COMPACT UNDERGROUND RADAR SYSTEM

Ichiro Sugimoto
Takashi Kikuta
Masaru Tsunasaki
Research Center, Osaka Gas Co., Ltd.

6-19-9, Torishima, Konohana-Ku
Osaka 554, Japan

ABSTRACT

Pulse radar systems, known as subsurface interface radars, have been widely used to locate underground objects. Three-dimensional tower-shaped antennas were developed to replace conventional plane antennas and accurately detect the location and depth of underground objects like gas pipes, water pipes and transmission cables.

The newly developed radar system using these tower-shaped antennas is capable of locating not only metal but polyethylene pipes. Another important feature of the new radar system is that there is no need for the cable to connect high-frequency signal processors, including a CRT display. In addition to this, the use of lead storage batteries for power makes it possible for a single person to operate the radar system. Since the new radar system has three frame memories of 512 k bytes and a IEEE standard 488-1978 terminal, image processing would be possible in the future.

INTRODUCTION

Many reseach efforts have been made into ways of locating underground objects (1),(2). In recent years, pulse radar systems have been studied by many research institutes (3)-(11) for detecting nonmetal objects buried under the ground.

Significant factors that affect the performance of a radar system are antenna design, decision of input pulse level, and their electrical matching. In considering operating conditions on busy streets, fewer operators and real-time output displays are strongly desired as well as quick handling so as not to cause traffic congestion.

The newly developed radar system contains three-dimensional tower-shaped antennas which accurately locate objects 0.5 to 3 meters deep under the ground, in particular utility-lines for gas, water, sewer pipes, and transmission cables. The level of input pulse signal was determined to meet the national radio wave regulations. Since low-frequency signal processors and CRT displays are mounted as a unit on the radar system along with the antennas and high-frequency circuits, a conventionally used cable was omitted in the radar system. Its battery-powered operation makes handling on streets tremendously easier. A more detailed decription follows.

THREE-DIMENSIONAL TOWER-SHAPED ANTENNA

Many try-and-error studies were conducted in order to design higher-performance antennas (12)-(14). A three-dimensional tower-shaped antenna was finally developed as shown in Figure 1 to replace the conventionally used plane antenna. This tower-shaped antenna transmits radio waves with sharper directivity and has fewer ringing noises that are inevitable in locating shallow underground objects.

In order to verify the performance of the new antenna, the transmitted pulse waves at a depth of 50 centimeters were monitored with a specially fabricated small dipole antenna. The measurement system is shown in Figure 2.

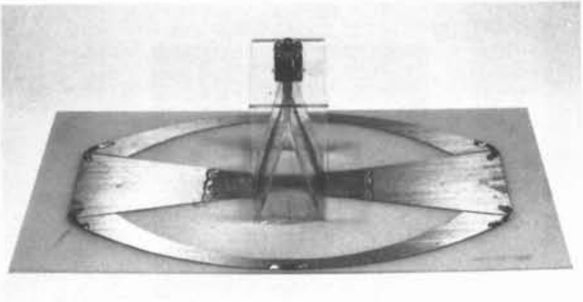


Fig.1 Three-dimensional tower-shaped antenna

The observed wave signals from a conventional plane antenna and the tower-shaped antenna are shown in Figure 3 and Figure 4 respectively. These figures clearly indicate that the newly developed tower-shaped antenna has less unwanted noise.

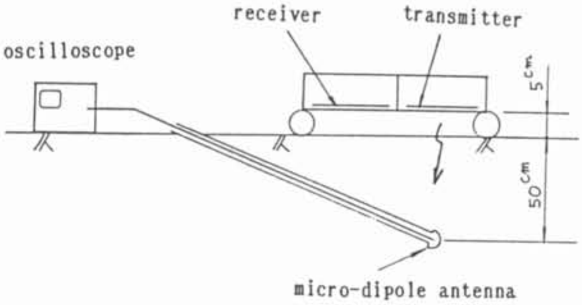
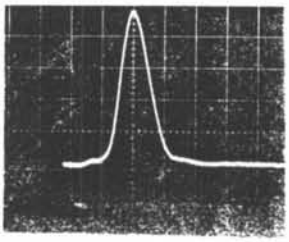


Fig.2 Measurement system



Input pulse

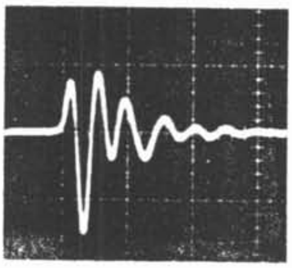


Fig.3 Plane antenna

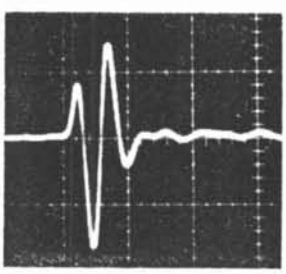


Fig.4 Tower-shaped antenna

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Configuration

This radar system contains two tower-shaped antennas shown in Figure 1, one is to transmit pulsed waves and the other is to receive reflected waves from underground objects. The received signal is fed to a signal processor and the B-scope of an underground cross section is displayed on a CRT in real time. The B-scope data is stored in frame memories for further image processing. The system configuration is shown in Figure 5.

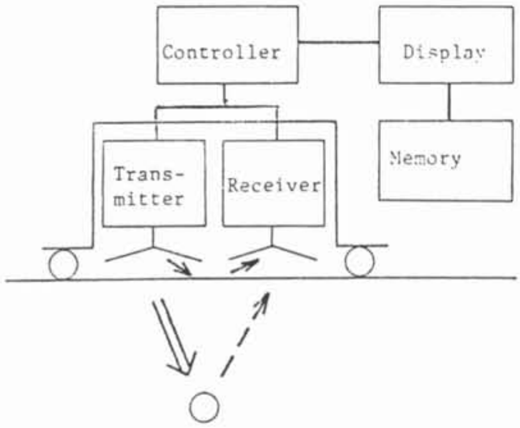

Fig.5 System configuration

Features

(1)Compact

All the elements-- antennas, high-frequency circuits, low-frequency processors, a CRT display, and memories are mounted together on a antenna container as shown in Figure 6 .

(2)Easy Handling

Lead storage batteries are used in place of an AC power cable so that one person can operate this radar system even on a busy street. The CRT makes it easy for an operator to see the B-scope display scanning a road surface.

(3)Frame Memory

Three 512 k bytes frame memories as well as a GP-IB (IEEE Standard 488-1978) terminal make it possible for the B-scope data to be sent out to external processors, such as engineering workstations or personal computers for more enhanced image processing.

Performance

(1)Locating Depth ; 3 m (subject to change depending on soil resistivity)

(2)Resolution ; identifies parallel pipes, 50 mm in diameter, 30 cm apart, at the depth of 1 meter.

(3)Scanning Speed ; 1.3 km/hour

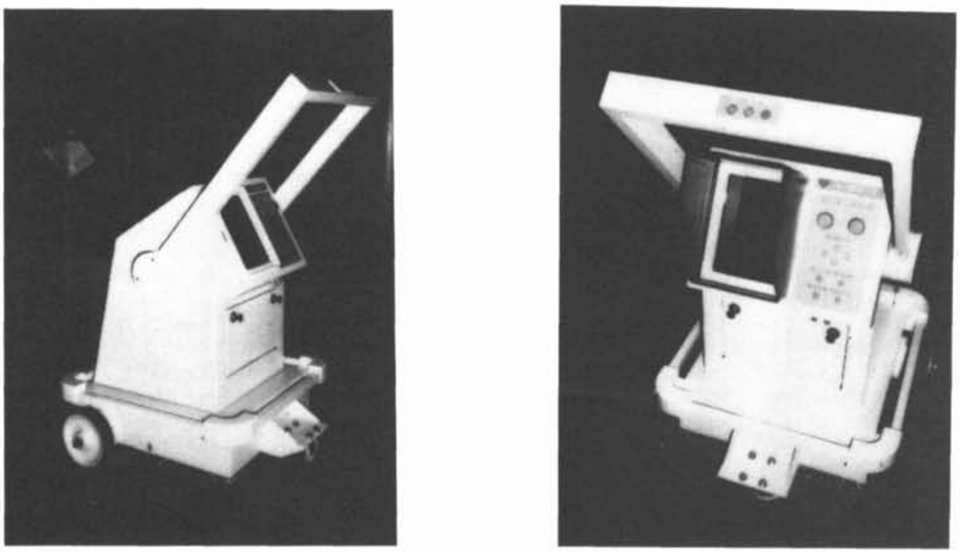

Fig.6 Compact underground radar system

Table 1 Specifications of compact underground radar system

Item	Performance
Radiation method	Impulse type (base band)
Display mode	Scope B (measurement/display of cross sections)
Transmitted pulse width and voltage	1.2 n sec ±10% : FWHM 97.5 v p_p ±10%
Receiving wave band	10～500 M Hz
Display	9-inch monochromatic CRT
Memory capacity	Frame memory : 512 k byte Character memory : 16 k byte
Recording	Monochromatic video signal hard copy
Output teminal	GP-IB terminal (IEEE standard 488-1978)
Dimensions	650 mm long × 540 mm long × 680 mm high
Power source	DC 12 v : Powered by lead storage batteries

Specifications

The specifications of this radar system are shown in Table 1.

CONCLUSION

Three-dimensional tower-shaped antennas were developed to accurately locate utility-lines buried at depths of 0.5 to 3 meters. In order to improve their operability, antenna elements and a CRT display were placed together on an antenna container to omit a connecting cable. In addition, for use of off-line image processing, frame memory and GP-IB terminal were included. Field tests using this newly designed system will start in December 1988.

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