G. C. HACKSTAFF & G. B. HOLDEN.

ORE CLASSIFYING AND SEPARATING PROCESS.

APPLICATION FILED NOV. 24, 1914.

1,219,408. Patented Mar. 13, 1917.

2 SHEETS—SHEET 1.

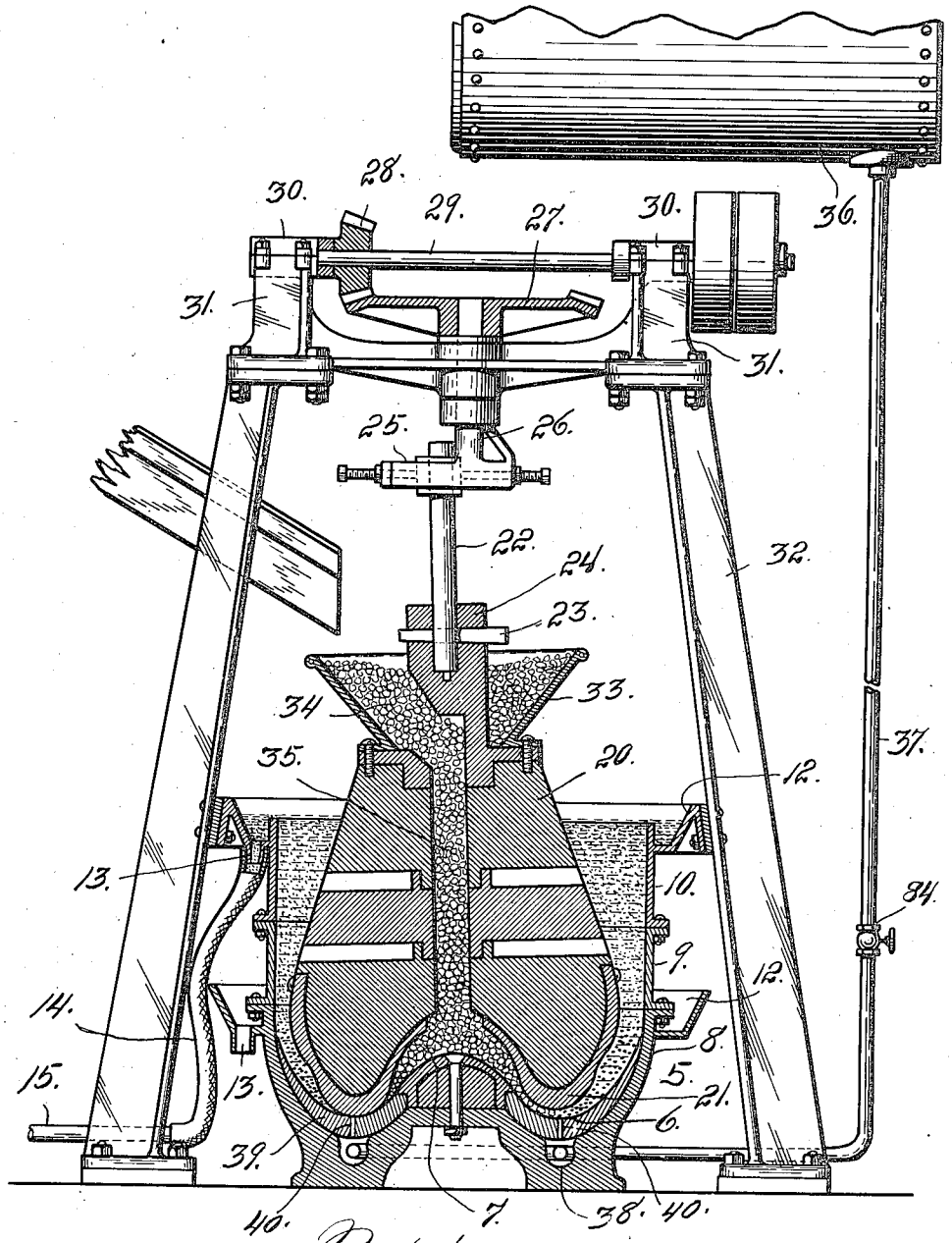


Fig. 1.

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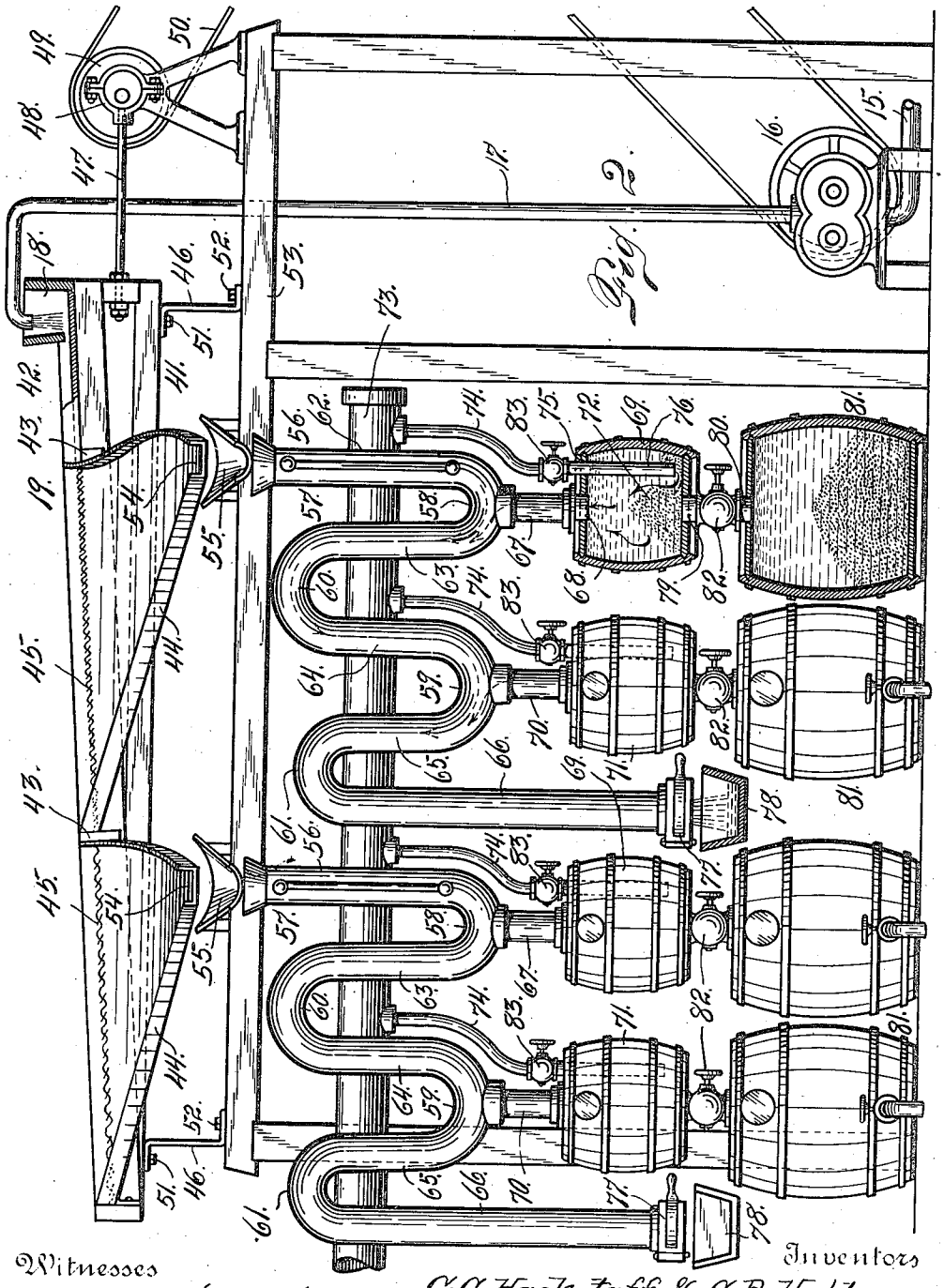
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UNITED STATES PATENT OFFICE.

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ORE CLASSIFYING AND SEPARATING PROCESS.

1,219,408. Specification of Letters Patent. Patented Mar. 13, 1917.

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To all whom it may concern:

Be it known that we, GEORGE C. HACKSTAFF and GEORGE B. HOLDEN, citizens of the United States, residing in the city and county of Denver and State of Colorado, have invented certain new and useful Improvements in Ore Classifying and Separating Processes; and we do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the characters of reference marked thereon, which form a part of this specification.

Our invention relates to a process of separating the metallic values from ores; it is also equally well adapted to the separation of other materials where foreign matter is mingled with the valuable product. An important feature of our process consists in combining mechanical and hydraulic classification prior to the performance of the separating step proper. Our improved process involves the introduction of the crushed ore to a pulverizer which reduces or comminutes the material to the desired degree, and employing an upwardly directed current of water of sufficient strength to carry all of the material of a predetermined maximum grade and smaller, over the top of the mortar or receptacle in which the pulverizing operation is effected. In other words, the mesh to which the material is pulverized before it leaves this mortar in response to the upward traveling current of the water, is determined by the strength of the current and by the height of the wall of the mortar. The higher the wall, the finer must be the pulverized material before it overflows this wall. If it is desired to discharge the pulverized material when in a coarser condition, it is only necessary to reduce the height of the wall. The wall of the mortar may be made in sections, which are readily removable and replaceable, and by virtue of this construction and arrangement, the degree to which the material is reduced or comminuted, may be regulated, as may be desired, and as circumstances may dictate. This pulverized material which, when it leaves the mortar, is of varying fineness, from a maximum to a minimum within a considerable range, is delivered to a mechanical classifier which consists of a series of pockets or chambers which are equipped or provided at their tops with screens of varying mesh, the finer mesh being uppermost or near the head of the metallic classifier and downwardly inclined from the head or the extremity where the material taken from the pulverizer is delivered thereto. There may be any desired number of these pockets and consequently, any desired number of sizes or meshes of screen for determining the different grades of material, classified according to size. These various sizes or meshes of material are taken from their respective pockets and delivered to an apparatus in which an upwardly directed current of water is employed for the purpose of hydraulic separation. The strength or pressure of this upwardly directed current may be regulated as desired and according to the material under treatment. In this final step of the operation, the strength of the upwardly directed current of water is so regulated that while it allows the metallic values which are of greater specific gravity to fall downwardly into a receptacle for the purpose, the lighter values are carried upwardly with the gangue and are afterward carried downwardly and brought into the path of another upwardly directed current, whereby a second separating act takes place. During this second operation, another grade of concentrates is caught in the receptacle beneath, while the lighter material is carried upwardly by the strength of the current of the water. Any number of these classifying and separating steps may be employed in connection with each grade of material as it is taken from the mechanical classifier. In other words, there may be any desired number of grades of material produced by the mechanical classifier, depending upon the number of sizes of screens and the corresponding number of pockets employed for receiving the material which passes through these screens; and each grade taken from its pocket may be further treated hydraulically for classifying and separating purposes to any extent desired, that is to say, whereby a number of different grades of concentrates may be obtained before the gangue is finally discharged into a trough which carries it to the desired location.

Having briefly outlined our improvement, together with the general construction of the

mechanism employed in carrying out the process, we will proceed to describe our invention more in detail, reference being made to the accompanying drawing, in which is illustrated an embodiment thereof. In this drawing,—

Figure 1 is a section taken through a combined pulverizer and hydraulic classifier.

Fig. 2 is an elevation partly in section illustrating the mechanical classifying apparatus, together with the construction employed for finally separating the metallic values hydraulically and in any desired number of grades.

Referring now specifically to the construction disclosed, let the numeral 5 designate a suitable mortar which comprises an upright bowl or casing having a curved depression 6 in its bottom surrounding an upwardly extending central part 7. The wall of the mortar above the lowest section 8 may be composed of any desired number of sections 9 and 10, depending upon the desired height. Troughs 12 surrounding the wall of the mortar and arranged to catch the overflow of material at the various levels, are formed upon the sections. As shown in the drawing, one of these troughs is formed integral with the section 8 and another trough with the section 10, which, as shown in the drawing, is uppermost. In case it is desired to employ the troughs 12, the two sections 9 and 10 would be removed. The material is taken from these troughs through outlet nozzles 13 and may be carried downwardly through a hose pipe or conduit 14 and delivered to a pipe 15 which in turn, carries it to a pump 16 which may carry it upwardly through a conduit 17 and deliver it to the head 18 of the mechanical classifier 19. Within the mortar 5 is located a rotary pulverizing member 20, which, as shown in the drawing, is largest at its lower end and tapers gradually toward the top. The lower portion of this pulverizing member is provided with a removable wearing plate 21 which may be composed of any suitable relatively hard material, and which may be readily removed when worn, without discarding the body of the pulverizing member. The upper part 24 of this member is connected with a depending shaft 22, by means of a key 23. The upper extremity of this shaft 22 is connected with a crank 25 of a shaft 26 whose upper extremity is connected with a gear 27 meshing with a pinion 28 fast on an operating shaft 29 journaled, as shown at 30, on the upper member 31 of an upright stationary frame work 32. During the operation of the shaft 22, the pulverizing member is rotated and oscillated. In other words, a sort of gyratory movement is imparted to the pulverizing member, which facilitates the performance of the required function. The upper portion of this pulverizing member is equipped with a hopper 33 which surrounds the member 24 and into which the crushed material 34 is fed. Leading downwardly from this hopper, is a passage 35 formed in the pulverizing member, the lower extremity of this passage being open, whereby the crushed material is delivered to the central part at the bottom of the mortar. Hence, this crushed material in the first instance, comes in contact with the raised central part 7 of the bottom of mortar, and is carried outwardly and downwardly therefrom, and finally passes to the lowermost part 6 of the bottom of the mortar, where it is advantageously acted upon by the pulverizing member during the rotation of the latter. The water employed in the classifying operation is taken as illustrated in the drawing, from a tank 36 through the medium of a supply pipe 37, provided with a controlling valve 84, and carried to a circular recess 38 formed in the bottom of the mortar below the wearing shoe 39. From this recess, relatively small ducts 40 lead upwardly and communicate with the bottom portion 6 of mortar. The water delivered to the mortar in this manner acts upon the pulverized material to carry the same upwardly around the pulverizing member, and cause it to overflow into one of the troughs 12, when it has reached the desired degree of pulverization. The higher the wall of the mortar before the overflow takes place, the finer will be the mesh to which the material is reduced which overflows in this manner. Hence, as heretofore indicated, by increasing or diminishing the height of the wall of the mortar by the employment of a greater or less number of sections 9 and 10, the fineness to which the material is reduced before it leaves the mortar, may be accurately regulated.

After this pulverized material overflows into the troughs 12, it is carried through the medium of the conduits 14 and 15, the centrifugal pump 16 and the conduit 17, to the head 18 of the mechanical classifier 19, as heretofore explained. This classifier is composed of a reciprocable frame work 41, which is provided with an upper portion 42, having openings 43 respectively communicating with pockets 44 leading downwardly. These pockets are covered by a layer of mesh material 45. The reciprocable structure is mounted on spring members 46 and is suitably inclined downwardly from the head or right hand extremity of the apparatus (see Fig. 2). As shown in the drawings, only two pockets and a corresponding number of screens 45 are employed; but it must be understood that any desired number of these pockets may be used, depending upon the number of different grades into which it is desired to separate the material. The reciprocating or vibratory

movement is imparted to the structure 41 through the medium of a pitman 47 connected with the strap 48 of an eccentric 49 which may be operated from a motor of any desired kind, through the medium of a belt 50 or other suitable connection. The spring members 46 are secured at their upper and lower extremities as shown at 51 and 52, to the mechanical classifier and the stationary frame work 53, respectively. The bottoms of the pockets 44 are inclined toward mouths or discharge openings 54 through which the material passes into chutes 55, by which it is delivered to a depending member 56 of a vertically disposed serpentine conduit 57 provided with a number of lower bends 58 and 59, and a number of top bends 60 and 61, said bends connecting vertically disposed parallel portions of the conduits 57. For instance, the lower bend 58 connects parallel portions 62 and 63 of the conduit, while the top bend 60 connects the parallel portions 63 and 64, the lower bend 59 connects portions 64 and 65, while the bend 61 forms the connection between the member 65 and a relatively long depending leg member or portion 66 of the conduit. The lower bend 58 of this conduit is in communication with the relatively short depending outlet pipe 67, whose lower extremity communicates through an opening 68 with a receptacle 69; while the bend 59 communicates through a similar pipe 70 with a similar receptacle 71. During the operation of the apparatus in carrying out the process, the concentrates or values 72 are caught in the receptacles 69 and 71. As shown in the drawing, each mechanically classified grade of material is subjected to two hydraulic operations, whereby the values which are of greater specific gravity, have two opportunities for settling in the concentrate receptacles 69 and 71. It must be understood, however, that a greater number of classifying acts may be employed in connection with each mechanically graded portion of the material in case it is found necessary, in order to completely separate the values from the gangue.

Each receptacle 69 receives a supply of water from a main conduit 73 through the medium of a depending pipe 74, which passes through an opening 75 formed in the top of the receptacle 69 or 71, as the case may be. This pipe 74 has a part 76 which extends downwardly within the receptacle, its lower open extremity being located near the bottom of the receptacle, whereby the upwardly directed current begins at the bottom of the receptacle and extends upwardly through the pipe member 67 and meets the material from the mechanical classifier as the latter leaves the bend 58 through the depending portion 62 of the conduit 57. This current of water is of sufficient strength to carry the gangue and some of the lighter particles of metal upwardly through the portion 63 of the serpentine conduit and through the top bend 60, whence it passes downwardly through the portion 64 of this conduit, and is again subjected to the action of an upwardly directed current of water from the conduit 71. This current acts to separate the gangue from the remaining metallic values which settle in the receptacle 71, the gangue being carried upwardly through the conduit member 65, through the top bend 61 and passes thence downwardly through the discharge portion 66 of the conduit. The lower or discharge end of this relatively long leg portion 66 is provided with a valve 77 which controls or regulates the discharge of gangue or other material into the trough 78. This valve is a very important feature as an element of the apparatus, since by virtue of the fact that the portion 66 of the conduit forms the long leg of a siphon, the travel of the material through each serpentine member is advantageously regulated. For instance, if this valve is adjusted to allow the material to escape relatively slowly, the passage of the material through the upper serpentine portion of the conduit will be retarded and the greater will be the tendency of the metallic values of concentrates to settle within the receptacles employed to receive them. Again, if the material is of such character that it may be treated with greater rapidity, the valve may be opened wider, whereby a relatively large quantity of material is allowed to escape within a given time. This will produce a suction or vacuum pull upon the material within the serpentine member of the conduit, and cause the same to travel therethrough at a relatively high speed. From this, it will be understood that by the careful adjustment of this valve, the operation of the separating mechanism may be perfectly regulated and controlled, whereby it is adapted for use in handling a great variety of materials.

Each of the receptacles 69 and 71 is in communication by way of a bottom opening 79, and a valve-controlled passage 80, with a relatively large receptacle 81 arranged directly below the receptacle 69 or 70, as the case may be. The concentrates which accumulate within the upper receptacles may be drawn therefrom into the respective large lower receptacles where they may be stored until the latter receptacles are filled or contain a sufficient quantity of concentrates to justify their removal. During the removal of the receptacles 81, the valves 82 must be closed until the storage receptacles are returned to their normal position.

As the apparatus for handling each grade of material taken from the mechanical classifier is precisely the same, the description

heretofore given of the apparatus connected with the uppermost pocket 44 of the mechanical classifier will be sufficient for the other similar constructions connected with the other pockets for handling the various grades of mechanically classified material.

Each of the pipes 74 is provided with a valve 83 located just above the top of the receptacle 69 or 71, as the case may be. The discharge of water from the pipe 73 into these various receptacles 69 and 71 may be controlled through the instrumentality of these valves. As the metallic values to be caught in the first receptacle 69 are relatively heavy, the strength of the upwardly directed pressure of water from the receptacle 69 may be relatively great; while the strength of the current which passes upwardly from the receptacle 71 may be less in degree, as a lighter grade of concentrates must be caught in the receptacle 71. By the employment of these valves, the strength of the upward pressure of water from any receptacle may be regulated as may be desired, and in strict accordance with the requirements and depending upon the material under treatment.

From the foregoing description, the manner of using the invention, as well as the various operations or steps necessary in practising our process, will be readily understood.

The current of water resulting from the pressure in the tank 36 passes upwardly within the mortar 5 and carries the material which has been pulverized to the desired degree, over the upper edge of the wall of the mortar and into a circular trough 12, whence the material passes through a conduit 14 to a centrifugal pump 16 which carries it upwardly through the pipe 17 to the mechanical classifier 19, as heretofore described. In the mortar 5, the material is pulverized, the mesh to which it is reduced being determined according to the height of the wall of the mortar, and the pressure of the upwardly rising current of water due to the head resulting from the elevation of the tank 36. This pulverized or comminuted material containing various grades, from a maximum to a minimum within a relatively wide range, is carried first through the conduits 14 and 15 to the centrifugal pump 16, and afterward through the pipe 17 to the mechanical classifier 19. In this last named structure, the material is classified according to the size, the upper screen member 45 being of the finest mesh, while the other screens diminish in mesh downwardly to the foot or lower extremity of the apparatus. For instance, the uppermost screen 45 may be what is known as 80 mesh, that is to say, having 80 perforations to the square inch; while the next screen below may be 40 mesh, and so on, downwardly. By virtue of this arrangement, the finest grade of material, mechanically speaking, is caught in the uppermost pocket, while the next grade is caught in the second pocket, and so on, downwardly. The coarsest grade of material is caught in the lowest pocket of the mechanical classifier.

The mechanical classification of material is regulated and controlled to an important extent by the varying force of the water passing through the apparatus, the same being regulated and controlled by the valve 77, as heretofore explained. For the same reason that this valve performs an important function in the hydraulic separation of the material, after it leaves the mechanical classifier, it has an important effect upon mechanical classification, since the speed of travel of the water through the entire apparatus may be varied at will through the medium of said valve.

Each of these grades is afterward hydraulically separated through the instrumentality of the upwardly directed current of water which travels through the serpentine conduit 57, which, as heretofore stated, may be of such structure as to form any desired number of products of the material. During this hydraulic treatment of the grades taken from the mechanical classifier, the separation of the concentrates or metallic values from the gangue is accomplished, the heavier grades of concentrates being caught in the first receptacle, or that farthest to the right (see Fig. 2), the next grade in the second receptacle, and so on, as many different grades of concentrates being obtained as may be desired in order to properly separate the metallic values from the gangue.

While the process has heretofore been described as applied to the separation of metallic values from their ores, it must be understood that it is not limited to such use, but is equally adapted for treating material of any kind where a separation by virtue of difference in specific gravity is required. For instance, it may be employed in the separation of pulverized coal from slate, rock or other impurities which it may contain when taken from the mine, coal of this character being employed in the manufacture of briquets or for use in furnaces, being delivered through the agency of a fan blower. The process may also be used in many other relations where the separation required is by virtue of the above principle.

Our process is not limited to the use of water pressure as heretofore described, since other liquids, as oil, or other fluids, as air or gas, may be employed, and a similar result obtained. From this, it will be understood that while we have in this specification, described the preferred manner of carrying out the process, namely, by the hydraulic

classification, mechanical classification by the use of water, and hydraulic separation, it must be understood that the invention is not limited thereto, though the use of water is undoubtedly preferable, if not absolutely necessary, in the treatment of ores for the separation of their metallic values from the gangue.

Having thus described our invention, what we claim is,—

1. The herein described process consisting first in hydraulically classifying pulverized material according to the weight of its particles and regardless of size and specific gravity; second, mechanically classifying the product thus formed, according to size and regardless of specific gravity; and finally hydraulically separating each sized grade according to its specific gravity only.

2. The herein described process consisting in subjecting pulverized material to an upwardly directed current of water regulated to carry over all material of a predetermined maximum weight; classifying the said product to form grades of varying size; and finally separating the particles of each grade according to specific gravity.

3. The herein described process consisting first in treating pulverized material in the form of pulp to segregate all of the particles of a predetermined maximum weight; second classifying this material to form grades varying in size, and finally separating the particles of each grade according to specific gravity.

4. The herein described process consisting in subjecting pulverized material, during the pulverizing operation, to an upwardly directed current of water under atmospheric pressure, whereby the particles are sized and caused to overflow entirely by said current, subjecting said overflow to mechanical classification and finally subjecting each mechanically determined grade to an upwardly directed current of water for separating purposes, the first and last named operations taking place entirely under water.

5. The herein described process consisting in pulverizing the material, subjecting the latter during pulverization to an upwardly directed current of water under pressure, whereby the material is sized and caused to overflow entirely by said current, subjecting the overflow material to mechanical classification, and subjecting each grade of the mechanically classified material to hydraulic separation.

6. The herein described process consisting in subjecting pulverized material during the pulverizing operation, to an upwardly delivered current of water, whereby the material is sized and caused to overflow entirely by said current of water, subjecting the overflow material to classification, whereby a number of different grades are formed varying in size, and finally subjecting each grade resulting from the last named classification to an upwardly directed current of water, whereby a separation is formed by virtue of the difference in specific gravity of the particles under treatment.

7. The herein described process consisting in subjecting pulverized material during pulverization to an upwardly directed current of water, whereby pulverized particles are sized and caused to overflow entirely by the current of water, subjecting said overflow material to mechanical classification, whereby a number of different grades varying in size is produced, and finally, subjecting each grade to upwardly directed currents of water, whereby the material treated is separated into a predetermined number of grades varying in specific gravity, substantially as described.

8. The herein described process, consisting in subjecting material during the pulverizing operation, to upwardly directed fluid pressure, whereby a portion of the material is separated from the remaining portion entirely by the fluid pressure, subjecting said separated portion or overflow to mechanical classification, and finally subjecting each mechanically determined grade to upwardly directed fluid pressure for separating purposes.

9. The herein described process consisting in subjecting pulverized material during pulverization, to upwardly directed fluid pressure, whereby the pulverized particles are sized and caused to overflow entirely by fluid pressure, subjecting said overflow material to mechanical classification, whereby a number of different grades varying in size, is produced, and finally subjecting each grade to upwardly directed fluid pressure, whereby the material treated is separated into a predetermined number of grades varying in specific gravity, substantially as described.

In testimony whereof we affix our signatures in presence of two witnesses.

GEORGE C. HACKSTAFF.
GEORGE B. HOLDEN.

Witnesses:
A. J. O'BRIEN,
A. EBERT O'BRIEN.