

June 21, 1960

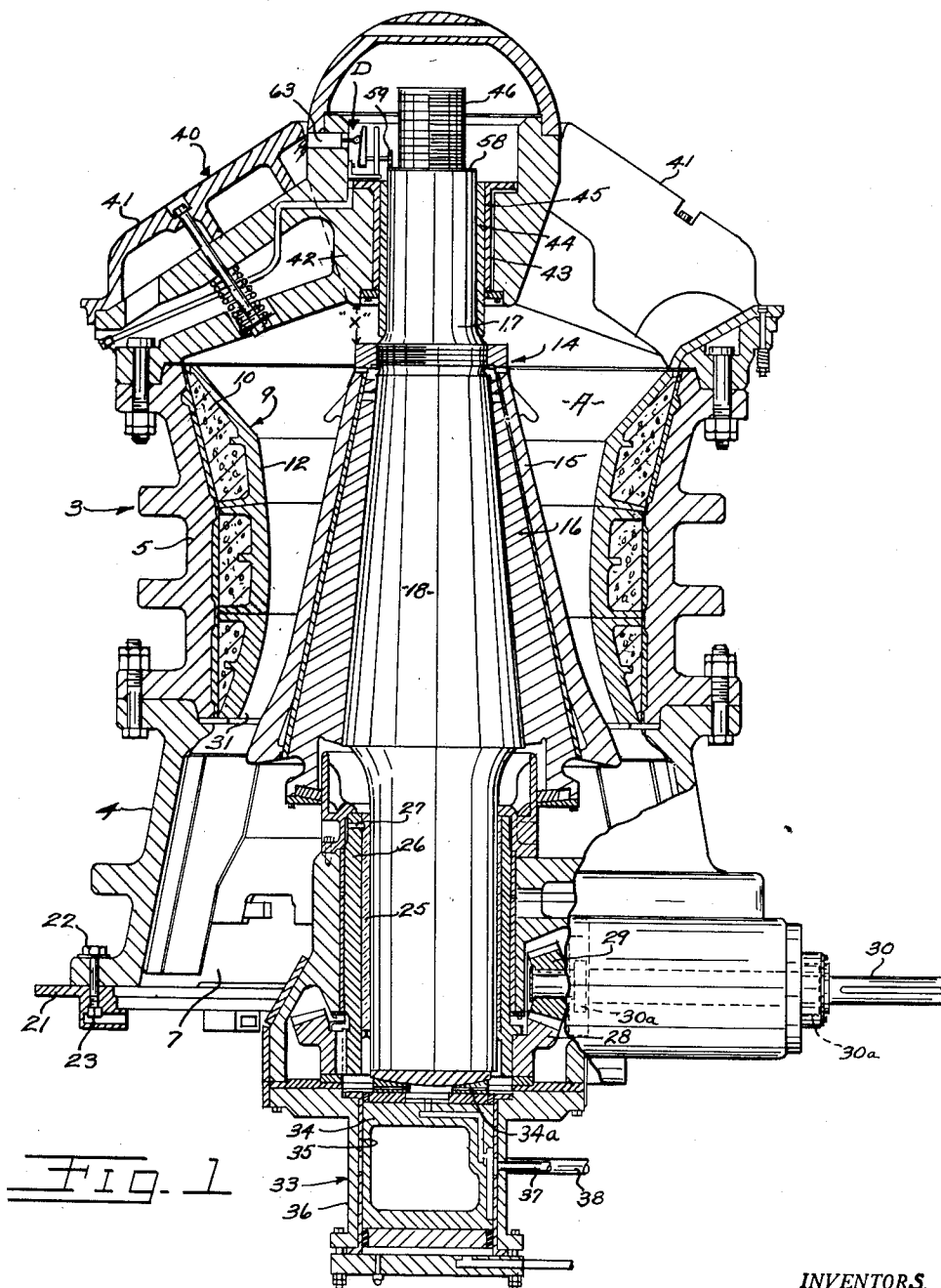
C. D. CROSS ET AL

2,941,732

DIMENSIONAL INDICATOR FOR INACCESSIBLE LOCATION

Filed Feb. 12, 1958

3 Sheets-Sheet 1



INVENTORS.
CARROL D. CROSS
ASHLAND S. HENDERSON
JOHN R. RIEDE
ROBERT R. REISINGER

BY *Hyde, Meyer, Baldwin & Doran*
ATTORNEYS

June 21, 1960

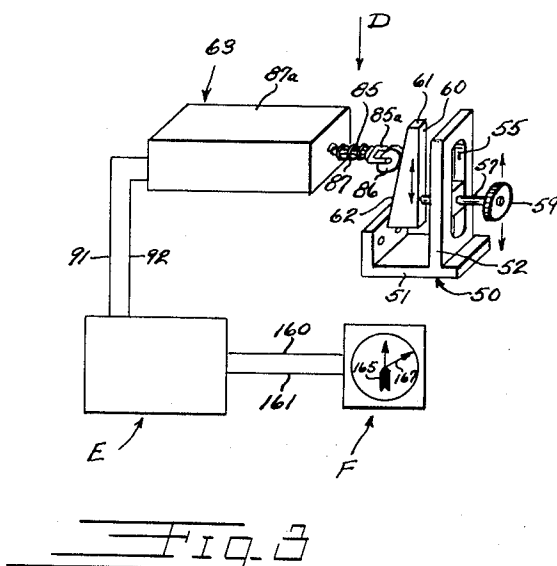
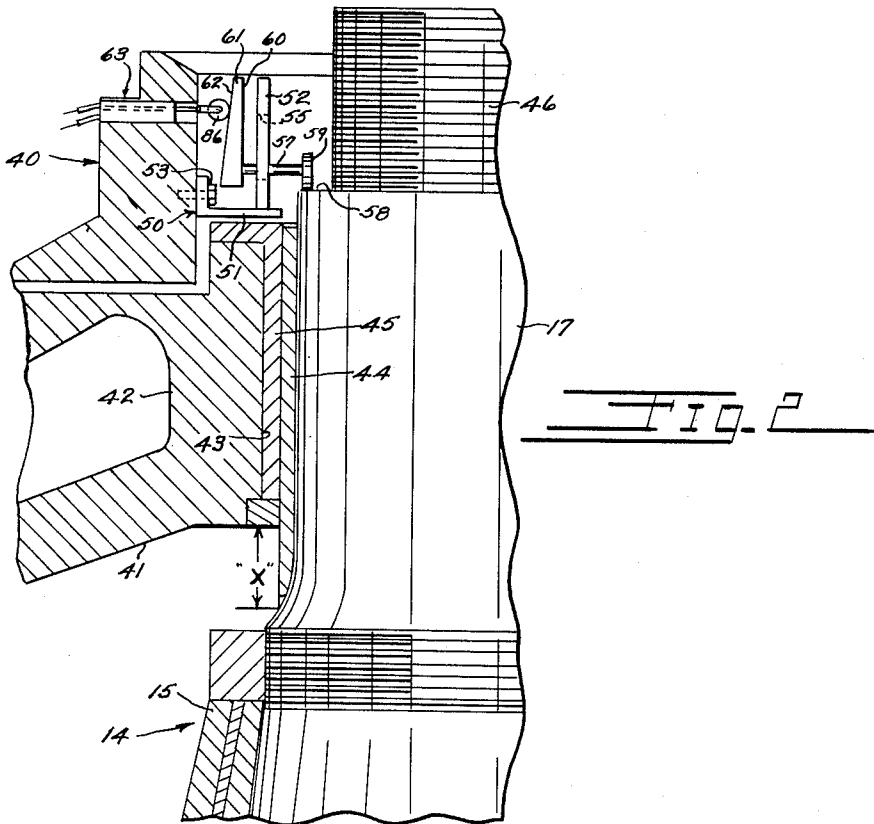
C. D. CROSS ET AL

2,941,732

DIMENSIONAL INDICATOR FOR INACCESSIBLE LOCATION

Filed Feb. 12, 1958

3 Sheets-Sheet 2



INVENTORS,
CARROL D. CROSS
ASHLAND S. HENDERSON
JOHN R. RIEDE
ROBERT R. REISINGER

BY: Hyde, Meyer, Baldwin & Doran
ATTORNEYS

2,941,732

DIMENSIONAL INDICATOR FOR INACCESSIBLE LOCATION

Carrol D. Cross and Ashland S. Henderson, Silver Bay, John R. Riede, White Bear Lake, and Robert R. Reisinger, Mahtomedi, Minn., assignors to Reserve Mining Company, Silver Bay, Minn., a corporation of Minnesota

Filed Feb. 12, 1958, Ser. No. 714,771

24 Claims. (Cl. 241—37)

This invention relates to a novel and improved method and means for determining and indicating the linear extent of a variable dimension in a relatively inaccessible location between relatively movable parts of an operating mechanism. More particularly the invention relates to means of the type above characterized for accurately sensing and indicating the amount of movement of a member which is movable relative to a cooperating member.

In the preferred embodiment to be described, the apparatus of the present invention is especially designed for use with an ore crusher utilized in the processing of low grade ferrous ores such as taconite, the apparatus being effective to accurately measure and indicate the spacing between the ore crushing members such that the crusher operation may be controlled to provide a substantially constant size of ore particle or lump output.

Present day methods of producing commercially useful quantities of iron from taconite ore sources call for what is known in the art as "beneficiation" of the mine run ore. One successful process of beneficiation of said ore comprises generally the initial steps of coarse and fine crushing, whereby the ore, as removed from the mine is broken up into successively smaller particles or lumps; secondly, concentration, wherein the ferrous material from said ore is comminuted and separated from the gangue material or tailings; and thirdly, pelletizing, wherein the concentrated ferrous material may be combined with binder and coating materials such as bentonite and pulverized coal and then formed into "pellets" in a manner known in the art.

The crushers which normally perform the coarse and fine crushing of the mine run ore are preferably controlled so that a predetermined size of particle or lump is obtained. In one specific operation to be hereinafter referred to as an exemplification of the use of the invention, a coarse crusher is controlled to deliver particles or lumps having at least one dimension less than seven inches, and one type of subsequent fine crusher is normally controlled to deliver particles or lumps having at least one dimension of less than four inches. The particle sizes as above referred to may be changed if desired in order to facilitate the crushing process in particular circumstances, and also if it is determined that other suitable sizes are more readily adaptable to the remaining process steps in the beneficiation of said ore material.

One type of coarse crusher which may perform this operation is known as a gyratory crusher and comprises generally a stationary shell of substantial cylindrical configuration having a plurality of plates or "concaves," as referred to in the art, rigidly fastened to and lining the interior wall thereof to define a fixed substantially annular crushing surface having a reduced waste portion. A crushing head, comprising a mantle generally conically shaped in external configuration, is mounted on a shaft, the latter being disposed vertically and supported on its lower end such that the mantle extends upwardly within the shell. The mantle is spaced radially inwardly of the

concaves to provide a downwardly converging annular space therebetween defining an ore crushing zone. The mantle-carrying shaft is normally gyratably driven from its lower end such that the mantle alternately approaches and recedes from the concaves to a limited extent at any point, except at the center of gyration, and hence, as the particles of ore material fall into the crushing zone, the same are nipped or crushed. The mantle is usually formed of a wear resistant material such as manganese steel of a predetermined thickness, as are the concaves, so that the crusher may be operative over prolonged periods of time before excessive wear requires replacement of said crushing members. The shaft is usually constructed and attached to its drive in a manner permitting limited endwise movement and it may be raised and/or lowered to any desired position within the shell by any suitable means so as to provide a predetermined spacing between the crushing members and hence to regulate the clearance aperture of the annular throat for the crusher. This throat is defined as the annular opening between the adjacent lower ends of the mantle and concaves and this opening determines the ultimate size of particle or lump output from the crusher.

As is known in the art, taconite is an iron-bearing ore containing approximately 25 to 35 percent of usable ferrous material, and is extremely hard in its initial state as removed from the mine deposit. Hence, when this material is charged into the crusher, it causes a high rate of wear to the mantle and concave steel surfaces with the result that the crushing zone and likewise the size of the crusher throat is gradually increased in its clearance dimension thereby causing the size of the particle or lump output to be similarly increased. As a result, as will later appear, the crushing head must be periodically adjusted and raised upwardly into the crusher shell a distance proportional to the wear of said crushing surfaces in order to maintain the desired size of lump output. Also, since the iron content of the taconite ore material is relatively low, relatively large quantities must be processed in order to obtain a predetermined quantity of usable ferrous material, and consequently, the rate of wear of the crushing surfaces is substantially high.

In the past, since the space between the crushing surfaces is relatively inaccessible, various indirect methods have been used in an attempt to determine and control the size of the crusher throat at the crushing zone, the best previous method being the observation of the lumps issuing from the crusher to determine whether they are coming out oversized. However, it has been found that the said methods are not entirely adequate, and oftentimes are highly time consuming. To control the size of the particle or lump output from the crusher, it is necessary to maintain the preselected clearance of crusher throat; however, with the ore material source or charge being placed directly into the crushing zone between the mantle and concaves, and since said mantle has a gyratory motion, it is highly impractical if not impossible to insert a measuring device directly into said zone in an attempt to obtain a measurement and indication of the size of the throat and/or the radial spacing between adjoining crushing zone surfaces.

Therefore, a primary object of the present invention is the provision of novel and improved apparatus particularly applicable for use with an ore crusher, and which is operable to determine and provide a visual indication of the spacing between preselected reference planes on the stationary concaves and the movable crushing head, such indication being representative of the initial average size of the crusher throat and being utilized as a basis for subsequent adjustment of the crushing head as the crushing surfaces of the mantle and concaves are gradually worn,

thereby providing a substantially constant size of ore particle or lump output from said crusher.

Another object of the present invention is the provision of novel and improved measuring and indicating apparatus as defined in the preceding object and including means operatively connected between the stationary crusher shell and gyrating mantle said means being actuatable to provide an indication of the change in the clearance space between the crushing members in response to an adjustment made to the crushing head.

Still another object of the present invention is the provision of novel and improved measuring and indicating apparatus as referred to in the preceding objects and wherein an axial adjustment to the gyrating crushing head within the crusher shell is transformed into a transverse linear movement to cause the actuation of electro magnetic means in said apparatus effective to result in a visual indication of the change in the spacing between the crushing head and stationary shell.

Another object of the present invention is the provision of novel and improved measuring and indicating apparatus as referred to in the preceding objects and wherein the electro magnetic means includes differential transformer means actuatable in response to an axial adjustment made to the gyrating crushing head within the crusher shell, said adjustment being effective to energize means to provide a visual indication of the proportionate change in the spacing between said crusher members.

The present invention further resides in certain novel features of construction and the arrangement of parts, and additional objects and advantages thereof will be apparent to those skilled in the art to which it pertains from the following description of the preferred embodiment and with reference to the accompanying drawings forming a part of the specification, and wherein:

Fig. 1 is a vertical sectional view of a gyratory type ore crusher embodying the measuring and indicating apparatus of the present invention and showing one form of actuating mechanism for said apparatus operatively connected between the gyrating crushing head and the stationary crusher shell and positioned such as to be actuatable in response to an axial adjustment to said crushing head.

Fig. 2 is an enlarged fragmentary vertical sectional view of the upper portion of the crusher of Fig. 1 and shows in detail the several components of the actuating mechanism of the measuring and indicating apparatus of the present invention;

Fig. 3 is a perspective view of the several components of the actuating mechanism and further shows in diagrammatic form their operative relation with the amplifier device and indicator mechanism of the apparatus of the present invention; and,

Fig. 4 is a schematic wiring diagram of the electrical circuitry of the several parts of the apparatus of the present invention and the manner in which the same are electrically and also mechanically interconnected with each other.

Referring now to the drawings, the measuring and indicating apparatus of the present invention is herein illustrated by way of example, and not as indicative of its scope of utility, for use with a gyratory vertical type ore crusher which is used to perform a coarse crushing operation on the ferrous ore material. The disclosed form of crusher, as viewed in Fig. 1 includes an elongated vertically upstanding barrel or shell 3 comprising a lower part 4 and an upper part 5. The lower end of said latter part is mounted and securely fastened to the upper end of said lower part 4 in substantial axial prolongation such as to provide such shell with a continuous interior cavity 7. A plurality of ring shaped concaves 9 are constructed of a suitable hard metallic material, each concave having a backing or support member 10 usually formed of a concrete base material and shaped

to conform to the interior configuration of each of said concaves. Said concaves are rigidly fastened to the interior wall of the upper part 5 of the shell 3 in such manner as to provide a substantially continuous annular crushing surface 12.

The present embodiment of crusher also includes a movable crushing head 14 comprising a mantle 15 of frusto conical contour and rigidly mounted over a similarly shaped base 16. The crushing head 14 is firmly fixed upon a drive shaft 17, the latter having a medial tapered portion 18 extending centrally through the base 16 and engaging the latter in a press fit relation. The mantle 15 of the crushing head 14 is also constructed of a suitable hard metallic material.

The crusher shell 3 is normally mounted on a base such as indicated at 21 in Fig. 1 and rigidly secured thereto by any suitable fastening means such as bolts 22 and nuts 23 in threaded engagement with the latter such that the lower part 4 and upper part 5 of said shell extend substantially vertically upwardly. The crushing head 14 is disposed centrally within the shell, the conical shaped mantle 15 being spaced inwardly of the concaves 9 so as to form therebetween a downwardly converging annular crushing zone, as is indicated by the reference character A.

The shaft 17 extends downwardly below the bottom of the shell 3 and at its lower end is adapted to be eccentrically driven by means now to be described.

An elongated sleeve 25 is placed over the lower end of the shaft 17, in such manner as to permit the latter to be freely rotatable and also to allow said shaft to be adjustably moved in a longitudinal direction by means to be presently described. An elongated eccentric bushing 26 embraces the outer surface of the sleeve 25 being securely fastened thereto by suitable means such as dowel pins 27. A bevel gear 28 is firmly attached to the lower end of the eccentric bushing 26, and is rotatably driven by means such as pinion gear 29. As shown in Fig. 1, the pinion gear 29 is mounted on the inner end of drive shaft 30, the latter being rotatably supported adjacent its ends by bearing supports 30a mounted in the lower part of the shell 3. Any suitable drive means such as an electric motor (not shown) may be adapted to rotatably drive the pinion shaft 30 and thereby rotatably actuate the bevel gear 28 and connected eccentric 26.

In this manner the shaft 17 and attached mantle 14 are gyratably driven such that the mantle is alternately carried toward and away from successive peripheral points or areas on the crushing surfaces 12 formed by the concaves 9 thereby orbitally varying the crushing zone so that as the ore material moves downwardly into and through said zone it is successively crushed to smaller sizes and finally is discharged from the crushing zone through the crusher throat 31, namely the annular opening between the adjacent lower ends of the stationary crushing surface 12 and the mantle 14. The crushed particles fall into the lower part 4 of the shell 3 wherein they are picked up and transported by suitable means such as an endless conveyor (not shown) and deposited into storage bins or the like in readiness for the beneficiation process.

As previously indicated the mantle is adapted to be raised and/or lowered within the shell in such manner as to change the clearance aperture of the crushing zone and hence the size of the throat so as to obtain any desired size of particle or lump output. For this purpose the lower end of the shaft 17 is supported on a hydraulically actuated elevating means as indicated generally at 33. Said elevating means includes a piston 34 vertically movably disposed in piston chamber 35 of housing 36, the housing being attached to the extreme lower end of the shell 3 directly below the shaft 17. Suitable bearing blocks 34a rigidly mounted on the upper face of the piston 34 provide spaced supports for the lower end of the shaft 17. The piston chamber is connected

in fluid circuit by means of conduits 37 and 38 to a suitable pressure fluid motor (not shown) which is operatable in a conventional manner to raise and/or lower the piston within the piston chamber and thereby cause a similar upward and/or downwardly directed movement to the shaft within the aforesaid sleeve 25. In this manner, the mantle carried by said shaft is occasionally raised and/or lowered within the crusher shell 3 to any preselected position relative to the concaves 9 to thereby maintain a predetermined size of crusher throat and hence to produce a desired size of particle or lump output.

The instant form of crusher also includes a spider 40, having in the present instance three equally circumferentially spaced legs 41 extending radially outwardly from a central hub 42 and rigidly connected at their outer ends to the upper edge of the top part 5 of the shell 3. The upper end of the shaft 17 extends completely through an aperture 43 formed centrally in the hub 42, being supported therein by suitable bearing members such as sleeve 44 and flanged bushing 45. The center of gyration of the shaft is within bushing 45, and the sleeve 44 and bushing 45 have cooperating convex-concave surfaces to permit the gyratory movement of the shaft around the center of gyration. The movement in this zone within bushing 45 is rather minute, and substantially less than that of the lower end of the shaft. The upper end of the shaft 17 may also be provided with suitable threads 46 to which a puller (not shown) may be threadably attached to provide for the removal of said crusher head from the shell when replacement and/or maintenance to the mantle 15 is required.

As previously mentioned, certain ferrous ores such as taconite are extremely hard, and consequently when this type of material is discharged downwardly between spider legs into the crushing zone of the instant form of crusher it causes an extremely high rate of wear to the concaves 9 and the mantle 15. As a result, the crusher throat and adjacent crushing zone are gradually incrementally increased in their radial dimension, thereby causing the size of the particle or lump output of the crusher to be similarly progressively increased. Likewise, as is above stated, since the ore material or charge is placed directly into the crushing zone, discharging therefrom through the throat 31, a direct measurement of the size of said throat and also of the crushing zone during the crushing operation is highly impractical.

The novel and improved apparatus of the present invention is therefore rendered operative to measure or detect and then provide a visual indication of the clearance spacing between the crushing head 14 and the stationary shell 3 which determines the desired size of crusher throat as established at the beginning of the crushing process. This may then be utilized as a basis for periodic subsequent adjustment of the crushing head to compensate for gradual wear of the surfaces of the mantle and the concaves. In this manner the crusher throat may be maintained at a predetermined value so as to provide a substantially constant size of ore particle or lump output from the crusher.

To accomplish this, the novel and improved measuring and indicating apparatus of the present invention includes generally an actuator mechanism D (Fig. 4, and top of Fig. 1) which is operative to detect and translate an adjustable vertical movement of the crushing head into a transverse lineal movement. This movement is effective to initiate an electrical impulse or signal representative of the vertical distance that said crushing head is moved within the shell 3. A signal amplifier E is connected in electrical circuit to the aforementioned actuator mechanism and is operative to receive and amplify the electrical impulse or signal from the latter to a predetermined magnitude representative of said crushing head adjustment, and an indicating device F is connected in electrical circuit to the signal amplifier E and is ef-

fective to transform the amplified electrical signal or impulse from the latter into a visual signal or indication representative of the change in the size of the crusher throat in response to and representative of the vertical adjustment made to the crushing head.

The actuator mechanism D includes a bracket 50 having a base 51 attached to a vertically upstanding leg 52. The base 51 is rigidly fastened by any suitable means such as bolts 53 to the spider 40 preferably intermediate adjoining legs 41 thereof. The upstanding leg 52 of said standard has an elongated vertical slot 55 extending therethrough which slidably accommodates a follower shaft or arm 57. One end of said follower arm extends toward the shaft 17 of the crushing head and projects over an annular horizontal shoulder 58 formed on said shaft adjacent the threads on the upper end thereof. A wheel-type follower 59, rotatably supported on said end of the follower arm 57, is adapted to rest upon the annular shoulder 58 and is operatively responsive to any vertical movement of the crushing head shaft 17. Such movement raises or lowers the follower arm 57 within the aforementioned slot 55 in the same direction as said shaft movement.

The opposite end of the follower shaft or arm 57 is rigidly connected to the rear side 60 of a vertically upstanding cam element 61. The opposite or front side of the cam element 61 has a vertically extending flat cam track surface 62 which inclines upwardly from its lower end convergently toward the oppositely disposed rear side 60. The slope of the cam surface 62 is of a predetermined value, as will hereinafter be more fully explained, and for a given upward and/or downward longitudinal movement of the shaft 17, the cam element is correspondingly moved so that a predetermined portion of the cam surface traverses a fixed point on the stationary spider. As will appear, vertical movement of the cam block 60 induces horizontal movement of a cam follower to be later described, whereby the cam follower travels through a lateral increment proportional to the vertical increment of travel of the shaft and cam block.

The actuator mechanism D also includes a signal generating device 63 (Figs. 3 and 4) which is actuable by the cam element 61 to generate an electrical signal representative of the magnitude of movement of the crushing head shaft 17. Specifically, the signal generating device 63 comprises a pair of matched differential transformers 65 and 66, indicated in broken line boxes D and G in Fig. 4, whose secondary windings 68 and 69 respectively, are connected in parallel in directly opposed relation by lead wires 71 and 72. The respective primary windings 73 and 74 of said transformers 65 and 66 are also connected in parallel by lead wires 75 and 76 and across the secondary winding 77 of power transformer 78. The primary winding 79 of said power transformer is connected through lead wires 80 and 81 to a suitable source of A.C. electrical energy (not shown). The differential transformer 65 is provided with an elongated metallic core 83 disposed intermediate the primary and secondary windings thereof and supported by suitable frame members (not shown). The core is adapted to be movable between said windings in response to the actuation of the aforementioned cam element 61. To accomplish this, the core 83 is integrally provided with a stem portion 85, Fig. 3, extending longitudinally outwardly from the latter and having a forked end 85a rotatably supporting a wheel-type follower 86 on its free end. Said stem extends toward the cam 61 so as to bring the follower 86 into engagement with the cam surface 62 of the latter. Suitable spring means, such as coil spring 87 surrounding the stem 85 and interposed between the forked end 85a of the latter actuator mechanism housing 87a is operable to bias the core 83 toward the cam 61, or to the right as viewed in Fig. 3, and hence retain the follower 86 in slight pressure engagement with the cam surface 62. Said follower is therefore positively

responsive in a lateral direction to the slightest movement vertically of the cam 61. With this construction it is now apparent that when the crushing head shaft 17 is periodically moved vertically upwardly within the crusher shell to place the mantle 15 in a new position relative to the fixed concaves 9, the follower arm 57 is also moved vertically in the same direction as said shaft. As heretofore indicated this movement also causes a vertical movement to the cam 61 which in turn, causes the stem 85 and attached core 83 of the differential transformer 65 to be moved a predetermined distance in a direction perpendicular to the initial movement of the shaft 17 or in a horizontal direction as viewed in Fig. 4. In this manner the core 83 is moved axially through the magnetic field, encompassed by the primary and secondary windings 73 and 68 of the differential transformer 65, to a new position which is effective to change the electrical characteristics and the signal output from the latter, the exact nature and function of which will hereinafter be more fully explained.

The differential transformer 66 which is usually disposed adjacent motor "M" to be later described, is likewise provided with an elongated metallic core 88 disposed between its primary and secondary windings 74 and 69, respectively. The core 88 represents an adjustable flux determining member which is initially set at a point with respect to the movable core 83 such that an initial indicated zero point is obtainable on the indicating device F. The function of the complete signal generating device will become clear in the description of an actual operation now to follow.

Assume that the mantle 15 has been set at a position relative to the stationary concaves 9 so as to provide clearance 31 effective to produce an ore lump output of a desired size. With the mantle thus located, the actuator device is in a standby or neutral condition whereby the cores 83 and 88 are each located within the magnetic field of their respective differential transformers 65 and 66. With the power transformer 78 connected to a suitable source of A.C. electrical energy, the primary windings 73 and 74 of said differential transformers 65 and 66, respectively, are likewise energized and develop, through conventional transformer action, a potential in each of the secondary windings 68 and 69 of the latter. As previously mentioned, the secondary windings 68 and 69 are connected in parallel in a direct opposing or bucking relation, when the actuator mechanism is in the aforesaid neutral condition with core 88 in a preset position. In this position the potential developed in secondary winding 68 is equal and opposite in phase relative to the potential developed in secondary winding 69. Hence, one potential cancels the other. Therefore, when the actuator mechanism is in starting neutral condition, it does not emit any signal.

Assume now that the crushing surfaces of the mantle 15 and concaves 9 have been worn sufficiently to necessitate a vertical upward adjustment to the crushing head 14 so as to return the throat to its desired clearance. As the crushing head 14 is moved vertically upwardly within the shell 3 by means of the aforementioned hydraulic elevating means 33, the follower 59 and attached arm 57 are also carried upwardly so that the cam 61 actuates the stem portion 85 of the core 83. As a result, the core 83 is moved axially through the magnetic field of its differential transformer 65 and effects a change in the potential that is developed in the secondary windings 68. Said changed potential, being in direct opposition to the potential developed within the secondary windings 69 of differential transformer 66, is effective to create a potential difference or signal therebetween which is directly proportional to the distance the crushing head 14 is moved. With particular reference now directed to Fig. 4, this potential difference or signal exists across lead wires 71 and 72 connecting the secondary windings of said

differential transformers in parallel, and by connecting signal lead wire 91 to wire 71 and signal lead wire 92 to wire 72, said potential difference or signal may then be transmitted through the latter and utilized, as will be hereinafter more fully explained, to actuate the indicator device F. As will also be later explained the differential transformer is again balanced to a null potential output condition to give a new setting at new core positions.

In the present form of crusher, as seen in Fig. 1, the crushing head 14 is disposed in its lowermost position within the shell 3, and may be moved vertically upwardly from this position a distance equal to the spacing between the top face of the mantle 15 and the underside surface of the spider hub 42, as identified by the reference character X. By knowing the size and geometry of the configuration of the several parts of the crusher including that of the mantle 15 and concaves 9, the change in the width of the crusher throat 31 can be readily calculated for any adjustment of the crushing head 14 as the latter is moved through a predetermined vertical distance. For instance, assuming that the crushing head 14 may be moved vertically upwardly from its lowermost position a total distance of approximately one foot, the change in the width of the crusher throat 31 may be readily determined, by one skilled in the art, per each inch or fraction thereof of said total distance. Likewise, in order that the actuator mechanism D may be of a suitable minimum size so as not to require substantially large moving parts which might interfere with the operation of the crusher, the cam surface 62 is preferably designed having a slope or inclination, such that for approximately each inch of vertical movement of the crushing head 14, said cam surface will move the stem 85 and attached core 83 a known fraction of one inch in a horizontal direction. Therefore the actuator mechanism D may be very compact in construction for the reasons above noted. However, it is not intended that the above defined physical characteristics of the crusher per se nor of the actuator mechanism be limiting in any sense, for it is apparent that various modifications of the cam 61 and its associated structure may be required when utilized with a similarly operative crusher but one having a different size and configuration of parts.

As previously mentioned, the measuring and indicating apparatus of the present invention also includes a signal amplifier E connected in electrical circuit with the actuator mechanism D and the indicating device F and which is operative to receive and amplify the potential difference or signal from said mechanism to a predetermined magnitude. This magnitude is representative of the crushing head movement effective to actuate the indicating device and thereby give an indication representative of said movement.

For this purpose, the signal amplifier E includes an input transformer 95 having a primary winding 96 connected directly across the signal lead wires 91 and 92 of the actuator mechanism D. Said transformer is also provided with a secondary winding 97 which is connected by wire 98 to the control grid 99 of the first tube 100 of a conventional A.C. amplifier indicated generally by the reference character 101.

There are numerous types of amplifiers well known in the art which may be readily utilized to develop an electrical signal sufficient to actuate the indicating device F; however, the one found to be adequate for the present purpose and function is one manufactured commercially by the Minneapolis-Honeywell Company of Minneapolis, Minnesota, and it is shown in Fig. 4. It includes said first mentioned tube 100 which is shown to be a duotriode of the type known as a 12AU7, coupled in cascade to a second duotriode tube 103, which may also be of the same type as tube 100, and a pair of duotriode power output tubes 105 and 106 of the type such as 12AX7 arranged in parallel, as defined in the art, and having

the input thereto connected to the output anode of tube 103.

The electrical power source for the instant form of amplifier comprises power transformer 108 having a primary winding 109 connected across an A.C. source of energy (not shown) by power leads L_1 and L_2 . Said transformer is also provided with a plurality of secondary windings which are effective to supply the operating potentials to the various components of the amplifier. Specifically, said transformer is provided with a secondary winding 111 which has its one end connected in parallel with one of the anodes 105a and 106a, respectively, in each of the power output tubes 105 and 106 by wire 112, and its opposite end similarly connected in parallel with the remaining anode of each of said power output tubes by wire 113. Said transformer also includes secondary winding 115 which is effective to supply the operating potential to one of the anodes of tube 103 by wire 117. In like manner, secondary winding 119 has its center tap 120 connected by wire 121, through dropping resistor 122 to the remaining anode 143 of tube 103 through wire 122a and load resistance 122b and thence through decoupling resistors 123 to the anodes of tube 100. The anode circuits of tube 100 are also shown to have the usual load resistances 100a and 100b, connected in series with by pass condensers 170 and 171, respectively. The winding 119 is also provided with leads F_1 and F_1 which are connectable to the filament leads of the tubes 100 and 103 also designated as F_1 and F_1 to thereby provide a filament energizing source for the latter. The power transformer 108 is additionally provided with a secondary winding 125 which has its terminals identified by the reference characters F_2 and F_2 , and which are similarly connectable to the filament leads of the output tubes 105 and 106 also designated as F_2 and F_2 to thereby provide an energizing source for said latter filaments.

The signal amplifier may be further characterized by stating that it is responsive to an electrical signal or impulse from the actuator mechanism D to provide an amplified signal or impulse to the indicator device F, and when said actuator mechanism is in its neutral condition, said signal amplifier is also in a state of quiescence no signal being then produced.

The electrical signal output of the secondary winding 97 of the transformer 95 is impressed on the input control grid 99 of tube 100, being further characterized by the resistor 131 and capacitor 132 connected in parallel with each other to form a filter network and additionally connected between the cathode 134 of the tube 100 and said input grid. The cathode 134, in turn, is seen to have a biasing network consisting of resistance 134a connected across a by pass condenser 134b, said resistance and condenser, in turn, being connected at their lower ends to ground lead 118a. The electrical signal is then amplified in the usual manner in tube 100, the output signal from the left hand section of said tube being taken from its anode 175, through coupling condenser 176, through wire 177 and applied to the grid 178 of the right-hand tube sections thereof. Said signal is amplified in both sections of said tube 100 and is taken from its anode 135 and applied, through wire 136, coupling capacitor 137, wire 138, variable resistor 139 and wire 140 to the first control grid 141 of tube 103. Resistances 179 and 180 located in the cathode and grid circuits, respectively, of said right-hand section of tube 100, provide the proper bias to the cathode 181 and grid 178, much in the same manner as resistances 134a and 131 in the left-hand section of said tube provide the bias respectively for cathode 134 and grid 99. Said signal is further amplified in said tube 103, the resistance 183 providing the proper bias for cathode 184 in the left-hand section of said tube, whereas the grid bias for grid 141 is provided through variable resistor 139. The output from tube 103 is then taken from its anode 143, through wire 144, coupling capacitor 145 and wire 146 to the

control grids 147 of the power output tubes 105 and 106. As seen in Fig. 4, the output tubes 105 and 106 are connected in parallel, i.e., the grid elements 147 of the left-hand section of each tube are connected together by wire 185, whereas the cathode elements 136 are connected together by wire 187. Wire 187 is also seen to be connected to each of the cathode elements 188 of the right-hand section of tubes 105 and 106 and to one end of biasing resistor 189, the latter being, in turn, connected at its opposite end to wire 118a. The grid elements 147 of the right-hand section of each tube 105 and 106 are also seen to be connected together by wire 190. Resistor 191 is connected between line 118a and wire 146 to thus provide the proper grid bias for the aforesaid grid elements 147. The anode 192 in the left-hand section of tube 105 and the anode 193 in the right-hand section of tube 106 are connected together through wire 112 to the secondary winding 111 of transformer 108, whereas anode 194 in the right-hand section of said tube 105 and anode 195 in the left-hand section of tube 106 are connected together and to the opposite end of secondary winding 111 by means of wire 113.

The resultant amplified signal of the amplifier tubes 105 and 106 is then taken from the secondary winding 111 of transformer 108, through wire 161 and utilized to actuate the indicator device, F, which in its present form includes a two phase motor M, having a pair of windings 150 and 151 displaced approximately 90 degrees from each other, and a recording instrument such as a meter F_1 or the like. The armature of the motor M is directly connected by any suitable linkage, as indicated diagrammatically at 156 to the recording instrument and is arranged to drive the same in response to its being rotatably actuated in a manner now to be described. Motor M is also operatively linked as indicated by broken line 155 to core 88 of the differential transformer 66 whereby rotation of motor M not only operates indicator F but moves core 88 to null balance position. The winding 150 of the motor M is connected across the power leads L_1 and L_2 and continuously energizable thereby, whereas, the motor winding 151 is connected across the output leads 160 and 161 of the signal amplifier E and energized by the amplified signal from tubes 105 and 106. When the signal amplifier is in its aforementioned quiescent state, i.e., when no signal is received from the differential transformer of the actuator mechanism D, only the winding 150 is energized and hence the motor M will not run. However, when the signal amplifier E produces an amplified electrical signal or impulse responsive to an adjustment made to the crushing head 14, this latter signal is impressed across the winding 151 of the motor M and effects the rotation of its armature at a speed directly proportional to the magnitude of said amplified electrical signal or impulse. As seen in Fig. 4, the lead 160 of the amplifier circuit is connected at its one end to the lower end of the motor winding 151 and is variably connected at its opposite end to the secondary winding 115 of transformer 108. A dropping resistor 197 is connected in said lead 160 so that the potential applied to motor winding 151 is of the proper value.

The conventional amplifier circuit as just described will function without the need of lead wire 160 to amplify a signal from the actuator mechanism D, but is normally provided in said circuit to provide a signal to the motor winding 151 in the event the amplifier tubes 105 and 106 become inoperative. With said lead 160 connected to the secondary winding 115 of transformer 108, and with the amplifier tubes 105 and 106 being inoperative such as occurs when said tubes burn out, a small signal is applied to the bottom end of the motor winding 151 which is effective to cause the motor to remain energized and thus indicate a reading on the meter 153, which reading hence indicates the inoperativeness of the tubes 105 and 106. The aforementioned linkage 156 connecting the armature of the motor M to the recording meter 153 may

be of any conventional construction such that for a given rotational speed of said armature, the indicating arm of said meter, as indicated by the reference character 165 in Fig. 4, is swung through a predetermined arcuate distance. The meter is suitably calibrated in a manner known to one skilled in the art, to give a direct indication corresponding to the vertical distance the crushing head 14 and mantle 15 are moved vertically within the crusher shell 3. It also effects a balance between cores 83 and 88 of the differential transformer as previously described. The positioning of the indicating arm 165 in addition to showing the extent of previous movement also gives the operator an indication of the spacing still existing between the crusher shell 3 and the gyrating crushing head 14 so that he will know how large an adjustment he may subsequently make to the latter without causing said members to clash and thereby damage the crusher. For example, as depicted in Fig. 4, the previous vertical adjustment made to the crushing head 14 is shown to have moved the top face of the mantle 15 to within three inches of the underside surface of the spider hub 42, that being the indicating position of the indicating arm 165, and the operator then knows, that if a subsequent adjustment to the crushing head must be made in order to obtain the desired size of particle or lump output, he may only move the latter a vertical distance of less than nine additional inches in order to prevent clashing between the crushing members.

Having thus set forth in detail the preferred embodiment of the measuring and indicating apparatus of the present invention, its operation, when utilized with the form of ore crusher disclosed herein will now be described.

Assume that the crushing surfaces of the concaves 9 and mantle 15 are substantially new and have not been worn as a result of previous crushing operation. Also assume that the crushing head 14 has previously been raised vertically upwardly within the crusher shell 3 to provide the desired size of crusher throat 31 and adjoining crushing zone A, and that as a result of said vertical adjustment, the meter F_1 of indicator mechanism F signifies that the spacing between the spider hub 42 and mantle 15, as designated by the reference "X" in Fig. 2, is approximately one foot. With the crushing members thus located, and the crushing head 14 being gyratably driven in the manner previously described, the taconite ore is then dropped into the crushing zone A and crushed into successively smaller lumps as it moves downwardly through the latter. Also, due to the gyration of the crushing head 14 and the downwardly converging configuration of the crushing zone A, the introduction of the taconite ore into the latter is effective to cause a rotation to the crushing head such that said ore is distributed substantially completely throughout the crushing zone to thereby provide for the entire annular surfaces of the mantle 15 and concaves 9 to partake of the crushing operation. In this manner, the particle or lump output from the crusher as the same falls through the crusher throat 31 is maintained at substantially its desired size.

Assume now that the crusher has been used over a predetermined period of time whereby the crushing surfaces of the concaves 9 and mantle 15 are worn and it is noted that the size of the particle or lump output is beginning to increase. The operator then actuates the hydraulic elevating means 33 in such manner as to move the crushing head 14 vertically upwardly within the crusher shell until the crusher throat 31 and adjoining crushing zone A are returned to their normally operative dimensional relationship thus returning the particle or lump output to the desired size. The vertical movement of the crushing head 14 operates the actuator mechanism D of the measuring and indicating apparatus of the present invention, in the manner previously described, to initiate an electrical impulse or signal which is proportional to said crushing head movement, and which is then effective to

result in an indication on the meter 153 of the indicator device F of the vertical distance the crushing head 14 has been raised within said shell. In this manner, the operator is capable, in a minimum period of time, of accurately controlling the operation of the crusher so that the particle or lump output is of the desired size. Additionally, the measuring and indicating apparatus provides a visual indication of the remaining distance or spacing between the crushing head 14 and shell, in the neighborhood of the top of the mantle and the spider hub at "X" in Fig. 1, so that in the event a subsequent adjustment must be made to the crushing head 14, the operator knows the maximum distance that the latter can be moved without reducing the dimension "X" to zero and causing crushing members to clash. It is also realized that as the crusher is used over prolonged periods of time wherein the crushing head 14 is repeatedly raised vertically upwardly within the shell 3, the measuring and indicating apparatus of the present invention is operative to provide a constant visual indication of said spacing so that the operator may provide for the replacement of the crushing members when the limit of corrective adjustment has been reached.

Although the respective complementary units 65 and 66 of the differential transformer are shown adjacent to each other in the broken line boxes D and E of Fig. 4, this showing is merely for diagrammatic simplicity. Actually the portion in box D is mounted on the crusher as indicated at 63 of Fig. 1, and the portion in box G is mounted on an instrument panel adjacent to motor M and indicating dial F_1 so as to facilitate movement of core 88 by motor M, as described.

Among the advantages of the invention not heretofore mentioned are the following. Our novel indicating means provides for re-setting the mantle to working position after it has been lowered temporarily because of unavoidable causes such as plugging of the crusher. Further, we can maintain a running check on the mantle position which may accidentally get out of proper working position because of service failures or variations in the mantle supporting mechanism. Also the invention permits us to maintain an accurate quantitative check on the wear of the co-operating crushing surfaces, so that we can schedule replacement of the mantle and concave elements with considerable accuracy. We can also safely avoid raising the mantle to a point where the mantle head nut might contact the spider, at which point of course there would be considerable likelihood of possible damage.

What is claimed is:

1. In an ore crusher of the character described wherein a fixed peripheral shell carries an outer crushing surface and a gyratory shaft member carries an inner crushing surface, said surfaces having complementary inclinations to the longitudinal axis of the shaft whereby endwise movement of the shaft changes the annular clearance space between said surfaces and provides occasional readjustment to compensate for progressive wear, said annular clearance space being relatively inaccessible for dimensional check purposes during the crushing operation, means for determining and indicating the dimensional extent of said clearance space, said means comprising an actuating member having a portion in operative contact with an accessible part of said shaft at a point remote from the loading zone of said crusher and hence protected from the impact of ore material being loaded therein, an actuated member having a part in operative contact with said actuating member, sensing means adjacent to said actuated member and adapted to emit an electrical signal responsive to movement of said actuated member said signal being proportional in intensity to said movement, and indicating means adapted to show the intensity of the said signal, said indicating means being calibrated in units of linear measure, there being an operative connection between said sensing means and

said indicating means whereby to transmit said signal to said indicating means.

2. In an ore crusher of the character described wherein a fixed peripheral shell carries an outer crushing surface and a gyratory shaft member carries an inner crushing surface, said surfaces having complementary inclinations to the longitudinal axis of the shaft whereby endwise movement of the shaft changes the annular clearance space between said surfaces and provides occasional readjustment to compensate for progressive wear, said annular clearance space being relatively inaccessible for dimensional check purposes during the crushing operation, means for determining and indicating the dimensional extent of said clearance space, said means comprising an actuating member having a portion in operative contact with an accessible part of said shaft at a point remote from the loading zone of said crusher and hence protected from the impact of ore material being loaded therein, sensing means including a differential transformer fixed with respect to said shell, said transformer having a movable core so disposed that upon movement of said core said transformer generates and emits an electrical signal which varies proportionally to said core movement, said core being operatively engaged by said actuating member whereby endwise movement of said shaft moves said actuating member and as a consequence moves said core, and indicating means adapted to show the magnitude of said signal, said indicating means being calibrated in units of linear measure corresponding to the extent of movement of said shaft, there being an electric circuit connection between said transformer and said indicating means.

3. In an ore crusher of the character described wherein a fixed peripheral shell carries an outer crushing surface and a gyratory shaft member carries an inner crushing surface, said surfaces having complementary inclinations to the longitudinal axis of the shaft whereby endwise movement of the shaft changes the annular clearance space between said surfaces and provides occasional readjustment to compensate for progressive wear, said annular clearance space being relatively inaccessible for dimensional check purposes during the crushing operation, means for determining and indicating the dimensional extent of said clearance space, said means comprising an actuating member having a portion in operative contact with an accessible part of said shaft, sensing means including a differential transformer having a first and a second movable core, said cores being so disposed that, upon movement of one of said cores relative to the other said core, the secondary circuitry of said transformer generates and emits an electric signal which varies proportionally to said core movement, the first said core being operatively engaged by said actuating member whereby endwise vertical movement of said shaft moves said actuating member, and as a consequence moves the first said core, indicating means adapted to show the magnitude of said signal, said indicating means being calibrated in units of linear measure corresponding to the extent of movement of said shaft, operating means responsive to said signal, means operatively responsive to said operating means and effective on said indicating means, and further means also operatively responsive to said operating means and effective on said second core whereby to move said second core and restore zero output balance in said differential transformer.

4. A device as defined in claim 3 wherein said actuating member contacts said gyratory shaft adjacent to the center of gyration thereof whereby said actuating member is actuated only by endwise movement of the shaft.

5. A device as defined in claim 3 wherein said shaft has a transverse shoulder part and said actuating member has a roll in contact with said shoulder.

6. In an ore crusher of the character described wherein a fixed peripheral shell carries an outer crushing surface and a gyratory shaft member carries an inner crushing surface, said surfaces having complementary inclina-

tions to the longitudinal axis of the shaft whereby endwise movement of the shaft changes the annular clearance space between said surfaces and provides occasional readjustment to compensate for progressive wear, said annular clearance space being relatively inaccessible for dimensional check purposes during the crushing operation, means for determining and indicating the dimensional extent of said clearance space, said means comprising an actuating member having a portion in operative contact with said shaft adjacent to its center of gyration, sensing means fixed with respect to said shell and consisting of a differential transformer having primary coil energizing means, and secondary coil output means comprising first and second secondary windings, a second core adjacent to said second secondary windings, a first core adjacent to said first secondary winding, said first and second secondary windings being connected in opposition whereby, when said movable core is in an initial idle position no secondary current is developed in said secondary coil means, but when said movable core is moved from said initial idle position through an increment of movement a corresponding secondary current is generated in and emitted from said secondary coil means, said current being proportional to said increment of movement, said first core being operatively responsive to movement of said actuating member whereby, when said shaft is moved endwise a secondary current signal is emitted corresponding in intensity to said shaft movement, and indicating means operatively responsive to said signal for showing the extent of shaft movement.

7. A device as defined in claim 6 wherein motor means is provided, in circuit connection with said secondary coil means, and operatively linked to said indicating means, and wherein said indicating means is calibrated in units of linear measure whereby to directly show the extent of endwise shaft movement.

8. A device as defined in claim 6 wherein said shaft gyrates around a relatively fixed center of gyration, and said actuating member is in contact with said shaft adjacent to said center of gyration, whereby said actuating member is actuated only by endwise movement of said shaft.

9. A device as defined in claim 8 wherein the contact between said actuating member and said shaft is achieved by means of a roll carried by said actuating member.

10. A device as defined in claim 6 wherein said actuating member has one end in contact with said shaft, and another end carries a cam, and wherein said movable core has a cam follower in operative contact with said cam.

11. A device as defined in claim 6 including, in combination therewith, operating means responsive to said secondary current, and core balancing means operatively linking said operating means with said second core whereby to move said second core to restore zero balance position with said first core whenever said first core has been moved as aforesaid.

12. In an ore crusher of the class described having a stationary shell with a fixed crushing surface formed on the interior wall thereof, and a crushing head defining a movable crushing surface vertically adjustably mounted in said shell in spaced relation to said fixed crushing surface, and gyratably actuatable therein, to provide for the crushing of material therebetween; actuator means operatively connected between the stationary shell and crushing head and movable in response to a vertical adjustment made to the latter, means operatively engageable with said actuator means and responsive thereto to provide an electrical signal representative of said crushing head adjustment, amplifier means electrically responsive to receive and amplify said electrical signal, and indicator means actuatable by the amplified signal of said amplifier means to provide a recognizable indication proportional to said crushing head adjustment.

13. In an ore crusher of the class described having a

stationary shell with a fixed crushing surface formed on the interior wall thereof and a crushing head defining a movable crushing surface vertically adjustably mounted in said shell in spaced relation to said fixed crushing surface and gyratably actuatable therein to provide for the crushing of ore material therebetween; actuator means operatively connected between the stationary shell and crushing head comprising an upright standard rigidly fastened to said shell, follower means slidably mounted in said standard and operatively engageable with said crushing head and movable in response to a vertical adjustment made to the latter, means engageable with said follower means and movably responsive thereto in a direction transversely of the crushing head adjustment, signal generating means actuatable in response to the movement of said last named means to provide an electrical signal representative of the magnitude of said adjustment, amplifier means electrically responsive to receive and amplify said electrical signal, and indicator means actuatable by the amplified signal from said amplifier means to provide a visual indication representative of said crushing head adjustment.

14. In an ore crusher of the class described having a stationary shell with a fixed crushing surface formed on the interior wall thereof and a crushing head defining a movable crushing surface vertically adjustably mounted in said shell in spaced relation to said fixed crushing surface and gyratably actuatable therein to provide for the crushing of ore material therebetween; actuator means operatively connected between the stationary shell and crushing head, comprising an upright standard rigidly attached to said shell, arm means slidably mounted in said standard and rotatably supporting a wheel-like follower, said follower engaging said crushing head and actuatable in response to a vertical adjustment made to the latter to slidably move said arm means within said standard, signal generating means actuatable in response to the movement of said arm means to provide an electrical signal representative of the magnitude of said adjustment, amplifier means electrically responsive to receive and amplify said electrical signal, and indicator means actuatable by the amplified signal from said amplifier means to provide a visual indication proportional to said crushing head adjustment.

15. In an ore crusher of the class described having a stationary shell with a fixed crushing surface formed on the interior wall thereof and a crushing head defining a movable crushing surface vertically adjustably mounted in said shell in spaced relation to said fixed crushing surface and gyratably actuatable therein to provide for the crushing of ore material therebetween; actuator means operatively connected between the stationary shell and crushing head, comprising an upright standard rigidly attached to said shell, arm means slidably mounted in said standard and rotatably supporting a wheel-like follower, said follower engaging said crushing head and actuatable in response to a vertical adjustment made to the latter to slidably move said arm means within said standard, signal generating means, actuating means in said signal generating means movably responsive to said arm means in a direction transversely of the crushing head adjustment to operate said signal generating means and provide an electrical signal therefrom representative of the magnitude of said adjustment, amplifier means electrically responsive to receive and amplify said electrical signal, and indicator means actuatable by the amplified signal from said amplifier means to provide a visual indication proportional to said crushing head adjustment.

16. In an ore crusher of the class described having a stationary shell with a fixed crushing surface formed on the interior wall thereof and a crushing head defining a movable crushing surface vertically adjustably mounted in said shell in spaced relation to said fixed crushing surface and gyratably actuatable therein to provide for the crushing of ore material therebetween; actuator means

operatively connected between the stationary shell and crushing head comprising an upright standard rigidly attached to said shell, a follower arm slidably mounted in said standard and rotatably supporting a follower wheel on its one end, said follower wheel engaging said crushing head and movable therewith in response to a vertical adjustment made to the latter to slidably move said follower arm longitudinally of said standard, cam means rigidly fastened to the opposite end of said follower arm, signal generating means, actuating means in said signal generating means movable by said cam means in a direction transversely of the crushing head adjustment to operate said signal generating means and provide an electrical signal therefrom representative of the magnitude of said adjustment, amplifier means electrically responsive to receive and amplify said electrical signal, and indicator means actuatable by the amplified signal from said amplifier means to provide a visual indication proportional to said crushing head adjustment.

17. In an ore crusher as defined in claim 14 and wherein the cam means is provided with an upwardly inclined cam surface engageable with the actuating means in the signal generating means being operable to move said actuating means in a direction transversely of the crushing head adjustment to operate said signal generating means.

18. In an ore crusher of the class described having a stationary shell with a fixed crushing surface formed on the interior wall thereof and a crushing head defining a movable crushing surface vertically adjustably mounted in said shell in spaced relation to said fixed crushing surface and gyratably actuatable therein to provide for the crushing of taconite ore material therebetween; actuator means operatively connected between the stationary shell and crushing head comprising an upright standard rigidly attached to said shell, a follower arm slidably mounted in said standard and rotatably supporting a follower wheel on its one end, said follower wheel engaging said crushing head and movable therewith in response to a vertical adjustment made to the latter to slidably move said follower arm vertically upwardly within said standard, cam means rigidly fastened to the opposite end of said follower arm and having a cam surface inclining upwardly toward said crushing head, signal generating means normally balanced to an inoperative condition, actuating means in said signal generating means, a follower on said actuating means rotatably engageable with said cam surface and movable therewith to cause a movement of said actuating means in a direction transversely of said crushing head adjustment and effect the energization of said signal generating means to an operative condition to provide an electrical signal therefrom representative of said adjustment, amplifier means electrically responsive to receive and amplify said electrical signal, and indicator means actuatable by the amplified signal of said amplifier means to provide a recognizable indication representative of said crushing head adjustment.

19. In an ore crusher of the class described having a stationary shell with a fixed crushing surface formed on the interior wall thereof and a crushing head defining a movable crushing surface vertically adjustably mounted in said shell in spaced relation to said fixed crushing surface and gyratably actuatable therein to provide for the crushing of ore material therebetween; actuator means operatively connected between the stationary shell and crushing head comprising an upright standard rigidly fastened to said shell, follower means slidably mounted in said standard and operatively engageable with said crushing head and movable in response to a vertical adjustment made to the latter, means engageable with said follower means and movably responsive thereto in a direction transversely of the crushing head adjustment, signal generating means including transformer means normally in an inoperative condition, said transformer means being actuatable to an operative condition in response to the movement of the follower engageable means and cause

17

said signal generating means to provide an electrical signal representative of said crushing head adjustment, amplifier means electrically responsive to receive and amplify said electrical signal, and indicator means actuable by the amplified signal of said amplifier means to provide a recognizable indication representative of said crushing head adjustment.

20. In an ore crusher of the class described having a stationary shell with a fixed crushing surface formed on the interior wall thereof and a crushing head defining a movable crushing surface vertically adjustably mounted in said shell in spaced relation to said fixed crushing surface and gyratably actuable therein to provide for the crushing of material therebetween, actuator means operatively connected between the stationary shell and crushing head comprising an upright standard rigidly fastened to said shell, follower means slidably mounted in said standard and operatively engageable with said crushing head and movable in response to a vertical adjustment made to the latter, means engageable with said follower means and movably responsive thereto in a direction transversely of the crushing head adjustment, signal generating means comprising a pair of differential transformers connected in electrical circuit such that the potential output of one of said transformers is normally of equal magnitude but of opposite phase relative to the potential output of the other of said transformers, a core in inductive relation with said one transformer and actuable in response to the movement of the follower engageable means to change the potential output thereof to a different value and cause a potential difference to exist between the latter and said potential output of said other transformer effective to provide an electrical signal representative of the vertical adjustment made to said crushing head, amplifier means electrically responsive to receive and amplify said electrical signal, and indicator means actuable by the amplified signal from said amplifier means to provide a visual indication representative of said crushing head adjustment.

21. In an ore crusher as defined in claim 20 and wherein the signal generating means comprises a pair of differential transformers each having a potential output winding, electrical circuit means connecting the latter in parallel circuit such that the potential output of one of said windings is normally of equal magnitude but of opposite phase relative to the potential output of the other of said windings.

22. In an ore crusher of the class described having a stationary shell with a fixed crushing surface formed on the interior wall thereof and a crushing head defining a movable crushing surface vertically adjustably mounted in said shell in spaced relation to said fixed crushing surface and gyratably actuable therein to provide for the crushing of ore material therebetween, actuator means operatively connected between the stationary shell and crushing head comprising an upright standard rigidly fastened to said shell, follower means slidably mounted in said standard and operatively engageable with said crushing head and movable in response to a vertical adjustment made to the latter, means engageable with said follower means and movably responsive thereto in a direction transversely of the crushing head adjustment, signal generating means including differential transformer means having a first and a second movable core normally in a balanced null-output position, said transformer means being actuable to an operative condition by movement of the first said core in operative response to movement of the follower engageable means, whereby to cause said differential transformer to emit an electrical signal representative of

18

said first core movement, amplifier means electrically responsive to receive and amplify said electrical signal, operating means actuable by the amplified signal, indicator means operatively responsive to said operating means whereby to provide a recognizable indication representative of the linear extent of crushing head adjustment, and means linking said operating means with said second core whereby to move said second core an amount to offset the previous movement of said first core and restore said differential transformer to balanced null-output position.

23. In an ore crusher of the class described having a stationary shell with a fixed crushing surface formed on the interior wall thereof and a crushing head defining a movable crushing surface vertically adjustably mounted in said shell in spaced relation to said fixed crushing surface and gyratably actuable therein to provide for the crushing of material therebetween, actuator means operatively connected between the stationary shell and crushing head comprising a standard rigidly fastened to said shell, follower means slidably mounted in said standard and operatively engageable with said crushing head and movable in response to a vertical adjustment made to the latter, means engageable with said follower means and movably responsive thereto in a direction transversely of the crushing head adjustment, signal generating means comprising a pair of differential transformers each having a potential output winding, electrical circuit means connecting the latter in parallel circuit such that the potential output of one of said windings is normally of equal magnitude but of opposite phase relative to the potential output of the other of said windings, a first core in inductive relation with said one potential output winding and actuable in response to the movement of the follower engageable means to change the potential output thereof to a different value and cause a potential difference to exist between the latter and said potential output of said other potential output winding effective to provide an electrical signal in said circuit means representative of the vertical adjustment made to said crushing head, amplifier means, means operatively connecting said amplifier means to said signal generating means to effect a transfer of the electrical signal from the latter to said amplifier means, said amplifier means being electrically responsive to receive and amplify said electrical signal, indicator means actuable by the amplified signal of said amplifier means to provide a visual indication representative of said crushing head adjustment, and a second core in inductive relation with said other potential output winding and actuable in step with the operation of said indicator means to increase the potential output of said other potential output winding to a value equal and opposed to the different potential output of said one potential output winding.

24. In an ore crusher as defined in claim 23 and wherein the means operatively connecting the signal generating means to the amplifier means comprises inductance means connected between the latter and the electrical circuit means and operative to effect a transmission of the electrical signal to said amplifier means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,066,281	Traylor	Dec. 29, 1936
2,293,502	Hermann	Aug. 18, 1942
2,408,524	Mestas	Oct. 1, 1946
2,457,558	Hornfeck	Dec. 28, 1948
2,578,869	Washburn	Dec. 18, 1951
2,743,874	Asplund	May 1, 1956