June 13, 1944. P. J. BAR 2,351,091

APPARATUS FOR TREATING SOLIDS IN FLUIDS

Filed Dec. 19, 1941

FIG. 1.

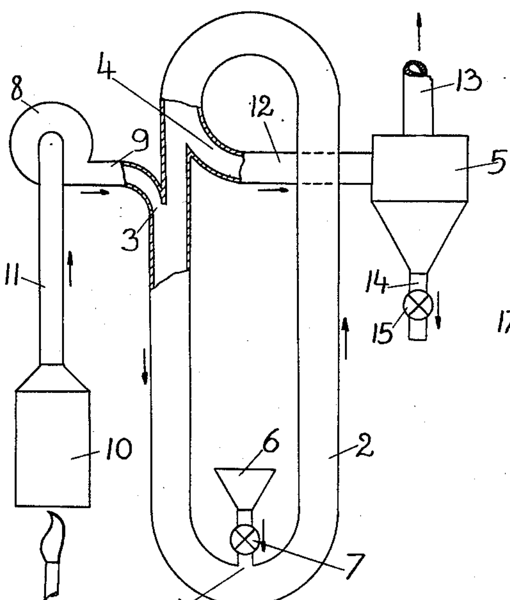


FIG. 2.

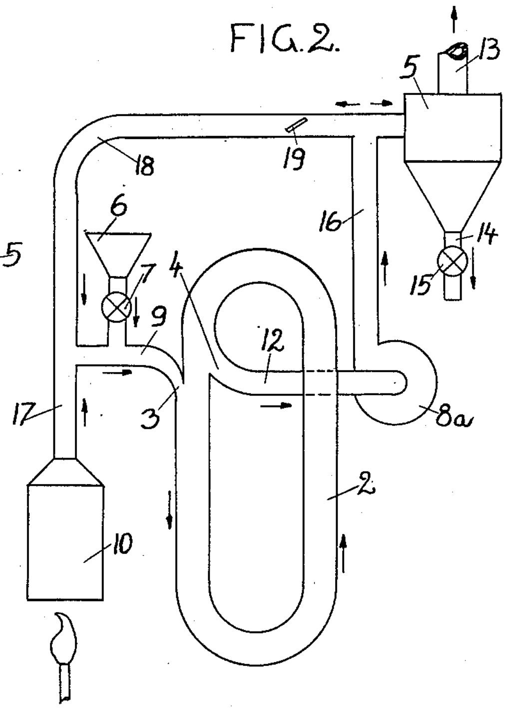
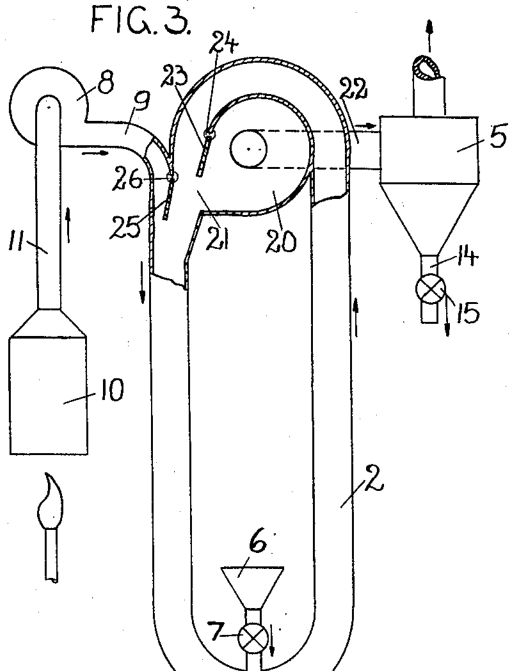


FIG. 3.



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Patented June 13, 1944 2,351,091

UNITED STATES PATENT OFFICE

2,351,091

APPARATUS FOR TREATING SOLIDS IN FLUIDS

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Application December 19, 1941, Serial No. 423,674
In Great Britain December 24, 1940

6 Claims. (Cl. 34—57)

This invention relates to improvements in floating contact treatment of solid particles in gas or vapour for the purpose of drying, calcining, heating, cooling, mixing, crystallising, carbonising, or for performing chemical reactions between solids and a gas, such as gas producing, combustion or others.

The object of the invention is to provide for control of the duration of the floating contact treatment and for improved control of conditions of such treatment. This object is achieved by floating contact treatment in a closed circuit in such manner that the conditioning fluid will be rapidly renewed whereas the solid particles will, in the average, be subjected to prolonged treatment.

According to this invention, both, solid particles and gas, are kept moving in a closed circuit for a controllable period of time. As a consequence of this, conditions of treatment can be freely selected in accordance with the properties of the material treated and the treatment desired, because the duration of treatment can be adapted to these freely selected conditions of treatment.

Preferably, solid particles and gas are circulated together. Fresh gas is continuously introduced into the circuit, and an equivalent amount of gas is continuously withdrawn from the circuit. It is an essential feature of the invention that solid particles are continuously or discontinuously introduced into the circuit in such manner that they become suspended in the gas and are carried along by the gas. This involves obvious limits as regards maximum size of solid particles and minimum velocity required for keeping the solid particles in suspension.

It is a further essential feature of this invention that the finished product—that is those solid particles, the treatment of which is completed—are withdrawn from the circuit suspended in the gas that is withdrawn. This means, it is an essential feature of this invention that isolated solid particles are not taken out of the circuit, and no separator for isolating finished solids from the gas is inserted in the circuit. Only after having been withdrawn from the circuit, the exhaust gas carrying the finished product in suspension is passed into a separator, where the finished product is isolated and discharged.

The third essential feature of this invention is that the closed circuit floating contact treatment is carried out in such manner that the solid particles remain in circulation considerably longer than the gas. Otherwise, power consumption and size of ducts required might well be excessive. Therefore, the rate of circulation of solids is higher than the rate of circulation of gas, in other words, the quantity of solid particles passing any point of the circuit per unit time, compared with the quantity of solids introduced and withdrawn per unit time, is higher than the quantity of gas circulated as compared with the quantity of gas introduced and withdrawn.

In order to be more clearly understood, the invention may now be described more in detail with reference to the accompanying drawing, which illustrates, in a diagrammatic manner, three examples of the many alternative ways in which the invention may be carried into effect.

Referring first to Figure 1, the solid particles to be treated are fed at point 1 into the ring duct 2 in such manner that these solid particles are carried along by the gas or vapour flowing in this duct.

Fresh gas is introduced into the ring duct at point 3, and an equivalent amount of gas is withdrawn at point 4 and passed into separator 5.

Movement in the ring duct at a velocity sufficient to keep the solid particles floating is maintained by means of the injector principle. The fresh gas is introduced at point 3 in a strong jet at such high velocity, that gas and solids are entrained from point 4 to point 3, mixed with the incoming jet, and the mixture then circulated around the ring duct again to point 4.

The point of withdrawal is designed as a classifier with the object of releasing only a small quantity of finished solids with the gas that is withdrawn and passed into separator 5, whereas the greater part of the solid particles is passed from point 4 to point 3 and thus retained in the circuit. As shown diagrammatically in the drawing, the withdrawal pipe 12 is arranged at the inner side of a bend of the ring duct 2. Owing to centrifugal force, the solid particles are bound to pass along the outer part of a bend, so that only a comparatively limited amount of the finest and lightest solid particles is carried along into separator 5, whereas the bulk of the solids is retained in the circuit.

Thus, the classifier has both, a quantitative and a qualitative selecting effect. A quantitative selecting effect because, in the average, each particle will make a number of circulations before being carried away from the circuit at point 4, and the concentration of solids in conduit 12 is lower than the concentration of solids in ring duct 2. The classifier will have a qualitative selecting effect, in so far as light and fine particles will be entrained with the exhaust gas, whereas coarse and heavy particles will be retained in the circuit, and it can, in most cases, be assumed—though with certain exceptions—that the finished product is lighter and finer than those particles, which have not yet undergone treatment for a sufficient length of time.

The feed of solid particles into the ring duct 2 is so arranged that the particles are fed from a hopper 6 through a feeder or air lock 7 at a controllable rate, continuously or discontinuously. By controlling the rate of feed and the velocity in ring duct 2, the period, during which the solid particles remain in the circuit, can be controlled within wide limits, because the selecting efficiency of a classifier depends largely upon the rate, at which solids are passed into it.

The fresh gas jet, which enters the ring duct at point 3, is blown in by fan 8 through conduit 9. In order to show diagrammatically the difference between fresh gas and exhaust gas, it is assumed that the fresh gas is hot. This will be true for most of the purposes, for which the invention may be used. Therefore, all drawings show a furnace or heater 10 as a symbol for the source, from which the fresh gas comes. Actually, conditions in the circuit depend, of course, upon the kind of treatment required in each individual case. In the case of drying, calcining and heating, the fresh gas is warm or hot—for the purpose of cooling, the fresh gas must be cold—for the purpose of chemical reactions, the fresh gas must have certain chemical properties.

The exhaust gas, after passing separator 5, is blown out through conduit 13, whereas the finished product is discharged through conduit 14 and air lock 15. The separator, in which the finished product is isolated from the exhaust gas, can be of any known kind such as a settling chamber, bag filter, electrostatic precipitator, cyclone or other kind. In all the accompanying drawings, a diagrammatic view of a cyclone is shown as a symbol for a separator.

The feed of solids can be at any point of the circular duct 2 or the fresh gas duct 9. Figure 2 shows feed into fresh gas duct, so that fresh gas and fresh solids enter the ring duct together, whereas two other drawings show feed into the ring duct 2 itself.

All the drawings show the fan outside the ring duct itself, and an injector for maintaining circulation in the ring duct. The fan may blow the fresh gas jet in, as shown in Figures 1 and 3, or the fan may draw gas out of the ring as shown in Figure 2.

The classifier arranged at that point of the ring duct, at which the exhaust gas is withdrawn, can also be designed in many alternative ways. A preferable design is shown in Figure 3, whereas, in the other drawings, the classifier is symbolised by showing the exhaust duct branched off at the inner side of a curved portion of the ring duct.

Referring now to Figure 2, the ring duct 2 with injector 3 and classifier 4 are the same as in Figure 1. The solids are fed from hopper 6 through feeder 7 into duct 9 and enter the ring duct 2 together with fresh gas.

Fan 8a is so arranged that the fan draws the gas through the ring duct. Accordingly, in the arrangement as shown in Figure 2, the ring duct is kept under a slight vacuum, whereas in the arrangement as shown in Figure 1, the ring duct is kept under a slight pressure. In either case, the kinetic energy required at point 3 for the fresh gas jet determines the amount of vacuum or pressure required.

As distinct from Figure 1, a double circuit is shown in Figure 2. This is of advantage when treatment in ring duct 2 has to be carried out within a close range of conditions, for instance temperature conditions. It may then increase the thermal efficiency of the system to dilute the fresh gas coming from furnace 10 with some exhaust gas, and to introduce this mixture into ring duct 2. Accordingly, Figure 2 shows how part of the gas withdrawn from ring duct 2 through conduit 12, fan 8a and conduit 16 is recirculated through conduit 18 and mixed with fresh gas coming from furnace 10 through conduit 17. An adjustable valve 19 is provided in conduit 18, to determine the proportion of gas recirculated in such way.

Referring now to Figure 3, this shows an arrangement, which is the same as that in Figure 1, except that a two stage centrifugal classifier is provided, by which the proportion of solid matter, which is carried away to the separator, is still better controlled.

In place of conduit 12 of Figure 1 branched off from the inner side of a bend of duct 2, a drum 20 is provided communicating with the ring duct through an opening 21, also at the inner side of a bend of the ring duct, in such way that gas passing into said drum through opening 21 will rotate in the drum in the same direction of rotation as in the curved portion of the ring duct, which it has just left. Leading axially from the centre of this drum, is a conduit 22, which leads to the separator 5. Most of the solid particles are, in the first instance, retained in ring duct 2 by centrifugal force, only a small portion passing with the gas through opening 21 into drum 20. Here, a further stage of classification is now effected. Within the drum, the greater part of the solid particles are again kept near the periphery by centrifugal force, and these return into ring duct 2 through opening 21, only a small portion finally passing out into conduit 22. Preferably, the drum is not completely circular but volute shaped.

In order that the selecting effect of the classifier may be controllable, a deflector 23 hinged at 24 is provided in opening 21. This deflector may either be inclined towards the conduit 2 or towards the drum 20, for respectively rendering more difficult or more easy the entrainment of solid particles into the drum. A similar flap 25 is also provided hinged at 26 at the point where conduit 9 joins the ring duct 2. By adjusting this flap, the injector effect may be controlled.

In all other respects, this figure is the same as Figure 1, and like references are employed to designate the same parts.

It may be emphasised that the shape of the ring duct is, obviously, altogether immaterial for the principal features of this invention. Any kind and shape of duct may be used, the cross section of the duct may be constant or vary in various parts of the duct, the duct may extend in vertical or horizontal direction, the duct may be in one plane or not, and round, rectangular or irregularly shaped piping may be used. The one essential feature is that the duct is endless, so that complete circulation of some fluid and some solid particles is possible.

In order to illustrate the invention further, the following practical example is added:

It may be assumed, by way of example, that Figure 1 shows a pneumatic ring dryer used for the purpose of drying 1,250 lb./hr. of grass from 82 to 10% moisture content. Accordingly, 1,250 lb./hr. of grass with 82% moisture are introduced continuously from hopper 6, and the plant has to be so designed and operated, that 250 lb./hr. of dried grass containing 10% residual moisture are continuously discharged from separator 5. This necessitates the evaporation of 1,000 lb./hr. of water, corresponding to a net heat consumption of about 1,000,000 B. T. U./hr. The total net heat consumption of the dryer including heating up of material and losses of sensible heat can be estimated to be about 1,250,000 B. T. U./hr.

As suitable working temperatures, 380° F. at the injector, point 3, and 200° F. exhaust temperature at and after point 4 may be selected. Heat throughput and temperature range as specified lead to a quantity of 26,500 lb./hr. of gas to be circulated in ring duct 2.

Fan and injector may then be so designed and controlled, that half the circulating quantity of gas, i. e. 13,250 lb./hr. is withdrawn through conduit 12, whereas the other 13,250 lb./hr. of gas carrying the main stream of uncompletely dried grass are passed from point 4 to the injector at point 3. Here, another 13,250 lb/hr. of fresh gas are introduced serving to make up for the exhaust gas and as driving jet to maintain circulation. In order to raise the temperature of the mixture after point 3 to 380° F., whereas the gas coming from point 4 has 200° F., the temperature of the fresh gas coming from duct 9 will have to be 560° F.

Ring duct 2 has to be so designed as to allow for passage of 26,500 lb./hr. of gas, and the duct must have sufficient length to allow for the specified temperature drop of the gas from 380° F. to 200° F. to be achieved by exchange of heat with the moist surface of the grass suspended in the gas. The length of the duct and the velocities may be assumed to be such that one full circulation of grass from the injector to the classifier takes 2 seconds. On the other hand, it may be assumed that the drying time required for reducing the moisture content of the grass from 82% to 10% when in violent floating contact with gas under prevailing velocity and temperature conditions as described, is of the order of one minute. This means that, in the average, each grass blade has to make 30 full circulations before being finished. Since input and output amount to 225 lb./hr. of bone dry grass, the rate of circulation of bone dry grass in the ring duct will have to be 6,750 lb./hr. Accordingly, the classifier has to be so designed and controlled, that out of the heavy stream of uncompletely dried grass circulating in the ring duct, only 250 lb./hr. of grass of 10% moisture are entrained with the exhaust gas into separator 5.

I claim:

1. In an apparatus for treating solid particles in a conditioning fluid comprising an endless duct, an injection nozzle for introducing fluid into said endless duct and maintaining continuous circulation of fluid within said duct, a deflector plate forming one wall of said nozzle and serving for controlling the fluid jet produced by the nozzle, means for introducing solid particles into said endless duct, said duct having an outlet located approximately opposite said injection nozzle, and a fan outside the endless duct producing the necessary pressure drop for operating the nozzle and for passing fluid through said outlet.

2. In an apparatus for treating solid particles in a conditioning fluid comprising an endless duct, an injection nozzle for introducing fluid into said endless duct and maintaining continuous circulation of fluid within said duct, a deflector plate forming one wall of said nozzle and serving for controlling the fluid jet produced by the nozzle, means for introducing solid particles into said endless duct, said duct having an outlet located approximately opposite said injection nozzle, a deflector in said outlet of the endless duct, and a fan outside the endless duct for producing the necessary pressure drop for operating the nozzle and for passing fluid through said outlet.

3. In an apparatus for treating solid particles in a conditioning fluid comprising an endless duct, an injection nozzle for introducing fluid into said endless duct and for maintaining continuous circulation of fluid within said duct, means for introducing solid particles into said endless duct, said duct having an outlet located approximately opposite said injection nozzle, and a drum having a tangential inlet and axial outlet so connected to said endless duct that they have a common wall, said wall having an opening therein forming the outlet of the endless duct and, at the same time, the inlet of the drum.

4. An apparatus for treating solid particles in a fluid comprising an endless duct, means for continuously circulating fluid within said endless duct as well as for introducing fluid into said duct, means for withdrawing fluid from said duct, a feeding device for introducing solid particles into said duct, a drum with a tangential inlet and axial outlet connected to said endless duct in such a way that they have a common wall, an opening in said common wall being the outlet of the endless duct and, at the same time, the inlet of the drum, and a hinged deflector in said opening, said deflector forming part of said common wall.

5. An apparatus for treating solid particles in a conditioning fluid comprising an endless duct, an inlet conduit disposed at an acute angle to said endless duct, an outlet on the inner side of a bend of said endless duct, a fan passing fluid through the whole apparatus and producing such a pressure drop between said inlet conduit and said endless duct that fluid is injected into the endless duct and circulation of fluid maintained throughout the endless duct, a hinged flap at the point where the inlet conduit joins the endless duct, means for heating the fluid prior to being injected into said endless duct, means for introducing solid particles into said endless duct, a classifier connected to the outlet of said endless duct and a hinged deflector arranged at this outlet to control the release of solid particles from the endless duct.

6. An apparatus for treating solid particles in a fluid comprising an endless duct, means for introducing solid particles into said endless duct, means for continuously circulating a particle floating fluid within said endless duct as well as for introducing fluid into said duct, and means for withdrawing fluid from said duct, said last-named means including a drum having a tangential inlet and axial outlet connected to said endless duct in such way that they have a common wall, and said wall having an opening therein forming the outlet of the endless duct and, at the same time, the inlet of the drum.

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