June 11, 1946. J. H. DEMING 2,401,723

METHOD AND APPARATUS FOR LOCATING OBJECTS

Filed Feb. 12, 1942 2 Sheets-Sheet 1

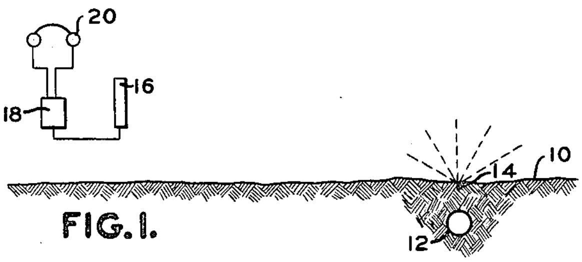

FIG. 1.

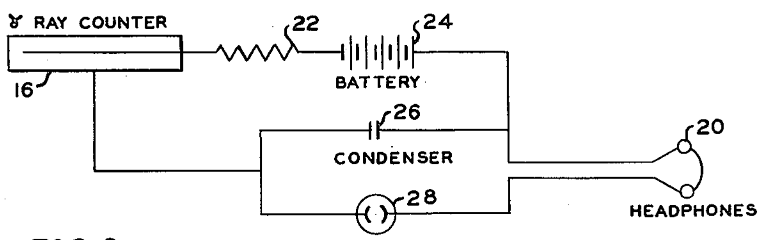

FIG. 2.

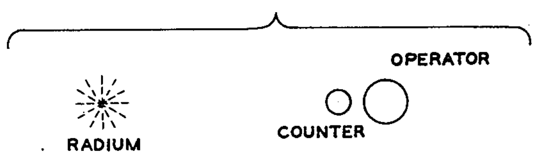

FIG. 5a.

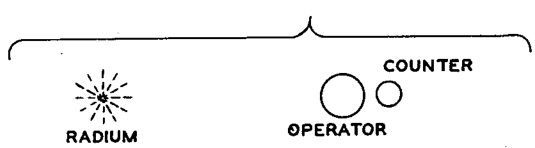

FIG. 5b.

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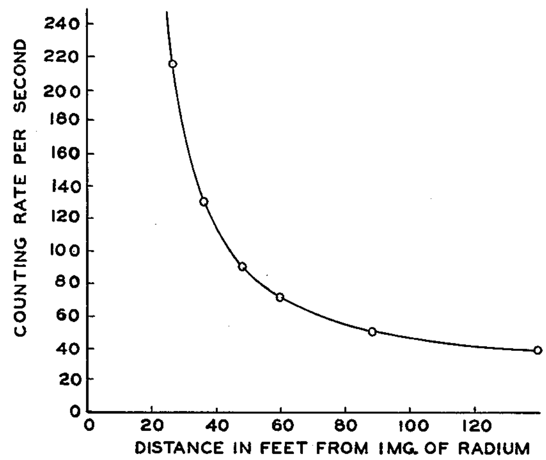

FIG. 3.

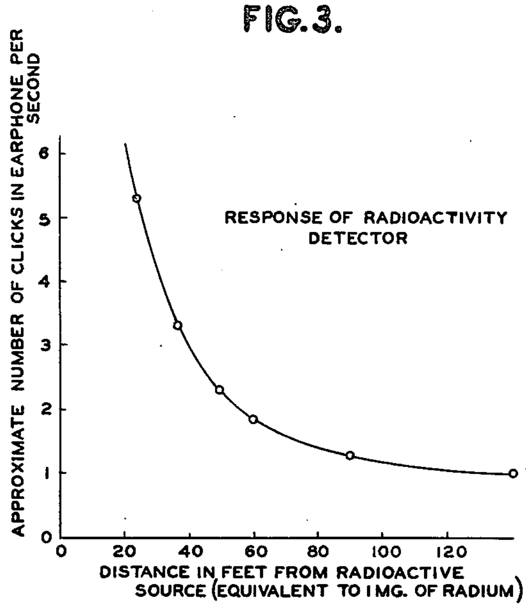

FIG. 4.

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METHOD AND APPARATUS FOR LOCATING OBJECTS

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Application February 12, 1942, Serial No. 430,603

6 Claims. (Cl. 250—83.6)

This invention relates to the locating of lost or hidden objects and more particularly to a method and an apparatus for relocating land mines which have been previously buried or planted by a retreating army. The principal object of the invention is to provide such a method and apparatus by means of which a dangerous object, such as a hidden explosive mine, can be readily located so that it can either be removed or suitably marked.

It is well known that frequently troops retreating or moving from one position to another plant explosive mines, usually below the surface of the ground, so that the movement of motorized equipment such as tanks and large trucks in passing over the mined section will discharge these mines, thus disabling the equipment. It often happens that in reoccupying previous battle positions it is desirable to relocate and "sweep up" mines previously planted. This is obviously a difficult and dangerous procedure since the mines must in the first instance be planted in such a manner that their position would not be readily ascertained by the enemy. Certain methods have been tried out to accomplish this purpose. The explosive charge is usually contained in a housing of steel or other metal, and attempts have been made to locate these mines by using the so called "treasure finders" which utilize the principle that a body of metal or a metallic object in the general vicinity of the detecting instrument will cause a variation in some characteristic of an electric circuit to provide an indication to the observer that the metallic object is near. By walking around in the general vicinity of such an object, the observer can tell, as by a change in frequency of a note heard in a pair of earphones, the exact spot at which the object is located.

In accordance with the invention the land mine is constructed so that it preferably contains substantially no metal. The explosive may, for instance, comprise one or more sticks of dynamite or other such material suitably waterproofed and a percussion or detonating device suitably constructed with the use of hard wood, plastic or some other non-metallic material. Thus, once a mine constructed along these lines has been buried it cannot be subsequently located by means of the "treasure finder" type of instrument mentioned hereinbefore. In order, however, that those who have planted the mine can subsequently readily relocate it, I incorporate in each mine a small quantity of a radioactive substance, the presence and location of which substance can subsequently

be determined through the use of an instrument sensitive to the radiation emitted by the substance. The radioactive material can be incorporated in the mine in any desired manner, as by the use of radioactive salts in the paint used on such mines. If a separate detonating device is used, the radioactive material can be attached to or housed within that device in any suitable manner. It is desirable that the radioactive material be as close to the surface of the ground as possible so that the greater part of the radiation will not be absorbed by the earth.

For a better understanding of the invention reference may be had to the accompanying drawings in which

Figure 1 is a vertical elevation through a section of the earth showing a buried mine and an instrument for detecting the location of the mine;

Figure 2 is a diagram showing the elements and the electrical connections for the detecting instrument;

Figure 3 is a curve showing the counting rates when one milligram of radium is set up at different distances from the detector;

Figure 4 is another curve showing the response of the detector as indicated by clicks in the earphones after being scaled down by the instrument shown in Figure 2; while

Figures 5*a* and 5*b* are diagrammatic illustrations showing the directional effect, or rather the shielding effect, of the body of the operator.

In Figure 1 of the drawings the earth's surface is indicated at **10** and a land mine or other object **12** is shown as buried a short distance below the surface. Preferably the mine is so constructed that it does not contain any appreciable amount of metal and thus an operator carrying one of the so called "treasure finder" instruments and moving about above the mine would have no indication of the existence or location of the mine, as has been explained hereinbefore.

While the mine **12** is being planted, or at such other time as the exact location of the mine is still known, a small quantity of a radioactive substance **14** is placed in a known position with respect to the mine and preferably directly above the mine, close to the surface of the earth, as is shown in Figure 1. As has already been stated, if desired, the radioactive material may be directly attached to the mine **12** or to any separate percussion device associated with the mine, but it is preferable that the radioactive material be at, or immediately below, the ground surface. A radiation detector or counter **16** is shown diagrammatically and is connected to a suitable instrument 18 which in turn has connected to it a pair of earphones 20 adapted to be worn by an operator. The detector 16 may be of the well known Geiger-Muller counter type, but it is preferred to use a high efficiency and rugged gamma ray counter of the type shown in either of the copending patent applications of D. G. C. Hare, Serial Nos. 364,020 and 412,617 filed November 2, 1940, and September 27, 1941, respectively. The gamma ray detector or counter which has been used in connection with the present invention is of the general type disclosed in the aforementioned pending application, Serial No. 412,617, and comprises a plurality of thin, parallel, separated plates connected together electrically to form a cathode and provided with one or more series of aligned openings through which fine wires are disposed, these wires being connected to form the anode. The cathode and anode are housed in a cylindrical casing containing a gas, such as argon, and the counter is connected in a circuit in such a manner that when a gamma ray enters the detector the discharge or tripping of the detector will influence the circuit to cause an indication to be given.

A diagram of an electrical circuit in which the gamma ray counter may be connected is shown in Figure 2. The elements shown in this figure with the exception of the counter and the earphones may be housed conveniently in a small box such as is shown at 18 in Figure 1. As shown in Figure 2, the anode and the cathode of the counter 16 are connected in series with an electrical resistance 22, a source of electrical supply such as the battery 24, and a condenser 26. A small gaseous discharge device, such as the neon lamp 28, and the pair of earphones 20 are connected in series across the condenser 26. It will be noted that the circuit, as shown in Figure 2, contains no elements such as radio tubes which will draw a heavy current from the battery. For this reason the battery supply will last for many months. The circuit shown in Figure 2 is not the only one that could be utilized in carrying out this method. Many others such as multi-vibrator circuits, Nehrer quench circuits, etc., will occur to those versed in the art.

In Figure 3 is shown the counting rates when one milligram of radium is set up at different distances from the detector. It will be noted that at considerable distances, i. e., about 150 feet, the source has little effect on the detector and the discharges are due to the radioactivity of the surrounding earth and to the effect of cosmic rays. The counting rate increases to twice the background value at a distance of 60 feet from the source and it increases steeply for smaller distances. The counting rate at 50 feet is about 70 counts per second and this rate would be too high for direct perception by the ear. With the circuit shown in Figure 2 the condenser and the neon lamp scales this number down so that only about one click is heard in the earphones 20 for every 50 discharges of the counter. The ear then perceives a counting rate of about two clicks per second at a distance of 50 feet from one milligram of radium. It is very easy to determine a change of frequency by a factor of two at these low frequencies and after some accommodation to the counting rates even changes of 50% can readily be detected. This scaling down of the number of clicks, as shown in Figure 4, has another important advantage. The discharges of the counter 16 occur at a random time distribution, and sometimes discharges follow each other very closely and then there may be a rather long interval between discharges. In order to evaluate the frequency of the counts the ear has to average these varying intervals and it must detect changes of the average counting rate. The scale circuit reduces this distribution to fairly regularly spaced clicks, and it is therefore much easier for the ear to observe changes of the regular counts.

In operation, it is merely necessary for an operator wearing earphones 20 and carrying the counter 16 and the instrument 18 to walk around in the general vicinity of the mine 12 and to follow the direction in which the clicking rates increase until the maximum counting rate is reached. This point will be, of course, the point of highest intensity of radiation from the source 14, and it will be known that the mine 12 is either directly below that point or is at a known position with respect thereto. The mine may then either be removed or a suitable marker may be placed in the ground to warn approaching tanks and other heavy equipment not to pass over that point.

Another feature of the invention is that an operator can easily obtain a directional effect with the equipment shown or, in other words, the body of the operator can be used as a shield for the gamma rays. Thus, as is indicated in Figure 5*a* where the operator is standing so that the counter is placed between him and the source, the counting rate may be, say, 4 per second. When the operator turns around so as to bring his body between the source and the counter, as is shown in Figure 5*b*, the counting rate will drop to about two clicks per second due to the absorption of gamma rays in the operator's body. The shielding effect allows the operator to find the direction in which the source is located and he need then merely walk in that direction until he reaches the point of greatest radiation intensity. In actual tests one-half a milligram of radium was planted in an unknown location in a field 25 yards square. It was found that an untrained person, using the equipment described, could find this source in from one to two minutes.

It is obvious that the size of the counter and the amount of the radioactive material should be chosen so as to be best adapted for the specific problem. In case there are no restrictions as the weight of the equipment, its sensitivity can be much increased and sources of radiation located from greater distances. Such equipment could be used for locating mines at sea from a mine sweeper.

It is not necessary that pure radium be used as the source. The refining process of radium is slow and expensive in its last stages. One could easily use radium from the early stages of its refining process and material which contains radium in a rather dilute form, such as a concentration of one milligram of radium dispersed in ten grams of carrier substance, would be quite suitable. This product would, of course, be substantially less expensive than pure radium.

Although a high efficiency gamma ray counter is preferred as the detecting device, the ordinary Geiger-Muller counter can be used in a similar manner, but, in order to obtain equal counting rates, its volume would have to be about 15 times greater than that of the counter disclosed, for instance, in the aforementioned pending application Serial No. 412,617. This naturally makes the equipment very bulky and furthermore the ordinary Geiger-Muller counter would have a much higher background due to cosmic rays. This, of course, prevents the detection of weak gamma ray intensities.

The ionization chamber could also be used as a detector but it has the disadvantage that the electric currents generated in it by the gamma rays are extremely small. They can be perceived with a suitable electrometer but apparatus of this kind would be rather impractical. The small current could be increased by means of a suitable amplifier but such equipment is elaborate and requires the attention of well trained operators.

Obviously many modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof, but only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. The method of locating a land mine buried in the earth which comprises placing substantially above and in a known position with respect to said mine a quantity of a radioactive substance when the mine is being buried, and subsequently determining the location of said mine by detecting at various points over the earth's surface in the general vicinity of the mine radiation emitted by said radioactive substance.

2. The method of locating a non-metallic land mine buried in the earth which comprises attaching to said mine a small quantity of a radioactive substance before the mine is buried or while its location is still known and subsequently locating the mine by detecting in the general vicinity of the mine the amounts of radiation emitted by said substance, said amount varying indirectly as the distance from the mine to the detector.

3. The method of locating a non-metallic explosive mine buried in the earth which comprises associating with said mine a small quantity of a substance capable of emitting gamma radiation before the mine is buried or while its location is still known and then subsequently locating the mine by detecting in the general vicinity of the mine the intensity of the gamma radiation emitted by the substance, said intensity varying indirectly as the distance from the mine to the detector.

4. The method of placing and subsequently locating an explosive mine formed of an explosive disposed in a casing which comprises utilizing a non-metallic material for said casing, associating with said mine a quantity of a radioactive substance, and subsequently determining the position of said mine by detecting radiation emitted by said substance and locating the point where the radiation has the greatest intensity.

5. The method of locating a buried explosive mine formed of an explosive disposed in a non-metallic casing which comprises placing a quantity of a radioactive substance at the surface of the earth in known position with respect to said mine, and subsequently determining the position of said mine by detecting radiation emitted by said substance, and locating the point of most intense radiation.

6. The method of locating a buried explosive mine near which has been previously positioned at a known location with respect thereto a quantity of a substance capable of emitting radiation, which comprises exploring the surface of the earth with a device capable of detecting radiation emitted by said substance, and locating the point at which the radiation has the greatest intensity, as indicated by said detecting device.

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