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Constructional Project

# EARTH RESISTIVITY METER

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Part 2

*Your assistance to the local Archeological Society could be invaluable with this simple subterranean site detector at your command.*

PART ONE of this project, last month, described the circuit principles and its construction. This concluding part is mainly concerned with field-work. But first, a bit more probe-work.

## FRAMED SUPPORT

The schematic in Fig. 10 shows a support frame and probe assembly combined, specially developed for use with the Twin Probe configuration. The top member is a wooden batten, 30mm × 50mm × 1050mm, the ends of which are bound with self-amalgamating tape to form hand grips. An aluminium platform is attached to the centre of this batten to carry the resistivity meter, held on by rubber bands.

The bottom member is a similar wooden batten, but this piece must have good insulating properties. Either, dry and coat with varnish, or devise insulating collars of Tuffnol or similar material, and fit where the probes go through the wooden batten.

The top and bottom battens are held together by metal conduit pipes, threaded at each end and secured by lock nuts. The probes in this frame would be the $C_2$ and $P_2$ probes. The $C_1$ and $P_1$ probes being, for instance, the probes shown in Fig. 9b last month.

## FIELD TEST UNIT

In Fig. 11 is shown the circuit diagram for a simple test unit which may be used to verify correct operation of the resistivity meter in the field. It consists of a rotary switch to select various resistors from zero to 1000 ohms.

The four 4mm plugs are to connect the $C_1$, $C_2$, $P_1$ and $P_2$ sockets on the resistivity meter. When the test unit is plugged in, the $C_1$ socket is connected to the $P_1$ socket, with the $C_2$ and $P_2$ sockets similarly connected.

The selected resistor is also placed across the current generator output. In use, the Field Test Unit is connected to the Resistivity Meter and checked against Table 4.

For ease of use, the circuit should be mounted inside a small diecast box.

## DOING THE FIELDWORK

Decide what features may be present in the area under investigation. If it is likely to be a solitary linear feature, a Roman Road perhaps, then it is suggested that you try the Wenner configuration.

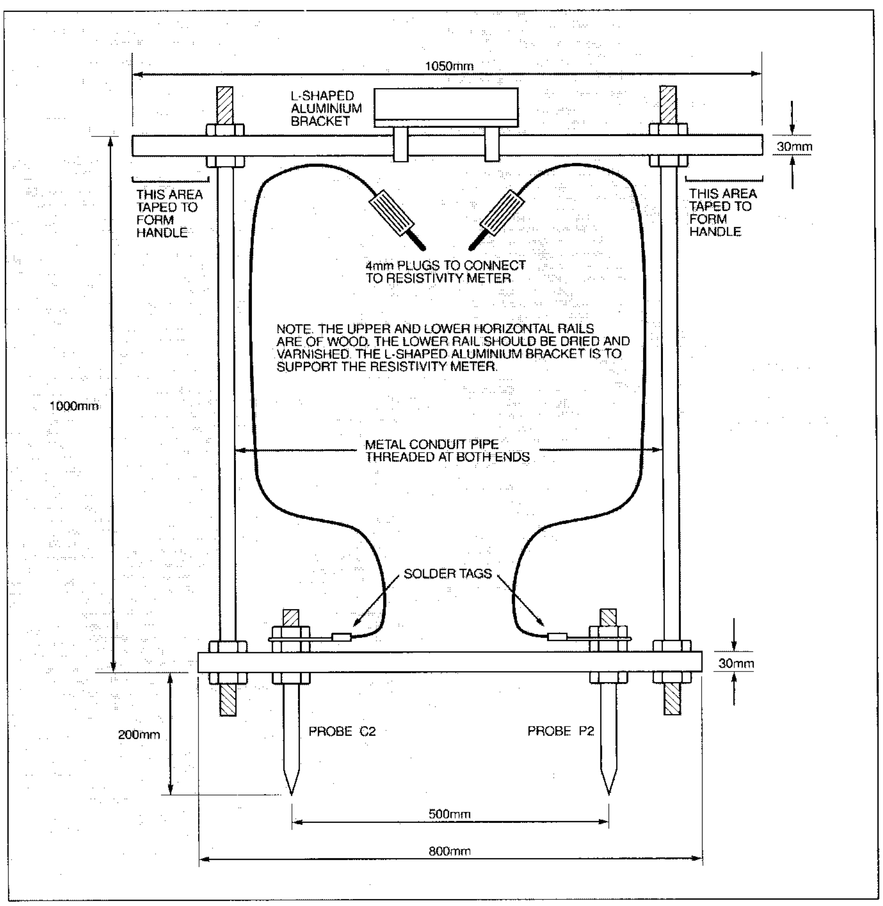



*Fig. 10. Support frame for Twin Probe configuration.*

**Table 4**

| Test Unit Resistor | Output Current | Resistor Volts | Volts Output | | |
|---|---|---|---|---|---|
| | | | Amp Gain × 10 | Amp Gain × 100 | Amp Gain × 1000 |
| 0Ω | 0.1mA | 0 | 0 | 0 | 0 |
| 1Ω | 0.1mA | 0.1mV | 1mV | 10mV | 100mV |
| 100Ω | 0.1mA | 1mV | 10mV | 100mV | 1V |
| 1000Ω | 0.1mA | 10mV | 100mV | 1V | 10V |
| 0Ω | 1mA | 0 | 0 | 0 | 0 |
| 1Ω | 1mA | 1mV | 10mV | 100mV | 1V |
| 10Ω | 1mA | 10mV | 100mV | 1V | 10V |
| 100Ω | 1mA | 100mV | 1V | 10V | xxx |
| 1000Ω | 1mA | 1V | 10V | xxx | xxx |
| 0Ω | 10mA | 0 | 0 | 0 | 0 |
| 1Ω | 10mA | 10mV | 100mV | 1V | 10V |
| 10Ω | 10mA | 100mV | 1V | 10V | xxx |
| 100Ω | 10mA | 1V | 10V | xxx | xxx |
| 1000Ω | 10mA | 10V | xxx | xxx | xxx |
| 0Ω | 50mA | 0 | 0 | 0 | 0 |
| 1Ω | 50mA | 50mV | 500mV | 5V | xxx |
| 10Ω | 50mA | 500mV | 5V | xxx | xxx |
| 100Ω | 50mA | 5V | xxx | xxx | xxx |
| 1000Ω | 50mA | 50V | xxx | xxx | xxx |

*NOTE: xxx indicates that the amplifier has saturated because the input voltage is too high and these indications should be ignored.*

Have ready a map of the area, as large a scale as practicable – or draw your own if you can do so. Carefully measure from field boundaries or buildings to each end of your proposed traverse (the line that you are going to work along) both on the map and on the ground. Measure each end of the traverse from at least two different points to positively locate them.

Another method to save measuring is to set out the traverse to run from one corner of a field to the diagonally opposite corner. Note that when laying out traverses, they should cross features at right angles for maximum sensitivity of detection.

Put the $C_1$ probe in the ground at the start of the traverse. Measure one metre along the traverse and put in the $P_1$ probe. Measure a further one metre and insert the $P_2$ probe, and then a further one metre and insert the $C_2$ probe (as in Fig. 8a last month).

Connect the resistivity meter and take the first reading. This is the reading on the indicator divided by the amplifier gain setting. Move the $C_1$ probe to one metre further along from the $C_2$ probe.

Reallocate the probes so that they run in the same order as before and reconnect to the resistivity meter. This act of moving only one probe and reallocating the probe connections is in effect the same as moving the whole configuration one metre along the traverse. Take the second reading and proceed in a similar manner until the end of the traverse is reached.

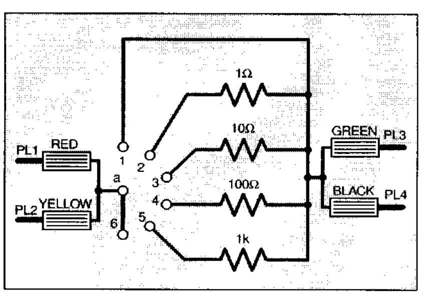



*Fig. 11. Circuit diagram for a Field Test unit.*

## TWIN-PROBING

If the features under investigation seem complex, then the Twin Probe configuration is a better choice, because a whole plan area of ground is measured rather than the single straight lines of the Wenner technique.

Lay out a square in the field, 20 metres by 20 metres, as in Fig. 8c. The right angles may be formed by any of the conventional methods, i.e. magnetic compass, optical square, theodolite or the "3, 4, 5" triangle method. If you already own any of the first three items, you will presumably know how to use them, so we will only consider the latter.

Lay a triangle on the ground, using strings or tapes. Keep adjusting the sides until one side is three metres long, another is four metres long and the last side is five metres long. The angle formed by the three metre side and the four metre side will be a perfect right angle. Extending these sides to 20 metres will thereby give two of the sides of your 20 metre square.

Once this square is completed, place temporary markers (garden canes) along two opposite edges one metre apart, and lay a tape measure across the first set of markers. We now have a strip one metre wide between one edge of the square and the tape.

Place the moving pair of probes $C_2$ and $P_2$ about 500mm apart at the 500mm mark on the tape and equidistant between the tape and the edge of the square. Insert the fixed pair of probes, spaced about 500mm apart approximately 15 metres away from the square to be measured.

If you contemplate measuring an adjacent 20 × 20 metre square, then arrange the fixed probe pair position so that it will be about the same distance from this proposed adjacent square. Take the reading and then insert the moving pair adjacent to the 1·5 metre mark on the tape and take the second reading.

Carry on until 20 readings have been taken, which should occur at 19·5 metres on the tape. Move the tape to the second pair of markers and repeat for the next 20 readings. Continue as above until you have all 400 readings.

## RECORDING READINGS

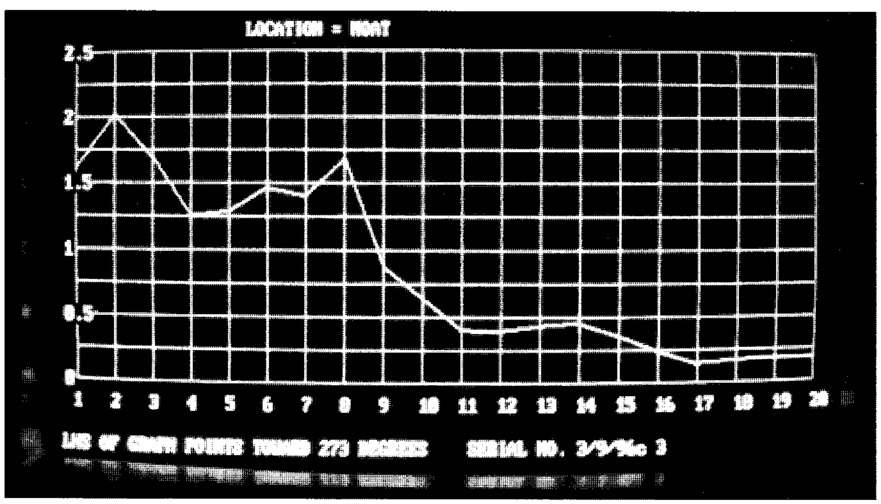
When recording site readings, note the amplifier gain setting, current used, and probe spacing.

Readings can be recorded on paper in columns for both types of survey. Make a note of which end of the column refers to which end of the transect on the plan, using possibly a combination of letters and numbers, e.g. A.B for the first transect, C.D for the second transect, and so on, numbering the individual readings from 1 to 20 (as in Fig. 8c).

The readings should be recorded as output voltage divided by gain setting of the amplifier. They can then either be left as comparative ohmic values, or converted to apparent resistivity figures.

Readings can also be spoken directly into a portable micro-cassette recorder, and transcribed at some later date. This is far more convenient than writing on paper in a wet field in a howling gale!

Linear transects can be presented as a graph, i.e., distance along transect in metres as the horizontal axis and resistivity readings along the vertical axis. Area investigations can be presented by drawing a grid of 20 × 20 units divided into 400




*This graph was generated from readings taken at the same site as in last month's similar graph, but in a different position.*

squares with each square having its individual reading noted in it.

This is difficult to interpret, so a series of colours may be used to represent bands of resistivity readings. These colours may be added with coloured pens, or generated by computer, perhaps using the author's program to draw linear graphs, area, colour, or shade plots of the results.

## QBASIC PROGRAM

As stated in Part 1, a copy of the author's program, written in QBasic (for a PC-Compatible computer), is available from the Editorial Office for the sum of £2·50 UK, £3·10 overseas surface mail or £4·10 airmail. This is to cover admin costs and postage, the disk itself is *free*.

The program can also be downloaded *free* from our FTP site: **ftp://ftp.epemag.wimborne.co.uk**, in the sub-directory: **pub/PICS/Earth.Meter**.

The program prompts you to enter details of the survey and then print them if required. It will then show either an on-screen graph for a linear survey of 20 readings, or greyscale or coloured squares for a 20 × 20 metre square. There is no facility offered for outputting the data to disk, though if you are familiar with QBasic, you should find it an easy option to implement.

In the "square" display mode, the program converts the resistivity results into six bands which correspond to the level of the readings, to produce the variation of colour or greyscale. This data can then be printed using the "print screen" key on the computer. *(Some combinations of PC and QBasic may not have this option available directly, requiring a Graphics sub-program to be loaded from DOS before loading QBasic – check with your User Manual. Ed.)*

When running the program, reply to the on-screen prompts as necessary, just pressing ENTER if any prompt is not relevant to you, and print the data that you require. You will, of course, require a colour printer if you want a colour square print. If a colour printer is not available, then use the greyscale option.

## ETHICS

Now, most importantly, a word or two about the ethics of resistivity surveying:

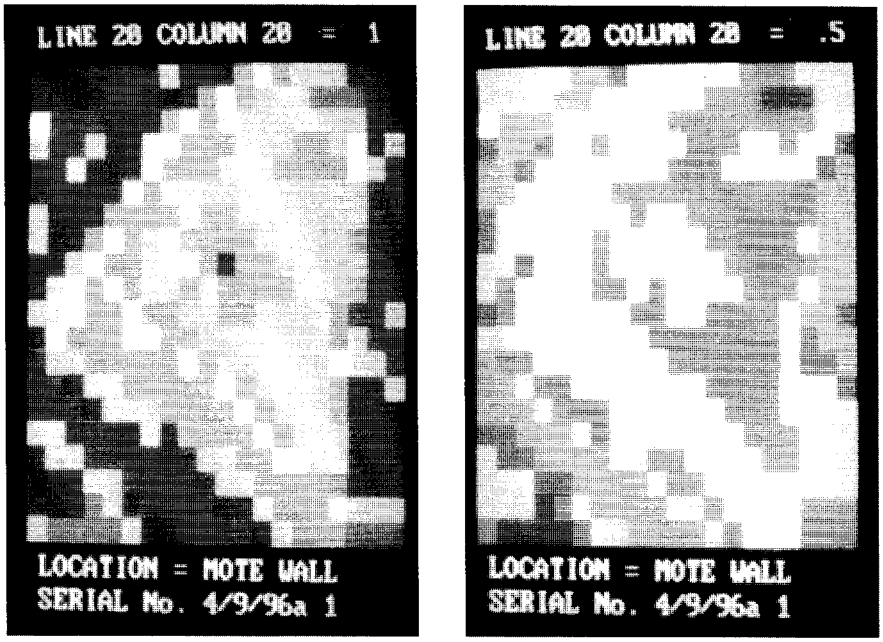
At some point, you will feel the urge to prove the results of your equipment by digging. Resist it! If it proves to be a site of any importance, your dig will certainly have destroyed information that is necessary to fully interpret it.

**Do not dig without an Archeologist's involvement.**

Although resistivity surveying itself is (apart the probing) non-invasive, do remember that *all land in the British Isles is owned or controlled by someone. Find who it is and ask their permission before you proceed.*

Only once has the author been unable to carry out a resistivity survey, being prevented by an over-zealous Town Council who wanted him to take out an expensive personal liability insurance.

Most landowners will not mind you using their land, providing you do not waste too much of their time with your enquiry. Explain to them that you will not dig holes. Show them your probes and how they are used.




*These two 20 × 20 square computer displays were generated from the same set of readings but using different screen colour allocations for each reading.*

Point out that you are unable to detect metallic artefacts such as coins and gold rings, etc. By stating this, you will indicate that you will not be competing with any metal detectorists who may already be allowed to use their land. It is also possible that some of them do not approve of metal detecting but see no harm in resistivity surveying.

Once you have got this far, you will probably be considered a harmless crank and left to it. When you ask for access, mention others that have previously given permission as this often helps. Conversely, if you antagonise any landowner, all the surrounding landowners will hear about it. Then you will have to go very far afield to gain access to suitable sites.

If the site that interests you is a Scheduled Ancient Monument, permission to carry out any form of research must be obtained from The Department of National Heritage, and it is doubtful if it would be granted to an amateur.

Scheduled Ancient Monuments appear on the Sites and Monuments Record held by the County Archaeologist of the county in question. If you have any doubt, phone him, and be prepared to experiment somewhere else if necessary.

## LOCAL GROUPS

Also make yourself known to local amateur Archaeological Societies, as some of these use resistivity equipment and dig under the guidance of qualified Archaeologists. They may find you useful in surveying sites that they are interested in. Some professional archaeological groups encourage public membership and arrange lectures, etc.

Membership of one of these groups can be useful in enabling you to discuss your results and techniques with qualified archaeologists. Remember, though, that they are probably not electronics experts and, with very few exceptions, will have no knowledge of the internals of their "black boxes".

The Romney Marsh Research Trust (RMRT) is the organisation of which the author is a member. This organisation supports a group of academics and scientists practising in the fields of archaeology, geography and history. The purpose of this organisation is to combine results to provide information on the formation and history of the Romney Marshes in Kent.

If you want to find out what local groups exist in your area, your local library should be able to tell you who and where they are.

## THANKS

The author expresses his gratitude to many members of the RMRT for discussions and practical assistance concerning resistivity surveying and many other technical subjects. He is especially grateful to Dr Mark Gardiner who allowed him access to his site at Broomhill in East Sussex to use known buried features to test the equipment.

## FURTHER READING

*Applied Geophysics*, W.M. Telford, L.P. Geldart, K.E. Sheriff, D.A. Keys. Cambridge University Press. ISBN 0521-20670-7.

*Applied Geophysics*, Griffiths and King. Pergamon Press. 1965.

*Seeing Beneath the Soil, Prospecting Methods in Archaeology.* A. Clark. Batsford. 1990. ISBN 0-7134-5858-5

The first two books are written to cover large-scale Geological Prospecting and are relatively old publications. However, they contain a large amount of theory regarding various probe configurations.

The last book listed is written by Dr A. Clark, a consultant in archaeological prospecting and dating, and is highly recommended. It is clearly written in non-mathematical language. Methods of setting out survey grids, interpreting and processing data, and descriptions of the workings of various types of probe configuration are all covered in detail. □