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TECHNIQUES AND EQUIPMENT FOR DETECTING UNDERGROUND SERVICES

by

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CONTENTS

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ABSTRACT

This report is intended to be a guide to engineers who wish to employ specialist techniques to locate underground services. The task may range from checking a whole site for the existence of buried pipes or cables to tracing the routes of services already known to be present. The need for such techniques arises at various stages in road works from the preliminary survey for a new scheme to the maintenance of an old road. The characteristics of the service to be located and the conditions under which this must be done vary widely and few of the devices available fulfil multiple roles. To assist the engineer in choosing the most appropriate equipment, the Report includes brief notes on the principles of operation of most types of device and lists a wide range of commercially available instruments together with an indication of the likely applications of each.

1. INTRODUCTION

Every year there is a considerable amount of damage caused to underground services during highway construction and maintenance operations. It is difficult to assess the cost of this damage on a national scale because of the complex nature of the problems which usually involve several organisations, varying repair procedures, and consequential losses. Enquiries among insurance companies have been fruitless. The companies were unable to give any details of the cost to them of claims arising from such damage because the figure is absorbed under the general heading of their public liability policies. However, figures provided by public utilities and contractors put the annual damage costs in the region of two to three million pounds.

The problem is not confined to highway engineering. It is common to many branches of civil engineering and building, causing disruption and expense as the network of underground services grows more complex and as the total extent of development increases.

Many devices are available and many firms offer services for locating buried pipes and cables. The purpose of this Report is to provide initial guidance to engineers who may need to employ these techniques, sometimes at very short notice to meet an emergency situation. The role of detection equipment and the different principles of detection are discussed. A list of manufacturers of commercially available equipment and the likely applications of each device are given.

2. NEED FOR DETECTION EQUIPMENT

Damage generally occurs during the use of mechanical excavation equipment. Newspaper reports obtained through a press-cutting bureau over a period of one year indicated that in one third of the incidents the location of the services was known to the contracting organisation. This, together with points raised during discussion with a number of authorities and contractors, showed that there is scope for improved communication within these organisations and for more supervision of the operator. With the larger contracting companies communication with the authorities owning the services is generally good but this is not so with the smaller companies.

There are however an unquantifiable number of incidents each year in which the locations of the services are not known precisely by their owners or by those responsible for the design and supervision of the work in hand. It seems therefore that the more widespread use of effective detection equipment at all stages in the planning and execution of road works could be beneficial. The techniques may assist in:

(a) Verifying information provided by others about the location of buried services
(b) Checking sites, either at survey stage or immediately prior to the commencement of construction, to detect any previously unrecorded or unnotified pipes or cables,
(c) Tracing services which have been damaged because precautionary measures have been inadequate.

3. TYPES OF DETECTION EQUIPMENT

Many public-utility depots have access to detectors but the instruments tend to be used for locating the utility's own specific services and opinions on their success vary widely. The use of detection equipment by the contracting industry and by design and supervisory engineers for survey purposes is not so well organised and appears to meet with less success. The ideal detector must be capable of detecting a wide variety of materials in differing physical surroundings. At one extreme there is the problem of checking for an isolated service on the line of a proposed road across open, rough countryside and, at the other, it may be necessary to map a tangle of mixed services in a crowded urban situation. The most common items that require location are electric cables (live and dead), telephone and television cables, and gas, water and drain pipes. The most common materials encountered are ferrous and non-ferrous metals, concrete, plastic, brick and clay pipes. Apart from locating a pipe or cable, the equipment should also be able to measure the depth of the service.

The principles on which most of the equipment operates are discussed briefly below and a list of manufacturers of detection equipment is given in Table 1. The information was obtained from trade literature and discussion with manufacturers and users. In some instances there was opportunity to observe the equipment in use, but it has not been possible to provide any indication of the accuracies of the various devices. Extensive field trials in co-operation with the manufacturers would be required to obtain reliable data.

3.1 Mine detector

The principle involved is disturbance of the inductive coupling between two coils by the presence of a metal object just below ground level. The two coils are included in the feedback loop of an oscillator so that, when the magnetic coupling between the coils is increased by the presence of a mass of ferrous metal, oscillation occurs. Audible indication of this is given through headphones. The conventional 'mine detector' equipment for location of buried objects is notoriously insensitive and difficult to use. A major disadvantage is that it is effective at only very shallow depths. Thus these instruments are of little use for the detection of buried pipes and cables in highway engineering.

3.2 Inductance change

This method involves the use of an air-cored coil as the inductive element of a tuned-circuit oscillator. The frequency of oscillation changes when the inductance of the coil changes in the proximity of a mass of ferrous metal. The main difficulty with this type of instrument is the large coil required to obtain an adequate depth of sensitivity.

3.3 Magnetometers

The gyroscope phenomenon exhibited by the spinning protons of hydrogen atoms under the influence of an electric current is the basis of the proton magnetometer. The precession rate of the spinning protons in a liquid is used to detect anomalies produced by metallic and some non-metallic objects in the earth's magnetic field. This method is unable to give a reliable interpretation particularly in congested conditions, and as the effect of the anomaly is detected over a relatively wide area precise location is extremely difficult even for an expert operator. A possible improvement could be the use of a flux-gate magnetometer which would be more efficient than the proton magnetometer; however there would still be problems with interpretations of results and depth location.

3.4 Magnetic-field detection

Live cables can be detected by the current generated in a simple search coil, with the detected signal being amplified to a set of earphones or speaker. This system is dependent upon the magnitude of the load current in the buried cable and can be adversely influenced by crowded ground conditions and cable insulation. A modification to this method, useful for tracing the path of cables and those pipes which carry metal conductors, is to pass a signal along the length of the pipe or cable using an oscillator and to detect the signal with the search coil as before. This method offers broader scope for detection but the equipment has to be electrically attached to the buried services. Both these methods give satisfactory indication of depth.

3.5 Re-radiated induction

This method appears to be the most effective in use at the present time. An electromagnetic signal is transmitted into the ground, inducing a current in the pipe or cable. The induced current causes the cable to re-radiate a signal which is then detected by a receiver. This technique has the advantage of needing no physical connections with the object to be located and produces accurate depth-readings, but again has the disadvantages of being unable to detect non-metallic pipes. An alternative for larger-diameter non-metallic pipes is to float a transmitter along the length of the pipe and detect its progress with the receiver.

3.6 Eddy current

This method is used for detecting metallic pipes and cables. A transmitter provides a pulse which is broken sharply. This generates eddy currents in the pipe and an associated decaying magnetic field is detected by a receiver. The decay rate depends on the size and conductivity of the pipe or cable. The method is sensitive but cannot give accurate depth measurements and is limited in commercial availability.

3.7 Radioactive methods

One recent approach to detecting fluid-carrying pipes is the use of radioactive isotopes. The principle involves placing an isotope in the pipe whose direction has to be traced. The radiation from the isotope is detected by a counter which gives an accurate positioning of the pipe. Some success has been achieved using this method but as yet it lacks accuracy in defining depth and has the drawback of requiring an entry point into the system.

3.8 Ultrasonics

Another technique currently being developed is based on the reflection of an ultrasonic wave by the pipe. A transducer emits the ultrasonic signal and detects the reflection. The time interval between the two is a measure of the depth. The difficulty with this method is the variable scatter due to the soil characteristics together with interference from other buried objects. At present, this method is not commercially viable although developments are being carried out using ultrasonics with holographic methods of recording the results which, if they are successful, could produce a possible means of detection.

3.9 Dowsing

Dowsing is performed by using an appropriate medium - a pair of L-shaped wires, a hazel twig or pendulum. Detection of buried objects depends upon the experience of the dowser in interpreting the movements of the medium. This method is not usually taken seriously. Used by skilled operators it has produced some remarkable successes but clearly cannot be considered to be a reliable technique.

4. COMMENTS

Although some detection techniques can be very effective in certain circumstances, several major difficulties still remain. There is no single piece of equipment which can be used to detect the presence of all types of buried obstacles and there is little prospect of this ever being achieved. Metallic objects are more easily detected than non-metallic and a live electric cable probably presents the least difficulty. At present there seems to be no reliable method for detecting plastic tubes or pipes of clay or concrete. In general it helps if it is possible to have access at some point to the service to be traced but methods depending on this facility obviously have seriously restricted applications.

The efficiency of many of the devices available is known to vary considerably depending on local conditions. Having made an initial selection of the equipment most likely to meet the task in hand it is suggested that, if time allows and before entering into sizeable commitments, potential users may wish to arrange for a demonstration to verify performance in representative conditions.

5. ACKNOWLEDGEMENTS

The work described in this Report was undertaken in the Scottish Branch of the Research Services Unit of TRRL. The author gratefully acknowledges the co-operation and information given by the Construction Industry Research and Information Association (CIRIA) and the Electricity Council Research Centre.

TABLE 1

Commercially available detection equipment

Name and address of manufacturer	Name of equipment	Principle of operation	Potential application	Remarks
Action Electronic Dev. Finsbury Court Finsbury Pavement Lond EC2A 1LN	Ferret	Floating transmitter Overground receiver	Fluid-carrying pipes	Needs entry point Accurate to depth of 25 ft.
This firm operates a location service *	Commander	Inductance change	For detection of valve covers and metal boxes	Very limited in depth penetration
	Goldak TR 5	Re-radiated induction or conduction	Metal Pipes and cables	Depth indication given
	Goldak 600	Magnetic field detection	Live cables	Depth indication given
Hattersley & Davidson Ltd Cobnar Works 803-817 Chesterfield Road Sheffield S8 0SR	Handy Pipe Locator	Conductance	Metal pipes and cables	Connection point needed except for live cables
Hepworth Electrical Dev. Ltd Riverholme Works Holmfirth,Huddersfield	Hepworth Cable Tracer	Magnetic field detection	Live cables	
Metal and Pipeline Endurance Ltd 76 Willoughby Lane Tottenham London N17 0SN	Locatron Detection	Re-radiated induction or conduction	Metal pipes and cables	Locatron indicates depth
This firm operates a location service *	Mapel Metal Locator	Inductance change	For detection of valve covers and metal boxes	Very limited in depth penetration

TABLE 1 (Contd)

Commercially available detection equipment

Name and address of manufacturer	Name of equipment	Principle of operation	Potential application	Remarks
J.C. Oliver Ltd David Little House Water Lane Leeds 11	The Revealer	Divining rod	All underground services are claimed to be detected	No scientific proof of this method
P and B Engineering Co.Ltd Crompton Way Crawley,Sussex	The P & B Cable Tracer	Conductance	Metal pipes and cables	Connection point needed except for live cables
E.Pass & Co Ltd Denton Manchester M34 3QH	Metalert	Inductance change	For detection of valve covers and metal boxes	Very limited in depth penetration
	Fisher M-Scope TW-5	Re-radiated induction or conduction	Metal pipes and cables	Depth indication given
	Fisher M-Scope PF-15	Inductance/Conductance	Metal Pi pes and cables	May need connection
Rank Precision Industries Ltd Phoenix Works Great West Road Brentford,Middlesex	Cintel Pipe and Cable Tracer	Conductance	Metal pipes and cables	Connection point needed except for live cables
Whiteley Electrical Radio Co. Ltd Radio Works Victoria Street, Mansfield, Notts	Cable identification and location equipment	Conductance	Metal pipes and cables	Connection point needed except for live cables Depth indication given

TABLE 1 (Contd)

Commercially available detection equipment

Name and address of manufacturer	Name of equipment	Principle of operation	Potential application	Remarks
A M G Zuurbier Ltd Holland House Kingsgate, Doncaster Yorks	Sewerin Pipe Locator	Conductance	Metal Pipes and cables	Connection point needed except for live cables
Littlemore Scientific Engineering Co. Railway Lane Littlemore Oxford OX4 4PZ	Elsec Metal Detector 684	Eddy currents	Metal pipes and cables	No depth reading selective
Nuclear Enterprises Ltd Bankhead Crossway South Edinburgh 11		Floating isotope	Fluid-carrying pipes	Entry point needed
Electrolocation Ltd 129 South Liberty Lane Bristol BS3 2SZ Underground Location Services Ltd Kendrick Mall Kendrick Street, Stroud, Glos.		These companies offer a comprehensive detection service for all underground pipes and cables using their own specialised equipment. This equipment will be commercially available in the near future.		

This list is not exhaustive. Details of other equipment, some of which is not yet available in the UK, may be obtained from technical journals, trade directories and other sources.

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