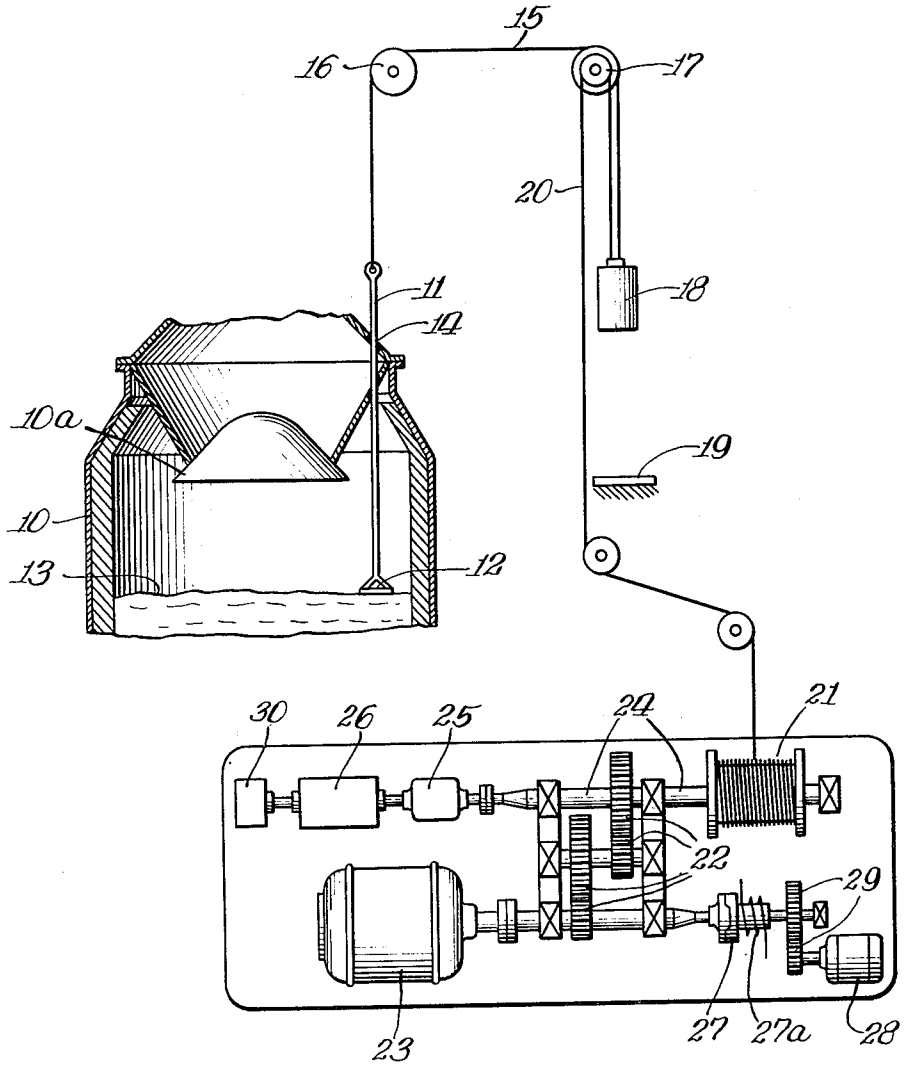
March 22, 1955 A. MOHR, JR., ET AL 2,704,401

STOCK LINE RECORDERS

Original Filed May 13, 1946 2 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

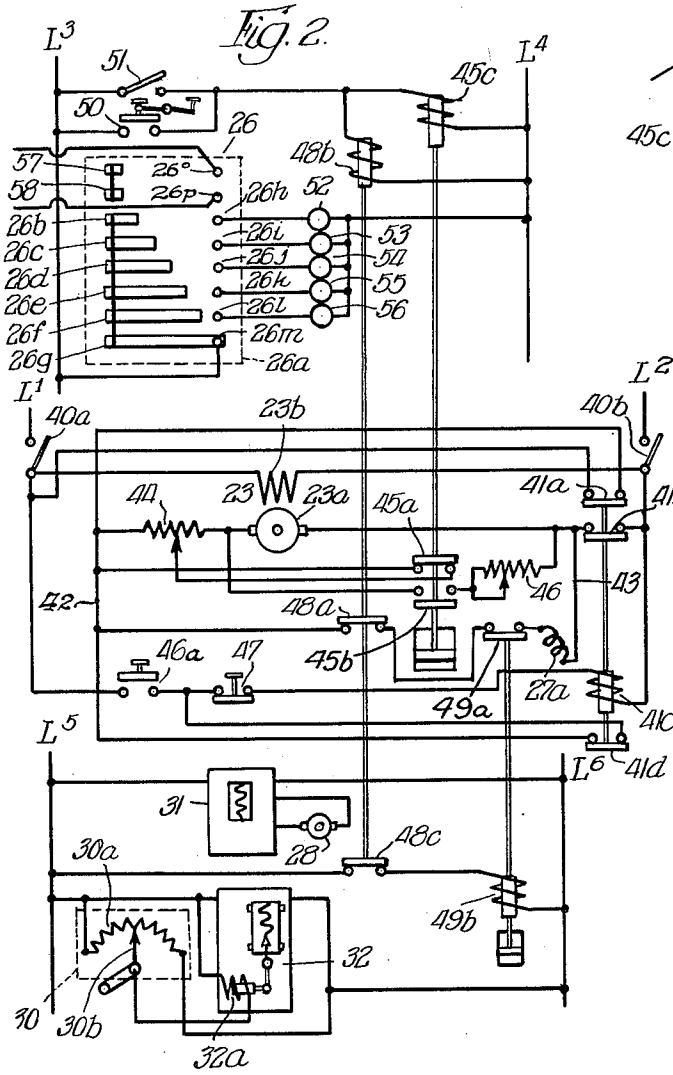


Fig. 3.

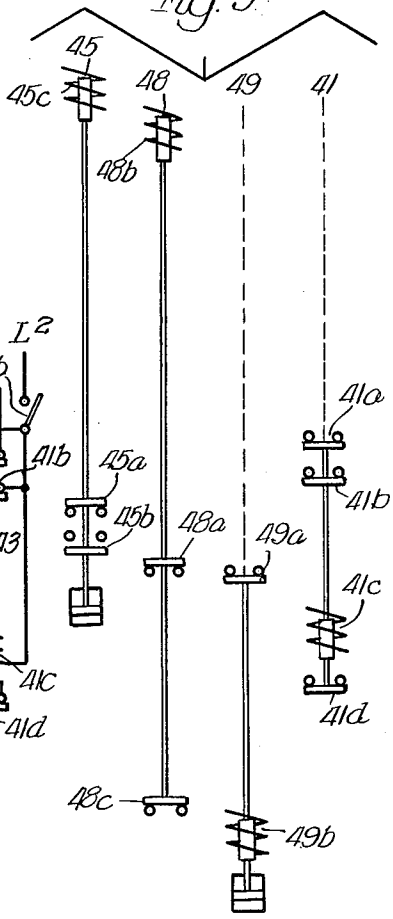
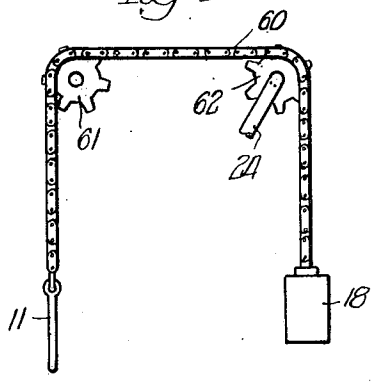


Fig. 4.



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STOCK LINE RECORDERS

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7 Claims. (Cl. 33—126.6)

The present invention relates to means for providing a continuous indication and a permanent record of the variation of the burden level in a blast furnace or the like.

In the operation of blast furnaces and the like, it is customary to provide for controlling the operation of the furnace charging means in accordance with the melting down of the furnace burden and to indicate on the outside of the furnace the instantaneous level of said burden. This is accomplished by means of a try rod which normally rests on top of the furnace burden.

During the operation of a blast furnace, additional charges are customarily introduced into the furnace by dumping the materials that make up the furnace burden onto a bell or material valve. When the proper amount of material is collected on the bell, means are provided for lowering the bell to permit the material to drop into the furnace. When the bell is lowered, it is necessary to temporarily withdraw or hoist the try rod from the top of the burden so as to prevent it from being buried by the new charge and thus rendered inoperative. The present invention covers means for thus operating the try rod in cooperation with the charging means for the furnace.

An object of the invention is to provide visual means outside of a blast furnace which continuously indicates the instantaneous level of the burden in the furnace by means of the try rod which extends into the inside of the furnace.

Another object is to provide visual and recording means for indicating the rate of descent of the burden in the furnace thus showing the rate of operation of a blast furnace.

Another object is to provide novel means for controlling the operation of the try rod in response to the change in the burden level of a blast furnace.

Another object is to provide a novel method of control for the operation of the try rod.

Another object is to provide means to prevent the burying of the try rod by new charges introduced in the furnace in case of failure of the power supply for the try rod operating means.

Another object is to provide simple and positive control means for the electric motor operating the try rod.

Normal operation of the system is initiated by push-button means, which causes a rod-lowering motor to be continually energized, likewise a rod height recorder, subject only to a failure of line current. In such event the rod is automatically raised to its uppermost position so that it will not be buried by new charges introduced into the furnace. In normal operation, the full energization of the motor is sufficient with the help of the weight of the try rod to lift a counterweight and lower the rod, but when the rod is supported by the burden, the motor alone cannot lower it further, and thus the rod follows the surface level of the burden. Also during normal operation, a second recorder shows the rate of rise or fall of the rod. When a charging operation is to occur, lifting of the try rod to its uppermost position is brought about by a reduction in the energization of the motor such that the counterweight overcomes both it and the weight of the try rod. This reduction is initiated either by push-button or by automatic means controlled by the charging mechanism. Actual reduction in energization is automatically delayed a set interval during which the rate recorder is automatically disconnected before the motor de-energization allows the counterweight to retract the rod. Upon completion of charging, full motor energization is resumed either by push button or automatically by the

charging mechanism, resulting in the lowering of the try rod and, again after a set interval, to allow time for the rod to come to rest on the burden, automatic resumption of operation of the rate recorder.

Other objects and advantages will hereinafter appear.

The accompanying drawings are illustrative of an embodiment of our invention. In the drawings:

Fig. 1 is a drawing showing schematically the try rod mounted on top of the furnace and the operating mechanism for the try rod.

Fig. 2 is a diagram of the electrical system for controlling the operation of the try rod in accordance with the invention.

Fig. 3 is a chart of the switches and relays of Fig. 2, having the coordinated windings and contacts horizontally aligned with the corresponding elements in Fig. 2, while

Fig. 4 shows a modification of certain elements of the actuating mechanism for the try rod.

Referring to Fig. 1, the same illustrates the top **10** of a blast furnace including a bell **10***a* of any conventional type, which normally closes the top of the furnace. The bell is adapted when closed, as shown, to accumulate a charge placed thereon and to release said charge into the furnace, when the bell is lowered. The top of the furnace is also provided with a try rod **11** having at its lower end a foot **12** of suitable shape which normally rests on the burden **13** in the furnace. The try rod extends vertically through a suitable guide **14** in the top of the furnace and its upper end is connected to one end of a rope **15** by which it can be lifted out of the furnace. The rope **15** passes over two sheaves **16** and **17** and has attached to its other end a counterweight **18**. The counterweight **18** is sufficient to overbalance the weight of the try rod off the burden **13** in the furnace and to raise it to its uppermost position, determined by the descent of the counterweight **18**. To limit the upward travel of the try rod and the corresponding descent of the counterweight **18**, the latter cooperates with a platform **19** arranged in its path so as to receive the weight when it has descended to the proper point.

To overcome the biasing force of the weight a second rope **20** is fastened to the weight and passed over the sheave **17** and is thereafter suitably guided by other sheaves. The second rope **20** is attached to a winding drum **21**. The winding drum **21** is connected through suitable gearing **22** to an electric motor **23**. This motor **23** is of such characteristics and is so constructed that it can remain for relatively long periods of time in a substantially stalled, constantly energized condition having very little rotary movement. In this constantly energized condition, it exerts a continuous torque in one direction on the winding drum **21**. The magnitude of this unidirectional torque can be increased by supplying more electrical energy to the motor **23**, and it can be decreased by reducing the supply of electrical energy to the motor. The normal operating condition of the furnace may be regarded as the condition between charging operations when the try rod **11** is resting upon the top of the burden **13**, as shown in Figure 1. In such normal operating condition of the furnace, the motor **23** is normally energized so that the pull which is exerted through the gearing **22** on the rope **20**, plus the weight of the try rod, is sufficient to overbalance the pull of the counterweight **18** to render the latter ineffective to raise the try rod **11** off the burden **13**. However, as will be indicated hereinafter, whenever the try rod is to be raised to its uppermost position, as during charging operations, the motor torque is reduced so that the pull on rope **20**, plus the weight of the try rod, is less than the pull of the counterweight **18** on the cable **15**, whereupon the try rod **11** is lifted off the charge and raised to its uppermost position. It will be noted that in the event of a failure of power supply to the motor **23**, the counterweight **18** will be immediately effective to raise the try rod to its uppermost position so that it will not be buried by new charges introduced into the furnace.

The system also includes means for recording at all times the position of the try rod **11** and further means to

record the cyclic operation of the control means for the try rod as will be explained more fully hereinafter.

For the aforementioned purposes the winding drum shaft 24 is geared through a speed reducer 25 to a commutating switch 26 which actuates a series of contacts, the latter being arranged to complete corresponding energizing circuits of a number of indicating lights as will appear hereafter. These circuits are successively energized in accordance with the rotation of the winding drum, hence in accordance with the movement of the try rod. Also connected to the motor through an electromagnetic clutch 27, having an energizing winding 27*a*, is a tachometer-generator 28 which in turn is connected to a recording and indicating instrument. Normally the electromagnetic clutch is energized so that the tachometer generator 28 rotates synchronously with the motor 23 and thereby generates a voltage which is a measure of the motor speed and thus of the speed and direction of movement of the try rod 11. When the try rod 11 is to be lowered onto the burden in the furnace, the motor 23 is energized to a degree to overcome the pull of the counterweight 18, thus lowering the try rod into contact with the burden and maintaining the try rod in contact with the burden. As the burden in the furnace recedes, the weight of the try rod augments this torque of the motor so that they preponderate over the weight of the counterweight 18, with the result that the try rod is permitted to move downwardly and thus remain in contact with the burden, the rate of rotation of the motor depending upon the speed with which the burden in the furnace descends. Thus the motor speed in this forward direction in which it is urged by its own electromagnetic torque and the weight of the try rod is a direct function of the speed of descent of the try rod. The voltage of the tachometer generator 28 when the clutch 27 is energized is therefore also a function of said speed of descent and this voltage is recorded by a suitable recorder 31 to afford a record of the speed of operation of the furnace. As the burden descends very slowly it is necessary to interpose a speed increaser such as the set of gears 29 shown in the drawing between the motor 23 and the tachometer generator 28. Also connected to the output shaft of the speed reducer 25 through the shaft of the commutating switch 26 so as to rotate in synchronism therewith, is a potentiometer 30 which thus responds to the movement of the drum 21 to serve as an indicator of the position of the try rod 11 in the furnace as will be explained in detail hereafter.

We shall refer now specifically to the diagram of connections shown in Fig. 2, in which the various electrical parts are shown in the normal positions they occupy when the try rod 11 is in its normal position resting upon the burden 13 (Figure 1). That is to say, the term "normal" position shall be considered with respect to all parts of the installation as corresponding to the positions they occupy when the blast furnace is in normal operation and the try rod 11 is normally resting upon the top of the burden 13. This circuit diagram illustrates a pair of bus bars L1 and L2 which for the purpose of illustration are assumed to supply 250 volts direct current. The bus bars may be connected to a supply source by means of a double pole knife switch, the two blades 40*a* and 40*b* of which are shown separately in the drawing. Connected across the bus bars in series with the blades 40*a* and 40*b* is the shunt field winding 23*b* of the hoist motor 23. The bus bars L1 and L2 are also connected to the main contacts 41*a* and 41*b*, respectively, of an electromagnetic main switching relay 41 which has an energizing winding 41*c* and holding or lock-up contacts 41*d*. The winding 41*c* of this switching relay 41 is normally energized, whereby the relay contacts 41*a*, 41*b* and 41*d* responsive thereto are normally maintained in their circuit closing positions. Closure of the contacts 41*a* and 41*b* energizes the wires 42 and 43, respectively. The armature 23*a* of the motor 23 is connected in series with a resistor 44 between the two wires 42 and 43. An adjustable part of the resistor 44 may be short circuited by the normally closed contacts 45*a* of an electromagnetic time-delay relay 45, which is normally deenergized and which we shall refer to as the motor controlling relay. There is also provided a shunt path around the armature 23*a* of the motor 23, comprising an adjustable resistor 46 and in series therewith the normally open contacts 45*b* of said electromagnetic motor controlling relay 45. Also connected between the switches 40*a* and 40*b* is the normally energized winding 41*c* of the electromagnetic main switching relay 41, in series with a manually operable, normally open push button switch 46*a* and a manually operable, normally closed push button switch 47. The normally open push button switch 46*a* is paralleled by the holding or maintaining contacts 41*d* of the main switching relay 41, which holding or lock-up contacts 41*d* move to closed position and establish a shunt across the manually operated push button switch 46*a* as soon as the relay coil is energized by the closing of said push button switch. Thereupon, this main switching relay 41 will remain locked up in this constantly energized condition as long as the blast furnace continues operating, or until the "Off" push-button switch 47 is pushed to open circuit position, or until a power failure occurs on the motor supply circuit L1—L2. Another circuit extends from the wire 42, through normally closed contacts 48*a* of an electromagnetic instrument controlling relay 48 and through normally closed contacts 49*a* of an electromagnetic timing relay 49, and thence through the energizing winding 27*a* of the electromagnetic clutch 27, to the wire 43. The instrument controlling relay 48 and the timing relay 49 both are normally deenergized, in which condition their respective contacts 48*a* and 49 both are normally in the circuit closing positions shown in Figure 2, so that the circuit through the electromagnetic clutch 27 remains continuous as long as the try rod 11 is resting upon the burden 13. The electromagnetic motor controlling relay 45 is designed to provide a time delay between energization of its winding and response of its armature, but immediate response of the latter upon deenergization of the winding. Relay 45 is provided with an energizing winding 45*c* which is connectable through a push button operated snap switch 50 across the bus bars L3 and L4 of a low voltage direct current power supply. This push button operated snap switch 50 is adapted to remain in closed position until manually actuated into open position, and vice versa. Its normal position is its open position, with the two relay windings 45*c* and 48*c* both deenergized, at which time the try rod is in its normal position resting on the burden 13. The switch 50 is provided for manually controlling the hoisting of the try rod, and may be paralleled by a second normally open switch 51 which may be operated from the automatic furnace charging equipment (not shown) so as to control the stock line recorder in response to certain operations of the automatic charging equipment of the furnace. For instance, it is desirable to lift the try rod to its highest position just prior to or at the time when the material on the furnace bell is to be dumped onto the furnace burden, and the switch 51 may be actuated by certain elements of the charging controller to control this function. The energizing winding 48*b* of relay 48 is connected in parallel with the energizing winding 45*c* of relay 45, both being responsive to switches 50 and 51. Relay coil 48*b* instantly deenergizes the clutch coil 27*a* by opening normally closed contact 48*a*, which disengages tachometer generator 28. A brief interval thereafter the time delayed relay 45 opens its contacts 45*a* and closes contacts 45*b*, relieving the torque on motor 23 which allows the counterweight to quickly lift the try rod off the furnace burden.

The position indicator 26 for the try rod is provided with a cylindrical drum 26*a* having a plurality of contact bars 26*b* to 26*g* of varying length, which upon rotation of the drum successively engage a series of stationary contact fingers 26*h* to 26*m* and circuits are completed successively between the drum and the respective fingers upon rotation of the hoisting drum thereby energizing the corresponding lights 52 to 56 to indicate the position of the hoisting drum and thus the position of the try rod.

In the extreme position corresponding to the upper position of the try rod, the drum or indicating switch may be provided with additional contact fingers 26*o* and 26*p* which are bridged by movable contacts 57 and 58, respectively, upon the position indicator 26 moving to its extreme position corresponding to the complete withdrawal of the try rod. This interlock may be used, for instance, to prevent the actuation of the instrumentalities which control the charging of the furnace, to render charging impossible unless the try rod is withdrawn from the burden.

The instrumentalities for recording the operation of the try rod will now be described. These instrumentalities are

operated from the alternating current bus bars L5, L6, shown in Fig. 2.

The tachometer generator 28 is connected to the movable element of a recording instrument 31, which is driven in the conventional manner by a motor connected to the lines L5, L6. As the voltage supplied by the tachometer generator 28 is a function of the speed of movement of the try rod, the graph produced by the instrument 31 indicates the speed of descent and ascent of the try rod, and as the recording film or paper chart moves at a constant velocity, the number of up and down movement of the try rod is also recorded by this instrument. The energizing coil 49*b* of the timing relay 49 is connected across the lines L5, L6, in series with the normally closed contacts 48*c* of the relay 48. The slide wire 30*a* of the recording potentiometer 30 is connected across the lines L5 and L6, while the movable contact arm 30*b* of said potentiometer is connected in series with the operating coil 32*a* of a recording instrument 32 across a variable part of the potentiometer resistor 30*a*. The contact lever 30*b* is directly coupled to the operating shaft of the potentiometer 30 so that the variation of the resistor 30*a* is a direct function of the position of the drum 21 and thus the try rod 11 in the furnace. The potential of the contact arm 30*b* is impressed upon the coil 32*a* which thus operates the recorder 32 to produce a graph which records the position, speed and direction of movement of the try rod in the furnace.

When the try rod is lifted for any reason such as for instance during charging of the furnace, it is desired to interrupt the indications of the tachometer generator. This is accomplished by deenergizing the electromagnetic clutch 27. When the relay 48 is energized it instantly opens its normally closed contacts 48*c*, thereby deenergizing the winding 49*b* of the time delay relay 49, thus resetting the latter. Normally closed contacts 48*a* are also opened, thereby deenergizing the clutch coil 27*a* so that the tachometer generator 28 is disconnected before the try rod is lifted, and no indication is obtained on the recorder 31.

When relay coil 48*b* is energized, instantly deenergizing the clutch coil 27*a*, the time delay relay operation coil 45*c* is also energized, and after a delay of approximately 2 seconds it opens its normally closed contacts 45*a*, inserting resistor 44 into the motor circuit of the armature 23, and closes normally open contact 45*b* which inserts the armature shunt resistor 46 into the circuit. These changes in the armature connections decrease the torque of motor 23 so that counterweight 18 overbalances the decreased pull on rope 20 and thus lifts the try rod 11 off the burden. Because the relay 45 is time delayed to respond later than the relay 48 when they are both simultaneously energized, the torque of the motor will not be reduced for lifting the try rod until after the tachometer generator 28 is disconnected by deenergization of the clutch coil 27*a*. The rate at which the try rod is lifted can be varied by adjustment of the resistors 44 and 46. The decreased torque which is exerted by the motor 23 with the resistors 44 and 46 effective in the circuit to reduce armature current flow is still sufficient to keep the cable 20 taut.

When it is desired to lower the try rod into the furnace after the new charge has been placed on the burden, contact 51 is opened by the automatic furnace charging equipment (not shown) and/or the push button switch 50 is opened. This deenergizes both relay coils 45*c* and 48*b*. Both relays commutate their respective contacts immediately. Normally closed contact 45*a* closes, shorting out a portion of the series armature resistor 44. Normally open contact 45*b* opens, opening the armature shunt circuit. Normally closed contact 48*c* closes and energizes the timing relay coil 49*b*, thereby initiating the operation of relay 49, but which operation is retarded by the time delay mechanism of the relay. The torque of the motor 23 now provides sufficient pull on cable 20 to overcome the effect of the counterweight 18, and the try rod descends onto the burden. Normally closed contacts 48*a* close immediately upon deenergization of relay coil 48*b*, but the circuit between wire 42 and the electromagnetic clutch coil 27*a* is not completed as the normally open contact 49*a* of the timing relay 49 is open until a sufficient time has elapsed for the try rod to come to rest on the burden. Timing relay 49 thereupon completes its time cycle (adjustable from 1 to 6 seconds approximately) and closes its normally open contact 49*a*, causing energization of the clutch coil 27*a*, so the tachometer generator 28 is again connected to the motor 23 and rotates synchronously with it. The rate of descent of the burden in the furnace is then indicated and recorded as previously described.

As previously described, the motor circuit is adapted to be energized through switch 40*a*, 40*b* from a relatively heavy duty direct current power circuit L1, L2, such as a 240 volt circuit; the control circuits for the relays 45, 48, switches 50, 51 and commutating switch 26 are preferably energized from a lower voltage direct current supply circuit L3, L4; and the instruments 30 and 31 are preferably energized from a separate instrument supply circuit L5, L6 supplying alternating current of conventional voltage. The motor control apparatus is first placed in normal condition by the operator closing the manual push-button switch 46*a* which completes the energizing circuit through winding 41*c* of relay 41, causing this relay to close its contacts 41*a*, 41*b* and 41*d*. The closing of contacts 41*a* and 41*b* energizes the motor 23, and the closing of contacts 41*d* establishes a shunt around the push-button switch 46*a*, thereby locking up the relay 41 in this energized condition until the operator pushes the "Off" push-button switch 47 to open circuit position, or until a power failure releases the locked up condition of the relay. In the event of such a power failure, the counterweight 18 will be immediately effective to raise the try rod 11 to its uppermost position so that it will not be buried by new charges introduced into the furnace. As previously described, the term "normal" position shall be considered with respect to all parts of the installation as corresponding to the positions they occupy when the blast furnace is in normal operation and the try rod 11 is normally resting upon the top of the burden 13. With the switches 50 and 51 in their normal open circuit positions, the try rod 11 immediately moves down into contact with the burden 13 as soon as the closing of the push-button switch 46*a* has energized the motor 23. The try rod will continue to move down with the upper level of the burden, as long as the switches 50 and 51 remain in their open circuit positions, with the relays 45 and 48 deenergized. During such descent of the try rod with the burden, the tachometer generator 28 will operate through recording instrument 31 to make a record of the rate of descent, and the potentiometer 30 will operate through the recording instrument 32 to record the position, speed and direction of movement of the try rod in the furnace. The commutating switch 26 will also operate through the lights 52—56 to indicate the position of the try rod at any instant.

The try rod is raised to its uppermost position each time that a charge is introduced into the furnace through the lower charging bell 10*a*. This can be accomplished manually through the closing of manual switch 50, or it can be accomplished automatically through the closing of automatic switch 51 responding to the furnace charging equipment. In either case, the resulting energization of the relays 45 and 48 will first operate through relay 48 to simultaneously open contacts 48*a* and 48*c*, the opening of the contacts 48*a* deenergizing the electromagnetic clutch 27, and the opening of the contacts 48*c* deenergizing the timing relay 49. Hence, the tachometer generator 28 is immediately disconnected and the relay 49 is immediately deenergized. Because of the time delay inherent in the operation of relay 45 upon energization, the contacts 45*a* are not opened and the contacts 45*b* are not closed until after the magnetic clutch 27 has been deenergized and the tachometer generator 28 has been unclutched from the winding drum 21. Thus, the reduction in motor torque which becomes immediately effective on the opening of contacts 45*a* and the closing of contacts 45*b* does not result in the lifting of the try rod 11 until after the magnetic clutch 27 has been released. Hence, the tachometer generator 28 and its recording instrument 31 are not affected by this lifting of the try rod.

In the reverse operation of lowering the try rod, as, for example, after the completion of a charging operation, the opening of the previously closed switch 50 or 51 will simultaneously deenergize the relays 45 and 48. The relay 45 has no time delay upon deenergization, and hence there is immediate closure of the contacts 45*a* and immediate opening of the contacts 45*b*, with immediate

increase in torque of the motor for immediate lowering of the try rod. The deenergization of the companion relay **48** also results in immediate closure of the contacts **48***c* and immediate energization of the winding **49***b* of time delay relay **49**. However, because of the time delay characteristics of this relay, its contacts **49***a* do not close for an appreciable interval, and accordingly the electromagnetic clutch **27** is not energized until the try rod has moved down into contact with the burden. Hence, the tachometer generator **28** and its recording instrument **31** are not affected by this power driven lowering of the try rod, but only become responsive to the lowering of the try rod pursuant to lowering of the burden, after closing of contacts **49***a*. On the other hand, the potentiometer **30** and its recording instrument **32** are continuously responsive at all times to all lifting and lowering movements of the try rod.

Fig. 4 shows a modified arrangement of the connections between the try rod **11** and the counterweight **18**. In this case, the ropes **15** and **20** in the system of Fig. 1 are replaced by a link chain **60** which passes over sprocket wheels **61** and **62**, respectively. Instead of being coupled to a winding drum, the shaft **24** is now coupled to the sprocket wheel **62** so that the torque exerted upon the sprocket wheel **62** by the differential pull of the motor **23** and the counterweight **18** (Fig. 1) is directly transmitted by the sprocket chain **60** to the try rod **11**. This arrangement obviates the necessity of a drum and a second rope and provides for more direct coupling between the motor **23** and the try rod. In all other respects the driving mechanism and the control for this modification is the same as that described heretofore.

What we claim as new and desire to secure by Letters Patent is:

1. In a system for indicating and recording the variation in height, of a variable mass of piled granular substance the combination comprising, a test member, means including an overbalancing counterweight connected to said test member and arranged to lift the latter and hold it suspended at its uppermost position, a non-reversible electric motor operatively connected to the aforesaid means to oppose the effect of said counterweight, and selective control apparatus maintaining said motor continuously energized in all positions of said test member and including means functioning in one control operation to increase the energization of said motor to a degree to render said counterweight ineffective and lower said test member to rest on top of said mass, and alternatively functioning in another control operation to reduce energization of said motor and render said counterweight effective to lift said test member with a rapid unimpeded motion and hold it suspended at its uppermost position, said counterweight being operative to lift said test member out of contact with said mass automatically in the event of a failure of the source of current supply to said motor.

2. The combination with a furnace of a try rod adapted to be lowered onto the burden in the furnace to determine the height thereof, means including a counterweight connected to said try rod and arranged to lift the latter away from said burden, a non-reversible electric motor arranged to oppose the lifting effect of said counterweight, and selective control apparatus maintaining said motor continuously energized in all positions of said try rod and including means functioning in one control operation to increase the energization of said motor sufficiently to lift said counterweight and permit said try rod to rest on the burden and alternatively in another control operation to reduce the energization of said motor and render said counterweight effective to lift said try rod with a rapid unimpeded motion to its uppermost position and hold it suspended out of contact with the burden.

3. A system for indicating and recording the variations in the level of the burden within a blast furnace comprising in combination a try rod adapted to rest on the burden, means including an overbalancing counterweight connected to said try rod arranged to lift the latter away from said burden, a non-reversible electric motor arranged to oppose the lifting effect of said counterweight, selective control apparatus maintaining said motor continuously energized throughout the operation of the furnace and including means to energize said motor sufficiently to lift said counterweight and permit said try rod to rest on the burden and alternatively to reduce energization of said motor and render said counterweight effective to lift said try rod with a rapid unimpeded motion to its uppermost position and hold it suspended in such position out of contact with the burden, and means responsive to the operation of said motor to indicate the movement of said try rod.

4. A system for indicating and recording the variations in the level of the burden within a blast furnace, comprising in combination a pulley, a rope passing over said pulley, a try rod attached to one end of said rope, said try rod being adapted to rest on the burden, an overbalancing counterweight for said try rod attached to the other end of said rope, a non-reversible electric motor operatively connected to said counterweight and arranged to oppose the effect thereof upon said try rod, selective control apparatus maintaining said motor continuously energized and including means to increase the energization of said motor to lift said counterweight and permit said try rod to rest on the burden, and alternatively to reduce the energization of said motor and render said counterweight effective to lift said try rod with a rapid unimpeded motion and to hold it suspended out of contact with the burden, and means responsive to the operation of said motor to indicate the movement of said try rod.

5. In a system for indicating and recording the variations in the level of the burden within a blast furnace, in combination, a loose pulley, a rope passing over said pulley, a try rod attached to one end of said rope, and adapted to rest on said burden, a counterweight fixedly attached to the other end of said rope, said counterweight being arranged to overbalance the pull of said try rod and to lift the same away from said burden, a non-reversible electric motor operatively connected to said counterweight, and means to connect said motor to a source of power, said last-named means including selective control means maintaining said motor continuously energized at all times during the normal operation of the furnace but at different controlled degrees of energization whereby to increase the energization of said motor in one operation to lift said counterweight for permitting said try rod to rest on the burden, and alternatively to reduce the energization of said motor in another operation and render said counterweight effective to lift said try rod and hold it freely suspended out of contact with the burden.

6. In a system for indicating and recording the variations in the level of the burden within a blast furnace, in combination with means for charging same, a loose pulley, a rope passing over said pulley, a try rod attached to one end of said rope, and adapted to rest on said burden, a counterweight attached to the other end of said rope, said counterweight being proportioned and arranged to overbalance the pull of said try rod at all times, tending to lift the same away from said burden, a non-reversible electric motor having a shunt field winding and an armature operatively connected to said counterweight, electromagnetic means energizable to connect said motor armature to a source of power for maintaining said armature continuously energized in all positions of said try rod, and means responsive to operation of said charging means to control the power supplied by said source to said armature to afford a motor torque sufficient to lift said counterweight and permit said rod to descend onto the burden, said control means alternatively providing reduction of the motor torque for permitting said counterweight to lift said try rod with a rapid unimpeded motion and hold it freely suspended out of contact with the burden.

7. In a system for indicating and recording the variations in the level of the burden within a blast furnace, in combination with means for charging same, a loose pulley, a rope passing over said pulley, a try rod attached to one end of said rope, and adapted to rest on said burden, a counterweight attached to the other end of said rope, said counterweight being arranged to overbalance the pull of said try rod at all times, tending to lift the same away from said burden, a source of electric energy, a non-reversible electric motor having a shunt field winding connected to said source of energy and an armature operatively connected to said counterweight, an adjustable series resistor, electromagnetic means energizable to connect said armature in series with said resistor to said source, an adjustable shunt resistor, an electro-magnetic means responsive to operation of said charging means for normally reducing said series re-

sistor to a degree to afford a motor torque sufficient to lift said counterweight and permit said try rod to rest on the burden and alternatively to increase said series resistor and connect said shunt resistor across the terminals of said armature for reducing the motor torque and permit said counterweight to lift said try rod with a rapid unimpeded motion to its uppermost position and hold it freely suspended out of contact with the burden, such rapid upward motion insuring that the try rod will be in a position clear of the charge upon the operation of said charging means.

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