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TABLE FEEDER FOR PEBBLE HEATER APPARATUS

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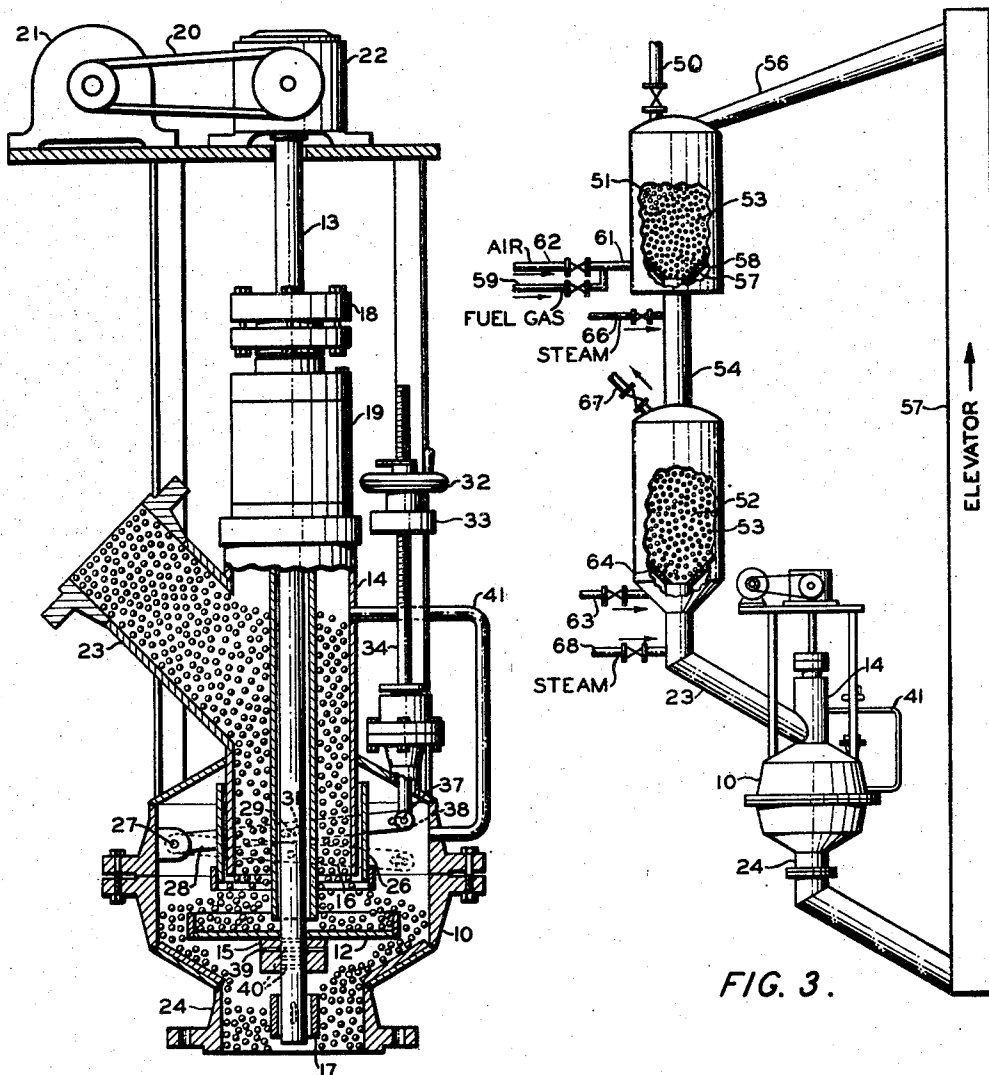


FIG. 1.

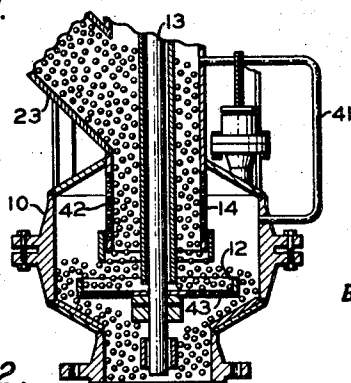


FIG. 2.

FIG. 3.

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TABLE FEEDER FOR PEBBLE HEATER APPARATUS

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7 Claims. (Cl. 214—17)

This invention relates to pebble heater apparatus. In one embodiment this invention relates to an improvement in the control of pebble flow through a pebble heater apparatus. In one embodiment this invention relates to an improvement in the control of pebble flow through a pebble heater apparatus utilizing a centrifugal feeder of the table type.

The type of operation and apparatus with which this invention is concerned involves circulating a contiguous fluent mass of refractory pebbles through a series of vertically arranged chambers generally comprising a pebble heater chamber, a conversion or reactant preheating chamber and a relatively narrow interconnecting neck or throat. That portion of the pebble mass descending through the heater is heated to a suitable predetermined temperature substantially above a desired conversion temperature and the thus heated pebbles pass through the neck or throat to the conversion chamber where they are contacted directly with a desirable hydrocarbon feed gas for a suitable contact time to effect a desired heating or conversion. The pebble mass descends through the bottom of the conversion chamber and is fed at a regulated rate by means of a centrifugal feeder of the table type, to an elevator which transfers the pebbles to an inlet at the top of the pebble heater for reheating and passage through the conversion zone, i. e. for pebble recirculation.

The term "pebble" as used throughout the specification denotes any solid refractory material of flowable form and size which can be utilized to carry heat from one zone to another. Pebbles are conventionally substantially spherical and are about $\frac{1}{8}$ " to 1" in diameter with the preferred size for high temperature processes about $\frac{3}{8}$ ". Pebbles must be of a refractory material which will withstand temperatures at least as high as the highest temperature obtained in the pebble heating zone. They may be of ceramic, metal, or other refractory materials. Pebbles constituted of alumina, zirconia, silicon carbide, Stellite, periclase, and mullite, in admixture with each other and/or with other materials, when properly fired, serve very well at high temperatures, sometimes withstanding temperatures up to about 4000° F. Pebbles may be relatively inert or catalytic in any given process.

In the general practice of the type operation previously discussed above, an inert gas such as flue gas, or steam, and the like, is injected into the pebble heater system at certain points as a sealing or plugging gas, to guide process gases in the system in the proper direction of flow. Thus, in general practice, a sealing gas is injected in an interconnecting throat of a pebble heater apparatus to prevent the escape of hot heat transfer gases in the pebble heating chamber into the conversion chamber, and to direct the hot gas flow in the desired upper direction. Sealing gas thus introduced also prevents escape of reactant gases from a lower conversion chamber into the interconnecting throat and on upwardly into the combustion chamber, directing them to the proper effluent outlet in the conversion chamber.

The practice of using a plugging or sealing gas applied in a manner as briefly illustrated above is well known. The sealing gas is injected at the specified point in the pebble heater system at a pressure slightly higher than that in the adjacent chambers so that sealing gas flows into those chambers, preventing thereby the flow of process gas out of those chambers in the improper direction. The amount of sealing gas employed is of course dependent on the pressure in the specific process system

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to which it is applied, but in any case that amount is relatively small as compared to the amounts of process gases handled. Sealing gas, generally steam, is employed at various points in a pebble heater system other than that specifically discussed above, such other points being generally in the inlet conduit admitting pebbles into a pebble heating chamber, and in the outlet conduit through which pebbles are withdrawn from a conversion chamber and passed to the pebble feeder. In this latter case, the sealing fluid thus injected prevents the passage of hydrocarbon vapors from the reaction zone of the pebble heater apparatus into the pebble elevator and ultimately the pebble heating chamber, by way of the elevator. When adding sealing gas at this particular point, the gas thus added passes downstream with the pebble mass and through the pebble feeder and finds its way on up through the elevator and finally through a vent stack in the top of the pebble heater chamber. Although a small amount of steam is lost in this manner, the cost of that small amount is easily justified. One form of the table feeder device briefly referred to herein comprises a horizontally disposed table adapted to be rotated at selected controlled rates, surrounded by a gas-tight housing and adapted to receive pebbles on its top surface from the reaction or heat transfer chamber of a pebble heater apparatus, and to discharge pebbles at a controlled rate from its top surface by means of centrifugal force to a pebble exit means through the housing, generally to an elevator for return to the pebble heater chamber. Pebbles are fed on to the rotating table from a pebble inlet conduit terminating inside the housing in a plane parallel with that of the table top, and having the opening of the terminated conduit axially disposed with respect to the table, and terminating at a regulated distance from the top table surface. In this manner pebbles are passed on to the table terminating as a mass thereon and ending the contiguity of the pebble mass extending from the pebble inlet of the pebble heating chamber down to and including the pebbles on the top surface of the rotating table. The distance from the top surface of the table to the end of the pebble inlet in close proximity thereto, can be adjusted. By regulating that distance, and by regulating the rate of revolution of the feeder table, the rate of discharge of pebbles is controlled, and consequently the rate of pebble flow through the entire pebble heater apparatus is thereby regulated.

My invention is concerned with the injection of a sealing gas into the pebble outlet conduit in a pebble heater conversion chamber connected with a centrifugal feeder device of the table type, and provides for improved control of pebble flow through the entire apparatus.

An object of my invention is to provide for improved control of pebble flow through a pebble heater apparatus.

Another object is to provide a process for the utilization of a sealing gas in a pebble outlet conduit in a pebble heater apparatus employing a centrifugal pebble feeder of the table type, in a manner to effect improved flow of pebbles from the table feeder and thereby to more accurately regulate the flow of pebbles through the pebble heater apparatus.

Another object is to prevent the "blowing" of sealing gas over the body of pebbles on the top surface of a rotating table of a centrifugal pebble feeder of the table type.

Other objects will be apparent to those skilled in the art in view of the accompanying discussion and disclosure.

I have found when operating a pebble heater apparatus in conjunction with a pebble feeder device employing a rotating table, briefly discussed above, that injection of sealing fluid into the pebble conduit connecting the pebble heater reaction chamber with the feeder, prevents accurate regulation of the pebble flow through the pebble heater apparatus by the table feeder. I have found that sealing fluid introduced into the pebble conduit in the conventional manner, blows across the surface of the body of pebbles on the rotating table, in a manner to disturb the normal pattern of flow; as a result, pebble flow through pebble feeder apparatus is erratic and poorly controlled and heat transfer and hydrocarbon conversion conducted therein are thereby nonuniform and inefficient.

This difficulty appears to occur as a result of normal

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fluctuations in operating pressures in the pebble heater apparatus by which I mean small changes in pressure that occur during normal operation, which changes are in no way related to any intended alterations in process conditions. For example, a pebble heater system can be operated at a pressure within the limits of from 2 to 6 p. s. i. g. After the selected operating pressure is established and normal operation is underway, small fluctuations, generally within the limits of 0.1 to 0.5 p. s. i. g. occur as a result of variations in such variables as feed composition, heat value of the combustion gas, accuracy limits of the automatic control system, and the like. These so called normal fluctuations are believed to be responsible for the erratic control of pebble flow through the pebble heater system by causing the flow rate of the sealing fluid to vary across the pebble feeder table, and at suddenly increased rates to "blow" pebbles from the table surface, and at decreased rates to de-emphasize the established blowing effect to the extent that the rate of pebble discharge is markedly decreased. In the general practice of pebble heater operation, a pebble recirculation rate is often in the range of from 40,000 to 50,000 pounds per hour. I have found that by variation in the normal operating pressure within the limits of 0.1 to 0.5 p. s. i. g., the change in pebble rate, i. e. pebble circulation, is varied in an amount of from 5 to 20 per cent. In one specific instance, I found that when the pressure in the gas reaction chamber of the pebble heater apparatus was increased by 0.2 pound, the pebble recirculation rate was increased by 3000 pounds per hour, which in this case was a nine per cent change. Such a variance in pebble rate will be appreciated by one skilled in the art to be extremely undesirable, and particularly so as regards a change in rate as high as from 10 to 20 per cent, since under these conditions of operation, operating complications set in such as overheating of the pebbles in the pebble heating chamber and subsequent overreacting in the gas reacting chamber, or the opposite effect as underheating of pebbles followed by underreacting of the hydrocarbon reactant. Dependent upon the occurrence of fluctuations in a system, and thereby the number of different changes in pebble recirculation rate that occur within a given period, either of these undesirable effects or a combination of them occur, causing thereby undesirable and inefficient operation of the pebble heater apparatus.

I have found that this difficulty, i. e. erratic pebble flow throughout the pebble heater system, that occurs when employing a sealing gas in the pebble conduit connecting the pebble heater reaction chamber with the table pebble feeder, can be overcome by passing the flow of injected sealing fluid around the feeder table and into the feeder housing, thereby utilizing the seal as before, while preventing the sealing fluid from blowing across the feeder table.

In a preferred embodiment of my invention I divert the flow of sealing fluid as above stated by the installation of a by-pass line to provide for conducting the injected fluid from the pebble conduit at a point immediately upstream of the table and for discharge of the sealing fluid into the housing surrounding the rotating table.

In another embodiment I can prevent the blowing of sealing fluid across the feeder table by means of a plurality of perforations in that portion of the pebble conduit within the housing, delivering pebbles to the table.

In still another embodiment I prevent the blowing effect by means of perforations in the table feeder proper by means of which sealing fluid is directed through the table and is thereby prevented from blowing across it.

In any case, my invention provides for directing the flow of sealing fluid from the pebble conduit into the feeder housing without permitting the sealing fluid to blow from the pebble conduit across the feeder table. Fundamentally, in the practice of my invention, the sealing fluid is passed along a path different than the path taken by pebbles at the time that they are discharged from the pebble outlet conduit on to and from the table surface.

For a further understanding of my invention reference is made to the attached diagrammatic drawings. It is to be understood that the drawings are diagrammatic only and may be altered in many respects by those skilled in the art and yet remain within the intended scope of my invention.

Figure 1 is a vertical cross section of one form of apparatus of my invention illustrative of my preferred em-

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bodiment, wherein I employ a by-pass line to divert the direct flow of sealing fluid from the pebble conduit outlet and across the feeder table, to a point inside the feeder housing. Figure 2 is a section of Figure 1 illustrated in more detail, of other embodiments of my invention, and illustrates particularly a means by which I can prevent sealing gas from blowing across the feeder table from the pebble conduit outlet without the by-pass arrangement as illustrated in Figure 1. Figure 3 is a flow diagram illustrating a typical application of pebble heater operation in conjunction with the improved pebble feeder apparatus of my invention.

With reference to Figure 1, horizontally disposed feeder table 12 in the lower portion of feeder housing 10 is supported therein by axially positioned rotatable shaft 13 and by support member 15. Cylindrical chamber 14 having lower open end 16 extends into the upper portion of housing 10, coaxially with respect to shaft 13 and is terminated so that open end 16 is at a fixed distance from the top surface of table 12. Chamber 14 and housing 10 form a gas-tight pressure-resisting enclosure. Shaft 13 is supported at its lower end by bearing 17 and near its upper end by bearing 18 and packing gland 19. Shaft 13 is engaged at its upper end with gear box 22 actuated by power means 21 such as a variable speed electric motor, through belt drive 20. Shaft 13 can be variably rotated by means of this arrangement. Pebble conduit 23 extends from the reaction chamber of a pebble heater apparatus (not shown) into vertical chamber 14 forming a gas-tight pressure-resisting system with housing 10 and chamber 14. Pebble conduit 24 provides for withdrawal of pebbles from housing 10. Sleeve 26 surrounds the end of conduit 14 and can be moved vertically so as to adjust the effective distance between rotating table 12 and the open end 16 of conduit 14. Sleeve 26 is fastened to the adjustment lever 28, the end of which is pivotally attached to the inner wall of feeder housing 10 by pivotal connection 27, in such a manner that the lever may be raised or lowered with its end at connection 27 as the fulcrum. Lever 28 is attached to sleeve 26 by means of a pin 29 attached to the sleeve and reposing in slot 31 of the lever. Hand screw 32 supported by internally threaded bracket 33, operating on vertical shaft 34 and extending downwardly through the upper portion of feeder housing 10 is connected to lever 28 and serves as an adjusting means for raising or lowering same. The lower end of shaft 34 is engaged with lever 28 by means of a pin 37 and a slot 38 similar to that described with respect to pin 29 and slot 31 hereinabove. Table 12 is attached to shaft 13 by means of a removable pin 39 through subjacent hole 40. The height of table 12 in relation to shaft 13 is adjusted by placing pin 39 through another of holes 40.

Conduit 41 is connected at one end to vertical cylinder 14 at a point preferably above the level of pebbles therein, and at the other with housing 10, and is in communication at its upper end with inner chamber 14 and at its lower end with inner feeder housing 10. Conduit 41, chamber 14, conduit 23 and housing 10 form a gas-tight, pressure-resisting enclosure. Conduit 41 provides for withdrawal of sealing fluid introduced into chamber 14 from conduit 23 and for passing same into housing 10, whereby the flow of sealing fluid follows a path different from the path followed by pebbles flowing from conduit 23 and chamber 14 and leaving the feeder table. It is obviously immaterial as to what point in chamber 14, conduit 41 is connected, and similarly it is immaterial as to at what point conduit 41 is connected to housing 10, the prime requisite being that the sealing fluid does not follow the same path followed by pebbles at the time they are discharged from the chamber 14 and the feeder table 12, at a rate sufficiently high to blow pebbles from their normal path of flow. As already stated, I have found that when using the by-pass arrangement herein, i. e. conduit 41, I prevent the undesirable blowing effect, and provide thereby for uniform flow of pebbles through the pebble heater apparatus, that continues independently of normal fluctuations in operating pressures, in the pebble heater apparatus.

In another embodiment of my invention as illustrated in Figure 2, I can accomplish the prime requisite above discussed by means of conduits or passage ways 42 in the portion of vertical chamber 14 inside housing 10, by means of which sealing gas entering chamber 14 from conduit 23 is passed directly into housing 10 without fol-

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lowing the same path followed by pebbles discharged from conduit 23 and chamber 14 and then from rotating table 12. As further illustrated in Figure 2, the passage of sealing fluid into housing 10 can be effected by means of perforations 43 in table 12, thereby permitting sealing fluid to pass directly into housing 10 without exerting the undesired blowing effect discussed above. Passage ways 43 are preferably disposed in at least a major number, i. e. more than about 1/2 of the total number of openings, in the surface of projection of the end of cylindrical chamber 14. In many instances it will be convenient to utilize both perforate passage ways 42 and 43. These openings necessarily have a diameter sufficiently small as to prevent the flow of pebbles there-through.

As has been illustrated in Figures 1 and 2, I have provided for uniform flow of pebbles through a pebble heater apparatus while employing a sealing medium in the pebble outlet conduit, which operation heretofore has been erratic and nonuniform due to the undesirable blowing effect discussed above. In various other embodiments of my invention, not specifically illustrated, the factor of fundamental importance is that the sealing fluid be withdrawn from the pebble mass so that it follows a path different from that of the pebbles when the pebbles are flowing from the pebble outlet conduit across the pebble feeder table into the housing.

With respect to Figure 3 which illustrates a typical operation of pebble heater apparatus in conjunction with the improved pebble feeder of my invention, pebble heating zone 51 and gas reaction zone 52 are insulated chambers each containing a contiguous fluent mass of pebbles 53 and connected by a heat insulated conduit to form pebble throat 54. Conduits 56 and 23 serve as pebble inlet and outlet for chambers 51 and 52, respectively. Pebbles are introduced into combustion chamber 51 and are passed downwardly through pebble throat 54 and conversion chamber 52 through conduit 23 to feeder table 12, in housing 10 (illustrated in Figure 1) to form a contiguous downwardly moving pebble mass extending from conduit 56 down to feeder table 12. Combustion chamber 57 is positioned subjacent pebble heating chamber 51. Chambers 51 and 57 are separated by perforate support 58 through which combustion gas formed in chamber 57 ascends to pass in direct heat exchange relation with pebble mass 53 in chamber 51. Fuel gas, usually natural gas, from line 59 is introduced through line 61 and admitted with oxygen or an oxygen-containing gas, preferably air, from line 62 to form a combustion mixture in line 61 which is burned in combustion zone 57. Hot combustion gas formed in zone 57 ascends through support 58 at a temperature selected to heat pebbles in chamber 51 to a temperature sufficiently above a predetermined temperature of a subsequent conversion or heat conversion step described hereafter. Such a required pebble temperature is usually within the range of 1000 to 3000° F. and is regulated by the combustion gas temperature which in turn is dependent on the specific components of the combustion mixture and the proportions of oxygen therein, and on the rate of flow of pebbles through chamber 51. Combustion gas having imparted heat to pebbles in zone 51 is passed as effluent from zone 51 through line 50. A hydrocarbon conversion stock is introduced into the lower portion of gas reaction chamber 52 through line 63, entering at a point below gas distribution plate 64, and is passed through chamber 52 in direct heat exchange relation with pebbles previously heated in zone 51. Steam is injected as a sealing gas into pebble throat 54 through line 66. A small amount of sealing steam is necessary, part of which flows upwardly into chamber 51, and part of which flows downwardly into chamber 52. Steam from line 66 is introduced at a pressure slightly higher than fluid pressure in chambers 51 and 52. Effluent product gas from chamber 52 is withdrawn from the upper portion thereof through line 67. Steam from line 68 is introduced as a sealing fluid into pebble outlet conduit 23 connecting gas reaction chamber 52 with rotating table 12 inside housing 10, illustrated in detail in Figure 1. Unless the flow of sealing steam thus introduced is diverted, it will pass from conduit 23 into chamber 14 and into housing 10 along the same path followed by pebbles discharged into housing 10 from pebble conduit 14 and rotating table 12, which effect is undesirable in view of the blowing effect and its relation to erratic and non-uniform pebble

flow through the apparatus already discussed. Steam is withdrawn from conduit 14 at a point preferably above the level of pebbles therein through conduit 41 and passed into housing 10. Steam thus disposed in housing 10 can in no way exert an undesirable effect upon pebble flow from table 12 in view of the relatively large volume of housing 10 and the dispersion of energy that results from passing the steam into such a relatively large volume. Steam eventually passes from chamber 10 through elevator 57 through conduit 56 into chamber 51, and is discharged from the system through effluent line 52. Normal fluctuations in operating pressure in zones 51, 54 and 52 have no effect whatsoever upon the control of pebble flow through the zones when employing steam as a sealing medium in line 23, when the improved pebble feeder apparatus of my invention is employed.

Obviously, passage ways 42 in conduit 14 and/or passage ways 43 in table 12, as illustrated in Figure 2 can be used in housing 10 as illustrated by Figure 3. If desired, these passage ways 42 or 43 can be used in conjunction with by-pass 41. Furthermore, if desired, by-pass 41, openings 42 and openings 43 can be used simultaneously.

As will be evident to those skilled in the art, various modifications of this invention can be made, or followed, in the light of the foregoing disclosure and discussion, without departing from the spirit or scope of the disclosure or from the scope of the claims.

I claim:

1. An improved feeder device for control of pebble flow through a pebble heater apparatus, comprising a housing, an upper cylindrical chamber integral with said housing and extending vertically through the top thereof and having an open lower end, said chamber and said housing together forming a gas-tight pressure-resisting enclosure, a conduit for introducing pebbles from said pebble heater apparatus into said upper chamber for flowing downwardly therethrough, means for injecting sealing fluid into said conduit, a rotatable horizontal table within said housing disposed below said open lower end of said upper chamber for receiving pebbles from said chamber, means for rotating said table to cause pebbles passed thereonto from said chamber to flow over the edge thereof and into the bottom of said housing, means for adjusting the distance between said open end of said chamber and said table for controlling the rate of flow of the pebbles from said chamber, means for removing pebbles from the bottom of said housing, a conduit disposed in by-pass relation to said lower end of said upper chamber and in communication at one end with pebbles at a point intermediate the point of injection of sealing fluid into said first mentioned conduit and said open lower end of said chamber in said housing, and at the other end in communication with the interior of said housing.

2. In an apparatus for controlling the gravitational flow of pebbles through a series of vertically disposed chambers, said apparatus comprising a housing, an upper cylindrical chamber integral with said housing and extending through the top thereof and having an open lower end, said chamber and said housing together forming a gas-tight pressure-resisting enclosure, means for introducing pebbles together with sealing fluid into said upper cylindrical chamber for flowing downwardly therethrough, a horizontal table within said housing and disposed below said open lower end of said upper chamber for receiving pebbles from said chamber, means for rotating said table to cause pebbles passed thereonto from said chamber to flow over the edge thereof and into the bottom of said housing, means for adjusting the distance between said open end of said chamber and said table for controlling the rate of flow of pebbles through said chamber, and means for removing pebbles from the bottom of said housing, the improvement comprising a conduit connected at one end to said chamber at a point upstream from said housing and at the other end with said housing in communication with its interior.

3. In an apparatus for controlling the gravitational flow of pebbles through a series of vertically disposed chambers, said apparatus comprising a housing, an upper cylindrical chamber integral with said housing and extending through the top thereof and having an open lower end, said chamber and said housing together forming a gas-tight pressure-resisting enclosure, means for introducing pebbles together with sealing fluid into said upper chamber for flowing downwardly therethrough, a hori-

zontal table within said housing and disposed below said open lower end of said upper chamber for receiving pebbles from said chamber, means for rotating said table to cause pebbles passed thereonto from said chamber to flow over the edge thereof and into the bottom of said housing, means for adjusting the distance between said open end of said chamber and said table for controlling the rate of flow of pebbles from said chamber, and means for removing pebbles from the bottom of said housing, the improvement comprising a plurality of passage ways through the side walls of said chamber in the portion thereof within said housing, and each having a diameter less than that of pebbles passed through said chamber.

4. In an apparatus for controlling the gravitational flow of pebbles through a series of vertically disposed chambers, said apparatus comprising a housing, an upper cylindrical chamber integral with said housing and extending through the top thereof and having an open lower end, said chamber and said housing together forming a gas-tight pressure-resisting enclosure, means for introducing pebbles with sealing fluid into said upper chamber for flowing downwardly therethrough, a horizontal table within said housing and disposed below said open lower end of said upper chamber for receiving pebbles from said chamber, means for rotating said table to cause pebbles passed thereonto from said chamber to flow over the edge thereof and into the bottom of said housing, means for adjusting the distance between said open end of said chamber and said table for controlling the rate of flow of pebbles from said chamber, and means for removing pebbles from the bottom of said housing, the improvement comprising a plurality of passage ways through said table and each having a diameter less than that of pebbles in contact therewith, and disposed in at least a major number in the surface of projection of the end of said cylindrical chamber.

5. An improved feeder device for control of pebble flow through a pebble heater apparatus, comprising a housing, a pebble conduit extending from said pebble heater apparatus and vertically into said housing through

the top thereof and having an open lower end, a rotatable horizontal table within said housing disposed below said open lower end of said pebble conduit for receiving pebbles from said conduit, means for rotating said table to cause pebbles passed thereonto from said pebble conduit to flow over the edge thereof into the bottom of said housing, means for removing pebbles from the bottom of said housing, and at least one conduit in direct communication at one end with the interior of said pebble conduit and at the other end with the interior of said housing.

6. In an apparatus for feeding particulate solids at a controlled rate by passing said solids through a cylindrical conduit onto a rotary table from which said solids overflow, the improvement which comprises a conduit adapted to permit only fluid to by-pass the end of said cylindrical conduit adjacent said table.

7. In a pebble heater apparatus including a pebble conduit having an open end which terminates adjacent an upper surface of a rotary table, which regulates the flow of pebbles through said conduit, and means for introducing fluid under pressure into said conduit, the improvement which comprises at least one conduit positioned in by-pass relationship with respect to the space between the terminal periphery of said pebble conduit and said table and in open communication with the interior of said pebble conduit.

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