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[54] RADIOACTIVE SOURCE SHIELD WITH SAFE POSITION INDICATOR

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[51] Int. Cl. G01t 1/26, G21f 5/00
[58] Field of Search .....250/108, 106 S, 83.3

[56] References Cited

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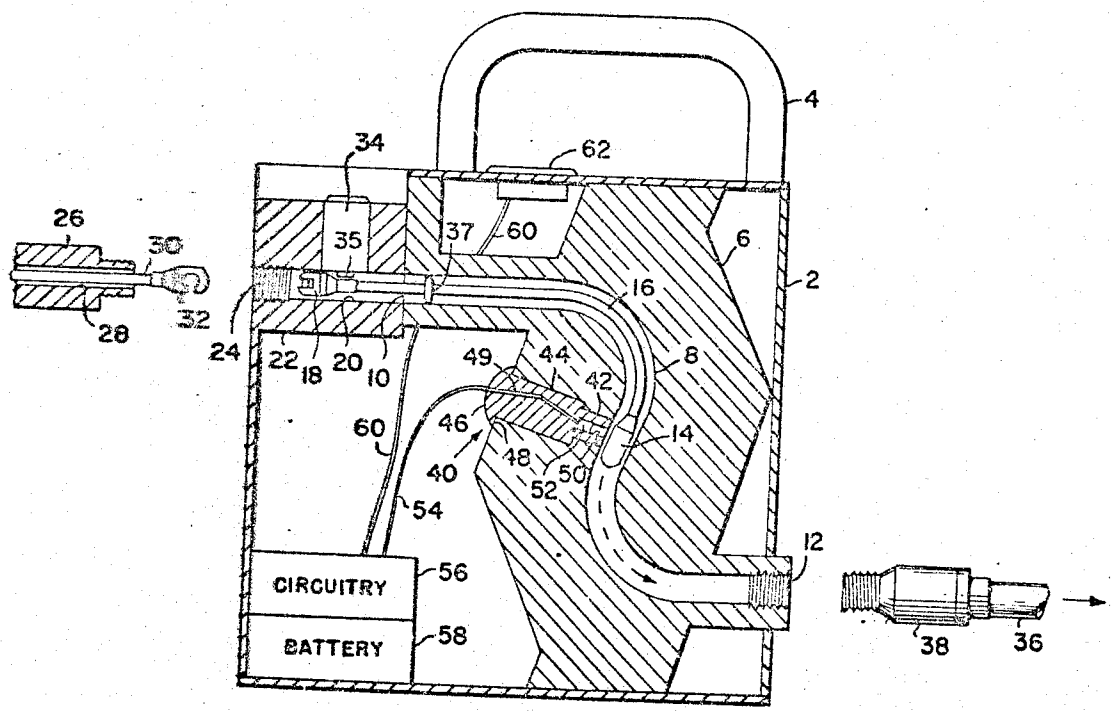
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[57] ABSTRACT

Apparatus for indicating when a radioactive source capsule is in a safe position within its shield comprises a gamma-sensitive photoconductor located in the shield in close proximity to the safe location of the radioactive source. The photoconductor operates a visual indicator through electrical circuitry designed so that a positive indication is given when the radioactive source is in its safe position.

6 Claims, 4 Drawing Figures



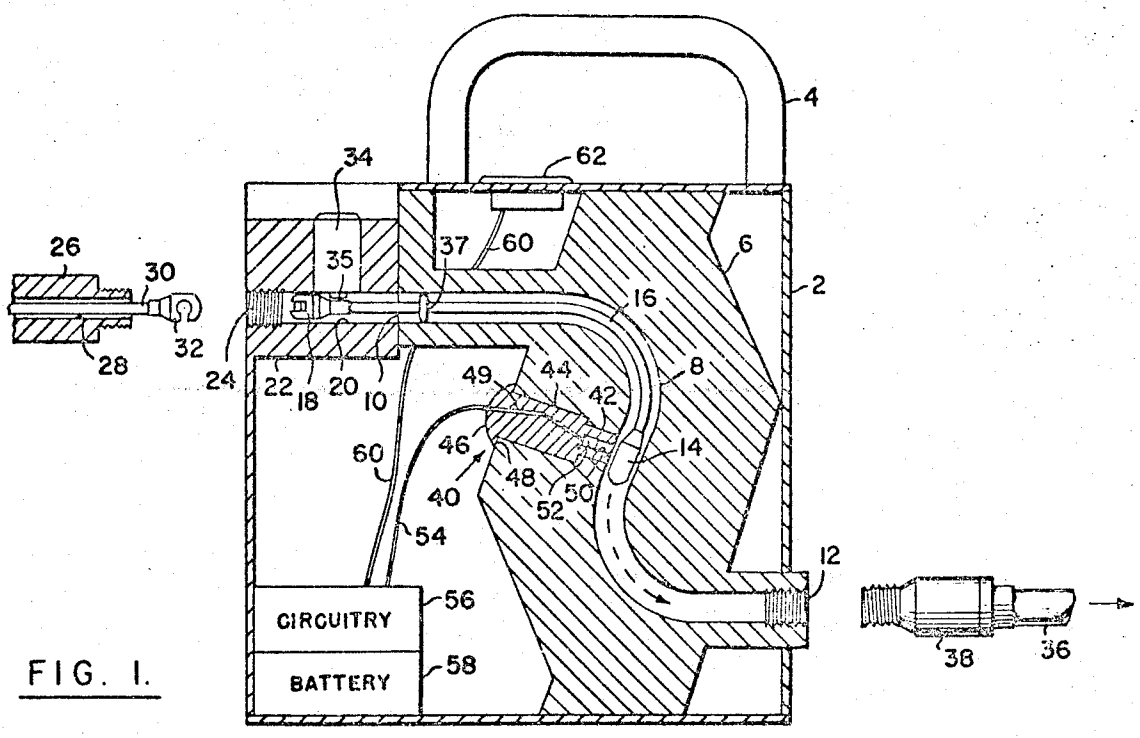


FIG. 1.

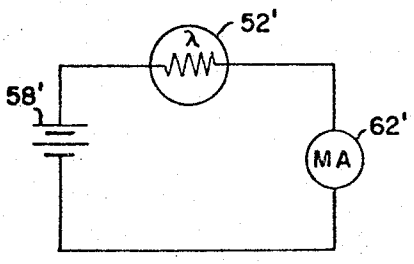


FIG. 2.

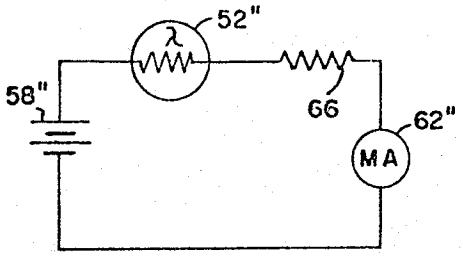


FIG. 3.

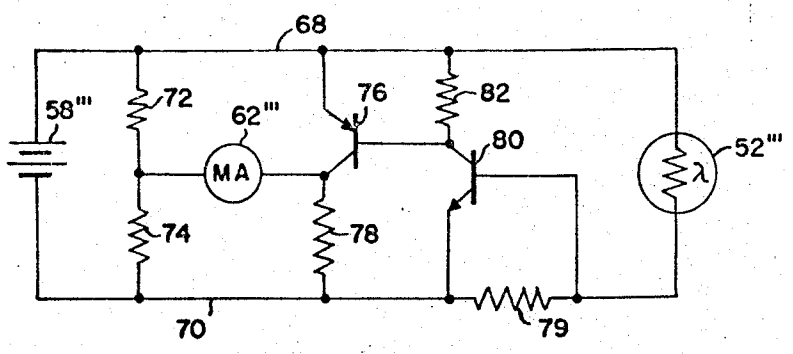


FIG. 4.

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RADIOACTIVE SOURCE SHIELD WITH SAFE POSITION INDICATOR

BACKGROUND OF THE INVENTION

This invention relates to radioactive source position indicators for use in conjunction with source capsule storage shields. The purpose of these indicators is to provide a visual indication when the radioactive source is in a safe position within its shield so that the user can know when it is safe to approach and handle the shield.

In the past 15 years, the usage of radioactive isotopes for industrial radiography has replaced the usage of X-ray equipment in many radiographic operations performed in the field. The use of radioactive isotopes has also become important in medicine.

The principal disadvantage of the use of radioactive isotopes is the fact that they emit gamma radiation continuous and thus must be shielded by a covering of dense material when not in use. Because of the dangers to personnel which are involved, it is desirable to make a survey of a radioactive exposure device when each exposure is completed in order to make sure that the radioactive source is in a safe, shielded position. This survey must be made with an instrument capable of detecting gamma radiation. In fact, government regulations require these precautions.

Even though precautions are required, and the prescribed procedures should be foolproof, many instances are reported each year where technicians and others are exposed to overdoses of radiation through the failure of the technician to follow the proper survey procedures.

Several attempts have been made in the prior art to overcome the problem of accidental exposure by the incorporation of mechanical and electromechanical indicators in the exposure device.

In most exposure devices, a radioactive source capsule is pushed or pulled through a tortuous passage in a shield by a control cable. In some devices, air pressure is used to move the radioactive source capsule. In the case of cable-controlled source capsules, it is common to rely on the position of the cable as an indication of the position of the source within the shield. Indicators have been provided which are activated by the control cable or by some other part which should move with the radioactive source capsule. In the case of air pressure control, microswitches have been arranged to be activated by the source capsule when it is in a safe position.

Several dangers are inherent in source position indicators in the prior art. As most of these indicators are complicated devices with several moving parts built as small as possible to conserve space and weight, they have a tendency to fail at inopportune times. Another serious fault of such indicators is the fact that they are activated not entirely by the source, but by some other part that should move with the source, for example, the control cable. If, for some reason, a source capsule became separated from its control cable it could remain exposed when the indicator is indicating a safe condition. Exposure devices which are equipped with indicators controlled by cables and other parts which move with the source capsule become more dangerous and hazardous than devices without source position indicators since technicians tend to rely on indicators on the device, and tend not to use an external survey meter such as a Geiger counter.

SUMMARY OF THE INVENTION

In accordance with the invention, a cable-controlled source capsule is used. Its presence at a safe position in the tortuous passage within a shield is detected by a gamma-sensitive photoconductor buried in the shield material in close proximity to the safe location of the radioactive source. The detector can only be activated by the source in the safe position. The principal advantage of the use of a gamma-sensitive detector buried in the shield material is the fact that it cannot be activated by the control cable or by anything other than the source capsule. In addition the gamma-sensitive detector has the advantage of extremely high reliability.

The detector activates an indicating device, for example a meter, through extremely simple circuitry which is designed so that the failure of any component will result in a readily recognized indication on the meter or other indicator that such a failure has occurred. The principal object of the invention, therefore, is to provide a source position indicator which is "fail safe" in its operation.

Since some of the radioactive sources used in industrial radiography have short half-lives, it is necessary to provide compensation for source strength variations in the indicating circuitry. Accordingly, a further object of the invention is to provide such compensation so that similar indications are provided when radioactive sources are in their safe position even though their strength may differ considerably.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical section of a radioactive source shield in a carrying case, the figure also showing an external control cable and a tube for transporting a source capsule from the shield to the position at which an exposure is to take place;

FIG. 2 is a schematic diagram of an electrical circuit for controlling an indicating meter in accordance with the invention;

FIG. 3 is a schematic diagram of an electrical circuit provided with means for compensating for variations in source strength; and

FIG. 4 is a schematic diagram of an alternative electrical circuit having compensating means.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows a carrying case 2 provided with a carrying handle 4. Within case 2, there is mounted a massive shield 6 consisting of lead or other dense material which cannot be penetrated by alpha, beta or gamma radiation. An S-shaped passage 8 extends through the shield material from an opening 10 to a threaded opening 12.

A radioactive source capsule 14, which is of conventional design, is shown in what is termed a "safe" position in the S-shaped passage 8. The passage is so shaped that radiation emanating from the radioactive isotope within capsule 14 cannot escape through openings 10 and 12 when the capsule is in this position.

A short length 16 of cable is attached at one end to the capsule and terminated at its other end in a connector 18, which extends into a passage 20 provided in a block 22 which is an integral part of the wall of the carrying case. The outer end of passage 20 is threaded at 24, the threads being provided so that member 26 can be connected to the carrying case. Member 26 has an internal passage 28, through which control cable 30 passes. A connector 32 on cable 30 is adapted to be engaged with connector 18 on cable 16 so that the position of the source capsule 14 can be controlled from a remote position through cables 30 and 16. A lock 34, having an extendible plunger 35 prevents the source capsule from moving downwardly to an unsafe position because of the engagement of plunger 35 with connector 18. In order to engage connectors 32 and 18, connector 18 is pulled outwardly so that it clears threads 24. A stop 37, attached to cable 16 and engageable by plunger 35, prevents connector 18 from being pulled so far outwardly as to expose the source capsule.

A tube 36 is provided with a threaded connector 38, which is adapted to be connected at opening 12. Tube 36 carries the radioactive source capsule to the position in which a radiographic exposure is to be made.

A plug, indicated generally at 40 is preferably made from lead or another suitable shielding material. Plug 40 is an integral element comprising a cylindrical portion 42, a larger cylindrical portion 44, and a cap portion 46, which has an annular face 48 which engages the external wall of the shield. Plug 40 fits into a conforming opening in shield 6, the opening extending from the exterior of the shield to the interior passage 8. The differences between the diameters of cylindrical portions 42 and 44, and the annular portion 48 of the cap

provide a stepped configuration of the plug which prevents the leakage of radiation. A tortuous passage 49 is provided in the plug elements 44 and 46 for an electrical cable.

Within cylindrical portion 42 a passage 50 is provided. Within passage 50 there is located a gamma-sensitive photoconductor 52. This photoconductor is preferably a cadmium sulphide or cadmium selenide cell, which is sensitive to gamma radiation, but may be any other device providing an electrical response, i.e., either a change in electrical characteristics or an electrical output, to alpha, beta or gamma radiation. A two-conductor cable 54 extends from detector 52 and through passage 49 in the plug elements 44 and 46 to the circuitry at 56. A single-conductor cable can be used as well if the circuit is completed through the shield material. A battery is indicated at 58. An electrical cable 60 extends from the circuitry indicated at 56 to an indicating meter 62, mounted in the cover of the carrying case.

From FIG. 1, it will be apparent that detector 52 will only respond to radiation from the radioactive isotope within capsule 14 when capsule 14 is in close proximity with detector 52. If capsule 14 were moved to a position such that radiation could be emitted through one of openings 10 and 12, it would be so remote from detector 52 that the detector would not respond to a significant degree. The tortuous configuration of passage 8 not only prevents the escape of radiation but also shields the detector 52 from external light.

In the electrical diagrams, primed reference numerals indicate elements which correspond to elements shown in FIG. 1.

FIG. 2 shows a simple, uncompensated circuit comprising battery 58', milliammeter 62', and photoconductor 52' connected in series. Photoconductor 52' is a cadmium sulphide cell or another photoconductor which has the characteristic that its resistance decreases as the intensity of radiation impinging upon it increases. In its operation, when the source capsule is in its safe position, the resistance of detector 52' is greatly decreased, and meter 62' gives a positive indication of the safe condition. In the use of the circuit of FIG. 2, a minimum meter indication should be established. If the technician operating the device observes a meter reading lower than this minimum when he expects the source capsule to be in its safe position, he should make a check with an external Geiger counter. It may be that the low reading is due to battery age, but, in no case, will the meter give the expected reading when the source capsule is not in its safe position. A short circuit across detector 52' will produce an extraordinarily high indication on the meter which may be protected by a series resistance. In either case, the meter will provide a readily recognizable indication of a malfunction.

When the technician is returning the radioactive source capsule to is safe position, he can observe the meter indication passing through its maximum as the source capsule approaches and moves past the detector. The continuous variation of the meter indication gives absolute assurance to the technician that the source capsule is in the vicinity of the detector. The technician simply adjusts the position of the source capsule until the meter gives a maximum reading. The lock 34 is then operated to extend plunger 35, and connector 32 is disconnected from connector 18. The meter can be at a remote location from the shield if desired.

It should be noted at this point that the electrical circuit of FIG. 2 is perfectly suitable where radioactive sources having relatively long half-lives are used. However, in the case of a radioisotope having a short half-life, for example, Iridium 192, which has a half-life of 74 days, consideration must be made for variations in source strength which occur over a period of time. In practice, the strength of the radioactive source might decrease over a period of time by a factor of 100. FIGS. 3 and 4 show alternative circuits by which these source strength variations are taken into account so that the meter indication, when the source is in its safe position, is approximately the same regardless of the source strength.

Referring particularly to FIG. 3 a battery 58'', a meter 62'', a detector 52'' and a resistor 66 are connected in series. Detector 52 '' is located adjacent the safe position of the source within the shield. The circuit of FIG. 3 operates similarly to that shown in FIG. 2 in that the presence of the radiation source in proximity with detector 52'' causes its resistance to decrease, and causes an increase in current through meter 62''. However, while the circuit of FIG. 2 is highly sensitive to differences in detector resistances, especially in the range of low resistances, in the case of FIG. 3, the inclusion of resistor 66 in series with the detector 52'' decreases the sensitivity of the circuit to differences in detector resistance in the low resistance range. The circuit of FIG. 3 consequently exhibits similar meter readings for radiation sources in the safe location regardless of their radiation intensities, and it is therefore capable of accommodating radiation sources having short half-lives.

The circuit of FIG. 4 produces a result similar to that produced by the circuit in FIG. 3, and, in addition, it provides amplification so that relatively insensitive detectors can be used, and weak radiation sources will be accommodated.

A battery 58''' has its positive end connected to line 68, and its negative end connected to line 70. Resistors 72 and 74 are connected in series between lines 68 and 70. The emitter-collector circuit of PNP-transistor 76 is connected in series with resistor 78 between lines 68 and 70, the emitter of the transistor being connected to line 68. Resistors 72, 74 and 78, along with transistor 76 form the arms of a Wheatstone bridge. Milliammeter 62''' is connected between the junction of transistors 72 and 74 and the connection between the collector of transistor 76 and resistor 78 to form the bridge. Photoconductor 52''' is connected at one terminal to line 68, and its other terminal is connected through resistor 79 to line 70. NPN-transistor 80 has its emitter connected to line 70, and its collector is connected directly to the base of transistor 76, and through resistor 82 to line 68. The base of transistor 80 is connected to the junction between resistor 78 and photoconductor 52'''.

The parameters of the various components are desirably selected so that the bridge is in a balanced condition when the resistance of photoconductor 52''' is high. As the resistance of the photoconductor decreases as a result of radiation, both transistors become increasingly conductive, and the bridge becomes unbalanced so that a current is registered by meter 62'''.

A Wheatstone bridge has the characteristic that it is most sensitive to variations in the resistance of one of its arms when it is near its balanced condition, and less sensitive when it is brought further away from its balanced condition. Accordingly weak and strong radiation sources are responded to similarly. Further compensation can be accomplished, if desired, by operating one or both of the transistor near saturation.

In summary, the radioactive source position indicator in accordance with the invention is "fail safe" in that it is impossible for it to indicate that the radioactive source is in its safe position when it is not. Malfunctions in the electrical circuitry will produce readily recognizable indications warning the operator that they exist. High reliability is achieved because of the simplicity of the apparatus and the absence of moving parts (with the exception of the meter movement). The auxiliary circuitry permits the apparatus to provide consistent responses to radioactive sources having short half-lives.

We claim:

1. A shield for storing a radioactive source comprising a mass of radiation-shielding material having a passage extending within said material through which the source may be moved between a safe storage location and a position for use, said passage being tortuous so that the safe storage location is one from which radiation cannot be emitted to the exterior of said mass of shielding material, radiation detecting means located closely adjacent to said safe storage location for providing an electrical response to radiation, for indicating the

intensity of the radiation received by said detecting means, and an electrical connection between said detecting means and said indicating means for actuating said indicating means in response to the intensity of radiation received by said detecting means from the source, said electrical connection comprising means for decreasing the sensitivity of the indicating means, in the high range of radiation intensities, to variations in the intensity of the detected radiation, below that sensitivity which would exist in the absence of said decreasing means.

2. A shield according to claim 1, in which said detecting means comprises a photoconductor, in series with a source of electric current and said indicating means, and said means for decreasing the sensitivity of said indicating means comprises a resistor in series with said photoconductor, said source of electric current and said indicating means.

3. A shield according to claim 1, in which said means for decreasing the sensitivity of the indicating means comprises a bridge circuit, means responsive to the detecting means for varying the resistance of one branch of said bridge, and wherein said indicating means is responsive to the output of said bridge.

4. A shield for storing a radioactive source comprising a mass of radiation-shielding material having a passage extending within said material through which the source may be moved between a range of storage positions and a position for use, means for preventing radiation from a radioactive source from escaping to the exterior of said mass of shielding material when said radioactive source is located within said range of storage positions, radiation detecting means located closely adjacent said range of positions within said passage for providing an electrical response to radiation, indicating means, and an electrical connection between said detecting means and said indicating means for actuating said indicating means in response to the intensity of radiation received by said detecting means from the source, said electrical connection comprising means for decreasing the sensitivity of the indicating means, in the high range of radiation intensities, to variations in the intensity of the detected radiation below that sensitivity which would exist in the absence of said decreasing means.

5. A shield according to claim 4, in which said detecting means comprises a photoconductor, in series with a source of electric current and said indicating means, and said means for decreasing the sensitivity of said indicating means comprises a resistor in series with said photoconductor, said source of electric current and said indicating means.

6. A shield according to claim 4 in which said means for decreasing the sensitivity of the indicating means comprises a bridge circuit, means responsive to the detecting means for varying the resistance of one branch of said bridge, and wherein said indicating means is responsive to the output of said bridge.

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