Nov. 7, 1967 J. DOWELL 3,351,385

APPARATUS FOR STEERING MINERAL MINING MACHINES

Filed Aug. 29, 1963 3 Sheets-Sheet 1

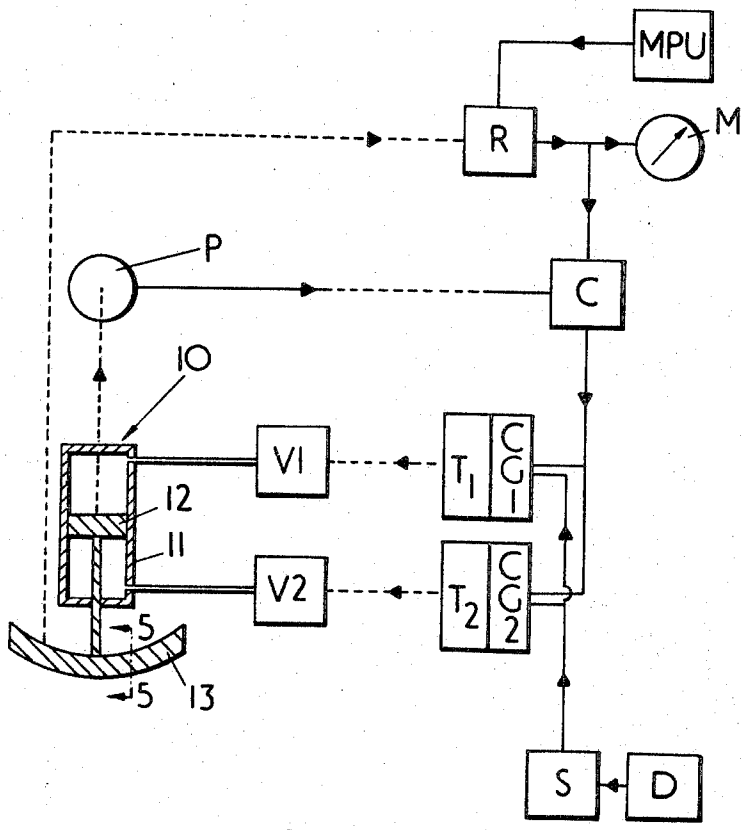


FIG. 1.

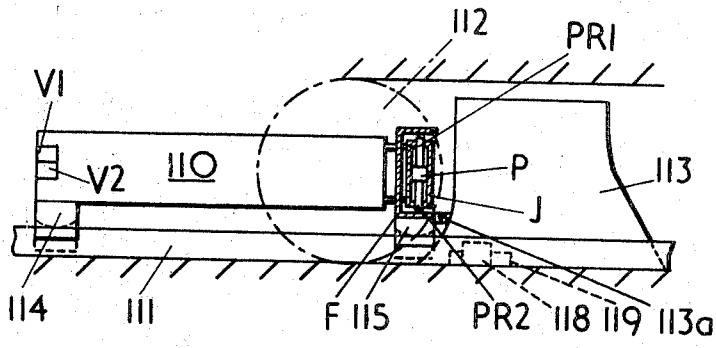


FIG. 2.

INVENTOR
JOSEPH DOWELL

BY Stevens, Davis, Miller & Mosher
ATTORNEYS

Nov. 7, 1967 J. DOWELL 3,351,385

APPARATUS FOR STEERING MINERAL MINING MACHINES

Filed Aug. 29, 1963 3 Sheets-Sheet 2

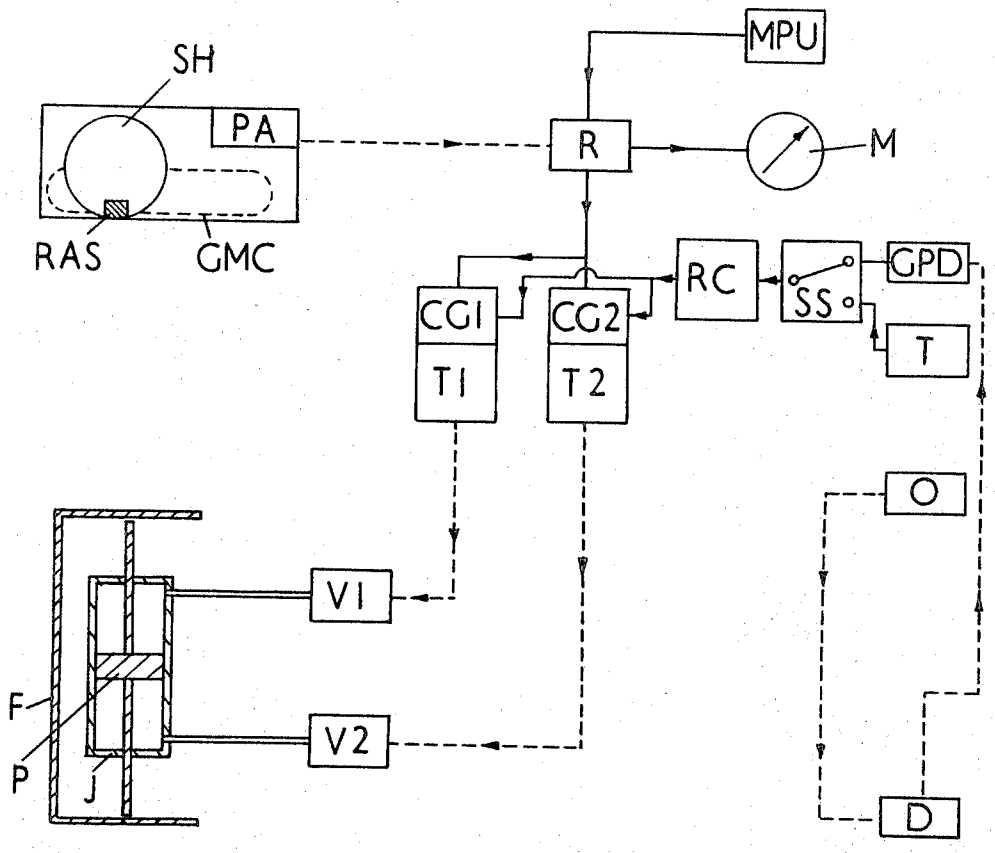


FIG 3

Inventor
Joseph Dowell
By Stevens, Davis, Miller & Mosher
Attorneys

Nov. 7, 1967 J. DOWELL 3,351,385

APPARATUS FOR STEERING MINERAL MINING MACHINES

Filed Aug. 29, 1963 3 Sheets-Sheet 3

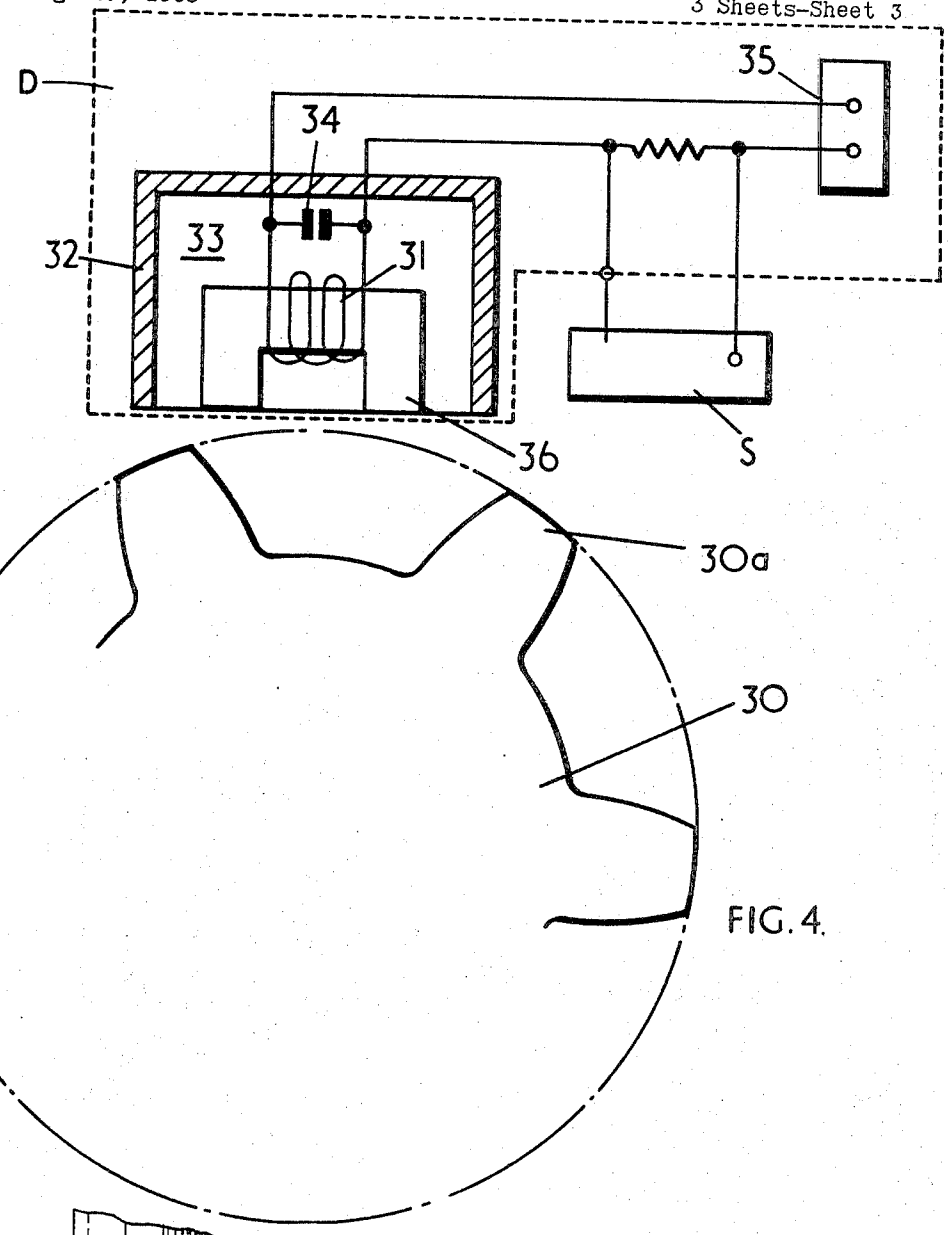


FIG. 4.

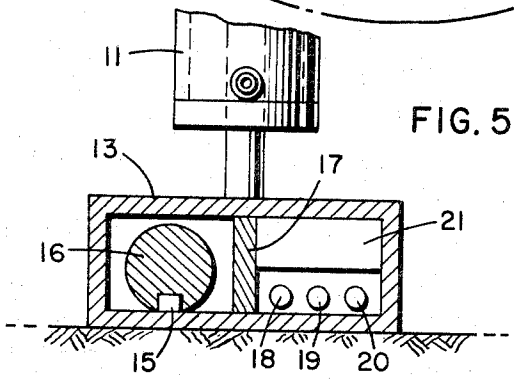


FIG. 5

INVENTOR
JOSEPH DOWELL

BY
Stevens, Davis, Miller & Mosher
ATTORNEYS

United States Patent Office

3,351,385

Patented Nov. 7, 1967

3,351,385

APPARATUS FOR STEERING MINERAL MINING MACHINES

Joseph Dowell, Coalville, England, assignor to Coal Industry (Patents) Limited, London, England, a company of Great Britain

Filed Aug. 29, 1963, Ser. No. 305,400

Claims priority, application Great Britain, Sept. 4, 1962, 33,864/62

5 Claims. (Cl. 299—1)

The present invention relates to apparatus of the kind utilizing the back-scatterng of electromagnetic radiation for steering a mining machine in a seam of mineral so that the machine follows a desired direction of travel with respect to the boundary of the seam. Apparatus of this kind has been proposed, and the present invention is particularly directed to an improved automatic form of such apparatus.

According to one aspect of the invention, in a system for automatically steering a mineral mining machine with respect to the boundary of a seam of mineral including circuit means adapted to give an output responsive to an amount of electromagnetic radiation back-scattered by material adjacent to the machine, gating means are provided whereby said output or a derivative thereof is only passed to further circuit means for spaced intervals in time, the latter circuit means being adapted to effect control of the direction of travel of the machine. With this system, steering correction is only obtained at discrete intervals of time or of distance along the path travelled by the machine in the mineral.

According to a second aspect of the invention, apparatus for automatically steering a mineral mining machine comprises an extensible hydraulic jack for adjusting the direction of travel of the machine in the mineral seam, a source of electromagnetic radiation, and a detecting device responsive to the amount of radiation back-scattered by material adjacent to the machine, the jack, source and device being mounted on the machine, and further comprises a ratemeter circuit connected to the detecting device and adapted to produce an output signal representative of the aforesaid amount of back-scattered radiation, trigger means fed with the ratemeter output arranged to operate valves controlling supply or exhaust of hydraulic fluid to or from the jack, and gating means adapted to pass the ratemeter output to the trigger means only for discrete periods in time, whereby steering correction is obtained only at discrete intervals of time or distance along the path travelled by the machine in the mineral.

Preferably the gating means is arranged to pass the ratemeter output to the trigger means at regular intervals.

Two specific embodiments of the invention will now be described with reference to the accompanying drawings, in which:

FIGURE 1 is a diagrammatic representation of a first embodiment of a system according to the invention for steering a longwall coal mining machine of the trepanner type which rides on the floor of the coal seam adjacent to an armored face conveyor;

FIGURE 2 is a diagrammatic side elevation of a longwall coal mining machine of the well-known drum or disc shearer type which rides on an armored face conveyor,

FIGURE 3 is a diagrammatic representation of a second embodiment of a system according to the invention for steering the machine shown in FIGURE 2,

FIG. 4 is a diagrammatic representation of a preferred form of distance sensing device for use in the systems shown in FIGS. 1 and 3, and FIG. 5 is a section through pad 13 taken along line 5—5 of FIG. 1.

Referring to FIGURE 1, the mining machine (not shown) is steered in the vertical plane by means of a double-acting hydraulic ram or jack 10 having a cylinder

11 rigidly secured to the machine body and a piston 12 rigidly secured to a support pad 13 which rides on the floor of the mineral seam. The control of fluid supply and exhaust to and from the jack 10 is effected by means of known electro-hydraulic valves V1 and V2 which are themselves controlled as will be hereinafter described. The precise construction of electro-hydraulic valves V1 and V2 forms no part of the present invention and can therefore be briefly described. Each of V1 and V2 comprises a hydraulic valve controlling fluid flow to and from the jack, the valve member being coupled to the armature of a solenoid. The valve is in the open condition when the solenoid is energized by an electric current, and in the closed condition when it is not. The hydraulic jack 10 is located just to the rear of the trepanning cutter head at the forward end of the machine in the normal position for such a machine, and pivots the machine about its rear end riding on the seam floor.

A radioactive source 15, such as thulium 170, is encased in shielding 16 and mounted in the underside of the jack 10. The source 15 is adjacent to a thick radiation shield 17, on the other side of which are arranged three parallel Geiger-Muller detector tubes 18, 19 and 20, their axes being parallel to the direction of travel of the machine. Items 15–21 are mounted in an insert in the underside of the support pad 13 so that the source 15 is disposed closely adjacent the strata underlying the pad 13 with the detectors adjacent the source and on the face side of it. For the sake of clarity, FIG. 5 shows items 15–21 on a larger scale. In an alternative embodiment (not shown) there may be two Geiger-Muller detector tubes arranged one on each side of the source, shielding being interposed between each tube and the source, and the tubes being parallel to the direction of travel of the machine. The casing including the source and the detector also includes, in a unit 21, a transistorized pre-amplifier for initial amplification of the signal from the detector tubes. The precise construction and electrical circuitry of the pre-amplifier unit 21 form no part of the present invention and do not differ from the construction and circuitry already well-known for pre-amplifiers for use in amplifying the signal from known Geiger-Muller detector tubes. The unit 21 is therefore not described in detail. The parts 10–21, V1, and V2 are all located on the mining machine, but the remaining parts to be described may be located either on the machine or in a main equipment console at a remote control station, for example at the end of the gate road in the mine. The connection between those parts of the system located on the machine and those parts located at the end of the gate road is by means of extra electrical conductors in the trailing cable attached to the machine and which normally serves to supply the electrical power for driving the machine cutting head. This connection is shown by dotted lines in FIGURE 1.

The signal from the pre-amplifier 21 is fed to a ratemeter circuit R. As with unit 21, the circuitry of the ratemeter R is wholly conventional, and therefore will not be described. The mains power to energize the ratemeter R is derived from a mains power unit MPU, the details of whose circuit once again form no part of the novelty of the present invention. The output from the ratemeter R, which is representative of the amount of radiation back-scattered by material adjacent to the machine and which varies according to the thickness of coal overlying the rock beneath the machine, is fed to a meter M and to a comparator C. The meter M gives a visual indication at a suitable control point at the end of the face or in the gate road of the thickness of coal beneath the machine. The comparator C is also fed with a signal derived from a linear potentiometer P attached to the piston 12 of the hy-

draulic jack. This potentiometer P is arranged to give an output voltage proportional to the jack extension. The comparator C compares the ratemeter signal and the jack potentiometer signal and produces an output representative of the steering correction required to restore the machine to a desired direction of travel, and this output is fed to trigger means comprising the trigger units T1 and T2. Each of the trigger units T1 and T2 comprises a monostable multivibrator circuit in conjunction with a coincidence gate stage and the manner of operation is such that when a signal arrives at the coincidence gate stages from the haulage sampling means S, to be described hereinafter, then the signal from the comparator C, which is continuously fed to the units T1 and T2 is enabled to operate. Unit T1 is the "low count trigger unit" and responds to signals of a low count rate which show that the coal thickness is less than desired (back-scattering by coal being greater than that by a corresponding thickness of rock). Unit T1 is arranged to give an output for a preset time after opening of the coincidence gate CG1 and this output then opens valve V1 for the said preset time and thus initiates a correspondingly predetermined extension of the jack **10**, since a predetermined quantity of fluid flows into the jack when the valve V1 is opened for a preset time, causing the machine to cut upwardly and tend to return to the desired level. Unit T2 is the "high count trigger unit" and responds to signals which show that the coal thickness is greater than desired. Unit T2 then opens valve V2 for a preset time causing the jack **10** to contract by a predetermined amount and the machine to cut downwardly.

Haulage sampling means S connected to the two units T1 and T2 acts to modify the operation of T1 and T2 in such a way that when a signal is fed to either T1 or T2 by the means S at any instant, then the appropriate one of the coincidence gates are opened and the appropriate valve V1 or V2 is energized.

The haulage sampling means S and an associated sensing head D is included because the distance separating the radio-active source and the cutter of the mining machine makes it necessary to prevent a further operation, once an operation of the steering mechanism has been made, until the source and detection equipment has determined the distance between the new floor level and the coal/rock interface.

Referring now to FIG. 4 which shows a preferred form of distance sensing head D, the necessary delay between each operation of the steering mechanism is achieved by counting the teeth **30***a* on a sprocket **30** which drives the machine's hauling chain, and permitting operation of the steering mechanism (if required) only once for every eight or sixteen or other convenient number of teeth counted, i.e. at regular intervals of distance travelled by the machine.

The distance sensing head D is located adjacent to the teeth **30***a* of the sprocket driving the haulage chain by which the machine is pulled along the face. The distance sensing head D consists of a simple search coil **31** whose reluctance is changed by the passage past it of each of the sprocket teeth **30***a*. The coil **31** is mounted in a strong case **32** and moulded in loaded Araldite **33**. The inductance of the coil is 2.1 mH, and this is tuned to resonate at 5.5 kc./s by a capacitor **34** located adjacent the coil **31**. The search coil **31** is fed from a 5.5 kc./s oscillator **35** which is located in the console equipment. The search coil **31** is provided with a gapped magnetic circuit **36**, the coil being located so that the gap faces the teeth **30***a* of the sprocket which drives the cutting machine's hauling chain. As each tooth **30***a* passes the gap a pulse is passed to the haulage sampling means S. The coil thus gives a pulse each time a tooth passes and these pulses are received by register or divider circuits of known construction which are arranged, in one particular example, to provide one output pulse for every sixteen sprocket teeth.

It will be seen, therefore, that in operation of this system, the output of the comparator C is only passed to the trigger means T1 and T2 at spaced intervals of distance along the path travelled by the machine.

A second embodiment of the present invention will now be described with reference to FIGURES 2 and 3.

Referring to FIGURE 2, the mineral mining machine, which in this example is a coal cutter-loader machine of the well-known drum shearer type, has a body **110** which rides on an armoured conveyor **111** and carries a cutter drum **112** and a plough member **113**. The body has sliders **114** and **115** which ride on the side frame members **116** of the conveyor and the plough member **113** is attached to the slider **115** by a pin **113***a*. The vertical position of the body **110** and drum **112** can be altered by a double acting hydraulic ram or jack comprising a cylinder J, piston P and piston rods PR1 and PR2. The rods PR1 and PR2 act on a frame member F attached to slider **115** and the cylinder J is rigidly attached to the body **110**. A γ-ray source (RAS in FIGURE 3), e.g. thulium 170, and detector means (GMC in FIGURE 3), e.g. a Geiger-Muller counter, are mounted in the bottom of the plough **113** in protective containers **118** and **119** respectively positioned with the source roughly centrally across its width and towards the end of the plough nearer to the cutter drum **112**, and with the detector means adjacent to the source and on the face side of it. An interlock is fitted so that the plough **113** cannot be disconnected from the machine body without the γ-ray source being made safe.

Referring now to FIGURE 3, the output from the detector means GMC is fed to a pre-amplifier PA similar to unit **21** shown in FIGURE 1 and the output from the pre-amplifier is fed to a ratemeter R located in a main equipment console, the latter being conveniently situated at the end of the main gate road serving the longwall face being mined by the machine. Connections from this console to equipment such as the mining machine and to the distance sensing head adjacent to the haulage sprocket are shown by dotted lines in FIGURE 3. The ratemeter R is conventional in circuitry and therefore is not described in detail.

As with the system shown in FIGURE 1, the ratemeter output is passed to a meter M, and also to coincidence gate stages shown as CG1 and CG2, one associated with each of two trigger units T1 and T2, these two units constituting the further circuit means hereinbefore referred to. As before, a mains power unit MPU supplies a stabilized +12 volts supply at 350 ma. to the ratemeter and to the other circuits to be shortly described. The ratemeter accepts the pulses from the pre-amplifier PA and integrates them to provide a D.C. output voltage which is proportional to the input count rate. A pulse-lengthening circuit and various values of integrating capacitor (selected by means of a switch) are included in the ratemeter circuit in order to provide compensation for variations caused by decay of the radioactive source RAS.

The trigger units T1 and T2 control the operation of the electro-hydraulic valves V1 and V2 respectively. Both the D.C. output from the ratemeter R and gating pulses from a part of the gating means to be described are fed to the coincidence gate stages CG1 and CG2, and, providing a gating pulse is present coincident with a D.C. output from the ratemeter above a preset maximum level or below a pre-set minimum level, either trigger unit T1 or T2 respectively will operate. As with the system described with reference to FIGURE 1, operation of trigger unit T1 effects energization of the solenoid or valve V1 for a given period, permitting a predetermined quantity of fluid to flow into the jack cylinder, causing the machine to tend to cut upwardly, while operation of unit T2 energizes the solenoid of valve V2 for a given period, causing the machine to cut downwardly.

The gating means herein referred to comprises coincidence gate stages CG1 and CG2 and the remaining parts (i.e. RC, SS, GPD, D and O, optionally plus T) now to be described which serve to generate pulses. A distance sens-

ing head D, identical to that described with reference to FIGURE 4 supplies one pulse per tooth of the haulage sprocket which passes a search coil, as previously described. The haulage sprocket will be located on the cutter loader machine if a conventional drum shearer haulage is employed, but it will be appreciated that the present invention is equally applicable to a machine moved along the face by a remote haulage at the face end, in which case the sensing head D will be located at the haulage at the face end. The pulses are passed to a gating pulse detector GPD which detects and re-forms them. The reformed pulses are then fed to the register circuit RC via a selector switch SS. The register circuit RC comprises a number of bistable dividers which are located on a pair of printed circuit boards, and serves to divide the number of pulses from sensing head D by a convenient number such as 4, 8, or 16, so that the register circuit RC only gives one output pulse per 4, 8 or 16 teeth of the haulage sprocket which pass the head. The oscillator O provides an output for driving the distance sensing head D. A second oscillator, not shown, is provided for controlling a time-gating circuit T which is an optional, though preferred, component of the gating means. Selector switch SS permits selection of either time-gating or distance-gating, that is to say, either the ratemeter output causes operation of the appropriate trigger means at regular intervals of distance travelled by the machine along the face if switch SS connects register circuit RC to gating pulse detector GPD, or the ratemeter output causes operation of the appropriate trigger means at regular (though adjustable) intervals of time if switch SS is in the other (lower in FIGURE 3) position. The detailed circuitry employed for the stages RC, GPD, T and O has not been described as appropriate circuits will be well within the knowledge of one skilled in the electronics art.

Returning now to the trigger units T1 and T2, these receive a signal from the coincidence gate stages CG1 or CG2 respectively dependent upon the level of the D.C. output from the ratemeter R and the presence of a gating pulse from register circuit RC. If the ratemeter D.C. output exceeds a preset reference level and assuming that a gating pulse from register circuit RC is present, trigger unit T2 will receive a pulse from coincidence gate stage CG2 and will operate and produce a pulse. This pulse is used to operate valve V2 for a time determined by the width of the pulse. This width is variable by an adjustable and manually pre-set potentiometer (not shown). Similarly if the D.C. output from the ratemeter R falls below a pre-set reference level (again assuming that the gating pulse is present), trigger unit T1 will operate and effect energization of valve V1 for a time governed by the width of the pulse. The levels of ratemeter output (corresponding to thickness of coal) at which the trigger circuits are operated may be pre-set by manual adjustment of variable potentiometers (not shown), one associated with each of the trigger units T1 and T2.

The trigger circuits T1 and T2 are divided between two printed circuit boards, one board (T1) being associated with the "Raise" solenoid valve V1, and the other with the "Lower" solenoid valve V2.

It will thus be seen that in operation of the machine, when the back-scattered radiation received by detector GMC indicates that the thickness of coal overlying the rock or shale is a certain value, then a ratemeter output of a certain D.C. level will reach coincidence gate stages CG1 and CG2. If this level is less than the predetermined value set in stage CG1, which will be when the coal thickness is less than that desired, then unit T1 will effect operation of valve V1, thus passing a given amount of fluid and moving the jack piston P a given amount in the direction (downwardly in FIGURE 3) which makes the machine cut upwardly. The next gating pulse will then permit the resultant of the continuous comparison of the ratemeter output and the preset levels to be passed to the appropriate one of the units T1 and T2 and if the level of ratemeter output is still below that corresponding to the desired coal thickness, then the valve V1 will again be opened and the piston P again shifted by the given amount in the same direction; thus an intermittent, but repeated adjustment of the machine position is made, the machine being allowed to cut for a certain distance (or time if switch SS is closed to T) before further steering control is applied. In the practical application of this form of automatic steering, it has been found very important that the machine should be allowed to cut for a short period when further control is not applied, in order to avoid difficulties of over-control and excessive hunting.

I claim:

1. A system for automatically steering a mineral mining machine with respect to the boundary of a seam of mineral using back-scattering of gamma ray, X-ray, bremsstrahlung radiation and the like, comprising first circuit means adapted to give an output in response to the amount of back-scattered radiation received by a detector on the machine, gating means adapted to pass said output when it is in error, namely, outside a given desired range, to a second circuit means adapted to control in response to said output the direction of travel of the machine relative to the boundary of the seam, said gating means including a distance sensing device adapted to sense movement of the machine along a mineral face and to produce in response to such movement a distance signal at spaced intervals of time corresponding to given incremental distances traveled by the machine along the mineral face, said gating means being further adapted to pass said output error signal to said second circuit means only if said distance signal is simultaneously present at said gating means.

2. A system as claimed in claim 1 wherein said distance sensing device comprises search coil means adapted to produce pulses in response to passage of the teeth of a chain sprocket wheel the rotation of which corresponds to linear movement of the mining machine along the mineral face.

3. Apparatus for automatically steering a mineral mining machine comprising: an extensible hydraulic jack connected to the machine for adjusting the direction of travel of the machine with respect to the boundary of a mineral seam; a source of electromagnetic radiation and a detecting device responsive to the amount of radiation back scattered by material adjacent to the machine, said source and said detector device being mounted on the machine and being spaced apart a predetermined distance by a shielding material mounted on the machine; a ratemeter circuit connected to the detecting device and adapted to produce an output signal representative of the aforesaid amount of back-scattered radiation; trigger means connected to the said ratemeter circuit and arranged to operate a valve controlling fluid supply to said jack in response to said output signal when it is outside a given desired range forming an error signal; a gating crcuit connected to said trigger means and including a distance sensing device adapted to sense movement of the machine along a mineral face and to produce in response to such movement a distance signal at spaced intervals of time corresponding to give incremental distances traveled by the machine along said mineral face, said gating means being adapted to pass the ratemeter output to said trigger means only when the distance signal is simultaneously present at said gating means.

4. Apparatus as claimed in claim 3, including two trigger means connected to said ratemeter circuit, a first trigger means being adapted to operate a first hydraulic valve only when the ratemeter output exceeds a given level and a second trigger means adapted to operate a second hydraulic valve only when the ratemeter output is less than a second given level, said first and second hydraulic valves being operable to control fluid supply to different sides

of a double-acting hydraulic jack connected to the mining machine for adjusting the direction of travel of the machine with respect to the boundary of a mineral seam.

5. Apparatus as claimed in claim 4 wherein said distance sensing device comprises search coil means adapted to produce pulses in response to passage of the teeth of a chain sprocket wheel the rotation of which corresponds to linear movement of the mining machine along the mineral face.

References Cited

UNITED STATES PATENTS

3,019,338	1/1962	Monaghan et al.	299—1 X
3,198,580	8/1965	Eberle	299—1

FOREIGN PATENTS

857,251	12/1960	Great Britain.

ERNEST R. PURSER, *Primary Examiner.*