This invention relates to apparatus used in the blast furnace smelting of iron ores and the like. It is particularly concerned with apparatus adapted to increase the pressure inside the blast furnace and at the same time to remove undesired solid and liquid constituents from the gas evolved by the blast furnace.

This apparatus is a continuation-in-part of our application Serial No. 644,507 filed March 7, 1957, now abandoned.

It has been known for many years that a number of advantages follow from operating a blast furnace under superatmospheric pressure. Such operation requires a furnace sealed against such pressure and provided with some means in its gas offtake pipe or down-comer, as it is called, to maintain the desired pressure in the furnace. Conventionally the gas offtake pipe has been provided with a valve of some sort for this purpose. Every blast furnace must be provided with some means for cleaning the gas discharged therefrom, as this gas carries over from the blast furnace appreciable quantities of dust and larger solid particles, as well as particles of liquid. If the gas is not cleaned, it clogs the lines and burners in the stoves and other apparatus where it is burnt.

The solid particles of coke, limestone and ore which are carried over in the blast furnace gas are highly abrasive and very destructive of the mechanism of such valves placed in the gas offtake pipe to maintain the blast furnace pressure. For this reason some blast furnace installations have gas cleaning means interposed between the gas offtake pipe and the pressure controlling valve. The arrangement required that the gas cleaner operate at superatmospheric pressure also, which entails certain difficulties well-known to those skilled in the art of blast furnace operation.

It is an object of our invention, therefore, to provide in combination with a blast furnace means for maintaining the desired pressure therein which also act as a gas cleaner. It is another object to provide such means highly resistant to abrasion. It is another object to provide such means the gas cleaning action of which is not affected by sudden changes in furnace pressure. Other objects of our invention will appear in the course of the following description and explanation thereof.

Our invention, to be described, makes use of an orifice positioned in the gas offtake pipe together with means for supplying washing liquid to the gas passing through and means for separately collecting dirty washing liquid and clean gas.

Two embodiments of our invention presently preferred by us are illustrated in the attached figures, to which reference is now made.

FIG. 1 is an elevation, partially schematic, of a blast furnace provided with one embodiment of our invention. FIG. 2 is a cross section through the apparatus of our invention taken on the plane 2-2 of FIG. 1 or the plane of FIG. 4 center. FIG. 3 is an elevation in section taken on the plane 3-3 of FIG. 2. FIG. 4 is an elevation of another embodiment of our invention.

In the figures a blast furnace 35, shown schematically, is provided with blast through tuyeres 36-36 positioned circumferentially around the base thereof and connected to blast pipe 37. Air or other blast gas is supplied furnace 35 by compressor 46, which is connected to stove 38 in which the blast is heated by blast furnace gas introduced through pipe 39. Hot blast from stove 38 is conducted to blast pipe 37 by delivery pipe 41. Blast furnace gas evolved in furnace 35 is taken off at its top through offtake pipes 43 and 44 which join in downwardly-inclined gas discharge main or down-comer 4.

Gas main 4 is provided with a transverse partition plate 25, shown in detail in FIGS. 2 and 3. Plate 25 is conveniently mounted between upper flange 26 and lower flange 27, which are attached to the portions of gas main 4 which are respectively above and below partition plate 25. Plate 25 is formed with a central aperture in which is set an orifice plate 30. Orifice plate 30 is desirably made from abrasion resistant material.

Gas main 4, at a location slightly upstream of plate 25 is provided with a plurality of radially disposed nozzles 31 which extend through the wall of the gas main and are connected at their outer ends to a header 32, which encircles gas main 4. Header 32 is connected through supply pipe 33 to a source of supply of water or other washing liquid, not shown.

That portion of gas main 4 downstream of plate 25 leads into the side of upright cylindrical precipitation chamber 5. This chamber is provided at its lower end with a conical portion 7 having a centrally located bottom opening 9 which is normally closed by a door 10. The door 10 is carried by a normally horizontal arm 12 pivotally mounted at a point 13 intermediate of its length and provided with a counterweight 14 adjacently positioned on the end opposite that of door 10 so that the latter is maintained closed. A latch 1 holds down the counterweight end of arm 12. A conduit 16 leads out from the lower end of conical portion 7 into a pipe 17 which is provided with an upright portion 18 and a turned-over open-end discharge section 19. A filler pipe 20 opens into precipitation chamber 5 at a point intermediate its ends and a staging gas pipe 26 leads out of precipitation chamber 5 from its upper end, which is otherwise closed.

It is seen from the foregoing description that in the embodiment of our invention illustrated in FIG. 1, the orifice and washing liquid spray nozzles are set directly in the down-comer pipe to the blast furnace. This gas main, in turn, leads into our precipitation chamber. It is not necessary that our apparatus take that form, and we find that the orifice and washing liquid spray nozzles may be separately mounted in an upright duct which may form a part of the precipitation chamber. This form of our apparatus is illustrated in FIG. 4.

In this embodiment of our invention upright tubular duct 3 connects at its upper end with gas main 4. Duct 3 is surrounded throughout its lower portion by a precipitation chamber 5 which may conventionally be formed as an upright cylinder of substantially larger diameter than duct 3. Precipitation chamber 5 is closed at its upper end by a tapered shoulder portion 6 which is sealed against the exterior of duct 3. Precipitation chamber 5 is provided at its lower end with a conical portion 7 having a centrally located bottom opening 9 which is normally closed by a door 10. The construction of the bottom portion of precipitation chamber 5 is identical with that previously described in connection with our first preferred embodiment. A filler pipe 20 opens into precipitation chamber 5 at a point intermediate its ends. The lower end 22 of duct 3 extends well down into precipitation chamber 5 and terminates at a point somewhat nearer its lower than its upper end.
chamber 5 is provided with a clean gas discharge pipe 23 which opens out of a wall chamber 5 at a level slightly above the lower end 22 of duct 3. A gas stream enters above the shoulder 6 of precipitation chamber 5, duct 3 is provided with a transverse partition plate 25. Plate 25 is conveniently mounted between upper flange 26 and lower flange 27 which are attached to the portions of duct 3 which are respectively above and below partition plate 25. Plate 25 is formed as before with a central aperture in which is set an orifice plate 30. Orifice plate 30 is desirably made from an abrasion resistant material.

Duct 3 at a level slightly above plate 25 is provided with a plurality of nozzles 31 which extend through the wall of the duct and are connected at their outer ends to a header 32 which encircles duct 3. Header 32 is connected through a supply pipe 33 to a source of supply of washing fluid, not shown. We have found that the nozzles 31 should be positioned so as to discharge washing liquid into the duct 3 within a zone or region extending not more than one duct diameter above plate 25 and this washing liquid should be consumed by the duct 3. The discharge of washing liquid into the turbulent gases in the manner we have described increases the turbulence in the gas stream created by its impingement on plate 25, and so increases the pressure drop across the orifice. This results in a higher top pressure in the blast furnace.

The operation of our apparatus will be described in connection with the preferred embodiment previously described and shown in FIG. 1. It will be understood by those skilled in the art of blast furnace operation that the restricted opening in gas main 4 provided by orifice 30 increases the pressure which compressor 40 can maintain in blast furnace 35 over what it would be if gas main 4 were not restricted in diameter. The area of the orifice and the blast supplied by compressor 40 are adjusted to provide the superatmospheric pressure desired in the furnace, which may range from less than 2 atmospheres to as high as perhaps 6 for 7 atmospheres. It happens that the greater the pressure drop across the orifice in our partition 25, the greater the efficiency of gas cleaning resulting, so that our invention is peculiarly adapted to high-pressure blast furnace operation.

The washing fluid which we prefer to employ is water, and an ordinary pressure is supplied to chamber 5 through filler pipe 20 until it reaches a level indicated by the dotted line 2. Water under ordinary pressure is also supplied to our header 32 so that nozzles 31 project sprays of water into our gas main 4. Blast furnace gas passes downwardly through gas main 4 past the water sprays coming from their nozzles 31. Downstream of nozzles 31 the gas stream strikes partition 25 and orifice plate 30 and must pass through the orifice thereof. The obstruction provided by orifice plate 30 produces a considerable turbulence in the gas at this point, which brings about intimate intermixing of gas and water droplets. The gas stream carrying impurities and water droplets then passes through the orifice of plate 30 at a considerably increased velocity over that which obtains in the upper part of gas main 4, and as it travels down the remaining portion of gas main 4, which is the same diameter as the upper portion of that main, it loses this velocity. When the gas stream enters precipitation chamber 5 it is forced into the much larger volume there provided and, of course, loses a very large portion of its former velocity, but the dirt particles mixed with water droplets continue onward without too much velocity loss into the bottom portion 7 of precipitation chamber 5. The bottom portion 7 of precipitation chamber 5 collects the wash which flows over the edge of the orifice in plate 30 and down gas main 4, and this water is maintained at a level 2 which is controlled by the height of overflow pipe 18 and the pressure of the gas upon the surface of the liquid in chamber 5. In operation this water level is maintained well below the level at which gas main 4 opens into chamber 5. The gas emerging from gas main 4 passes upward through chamber 5 and out as clean gas through discharge pipe 23.

The turbulence upstream of plate 25 brought about by the orifice is pretty well confined to a zone extending about one duct diameter above plate 30. We discharge our washing liquid directly into the turbulent gas stream in this zone in such a way as to increase that turbulence as much as possible. We find that that turbulence is greatly increased when the stream of washing liquid is discharged more or less parallel to plate 30, but the turbulence may also be increased by inclining the washing liquid discharge pipes in an upstream direction. Discharge of the washing liquid in a downstream direction does not increase the turbulence of the gas stream.

The operation of the embodiment of our invention shown in FIG. 4 is substantially the same as that of the embodiment of FIG. 1 just described. The gas emerging from the bottom 22 of duct 3, however, passes upwardly through the annular space between duct 3 and precipitator chamber 5 and is drawn off as clean gas through discharge pipe 23.

Solids accumulate in the bottom portion 7 of precipitation chamber 5 and are removed therefrom from time to time. As the weight of solids supported by door 10 increases, it tends to overbalance the force exerted by counterweight 14, and the door 10 is very easily opened by lifting latch 1, which causes arm 12 to pivot so that door 10 swings downwardly and discharges the solids supported by it.

The movement of waste gases through the orifice in orifice plate 30 produces a pressure drop across this orifice which may be measured by conventional means. As we have mentioned, the efficiency of removal of dirt from the blast furnace gas increases as this pressure drop is increased. We find that a pressure drop equivalent to about 30 inches of water provides adequate cleaning under most circumstancess. If for any reason it is desired to operate the furnace with a different pressure, the construction of our apparatus facilitates change. It is only necessary to pull out plate 25, provide it with an orifice plate 30 having an orifice of the desired size, and return plate 25 to its original position. This same procedure is followed when it becomes necessary to remove orifice plate 30. An admixture of water is provided to facilitate removal of the solid particles entrained in the blast furnace gas. These particles erode the orifice and increase its size until eventually the pressure in the furnace may fall below the level desired.

The nozzles 31 which we employ may be spray nozzles of conventional types or may be merely open-end pipes as shown in FIG. 3.

Although we have spoken of the level of the water held in the bottom portion 7 of our precipitation chamber, it will be understood that this body of water it not at rest. Gas is not generated by a blast furnace at a constant rate and the changes in pressure of the gas in precipitation chamber 5 are sufficient to bring about a considerable agitation and splashing of the water held therein. In our apparatus, as shown in FIG. 1, our precipitation chamber 5 acts as a surge tank and enables our apparatus to operate successfully even though the gas pressure fluctuates widely. The range of fluctuation which can be tolerated is determined by the height of pipe 18 to its upper bend. In our apparatus of the form shown in FIG. 4, the range of fluctuation is determined by the height of the opening of discharge pipe 23 or the height of pipe 18 to its upper bend, which is lower. It is necessary that the opening of discharge pipe 23 be positioned somewhat above the lower end 22 of duct 3 to minimize splashing of the water and dirt particles it contains over into the discharge pipe 23.
We claim:
1. In a blast furnace having means for compressing the blast feed gas and a gas discharge pipe, the improvement comprising, in combination therewith, a flat partition in the gas discharge pipe positioned transversely to the pipe axis and dimensioned to close off a portion of the pipe, thereby creating back pressure in the blast furnace and a zone of turbulence immediately upstream of the partition, a washing liquid delivery conduit opening transversely into the gas discharge pipe in the zone of turbulence upstream of the flat partition and adapted to discharge washing liquid transversely of the gas discharge pipe, and means connected to the gas discharge pipe downstream of the partition for separately collecting dirty washing liquid and clean gas.

2. In a blast furnace having means for compressing the blast feed gas and a gas discharge pipe, the improvement comprising, in combination therewith, a flat partition in the gas discharge pipe positioned transversely to the pipe axis, a central orifice in the partition dimensioned to raise the back pressure in the blast furnace above atmospheric pressure and create a zone of turbulence in the gas discharge pipe immediately upstream of the partition, at least one washing liquid delivery conduit opening transversely into the gas discharge pipe in the zone of turbulence upstream of the flat partition and discharging washing liquid so as to increase that turbulence and the back pressure in the blast furnace, a source of washing liquid connected to the conduit, and means connected to the gas discharge pipe downstream of the partition for separately collecting dirty washing liquid and clean gas.

3. Apparatus of claim 2 in which the washing liquid delivery conduit is positioned upstream of the flat partition a distance less than one discharge pipe diameter therefrom.

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