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SUFFIELD MEMORANDUM

NO. 1129

MK 1 DRESTECTOR — AN EXPERIMENTAL PROTOTYPE MAGNETOMETER FOR DETECTION OF STRUCTURAL STEEL IN CONCRETE (U)

by

J.E. McFee, M. Bell and G. Briosi

PCN No. 27B10

August 1984

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ABSTRACT

An experimental prototype hand-held detector capable of detecting reinforcing rod and prestressing cable in concrete has been built. The prototype instrument, called the MK 1 DREStector, has in preliminary tests consistantly detected vertical and horizontal number 4 reinforcing rod (approximately 12.7 mm diameter) buried at a nominal depth of 0.02 m beneath the surface of a vertical concrete wall. Based on measured sensitivity of the instrument, the MK 1 should be capable of detecting horizontal number 4 rod at a depth of 0.125 m.

ABSTRACT (Cont'd)

The DREStector concept should enable *in situ* assessment of the quantity and location of steel present or determination of the absence of steel in a target. When used in conjunction with field engineering skills, the device should assist the military engineer to rapidly identify and/or prepare a structural concrete target for explosive demolition. Other potential applications might include use as a training aid for target recognition and construction engineering uses.

A brief description of the theory of magnetic fields associated with ferrous rods and a computer modelling study are presented to emphasize the salient features related to localizing and identifying a rod based on measurements of its associated field. The experimental MK 1 prototype DREStector is described and field experiments to test its performance are discussed.

Experiments and theory both indicate that identification of an isolated steel reinforcing rod or cable buried in concrete is feasible. Accordingly, the field discrimination between reinforced and prestressed/post-tensioned concrete members should also be possible based on the location and concentration of steel.

The development of an improved MK 2 version of the DREStector is proposed. The as yet to be developed device should cost less than $1000 per unit, be similar in size and power requirements to a pocket calculator and incorporate specific features for military engineering use.

Although the development proposal appears to be straightforward, it is estimated that two years would be required to refine and optimize the device and associated techniques to advance it to the desired working prototype stage. A plan for the related research is also outlined.

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FIGURES

ACKNOWLEDGEMENT

The authors wish to acknowledge
the assistance of Mr. Garry Jensen
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1.0 INTRODUCTION

The field identification of the various types of structural concrete members for demolition tasks can be difficult, particularly if the design is not common. Classifying the general type of member (i.e., reinforced or prestressed/post-tensioned concrete) can further be complicated by the construction methods used (cast-in-place or pre-cast), the date of construction and the location (i.e., Europe versus North America). The common factor in all structural concrete members, besides the concrete, is that all tensile loads must be carried by the steel present, whether the steel is in the form of deformed bars or rods or wire rope or cable[1].

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[1] In the remainder of this report, "rod" refers to reinforcing rod or bar and "cable" or "prestressing cable" refers to both prestressing and post-tensioning cable or rope.

If, for explosive demolition, the steel is to be attacked, then the size, location and extent of steel present are significant factors. The explosive energy requirements, in terms of the number, type and location of demolition devices, and the associated capabilities and limitations of the demolition devices used must be coordinated with the amount and location of steel present to achieve a successful demolition.

This report describes the experimental MK 1 prototype and proposes an improved MK 2 version of an effective, relatively simple hand-held detector for reinforcing steel. The device, dubbed the DREStector, should enable *in situ* assessment of the quantity and location of steel present or determination of the absence of steel in a target. When used in conjunction with field engineering skills, the device should assist the military engineer to rapidly identify and prepare a structural concrete target for demolition.

This report is not specific in the role of the DREStector, beyond the general detection of reinforcing steel for demolition. Further applications might include determining the absence of steel for wall breaching or for construction engineering tasks. The DREStector may also be a valuable training aid for reconnaisance and/or target recognition purposes.

The degree of risk associated with the successful development of the proposed MK 2 DREStector is considered to be relatively low in view of the existing technology base at DRES in the areas of demolitions and detection technologies. The perceived benefits, on the other hand, could be large.

This report briefly outlines the technical aspects associated with the proposed development and includes a discussion of the related components and assembly, as well as some preliminary test results and projections for future development. Section 2.0 provides a brief summary of the associated theory and some preliminary computer modelling studies. Section 3.0 describes the construction of the existing MK 1 prototype DREStector. Section 4.0 describes some preliminary trials using the MK 1 to detect reinforcing rod. The results of the trials and discussion are presented in Section 5.0. A proposed MK 2 version, incorporating a number of improvements and features for military engineering applications is described.

2.0 THEORY

In principle, the magnetic profile, defined as the measured magnetic field as a function of position for a specified sensor path (usually a straight line), may be used to determine the location and size of buried steel rod or cable. Computer modelling has shown (see Section 2.1) that the depth, orientation and diameter of an isolated rod (rod centers separated by at least twice the depth) may be determined by measuring the width and height of its profile, although multiple rods, spaced close together, may complicate matters.

The magnetic profile may also be used, in principle, to distinguish between reinforcing rods and prestressing cables. In cross section, reinforcing rods generally form a rectangular grid pattern near the tensile surface of a concrete face whereas prestressing cables can be concentrated (i.e., in bundles) and found in several different patterns and positions. The diameters of the two may be similar or different. Prestressing cable is typically of a higher tensile strength steel than reinforcing rod. Although it is possible in principle to distinguish magnetically between two types of steel, a strictly controlled geometry, likely obtainable only in a laboratory, is required. Nevertheless, the differences in spatial orientation, distribution and diameter of rods or cables may allow one to distinguish between the two by observing magnetic profiles in one, two or three dimensions measured on one or more concrete faces or edges. (On a beam, for example, a survey in three dimensions on the accessable faces could be performed, whereas for a wall, typically only a two dimensional survey on one face would be possible.)

2.1 Computer Modelling

A computer simulation study was conducted to determine whether or not a magnetometer would be capable of detecting steel rod or cable situated in the ambient magnetic field of the earth at the geographic location of our laboratory. (At our location, the strength of the earth's field is 60000 nT and the field is inclined at an angle of 17 degrees from vertical. The ambient magnetic field in West Germany and at this location are roughly the same.) It was also felt that such a simulation could determine the maximum depth of detection for different diameter rods. The rod or cable was modelled as a horizontal steel rod, infinite in length, with a constant relative magnetic permeability, whose magnetic moment was induced by the ambient magnetic field of the earth. (The assumption of infinite length is valid provided that the distance from the sensor to the center of the rod is small compared to the length of the rod. For the present problem, this is always true.) Permanent magnetization was neglected. The magnetometer path was assumed to be a horizontal straight line passing at constant height over the rod.

There are two general types of magnetometer sensors — total field magnetometers and vector magnetometers. The former measures the magnitude of the field but not its direction, while the latter measures a single component of the field vector. For a horizontal rod, only the total field and the vertical vector component measurements will be invariant with respect to a rotation in a horizontal plane. This invariance is desirable since one has no *a priori* knowledge of the orientation of the rod in the horizontal plane. As mentioned below, vector sensors are presently better suited to the role of detection of reinforcing steel. Thus, the simulation assumed that a vertical vector magnetometer was used. (It should be noted, however, that at the latitude of this laboratory total field profiles and vertical component vector profiles are very similar.)

Some results of the simulation are summarized in Figures 1 and 2. Figure 1 shows the variation in total magnetic field for a profile perpendicular to the direction of a number 4 reinforcing rod (nominal diameter 12.7 mm) at various depths. (Depth is defined as the distance of closest approach of the sensor, which is assumed to be a point, to the center of the rod.) It can be seen that the width of the profile, measured as the full width at half maximum, is approximately equal to the depth of the rod. The peak field does not occur directly above the center of the rod, but rather is horizontally displaced by an increasing amount as depth increases. The displacement is small, however, being approximately 8 mm at a depth of 0.10 m and 25 mm at a depth of 0.25 m. Figure 2 shows profiles obtained for various orientations with respect to the rod direction in a horizontal plane at a fixed rod depth of 0.10 m. It can be seen that the minimum width occurs for a profile perpendicular to the rod direction and broadens as the traverse direction is rotated toward the rod direction. The peak magnetic field is seen to be a function of rod depth and diameter but is approximately independent of rod orientation. For a fixed geometry, the magnetic field varies as the square of the rod diameter. The calculations were found to be very insensitive to the value of the relative permeability of the rod, provided that the value was in excess of 50. This is virtually always the case for steel in the ambient field of the earth.

Thus, in principle, a trained magnetometer operator could determine the depth of burial and diameter of a steel rod or cable by measuring profiles across the rod at different angles with respect to the north-south line in a horizontal plane. The narrowest magnetic profile would be at right angles to the rod and the width of that profile would be equal to the depth of burial. The rod diameter could be determined from the peak field value.

Because the magnitude of the horizontal component of the earth's magnetic field is approximately 30% of that of the vertical component at the location of this laboratory, the profiles discussed above are insensitive to rotations of the rod in a horizontal plane. For vertical rods, profiles for a component parallel to the north-south direction in a plane perpendicular to that direction are very similar in shape to those discussed previously but are approximately 30% smaller in magnitude. If the measurement plane is perpendicular to the east-west direction, the field vanishes. Thus, vertical rods will be generally more difficult to detect than horizontal ones.

As mentioned, the computer simulation was based on a number of assumptions, which if not valid, will affect measurement of the profiles. The ability of the operator to maintain the magnetometer at an approximately constant height above the rod in practice, will require some testing. Permanent magnetization may substantially increase or reduce the magnetic profiles. If a vector magnetometer is used, fluctuations of the sensor orientation will cause variations in the output of the magnetometer which may obscure the variations in output due to the field of the rod. The significance of these factors could only be determined by experiment and thus it was felt necessary to build a prototype hand-held magnetometer to test the feasibility of detecting reinforcing steel.

3.0 THE EXPERIMENTAL MK 1 PROTOTYPE DRESTECTOR

A discussion of the various types of magnetometers available is beyond the scope of this report. It is sufficient to note that there are several types of magnetometers which would be capable of measuring magnetic fields as low as 35 nT. Of these, however, only the thin film magnetometer and the fluxgate, both vector magnetometers, are, in our view, of sufficiently low cost and compact size to warrant further investigation at this time. The thin film magnetometer was not pursued since reports [1] indicated that one of the very few commercially available thin film sensors (manufactured by Honeywell) had stability problems and a high power consumption.

It should be emphasized that the instrument to be described has not been optimized for the task of magnetic detection and identification of structural steel, but is rather intended to demonstrate feasibility of such techniques.

3.1 The Thorne Detector and Circuitry

The sensor employed in the MK 1 DRESteector is a Thorne LCM-2 fluxgate magnetometer [2]. The sensor was chosen because it has self-contained drive circuitry and a built-in peak detector. All are housed in a compact (30 mm × 20 mm × 15 mm), robost package. The sensor is capable of operation from −40 degrees to +60 degrees Celsius. It has a nominal minimum sensitivity of 100 nT for a 0.01 Hz to 10 Hz bandwidth if used with the detection circuit suggested by the manufacturer. For this study the circuit was substantially modified to enable the use of a more widely available LF355 operational amplifier which has low noise, low drift and low cost. The circuit, whose schematic is shown in Figure 3 and whose printed circuit board artwork is shown in Figure 4, is essentially a combination voltage amplifier and band pass filter. A lower frequency cutoff of either nominally 0.036 Hz, 0.057 Hz or 0.11 Hz may be selected to reject low frequency components of the ambient field. This is necessary since the ambient field completely obscures the field due to the objects of interest if dc measurements are made. Since different sensor speeds are desirable for different applications, different low frequency cutoffs are necessary. One of two output sensitivities may be selected as well. The sensor and circuit are powered by two 9 V transistor radio batteries.

The detection circuit has been designed to satisfy the following criteria:

(1) The circuit input impedance must be greater than 5 M ohms. This is necessary due to the 1 M ohm output impedance of the sensor.

(2) The nominal circuit pass band is 0.036, 0.057 or 0.11 Hz to 12 Hz. Although the bandwidth of the sensor is dc to 15 Hz, there is little information of interest in this application above 12 Hz. As previously mentioned, the sensor and circuit must be ac coupled.

(3) The circuit must have an output impedance low enough to drive a low impedance measuring device such as an analog meter.

(4) Circuit amplification must be adequate to take advantage of available sensor sensitivity (9.4 mV/1000 nT ± 10%).

The limit of detection, for the high sensitivity setting, of a mild steel prolate spheroid (short axis = 0.020 m, major-to-minor axis ratio: 3.75) is found to be approximately 0.23 m (sensor center to spheroid center) when the symmetry axis of the spheroid and the magnetic axis of the sensor are approximately colinear. If the magnetic field of the spheroid is assumed to be due solely to an induced magnetic moment, this corresponds to a sensitivity of 125 nT. Thus the MK 1 DREStector, would be capable of detecting an unmagnetized number 4 reinforcing rod up to a depth of approximately 0.125 m.

The power consumption of the Thorne sensor is 550 μW and that of the entire circuit is 39 mW. Measured circuit bandwidth (3 db to 3 db point) is 0.037, 0.071, 0.140 Hz to 13.2 Hz for the 0.036, 0.057, 0.110 Hz switch settings.

3.2 The Experimental MK 1 DREStector Package

The complete MK 1 DREStector is shown in Figures 5 and 6. A nonferrous casing is required to house the sensor and so, to hasten construction, a readily available, but larger than necessary, plastic case has been used. The magnetic field reading is displayed using a standard moving coil analog meter mounted on the top of the box. A sensitivity switch is used to select one of two magnetic field ranges, a filter switch allows selection of one of three low frequency cutoffs and a power switch turns the instrument on. A pushbutton is used to recover from a condition called "latchup" which occurs when the instrument is first turned on (see 5.1). The sensor is mounted inside the box near one corner at the bottom, with the magnetically sensitive axis perpendicular to the plane of the bottom of the box. Because the sensor cannot be seen, its position in the plane of the bottom of the box has been marked both on the bottom and top of the box.

4.0 PRELIMINARY FIELD EXPERIMENTS

The MK 1 DREStector was tested on a vertical reinforced concrete wall situated at the DRESTC site at DRES. Number 4 reinforcing rod (12.7 mm nominal diameter) was buried at a nominal depth of 20 mm beneath the concrete surface. The rod was buried in a square grid pattern approximately 0.30 m on a side (rod center to rod center), thus providing both horizontal and vertical rod. More details on the wall structure may be found in [5].

The DREStector was moved slowly in a series of vertically displaced horizontal scans over the concrete surface with the bottom surface of the detector in contact with the concrete surface. Meter fluctuations were observed and peaks in the magnetic field were localized.

5.0 RESULTS AND DISCUSSION

After the operator had become accustomed to the normal meter fluctuations, rods could be very quickly localized. (The source of these fluctuations is described in Section 5.1 and improvements which would substantially reduce such fluctuations are described in Section 5.2.)

Although the exact locations of the reinforcing rods were not known to the operator, the DREStector was able to localize sharp peaks in the magnetic field with widths of approximately 20 mm and horizontal and vertical spacings of approximately 0.3 m. Deviations from these widths and spacings were seen to occur on occasion but these were in all likelihood due to variations in the depth of burial of portions of the rods. Tracing the peaks allowed both horizontal and vertical rods to be mapped on the wall, revealing a distinct 0.30 m square grid pattern.

5.1 Deficiencies in the MK 1 Design

There are a number of deficiencies in the present prototype that, while not rendering the instrument useless, do make operation of the instrument more troublesome. These are itemized below.

(1) Satisfying the criteria of the detection circuit causes what is called a "latch-up" problem. When turned on, the circuit latches to the positive supply rail. This problem is caused by the high impedance resistors used in the circuit which are, in turn, necessary to prevent loading of the output impedance of the sensor. If such a sensor is used, the only way to prevent latch-up, while still meeting circuit requirements, is to increase the number of operational amplifier stages in the circuit. This will increase both the cost and the power consumption.

(2) Even when no ferrous material is present, the meter needle will fluctuate when the sensor is moved, due to fluctuations of the sensitive axis of the sensor about the vertical with respect to the concrete surface. A simple calculation shows that a 2 degree tilt of the sensitive axis corresponds to an apparent field change of 36.5 nT (assuming a worst case ambient field of 60000 nT perpendicular to the concrete surface). Because the sensor package does not slide smoothly over the surface irregularities of the concrete, this tends to increase sensor orientation fluctuations. After approximately an hour of familiarization with the continuing presence of such "background" fluctuations, the operator was able to ignore them when looking for a field fluctuation due to a rod. It is desirable, however, to minimize such background fluctutaions in order to minimize operator fatigue and reduce the necessary familiarization period.

(3) Sensitivity is limited by the sensor and should be improved. The maximum depth of detection of number 4 rod by the MK 1 is 0.125 m. Detection to a depth of 0.20 m would be desirable. Such sensitivity would correspond to an intrinsic sensor noise level of approximately 40 nT or slightly in excess of the limiting sensitive axis fluctuation noise described above.

(4) The package, although capable of being hand-held, is bulky and awkward. This contributes to operator fatigue. Further, it is difficult to determine the exact position of the sensor when the instrument is in use, since the case is much larger than the sensor.

(5) The output is displayed on an analog meter. This form of display may not be adequate for some situations, such as nighttime use, and may not be the ideal method to enable ready interpretation of the output. Also, the motion of the permanent magnet in the meter contributes to the background noise fluctuations.

(6) The meter is situated in the same case as the sensor. This makes it difficult to read the meter while moving the sensor, since one's eyes must remain directly over the box to avoid substantial parallax error.

5.2 Possible Improvements (MK 2 Proposal)

Most of the shortcomings of the experimental MK 1 prototype DREStector can be eliminated. The manner in which this may be accomplished is discussed below, outlining the approach toward a MK 2 DREStector.

5.2.1 The Low Power Brown Magnetometer — The United States Naval Surface Weapons Laboratory has developed a modification to the basic Brown magnetometer which is very rugged, consumes very little power and is up to 100 times more sensitive than the Thorne detector [1,3,4]. One version of the low power Brown magnetometer was constructed in the DRES laboratory and evaluated for comparison with the Thorne sensor and circuit. The Brown magnetometer had similar sensitivity to the latter detector since its detection limit for the same spheroid and geometry as Section 3.1 was also 0.23 m. Power consumption is 200 μW with 300 drive turns, but this can be reduced to 120 μW if 400 turns are used.

Naval Surface Weapons Laboratory has reported [3] achieving noise levels of approximately 1 nT for a power consumption of less than 300 μW. The Brown magnetometer constructed in the DRES laboratory could easily approach these sensitivity and power consumption figures by modifying the drive circuit and increasing the number of sense and drive windings on the core.

The Brown magnetometer output has a low impedance (33 k ohm), making its output signal easier to amplify than that of the Thorne sensor.

The low-cost Brown core can be wound in 3 hours on the DRES coil winder. A complete Brown magnetometer (30 nT pp noise and 120 μW power consumption) would cost approximately $50 for the wound sensor, drive circuit, peak detector and printed circuit board. By contrast, the Thorne sensor alone cost about $150 in single lot quantities, although in larger quantities the cost could be appreciably reduced.

Decreasing the upper frequency cutoff of the passband might decrease rapid output fluctuations due to motion of the sensitive axis of the sensor.

At a typical sensor speed of 25 mm/sec, a 12 Hz cutoff corresponds to spatial fluctuation periods of approximately 2 mm. Since profile widths less than 10 mm are not expected, fluctuations more rapid than 6 Hz would not be due to the objects of interest and could be eliminated by decreasing the upper cutoff frequency to approximately 6 Hz.

5.2.2 Control Electronics and Packaging — In an improved design (Fig. 7), the position of the sensor could be more precisely determined by housing it and its drive/sense circuit in a case which is only slightly bigger than the sensor. A second or "display" case would contain additional signal conditioning circuitry, an output display and a low cost microprocessor. The two cases would be connected by a thin, possibly coiled or retractable, flexible cable.

The sensor case would be much like the "mouse" [6] used by some personal computers. It would have a flat bottom and a flat profile, with a tracking ball mounted in the bottom of the case. The tracking ball would allow the sensor to roll smoothly over a surface, and together with the small size of the sensor package, would decrease operator fatigue compared to the MK 1. Further, the tracking ball could be used to automatically determine the position of the sensor with respect to an arbitrary reference point, such as one corner of a wall or edge of a beam. The sensor case could be moved along the concrete surface, in much the same manner as a "mouse" or a stethoscope, while the operator watched the magnetic field fluctuations displayed on the second case. A pushbutton on the sensor case could be used to temporarily lock a field reading on the display, to resume measurement and storage of field readings or to control other functions of the instrument.

The display case would be approximately the size of a pocket calculator and its electronics would have a similar power consumption. Pushbuttons on the display case would control a number of microprocessor functions such as data collection, calculation of rod size, depth and orientation and even general calculator functions. The microprocessor could be used to characterize magnetic fluctuations due to surface roughness on a portion of concrete where no steel was present. The information obtained might then be used to optimize the circuit by automatically altering the high frequency cutoff to minimize the effect of such fluctuations on the surfaces where steel was present. This would improve sensitivity and reliability in critical applications. Finally, sophisticated functions such as shape analysis of the profiles to identify multiple cable bundles, could be performed. With such a system, localization of a peak in a magnetic profile and determination of the width, would be quite simple.

Output display would initially be an LCD bar graph display, such as the type used as VU meters in modern home audio systems. The magnetic field due to such displays is substantially less than that due to a moving coil meter. LCD bar graph displays consume little power and are easier to read than moving coil meters. A digital display or an audio output could also be included if desirable for field use.

6.0 CONCLUSIONS AND RECOMMENDATIONS

An experimental prototype detector capable of detecting reinforcing rod and prestressing cable in concrete has been tested. The prototype instrument, called the MK 1 DRESTector, has in experiments consistantly detected number 4 reinforcing rod (approximately 12.7 mm diameter) buried at a nominal depth of 0.02 m beneath the surface of a vertical concrete wall. Based on measured sensitivity of the instrument, the instrument should be capable of detecting number 4 rod at a depth of 0.125 m.

Experiments and theory both indicate that identification of an isolated steel reinforcing rod buried in concrete by localizing the peak in its associated magnetic profile and determining the profile width, is feasible.

An improved version of the DRESTector has been proposed. The MK 2 DRESTector development would take advantage of improved sensor and human engineering factors to greatly facilitate rod localization. A number of minor flaws associated with the experimental MK 1 prototype DRESTector would be eliminated, sensitivity would be improved (horizontal number 4 rod could be detected at approximately 0.25 m depth) and power consumption would be lowered by a factor of at least 2.

The degree of sophistication and reliability associated with the final product will be influenced by the desired scale of issue (i.e., one per Regiment versus one per Section) and eventual use. Microprocessors and more refined displays would add to the cost, but improve the ease of measurement and interpretation of data. The projected unit cost would likely be a few hundred dollars but, in any event, would not exceed $1000.

It is conceivable, based on the above work, that the spatial distribution of the magnetic field may be used to distinguish between reinforced and prestressed concrete members. Further development with sponsor input is required, however, to determine the best approach. Computer modelling will enable projections to be made by obtaining magnetic profiles for typical geometries of reinforcing rods and prestressing cable. These profiles can then be analysed to determine the most suitable measurement methods to employ. The final test would be to use these methods or techniques with the improved prototype MK 2 DREStector on various controlled samples of reinforced and prestressed concrete in which the number, size and location of the rods or cables are known. Evaluation during training exercises would be a desirable part of the MK 2 field testing program and if, possible, would present an opportunity for user input with respect to performance, desirable features and development. User guidance will be a necessary component of the proposed development in order to refine the associated operational aspects.

In summary, it is likely that the proposed device will be a valuable aid for reconnaissance, demolition and training. However, the related data must be used in conjunction with military engineering skills in order to accomplish the desired objectives.

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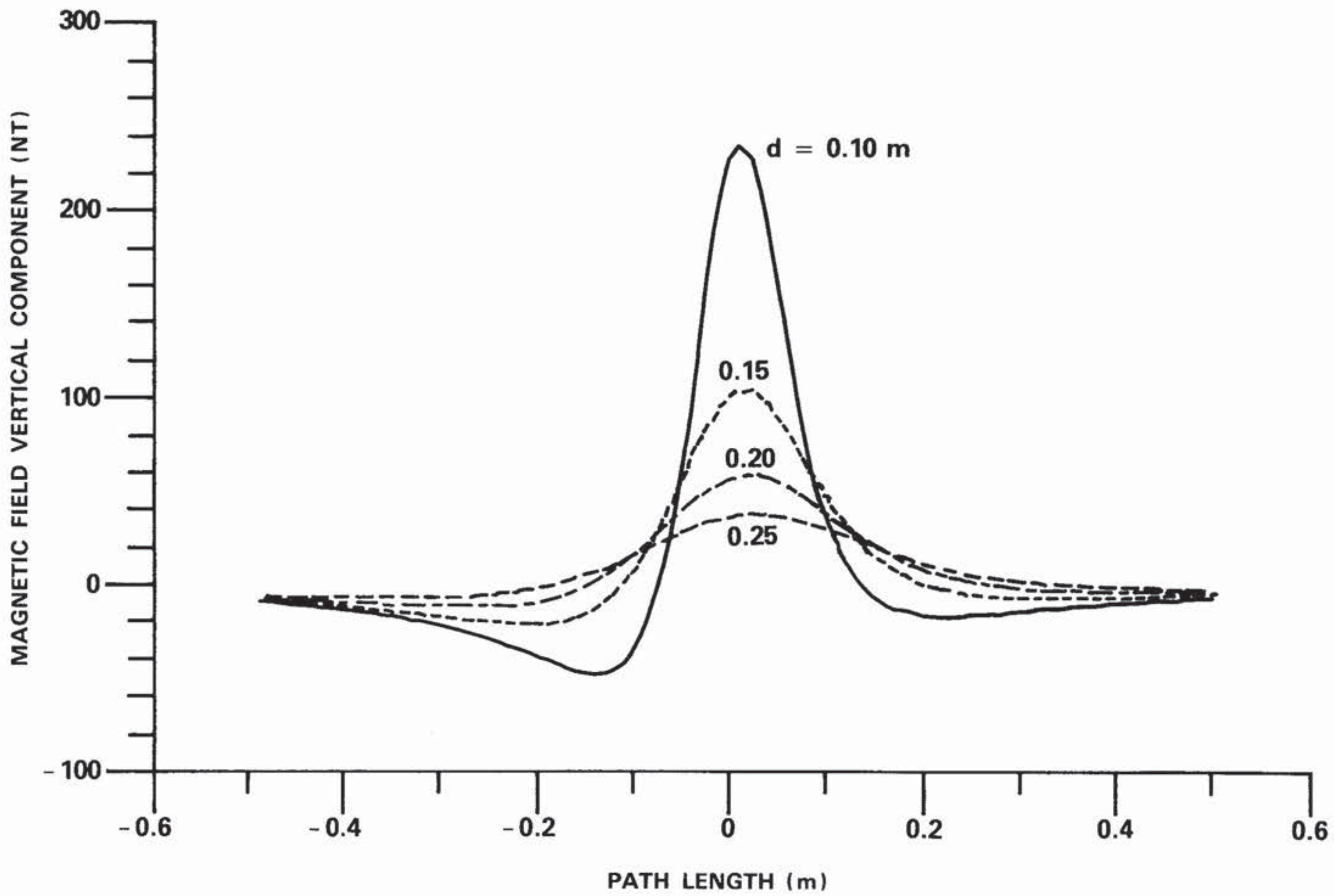

FIGURE 1

Calculated magnetic profiles of a horizontal number 4 reinforcing rod buried at varying depths (d) from the sensor. Traverse direction is perpendicular to the rod direction which is east-west. Rod center is directly below sensor at zero traverse distance. Assumptions for calculation are found in Section 2.1.

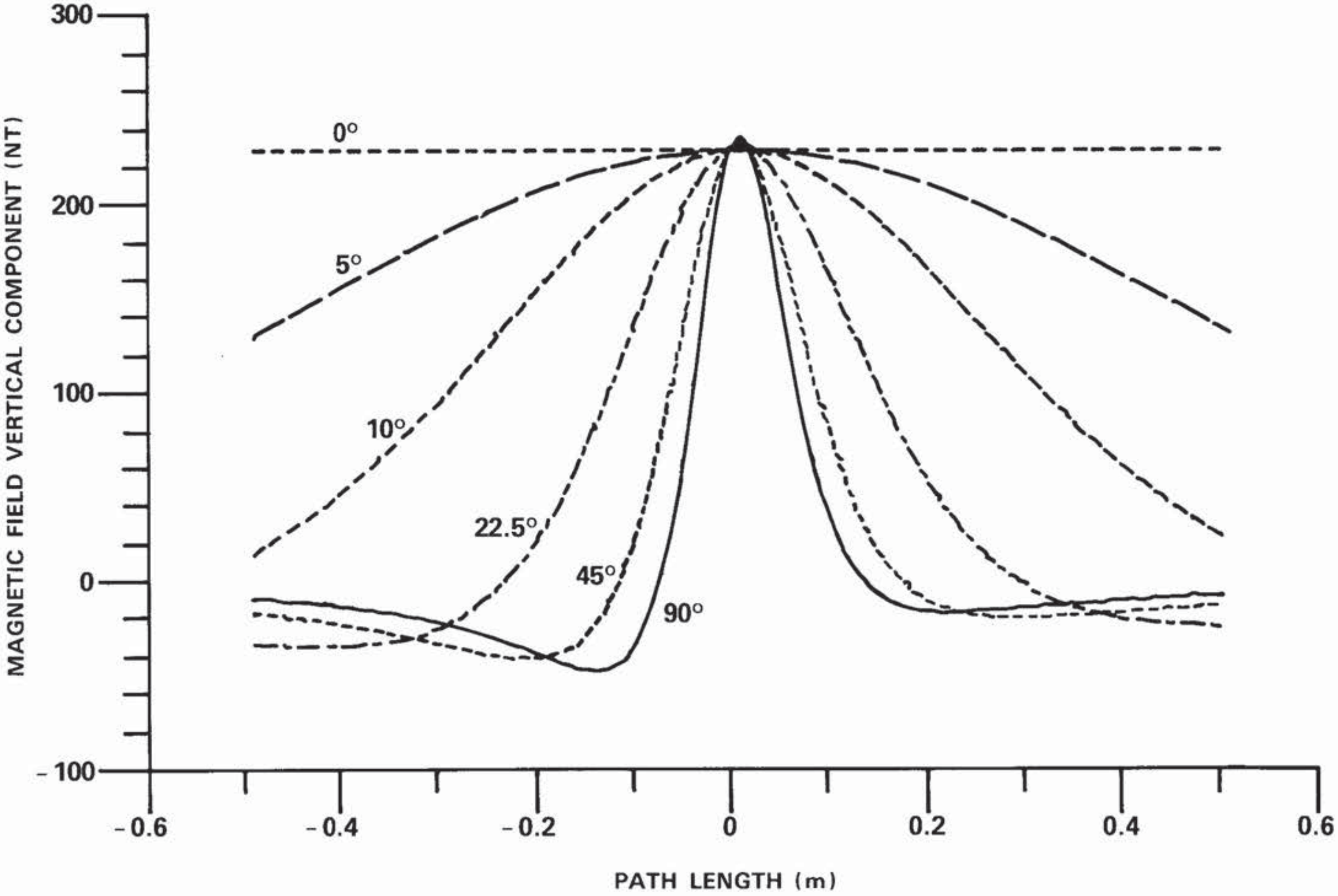

FIGURE 2

Calculated magnetic profiles of a horizontal number 4 reinforcing rod for various traverse angles in a horizontal plane with respect to the rod direction. Rod center is 0.10 m directly below sensor at zero traverse distance. Assumptions for calculation are found in Section 2.1.

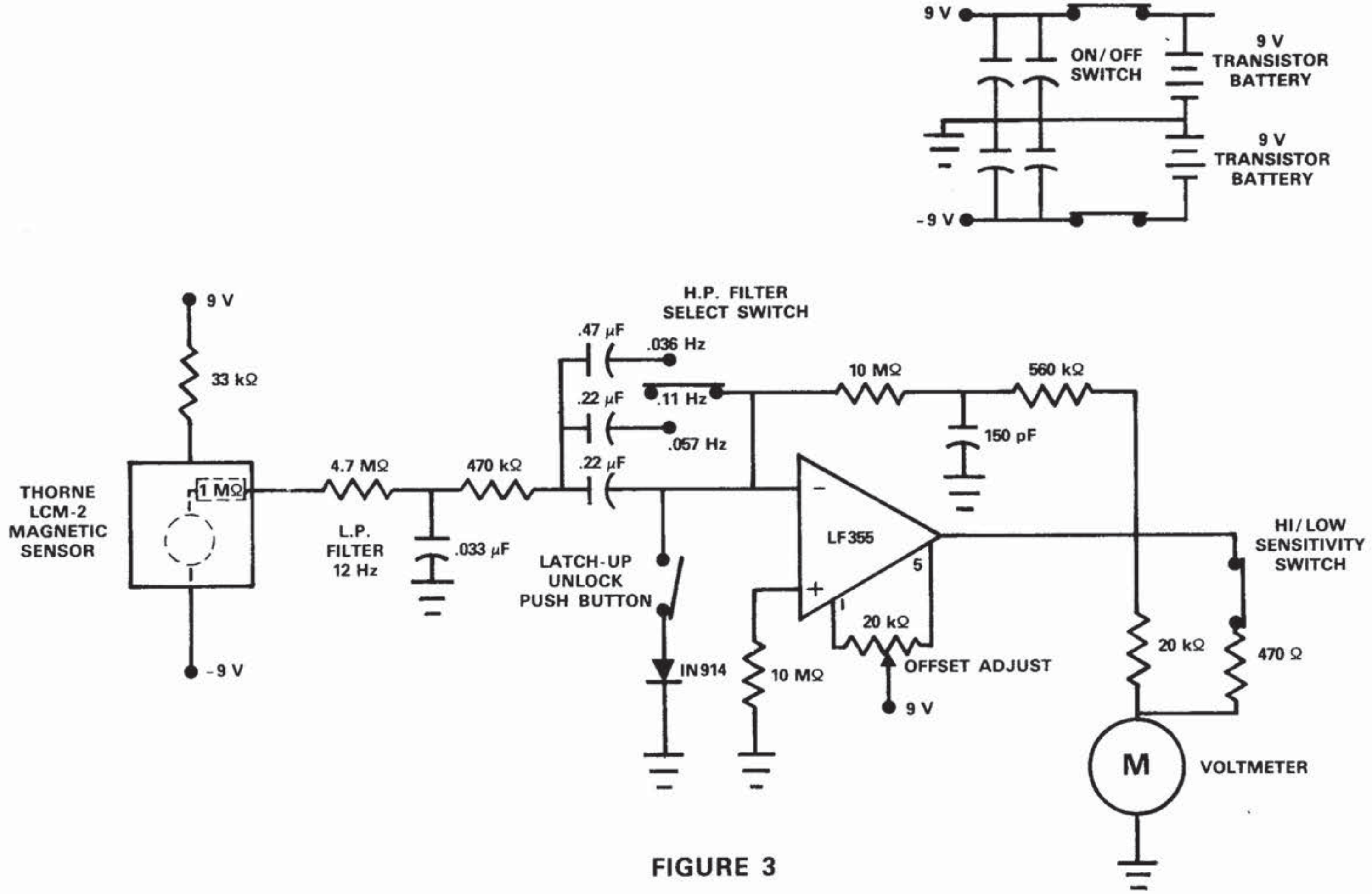

FIGURE 3

MK1 DREStector Circuit Schematic

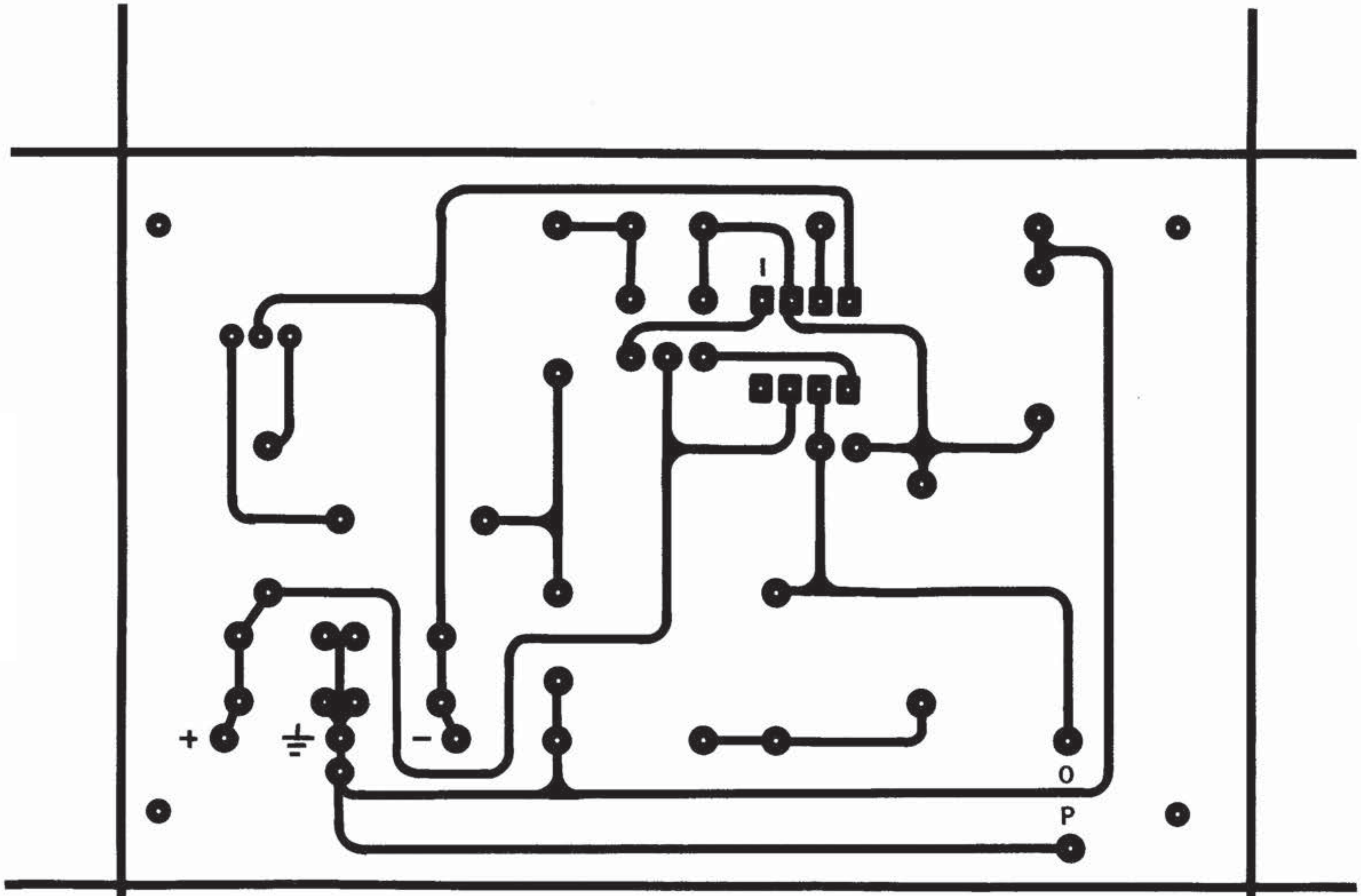

FIGURE 4

MK1 DREStector Circuit Artwork

FIGURE 5

MK1 DREStector Assembled

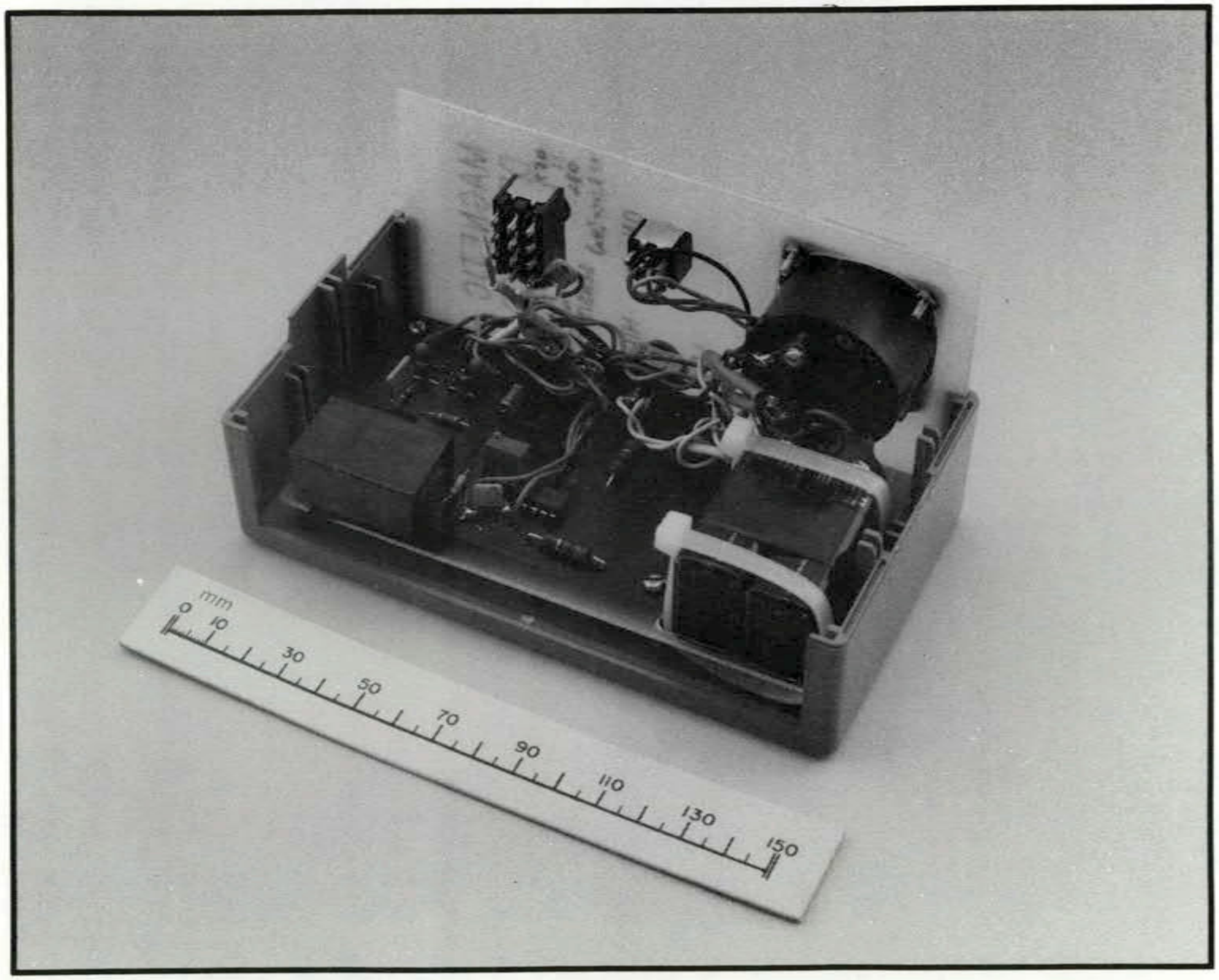

FIGURE 6

MK1 DREStector (cover removed to show electronics)

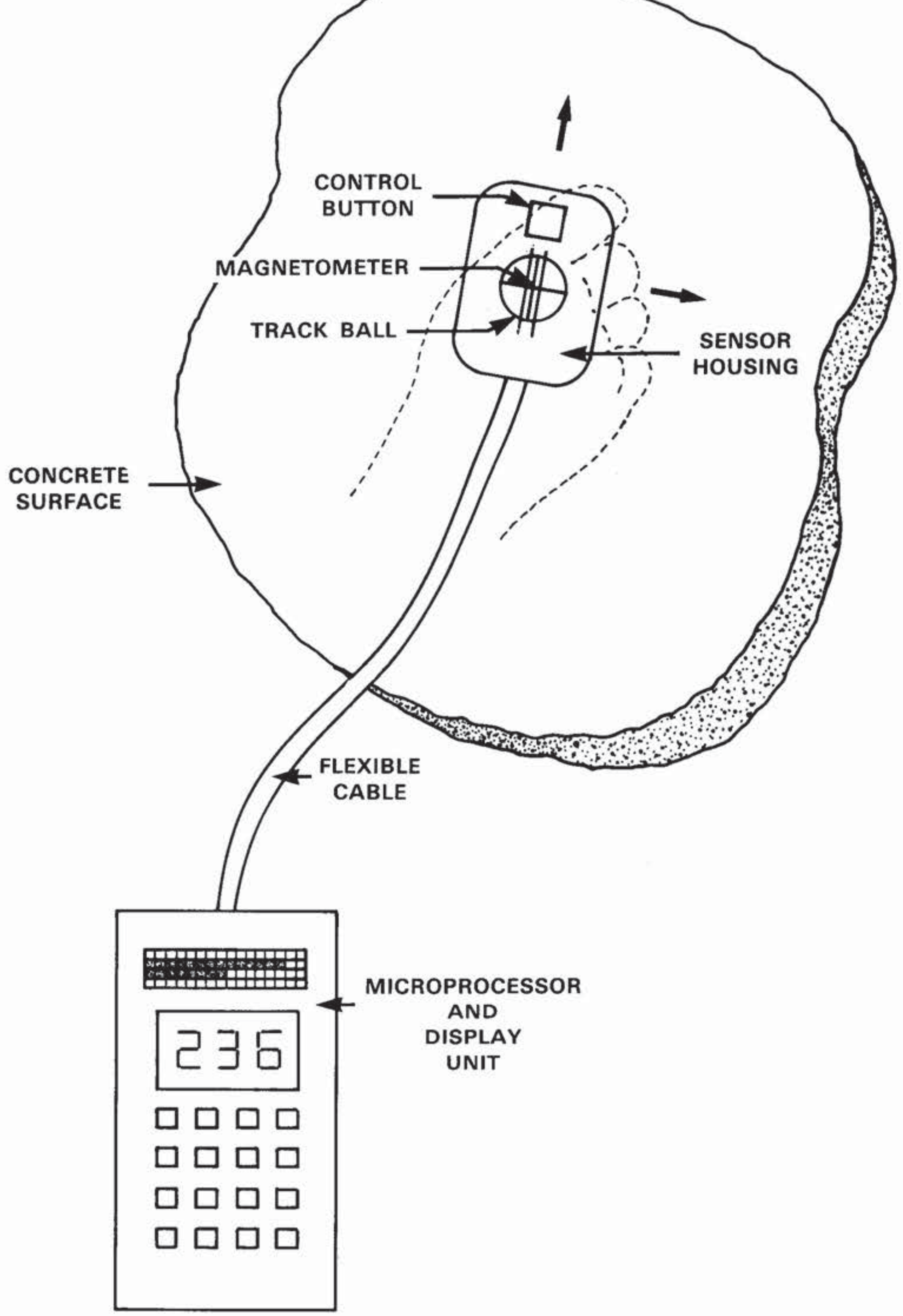

FIGURE 7

Proposed MK2 DREStector (artist's conception)

(NON-CONTROLLED GOODS)
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13. ABSTRACT

An experimental prototype hand-held detector capable of detecting reinforcing rod and prestressing cable in concrete has been built. The prototype instrument, called the MK 1 DREStector, has in preliminary tests consistantly detected vertical and horizontal number 4 reinforcing rod (approximately 12.7 mm diameter) buried at a nominal depth of 0.02 m beneath the surface of a vertical concrete wall. Based on measured sensitivity of the instrument, the MK 1 should be capable of detecting horizontal number 4 rod at a depth of 0.125 m.

The DREStector concept should enable *in situ* assessment of the quantity and location of steel present or determination of the absence of steel in a target. When used in conjunction with field engineering skills, the device should assist the military engineer to rapidly identify and/or prepare a structural concrete target for explosive demolition. Other potential applications might include use as a training aid for target recognition and construction engineering uses.

A brief description of the theory of magnetic fields associated with ferrous rods and a computer modelling study are presented to emphasize the salient features related to localizing and identifying a rod based on measurements of its associated field. The experimental MK 1 prototype DREStector is described and field experiments to test its performance are discussed.

Experiments and theory both indicate that identification of an isolated steel reinforcing rod or cable buried in concrete is feasible. Accordingly, the field discrimination between reinforced and prestressed/post-tensioned concrete members should also be possible based on the location and concentration of steel.

The development of an improved MK 2 version of the DREStector is proposed. The as yet to be developed device should cost less and $1000 per unit, be similar in size and power requirements to a pocket calculator and incorporate specific features for military engineering use.

Although the development proposal appears to be straightforward, it is estimated that two years would be required to refine and optimize the device and associated techniques sufficient to produce an advanced development model. A plan for the related research is also outlined.

KEY WORDS

Computer

Concrete

Denial

Detection

Identification

Magnetic

Magnetometer

Model

Munitions

Reinforced

Runway

Structural Steel

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