FEEDING ARRANGEMENT FOR AN ELECTRIC FURNACE HAVING A TUBULAR ELECTRODE

12 Claims, 1 Drawing Fig.

ABSTRACT: In an electric furnace in which particulate solid material is fed to the furnace hearth from a normally stationary feed pipe through an axially expandable and contractable conduit and through the bore of the electrode, a charging chamber is mounted between the conduit and the electrode and provided with slide valves in its feeding and discharge portions respectively. Suitable operation of the valves permits the material to be introduced into the furnace without release of significant amounts of furnace gases.
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This invention relates to electric furnaces, and particularly to improvements in a furnace feeding arrangement in which material is supplied to the furnace hearth from a normally stationary feed pipe having an upright axis through an axially expandable and contractable conduit and through a bore in an electrode mounted for axial movement.

In known feeding arrangements of the aforesaid type, the fed material falls freely from the feed pipe into the electrode bore. The gas pressure in the bore of the electrode is much higher than ambient atmospheric pressure in such electric furnaces when employed for the manufacture of high-grade calcium carbide or of ferrous alloys, and the hot and usually poisonous furnace gas tends to escape through the feed channel. It has therefore been found necessary in conventional feeding arrangements to connect the stationary feed pipe with a suction line. It was unavoidable heretofore that the hot gases flow through the expandable conduit, and it has been difficult under these conditions to maintain an adequate sealing connection between the bore of the electrode, which must be moved for axial movement, and the feed pipe.

The primary object of the instant invention is the provision of an improved feeding arrangement in which the expandable and contractable conduit between the electrode bore and the normally stationary feed pipe is protected against contact with significant amounts of the furnace gases.

With this object and others in view, as will hereinafter become apparent, the feeding arrangement of the invention is provided with a charging chamber having a feeding portion and a discharge portion downwardly spaced from the feeding portion. Mounting elements respectively secure the discharge portion to the electrode and secure the feeding portion to the aforementioned axially expandable and contractable conduit. A first valve is movably arranged in the feeding portion and a second valve in the discharge portion. A valve actuating mechanism can move each of the valves between two respective positions in which the valve opens and closes the associated chamber portion to the passage of material from the feed pipe to the bore of the electrode through the charging chamber.

Other features and many of the attendant advantages of this invention will readily be appreciated as the same becomes better understood by reference to the following detailed description of a preferred embodiment when considered in connection with the appended drawing.

The sole FIGURE of the drawing shows a furnace equipped with the feeding arrangement of the invention in fragmentary elevational section, and partly in a diagrammatic manner.

Only as much of the furnace has been illustrated in the drawing as is needed for an understanding of the invention, the furnace chamber proper having been omitted together with the hydraulic hoist mechanism which permits a heavy tubular electrode 2 to be raised and lowered relative to the furnace hearth.

The upright axial bore of the electrode 2 is provided with tubular liner 4 which upworks from the electrode and is equipped with a flange 6 on its projecting top. The flange 6 is vertically connected with a bottom flange 8 on a coaxial connecting pipe 10 by a short section 12 of flanged corrugated tubing. A switch supporting plate 16 is clamped between the lower flange 14 of the tubing section 12 and the flange 6 of the liner 4. A switch actuating plate 20 is similarly clamped between the upper flange 18 of the corrugated tubing section 12 and the flange 8 of the connecting pipe 10. An upright bracket 22 on the plate 16 carries two vertically spaced limit switches 24, 26 whose operating buttons 28, 30 are directed against opposite horizontal faces of the switch actuating plate 20. A heavy helical wire spring 32 is coiled about a pin 34 which passes through vertically aligned apertures in the plates 16, 20, the spring 32 being arranged to oppose axial deformation of the tubing section 12 under applied stresses.

A nipple 36 fastened to the outer wall of the connecting pipe 10 and communicating with the interior of the pipe is obliquely downwardly directed. It is connected by flexible tubing 38 and a solenoid-operated valve 40 to a compressor not shown, whose intake is connected to the furnace chamber. The nipple 36 thus forms a nozzle for injecting compressed furnace gas into the connecting pipe 10 and the liner 4 in the electrode bore.

The upper flange 42 of the connecting pipe 10 is bolted to a flange 44 on the lower, discharge portion of a charging chamber 46. An approximately T-shaped carrier arm 48 projects from a vertical outer wall of the chamber 46 at right angles to the common axis of the several tubular elements which constitute the vertical main portion of the feed channel in the illustrated apparatus.

The upright branches 50, 52 of the arm 48 are connected to imperforate respective end walls of cylinders 54, 56 by means of pivot pins 58, 60. The cavities of the cylinders 54, 56 are divided into compartments 82, 92 and 84, 94 by pistons 62, 64 carrying piston rods 70, 72 which project through apertured end walls 66, 68 of the cylinders 54, 56 toward the chamber 46, and are attached to plate-shaped slide valves 74, 76.

When the pistons 62, 64 are moved in the cylinders 54, 56, the slide valves 74, 76 respectively move into and out of the feeding portion 78 and the discharge portion 80 of the chamber 46, thereby either opening or closing the associated chamber portions to the downward passage of material to the bore of the electrode 2. The compartments of the two hydraulics motors constituted mainly by the cylinders 54, 56 and the pistons 62, 64 are supplied with pressure fluid or vented through connected flexible conduits 86, 88 and a solenoid valve 90, and through connected flexible conduits 96, 98 and a solenoid valve 100. The valve 90 is connected simultaneously with the front compartment 84 of the cylinder 56 and with the rear compartment 82 of the cylinder 54. The valve 100 is connected with the front compartment 92 of the cylinder 54 and with the rear compartment 94 of the cylinder 56. Nonilluminated throttling sections in the conduits 88, 96 delay movement of the pistons 62, 64 in a direction away from the chamber 46.

A nipple 102 leads obliquely downwardly into the chamber 46. It is connected by flexible tubing 104 with a solenoid valve 106 on a nonilluminated tank containing nitrogen under high pressure.

The rim 108 about the upwardly directed feed opening of the chamber 46 is fixedly fastened to a tube 110 in telescoping engagement with the bottom portion of a normally stationary feeding pipe 112. The tube 110 is guided to the pipe 112 by an internal flange 114 at the top end of the tube 110 which envelops the outer wall of the pipe 112, and by an external flange 116 on the lower end of the pipe 112 which slides on the inner wall of the tube 110. An outer flange 118 on the lower end of the tube 110 and an annular disc 120 radially projecting from the pipe 112 are sealingly connected by bellows 122 of corrugated metallic tubing.

The weight of the chamber 46 and of the aforesaid elements extending upwardly from the chamber is balanced by a counterweight 132 suspended from a flexible cable 126 which runs over guide pulleys 130, 128 to a radial bracket 124 on the flange 118.

A feeder having a horizontal screw 136 in a casing 140 communicates with the feed pipe 112 through a discharge opening 134 in one end of the casing 140. Particulate solid material is supplied to the feeder through an opening 138 at the other end of the casing 140. A vent pipe 142 coaxial with the pipe 112, the tube 110, the chamber 46, the connecting pipe 10, and the liner 4 permanently connects the interior of the casing 140 with the ambient atmosphere.

The feeder is mounted on a stationary platform 144 which is a part of the supporting furnace frame, not otherwise shown, and also carries the mounting brackets 148, 150 for the guide pulleys 128, 130. The feed pipe 112 passes freely through an aperture 146 in the platform 144.

The aforesaid apparatus is operated as follows:
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In the illustrated position, the lower slide valve 76 closes the discharge portion 80 of the chamber 46 and the slide valve 74 opens the feeding portion 78. The valve 100 connects the compartments 92 and 94 to the discharge conduit of a nonillu-

strated pressure pump while the compartments 82, 84 are vented to a nonilluminated sump by the valve 90. When the valve 106 is briefly opened, a jet of nitrogen is discharged into the chamber 46 from the nozzle 102, and the chamber 46, the tube 110, and the pipe 112 are purged of residual furnace gases which are diluted and discharged through the vent pipe 142.

The feeder screw 136 is turned by a nonilluminated motor while a solid furnace charge is supplied through the opening 138. The screw 136 is operated long enough to transfer a desired batch of material to the chamber 46. The valve 100 is thereafter switched to the venting position while the valve 90 is moved to connect the nonilluminated pump to the compart-
m ents 82, 84. The pistons 62, 64 move in opposite directions, and the slide valve 74 is almost completely closed before the valve 76 permits furnace gas to enter the chamber 46. The contents of the chamber are dropped into the connecting pipe 10.

The valve 40 is simultaneously opened for one or more short periods to discharge blasts of compressed furnace gas into the connecting pipe, and thereby to hasten the downward movement of the charge and to prevent its being welded to the pipe 10. Ultimately, the solenoid valves 90, 100 are returned to their initial positions, and the slide valves 74, 76 resume the illustrated positions.

If so desired, a narrow bypass may be provided at the valve 40, or the valve may be prevented from fully closing so that a weak steam of compressed furnace gas is discharged from the nozzle 36 at all times and prevents the nonilluminated molten charge in the furnace from entering the bore in the electrode 2. Electrodes of the type for which this invention is most useful may weigh as much as 80 tons and are raised and lowered by hydraulic hoists of corresponding capacity. It would not be practical to make the walls of the chamber 46 of a thickness sufficient to prevent destruction of the chamber if the full force of the hoisting mechanism were applied, as might occur if the pipe 112 jams in the tube 110. The limit switches 24, 26 are effective in preventing damage to the chamber 46.

The corrugated tubing section 12 is stiff enough to resist axial deformation under the stresses encountered in normal operation. It expands or contracts axially under stresses higher than those which could cause damage to the chamber 46, and the resulting relative movement of the plate 16, 20 causes the closing of the limit switch 26 when excessive compressive stress is applied to the tubing section 12, and causes closing of the switch 22 under excessive tensile stress. The precise stress value at which either switch is operated may be set by suitably selecting the spring 32. The switches 22, 26 may be arranged in circuit with visible or audible alarms, or they may actuate relays which stop the movement of the electrode 2 by the nonilluminated hydraulic hoist.

The electrode 2 is consumed during operation of the furnace and must be replaced from time to time. For this pur-
pose, the flanges 6, 14 are released from each other. The weight of the chamber 46 and of associated furnace elements is balanced by the counterweight 132, and the chamber may be raised manually to provide ready access to the partly con-
sumed electrode, and to permit its replacement by a new elec-

trode to which the chamber 46 together with the connecting pipe 10 is lowered. The flange 14 is thereafter fastened to the top flange on the liner of the new electrode.

For the convenience of pictorial representation, the axial lengths of the tube 110 and of the pipe 112 have been greatly reduced in the drawing as compared to other dimensions illus-

trated, and similar dimensional distortions have been resorted to elsewhere. Neither the electrical power circuit of the elec-
trode 2 nor the automatic controls which normally operate the feed screw 136 and the solenoid valves 90, 100, 108, and 40 in timed sequence have been shown nor described since they will be obvious to those skilled in the art.

The lower end of the feed pipe 112 and the tube 110 jointly constitute an axially expandable and contractable conduit which is necessary in feeding arrangements of the general type discussed herein to permit vertical adjustment of the electrode 2. The conduit constitutes a portion of the feeding arrange-
ment which is most sensitive to the heat of the furnace gases, particularly when combined with the unavoidable mechanical stresses transmitted by the moving furnace charge. The chamber 46 with its two slide valves 74, 76 reduces the flow of furnace gases into the conduit 110, 112 to a minimum so that the seals between the telescopically engaged conduit portions are capable of extended useful service. At least some of the advantages of this invention are available even if the two slide valves 74, 76 operate simultaneously. For best results, it is preferred that the opening movement of each valve lag behind the closing movement of the other. The aforementioned throttling elements in the conduits 88, 96 adequately perform this function without requiring moving parts. Other equivalent delay mechanisms will readily suggest themselves to those skilled in the art, and may be resorted to where required.

We claim:

1. In a feeding arrangement for an electric furnace including a normally stationary feed pipe having a vertically extending axis, an electrode formed with a bore axially aligned with said pipe, said electrode being mounted for axial movement, and axially expandable and contractable conduit means interposed between said pipe and said bore and connecting the same for passage of material from said pipe to said bore, the improve-

ment which comprises:

a. a chamber having a feeding portion and a discharge por-
tion, said discharge portion being downwardly spaced from said feeding portion;

b. mounting means respectively securing said discharge por-
tion to said electrode and securing said feeding portion to said conduit means;

- c. first valve means movable in said feeding portion;
- d. second valve means movable in said discharge portion;
- e. valve actuating means for moving each of said valve means between two respective positions in which the valve means open and close the associated portions of said chamber to the passage of said material from said feed pipe to said bore through said chamber.

2. In an arrangement as set forth in claim 1, each of said valve means including a slide valve member, and said valve ac-
tuating means including means for moving each of said slide valve members transversely of said axis.

3. In an arrangement as set forth in claim 2, actuating means including two pressure-fluid operated motors respectively asso-
ciated with said slide valve members each motor including a cylinder member defining a cavity and a piston member slide-
able in said cavity and dividing the same into two compart-
ments, one member of each motor being mounted on said chamber and the other member being operatively connected to the associated slide valve member, and fluid supply means for supplying fluid under pressure to each of said compart-
ments.

4. In an arrangement as set forth in claim 3, said fluid supply means including a source of said pressure-fluid, and a conduit simultaneously connecting respective compartments of said motors to said source.

5. In an arrangement as set forth in claim 1, said expandable and contractable conduit means including two telescoping tub-
ular members secured to said feed pipe and to said chamber respectively for relative axial movement, and sealing means sealing said tubular members to each other during said move-
ment.

6. In an arrangement as set forth in claim 1, a source of a purging gas under positive pressure, and an injection nozzle mounted on said chamber and communicating with said source for injecting said gas into said chamber.

7. In an arrangement as set forth in claim 6, a connecting tube axially interposed between said chamber and said elec-
trode and connecting said chamber to said bore, a source of furnace gas under pressure, said furnace gas being different from said purging gas, and another injection nozzle mounted on said connecting tube in a position to inject said furnace gas into said connecting tube in a downward direction.

8. In an arrangement as set forth in claim 1, an axially deformable tubular member interposed between said chamber and said electrode, said tubular member connecting said discharge portion to said bore, limit switch means, and switch operating means for operating said limit switch means in response to a predetermined axial deformation of said tubular member.

9. In an arrangement as set forth in claim 8, said limit switch means including two limit switches, and said switch operating means including means for operating one of said limit switches when the axial dimension of said tubular member reaches a predetermined minimum value, and for operating the other limit switch when said axial dimension reaches a predetermined maximum value.

10. In an arrangement as set forth in claim 8, a spring member operatively interposed between said chamber and said electrode for opposing axial deformation of said tubular member.

11. In an arrangement as set forth in claim 1, venting means permanently venting said feed pipe to the atmosphere.

12. In an arrangement as set forth in claim 1, the mounting means securing said discharge portion to said electrode being releasable, and balancing means upwardly biasing said chamber with a force sufficient to prevent downward movement of said chamber when the same is released from said electrode.