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USE OF A METAL DETECTOR TO DETECT BURIED DRUMS IN SANDY SOIL

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Summary

A commercially available metal detector was used to detect buried steel drums, in a variety of patterns, at a site consisting of relatively dry sand. The results were quite promising when viewed in the context of the overall project which used a number of different methods. Single thirty gallon steel drums were detected to a depth of six feet beneath the ground surface. A group of adjacent drums in different configurations at five feet of cover was detected and delineated.

This relatively inexpensive (~ \$400—\$500) instrument could be used to detect buried objects at most hazardous materials dump sites. It remains, however, to determine if the same promising results hold for drums buried in other soil types and moisture contents, and to what extent background metal objects (fences, trucks, etc.) modify these conclusions.

Introduction

This paper is one in a series concerned with detecting buried drums in sandy soil using a number of different nondestructive testing (NDT) techniques. Most of the details of the project can be found in the companion papers published in this Journal [1, 2]. Thus only a concise description of the site and experimental method will be given here. It is followed by the results and conclusions obtained using a commercially available metal detector which is the focus of this particular part of the project.

Site Details

An abandoned sand quarry was available where drums could be buried permanently. The quarry was located at a somewhat remote location, the nearest road and utilities being 1000 feet from the test site. Thus background disturbances from man-made objects were minimal. The soil was

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primarily a uniform sand with a water table about 20 ft from the surface which was much deeper than the maximum depth of drum burial. The lack of stratified layers in the soil proved ideal for the type of work performed. Details of the exact nature of the soil can be found in [2].

The containers were placed in hand-excavated and equipment-excavated holes varying from 1 to 14 ft in depth. Containers placed in the excavations varied in size from 2 gallons to 55 gallons and were made from both steel and plastic. The container burial patterns were as follows:

Pattern 1: three 30 gallon steel containers buried at 3 ft depth, but at different orientations, i.e. 0°, 45°, 90°.

Pattern 2: four 55 gallon steel containers buried at 4.5 ft depth in two groups, one by itself, the other three side by side.

Pattern 3: four steel containers of various sizes (2, 5, 30, 55 gal) buried at constant depths of 3.5 ft (all at 3.5 ft of soil cover).

Pattern 4: four 30 gallon steel containers buried at 1, 3, 6 and 11 ft depths.

Pattern 5: a random burial site approximately 12 × 12 × 5 ft deep, which was filled with 10 steel drums and 1 plastic drum of various sizes. (This pattern was called the "trash dump".)

Pattern 6: four 40 gallon plastic containers buried at 1, 3, 6 and 11 ft depths.

Pattern 7: two 40 gallon plastic containers buried at 2 ft depth, one filled with fresh water, the other filled with salt water.

All patterns were separated by sufficient distance so that interaction between them was relatively unlikely, and within each pattern sufficient distance was allowed for the same reason.

Experimental method

In the type of metal detector used in the present study (see Fig. 1) a transmitting coil generates a continuous electromagnetic signal which subsequently arrives at the receiver coil via two different paths. The portion of the signal through the air is little affected by the subsurface material. The portion through the subsurface is affected by the electrical conductivity

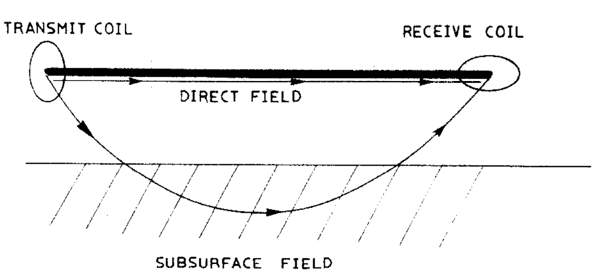

Fig. 1. Schematic diagram of the concept upon which a metal detector functions.

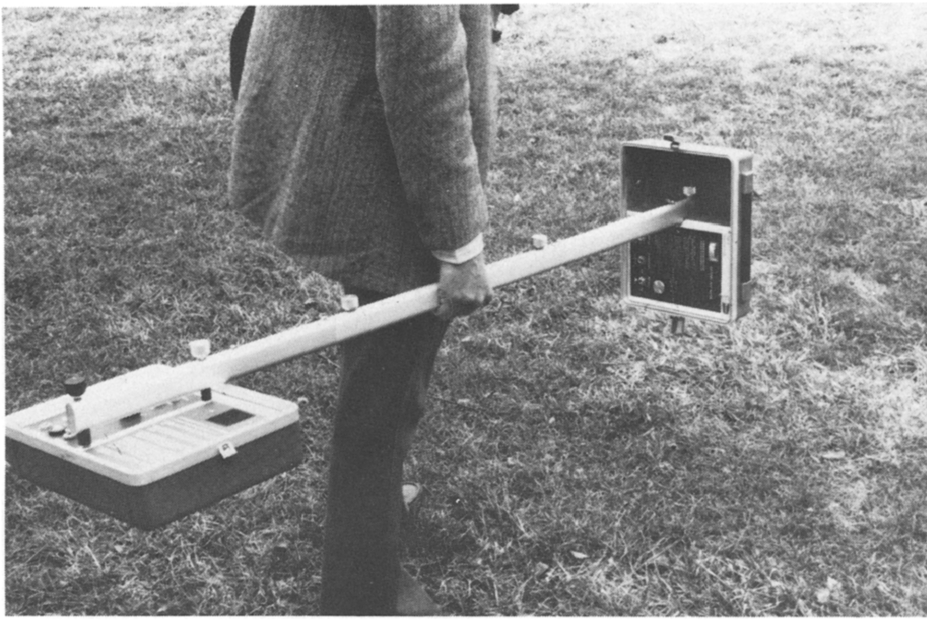

Fig. 2. Photographs of the apparatus used in this study.

(and magnetic permeability) of the subsurface material. If metal is present, eddy currents generated in the metal alter the field arriving at the receiving coil and hence the presence of metal is indicated. Figure 2 is a photograph of the actual unit used in the study. This unit is similar to many commercially available metal detector units. As with other units, the metal detector is a qualitative audible technique and gives essentially three responses: strong, weak or zero response with no gradations in between. This is opposed to other methods which are quantitative, such as the very-low-frequency electromagnetic method (VLF-EM) [2] where actual curves of response can be obtained.

Results

Described in this section are the results of the metal detector passing over the ground surface in the vicinity of the seven patterns described earlier.

Pattern 1 (steel drums): All three drums at different burial orientations gave strong responses in their immediate vicinity.

Pattern 2 (steel drums): Fig. 3 indicates the results of the metal detector scan directly over the drums of pattern 2. It is seen that the three drums are very easily detected and the single drum is weakly indicated. If the scans (traverses) are offset from this center line scan, the three drums are detectable out to five feet offset, and the one drum to two feet offset. This offset detection capability has been called lateral scan sensitivity in previous papers in this series [1, 2].

Pattern 3 (steel drums): Fig. 4 indicates the metal detector results over the drums of pattern 3. The smallest steel drums are barely detectable under 3.5 feet of soil cover, whereas the larger ones are readily detected.

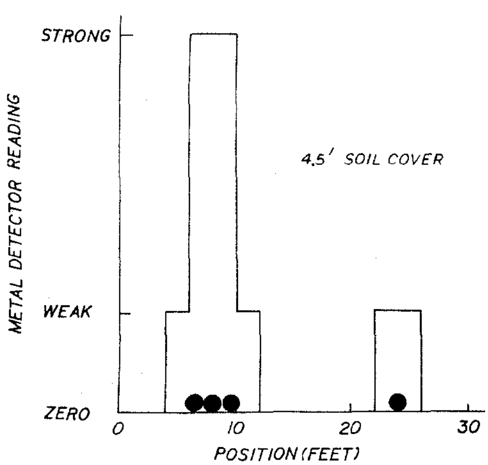

Fig. 3. Metal detector response over pattern 2.

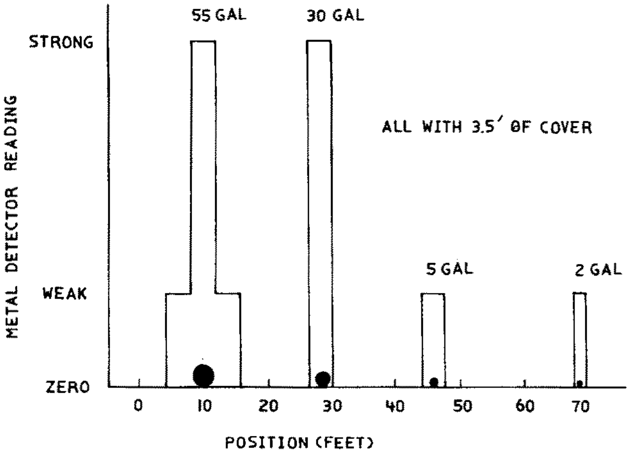

Fig. 4. Metal detector response over pattern 3.

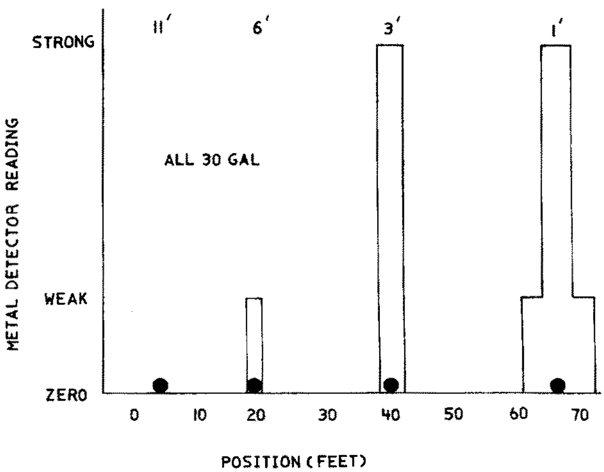

Fig. 5. Metal detector response over pattern 4.

Pattern 4 (steel drums): Fig. 5 shows the results of the scan over the drums of pattern 4. Here it is seen that the limit of detection is about six feet of cover over a single 30 gallon steel drum.

Pattern 5 (steel drums): Fig. 6 shows the distribution of objects placed in the "trash dump". Figure 7 indicates the region where a strong signal is obtained while scanning the area with the metal detector. It is seen that the metal detector quite accurately determines the region of maximum steel concentration.

Pattern 6 (plastic drums): The metal detector gave no response over this pattern.

Pattern 7 (plastic drums): The metal detector gave no response over this pattern.

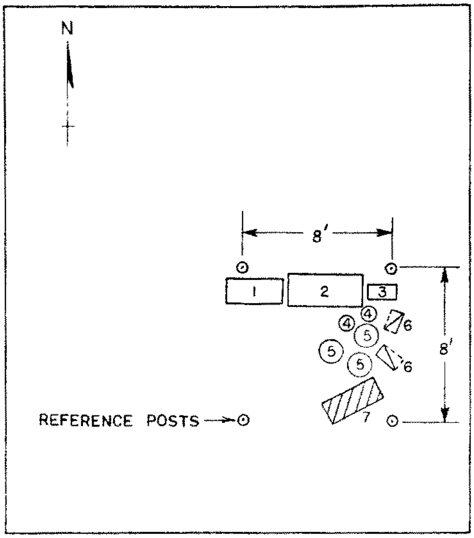

Fig. 6. Distribution of objects in the "trash dump" of pattern 5. Key: metal drums: 1: horizontal, 30 gal; 2: horizontal, 55 gal; 3: horizontal, 5 gal; 4: vertical, 5 gal; 5: vertical, 30 gal; 6: 45° angle, 5 gal; plastic drum: 7: horzontal, 30 gal.

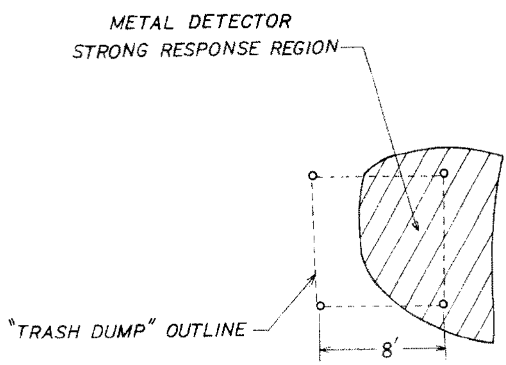

Fig. 7. Metal detector response in the vicinity of the "trash dump" of pattern 5.

Conclusions

It appears from this work that a high quality metal detector (cost about \$400—500) is capable of detecting isolated buried drums to depths from 6 inch (for small drums) to 6 feet (for a 30 gallon steel drum). Since the burial of hazardous waste liquids in drums are usually multi-drum and at most 2 to 3 feet deep, the metal detector is probably capable of detecting and delineating most dump sites containing metal (usually steel) drums. The metal detector is also one of the cheapest of the possible NDT instruments used for buried drum detection [3, 4], making it quite attractive in this regard.

It remains to be seen if the same very positive results will be found when the metal detector is used in high-water-content fine-grained soils (silts and clays) and in soils which are further complicated by significant stratification (i.e., a non-homogeneous disposition of the soil).

As an aside, a very inexpensive (about $40) metal detector was also evaluated at the site. The performance in this case was very poor. The only drum detected was the 30 gallon steel one at one foot of cover. The "trash dump" (containing a concentration of metal at 5 feet depth) could not be detected nor could the other patterns described and successfully located by the more sophisticated (and costly) metal detector shown in Fig. 2. The relative merits of the metal detector and VLF-EM techniques are discussed in a companion paper [2].

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