

Oct. 10, 1939.

H. E. DUNN

2,175,457

PREFERENTIAL PNEUMATIC GRINDING AND SCRUBBING OF ORES AND MINERALS

Filed Nov. 19, 1936

2 Sheets-Sheet 1

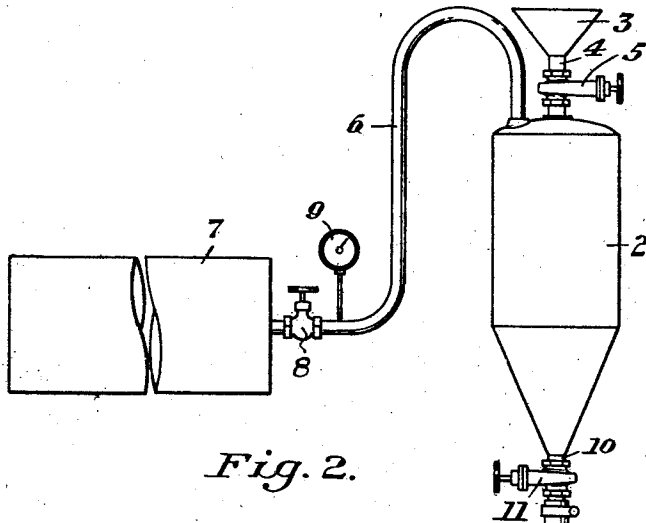


Fig. 1.

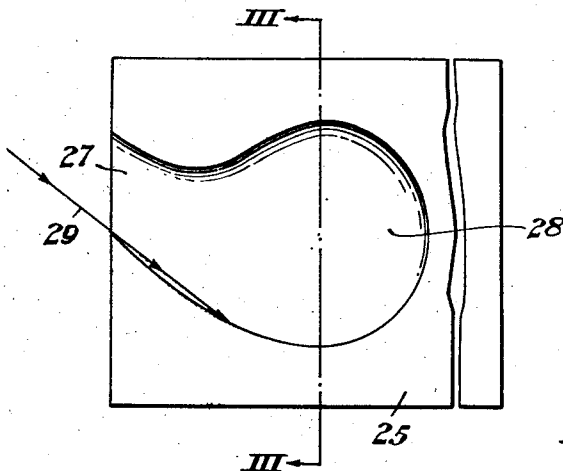
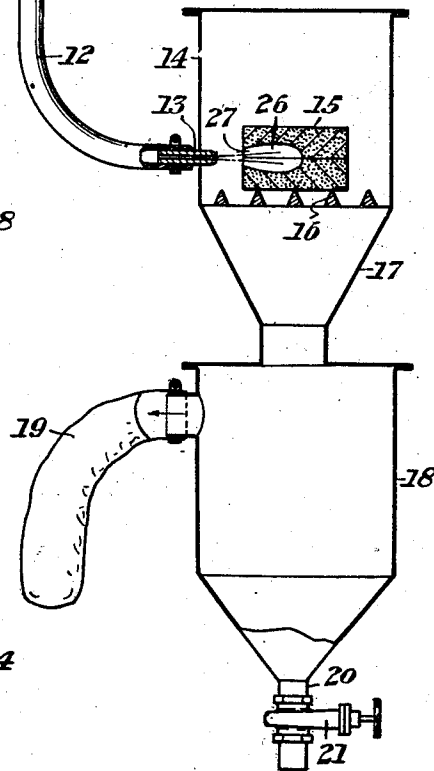
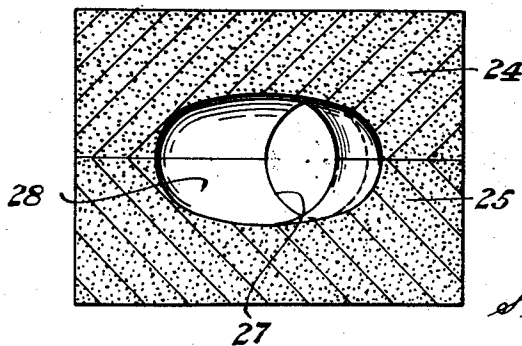


Fig. 3.



INVENTOR
Holbert Earl Dunn

by
S. T. Tilling, Blunk & Parmelee
H. A. A. Tilling

Oct. 10, 1939.

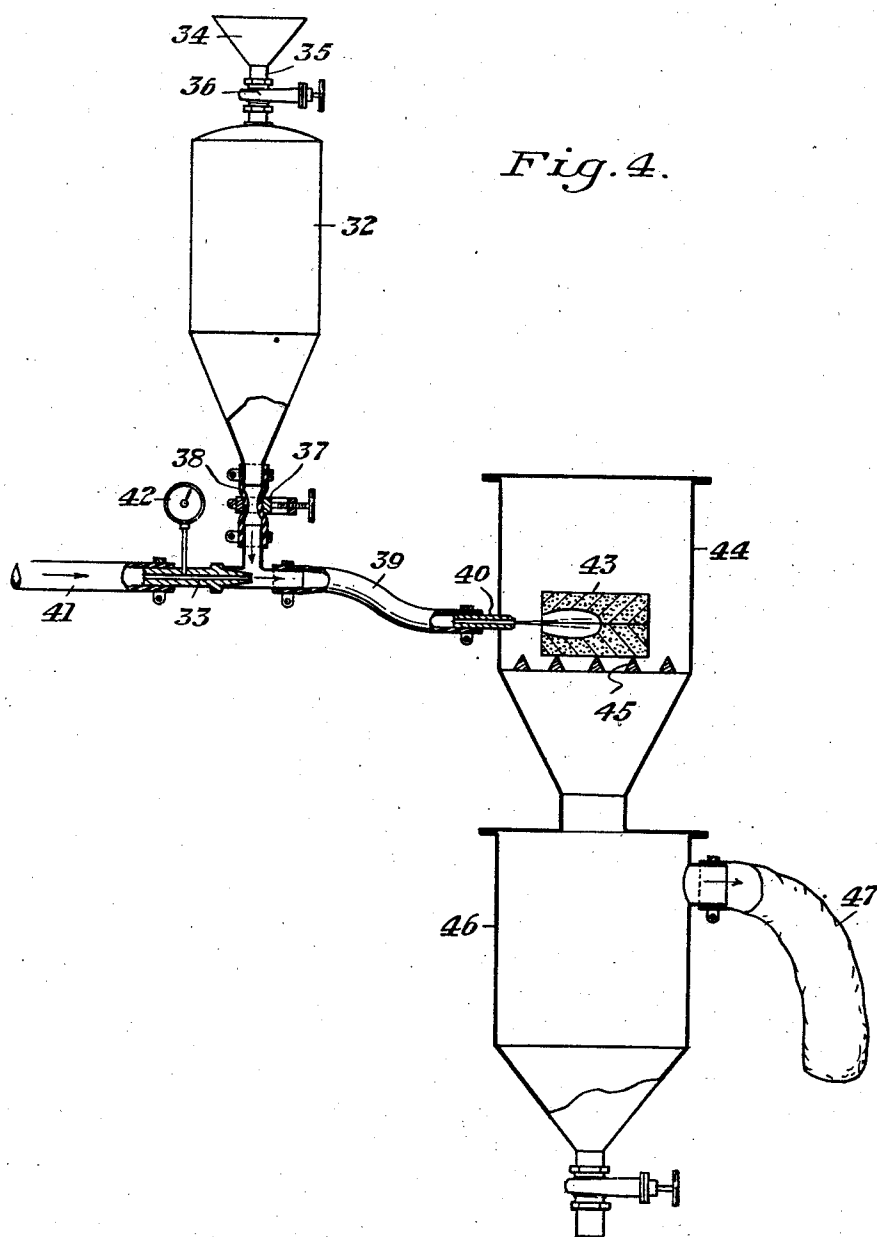
H. E. DUNN

2,175,457

PREFERENTIAL PNEUMATIC GRINDING AND SCRUBBING OF ORES AND MINERALS

Filed Nov. 19, 1936

2 Sheets-Sheet 2



INVENTOR
Holbert Earl Dunn

by
Stebbins, Benson & Parmelee
His Atty.

UNITED STATES PATENT OFFICE

2,175,457

PREFERENTIAL PNEUMATIC GRINDING AND
SCRUBBING OF ORES AND MINERALSHolbert Earl Dunn, Crafton, Pa., assignor to
Vanadium Corporation of America, Bridgeville,
Pa., a corporation of Delaware

Application November 19, 1936, Serial No. 111,627

3 Claims. (Cl. 83-46)

This invention relates to the preparation of ores and minerals for subsequent concentration, whereby the usual procedures of fine grinding in ball mills, rod mills, pebble mills, disc grinders and the like may be supplemented or entirely eliminated when it is desired to attain the maximum degree of attrition or wear on the surface of individual grains or groups of grains with a minimum of breaking or rupturing across these grains. The invention is particularly applicable to the removal of adhering coatings of valuable minerals from cores of worthless minerals or of worthless coatings from valuable cores.

Such a procedure becomes particularly desirable when the texture of the ore is such that the single grain size to which it is necessary to grind in order to liberate the locked minerals becomes so small that the usual grinding practices function essentially by breaking across the grains, resulting in objectionable overgrinding of one or the other constituent or, as is often the case, overgrinding of both constituents, thereby rendering subsequent concentration procedure less effective.

To offset these difficulties with existing grinding methods and equipment, it is customary to make use of screens or classifiers in closed circuit with the grinding equipment in order to remove from the mill the particles that are already sufficiently fine and to return the oversize to the mill to be reground. When screens are used, separation of the particles depends upon their size, while classifiers separate the particles according to their settling velocity as influenced by their specific gravity and shape. However, the efficiency of these devices is not as high as could be wished, and more or less undesirable overgrinding results.

For example, if it is desired to concentrate an ore consisting essentially of a sandstone whose cementing material carries the values in the form of soft earthy mineral incrustations on the hard sand grains, and comminution is carried out in the usual manner, it is found that when grinding has reached the point where, say, 90% of the single grains are liberated, a considerable portion of the sand grain gangue has been reduced by fracturing to such a degree of fineness that its separation from the finely ground values is rendered exceedingly difficult. On the other hand, ideal comminution, as applied to an ore of this type, would consist in separating the contiguous single grains without rupturing them, then scrubbing, rubbing or abrading away the incrusting mineral values without further fractur-

ing the sand grains, and with little or no wear on the sand grains themselves.

I have found that the objections to prior methods of grinding ores and minerals may be overcome or greatly decreased by introducing the particles of ore to be treated into a compressed air stream and projecting the stream of particles against the walls of an impact chamber made of wear resisting material in such manner as to cause scrubbing, rubbing, abrading or superficial pulverization of the grains of the particles but not to materially rupture the grains. The stream of particles to be treated is preferably projected against the walls of the impact chamber substantially tangentially of the walls so as to produce a swirling action of the particles which causes them to be rounded and abraded without substantially rupturing them. In this manner, I can scrub the grains of ore free from incrusting mineral values and control to an unusual degree the amount of core fines produced.

Since air under pressure will discharge from a proper nozzle at a velocity of around 650 feet per second, and the point of contact of the ore particle with the impact chamber in the case of angular grains may be initially infinitesimally small, enormous crushing strains may be developed of the order of 30 to 40 times the resisting power of the strongest rock.

Close regulation of the force applied is obtained by controlling the quantity of ore thrown in proportion to the propelling jet; the larger the quantity of ore the more moderate the velocity, at the same time applying no greater initial air pressure than is required to induce rounding of the particles and stripping of the outer layers, unless the particles consist of more than a single grain, when it is desirable, at least during preliminary passes through the impact chamber to produce breaking through the particles to further free the single grains.

In the accompanying drawings which illustrate a preferred embodiment and modification of apparatus suitable for carrying out my process;

Figure 1 is a somewhat diagrammatic illustration of the whole apparatus;

Figure 2 is a top plan view of one of the two recessed blocks of wear resisting material which, when assembled together, form the impact chamber;

Figure 3 is a transverse vertical section through the impact chamber taken in a plane corresponding to the line III—III of Figure 2; and

Figure 4 is a view similar to Figure 1, but illustrating a modified form of apparatus in which

an air injector is employed for withdrawing the ore particles from the feed chamber and projecting them into the impact chamber.

Referring now more particularly to the accompanying drawings, and for the present to Figures 1 through 3, the ore to be ground or scrubbed is introduced into a feed chamber 2 through a funnel 3 and conduit 4 provided with a valve 5. Air under pressure is supplied to the top of the feed chamber by means of a conduit 6 connected to a compressed air tank 7, the flow of air being controlled by valve 8 and the pressure indicated by a gauge 9.

The outlet 10 of the feed chamber 2 is controlled by a valve 11 and is connected to a flexible conduit 12 which may be a rubber hose. The exit end of the conduit 12 is provided with a nozzle 13 which may be of the construction commonly employed in sand blast apparatus. The nozzle projects through the wall of a rubber lined steel housing 14 inside of which an impact chamber 15 is located. The impact chamber is supported on a grating 16 in position to receive the stream of ore and air from the nozzle 13. After the ore particles have been treated in the impact chamber, they are discharged through a cone-shaped passage 17 to a receiver 18. The receiver 18 and the impact chamber 15 are maintained substantially at atmospheric pressure by connecting a cloth filter bag 19 to the receiver. The filter bag releases the incoming air and at the same time prevents the loss of fine particles of ore in suspension. The ore is discharged from the receiver through an outlet 20 controlled by a valve 21.

The construction of the impact chamber 15 is illustrated in detail in Figures 2 and 3. In these figures, the impact chamber is shown in full size. The impact chamber is made of blocks 24 and 25 of hard wear resisting material such as silicon carbide, aluminum oxide, or sintered tungsten carbide or hard metal carbide composition. The blocks are formed with complementary recesses which form an impact chamber 26. The impact chamber has a restricted opening 27 which is located in such position as to receive the stream of ore and compressed air from the nozzle 13, the opening having a diameter of about 2 or 3 times the diameter of the pattern of the projected particles in the plane of the opening. A chamber having an opening 27 of $\frac{1}{8}$ to $\frac{3}{4}$ inch diameter and a bowl 28 of approximately $1\frac{3}{4}$ inch diameter is sufficiently large to receive a stream of ore particles from a $\frac{1}{8}$ to $\frac{3}{4}$ inch nozzle when presented to the stream within a distance of, say, one inch from the face of the nozzle. The stream of ore particles is projected into the chamber 26 substantially tangentially with the wall of the chamber, as indicated by the arrows 29 in Figure 2. The chamber, as will be noted, is formed by curved walls forming a chamber which is substantially in the shape of an oblate spheroid. A chamber of the shape of an ovoid or other chamber having rounded walls which cause rotation and swirling of the ore particles may be employed, however.

In carrying out the process with the apparatus shown in Figures 1 through 3, the ore to be treated is charged through the funnel 3 into the receiving chamber 2 while the valve 11 is closed. When the entire charge has entered the feed chamber, the valve 5 is closed and compressed air is admitted through the conduit 6. The valve 11 is then opened and a stream of ore particles

and compressed air is forced through the conduit 12 and nozzle 13 into the impact chamber 15. The treatment in the impact chamber causes abrading or rubbing away of the surfaces of the grains without substantial rupturing of them. The particles of ore striking the walls of the impact chamber lose their velocity almost instantaneously. The particles which have passed through the impact chamber are discharged through the same opening 27 through which they entered and fall through the grating 16 into the receiver 18.

By applying air pressure to a charge of ore particles in the manner above described, I produce maximum loading of the air blast with ore particles and consequently minimum velocity for the corresponding air pressure used, and consume the minimum quantity of air. When higher velocities are necessary and it is found desirable to limit the air pressure, increased velocity may be obtained by the arrangement shown in Figure 4. In this embodiment, the ore particles are withdrawn from a feed chamber 32 by means of an air inspirator 33. The ore particles are introduced into the feed chamber 32 through a funnel 34 and conduit 35 controlled by a valve 36. A clamp 37 which fits around a piece of rubber tubing 38 connected to the delivery end of the chamber 32 is provided for controlling the flow of ore to the flexible conduit 39, which is provided with a nozzle 40, as in the other embodiment already described. The air injector 33 is connected by an air conduit 41 to a source of compressed air (not shown), and the inspirator is provided with a pressure gauge 42. The remainder of the apparatus is substantially identical with that described in connection with the other embodiment. The stream of ore particles is projected into an impact chamber 43 located within a housing 44, and the particles which have been treated in the impact chamber are discharged through a grating 45 into a receiver 46, to which a filter cloth bag 47 is connected.

In either method of feeding the ore, mechanical air locks may be substituted for the manually controlled valves. A multiplicity of impact chambers may be operated from a single feed chamber to provide the necessary capacity, although a single $\frac{1}{8}$ inch nozzle will treat from 300 to 1800 pounds of ore per hour within its range of velocities for a pressure of 80 pounds per square inch.

As an example of the operation of my process, I may break in crushers and rolls a sandstone having a single grain size between 48 and 100 mesh, to all pass an 8 mesh screen, and charge this material into my preferred apparatus illustrated in Figures 1 through 3, using a $\frac{3}{8}$ inch sand blast nozzle and apply 100 pounds per square inch air pressure. I have found under such conditions, by screen analysis after a single pass or treatment, that about one-third of all the sizes larger than 48 mesh have been reduced to minus 65 plus 150 mesh grains with only 2% increase in the amount of minus 200 mesh fines present. A second pass results in another one-third reduction of the original content of plus 48 mesh material with a 3% increase in the original minus 200 mesh content, while a third, fourth and fifth pass produce no sensible further alteration in screen analysis, but have visibly increased the rounding of the grains.

By increasing the air pressure to 140 pounds per square inch, the same result is obtained in two passes as required three passes at 100 pounds

pressure, but an almost identical screen analysis is maintained even after five passes at 140 pounds pressure as that attained on the second pass.

ferred form and a modification of apparatus for carrying out my process, it is understood that the invention is not limited to the use of the type of apparatus illustrated or the materials of construction cited, or to the preferred procedure above described, but may be otherwise embodied

The screen analyses in the two tests just described, were as follows:

PNEUMATIC CRUSHING TEST FEED — 8 MESH

$\frac{1}{8}$ inch diameter nozzle—100 pounds per square inch air pressure

Tyler mesh	Heads		1st pass		2nd pass		3rd pass		4th pass		5th pass	
	Weight	Cum.	Weight	Cum.	Weight	Cum.	Weight	Cum.	Weight	Cum.	Weight	Cum.
On—	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
10	7.34	7.34	4.11	4.11	1.93	1.93	1.80	1.80	1.12	1.12	1.72	1.72
14	9.87	17.21	6.39	10.50	3.38	5.31	3.14	5.08	2.62	3.74	3.43	5.15
20	6.33	23.54	4.11	14.61	2.42	7.73	2.52	7.55	1.87	5.61	2.15	7.30
28	5.32	28.86	3.20	17.81	1.98	9.66	1.90	9.44	1.50	7.11	1.72	9.02
35	6.08	34.94	4.11	21.92	2.90	12.56	2.52	11.96	2.25	9.36	2.58	11.60
48	7.85	42.79	6.85	28.77	5.80	18.36	5.66	17.62	5.62	14.98	5.15	16.75
65	14.94	57.73	15.53	44.30	15.94	34.30	16.35	33.97	17.23	32.21	15.88	32.63
100	21.77	79.50	26.47	70.77	31.39	65.69	30.18	64.15	34.83	67.04	32.62	65.25
150	9.87	89.37	14.61	85.38	16.91	82.60	18.86	83.01	15.36	82.40	16.74	81.99
200	5.06	94.43	7.31	92.69	8.70	91.30	8.81	91.82	9.36	91.76	9.44	91.43
Pass 200	5.57	100.00	7.31	100.00	8.70	100.00	8.18	100.00	8.24	100.00	8.57	100.00
Total	100.00		100.00		100.00		100.00		100.00		100.00	

$\frac{1}{8}$ inch diameter nozzle—140 pounds per square inch air pressure

Tyler mesh	Heads		1st pass		2nd pass		3rd pass		4th pass		5th pass	
	Weight	Cum.	Weight	Cum.	Weight	Cum.	Weight	Cum.	Weight	Cum.	Weight	Cum.
On—	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
10	7.34	7.34	2.00	2.00	1.37	1.37	1.08	1.08	1.30	1.30	1.40	1.40
14	9.87	17.21	4.50	6.50	2.74	4.11	2.70	3.78	3.03	4.33	2.34	3.74
20	6.33	23.54	3.00	9.50	2.23	6.39	2.16	5.94	2.16	6.49	1.87	5.61
28	5.37	28.96	2.50	12.00	1.83	8.22	1.62	7.56	1.73	8.22	2.40	7.01
35	6.08	34.94	3.50	15.50	2.74	10.96	2.70	10.26	2.60	10.82	2.34	9.35
48	7.85	42.79	6.50	22.00	5.94	16.90	5.95	16.21	5.62	16.44	5.14	14.49
65	14.94	57.73	18.00	40.00	16.44	33.34	16.68	31.89	16.02	32.46	15.89	30.38
100	21.77	79.50	27.50	67.50	33.78	67.12	32.43	64.32	34.20	66.66	33.17	63.55
150	9.87	89.37	16.50	84.00	15.98	83.10	17.84	82.16	16.02	82.68	17.29	80.84
200	5.06	94.43	8.00	92.00	8.22	91.32	8.65	90.81	8.66	91.34	10.28	91.12
Pass 200	5.57	100.00	8.00	100.00	8.68	100.00	9.19	100.00	8.66	100.00	8.88	100.00
Total	100.00		100.00		100.00		100.00		100.00		100.00	

If, instead of increasing the air pressure to 140 pounds as in the second example, I employ a finer feed, say, minus 48 mesh of the same material, I find that after five passes through the pneumatic scrubber at 100 pounds pressure I have reduced each screen size by three to four per cent and that after ten passes each screen size has been reduced by six to nine per cent, practically straight line crushing normally attainable in crushers and rolls only on coarse sizes (plus 8 mesh).

On the other hand, if only scrubbing is desired, I find that at 30 pounds air pressure, no noticeable change in screen analysis is obtained in one pass nor any appreciable rounding of the grains, but at 100 pounds pressure, noticeable rounding is observed on a single pass.

The process may be used to remove surface layers from grains already separated by other means or to separate particles consisting of many grains into those individual grains and then removing the surface layers from each of them. In other words, as previously noted, the process may supplement the comminution processes, or, not only supplement them, but also replace them in part.

Thus, it is apparent that a variety of grinding and scrubbing characteristics may be secured by easily controlled variations in air blast pressure, size of feed and rate of ore feed or loading of the air blast for a given size of nozzle.

While I have specifically described the pre-

and practiced within the scope of the following claims.

I claim:

1. Apparatus for grinding or scrubbing ores and minerals, comprising an impact chamber formed of wear resisting material, a housing for the impact chamber, and means for projecting a stream of compressed air and particles to be treated into the impact chamber, the impact chamber having a constricted opening through which the projected particles enter and exit, the impact chamber having a closed cavern-like bowl formed substantially in the shape of an oblate spheroid to produce a swirling action and rounding of the particles impacted against it.

2. Apparatus for grinding or scrubbing ores and minerals, comprising an impact chamber formed of wear resisting material, a housing for the impact chamber, means for projecting a stream of compressed air and particles to be treated into the impact chamber, the impact chamber having a constricted opening through which the projected particles both enter and exit, said opening having a diameter of about two or three times the diameter of the pattern of the projected particles in the plane of the opening, the walls of the impact chamber being curved so as to produce a swirling action of the particles impacted against them, the impact chamber having a bowl of considerably larger diameter than the constricted opening through which the projected particles enter and exit, the bowl being substan-

tially circular in cross section at its largest diameter.

5 3. Apparatus for grinding or scrubbing ores and minerals, comprising an impact chamber formed of wear resisting material, a housing for the impact chamber, and means for projecting a stream of compressed air and particles to be treated into the impact chamber, the impact

chamber having a constricted opening through which the projected particles both enter and exit, the impact chamber having a bowl in the form of an oblate spheroid and of larger diameter than said constricted opening, said constricted opening having a diameter appreciably larger than that of the stream of incoming particles.

HOLBERT EARL DUNN.