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R. MONAGHAN ET AL

3,019,338

THICKNESS DETECTOR FOR COAL MINING MACHINE

Filed Aug. 28, 1957

3 Sheets-Sheet 1

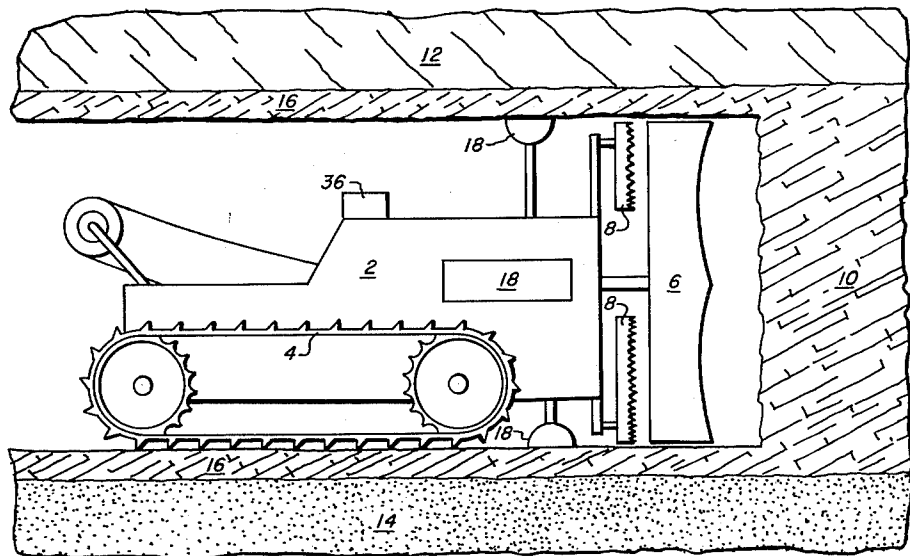


Fig. 1

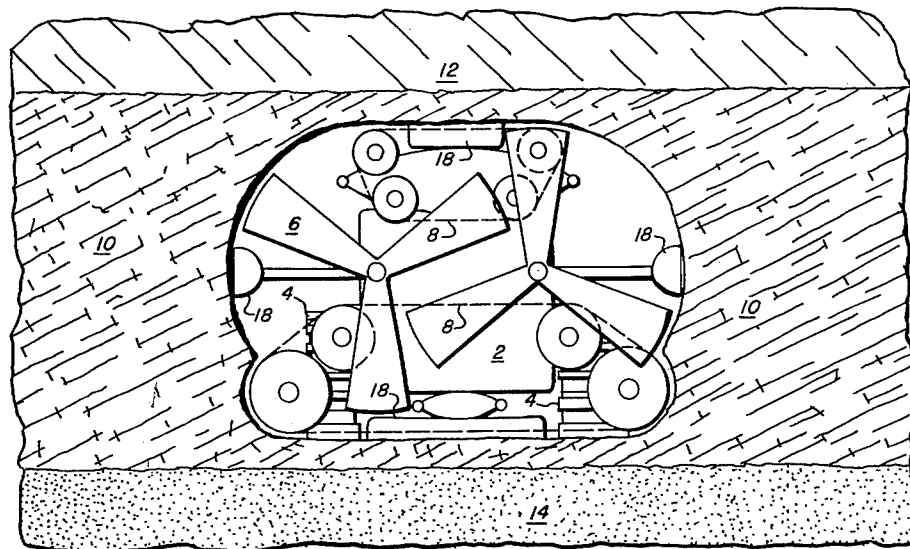


Fig. 2

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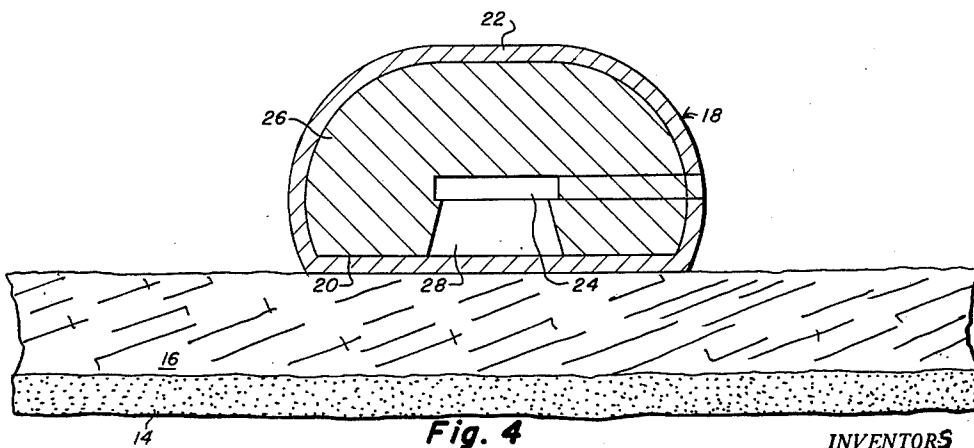
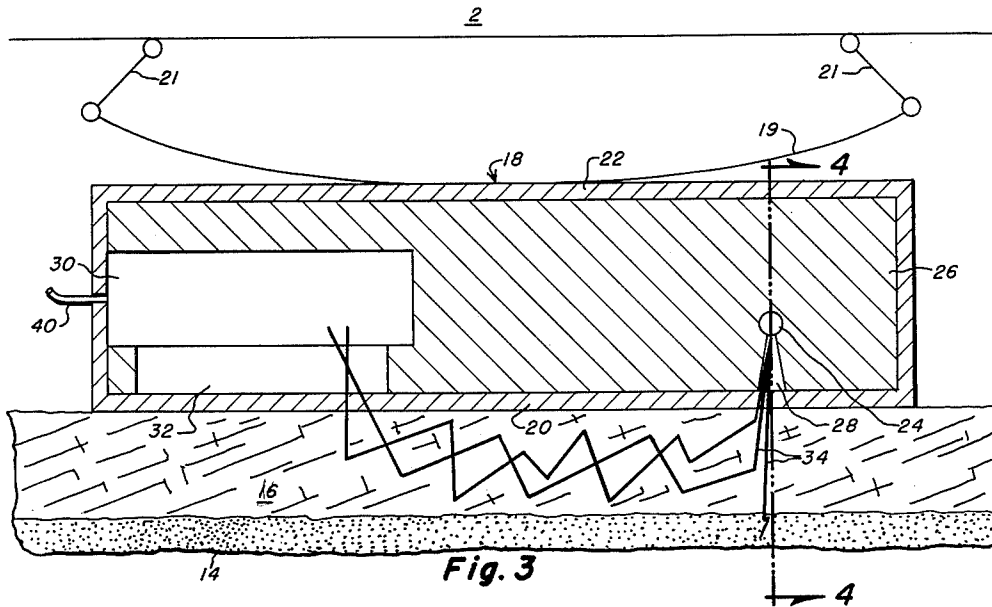
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

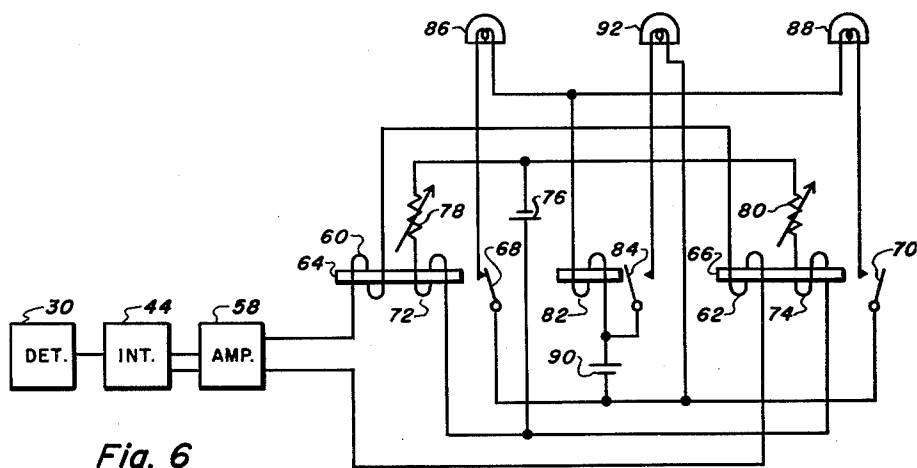


Fig. 6

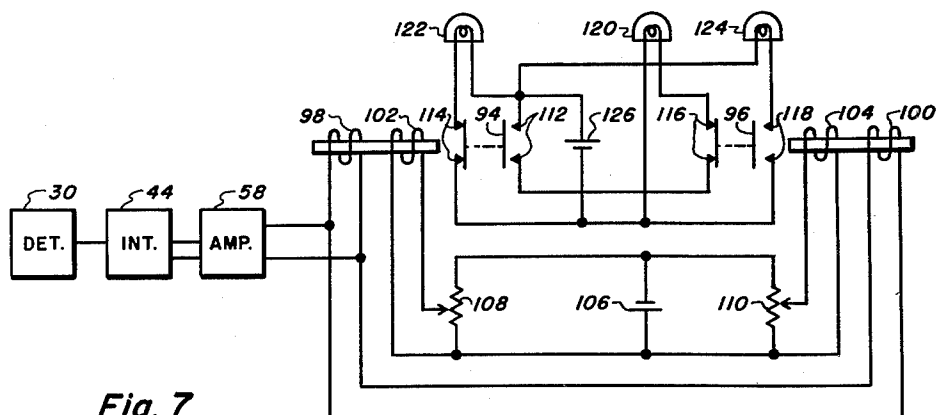


Fig. 7

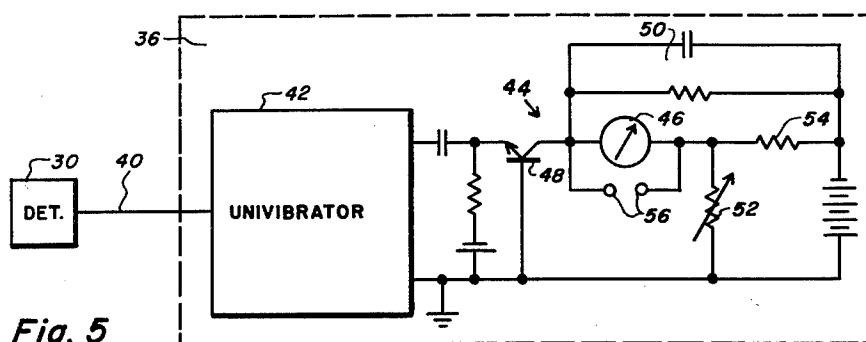


Fig. 5

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THICKNESS DETECTOR FOR COAL MINING MACHINE**Ralph Monaghan, Billy F. Wilson, and Guenther Knapp, Tulsa, Okla., assignors to Well Surveys, Incorporated, a corporation of Delaware**

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8 Claims. (Cl. 250—83.3)

This invention relates to thickness measurement and is particularly directed to novel methods and apparatus for measuring the thickness of a coal seam by means of radioactivity.

In the art of coal mining, various and sundry devices have been proposed to make the work less strenuous and less dangerous for the miners, and to increase coal production. In accordance with this, several machines have been proposed which mine the coal automatically with a minimum of supervision by the operator. These coal mining machines are generally self-propelled devices having rock cutting mechanism on the front. The machines are usually operated by a workman who is either carried by the machine or who walks beside it. However, in some instances the machine may be operated by remote control.

It has been found in practice that coal deposits very frequently overlies deposits of a soft, powdery clay, known as "fire clay." Unfortunately, the fire clay provides little or no traction for the tracks of the coal mining machines and, if the fire clay is exposed during mining operations, the tracks of the machines merely dig in, as the wheels of a car do in soft mud. Moreover, the coal deposits are often covered with a weak shale formation which is very susceptible to caving and which, if exposed, may cause the mine roof to collapse. To prevent these misfortunes, it is desirable not to mine all of the coal in a seam but, rather, to leave thin layers of coal along the upper and lower edges of the seam covering the adjacent formations.

Heretofore, no satisfactory methods or apparatus have been proposed for measuring the thickness of the coal above and below the portion mined. Accordingly, the miners have merely estimated the thickness left with the result that, in some instances, the amount of coal left has been unnecessarily thick causing some coal to be wasted while, in other cases, the amount left has been too thin and the dangers outlined above have been encountered.

These disadvantages of the prior art are overcome with the present invention and novel apparatus is provided for continuously measuring the thickness of the coal seam above and below the portion mined during the mining operation and for providing a warning or indication to the operator whenever the desired limits are exceeded.

The advantages of the present invention are preferably attained by providing the mining machine with means for irradiating the formations together with a detector for measuring radiations scattered by the formations and suitable electronic apparatus for converting the output of the detector into a warning or signal for the operator.

Accordingly, it is an object of the present invention to provide novel methods and apparatus for measuring the thickness of a seam of coal.

Another object of the present invention is to provide novel methods and apparatus for measuring the thickness of a seam of coal by means of radioactivity.

A further object of the present invention is to provide novel methods and apparatus for measuring radioactivity scattered in a seam of coal.

An additional object of the present invention is to provide novel means for detecting the thickness of a surface material overlying a base material having a great-

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er radiation absorption coefficient than said surface material.

A specific object of the present invention is to provide means for irradiating a seam of coal with radioactivity, means for measuring radioactivity scattered by the coal, and electronic means for indicating the thickness of the seam of coal.

These and other objects and features of the present invention will be apparent from the following description thereof wherein reference is made to the figures of the accompanying drawings.

In the drawings:

FIG. 1 is a diagrammatic side view of a typical coal mining machine embodying the present invention;

FIG. 2 is a diagrammatic front view of the coal mining machine of FIG. 1;

FIG. 3 is a longitudinal section of a typical coal thickness detector embodying the present invention;

FIG. 4 is a cross-section of the detector of FIG. 3 taken on the line 4—4 thereof;

FIG. 5 is a schematic diagram of an indicating device for the device of FIG. 3;

FIG. 6 is a schematic diagram of a modified form of the indicating device of FIG. 5; and

FIG. 7 is a schematic diagram of a further modified form of indicating device.

In those forms of the invention chosen for purposes of illustration in the drawing, FIGS. 1 and 2 show a diagrammatic representation of a typical coal mining machine embodying the present invention. The coal mining machine 2 is driven by tracks 4. Two sets of cutting blades 6 are mounted on the front of the machine and chain cutters 8 are mounted adjacent the top and bottom of the machine.

As indicated above, the coal seam 10 will frequently be found sandwiched between formations of stratified shale 12 and powdery fire clay 14. The shale 12 is generally very weak and, if all of the coal in seam 10 is cut away, the probability of the shale caving in is quite high. Moreover, if the fire clay 14 is exposed, the tracks 4 of the coal mining machine 2 will dig into the fire clay, and the coal mining machine will lose traction and become stuck.

To overcome these dangers, it is desirable to leave a layer 16 of coal above and below the region which is mined. The coal layer 16 above the mined area must be thick enough to have sufficient strength to support the overlying formations while the coal layer below the mined area must be thick enough to prevent exposure of the fire clay 14. On the other hand, it is obviously uneconomical to make these layers too thick. Moreover, the location of the various formations may be different at different points in the mine. In view of this, thickness detector units 18 are mounted on the coal mining machine 2 in appropriate positions to provide a continuous indication of the thickness of the coal layers 16 which are being left.

It has been found that, since coal is less dense than either the shale or the fire clay, the coal will scatter gamma rays with less attenuation than other more dense material. Accordingly, if the coal layer 16 is irradiated with gamma rays, a measurement of gamma ray intensity, made near the gamma ray source but spaced and shielded therefrom, will provide an indication of the thickness of the coal.

FIGS. 3 and 4 show a preferred form of coal thickness detector unit 18 which has been found to be highly satisfactory in performance while being rugged in construction and easy to maintain. The thickness detector unit 18 is preferably formed generally in the shape of a right circular cylinder but has one side 20 thereof flattened for engagement with the surface of the coal layer

16. A housing 22 of steel or the like is provided about the exterior of the thickness detector unit and a source of radioactivity 24 is mounted within the thickness detector unit adjacent one end of the housing 22. The source 24 may be either a natural or an artificial source of radioactivity. As seen in FIGS. 3 and 4, suitable shielding material 26, such as lead, is disposed about the source 24 on all sides except for a window 28 which communicates with side 20 of the thickness detector unit to collimate the beam of gamma rays and direct them toward the formations. The window 28 may extend perpendicular to the axis of the thickness detector unit 18 or may be at a slight angle to the perpendicular, however, in the latter case, an angle of less than 45 degrees is preferred. While this construction is preferred, the source may, if desired, be placed immediately adjacent side 20 of the instrument so that the radiations are uncollimated.

Mounted adjacent the opposite end of the housing 22 is a radiation detector 30. The detector 30 may be an ionization chamber, Geiger-Muller counter, proportional counter, scintillation counter or other suitable radiation detection device. Shielding material 26 extends about the sides and back of the detector 30 to prevent unwanted radiations from reaching the detector. Moreover, shielding material 26 fills the space between the radioactivity source 24 and detector 30 to prevent radiations from passing directly from the source to the detector without penetrating the formations. To allow radiations which have penetrated the formations to reach the detector 30, a window 32 is provided in the shielding material 26 adjacent the detector 30 and communicating with the flat side 20 of the thickness detector unit 18. Obviously, if necessary or desirable, the source 24 and detector 30 may be mounted in separate smaller housings if suitable shielding is provided.

For best results, the thickness detector units 18 must be maintained in engagement with the surface of the formation they are to measure. Accordingly, the thickness detector units 18 are preferably resiliently mounted on the coal mining machine 2 in any suitable manner. As seen in FIG. 3, one form of resilient mounting which may be employed is to secure the thickness detector unit 18 to a leaf spring 19 which is attached to the coal mining machine 2 by means of shackles 21.

In use, radiations from the radioactivity source 24 pass through window 28 to irradiate the formations. The interaction of the radiations with the formations will, of course, depend upon the type of radiation emitted by the source 24. In the preferred form of the invention, wherein the source 24 is a gamma ray source having a strength in the range from 10 millicuries to one curie, the gamma rays penetrate the formations and become scattered or absorbed. The gamma rays interact with atoms of the material and are scattered and absorbed. The amount of scattering and absorption depends on the density of the material. When the gamma rays from source 24 penetrate the coal layers 16, as seen at 34 in FIG. 3, some of the gamma rays will be absorbed. However, many more will be scatter about within the formations and some will return to the vicinity of the thickness detector unit 18 and will pass through window 32 to the radiation detector 30. If the coal layer 16 is relatively thick, the number of scattered gamma rays reaching the detector will be high whereas, if coal layer 16 is relatively thin, most of the gamma rays will penetrate through the coal layer 16 into the denser shale 12 or fire clay, as the case may be, and will be absorbed to a greater degree. Thus, in the latter case, the number of scattered gamma rays will be low. Therefore, by measuring the number of scattered gamma rays reaching detector 30, an indication may be obtained of the thickness of the coal layer 16.

For measuring the gamma rays, the detector 30 must not be placed too close to the radiation source 24 or

gamma rays will penetrate through the shielding material 26 to actuate the detector 30 without passing into the formation. Obviously, such a signal would have no relation to formation thickness and would be useless. Furthermore, it has been found that, within limits, the farther the detector 30 is spaced from the source 24, the greater the distinction which the detector can see between different thicknesses of formation. On the other hand, at any given formation thickness, the number of gamma rays reaching the detector decreases as the source to detector spacing increases. Obviously, the optimum spacing will be dependent upon the strength of the source 24 and, within the preferred range of source strength, it has been found that source to detector spacings of less than 4 feet will provide the best results with the exact spacing depending on the range of formation thickness to be measured.

To make the formation thickness indication available to the operator of the coal mining machine, as seen in FIG. 1, the outputs of the various thickness detector units 18 are supplied through wires or the like, not shown, to suitable indicating devices 36 mounted in any convenient location on the coal mining machine adjacent the operator. The indicating devices 36 translate the outputs from the thickness detector units 18 into a suitable visible or audible signal and may be designed simply to provide a warning when safe limits are exceeded or actually to indicate the thickness of the coal layer 16.

FIG. 5 is a schematic diagram of a desirable electronic circuit for an indicating device of the former type, that is, one which provides a warning when safe limits are exceeded. If necessary or desirable, all of the thickness detecting units which are in engagement with a common surface of the formation may be connected to a single indicating device. However, preferably, each thickness detecting unit will be connected to its own indicating device. Thus, as seen in FIG. 5, the output from the radiation detector 30 in the thickness detecting unit 18 is passed through conductor 40 to the indicating device 36. The indicating device 36 preferably comprises a univibrator 42 which emits a pulse of uniform height and width each time a pulse is received from the detector 30. From the univibrator 42, the uniform pulses are passed to an integration circuit 44 which counts the pulses received from the univibrator and indicates the number of counts per unit time on a milliammeter 46 which may be calibrated in units of formation thickness.

The integration circuit 44 is essentially a resistance bridge circuit which is balanced when no pulses are being received from the univibrator 42. Transistor 48 and time delay circuit 50 comprise one side of the bridge while resistances 52 and 54 comprise the other side of the bridge. Meter 46 is connected between the midpoints of the two sides of the bridge. Preferably, resistance 52 is made variable to permit adjustment of the zero or no current point on meter 46.

In operation, when a pulse from the univibrator 42 is applied to the emitter of transistor 48, the resistance of the collector circuit of transistor 48 is altered. Consequently, current is drawn through meter 46 and delay circuit 50 and causes a deflection of meter 46. The length of integration time is determined by the delay circuit 50 and, if desired, the capacitor of the delay circuit 50 may be made variable to permit the time constant to be varied. If additional pulses are applied to transistor 48 from the univibrator 42, the amount of current drawn through meter 46 and the delay circuit 50 will be proportionately greater. Thus, the meter 46 provides an indication of the number of counts per minute received by the integrator 44 from the univibrator 42 and, since the univibrator emits one pulse for each one received from the detector 30, the deflection of the meter 46 corresponds to the number of gamma rays striking the detector 30.

Moreover, as indicated above, when the formations are irradiated with gamma rays, some of the gamma rays will be absorbed in the formations while others will be scattered and some of the scattered gamma rays will strike the detector. Also, since the number of scattered gamma rays reaching a spaced detector is less in denser formations, and since coal is less dense than the shale or fire clay which is generally found above or below the coal, the number of gamma rays reaching the detector will be a function of the thickness of the coal. Thus, using a 400 millicurie cobalt source with a source to detector spacing of approximately 2 feet, applicants obtained counting rates of 4800 counts per minute for coal thicknesses less than 2 inches while 18,000 counts per minute were received for coal thicknesses of about 6 inches and 24,000 counts per minute were obtained with a foot of coal. Since these counting rates are clearly distinguishable, the meter 46 may be calibrated in inches of coal thickness and can, therefore, provide a direct reading of the coal thickness.

Because of the darkness, dust and various other conditions existing in coal mines, it may be difficult to read the meter 46. Accordingly, contacts 56 may be provided and signalling means, such as those of FIGS. 6 and 7, may be connected thereto as an alternative or in addition to meter 46. Preferably, as seen in FIG. 6, the output from integration circuit 44 is amplified by amplifier 58 and, then, is supplied to windings 60 and 62 of polarized relays 64 and 66 which control switches 68 and 70. The windings 60 and 62 are connected in series with each other across amplifier 58. The other windings 72 and 74 of relays 64 and 66 are biasing windings and are connected in parallel with each other across a battery 76 or other suitable constant voltage source. Current from battery 76 flows through biasing windings 72 and 74 and tends to maintain switch 68 closed and switch 70 open.

Under normal conditions, that is, when the coal layer 16 of FIG. 1 is neither too thick nor too thin, the output from detector 30 will be sufficient to keep switch 68 open, but will not be large enough to close switch 70. When the coal layer 16 is too thin, most of the gamma rays will penetrate through the coal layer 16 into the denser shale or fire clay and will be absorbed, as indicated above. Consequently, the output from detector 30 will decrease and will allow switch 68 to close and provide an indication that the layer 16 is too thin. On the other hand, if the coal layer is too thick, more gamma rays will be scattered and less of them will be absorbed. Therefore, the output from detector 30 will increase sufficiently to close switch 70 and provide an indication that the layer 16 is too thick. To permit the values of these limits to be adjusted to desired levels, a variable resistor 78 is connected in series between battery 76 and biasing winding 72 which controls the minimum thickness switch 68. Similarly, variable resistor 80 is connected in series between battery 76 and biasing winding 74 to control the maximum thickness switch 70.

As seen in FIG. 6, switches 68 and 70 are connected in parallel across winding 82 of normally closed solenoid switch 84. A light 86 is connected in series between winding 82 and minimum thickness switch 68 and a second light 88 is connected in series between winding 82 and maximum thickness switch 70. A battery 90 or other suitable constant voltage source is connected in series between both switches 68 and 70 and the winding 82 while a third light 92 is connected across battery 90 through the contacts of switch 84.

As stated above, when the thickness of the coal layer is within the desired limits, switches 68 and 70 will be open and switch 84 will be closed. Thus, current from battery 90 will cause light 92 to be lit indicating that the coal mining machine is operating within the desired limits. If the coal layer becomes too thin, the output from detector 30 will decrease, allowing switch 68 to close. When this happens, current from battery 90 will flow through

winding 82 opening switch 84 to extinguish light 92 while causing light 86 to be lit to indicate that the minimum limit has been exceeded. When the condition has been corrected, the pulse rate from the detector 30 and the current from the integrator 44 and the amplifier 58 will raise sufficiently to open switch 68. The current from battery 90 then cannot flow through winding 82. Consequently, switch 84 recloses extinguishing light 86 and relighting light 92. Similarly, if the coal layer becomes too thick, the output from detector 30 will increase and cause switch 70 to close. Then, current from battery 92 can flow through winding 82 to open switch 84 and extinguish light 92 while causing light 88 to be lit.

In this way, the operator can tell at a glance whether or not he is operating within the selected limits. The thickness detecting units may be mounted on the coal mining machine in such a way as to measure the thickness of either the roof or floor of the mine and, as previously noted, separate indicating devices may be provided for each thickness detecting unit or, if desired, all of the thickness detecting units which engage a common surface may be connected to a single indicating device. If desired, the variable resistors 62 and 64 may be calibrated in units of thickness to facilitate operation of the device. Further, if desired, audible warning means may be provided either in place of or in addition to the visible signals to indicate the maximum and minimum thickness levels. In addition, if the coal mining machine is to be completely automatic, closing of switches 68 and 70 may serve to actuate controls to correct the operation of the machine.

FIG. 7 illustrates a modified form of indicating device which is controlled by two double contact, double wound polarized relay switches 94 and 96. The output from detector 30 is counted by integrator 44 and the output of the integrator 44 is amplified by amplifier 58, as before, and is passed through windings 98 and 100 of switches 94 and 96. In this form of the invention, the windings 98 and 100 are shown connected in parallel, although a series connection may be used. Windings 102 and 104 of switches 94 and 96 are biasing windings and are connected in parallel with each other across battery 106. A potentiometer 108 regulates the minimum thickness limit of the indicating device, while potentiometer 110 regulates the maximum thickness limit.

As stated above, switches 94 and 96 are double contact switches. Thus, switch 94 is normally urged into position to close contacts 112 but, when actuated, moves to open contacts 112 and close contacts 114. Similarly, switch 96 is normally urged into position to close contacts 116 but, when actuated, opens contacts 116 and closes contacts 118. Three lights 120, 122 and 124 are provided to give a visible indication when one of the various limits is exceeded and are connected in parallel with each other across a battery 126 or other suitable voltage source through the contacts 112, 114, 116 and 118 of switches 94 and 96. Thus, light 120 is connected across battery 126 through normally closed contacts 112 and 116 and will be lit during normal operations. Light 122 is connected across battery 126 through normally open contacts 114 and is normally not lit. However, when the output from detector 30 through winding 98 falls below the value for the current from battery 106 in biasing winding 102, switch 94 is actuated to open contacts 112, extinguishing light 120, and closing contacts 114 to cause light 122 to be lit, indicating that the minimum limit has been exceeded. Similarly, light 124 is connected across battery 126 through normally open contacts 118 and is normally not lit. However, when the output of detector 30 through winding 100 increases above the value of the current from battery 106 in biasing winding 104, switch 96 is actuated to open contacts 116, extinguishing light 120, and closing contacts 118 to cause light 126 to be lit, indicating that the maximum limit has been exceeded.

While the foregoing discussion has been limited to the use of gamma rays for measuring coal thickness, it will

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be obvious that the same apparatus may be employed for measuring thicknesses of any surface material which overlies a base material having a higher radiation absorption coefficient than the surface material. Furthermore, if desired, other forms of radio-activity may be found useful for similar measurements. In addition, it will be apparent that the apparatus of the present invention is not limited to measuring the roof or floor of a coal mine but may also be employed for measuring the walls of a mine. Additionally, while the apparatus of the present invention has been described as providing an indication of formation thickness for the operator of a coal mining machine, it will be clear that the output of applicants' device may, if desired, be applied to control mechanisms which would enable the coal mining machine to be operated by remote control or made completely automatic.

Numerous other variations and modifications may obviously be made without departing from the invention. Accordingly, it should be clearly understood that those forms of the invention described above and chosen for purposes of illustration in the drawings are illustrative only and are not intended to limit the scope of the invention.

We claim:

1. A device for indicating the condition of a phenomenon relative to predetermined minimum and maximum limits, said device comprising signal means for establishing a D.C. signal systematically related to said phenomenon, first and second polarized switches, each of said switches having first and second windings, means for applying said signal to both of said first windings, a source of D.C. bias independent of said signal means, means for applying said bias to the second winding of said first polarized switch to oppose the magnetic field in the first polarized switch set up by said signal, said means including first regulating means maintaining the bias in said second winding of said first polarized switch at a value which causes said first polarized switch to be actuated when said signal falls below a predetermined minimum value, first indicating means actuated by the operation of said first polarized switch to indicate when said minimum value is passed, thereby indicating that said phenomenon has passed a first predetermined limit, means for applying said bias to the second winding of said second polarizing switch to oppose the magnetic field in said second polarized switch set up by said signal, said means including second regulating means maintaining the bias in said second winding of said second polarized switch at a value which causes said second polarized switch to be actuated when said signal rises above a predetermined maximum value, and said indicating means actuated by the operation of said second polarized switch to indicate when said maximum value is passed, thereby indicating that said phenomenon has passed a second predetermined limit.

2. A formation measuring device comprising a housing, a radiation source mounted in said housing, a radiation detector establishing a D.C. signal systematically related to a phenomenon to be measured, said detector being mounted in said housing and spaced a predetermined distance from said source, shielding material located in said housing between said source and said detector, means for maintaining said housing in operative relationship with a formation to be measured, first and second polarized switches, each of said switches having first and second windings, means for applying said signal to both of said first windings, a source of D.C. bias independent of said detector, means for applying said bias to the second winding of said first polarized switch to oppose the magnetic field in the first polarized switch set up by said signal, said means including first regulating means maintaining the bias in said second winding of said first polarized switch at a value which causes said first polarized switch to be actuated when said signal falls below a predetermined minimum value, first indicating means actuated by the operation of said first polarized switch to indicate when said

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minimum value is passed, thereby indicating that said phenomenon has passed a first predetermined limit, means for applying said bias to the second winding of said second polarized switch to oppose the magnetic field in said second polarized switch set up by said signal, said means including second regulating means, maintaining the bias in said second winding of said second polarized switch at a value which causes said second polarized switch to be actuated when said signal rises above a predetermined maximum value, and second indicating means actuated by the operation of said second polarized switch to indicate when said maximum value is passed, thereby indicating that said phenomenon has passed a second predetermined limit.

3. An integration circuit comprising a four branched resistance bridge, a fixed resistance and a variable resistance comprising the two branches on one side of said bridge, a time delay circuit comprising one branch of the opposite side of said bridge, a forward biased transistor comprising the final branch of said bridge circuit, the collector of said transistor being connected to said delay circuit, and means connected between the midpoints of the two sides of said bridge for receiving and utilizing current flowing therebetween.

4. A device for indicating the output of pulse generating means, said device comprising a univibrator receiving the output of said pulse generating means and emitting pulses of uniform height and width in response to said output, and an integration circuit receiving the pulses emitted by said univibrator and providing an indication of the number of said pulses, said integration circuit comprising a four branched resistance bridge, a fixed resistance and a variable resistance comprising the two branches on one side of said bridge, a time delay circuit comprising one branch of the opposite side of said bridge, a forward biased transistor comprising the final branch of said bridge circuit and receiving the pulses from said univibrator, the collector of said transistor being connected to said time delay circuit, and an ammeter calibrated in desired units connected between the midpoints of the two sides of said bridge.

5. A formation thickness measuring device comprising a housing, a gamma ray source mounted in said housing, a gamma ray detector mounted in said housing and spaced a predetermined distance from said source, shielding material located in said housing between said source and said detector, means for maintaining said housing in engagement with a formation to be measured, a univibrator receiving the output of said detector and emitting pulses of uniform height and width in response to said output, and an integration circuit receiving the pulses emitted by said univibrator and providing an indication of the thickness of said formation, said integration circuit comprising a four branched resistance bridge, a fixed resistance and a variable resistance comprising the two branches on one side of said bridge, a time delay circuit comprising one branch of the opposite side of said bridge, a forward biased transistor comprising the final branch of said bridge circuit and receiving the pulses from said univibrator, the collector of said transistor being connected to said delay circuit, and an ammeter calibrated in inches of formation thickness connected between the midpoints of the two sides of said bridge.

6. Apparatus for measuring the thickness of a layer of solid material over which a vehicle is propelled, said layer covering and being supported by a base material, said apparatus comprising a housing, a gamma ray source mounted in said housing, a gamma ray detector also mounted in said housing and spaced a predetermined distance from said source, shielding material located in said housing between said source and said detector, means mounting said housing on said vehicle in such manner that said housing is urged against said layer when said vehicle is propelled thereover, and means responsive to the output

of said detector for indicating the thickness of said layer as said vehicle is propelled thereover.

7. Apparatus for measuring the thickness of a layer of solid material over which a vehicle is propelled, said layer being supported by a base material, said apparatus comprising a gamma ray source mounted on said vehicle in a collimating shield in such manner that the collimated gamma rays substantially all strike said layer as said vehicle is propelled thereover, a gamma ray detector mounted on said vehicle in a collimating shield in such manner that gamma rays impinging thereon come substantially only from said layer, said detector being spaced from said source by such predetermined distance that substantially all of said gamma rays impinging upon said detector originate in said source and are scattered within said layer as said vehicle is propelled thereover, and means responsive to the output of said detector for indicating the thickness of said layer as said vehicle is propelled thereover.

8. The method of measuring the thickness of an exposed layer of solid material covering and supported by a base material of density greater than that of said layer, said method comprising the steps of irradiating said layer with gamma rays by urging a source of gamma rays against said layer substantially without absorbing material therebetween, thereby causing some of said gamma rays to be absorbed by said base material and causing other of said gamma rays to be scattered within said solid layer, detecting at a predetermined distance from the place of irradiating the intensity of gamma rays scattered within said solid layer by urging a gamma ray detector against

said layer substantially without absorbing material therebetween, and utilizing the result of said detecting step to provide an indication of the thickness of said solid layer.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,019,338

January 30, 1962

Ralph Monaghan et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 63, for "gamm" read -- gamma --; column 3, line 60, for "scatter" read -- scattered --; column 6, line 61 for "for" read -- of --; column 7, line 5, for "radio-activity" read -- radioactivity --; line 44, for "polarizing" read -- polarized --; line 46, for "maitaining" read -- maintaining --

Signed and sealed this 12th day of June 1962.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents