 for the first data to be recorded. It is important to have the same sense of current circulation in the Tx and Rx loops.

Note: Always have the instrument beside the Tx loop and run the other connecting wire to the distance Rx loop so as to avoid any additional resistance in the Tx loop.

Five 50 metre side loops are laid out with extra wires Y and Z laid alongside the loops. The x's mark the position of joins (ends) in the cables, i.e. the ends of the two 100 metre cables making one loop. If twin-flex is used the two cores are connected in parallel.

Cable Y is connected to loop A, (preserving polarity), B is held open circuit usually with cable Z connected. Using loop C as a transmitter and A as a receiver, readings at a separation of 100 metres are obtained. With loop D as transmitter, readings with a separation of 150 metres are obtained.

On completion, loop D is closed at position 1 and the instrument is moved diagonally across to position 2. Cable Z is connected to the instrument receiver terminals making B the receiver loop. Connecting loop D as transmitter gives 100 metres separation data and loop E gives 150 metre separation.

Note: It is important to ensure that all loops not being used are open-circuit.

Whilst these measurements are being made the field assistants pull loop A (two separate cables) past position 1 and form it as shown in figure 6.4 They also pull the front end of cable Y up to position 3 and connect up loop C as the third receiver ensuring that the ends of cable Y are open circuited. Once readings are recorded at position 2 the operator proceeds to position 3 and continues the data acquisition.

7. FIELD MEASUREMENTS

7.1 NECESSARY EQUIPMENT

The equipment required for a SIROTEM field survey is:

1) ONE SIROTEM INSTRUMENT CONSOLE.
2) ONE SIROTEM RECHARGEABLE BATTERY PACK.

   Note: Two packs may be required for a full day's operation if high current (above 4A peak) and/or long averaging stacks are being employed. Alternatively, 2 x 12 volt vehicle batteries can be used (see section 7.2 below).
3) REEL(S) OF LOOP CABLE (according to requirement, see section 7.3 and section 6)
4) ONE BATTERY PACK TO CONSOLE CONNECTING CABLE
5) ONE LOOP TO CONSOLE CONNECTING CABLE
6) BATTERY CHARGER AND CONNECTING CABLE.

   (May be left at base).
7) SPARE ROLLS OF PRINTER PAPER (according to requirement - around 100 records may be obtained from one roll of paper, depending upon the number of channels selected.)
8) SPARE FUSES FOR BATTERY PACK - 10 Amp.

7.2 Power Source Other than Standard Battery Pack

As an alternative power source to the special SIROTEM Battery Packs, any other power supply which provides the necessary 22-24 Volts, has sufficient power output (greater than 22VA) and adequate capacity (more than 10 Amp. hours), for continued operation may be used.

Special leads will be required with battery terminal connectors on one end and the power input plug to the SIROTEM console on the other end.

Care should be taken to ensure that the leads are fused (with in-line fuses) as close to the battery as possible with 10 Amp. fuses.

CAUTION

At no time during power ON, should the leads be disconnected from either battery.

7.3 Type of Loop Cable

- resistance - as this determines in the case of the Tx loop how much current can be drawn from the Battery Pack.
- Size - this determines how much can be wound on a given reel.
- weight
- configuration ("figure 8" as opposed to round cross-section). This determines how it packs on a reel.
- cost
- availability

Common household twin-flex (24/0.20 mm metric spec), satisfies most of these criteria well. It is very easily obtainable (in the smallest towns) which is good if replacement cable is needed while on survey, and is relatively inexpensive, light and the figure 8 packs well on a reel. It's resistance is 2.5 ohms per 100 metres which means a total of 10 ohms in a 100 m. x 100 m. loop, permitting a transmitter current of 2 amps. For a 50 m. x 50 m., it allows a current of 4 amps. In most cases this amount of current is adequate. To increase the current output, 2 cables can be laid for each loop and connecting the 2 cores in each cable in parallel, 1 cable used for the transmitter and 1 for the receiver.

Other cables are available which have lower resistance but they are heavier, more expensive and less easy to obtain. For special survey requirements these disadvantages can be overlooked. One special cable that is available through GEOEX is a figure 8 configuration with one core having over three times the cross sectional area of the other (50/0.25 mm - 24/0.20 mm^2) and consequently only 0.7 ohms/100 m. resistance as opposed to 2.5 ohms/100 m. This permits a current output of 7 - 8 amps in a 100 x 100 m. loop.

This will double the output current. Alternatively, the 2 cores in 1 cable and 1 of the cores from the other cable can be connected in parallel to the transmitter to reduce the resistance to 1/3 and increase the current output to 3 times, or 6 amps for a 100 m. x 100 m. loop. The remaining single core is used for the receiver loop. Some means of distinguishing Tx cables from Rx cables around the loop will be required.

NOTE:

Do not do this for small loops if it permits drawing more than the maximum 10 amps.

For small loop sizes where many turns are required, multiconductor ribbon cable can be considered. It is, however, expensive and requires special connectors.

7.4 FIELD MEASUREMENT PROCEDURE

(Numbers in brackets refer to the items illustrated in Figure 3.1)

1. Before leaving for the survey site:
    - (A) check that the Battery Pack is fully charged (see Sect. 4.2 Step 3).
    - (B) Obtain a full calibration (taking approx. 25 mins.) according to the procedure described in Sect. 4.2 Step 6.

2. At the survey site, connect the SIROTEM console to the Battery Pack (through the Power Socket (20)) and switch on the power (13). The Indicator light (12) should commence to flash. If not, refer to the Fault Finding Procedures (Section 9.4).

3. Then conduct a short calibration (e.g. with the Channels thumbwheel switch (5) at "8" and the Stacks switch (6) to 1024, to check that the system is still operational after transport. It should not differ substantially from the full calibration taken at base.

4. Connect the SIROTEM console to the loops via the appropriate cables with the Loop Socket (21).

   Ensure that the console is <u>outside</u> the transmitter loop and at least 3 metres from it to avoid currents being induced in the console chassis which cause a malfunction of the electronics.

   To ensure correct signal polarity is established the connectors at the loop end of the cables are labelled positive and negative, transmitter and receiver.

   Connect either the receiver or transmitter ends to one loop. Connect the second pair of cables to the other loop, ensuring that the same polarity cable connector goes to the same side of the receiver as for the transmitter loop.

5. To check for loop integrity set the Meter Function switch (10) to "Loop Check" Tx and then Rx. In each case the Panel Meter needle (9) should deflect and indicate the resistance of the

(i) If the numbers are monotonically decreasing to the very last channel it means that the noise level has not yet been reached. Increase the number of channels and repeat the run. Continue selecting more channels until the last few channels contain only noise.

(ii) If the noise in the last, say, 4 Channels is above $\pm$ 250 nV/A, increase the number of stacks and repeat the run. If the variations are still high, even with the number of stacks set at a maximum of 4096, it means that the ambient noise level in the area is unusually high. See Section 7.6 for ways of overcoming noise interference.

The selection of the ideal number of channels and stacks may sometimes have to be comprised against the time taken for a reading. Table 2 gives the measurement times for all settings of channels (5) and Stacks (6).

8. When ready to commence routine measurements the positions of switches 1 - 6 and 14 need to be set according to what is required. Time will be saved by turning Resistivity Calculation switch (4) "off" if loop configurations other than coincident are being used.

9. With the final settings selected above, press "INITIATE" and wait for a printer output. If the mean errors are acceptable the rest of the survey may be continued with only occasional use of statistics to save time.

   If the mean errors are unacceptable, increase the sferics limit (switch 2) to a higher number and repeat the reading. If the problem is not solved in this way, carry out a calibration to check if any instrument problem has developed.

10. Once measurements at a given station have been completed, turn off the instrument, disconnect the connections to the loop and move to the next station. The battery may be left connected to the instrument during transport.

11. At the next station, reconnect the cables to the loops, test for loop continuity and if OK, proceed as before.

12. The presence of likely sources of spurious readings should be noted such as large metal objects near the loop cable and surface features such as creeks, alluvial deposits, etc.

13. It is recommended that a plot of the profiles of results from a few channels (selected at both early and late delay times) be made during the survey to check the validity of the data, and to identify spurious results such as caused by cultural interference. (See example figure 7.1).

13. (cont.)

Logarithmic paper may be needed to cover the complete range of transient signals. Plotting of results from a given station can be done at the next station, whilst waiting for a new measurement.

14. If instrument problems develop at any stage during the survey, refer to the Fault Finding Procedure Section (Sec. 9).

15. After the last run of the day, obtain a calibration using the same settings of number of channels and stacks as used during the survey.

7.5 Methods of Assessing if Profile Anomaly is caused by a Buried Conductor.

(1) A number of contiguous channels should show the anomaly. In many cases all channels will not show it, e.g. if conductive overburden response is present, the conductive body anomaly may be obscured and appear only at later delay times (e.g. beyond ~3 msecs); at very late delay times the noise level may be too great to enable the anomaly to be detected.

(2) The response should be evident at more than one station. If it does occur at only one station, it is symptomatic of either the transmitter and receiver loops touching at some point, or an open-circuited receiver loop.

(3) The value in any channel should be at least a factor of ~ 3 above the noise level for that channel otherwise it may be only noise.

8. TYPICAL TEM PROFILES

8.1 General

The profiles shown below should be taken as an indication only of the expected profile characteristics for a given situation. The actual response depends on a number of parameters apart from those shown, e.g. loop size (or separation), depth and dip of buried conductor, etc.

The response for a single delay time is shown. In the field, this response should be detectable in a number of contiguous channels.

8.2 Coincident Loops

8.2.1 Vertical Plate

- 2 peaks of equal amplitude
- low directly over plate - equal to background if plate relatively deep and thin.
  - more than background if otherwise.

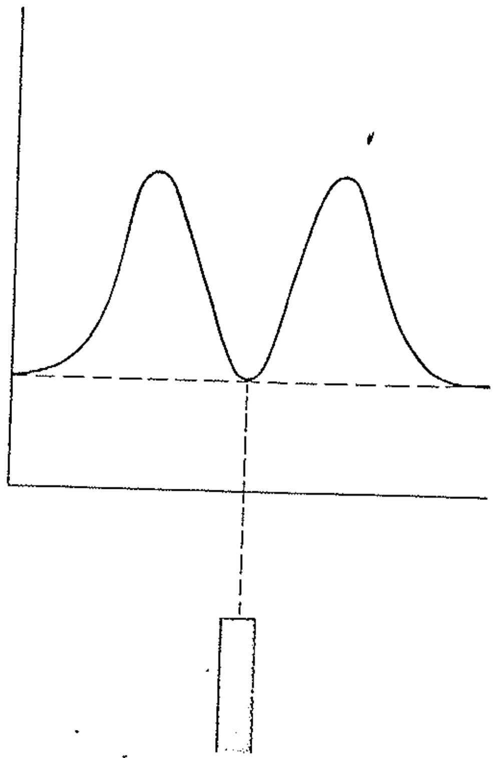


Figure 8.1

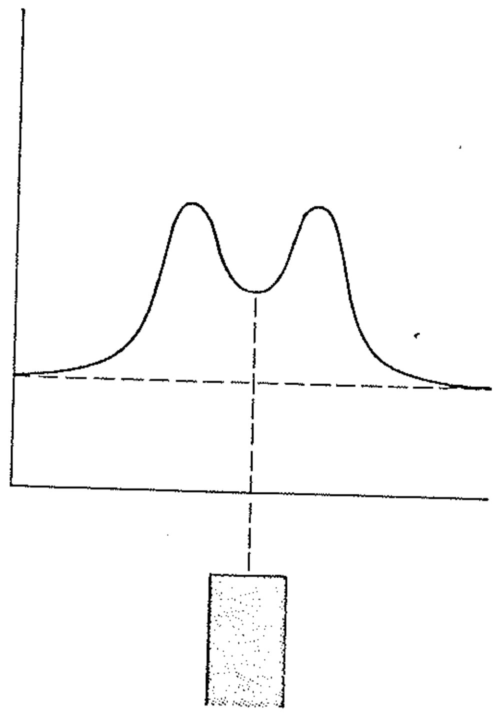


Figure 8.2

8.2.4 Edge of Conductor

- step-like increase in level with slight additional peak at edge.

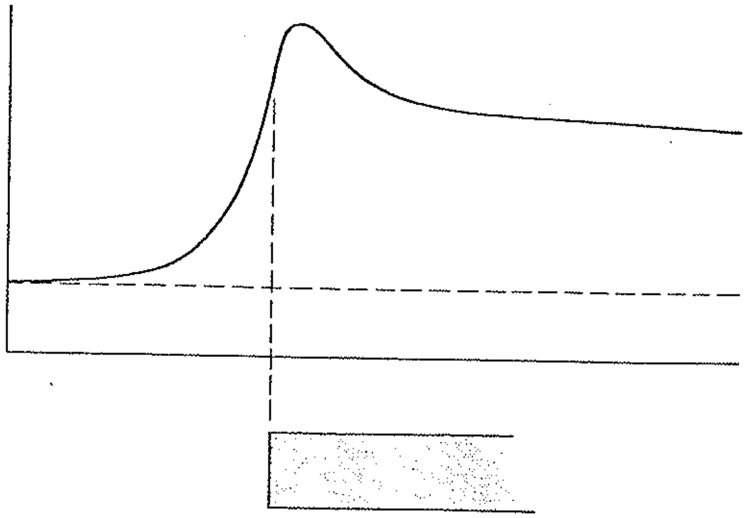


Figure 8.6

8.3 Separated Loops

8.3.1 Vertical Plate

- symmetrical low* with peaks either side.
- negative* values directly over plate.

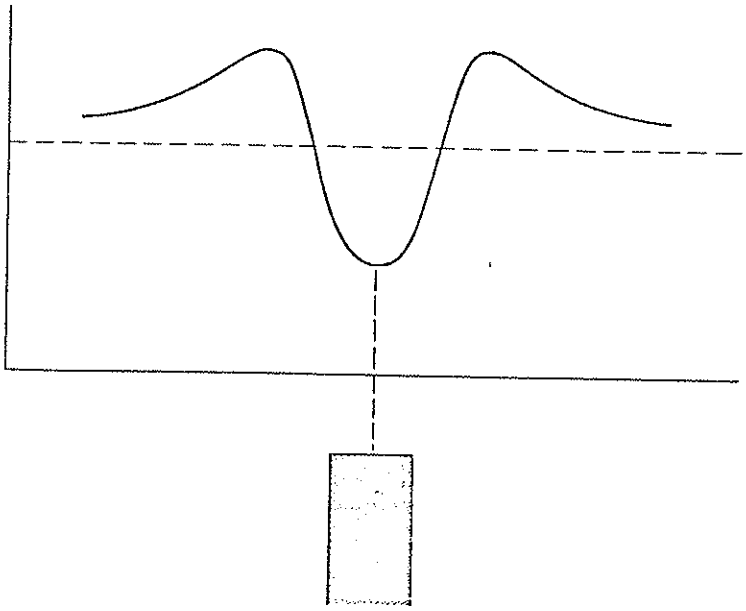


Figure 8.7

* If a peak is preferred over the body, it is only a matter of reversing the polarity connections on the Rx loop.

8.3.2 Dipping Plate

- asymmetrical with low* over top of peak and high down dip.

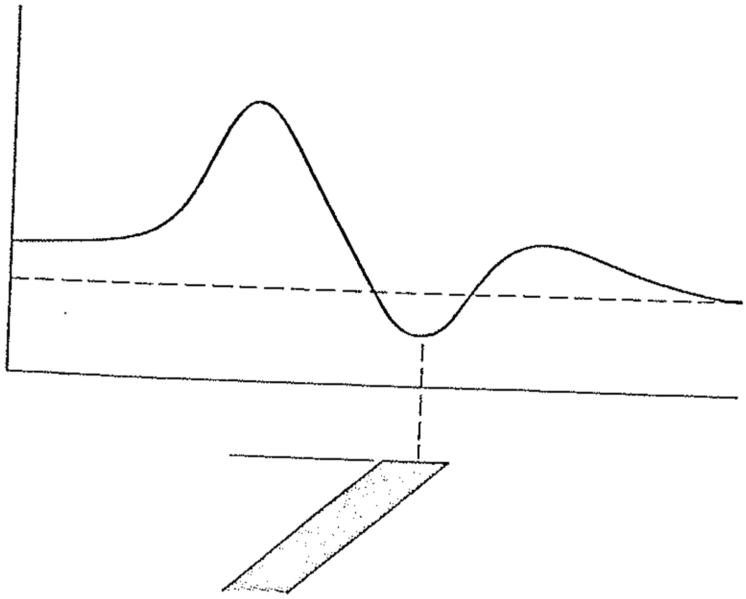


Figure 8.8

8.3.3 Sphere

- single symmetrical trough,* or two if depth shallow compared with loop size.

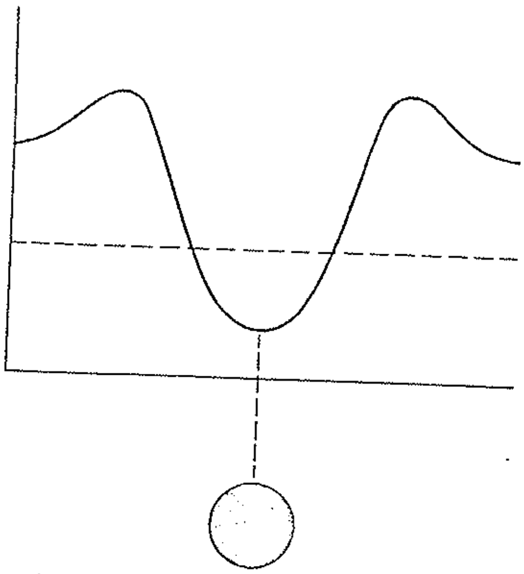


Figure 8.9

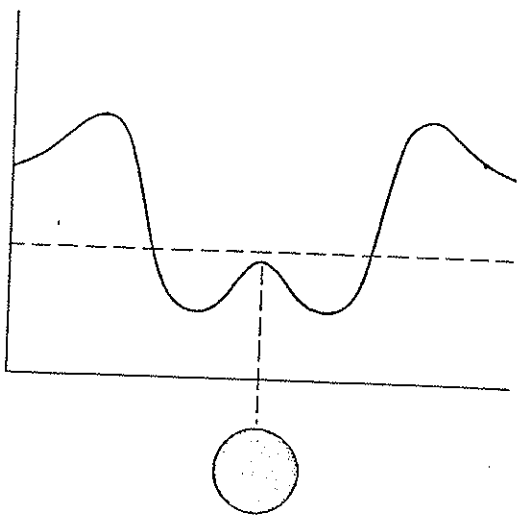


Figure 8.10

* If a peak is preferred over the body, it is only a matter of reversing the polarity connections on the Rx loop.

8.4 Dual Loop (after Spies)

8.4.1 Vertical Plate

- main peak directly over plate and subsidiary peaks either side.

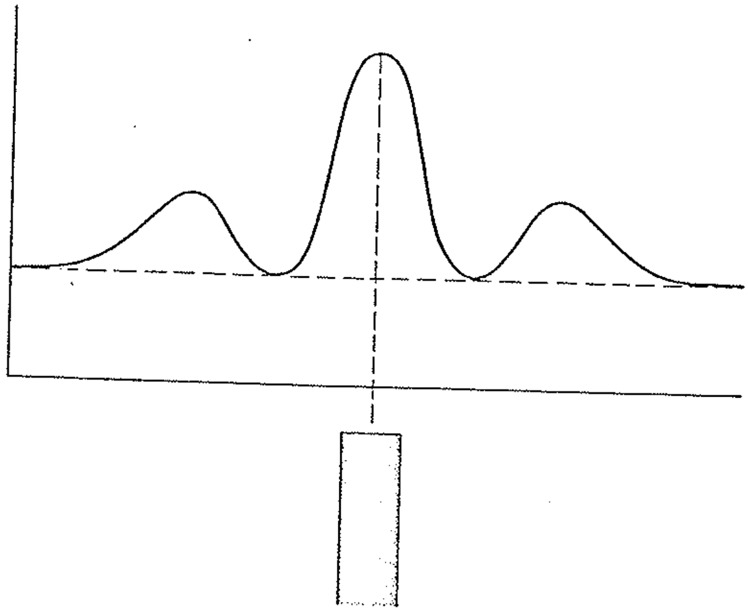


Figure 8.11

8.4.2 Dipping Plate

- main peak directly over top of plate with secondary peak down-dip and lesser peak up-dip.

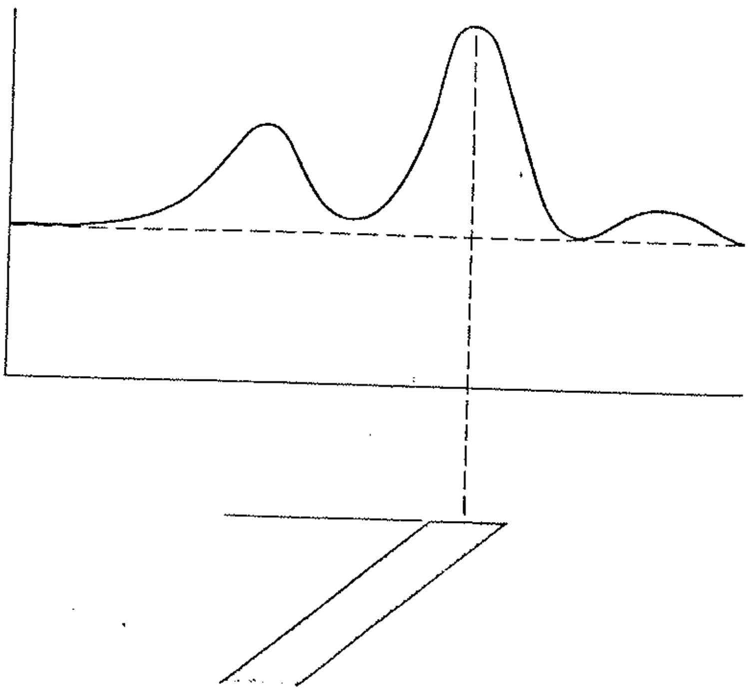


Figure 8.12

9. FAULT-FINDING PROCEDURE

The most simple and effective means of servicing SIROTEM is by replacement of circuit boards. Replacement boards can be obtained from Geoex, Australia. The defective boards should be returned to Geoex for repair. More complex repairs should be left to an experienced engineer trained in the servicing of SIROTEM.

NOTE: The warranty will be invalidated by unauthorised repairs. See Warranty, page (iv).

It is assumed that the operator has at least an ohm-meter and a set of spare circuit cards.

Numbers in brackets refer to the items illustrated in figure 3.1.

NOTE: Card changeover procedure:

1. Always turn power off before removal and replacement.
2. Be sure to put cards in correct slots and properly orientated.
3. Replace only one card at a time.
4. Observe strict cleanliness in handling and storing cards.

---

1. Check that the Battery Pack is properly connected to Instrument.
2. Plug in Calibration (CAL) Unit.
3. Check that the Power Switch (13) is 'on'.
4. Does Power Indicator (12) flash? If not, check:
   - (i) Battery voltage. It should be between 10 and 13V $\pm$, if less than 10V, battery is flat.
   - (ii) Battery Pack fuses,
   - (iii) Battery Pack to Instrument connection.

   If all OK, replace Regulator card. If the Indicator (12) still does not flash, proceed to Step 5. If following steps check OK, suspect faulty Indicator (12).

5. Set Channels Thumbwheel Switch (5) and Stacks (6) to the same settings as the Calibration sample supplied.

6. Press INITIATE Switch (15).

7. Does Tx Current Meter (9) fluctuate?	If not, check CAL Unit transmitter pins which should measure 10 ohms or less between them. If faulty, repair or replace CAL Unit. If neither possible proceed to Step 10 and read footnote. If CAL Unit OK, replace Transmitter board, then MPU, and lastly Regulator card, checking operation at each changeover. If still no indication is visible proceed to Step 8 and continue check-out. If following steps checkout OK, suspect faulty meter - if not read footnote.
8. Does Receiver Loop Test Meter (9) fluctuate?	Check meter movement carefully as deflection is only slight. If no movement, check meter operation by removing the CAL Unit and placing a short circuit across Rx Input

Terminals (21). Switch to Rx Loop Check (10). If meter deflects, replace Receiver card. Remove the short-circuit across the receiver terminals and again check Rx Loop Check (10). The meter should deflect to full scale. If not, replace the Receiver card. If both tests give satisfactory results, the receiver card is operating satisfactorily.

9. Approximately 2 minutes after INITIATE Switch (15) is pressed, a print-out should occur.

If no print-out occurs, replace Printer module (which includes printer electronics), Interface card, Regulator card, MPU card, ADC card and lastly Receiver card in that order. Check operation after each changeover.

10. Does printout agree with CAL specimen sample to within 5%?

Ensure specimen sample settings are the same. If readings are erratic or low, replace ADC card, MPU card, again checking performance at each changeover. Read footnote.

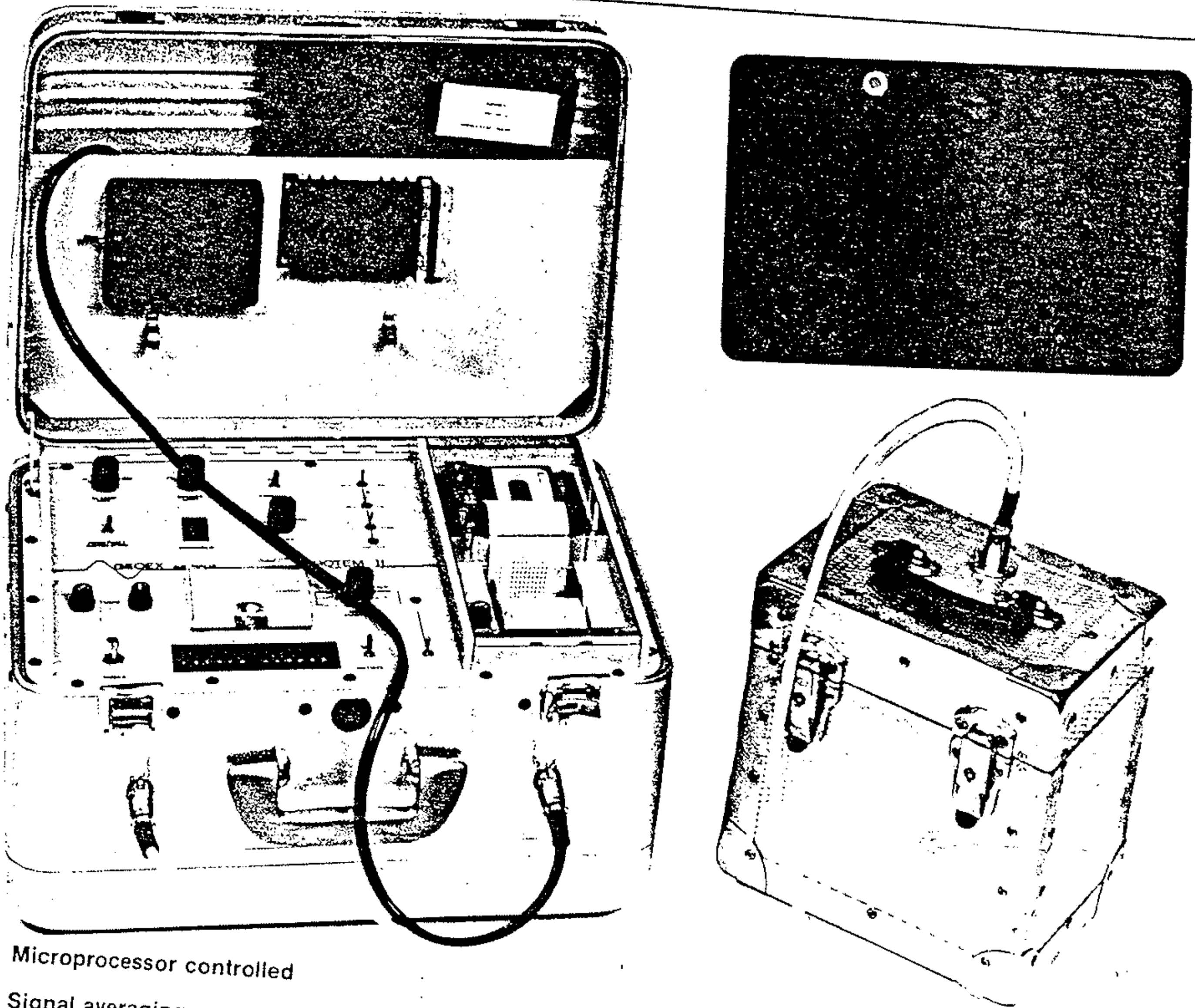
(3) Maintain battery in a good charged condition.

(4) Keep the outside of battery clean and dry, and especially, the terminals and connections.

GEOEX PTY. LTD.

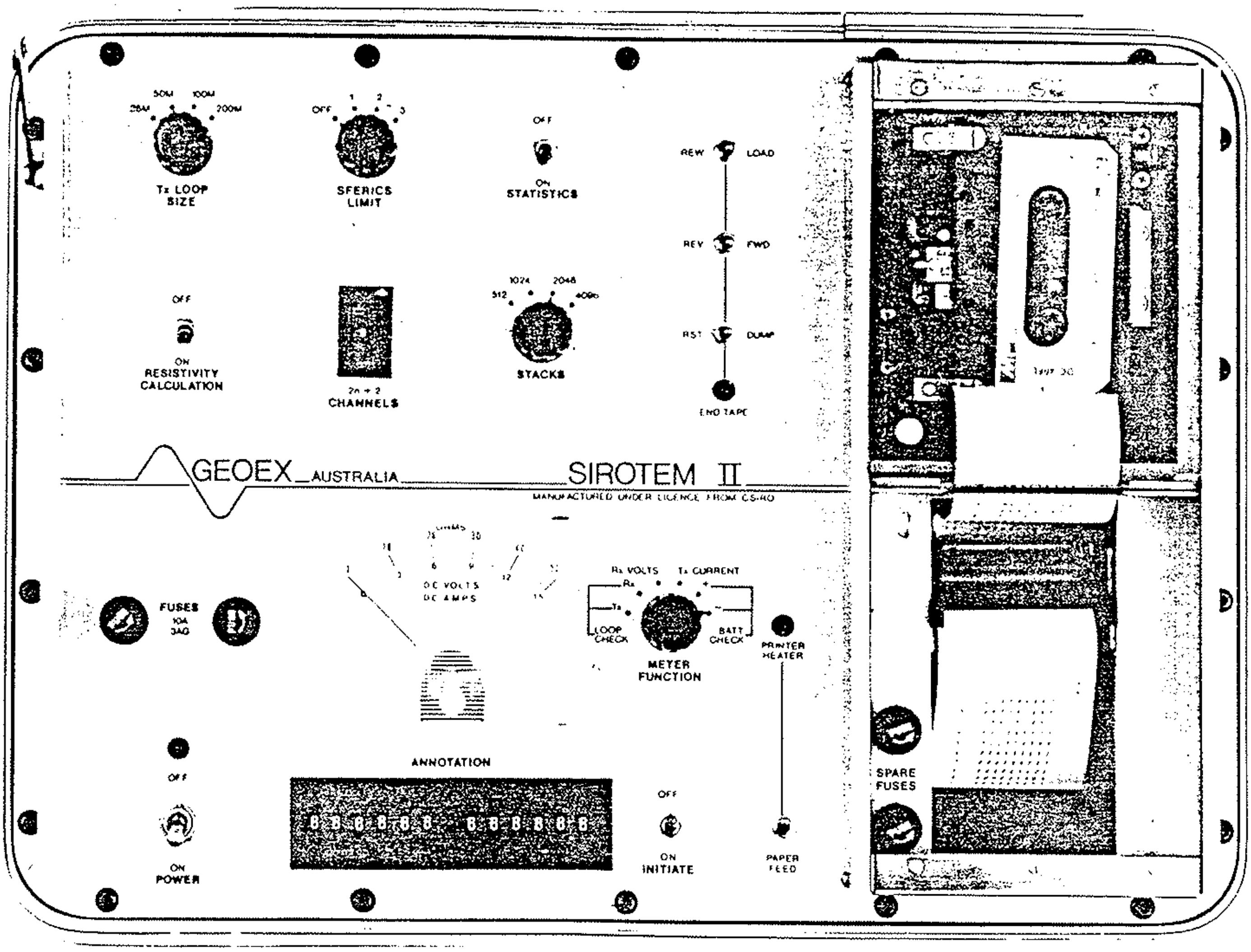
SIROTEM II

Computerised Transient EM System



- ★ Microprocessor controlled
- ★ Signal averaging over 8000 pulses
- ★ Intelligent noise rejection
- ★ 165 msecs. time delay
- ★ 10 to 32 sampling channels
- ★ Automatic zeroing
- ★ Automatic printout of normalised voltages
- ★ Wide choice of loop sizes and configurations
- ★ Combined transmitter and receiver console
- ★ 24 kg total weight (incl. battery pack)
- ★ Simple operation
- ★ Cassette recording
- ★ Automatic resistivity calculation

50 MARY STREET, UNLEY, SOUTH AUSTRALIA
POSTAL ADDRESS: P.O. BOX 42, UNLEY, SOUTH AUSTRALIA 5061
TELEPHONE 272 5211 CABLES GEOEX



Options:

— Downhole receiver coil. (See separate specifications.)
— Discrete surface receiver coil.
— High current version (under development).
— Backpack mounted console and power pack.

GEOEX

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GEOPHYSICAL CONSULTANTS & CONTRACTORS

SIROTEM is an outgrowth of research into electromagnetic prospecting techniques conducted by the Division of Mineral Physics of the Australian Research Organisation, CSIRO. This research has paid particular attention to the problems encountered in highly conductive terrain and in the presence of high background noise.

Much later delay times than had been previously possible, have been incorporated in SIROTEM. To speed up operations and reduce the effect of spurious noise, SIROTEM records all the channels simultaneously. Signal averaging techniques are used to resolve weak signals under the control of a microprocessor, which also organises the data for output onto a printer. The microprocessor is also used to calculate standard deviations and to convert the data to apparent resistivity. Mains interference and other background EM transmissions are minimised by special filtering and phase-lock circuitry.

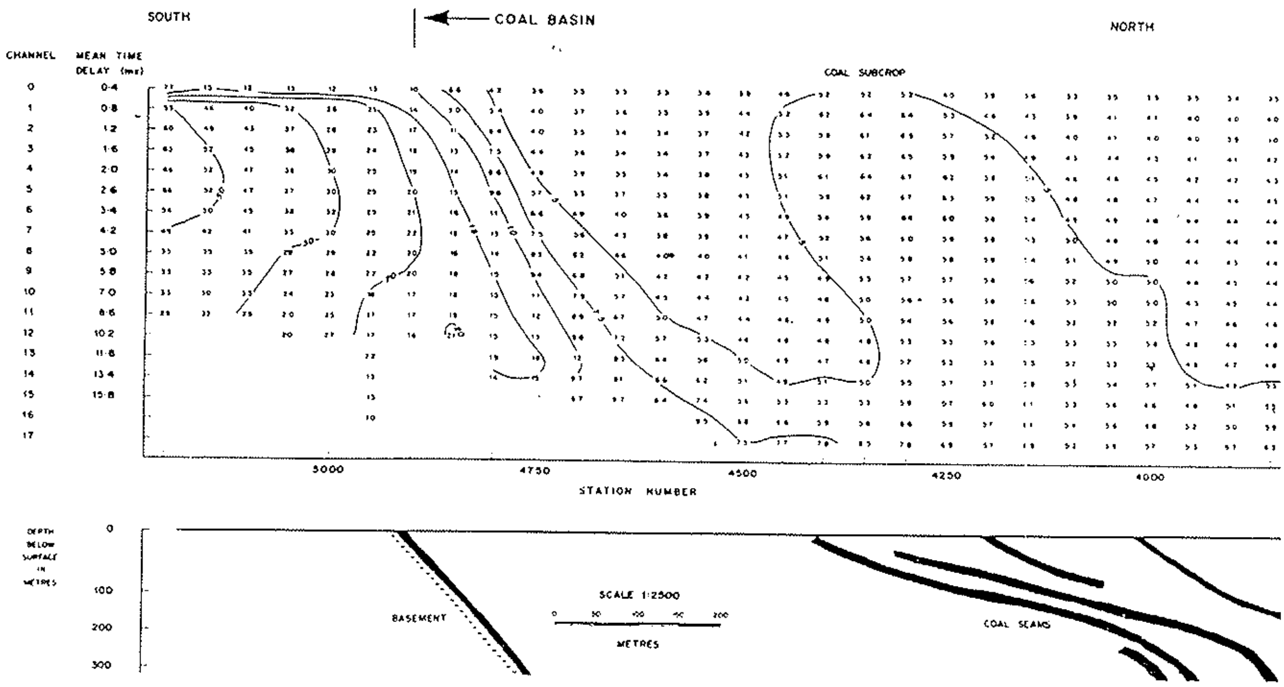
Extensive field evaluation over mineralised zones has demonstrated the ability of SIROTEM to clearly define targets at depths in excess of the loop diameter even when overburden conductivities are greater than 0.1 siemens/m. Apparent resistivities are measured precisely and electrode contact effects are avoided in mapping structure (see below).

Case-histories supplied on request (14 currently available).

CASE-STUDY No. 10

SIROTEM RESISTIVITY SECTION LINE H1700

LEIGH CREEK COAL BASIN
SOUTH AUSTRALIA



Representative:

50 MARY STREET, UNLEY, SOUTH AUSTRALIA

POSTAL ADDRESS: P.O. BOX 42, UNLEY, SOUTH AUSTRALIA 5061

TELEPHONE 272 5211 CABLES GEOEX

APPENDIX III

SPECIFICATION OF DATA FORMAT ON CASSETTE

Each reading that is recorded on the cassette is written as a block of data containing a variable number of fixed length (82 characters) records - the number of records depends on how many channels are selected.

The format of each block is:

1st Record - 80 null characters, carriage return (CR), line feed (LF).

2nd Record - 1st character 'A', 12 character annotation, 3 spaces, 4 groups of channel readings, CR, LF.

Intermediate Records - 5 groups of channel readings, CR, LF.

Last Record - n groups of channel readings, No. of stacks, Current, Sferics Limit Percentage, No. of readings rejected, spaces to fill record if needed, last character 'Z', CR, LF.

Each channel reading comprises a group of:

16 characters containing:

1 space, 2 digit channel number,
4 digit significant number, 1 space,
1 digit exponent of 10,
1 space or minus sign for negative readings,
3 digit error percentage, 3 spaces.

The format of the Stacks, Current, Sferics Details is 2 groups of 16 characters each containing:

1st group - 3 spaces, 4 digit no. of stacks,
3 spaces, 3 digit Current (includes decimal point).
3 spaces.

2nd group - 4 spaces, 3 digit Sferics Limit Percentage,
2 spaces, 4 digit No. of Readings Rejected,
2 spaces, 1 space or 'Z' character if 80th character in this record.

APPENDIX V.

SIROTEM DOWN HOLE PROBE

Low Battery Test. The battery test adaptor fits into the top of the probe. The needle should be in the red region for reliable operation, the green region indicates low battery voltage.

To change the batteries

1. Unscrew plastic top sub-assembly and remove the battery compartments.

2. Unplug DIN connector from back of battery compartment.

3. Remove batteries by sliding them out one at a time and prying off clasps with a screwdriver.

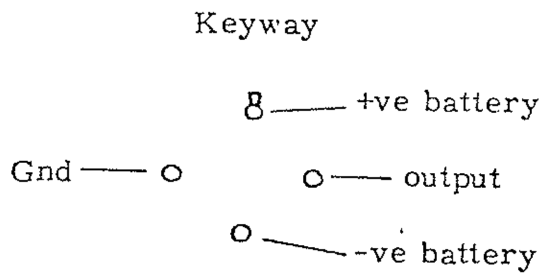
4. Replace batteries using 9V radio batteries.

5. When reassembling ensure "O" rings are free of dirt.

Always store probe horizontally - To prolong battery life the probe is fitted with mercury switches which shut off the power when the probe is horizontal.

Cable Head connections

The down hole tool pin configuration is as follows:



Top View

The ground and output pins should be connected to the SIROTEM receiver input.

n V
A

1	1486	4	000
2	8422	3	000
3	4873	3	000
4	2790	3.	000
5	1628	3	000
6	7376	2	000
7	2571	2	000
8	8490	1	000
9	27.81	1	000
10	9998	0	000
11	3540	0	001
12	1175	0	003
13	0754	0	003
14	0698	0	004
15	0465	0	005
16	0389	0	005
17	0276	0	006
18	0154	0	010
19	0154	0	009
20	0139	0	010
21	0082	0	015
22	0063	0	019
23	0049	0	023
24	0029	0	035
25	0055	0	022
26	0019	0	050
27	0011	0	088 -
28	0024	0	041 -
29	0028	0	035 -
30	0029	0	034 -
31	0062	0	013 -
32	0040	0	022 -

001024
4 .8
000
000

100
003

n V
A

1	1480	4	000
2	8460	3	000
3	4900	3	000
4	7789	3	000
5	1621	3	000
6	7404	2	000
7	2521	2	000
8	8604	1	000
9	2894	1	000
10	1134	1	000
11	3253	0	001
12	0615	0	003
13	0391	0	003
14	0490	0	003
15	0250	0	006
16	0187	0	003
17	0141	0	004
18	0047	0	011
19	0088	0	006
20	0027	0	015
21	0022	0	020
22	0003	0	093
23	0003	0	126
24	0008	0	031 -
25	0000	0	350
26	0002	0	084
27	0009	0	033 -
28	0000	0	602
29	0003	0	063 -
30	0020	0	010 -
31	0009	0	015 -
32	0018	0	009 -

512
4..8
000
000

100
003

n V
A

1	9184	4	000
2	7276	4	000
3	4710	4	000
4	2798	4	000
5	1618	4	000
6	7318	3	000
7	2472	3	000
8	8251	2	000
9	2877	2	000
10	1033	2	000
11	2965	1	000
12	9587	0	000
13	7334	0	000
14	6170	0	000
15	5254	0	001
16	4313	0	001
17	3517	0	002
18	2839	0	002
19	2319	0	002
20	2061	0	002
21	1718	0	002
22	1357	0	002
23	1113	0	003
24	0970	0	003
25	0847	0	003
26	0689	0	003
27	0516	0	003
28	0404	0	003
29	0349	0	003
30	0287	0	004
31	0208	0	005
32	0160	0	006

001024
4 .8
000
000

100
003

n V
A

1	9213	4	000
2	7293	4	000
3	4673	4	000
4	2795	4	000
5	1606	4	000
6	7321	3	000
7	2455	3	000
8	8245	2	000
9	2874	2	000
10	1027	2	000
11	2903	1	000
12	1111	1	000
13	7792	0	000
14	6359	0	000
15	5672	0	001
16	4691	0	001
17	3938	0	001
18	3229	0	002
19	2787	0	002
20	2380	0	002
21	1872	0	002
22	1362	0	002
23	1071	0	002
24	0871	0	002
25	0742	0	002
26	0598	0	002
27	0401	0	002
28	0296	0	003
29	0245	0	003
30	0224	0	003
31	0168	0	003
32	0126	0	004

512
4 .8
000
000

100
003

DUE to having to Change YOUR CAL Box Tx RESISTOR YOUR Cal results have like wise changed

Also the interpolator modification reduces 'tail' (increases resolution). These results are your new cal readings

(They may still change slightly due to ageing of the Tx load resistor.)