Dec. 7, 1965 N. B. MELCHER ET AL 3,221,906

SEALING SYSTEM FOR BLAST FURNACE BELLS FOR HIGH PRESSURE TOP OPERATION

Filed Feb. 11, 1964 3 Sheets-Sheet 1

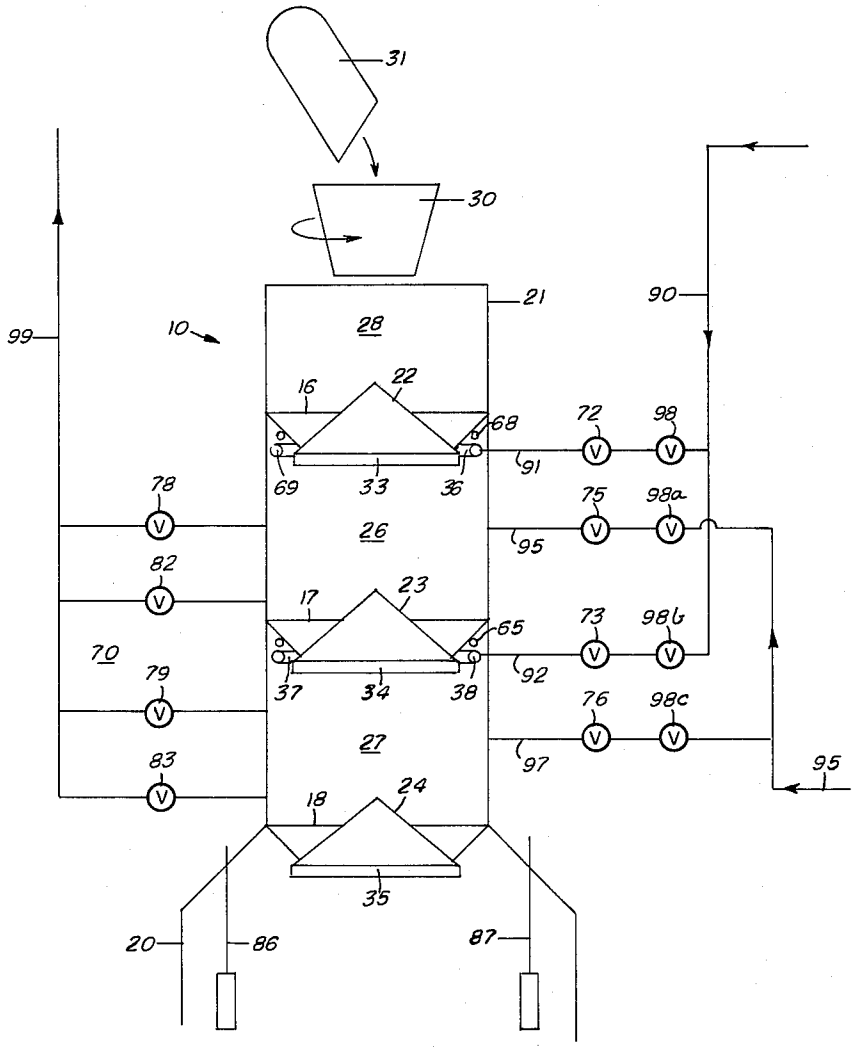


FIG. 1

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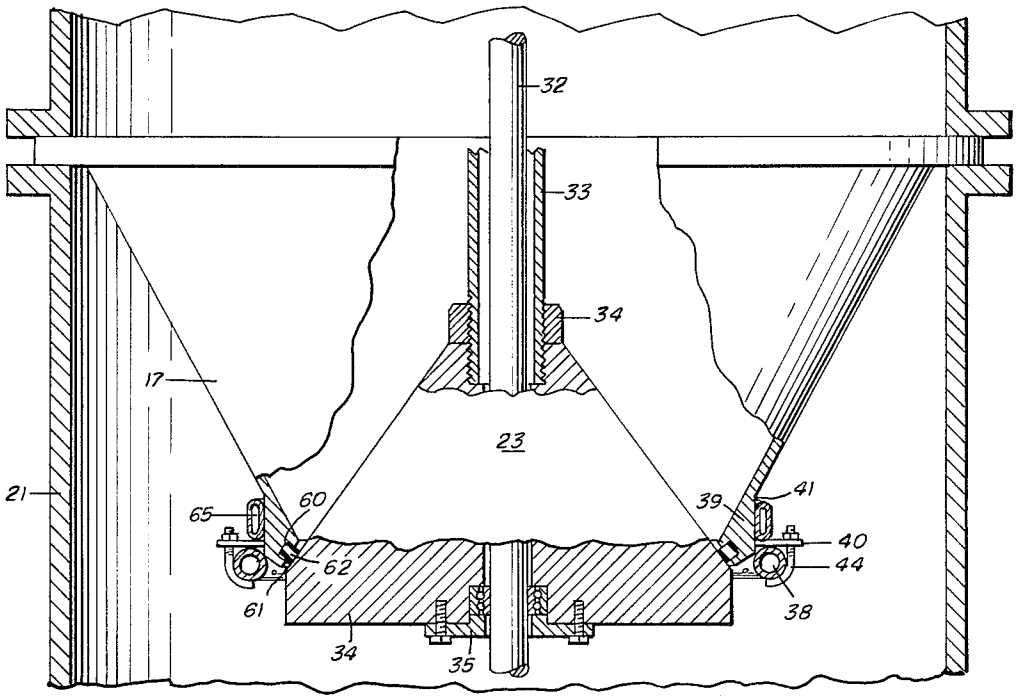


FIG. 2A

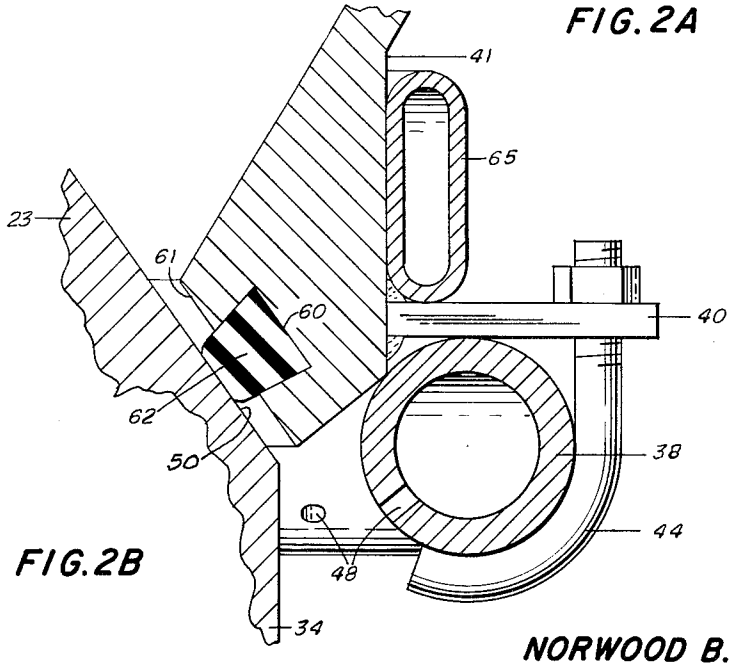


FIG. 2B

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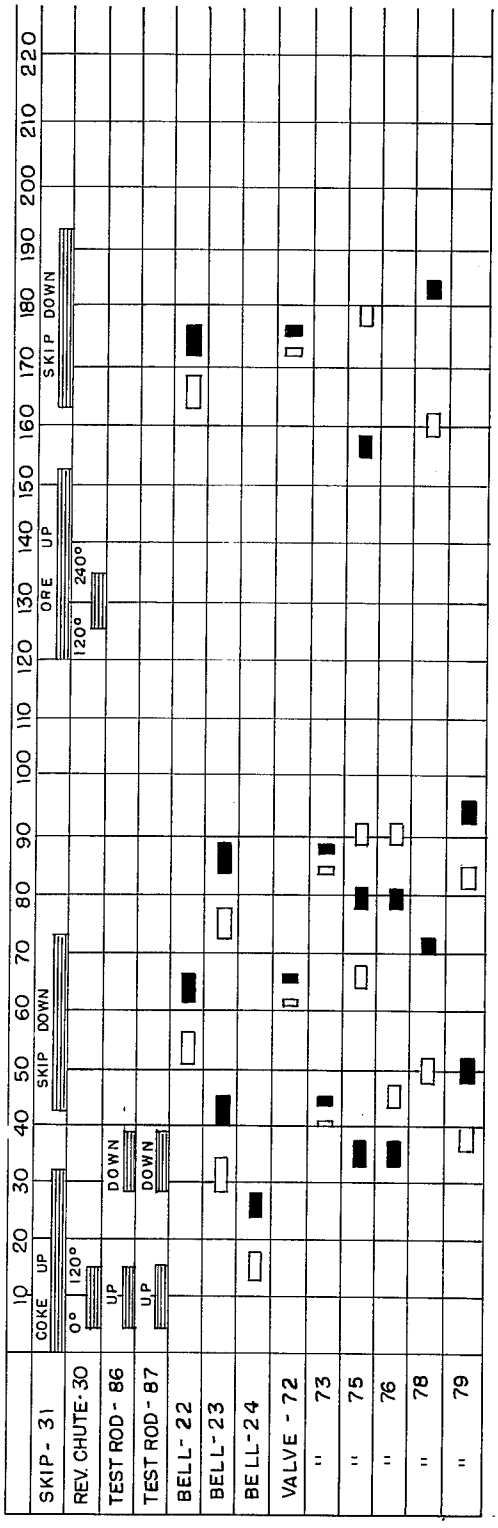


FIG. 3

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3,221,906

SEALING SYSTEM FOR BLAST FURNACE BELLS FOR HIGH PRESSURE TOP OPERATION

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5 Claims. (Cl. 214—36)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention herein described and claimed may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of royalties thereon or therefor.

The present invention relates to improved blast furnace bell and hopper structures and a method for operating such structures. More particularly, it concerns apparatus made an integral part of bell and hopper structures which facilitates operation of a blast furnace at ultra high pressures, including top pressures as high as 40 p.s.i.g. The desirability of operating a blast furnace at a high top pressure is now well recognized in the art. Many advantages including low coke rate, low flue dust with decreased dust losses, lower gas cleaning cost, and higher iron production, can normally be expected to follow from high pressure operation. However, extended working of a blast furnace at the relatively higher pressures becomes economically feasible only when a tight gas seal between the furnace proper and the furnace top assembly can be maintained without frequent overhauls of the sealing means. A major contributing factor to lost furnace time when operating at high top pressure is the relatively short effective life of bells and bell hoppers due to the strong erosive action of the abrasive, hot dust-laden gases escaping past such parts during the times they are separated for the repeated chargings of coke, ore and other materials regularly required for continuing operation. The method and apparatus according to the present invention permits a tight seal between bell and hopper parts to be sustained even after prolonged furnace operation at high pressures.

Characterizing the principal features of the bell and hopper structures of the present invention are a special non-metallic to metal seal means, and further means to protect the non-metallic substance of the seal by cleaning and cooling the contacting surfaces of the seal means and surfaces adjacent thereto. A resilient non-metallic substance is preferred for this seal means to allow a tight closure to be effected in the event such substance may possibly contact a roughened surface. Cleaning the contacting surfaces is accomplished using gases under high pressure, and preferably cleaned blast furnace gases. Such gases are supplied at high pressure to a blow pipe structure, close by these contacting surfaces, which functions to blow jets of these gases directly upon the relevant bell surface whereby they sweep over the bell as it is being moved into place to close the hopper. Provision is made to cool the closure area by supplying circulating coolant to a conduit surrounding a portion of the hopper adjacent the closure area, although it is obvious that other cooling expedients may be used for this purpose.

It is therefore an object of the present invention to provide a method and means permitting use of high top pressures in blast furnace operations to be economical and efficient.

Another object of the invention is to provide means for obtaining a tight seal for a bell and hopper structure functioning in a blast furnace operating at high top pressures.

A further object of the invention is to provide cleaning and cooling means, as an integral part of a blast furnace bell and hopper structure, which allows such structure to continue to effectively seal the blast furnace even after extended operation thereof at high top pressures.

These and other objects of the present invention will be more clearly understood from the following description of a preferred embodiment of the invention considered together with the accompanying drawing wherein:

FIG. 1 is a schematic representation of some of the various basic structural components constituting the upper section of a blast furnace including bell and hopper arrangements according to the present invention;

FIG. 2A is a cross-sectional view of a portion of the improved bell and hopper structure represented in FIG. 1;

FIG. 2B is a fragmentary sectional view showing particular details of the structure represented in FIG. 2A; and

FIG. 3 is a chart on which are represented the sequential relationships between operations of the basic directing and controlling equipment essential to the performance of the bell and hopper structure according to the present invention.

In the schematic representation of FIG. 1, an upper portion of a blast furnace **10** may be seen to include a furnace stack **20** having vertically arranged over an upper opening therein a cylindrical shell **21**. To the inner surface of shell **21** are attached three inverted truncated, conical shells **16**, **17** and **18**, in a superimposed relationship. Three generally conically shaped bells **22**, **23** and **24**, shown fitted within the lower circular openings in conical shells **16**, **17** and **18**, respectively, coact therewith to form separately operable bell and hopper structures which define an upper chamber **26** between bells **22** and **23**, and a lower chamber **27** between bells **23** and **24**. The top bell and hopper structure comprising conical shell **16** and bell **22**, located close to the upper open end of cylindrical shell **21**, is operative to provide a base for a compartment **28** constituting a receptacle to which charging materials for the blast furnace are initially supplied from a revolving chute **30**. Charging materials are delivered to chute **30** by means of a skip-car or bucket arrangement depicted in FIG. 1 as a skip-car **31**, whose operation is coordinated with that of the blast furnace bell and hopper structures in a manner well known in the art.

Appropriate vertical displacements of bells **22**, **23** and **24** relative to the respective conical shells in which they function, are facilitated by a conventional lever operated, nested shaft construction of the type disclosed in Patent No. 2,408,945, issued to Mohr, Jr., et al., on October 8, 1946. In FIG. 2A of the present disclosure this construction may be seen to comprise a shaft **32** passing through a tubular shaft **33** screwed into a fitting **34** fastened to the top of bell **23**. Shaft **32** extends through a central opening in bell **23**, and a bearing device **35** fixed therein, and thence into a fitting on bell **24** fixing the shaft thereto. Hopper **30** between skip **31** and the upper bell **22** is adapted to revolve whereby it facilitates the distribution of the charges uniformly into the furnace. Charging is accomplished at three positions of the revolving hopper during a dumping cycle. An initial dumping from the skip occurs with the revolving hopper stopped at a 120° point followed by dumping with the revolving hopper stopped at the 240° point and at the 360° or 0° point. Charges are thereafter dumped in accordance with this pattern as required by furnace conditions and its operational schedule.

Bells **22**, **23** and **24**, as seen in FIG. 1, also comprise as integral parts of their respective base portions, short, cylindrical sections **33**, **34** and **35**. Fixed in position so as to be suspended closely adjacent to the base portions of each of the respective bells **22** and **23**, is a blow pipe

structure, indicated by numerals **36** and **37** in the drawing. As shown in FIGS. 2A and 2B, this structure is mainly comprised of a ring shaped tubular pipe **38**, which is maintained in its suspended position with respect to bell **23** by supporting devices depending from a rim section **39** of the conical shell **17** associated with the bell. Comprising this pipe support structure is a circular flange **40** welded to an outer cylindrical surface **41** of rim **39**, and a number of J-shaped hooks **44**, bolted to flange **40** at suitably spaced points adjacent its outer peripheral edge. Pipe **38** is firmly held between hooks **44** and the underside of flange **40** so as to bear against a lower, outer edge of rim **39** whereby the bottom half of the pipe is situated below the lowest edge of the rim. Evenly spotted around the lower wall of pipe **38** which faces bell **23**, are approximately 100 relatively small radial passages **48** opening into the pipe. These passages are downwardly disposed so as to align their openings approximately parallel to the incline of the bell's conical surface **50**. As will be hereinafter fully explained, this construction allows gases under pressure discharge from passages **48**, to impinge directly upon surface **50** of the bell when it is rising from a position of any appreciable distance from the closed phase thereof shown in FIGS. 1 and 2A.

As was hereinbefore indicated, operation of a blast furnace at high top pressures can be satisfactorily accomplished only when an effective seal is obtained between the bell and hopper elements of the furnace following any furnace charging procedures. According to the present invention, a requisite positive seal is gained for its bell and hopper structures with means characterized by a non-metallic to metallic contact between the sealing parts thereof. Although accomplishing this positive seal for the middle bell and hopper elements **23** and **17**, is essentially the key to successful high top pressure operation, preferred operation requires that the upper bell and hopper elements **22** and **16**, as well as these middle elements be equipped to effect the non-metallic to metallic seal. However, the stack bell and hopper elements **24** and **18**, being in the hottest area of the bell and hopper system, operate to effect only a metal to metal seal by their closure.

With reference to FIGS. 2A and 2B, it may be seen that a construction comprising the sealing parts for the middle or intermediate bell and hopper elements **23** and **17**, includes a keying mortised groove **60**, circumscribing the middle of a lower inner conical surface **61** of rim **39**, and sloped to parallel the inclined conical surface **50** of bell **23**, and a gasket **62**, of non-metallic, resilient material, shaped to fit into the key of groove **60**. The gasket **62** is securely retained in groove **60** by a suitable adhesive, such that a relatively short portion of the gasket extends outside rim **39**. As is evident from the showing in FIG. 2B, this extended portion of the gasket is compressible by the bell's conical surface **50**, as it rises to effect a closure of the bell and hopper structure. Various resilient materials capable of withstanding temperatures above 250° F. can be used for the sealing gasket. An applicable sealing substance is a silicon rubber composition such as the General Electric, general purpose class 400 silicone rubber materials whose physical properties are a hardness of 40±5 durometer, a tensile strength of 700 p.s.i. and above, a 240 percent elongation, a 25 percent maximum compression set at 300° F. for 70 hours, and effectiveness in a −80° F. to +500° F. temperature range. A General Electric extreme high temperature class 700 silicone rubber material may also be fabricated into a suitable sealing gasket.

To aid the maintenance of a favorable temperature about the sealing gasket **62**, provision is made to cool rim **39** by circulating coolant around the outer wall of the rim. For this purpose a tube **65** of copper, or like good heat transfer material, is flattened to provide a wide heat transfer surface which is secured by welding, or the like, to outer cylindrical surface **41** of rim **39**, and to the support flange **40** fixed to this cylindrical surface. Tubing of sufficient length is provided to completely encircle the surface **41**, and inlet and outlet coolant connections are made thereto through the enclosure about the bell and hopper structure in a manner well known in the art. As is schematically shown in FIG. 1, upper bell and hopper elements **22** and **16**, also have cooperatively associated therewith a tube **68** for carrying coolant to protect their resilient sealing gasket (not shown), in addition to the blow pipe structure **36**, appropriately located by its attachment to a support flange on the hopper shell **16**, to allow gases under pressure to pass from a pipe **69** to impinge upon the conical surface of bell **22**.

As is now readily apparent from the previous explanations, the blow pipes **38** and **69** must function in conjunction with the operational control for vertically displacing the bells associated therewith to assure that the metallic surface of each such bell is clean of charging materials before that surface contacts the non-metallic sealing gasket in the rim of the hopper shell related thereto. Moreover, this operational control for the bells is also coordinated with instrumentalities controlling pressure equalization in the bell and hopper chamber **26** and **27**, and means operative to determine the height of the burden in the blast furnace proper. Since the gases jetted from the blow pipes for dispersing charging materials tending to adhere to the bells are preferably derived from gases normally available from blast furnace operation, such gases must be suitably conditioned before they can be used as indicated. Exemplifying the gases supplied for use in the blow pipes are gases which have been cleaned to a residual dust content of .005 grain per standard cubic foot, at 0 p.s.i.g. and 125° F., and saturated with water vapor, and subsequently compressed to 100 p.s.i.g. and 100° F. The blast furnace gases thusly processed are supplied from a compressor to a pressure receiver from which they are released to effectuate the pressure equalization procedures, hereinbefore noted, as well as the cleaning of the bells' surfaces by means of the blow pipes.

A requisite control for the aforesaid coordinated operational functions is obtained in the present invention by a system of valves, generally indicated by numeral **70** in FIG. 1, through which the conditioned gases must flow before they can become effective in the blast furnace top enclosure **21**. Included among the valves of system **70** are blow pipe control valves **72** and **73**, equalizer valves **75** and **76**, relief valves **78** and **79**, and pop safety valves **82** and **83**. Additionally provided are vertically displaceable test rods **86** and **87**, shown in FIG. 1 as projecting through the top of furnace **20** to sense the height of charging material or burden therein, whose operational requirements are interrelated with those involving the valves of system **70**. The valve structures of system **70** may have any one of a number of conventional forms including the rack and pinion type disclosed in FIG. 4 of the aforementioned Mohr, Jr., et al. patent. Such valves may also comprise solenoid operated plugs or eccentric plugs which are actuated by cranks driven by a motor through suitable linkages moving between cam type limit switches. Test rods **86** and **87** may also take different forms including those in the nature of that shown in Patent No. 2,426,347 issued to W. M. Fulton on August 26, 1947, and Patent No. 3,014,603 issued to H. Taubmann on December 26, 1961.

Referring once more to FIG. 1, it will be seen that the valves of system **70**, shown at the right side of the figure, are operative in conduits to which the conditioned blast furnace gases are fed from their pressure receiver, and the valves shown at the left side of the figure are operative in conduits through which gases in the enclosure **21** are discharged to atmosphere. More particularly, a conduit **90** is provided from which gases at 100 p.s.i.g. flow into parallel conduits **91** and **92** wherein blow pipe control valves **72** and **73**, respectively, are operative. A

further conduit **95** is provided from which gases at pressures ranging from 4 to 44 p.s.i.g., to correspond to that in the furnace top structure, flow into parallel conduits **96** and **97** in which the pressure equalizer control valves **75** and **76**, respectively, are operative. Conventional throttle valves **98**, **98***a*, **98***b* and **98***c*, precede the control valves in each of the conduits **91**, **92**, **96** and **97**, to permit field adjustments of the related gas flows to be made as needed. Relief valves **78** and **79**, along with pop safety valves **82** and **83**, are separately operable in respective individual conduits connected in parallel to join a main conduit **99**, opening to atmosphere.

In operation, chamber **26** between bells **22** and **23** is pressurized whenever bell **22** is in its closed position and is depressurized to allow bell **22** to drop its charge onto bell **23**. Valve **78** is made operative to depressurize the chamber. Operating pressure is maintained at all times in chamber **27** between bells **23** and **24**. However, to keep chamber **27** cool, a new supply of the pressurized gas is put into this chamber according to a schedule for the operations, to be hereinafter more fully explained, and the hot gas is removed through valve **79**. Safety valves **82** and **83** are provided to operate in case excess pressure builds up in a chamber.

As was previously described, the control valves of system **70**, in cooperation with test rods **86** and **87**, achieve a sequential operation which is coordinated with the functions of the bell and hopper structures. Referring now to the chart of FIG. 3, on which are represented details of several such sequences of coordinated operations, there will be found listed in the chart's left-hand column the devices relevant to the functioning of the blast furnace top structures, and marked across the top line of the chart a time scale in seconds to which the functions of these devices are related. Appropriate furnace charging programming equipment is provided to regulate and coordinate the sequences as set forth in the chart, and to interlock these charging operations in a forced sequence such that the charging of the furnace must proceed as indicated or the operations will be halted. Equipment of this type includes various control and limit switches in energizing circuits of electrically operated actuator means for the valves, rods, bell drives, etc., wherein such switches are arranged to be worked by a timed programmer apparatus. Various kinds of conventional control sequencing devices are adaptable for use in such apparatus. Among such devices are a timed revolving drum perforated to receive switch actuator pins selectively positioned thereon in a predetermined manner, and a magnetic storage drum or tape having a plurality of tracks on which switch operate control signals are selectively recorded.

For the purposes of the present disclosure, it can be assumed that conditions at the start of the charted operations are as follows:

An ore load and a coke load are on bell **24**.

An ore load on bell **23**.

No load on bell **22**.

Pressures in hopper chambers **26** and **27** are equalized to the pressure within the furnace.

Equalizer valves **75** and **76** are open.

Relief valves **78** and **79** are closed.

Test rods **86** and **87** are on the furnace burden.

A coke skip **31** is loaded in the pit.

Chute **30** is positioned at 0°.

If the test rods **86** and **87** sense that the burden of the furnace is low enough to take another charge, the actuation of a "skip up" control button will start the hoisting of the skip car loaded with coke. As the skip car leaves the pit and moves upwardly to deposit coke into compartment **28**, the test rods are withdrawn from the furnace, and chute **30** revolves moving to the 120° position, all of which is indicated on the chart between time units 0 to 30. Once the test rods are withdrawn, bell **24** moves downwardly to open hopper **18**, and remains down for a predetermined interval of time wherein the ore and coke loaded thereon is charged into the furnace. Thereafter bell **24** rises to close its hopper, as indicated on the chart between time units **25** and **29**. As soon as bell **24** effects a closure, test rods **86** and **87** are again lowered to the burden, while bell **23** moves down to open hopper **17** and deliver an ore load to chamber **27**. When bell **23** completes its downward course, the equalizer valves **75** and **76** are both operated to close. Once valve **76** is closed, relief valve **79** will open. Bell **23** remains down for a predetermined interval of time after which it starts to move up. However, as indicated on the chart between time units **40** and **45**, when bell **23** starts up to close hopper **17**, the blow pipe control valve **73** opens and remains open for the interval during which the bell rises.

As a result, gases under 100 p.s.i.g. pressure are steadily released from the passages **48** in blow pipe **38**, and jetted against the conical surface of bell **23**, until the bell surface is brought into contact with the resilient gasket **62** in the rim of the hopper shell.

Closure of hopper **17** by bell **23**, and control valve **73** therewith, are followed by the opening of equalizer valve **76**. When reaching open position, valve **76** initiates the operation of a timer for a predetermined interval at the end of which a control is activated to close relief valve **79**. Further, if the skip car has reached the dumping position at the top of the furnace, and the dump time interval has expired, relief valve **78** will open. In the event relief valve **78** does open, bell **22** starts to move down opening the upper hopper to allow delivery of a coke load to chamber **26**. After reaching its full down position, bell **22** remains lowered for a predetermined interval of time before it again rises to close its hopper. However, as is made evident by the sequence chart of FIG. 3, between time units **61** and **66**, blow pipe control valve **72** opens as bell **22** starts to rise and remains open until closure of hopper **16** is approximately completed, whereby the conical surface of the bell is cleaned of charge particles and gas dust by gases issuing from blow pipe **69**, under high pressure. As soon as valve **72** closes contemporaneously with bell **22**, the equalizer valve **75** will open, and when valve **75** reaches its open position a timer is made operable for a predetermined period at the end of which relief valve **78** will close. Upon closure of valve **78**, bell **23** starts to move downwardly to open hopper **17** and allow delivery of the coke load to chamber **27**. As soon as this hopper is opened equalizer valves **75** and **76** are both closed, and upon closure of valve **76**, the relief valve **79** is opened.

Bell **23** remains down to maintain its hopper open for a predetermined time interval, and thereafter starts to rise. As bell **23** rises, blow pipe control valve **73** opens to effect the cleaning of bell **23** in a manner hereinbefore explained, whereupon valve **73** closes as the hopper is closed by the bell. Equalizer valve **75**, along with equalizer valve **76** open following closure of the hopper, and when valve **76** reaches its open position, a timer operates for a predetermined time interval at the end of which relief valve **79** closes.

At the end of the operational sequence involving the first skip load, the following conditions prevail:

Ore and coke loads are on bell **24**.

No load on bell **23**.

No load on bell **22**.

Pressure in hopper chambers **26** and **27** are equalized to match the pressure in the furnace.

The equalizer valves are open.

The relief valves are closed.

The test rods are down to sense the height of burden.

A loaded ore skip is in the pit.

Chute **30** remains positioned at 120°.

Operations again commence as the skip car of ore starts to hoist to the dumping position at the top of the furnace. After a predetermined dump time, which starts when the car reaches the dumping position, the equalizer valve **75**

closes. In the sequence of operations which follows, the relief valve **78** opens, and the lowering of bell **22** is initiated to open hopper **16**. After a predetermined interval of time, bell **22** moves up to close its hopper while blow pipe control valve **72** is open to effectuate a cleaning of the bell's surface. The control valve **72** closes as the bell **22** closes its hopper, whereupon equalizer valve **75** starts to open. After valve **75** reaches an open position, a predetermined time interval elapses before relief valve **78** closes. Subsequent activations of the bells, valves, test rods, etc., thereafter continue in substantially the same sequences hereinbefore set forth.

It should be evident that the operational sequences previously described, are only illustrative of a pattern upon which can be based almost all other regular charging operations for a blast furnace. For example, in any continuous charging operations for the blast furnace according to this pattern, the several predetermined time intervals noted therein can be varied by suitable adjustments of the related programming equipment to conform to any specified operational requirements. As was previously indicated, there are many different forms of such programming equipment known to the art, that can be adapted to govern the timed sequencing of the coordinated control for the various valves, bells, test rods, skip car and chute, with which the present invention is concerned. Nevertheless, the particular type of equipment actually used for regulating the operational sequences does not constitute any significant part of the invention.

While preferred forms of the method and physical embodiment of the invention have been illustrated and described herein, it is understood that the invention is not liimted thereby, but is susceptible to change in form and detail.

What is claimed is:

1. In a blast furnace charging apparatus having bell and hopper devices, means intermittently operative to displace a bell of said devices between opened and closed positions with respect to a hopper cooperatively related therewith, and mechanisms to clean a surface of said bell, said mechanisms comprising a conduit having a multitude of passages directed outwardly therefrom, elements supporting said conduit on said hopper whereby said multitude of passages of said conduit have their outer openings facing the surface of said bell designed to contact said hopper when it is closed thereby, supply lines for furnishing a gaseous stream under pressure to said conduit, control valve means in said supply lines operable to disrupt or continue the flow of said gaseous stream therein to said conduit, and operation coordinating means responsive to said bell displacing means to regulate the operation of said control valve whereby the flow of a gaseous stream under pressure is maintained in said supply lines and released to said conduit during the time said bell is displaced from an opened to a closed position with respect to said hopper such that said gaseous stream is jetted out of said multitude of passages and on to said hopper contacting surface of said bell.

2. The blast furnace charging apparatus of claim **1**, wherein the said devices include a plurality of interdependently controlled and separately operable bell and hopper structures, each of said structures having individual means operable to displace the bell thereof between opened and closed positions with respect to the hopper cooperatively associated therewith, several of said plurality of structures each having cooperatively associated therewith an individual one of said mechanisms to clean a bell surface wherein the respective valve means of said individual mechanisms are separately operable to control the gaseous flow to the conduit operatively connected thereto, said operation coordinating means being responsive to the operation of each of said individual bell displacing means to separately regulate the operation of the said respective control valves whereby the gaseous stream jetted out of said multitude of passages of any conduit impinges upon the hopper contacting surface of the appertaining bell.

3. The blast furnace charging apparatus of claim **1** wherein a sealing means is effective to maintain a pressure tight closure between said bell and hopper of said devices when said bell is in closed position with respect to said hopper, said hopper comprising a rim portion having a surface thereon substantially parallel to said surface of said bell designed to contact the hopper, a groove in said rim surface, and a relatively heat resistant resilient gasket securely retained in said groove and having a portion thereof extending outside said groove, whereby said extending portion is compressed by said contacting surface of said bell when the latter is in said closed position with respect to said hopper.

4. The blast furnace charging apparatus of claim **3** wherein said rim comprised by said hopper includes an outer surface adjacent said conduit, said elements supporting said conduit on the hopper being dependent from the said outer surface, and a duct affixed to said outer surface and adjacent to said supporting elements, carrying a coolant circulating therein for protecting the said gasket in the rim from adverse heating effects.

5. The blast furnace apparatus of claim **1** wherein the said conduit comprises a closed ring of tubular pipe and substantially all of said multitude of passages therein are evenly spaced along an inner wall of said pipe and directed toward a common point on the axis of the ring defining the shape of said vessel.

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