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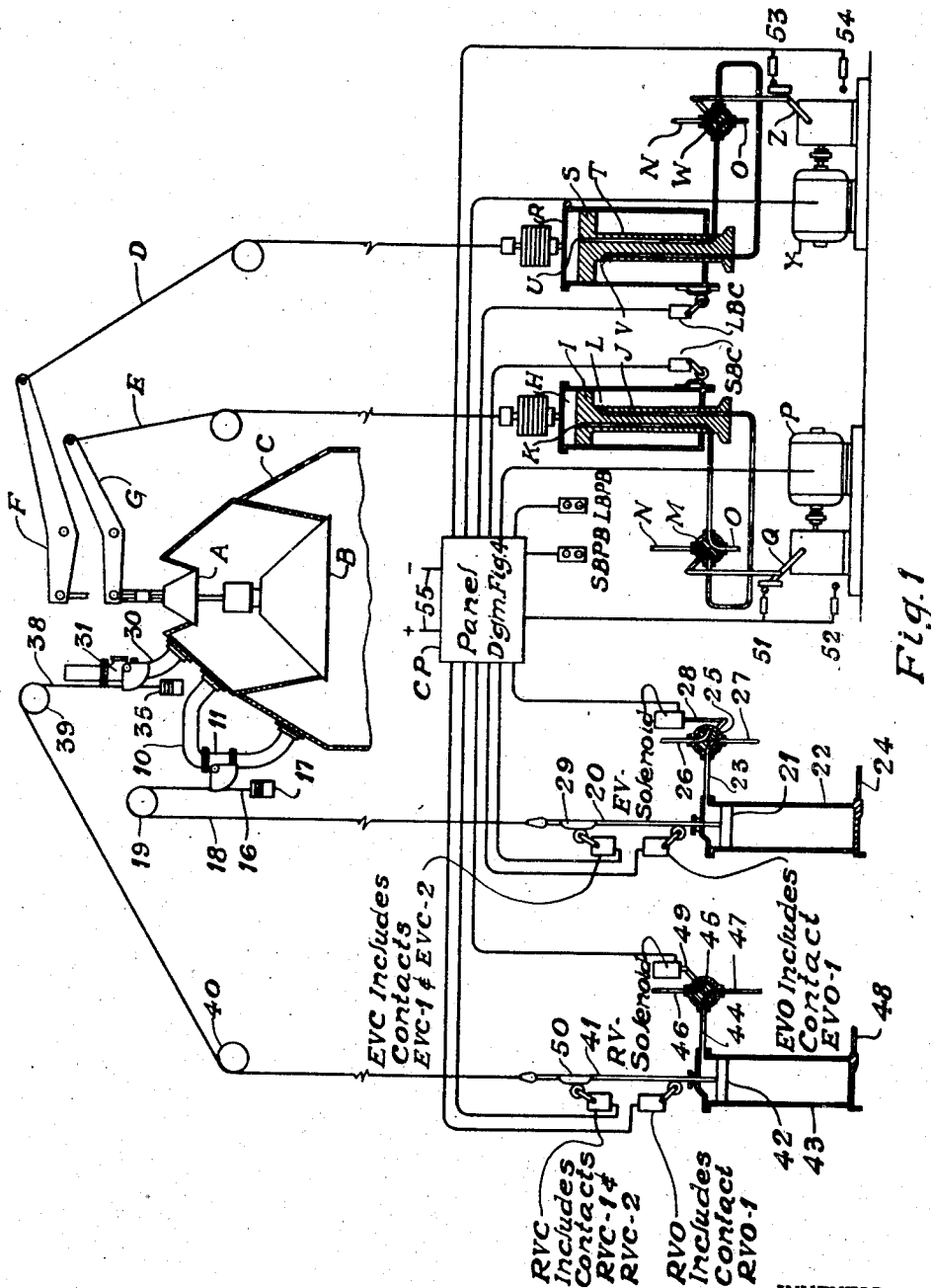
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2,411,487

BLAST FURNACE CONSTRUCTION

Filed April 5, 1945

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

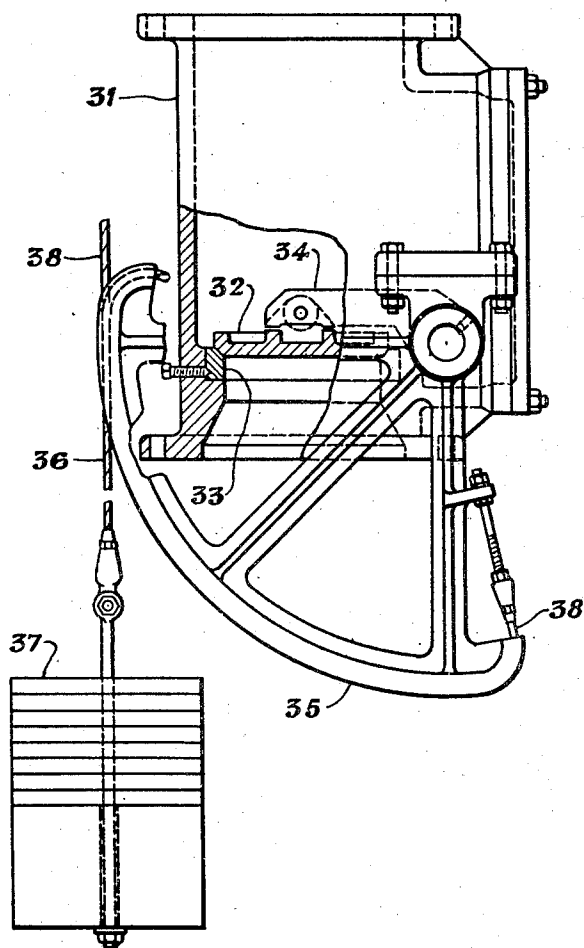


Fig. 2

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4 Sheets-Sheet 3

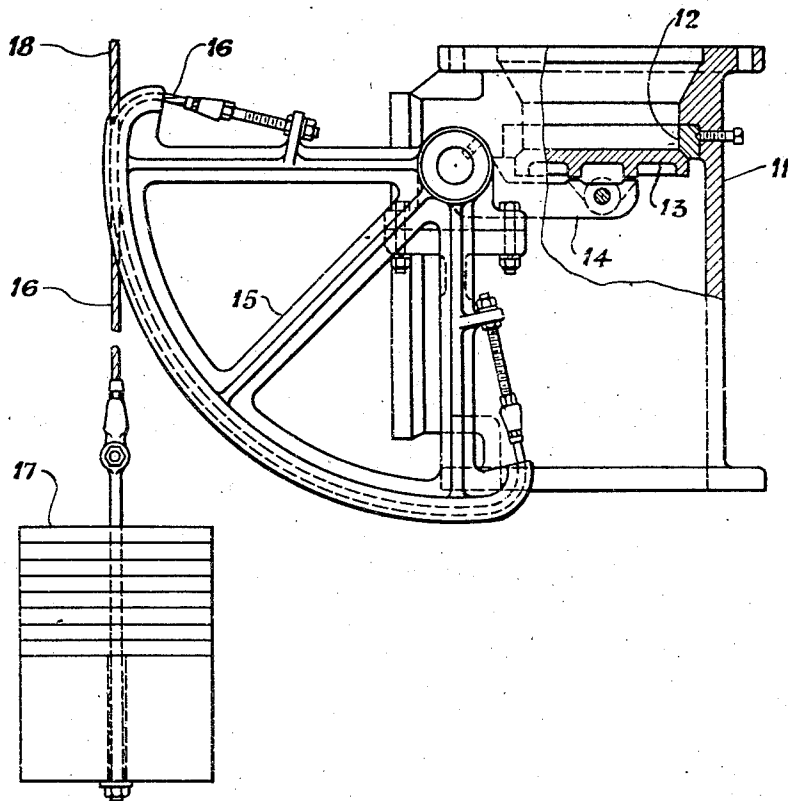


Fig. 3

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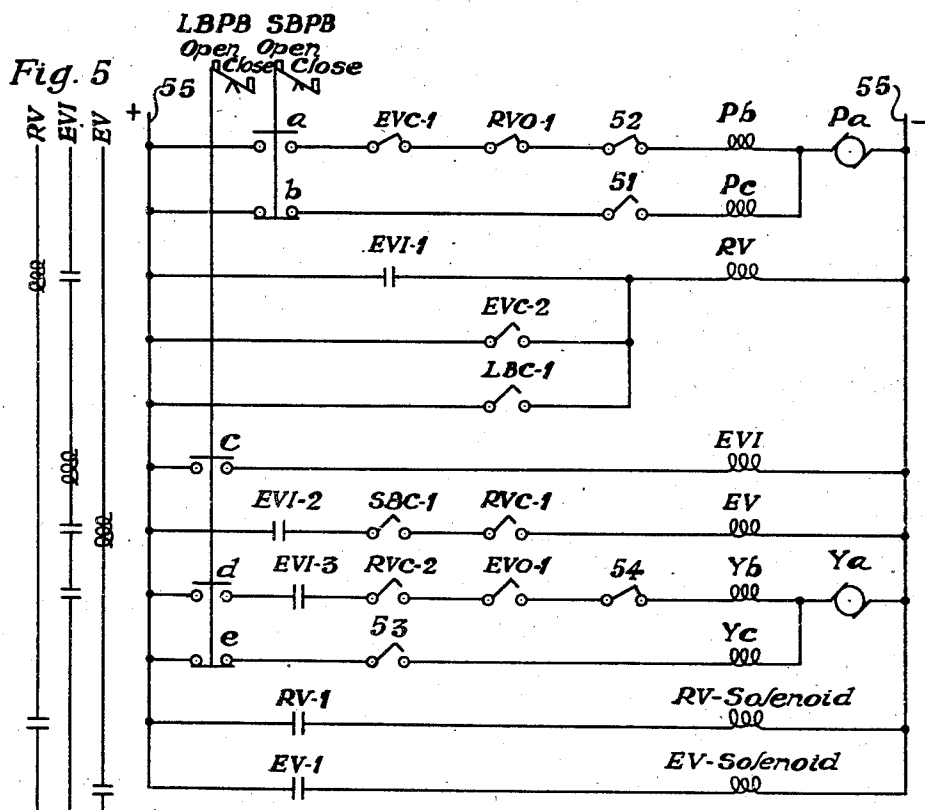


Fig. 4

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BLAST FURNACE CONSTRUCTION

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4 Claims. (Cl. 266-27)

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The present invention relates to improvements in blast furnace construction.

Blast furnaces are commonly provided at the top thereof with two bells arranged in series, an uppermost bell termed a small bell and a lowermost bell termed a large bell. Said bells are opened alternatively to permit the insertion of material into the furnace while preventing the escape of large quantities of gas from the interior of the furnace. The Fox, Rice and Whitcomb Patent No. 2,215,872, patented September 24, 1940, discloses a blast furnace construction having an equalizer valve between the small bell and the large bell, together with certain permissive interlocking mechanism therebetween. This equipment is applicable under ordinary conditions in which the pressure within the top of the blast furnace is not too high.

There appear to be certain advantages in operating blast furnaces at increased internal pressures such that the pressure at the top of the blast furnaces might approximate one atmosphere above mean atmospheric pressure. The use of an equalizer valve would be necessary in connection with such a blast furnace, but it would not be sufficient. In addition thereto it becomes necessary to introduce a relief valve, the equalizer valve being utilized to equalize the pressure between the top of the furnace chamber and the region between the bells prior to opening the large bell, the relief valve being used to reduce the pressure in the region between the bells to atmospheric pressure prior to opening the small bell.

An object of the present invention is to provide a blast furnace construction having an equalizer valve and a relief valve such as above referred to, together with novel interlocking means therebetween and with the furnace bells.

A further object is to provide an improved blast furnace construction having interlocking means as above referred to in which the mechanisms under control must actually respond and make their necessary movements before the next succeeding movements may be made.

A further object is to provide a blast furnace construction having interlocking means of permissive type in that it gives permission for certain functions to take place, but also requires them to take place as prerequisites to bell opening operations.

A further object is to provide a blast furnace construction having improved interlocking means which prevents the functioning of the parts under improper conditions.

A further object is to provide a blast furnace

construction having interlocking means such as above referred to which is simple and not likely to get out of order.

A further object is to provide a blast furnace construction having interlocking means between the large and small bells, an equalizer valve, and a relief valve well adapted to meet the needs of commercial service.

Further objects will appear as the description proceeds.

Referring to the drawings—

Figure 1 is a diagrammatic view illustrating one embodiment of the present invention;

Figure 2 is a detail view, partly in section, showing a relief valve which may be used in the practice of the present invention;

Figure 3 is a detail view, partly in section, showing an equalizer valve which may be used in the practice of the present invention;

Figure 4 is a panel diagram showing relay and other instrumentalities which may be used in carrying out the objects of the present invention; and

Figure 5 is a diagram which may be used in locating the instrumentalities in certain of the relay circuits shown in Figure 4, the contactors and coils in said relay circuits being located in line with the corresponding instrumentalities in Figure 4.

Referring first to Figure 1, the letter A represents a small bell (located uppermost) and the letter B indicates a large bell (located lowermost), which cooperate with one another in the charging of the blast furnace C, which provides a furnace chamber below the large bell B. The two bells A and B may be arranged coaxially in a manner which is common in practice, the bell A being controlled by a cable E, while the lower bell B is controlled by the cable D, levers F and G being connected to said cables D and E, respectively, said levers F and G being connected to the bells B and A, respectively. The cable E is connected to the hydraulic cylinder H, which is adapted to have a reciprocating movement along a vertical axis.

Disposed within the small bell cylinder H is the piston I, which piston is carried by the piston rod J. Said piston rod J and piston I are stationarily mounted. The piston rod J is provided with the port K communicating with the space above the piston I and is also provided with the port L communicating with the space below said piston I. The letter M indicates a four-way valve, which need not be described in detail, inasmuch as such valves are well known and are readily purchas-

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able in the open market. It will be sufficient to state that when said four-way valve M is in one predetermined position, it provides communication from the fluid inlet N through port L to the space below the piston I. At the same time said valve M provides access from the port K to an exhaust O. When said four-way valve M is in another predetermined position it permits access from the fluid inlet N through the port K to the space above the piston I. At the same time it permits access from the space below the piston I to the exhaust O. Said four-way valve M is adapted to be operated by means of the motor P, which, through any preferred power transmitting mechanism, operates the crank Q. Said crank Q may be connected to said four-way valve M through any preferred mechanism. Said crank Q may also operate certain limit switches, which will be described presently.

The cable D is connected to the cylinder R, which is also adapted to have a reciprocating movement along a vertical axis. Said cylinder R is provided with the piston S carried by the piston rod T. Said piston S and piston rod T are stationarily mounted. Said piston rod T is provided with the port U, providing access to the space above said piston S. Said piston rod T is also provided with the port V, providing access to the space below said piston S. The letter W indicates a four-way valve similar in function to the four-way valve M above described. When said four-way valve is in one predetermined position, it permits access from the source of fluid pressure N to the space on the under side of the piston S, and at the same time provides access from the space above the piston S to the exhaust O. When said four-way valve W is in another predetermined position, it permits access from the source of fluid pressure N to the space above the piston S, and at the same time permits access from the space below the piston S to the exhaust O. Said four-way valve is adapted to be operated by means of the electric motor Y, which, through any preferred power transmitting mechanism, is adapted to turn the crank Z. Said crank Z is connected to the four-way valve W through any preferred connecting means, which need not be described.

The numeral 10 indicates a by-pass conduit, one end of which is connected to the interior of the furnace chamber adjacent to the top thereof and the other end of which is connected to the space between the large bell B and the small bell A. Disposed intermediate of the length of the conduit 10 is the equalizer valve 11, shown more in detail in Figure 3. By referring to Figure 3 it will be noted that said equalizer valve 11 includes the stationary seat 12 adapted to be contacted by the movable valve member 13. Said movable valve member 13 is pivotally mounted at the end of a swinging arm 14, which arm is fast to the swinging arcuate member 15 journaled within a portion of the valve 11. Said arcuate member 15 has two grooves in its periphery, one for receiving the cable 16, from an extremity of which is suspended the counterweight 17. The other end of said cable 16 is fast with the arcuate member 15. The counterweight 17 serves to bias the arcuate member 15 in a counterclockwise direction to hold the valve member 13 against its seat 12. The other groove in the arcuate member 15 is provided with the cable 18, one end of which is fast with the arcuate member 15. Lifting of the cable 18 will tend to raise the counterweight 17 and move the arcuate member 15 in a clockwise direction to move the valve 13 from its seat to open the equalizer valve 11.

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ate member 15 in a clockwise direction to move the valve 13 from its seat to open the equalizer valve 11.

As shown in Figure 1, the cable 18 is trained over a sheave 19 and has its lower extremity connected to the piston rod 20, which is connected to the piston 21 in the cylinder 22. The cylinder 22 is provided at its top with the inlet conduit 23 and at its bottom with the exhaust conduit 24. Said inlet conduit 23 is connected to the three-way valve 25, which may be of usual conformation. Said three-way valve 25 is provided with the air inlet conduit 26 and with the exhaust conduit 27. Said valve 25 is responsive to the plunger 28, which is adapted to be controlled by instrumentalities to be explained more in detail presently. It may be stated briefly at this point that the valve 25 is biased to a position wherein air above the piston 21 will be exhausted through the conduit 27 to the atmosphere and said plunger will be raised to its uppermost position. Air under pressure from the supply conduit 26 may be communicated through the conduit 23 to the region above the piston 21 to force said piston downwardly to exert a downward pull on the cable 18 to lift the counterweight 17 to move the valve member 13 from its seat to open the equalizer valve 11. The piston rod 20 of the cylinder 22 is provided with a cam 29 adapted to operate a pair of limit switches, to be described presently.

Communicating with the space between the small bell A and the large bell B is a relief conduit 30 provided with the relief valve 31, the details of which are illustrated in Figure 2. Said relief valve controls access from the region between the bells A and B to the atmosphere.

Referring to Figure 2, it will be noted that the relief valve 31 includes the movable member 32 adapted to be seated against the stationary valve member 33. Said movable valve member 32 is pivoted to a swinging arm 34 fast with an arcuate member 35. Said arcuate member 35 has a pair of grooves in its arcuate periphery, one for receiving a cable 36 which suspends the counterweight 37. The other end of the cable 36 is secured, through means not illustrated, to the arcuate member 35. The other groove in the arcuate periphery of the arcuate member 35 receives the cable 38, one end of which is secured to the arcuate member 35. By reference to Figure 1 it will be noted that the cable 38 is trained over the sheaves 39 and 40 and has its other extremity connected to the piston rod 41 fast with the piston 42 in the operating cylinder 43.

Communicating with the space above the piston 42 in the operating cylinder 43 is the conduit 44 provided with the three-way valve 45. Communicating with the valve 45 is the conduit 46 for supplying air under pressure, and also communicating with the valve 45 is the conduit 47 for discharging air to the atmosphere. The lower region of the operating cylinder 43 is provided with the exhaust conduit 48 for passing air from below the piston 42 to the atmosphere. Said valve 45 is responsive to a plunger 49, which in its lowermost or biased position connects the air supply conduit 46 to the region above the piston 42, whereby to force said piston downwardly to exert a pull on the cable 38 to raise the counterweight 37 to open the relief valve 31.

The piston rod 41 of the operating cylinder 43 is provided with the cam 50, which as the piston

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rod moves relative to the operating cylinder 43, controls a pair of limit switches, which will be described presently.

Reference will now be made to a number of limit switches employed in the practice of the present invention.

The motor P, as above indicated, operates the crank Q, which in turn, at two extremes of its travel, operates limit switches 51 and 52. The motor Y, as above indicated, operates the crank Z, which in turn, at two extremes of its travel, operates the limit switches 53 and 54.

The small bell operating cylinder H is adapted to control the limit switch SBC and the large bell operating cylinder R is adapted to control the limit switch LBC. The cam 29 movable with the piston rod 20 of the equalizer valve operating cylinder 22 is adapted at the upper region of its stroke to control the limit switch EVC and at the lower region of its stroke to control the limit switch EVO.

The cam 50 movable with the piston rod 41 of the relief valve operating cylinder 43 is adapted in the upper portion of its stroke to control the limit switch RVC and at the lower region of its stroke to control the limit switch RVO.

The three-way valve 25 for controlling the operating cylinder 22, which in turn controls the equalizer valve 11, is responsive to the solenoid EV-solenoid, and the three-way valve 45 for controlling the cylinder 43, which in turn controls the relief valve 31, is responsive to the solenoid RV-solenoid.

The various solenoids and switches above mentioned are controlled from a panel CP supplied by the electric conductors 55-55. The control panel CP is connected to the various switches and solenoids through multiple wire cables, as illustrated in Figure 1. The circuits embodying said multiple wire cables, switches and solenoids will be clear from the diagram appearing in Figure 4.

The valve 25 associated with the equalizer valve 11 is biased to a position corresponding to that in which the region above the piston 21 is connected to atmosphere. When the EV-solenoid is energized, the valve 25 is positioned to cause high pressure air to enter the region above the piston 21, thereby opening the equalizer valve 11.

The valve 45 associated with the relief valve 31 is biased to a position in which air under pressure is introduced above the piston 42, thereby opening the relief valve 31. So long as RV-solenoid is energized, relief valve 31 is closed.

Limit switch EVC is provided with two pairs of contacts EVC-1 and EVC-2. The pair of contacts EVC-1 are closed when the equalizer valve 11 is closed, that is—when the piston 21 is up. The pair of contacts EVC-2 are open when the equalizer valve 11 is closed.

Limit switch EVO includes the pair of contacts EVO-1, closed when the equalizer valve 11 is open.

Limit switch RVC includes two pairs of contacts RVC-1 and RVC-2, both of which are closed when the relief valve 31 is closed, that is—when the piston 42 is up.

Limit switch RVO includes a pair of contacts RVO-1, closed when the relief valve 31 is open.

The limit switch SBC for the small bell cylinder includes the pair of contacts SBC-1, closed when the small bell A is closed.

The limit switch LBC for the large bell cylinder includes the pair of contacts LBC-1, closed at all times except when the large bell B is closed.

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This pair of contacts LBC-1 close as soon as the large bell B leaves its closed position.

Limit switch 51 is biased to closed position and is open when the small bell valve M is in bell-closing position. Limit switch 52 is biased to closed position and is open when the small bell valve M is in bell-opening position.

Limit switch 53 is biased to closed position and is open when the large bell valve W is in bell-closing position. Limit switch 54 is biased to closed position and is open when the large bell valve W is in bell-opening position.

Referring now to Figure 4, the various instrumentalities above mentioned are shown diagrammatically in an electrical control circuit. In addition to the instrumentalities previously mentioned, the diagram of Figure 4 shows the following instrumentalities:

The small bell push button SBPB includes a walking beam operating member having the alternatively operative buttons marked "Open" and "Close." When the "Close" button is depressed, a switch *a* is moved to open position and a switch *b* is moved to closed position. When the button "Open" is depressed, the switch *a* is moved to closed position and the switch *b* is moved to open position.

The large bell push button LBPB is also provided with a walking beam operating member provided with the alternatively operative buttons "Open" and "Close." Said large bell push button controls the switch *c*, *d* and *e*. When the "Close" button is depressed, switches *c* and *d* are moved to open position and the switch *e* is moved to closed position. When the "Open" button is depressed, switches *c* and *d* are moved to closed position and switch *e* is moved to open position.

As shown in the diagram of Figure 4, the motor P is provided with the armature *Pa* and with the two series field windings *Pb* and *Pc*, which serve to operate the motor in two directions.

The motor Y is provided with the armature *Ya* and with the two series field windings *Yb* and *Yc*.

The control panel CP also includes relays EVI, RV and EV, the operating coils of which are indicated in Figure 4 by the reference letters just mentioned. The operating coil EVI when energized is adapted to close the pairs of contacts EVI-1, EVI-2 and EVI-3, which contacts are biased to open position when the coil EVI is not energized.

The operating coil RV when energized is adapted to close the pair of contacts RV-1, which contacts are biased to open position when the coil RV is not energized.

The operating coil EV when energized is adapted to close the pair of contacts EV-1, biased to open position when the coil EV is not energized.

The mode of operation of the above described embodiment of the present invention is substantially as follows:

After a load of material has been charged upon the small bell A, said small bell may be opened by pushing the "Open" button of the push button SBPB. This closes the circuit through the series field winding *Pb* and armature *Pa* because of the fact that the limit switch contacts EVC-1 are closed (equalizer valve 11 being closed) and limit switch contacts RVO-1 are closed (the relief valve 31 being open). The motor P moves the valve M into position to raise the small bell

cylinder H and open the small bell A. As soon as the valve M is in this position, limit switch 52 opens and the motor P stops. Meanwhile limit switch 51 closes. When it is desired to close the small bell, the "Close" button of SBPB is depressed. This closes the circuit through the switch b and through the series field winding Pc and armature Pa. The motor P moves the valve M into position to lower the small bell cylinder H and close the small bell A. As soon as the valve M is in this position the limit switch 51 opens and motor P stops. In this manner the small bell A is opened and closed. This cycle may be repeated several times in order to discharge several loads of material upon the large bell.

At intervals it will be desired to open the large bell B in order to discharge into the blast furnace the material which has been delivered from the small bell A. The large bell B may be opened by pushing the button marked "Open" of the push button LBPB. This closes the circuit through the switch c, causing coil EVI to be energized. The resulting closure of the contactor EVI-1 causes the coil RV to be energized. This causes contactor RV-1 to close, thus energizing the solenoid RV-solenoid. This leads to the closure of the relief valve 31. The instrumentalities in Figure 1 are shown as though the operation were stopped with the relief valve closed, the equalizer valve closed and the large bell and small bell both closed. This is a transient condition.

Energization of the coil EVI also results in the closure of contactor EVI-2, completing a circuit through the coil EV as soon as the relief valve 11 closes (thereby closing the limit switch contacts RVC-1). Contacts SBC-1 are closed because the small bell A is in closed position.

Energization of the coil EV causes the closure of the contactor EV-1, which causes energization of the solenoid EV-solenoid. This leads to the opening of the of the equalizer valve 11. Energization of the coil EV-1 also results in the closure of the contacts EVI-3, completing a circuit through the series field winding Yb and the armature Ya of the motor Y, since the switch d is closed and the relief valve 31 is closed (whereby limit switch contacts RVC-2 are closed) and the equalizer valve 11 is open (whereby limit switch contacts EVO-1 are closed). The motor Y operates to move the valve W to a position to cause a large bell operating cylinder R to lift, opening the large bell B. As soon as the valve W has moved to the cylinder lifting position the limit switch 54 is opened, stopping the motor Y. Meanwhile the limit switch 53 closes.

The large bell B is closed by depressing the "Close" button of the push button LBPB. This closes the circuit through the switch e through the limit switch 53 and through the series field winding Yc and the armature Ya of the motor Y. The motor Y operates in a direction to move the valve W into position for lowering the cylinder R. As soon as the valve W attains this position the limit switch contacts 53 open. Lowering of the cylinder R results in the closure of the large bell B.

The depressing of the "Close" button of LBPB results in the opening of the switch c, which leads to the deenergization of the coil EVI, resulting in the opening of contacts EVI-1, EVI-2 and EVI-3. Opening of the contacts EVI-2 causes the deenergization of the operat-

ing coil EV, causing the contacts EV-1 to open, deenergizing the solenoid EV-solenoid, causing the exhausting of air from the upper portion of the cylinder 22, causing the equalizer valve 11 to close. This causes the limit switch contacts EVC-2 to open. When the large bell B fully closes, limit switch contacts LBC-1 are opened. Coil RV is now deenergized because contacts EVI-1, EVC-2 and LBC-1 are all open. Consequently the contacts RV-1 open, leading to the deenergization of the solenoid RV-solenoid, thus causing the relief valve 31 to open. The cycle is thus completed.

The interlocking arrangement as illustrated and described is of the forced type; that is, the mechanisms under control must actually respond and make their necessary movements in order to actuate the limit switches whose contacts are included in the control circuits. The interlocking arrangement is of the permissive type in that it gives permission for certain functions to take place, but it also requires them to take place as a prerequisite of bell-opening operations. The interlocking arrangement illustrated and described prevents the operations from taking place under improper conditions.

Recapitulating certain advantages of the present invention, the following may be mentioned:

1. The small bell A can open only when the equalizer valve 11 is closed and the relief valve 31 is open.
2. The large bell B can open only when the relief valve 31 is closed and the equalizer valve 11 is open.
3. The relief valve 31 must be closed and the small bell A must be closed before the equalizer valve 11 can be opened.
4. The relief valve 31 can be opened only when the equalizer valve 11 is closed and the large bell B is closed.

Though a preferred embodiment of the present invention has been described in detail, many modifications will occur to those skilled in the art. It is intended to cover all such modifications that fall within the scope of the appended claims.

What is claimed is:

1. A blast furnace comprising, in combination, a furnace chamber, a lowermost charging bell, a topmost charging bell at the top of said chamber, said bells being arranged in series with one another, means for operating the lowermost of said bells, means for operating the uppermost of said bells, a by-pass conduit adapted to connect the space between said bells with said furnace chamber, an equalizer valve in said conduit, motive means for said equalizer valve, a relief valve for providing communication between the space between said bells and atmosphere, motive means for said relief valve, and means for interlocking said operating means for the uppermost of said bells with said equalizer valve and said relief valve to permit said uppermost of said bells to open only when said equalizer valve is closed and said relief valve is open.
2. A blast furnace comprising, in combination, a furnace chamber, a lowermost charging bell, a topmost charging bell at the top of said chamber, said bells being arranged in series with one another, means for operating the lowermost of said bells, means for operating the uppermost of said bells, a by-pass conduit adapted to connect the space between said bells with said furnace chamber, an equalizer valve in said conduit, motive means for said equalizer valve, a relief valve for providing communication between the

space between said bells and atmosphere, motive means for said relief valve, and means for interlocking said operating means for the lowermost of said bells with said relief valve and said equalizer valve to permit said lowermost of said bells to open only when said relief valve is closed and said equalizer valve is open.

3. A blast furnace comprising, in combination, a furnace chamber, a lowermost charging bell, a topmost charging bell at the top of said chamber, said bells being arranged in series with one another, means for operating the lowermost of said bells, means for operating the uppermost of said bells, a by-pass conduit adapted to connect the space between said bells with said furnace chamber, an equalizer valve in said conduit, motive means for said equalizer valve, a relief valve for providing communication between the space between said bells and atmosphere, motive means for said relief valve, and means for interlocking said relief valve and said operating means for said uppermost of said bells and said equalizer

valve to permit said equalizer valve to be opened only when said relief valve and said uppermost of said bells are closed.

4. A blast furnace comprising, in combination, a furnace chamber, a lowermost charging bell, a topmost charging bell at the top of said chamber, said bells being arranged in series with one another, means for operating the lowermost of said bells, means for operating the uppermost of said bells, a by-pass conduit adapted to connect the space between said bells with said furnace chamber, an equalizer valve in said conduit, motive means for said equalizer valve, a relief valve for providing communication between the space between said bells and atmosphere, motive means for said relief valve, and means for interlocking said relief valve, said equalizer valve and said operating means for the lowermost of said bells to permit the opening of said relief valve only when said equalizer valve is closed and said lowermost bell is closed.

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