

May 6, 1941.

J. A. ADAMS

2,240,822

SYSTEM AND METHOD FOR AUTOMATIC FEED CONTROL

Filed Oct. 25, 1937

2 Sheets-Sheet 1

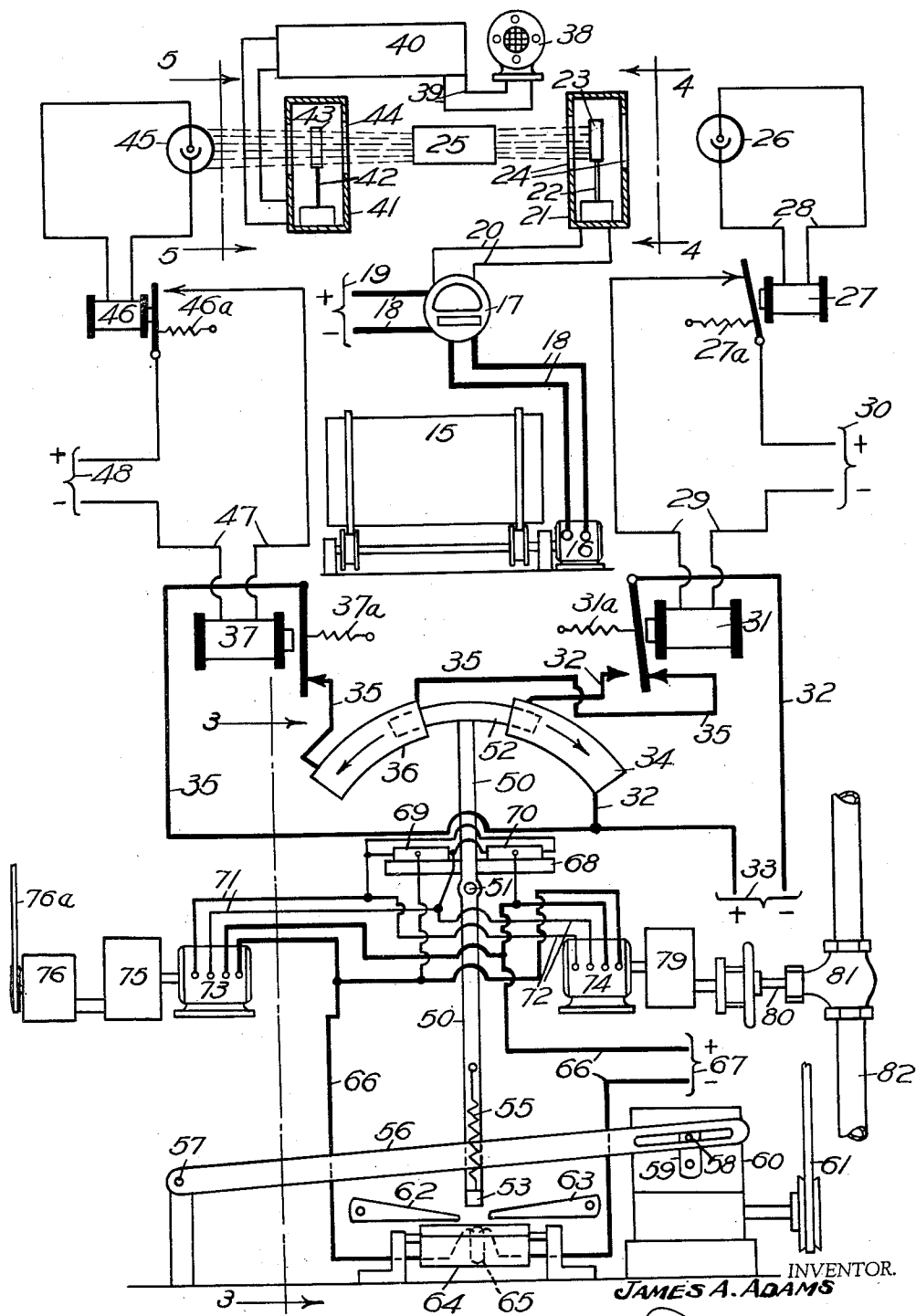


Fig. 1.

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2 Sheets-Sheet 2

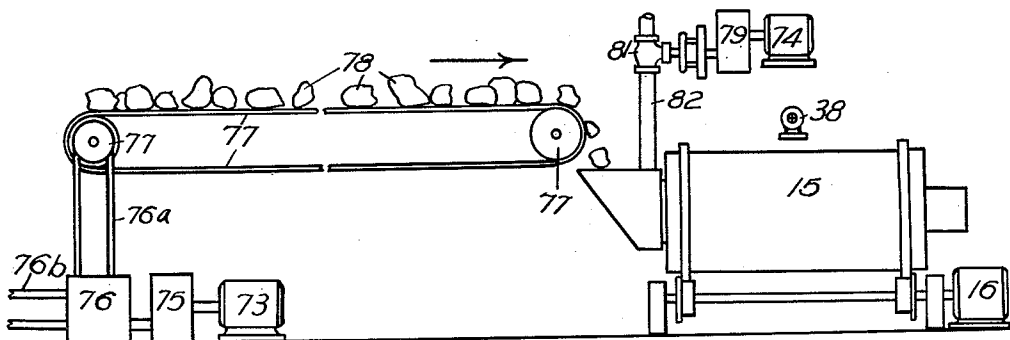


Fig. 2.

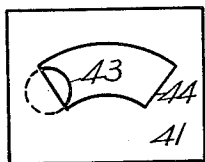


Fig. 5.

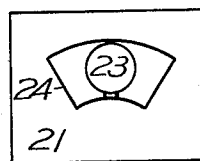


Fig. 4.

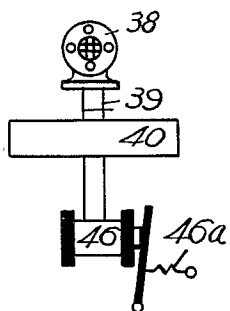


Fig. 6.

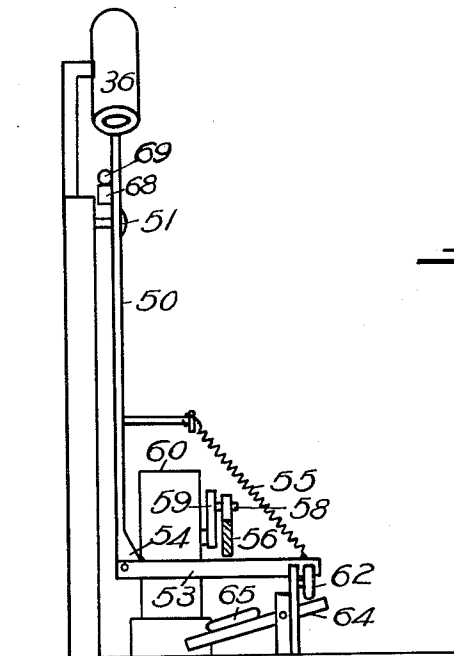


Fig. 3.

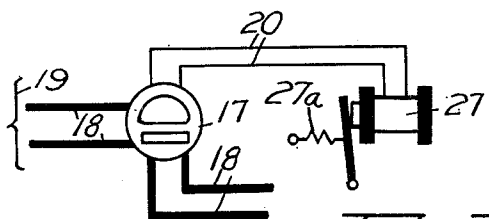


Fig. 7.

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UNITED STATES PATENT OFFICE

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SYSTEM AND METHOD FOR AUTOMATIC
FEED CONTROL

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This invention relates to an improved system for automatically controlling the feed of material to a grinding mill or the like.

In the reduction of ore, for instance, the rock containing the values is fed into a mill, together with water, where the ore is crushed and ground preparatory to the next step in the separation and recovery of the values.

The rate at which the ore and the water are fed into the mill, determines the efficiency of the grinding process. Too much or too little of the ore or the water lowers the output of the mill and the quality of the grind.

Those skilled in the art, know that the sound emitted from an ore grinding mill is indicative of the grinding conditions within. The power being consumed by the milling operation is another indication of conditions and of the work being accomplished inside of the mill.

Therefore, it is an object of this invention to provide a system of automatic feed control for grinding mills that will detect and correct any departure from the optimum quantities of solids and/or liquid being fed to the mill.

Another object is to provide a system of this character that will be jointly actuated and governed by the sound emitted by the mill and the power consumed in its operation.

A further object is the provision of a system of feed control for grinding mills or the like, that readily may be installed and applied to grinding mills that are already in use.

Other objects and advantages reside in details of design and arrangement that will be disclosed more fully in the following description and in the drawings wherein like parts are similarly designated and in which:

Figure 1 is a diagrammatic representation of a control system according to this invention;

Figure 2 is a diagrammatic representation of an arrangement of the controlling means according to this invention;

Figure 3 is a diagrammatic sectional view on line 3—3 of Figure 1;

Figure 4 is a fragmentary view on line 4—4 of Figure 1;

Figure 5 is a fragmentary view on line 5—5 of Figure 1; and

Figures 6 and 7 illustrate modified arrangements of circuits shown in Figure 1.

Description

While it will be apparent as the description proceeds, that the objects of the present invention may be carried out by means other than

those disclosed herein, the structure described and illustrated is well suited for the purposes of the present invention and typifies the essential features of the invention, it being within contemplation of the invention that equivalents may be substituted wherever practical.

In the drawings, reference character 15 denotes a typical grinding mill, that is driven in any suitable manner and here indicated by an electric motor 16, the power demand for which is measured by a meter 17, here shown in an electrical circuit 18 which connects a source of electrical energy 19 with the motor. Connected with the meter is a control circuit 20 that conducts energy to a current-responsive instrument, such as a galvanometer 21, to actuate it according to the power consumed by the mill-driving motor 16. An arm 22 in the galvanometer 21, carries a disk target 23 that follows an arcuate path between the arcuate windows 24 on opposite sides of the galvanometer housing, as the arm is deflected by variations in the current value.

A source of light 25 directs a beam through the windows 24, when the target moves from its predetermined normal position, onto a photoelectric cell 26. When the target is in its normal central position as shown in Figures 1 and 4, the light beam is interrupted thereby and the cell is not energized.

The photoelectric cell 26 is connected with a sensitive relay 27 by a circuit 28. The relay 27 serves to open and close a control circuit 29 that conducts energy from a source 30 to a main relay 31 that controls a main circuit 32, that conducts energy from a source 33 to an arcuate solenoid 34. The arrangement is such that when the light beam is interrupted by the target 23, the relay 27 permits the circuit 29 to be closed by a spring 27a, to energize the main relay 31, that is opposed by spring 31a, to open circuit 32 and to establish conductive contact with a circuit 35 that is connected to a second arcuate solenoid 36 and is subject to the control of another main relay 37. Both main circuits 32 and 35 are connected with a common source of energy 33 and the arrangement is such that both cannot be simultaneously energized since relay 31 is connected to contact one or the other of the circuits, but not both.

A microphone 38 is connected by a circuit 39 to an amplifier 40 the output of which is delivered to a second galvanometer 41, that includes an oscillating arm 42, a target 43 and windows 44 similar to the first mentioned galvanometer assembly. Another light beam is di-

rected from the common source 25, or any other source, through the windows 44 and onto a second photoelectric cell 45 that controls the main relay 37 through the intermediary of a sensitive relay 46, and a circuit 47, inclusive of a source of energy 48. The arrangement is such, that when the target swings from its normal central position to the side as shown in Figures 1 and 5, the light beam energizes the cell 45 to open control circuit 47 to close the main circuit 35 by the action of a spring 37a which is unopposed when the relay 37 is de-energized. Whether or not the closing of the main relay switch 37 completes the closing of the circuit 35, depends upon the position of main relay switch 31, which when not energized closes circuit 32 and when energized closes circuit 35 as shown in Figure 1.

A normally-balanced element, such as a pendulum beam 50 is pivoted at 51 and carries thereabove an arcuate magnetic core piece 52 that is engaged by the arcuate solenoids 34 and 36 to be drawn into whichever one is energized, if any, the normal condition being that neither solenoid is energized and the pendulum beam is in its central position as shown in Figure 1, for clarity. However, the condition illustrated in Figure 1 is such that solenoid 36 is energized and the core piece 52 may be considered as about to move thereinto or to the left as viewed in Figure 1 of the drawings. The term "left" is used merely for convenience in illustrating, and has no permanent significance.

At the lower end of the pendulum beam 50 is a pivoted arm 53 that is urged upwardly against a stop 54 by a spring 55. Above the arm 53 is an oscillating rod 56 that is pivoted at 57 and is moved in its oscillatory cycle by a crank pin 58 on a crank 59 which is rotated constantly by a speed reducer 60, driven by any convenient motive power not shown, through the intermediary of a belt 61.

On each down stroke, the rod 56 forces the arm 53 downwardly and as long as the pendulum assembly is in its normal central position the arm 53 contacts nothing. But when either arcuate solenoid 34 or 36 is energized, the pendulum swings from its central position so that the arm 53 will contact either pivoted wedge 62 or 63, to depress the one thus engaged, which will, in turn, depress the upper end of an inclined, horizontally pivoted switch element 64 that carries a mercury tube type switch 65, to close a main circuit 66 inclusive of a source of power at 67.

Carried on the pendulum beam 50, is a cross arm 68 that carries two mercury tube type switches 69 and 70 respectively that are cross connected to serve jointly as a motor reversing switch, through reversing circuits 71 and 72.

The main circuit 66 and the reversing circuits 71 and 72 are connected respectively to a motor 73 and a motor 74. The motor 73 is in driving connection with a speed reducer 75, the output of which controls the speed and driving ratio of a variable speed transmission unit 76 that drives a conveyor 77, through the intermediary of a V-belt 76a, at selected speeds, to feed ore 78 or the like, to the grinding mill 15. Power input to the transmission unit 76 is from a source not shown through a belt 76b. The motor 74 drives another speed reducer 79, the output of which turns a valve stem 80, to open or close a valve 81, that controls a flow of liquid, such as water, from a source not shown, through a conduit 82 to the mill 15.

Operation

In use, the microphone 38 is placed adjacent the mill 15, as shown in Figure 2, to pick up the sound emitted by the mill during its operation. So by this arrangement, and the circuits hereinabove described, the sound of the mill and the power consumed thereby, jointly control the movements of the pendulum beam 50 which, in turn, closes the main line switch 65 which completes the circuit 66 to energize the motors 73 and 74 to drive them in the direction determined by the reversing switches 69 and 70 which, in turn, is governed by the direction of deflection of the pendulum beam 50 and the cross arm 68. The upper end of the pendulum will, of course, swing toward the solenoid that is energized, if any, it being possible to have but one solenoid energized at one time.

Normally, both targets 23 and 43 are in a central position to interrupt both light beams and prevent both cells 26 and 45 from being energized thereby. This normal condition permits the pendulum to hang centrally with all main circuits open and all control devices stationary.

Then, for instance, suppose that the power demand by the mill goes down below normal and the mill becomes quiet. This condition will actuate the target 23 that is controlled by the power demand, to move and pass the light beam from the source 25 to cell 26 which will actuate the relays 27 and 31 to close circuit 32 to draw the upper end of the pendulum beam 50 into solenoid 34 which, merely for convenience of illustration, is toward the right as viewed in Figure 1.

The movement of the arm 53, that is carried on the lower end of the pendulum beam, to a position over pivot wedge 62, will force it to operate the main switch element 64 to thereby close the main circuit 66. The tipping of the mercury switches 69 and 70 will close the motor-reversing circuits 71 and 72 in connections to rotate the motors 73 and 74 in the direction to reduce the speed and feed of the ore-conveyor belt 77 and the flow of water through the conduit 82, because the instant condition of the mill requires such reductions.

Then, for another example, suppose the power consumption is normal and the mill becomes abnormally noisy. This condition will actuate the target 43 to move it to pass the light beam to the photoelectric cell 45 so that the sensitive relay 46 will be energized to break the control circuit 47, to completely close the main circuit 35 as illustrated in Figure 1. This will move the pendulum beam toward the solenoid 36, to close the main circuit 66 and the motor-reversing circuits 71 and 72 to drive the motors 73 and 74 in a direction to increase the feed of ore and water to the mill, this condition requiring such increase.

These are typical examples of the operation of the system that is the subject of the present invention. Obviously, other circuits and arrangements could be used to effect desired results. The invention resides in the broad idea of a system of joint control of feed to a mill, by the two factors of the power being consumed, and the noise being emitted by the mill, during operation.

In some installations, it may be preferable to connect the power demand control factor to operate relay switch 37 and to connect the sound control factor to operate relay 31.

Power demand alone is not ordinarily a direct

function of the amount of feed being delivered to a grinding mill of the type involved in this inventive concept. Normally, there is a point of minimum power consumption or power demand, which may or may not indicate optimum feed to the mill. If the feed decreases after the minimum or critical power demand has been reached, an unbalanced condition will develop in the mill, due primarily to the attrition members therein which will actually cause an increase in power demand, even though the feed to the mill has decreased and the amount of useful work being accomplished has also decreased. These erratic conditions are met, according to the present invention, by employing another factor such as the sound emitted by the mill, to cooperate with the power demand by the mill to effect optimum feed to the mill and maximum operating efficiency.

From the foregoing it will be apparent that while sound and power are the factors measured in the preferred arrangement, other factors may be similarly used where practical. Because power demand is a more dependable criterion of optimum grinding conditions, a measure of this factor alone, under certain conditions, will be sufficient for feed regulation. Usually, a control of two factors will be essential, however, to avoid errors that otherwise would be occasioned in the measure of an erratic condition of a single factor used alone.

In Figure 6, an arrangement is shown wherein the output of the microphone 38 is conducted to the amplifier 40 by the circuit 39 and the output of the amplifier then is conducted directly to the sensitive relay 46 which functions as hereinabove explained. In Figure 7, the circuit 20 is connected directly to the sensitive relay 27 to actuate it and effect the sequence of events hereinabove described. The photoelectric cells may be omitted by using these arrangements. A sound of predetermined magnitude or force may be amplified to actuate relay 46 and similarly, a power demand of predetermined value may be used to actuate relay 27.

The control motors 73 and 74 respond to the functions of the mechanism illustrated and described, their directions of rotation being determined by conditions in the mill. These control motors operate only intermittently and for brief periods. Motor 73 does not drive the conveyor element 77 but merely serves to change the output ratio of the variable speed transmission unit 76. Motor 74 operates for brief periods to open or to close the valve 81.

Obviously other types of reversing motors could be substituted for the type illustrated and other circuits and reversing switches could be used therewith to be controlled by the movements of the pendulum beam element 50 or any equivalent element.

The two factors of power demand and the sound emitted from the mill, cooperate to control both water flow and material feed to the mill but if either the feed or the flow are constant, the other input could be automatically varied to change the ore-water ratio. Therefore, under certain conditions either the material feed control or the water-flow control may be omitted. The mechanism then would start, stop and reverse but one of the motors, either 73 or 74 to control but one input to the mill, i. e., solid material or water, the other being subject to manual control or fixed at a constant rate. Obviously, the changing of either one of the inputs would change the ratio therebetween

to correct grinding conditions, if such was required.

When both solid-feed and liquid-flow to the mill are under automatic control, various arrangements of circuits can be used. For instance, the motors 73 and 74 can be so connected to the reversing switch that both inputs are increased or both decreased simultaneously, or the motors can be arranged so that when one input increases the other decreases to quickly vary the ore-water ratio. The arrangements will depend upon conditions. By this system, the control factors and means to use them, are provided to suit various circumstances.

This disclosure is intended to teach the principle that the feed to a grinding mill or the like, may be controlled automatically, by one or more measured factors of the operating conditions. These factors may be other than the ones described and preferably a plurality of factors may be used so that one is a cross-check on the other to the end that the ultimate control is the joint effect of two or more measured factors. The mechanism used to accomplish the control of the feed, may be electrical as illustrated or it may be mechanical or a combination of both, the electrical system disclosed being merely illustrative of one means to carry into effect the above stated discovery of a new principle of automatic feed control.

What I claim and desire to secure by Letters Patent is:

1. A system of feed control for an electrically driven grinding mill, comprising a source of fluid flow to the mill, a feed-element for the mill, two mechanically opposed solenoid coils, a magnetic movable element positioned to be acted upon by either solenoid coil, an electrically driven mechanism controlling solid and liquid feed to the mill and controlled by movements of the magnetic movable element, a source of electrical energy, a sound-actuated relay-switch controlling the connection of one of the solenoid coils with the source of electrical energy, and a power demand-actuated switch controlling the connection of the other solenoid coil with the source of electrical energy.

2. A system of controlling feed to a grinding mill, comprising means to feed the mill inclusive of a source of liquid flow and a solids conveyor, mechanism controlling said feed to the mill, a source of electrical energy, electrical circuits operatively connected with the mechanism, a microphone positioned to pick up sound waves emitted by the mill, a source of a light beam, a photoelectric cell positioned in the path of the beam, a current-sensitive movable target between the cell and the source of light, an electric circuit conducting the output of the microphone to the target, a source of a second light beam, a photoelectric cell positioned in the path of the second beam, a current-sensitive movable target positioned in the second beam between the latter cell and the light source, a circuit connected to register the power demand of the mill on the second said movable target, and relay-switches connected with the respective cells and controlling the connection of the said mechanism-operating circuits with the source of electrical energy.

3. A system of automatic feed-input control to a grinding mill or the like comprising a variable flow of liquid into the mill, a variable solids-feed element for the mill, means for automatically varying the rate of feed of at least one of said

inputs to the mill according to mill-operating conditions comprising an electric circuit inclusive of a source of electrical energy, a mill-sound actuated switch for the circuit, a mill power-demand actuated switch for said circuit, the results effected by the operation of one of said switches being subject to the position of the other, and electromagnetic apparatus connected in the circuit and governed by the position of said switches and controlling the rate of input to the mill.

4. A system of automatic feed-input control to a grinding mill or the like comprising a variable solids-feed element for the mill, means for automatically varying the rate of feed to the mill according to mill-operating conditions comprising an electric circuit inclusive of a source of electrical energy, a mill-sound actuated switch for the circuit, a mill power-demand actuated switch for said circuit, the results effected by the operation of one of said switches being subject to the position of the other, and electromagnetic apparatus connected in the circuit and governed by the position of said switches and controlling the rate of input to the mill.

5. A system of automatic feed control for a grinding mill or the like, comprising a variable feed element for the mill, electrically operated mechanism for controlling said feed element, inclusive of two opposed solenoid coils, a movable beam element between the coils, a motor, a motor control switch operated according to the movements of the beam element, a magnetic core on the beam element for each of said solenoid coils, and a source of electrical energy operatively connected with the said mechanism, and a mill sound-actuated relay-switch and a mill power demand-actuated relay-switch for the respective coils whereby they jointly control feed input to the mill according to mill operating conditions, through the intermediary of the beam element.

6. In apparatus of the character described, inclusive of variable means effective for controlling feed to a grinding mill or the like, mechanism for automatically governing said feed comprising a movable beam element, an electric circuit inclusive of a switch operable according to the position of said beam element, and electromagnetic mechanism responsive to the factors of mill power demand and mill sound jointly, positioned and adapted to move said beam element according to mill operating conditions whereby the said variable feed means is varied.

7. In apparatus of the character described, inclusive of electrically driven variable means effective for governing feed to a grinding mill or the like, mechanism for automatically controlling said variable means, comprising a movable beam element, an electric circuit inclusive of a switch and a source of actuating electrical energy connected with said variable means and operated according to the position of said beam element, and electromagnetic mechanism responsive to the factors of mill power demand and mill sound jointly, positioned and adapted to move said beam element according to mill operating conditions whereby the said variable feed means is varied.

8. In apparatus of the character described, inclusive of electrically controlled variable means

effective for governing feed to a grinding mill or the like, mechanism for automatically operating said variable means, comprising a beam element mounted for arcuate movement, an electric circuit inclusive of a switch and a source of actuating electrical energy connected with said variable means and operated according to the position of said beam element, and electromagnetic mechanism responsive to the factors of mill power demand and mill sound jointly, positioned and adapted to move said beam element along its normal arcuate path according to mill operating conditions, and means intermittently to move a part of said beam element out of its normal arcuate path whereby the said variable feed means is varied.

9. A system of automatic feed-input control to a grinding mill or the like comprising a variable feed element for the mill, and means for automatically varying the rate of feed to the mill according to mill-operating conditions comprising an electric circuit inclusive of a source of electrical energy, a mill-sound actuated switch for the circuit, a mill power-demand actuated switch for said circuit, the switches being connected with said circuit so that the results effected by the operation of one of said switches is subject to the position of the other, and electromagnetic apparatus connected in the circuit and associated with the feed element and governed by the position of said switches thereby controlling the rate of input to the mill.

10. In a system of automatic feed control for grinding mills and the like, the improvement which comprises means for automatically governing the rate of feed to the mill, which includes a variable feed element for the mill, electrically operated mechanism inclusive of a suitable energizing circuit governing the variable feed element, a mill-sound-responsive electric switch, a mill power-demand-responsive switch, said switches being connected in said circuit so that the results effected by the operation of one switch depends upon the operative position of the other switch.

11. In a system of automatic feed control for grinding mills and the like, the improvement which comprises means for automatically governing the rate of feed to the mill, which includes a variable feed element for the mill, electrically operated mechanism inclusive of a suitable energizing circuit governing the variable feed element, a mill-sound-responsive electric switch, a mill power-demand-responsive switch, said switches being connected in said circuit so that the results effected by the operation of one switch is modified by the operation of the other switch.

12. In a method for automatically controlling feed to a grinding mill or the like having a variable feed element, the improvement which comprises actuating an electric switch by the sound of the mill, actuating another electric switch by the power demand of the mill, and coordinating the results effected by the operation of the switches so that one modifies the other, and governing the operation of the variable feed element by the resultant effected by the two coordinated switches.

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