Dec. 13, 1938. R. S. DEAN ET AL 2,139,808

APPARATUS FOR PULVERIZING MINERAL AGGREGATES

Filed June 16, 1934 2 Sheets-Sheet 1

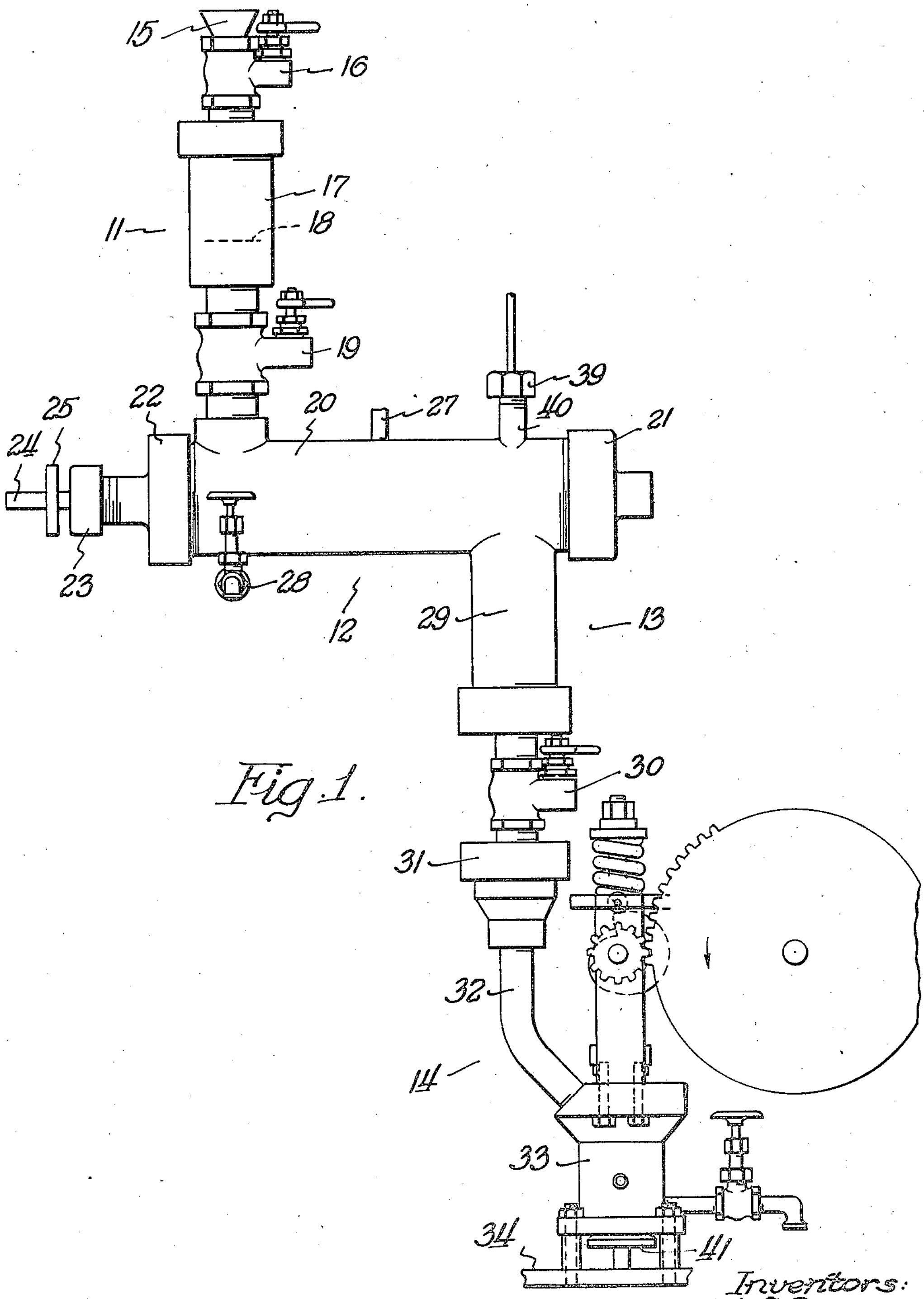

Fig. 1.

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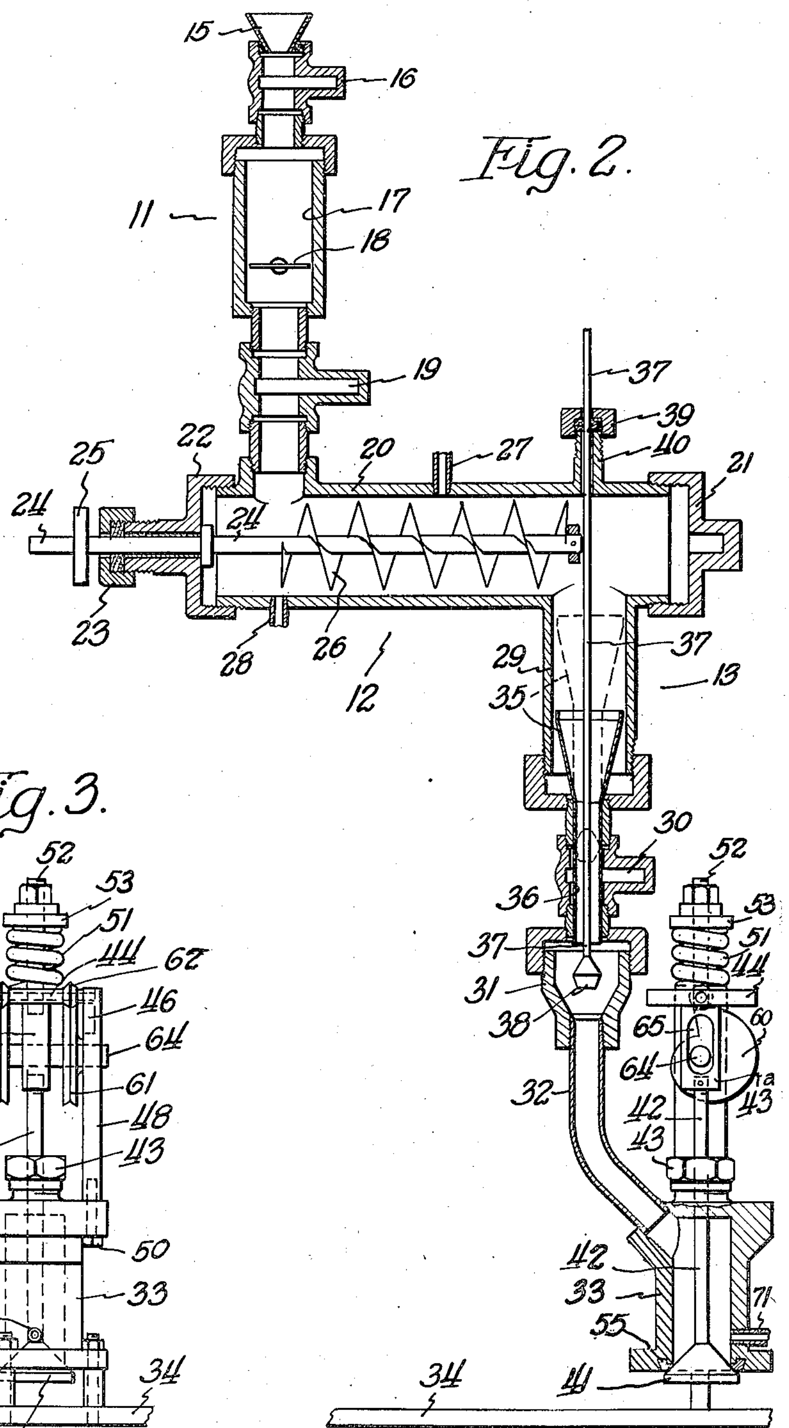

Fig. 2.

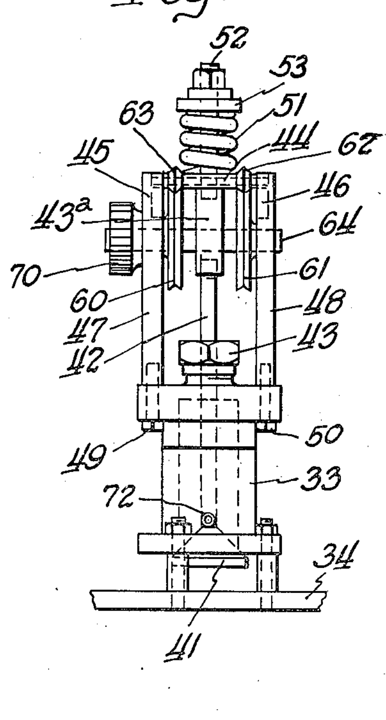

Fig. 3.

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UNITED STATES PATENT OFFICE

2,139,808

APPARATUS FOR PULVERIZING MINERAL AGGREGATES

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Application June 16, 1934, Serial No. 730,974

6 Claims. (Cl. 83—93)

Our invention relates, generally speaking, to a novel method and means for treating inorganic materials, and is particularly concerned with improvements relating to the explosive shattering or disintegrating of minerals. Combined with the explosive shattering may be a treatment of the materials to be shattered for the removal of soluble substances contained in the material with preparation of the material for magnetic separation. The present method and means may be considered as representing improvements over the disclosure made in our copending application Serial No. 612,524, filed May 20, 1932, now Patent No. 2,078,933, issued May 4, 1937.

Referring briefly to this patent, we have shown therein a method and apparatus for disintegrating minerals by subjecting the material to a preliminary process so as to produce aggregates of substantially uniform size, soaking the resulting substance in water and charging it into a sealed container which is then subjected to heat until a relatively high pressure and temperature is developed and an equilibrium is established between vaporized and unvaporized water. This container is then suddenly opened to atmospheric pressure and the material is discharged. The water contained in the material and particularly in the pores, seams and fissures thereof is explosively converted into seam at the moment of discharge and the explosive force of the steam disrupts the material into its individual or component parts. The particular virtue of this process resides in the fact that the ore is crushed or disintegrated differentially, saving a great deal of time and labor and furnishing a superior result when compared with previously known processes for shattering or crushing ore.

As has been remarked above, the present invention may be considered to represent noticeable improvements over the disclosure in the aforementioned patent, particularly with respect to the efficiency of operation in the individual steps involved as well as the results which are accomplished. Several objects of the present invention may be mentioned:

For example, one object has to do with the handling and explosive shattering treatment of ore and the like in a continuous process which may be controlled automatically or semiautomatically or, if desired, manually. It is understood, of course, that the method and apparatus described herein are not strictly limited to the treatment and preparation of ore nor, in fact, to any particular material. The invention may be used in all such cases where composite materials or substances are to be reduced or disintegrated. Of course, the particular field of application of this invention is to be found in the treatment and preparation of ore.

It is important in a continuous process, as intimated above, to coordinate the feeding or supply of the raw material with the discharge or output thereof. Accordingly, another object relates to novel means used in practising our method whereby the material is fed into the treatment apparatus in predetermined cycles and in amounts related to the explosion cycles with concurrent release or discharge.

Another object has to do with the preparation of the material intermediate of the supply cycle and the explosion discharge cycle. In other words, we have provided means in one embodiment of the invention for properly preparing the material after it is charged into the apparatus and preparatory to the explosive shattering thereof.

A further object has to do with provisions for controlling the coordination of the feed of the material with the preparation and subsequent discharge in a continuous process of production.

Another object is concerned with the novel construction, operation and control of a discharge valve employed in our novel apparatus.

Still another object relates to providing a treatment of this character whereby certain cumbersome steps are eliminated which were previously thought to be indispensable. For example, a pretreatment of the material was considered important in the past. Our invention, in one embodiment may be successfully practiced for treating dry, possibly somewhat preheated material. It will be apparent that the elimination of the pretreatment, for example, the pre-soaking of the ore in water, represents an important advantage.

There are several other objects and features which will be brought out as the description progresses.

The invention will now be described with reference to the accompanying drawings in which

Fig. 1 represents an elevational view of our new explosive shattering machine;

Fig. 2 is a sectional view of the machine shown in Fig. 1; and

Fig. 3 shows a side elevation of our new explosion chamber and associated discharge valve.

The machine shown in the drawings consists of a number of parts which perform certain coordinated functions, namely, the receipt of the raw material for treatment, its preparation and movement within the machine, and finally its explosion and discharge. It should be noted that in the machine shown we have provided a special preparation chamber. However, the invention can also be practiced without such a preparation chamber, as will be explained presently. The structure shown in the drawings is also provided with means for moving the material within the apparatus so as to agitate it and to convey it at the same time from a point adjacent to the supply chamber to a feed point adjacent to the explosion chamber. Such mechanical feed or conveying of the material can be dispensed with, if desired, and gravity feed can be adopted or incorporated within the scope of the invention. The drawings merely illustrate a certain embodiment of the invention for the purpose of teaching others how to apply it but it is to be understood that the drawings as well as the following detailed description are not intended to express any limitations of the invention and the scope thereof.

Like parts will be denoted in the following description by like reference numerals throughout the drawings. Elements and parts which may be assumed to be well known will be described only when such description is required for a clear understanding of the structure or the corresponding function.

Referring now to the drawings, the machine shown therein comprises a charging or feed portion or chamber generally indicated by reference numeral 11. This charging portion connects with a preparation chamber, denoted by numeral 12, terminating in the feed portion 13 for feeding or conveying the treated or prepared material to the discharge end of the machine which is generally indicated by the reference numeral 14. Raw material which may be pre-treated, e. g., soaked in water, as described fully in our previously noted patent, may be fed into the machine at the flaring funnel-like part 15 shown at the top of the drawings, Figs. 1 and 2. It should be noted, however, that such a pretreatment is not absolutely necessary even in the case of materials which heretofore were assumed to require soaking in water prior to the explosive shattering. The material may be fed into the mechanism in dry condition, or, in certain cases, somewhat pre-heated. The manner of conveying the material to the charging funnel 15 is, generally speaking, immaterial. Of course, care should be taken in a process of continuous treatment that the supply of raw material is suitably adjusted to the operating speed of the machine.

A valve 16 is provided adjacent to the intake or charging funnel 15 for controlling the supply operations. The action of this valve is coordinated with the operation of the other control equipment yet to be explained. The valve may be of the sliding type or of another suitable construction. A handle has been shown for actuating the valve but it is understood that the valve may be actuated automatically under the control of a suitable governing mechanism for coordinating the functions of the various operating parts in accordance with the requirements in any given case. The points which are to be considered for an understanding of the coordination of the charging cycle and the explosion cycle will be explained in conjunction with the detailed description of the mechanism rendered below.

The raw material is admitted into the charging lock or chamber 17 which is provided with a butterfly valve 18. The chamber is so constructed and the apparatus of the cooperating valves is so related as to prevent the escape of steam through the charging valve 16 to the outside. A control valve 19 which may be structurally similar to the charge inlet valve 16 and which also may be subjected to the automatic control of suitable governing mechanisms is provided at the lower end of the charging chamber 17. The cycle for charging the machine with raw material, i. e., the cycle of operation with reference to the charging chamber 17 is as follows: The butterfly control valve 18 and the lower charge outlet valve 19 are caused to close. The charge inlet or intake portion of the machine is thus functionally isolated or separated from the remaining mechanism. The upper charge inlet or intake valve 16 is now quickly opened in order to admit the required charge of raw material into the charging chamber 17. The inlet valve then closes immediately, whereupon the butterfly valve 18 and the lower charge outlet valve 19 open to restore the functional connection of the charging chamber with the preparation chamber 12. It will be observed that these operations are executed in such a sequence that escape of steam through the charging chamber or charging lock to the outside is prevented. The operations of the charging chamber 17 are independent of the remaining mechanism, but coordinated therewith in such a manner that all parts operate with maximum efficiency in a continuous process of production.

Referring now to the central portion of the apparatus, the preparation chamber may consist of a suitable container 20 which is closed at one end by means of a cap 21 and is provided at the other end with a tubular cap 22, forming a stuffing box closed by means of a cap nut 23 as shown. A shaft 24 carrying a sprocket drive member 25 extends through the packing in the stuffing box into the interior of the preparation chamber 20. This shaft may carry a suitable auger or screw conveyor 26, as shown in Fig. 2, for agitating the charge of raw material and for moving the same through the preparation chamber where the material is subjected to the action of steam admitted through the inlet 27. The shaft is rotated by means of the sprocket 25 which may be operated from a suitable drive mechanism. A drain 28 is provided to permit draining of water from the preparation chamber for cleaning and for other purposes. The point where the drain is placed is disposed somewhat lower than the discharge end of the container 20, so that the preparation chamber may be thoroughly drained of condensed and accumulated water and precipitates if desired or necessary.

It will be apparent from the above explanations that the raw material is admitted for treatment in either dry or wet condition, as the case may be, and in predetermined successive charges, which are then conveyed through the preparation chamber due to the action of the auger conveyor. The raw material is agitated within the preparation chamber and simultaneously subjected to the action of steam. The pores and interstices of the material, assuming that the same is admitted in dry condition, will now be saturated with steam. The agitation, due to the rotary and to the longitudinal motion caused by the screw conveyor, will assist the ingress of steam into the material. In case presoaked material is introduced into the machine, the action of steam will cause quick conversion of the water contained in the material into steam. Very good results have been obtained with material introduced into the machine in dry condition. The speed of the screw conveyor can be regulated according to the time required for preparing any particular material. It should be mentioned at this point that pre-heating of the raw material may be desirable in certain cases. The ingress of steam into the pre-heated material will be accelerated and too much condensation of the water will be prevented which might occur due to the introduction of cold material. It is also advisable to operate the machine so as to shorten the time between explosions to a minimum in order to avoid cooling the machine and resulting condensation.

The mechanism for conveying the treated material to the explosion chamber will be explained next. This mechanism is located at the discharge end of the preparation chamber 20 and comprises the feed chamber 29 (which may be an integral part of the preparation container 20) carrying at its lower end a valve 30, similar in structure to the previously described valves 16 and 19. A delivery housing 31 is connected to the control valve 30, and a connector 32 extends from the delivery housing or member to the explosion chamber 33 which may be mounted on a base 34. The mechanism for controlling the feeding of the treated material from the preparation chamber 20 to the explosion chamber 33 comprises a funnel-like member 35 having a tubular extension 36 which is slidably disposed in the lower portion of the chamber 29 and extends slidably through the housing of valve 30 and through the upper portion of the delivery housing 31, as is particularly indicated in Fig. 2. This delivery funnel and its tubular extension 36 represent the delivery means for conveying the treated material to the explosion chamber. The charge of treated material is received by this funnel 35 and is delivered to the explosion chamber under the control of a mechanism comprising the movable rod 37 which carries at its lower end a delivery or feed cone member 38. The control rod 37 extends centrally through the movable feed funnel 35 and to the outside through a stuffing box 39 provided on an extension 40 protruding from the preparation container 20.

The control rod 37 is shown in Fig. 2 in its delivery position. The delivery funnel 35 is in its lowermost position and free delivery of the treated material from the preparation chamber through the feed chamber 29 and through the funnel 35 to the connecting member 32 (and from there to the explosion chamber 33) is possible. Assuming, however, that the rod 37 is raised, the plug or cone 38 will engage the end of the tubular neck 36 of the funnel 35 and will lift the funnel upwardly, keeping its delivery end closed. The funnel will thus be placed into the position shown in Fig. 2 in dotted lines and will receive the treated material as it is conveyed to the end of the chamber 20 by the screw conveyor 26. Control valve 30 is closed while the funnel 35 is being charged. It will be observed that this operation is again accomplished in a manner which excludes functional interference, i. e., the charging of the delivery funnel 35 with the treated material takes place while the funnel and its associated parts are functionally separated or isolated from the remaining parts of the machine.

The feed or delivery of the treated material from the funnel 35 to the explosion chamber 33 is preceded by the opening of the valve 30 so as to allow the free movement of the control rod 37 and accordingly of the delivery funnel 35—36. The funnel assumes then its position shown in full lines, while the rod 37 continues its downward movement in order to remove the cone or plug 38 from the end of the funnel neck 36. The charge of the treated material can then drop into the connector member 32 for delivery and feed into the explosion chamber 33.

The explosion chamber is provided with a discharge valve 41 connected to an operating rod 42 which extends through a stuffing box 43 disposed on the explosion chamber housing. The valve control rod 42 is connected to a yoke 43*a* which in turn is connected to the tappet 44, guided in suitable pockets 45 and 46 (indicated in Fig. 3) provided in the supports 47—48. These supports may be mounted at 49—50 on the upper part of the explosion chamber housing 33. A spring 51 is provided around the post 52, between the tappet 44 and a suitable retaining member 53 in order to provide tension for the valve plug 41. The discharge valve rod 42 is then biased in an upward direction closing the explosion chamber by means of the valve 41, as particularly shown in Fig. 2. The valve plug may be made of hardened steel and the valve seat, cooperating with the plug, may be made of lead. The valve seat is inset and is indicated in Fig. 2 by the numeral 55.

Referring to the preceding description of the feeding of the treated material, the valve 41 at the discharge opening of the explosion chamber is closed when the treated material is discharged or fed into the explosion chamber. The feed funnel is then raised as described and valve 30 will be closed to prepare for the explosive discharge when the feeding of the prepared material to the explosion chamber is completed. The discharge valve 41 of the explosion chamber will then be opened by a cam mechanism which comprises cams such as particularly indicated at 60—61 in Fig. 3 which cooperate with rollers 62—63 provided in the tappet 44 and adapted to engage the cams. It is understood, of course, that only one cam may be provided instead of two cams and that various other changes may be made. The form of the cams is shown in Fig. 2. These cams are carried on a shaft 64 which extends through an opening 65 in the connecting link or yoke 43*a*. A suitable drive which may comprise a sprocket 70 or the like, as indicated in Fig. 3, may be provided for actuating the cams. This drive may be automatically governed by a mechanism which coordinates the functions of the various valves and other previously mentioned control devices.

The explosion cycle or sequence of events to be considered in connection with the explosion and discharge of the material is as follows: Assuming that an explosion has just occurred, the cam operating mechanism rotates the cams 60—61 to the position shown in the drawings, thereby closing the discharge valve 41 and preparing the mechanism for another discharge explosion. The valve 30 disposed below the funnel feed 35—36 opens now. The feed funnel 35, supplied with a charge of treated material, drops downwardly until it is in the position shown in full lines in Fig. 2. The control rod 37 continues its downward movement in order to remove the plug or cone 38 from the end of the funnel neck 36 so as to allow the charge of the treated material to drop through the connecting tube 32 into the chamber in the explosion housing 33. The funnel plug is then raised by means of the control rod 37 and engages the funnel neck to lift it clear of the valve 38. This valve closes now in order to separate the explosion chamber functionally from the feed portion of the machine. The discharge valve control apparatus now rotates the cams 60—61 into a position to release the discharge valve 41. The valve 41 opens due to the pressure within the explosion chamber, the explosion occurs, and the material is shattered, as described previously and is delivered to the outside.

Referring to the explosion chamber housing 33, we have also provided an emergency drain extension 71 which may be used for draining and cleaning the explosion chamber of water and precipitates. This drain is normally used only upon starting the machine.

A steam inlet 72 is indicated on the explosion chamber housing 33. Such an inlet is normally not required when the machine is used in conjunction with the preparation chamber described previously. However, as has been mentioned elsewhere, the preparation chamber might not be required in all cases. Machines may be furnished without the preparation chamber. In this case the charges of raw material would be delivered directly into the explosion chamber either by means of a suitable feed mechanism, such as shown, or suitably modified, and steam would be admitted through the inlet 72 preparatory to the explosive discharge. Means for agitating the material within the explosion chamber may be provided if desired. Short steaming periods on dry material have been successfully applied. It may be mentioned that good results were obtained on charges that contained about 3% water when exploded.

The following refinements and/or modifications may be carried out, if desired:

It is possible, for example, to apply a treatment for the removal of water soluble or solution soluble substances contained in the material to be treated. The solvent, which may be water or any suitable solution, depending on the kind of soluble substances that are to be dissolved, will penetrate the material under the pressure within the machine and then on explosion will be brought to the surface where it may be easily removed. The nature of explosion shattering as herein described is particularly favorable to the application of chemical reactions to bring about solutions under autoclave conditions. The pressure within the machine will facilitate penetration of a solvent or reagent into the material. Thus, a caustic treatment can be readily combined with the crushing operation. The following specific examples may be noted:

In the case of iron ore, the water introduced into the preparation chamber will penetrate into the individual ore bodies and will dissolve the water soluble constituents. The pressure is then, in the course of the new process, suddenly released and the ore is broken down. The water which has permeated the material and dissolved the water soluble constituents will now come to the surface of the resulting smaller bodies of the crushed material and deposit its dissolved constituents on the surface from which it can easily be dissolved.

The ore may also be treated with a solution such, for example, as sodium hydroxide under pressure as described and a reaction may be brought about throughout the mass of the ore. On releasing the pressure, the ore is brought into condition for magnetic separation.

For the purpose of explaining the results produced by the several forms of our invention a discussion of the theory of the mechanism of the process may be useful. In the practice of our invention shattering may be conceived as taking place in three ways—

1. The expansion of steam or water in the pores or crevices of the material to be shattered;
2. The breaking apart of the component parts of the material by an explosion wave; and
3. The impact of the particles against each other and against the solid parts of the apparatus.

An increase in the size of the charge or decrease in the free path of discharge favor the mechanism 3, while decrease of charges and increase in treatment time and amount of water per unit weight of change favor mechanism 1 and 2. Maximum differential shattering, minimum production of fines, and maximum chemical effects will be obtained with relatively small charges, long treatment times and high ratio of water weight to charge weight should be used.

On the other hand when it is desired to produce efficient crushing regardless of mechanism the time of treatment and ratio of water to weight of charge will be kept to a minimum and the total weight of charge made as large as possible. These results are obtained in the practice of our invention by eliminating the preparation chamber as already mentioned and using a dry or slightly preheated charge. When the steam is admitted films of water are deposited on the ore particles, these films are superheated and allowed to expand suddenly thus causing the ore particles to strike against one another and be disintegrated. Smaller amount of shattering may also be caused by mechanisms 1 and 2 above. We have found that good results may be obtained with a water content of 1/1000 to 1/15 of the weight of the charge and with steaming times of only a few seconds between explosions. It should be pointed out that in this case it is not necessary to heat the entire charge but only to bring the water film on the surface of the particles to a superheated condition before allowing sudden expansion. By this means we have shattered dolomite from ½ to ¾-inch pieces to pass a 48-mesh screen for a steam cost of less than 1 cent.

As described in our Patent No. 2,078,933, previously mentioned, the steam pressure in the explosion chamber at the moment of discharge will naturally vary with the character of mineral being crushed as well as with the nature of the crushing action sought. As described in said patent, in the ordinary case, pressures between 150 and 200 pounds per square inch have proved satisfactory. It will likewise be evident that the temperature of the steam employed is subject to wide variation, it being necessary only to maintain a temperature sufficiently high so that water vapor is retained as steam at the pressures utilized.

Other changes and modifications may be devised according to the purpose in view. It is understood that such changes are considered to be within the scope of the invention and are contemplated in the practice thereof provided that they wall within the scope of the following claims.

We claim:

1. Apparatus for explosively disintegrating minerals comprising, a supply chamber for receiving raw material, a preparation chamber adjacent to said supply chamber for treating said

material, said supply and preparation chambers being in communication, an explosion chamber adjacent to said preparation chamber for receiving said treated material for explosively disintegrating the same and for discharging said disintegrated material, said preparation and explosion chambers being in communication, an intake control valve for sealing said supply chamber to the outside, a supply control valve for sealing said supply chamber relative to said preparation chamber, a feed control valve for sealing said preparation chamber relative to said explosion chamber, and a discharge control valve for sealing said explosion chamber to the outside, whereby material charged into the supply chamber may be maintained above atmospheric pressure throughout its passage through the said three chambers and whereby said preparation chamber may at all times be maintained at a pressure above atmospheric by closing the valves leading to the supply and explosion chambers respectively when these chambers are open to atmosphere.

2. Apparatus for explosively disintegrating minerals comprising, a supply chamber for receiving raw material, a preparation chamber adjacent to said supply chamber for treating said material, an explosion chamber adjacent to said preparation chamber for receiving said treated material for explosively disintegrating the same and for discharging said disintegrated material, an intake control valve for sealing said supply chamber to the outside, a supply control valve for sealing said supply chamber relative to said preparation chamber, a feed control valve for sealing said preparation chamber relative to said explosion chamber, a discharge control valve for sealing said explosion chamber to the outside, operating means in said preparation chamber for mechanically agitating material admitted thereto from said supply chamber and for moving said material through said preparation chamber, and feeding means associated with said preparation chamber for feeding prepared material thru said feed control valve to said explosion chamber.

3. Apparatus for explosively disintegrating minerals comprising, a supply chamber for receiving raw material, a preparation chamber adjacent to said supply chamber for treating said material, an explosion chamber adjacent to said preparation chamber for receiving said treated material for explosively disintegrating the same and for discharging said disintegrated material, an intake control valve for sealing said supply chamber to the outside, a supply control valve for sealing said supply chamber relative to said preparation chamber, a feed control valve for sealing said preparation chamber relative to said explosion chamber, a discharge control valve for sealing said explosion chamber to the outside, operating means in said preparation chamber for mechanically agitating material admitted thereto from said supply chamber and for moving said material thru said preparation chamber, means cooperating with said preparation chamber for conveying prepared material thru said feed control valve to said explosion chamber, and means for governing the actuation of said control valves and of said operating means and of said feeding means.

4. Apparatus for effecting the continuous explosive shattering of inorganic material comprising a chamber for successively receiving charges of raw material, a treating chamber serially related thereto for successively preparing said charges, delivery means connected with said treating chamber for successively receiving said prepared charges, an explosion chamber, means for actuating said delivery means to feed said prepared charges successively to said explosion chamber, valve means for closing each of said chambers, and valve means cooperating with said explosion chamber for effecting the successive exploding of said charges delivered thereto and for causing the discharge thereof.

5. In an apparatus for explosively shattering ore, a first chamber for preparing a charge of ore for explosion, a second chamber for exploding said ore, a passageway between said chambers, a valve in said passageway, and means disposed in the passageway between said chambers for delivering said prepared charge from said first chamber to said second chamber, said means comprising a tubular movable delivery chamber, a movable plug, means for moving said plug to engage one end of said delivery member to close the same and to move said delivery member toward said first chamber to receive said charge and for then moving said plug and said delivery member toward said explosion chamber to deliver said prepared charge into said explosion chamber, said valve being closable when said delivery means is moved toward the first chamber.

6. Apparatus for disintegrating inorganic material comprising a closed system having an intake opening at one portion thereof and a discharge opening at another portion thereof, a material receiving chamber, a material conditioning chamber, and an explosion chamber, all interconnected and forming a part of said closed system, means for delivering steam under pressure to the conditioning chamber and to the explosion chamber, valves between each of said chambers whereby material may be passed from one chamber to another without material change in the pressure in said chamber, a valve closing said material receiving chamber but adapted to be opened to permit charging of material thereto, and a valve closing said discharge opening and adapted to be opened when the valve between the conditioning chamber and explosion chamber is closed whereby to permit material to be explosively discharged therethrough.

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