(No Model.)

C. M. BALL & S. NORTON.

PROCESS OF AND APPARATUS FOR SEPARATING ORES MAGNETICALLY.

No. 449,726. Patented Apr. 7, 1891.

Fig. 1.

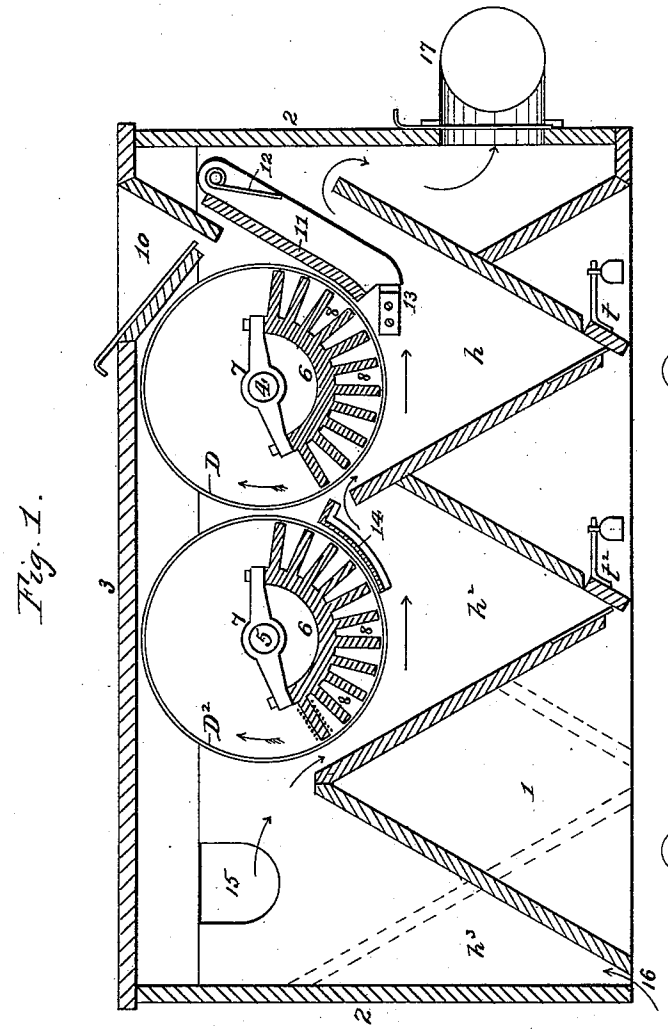


Fig. 3.

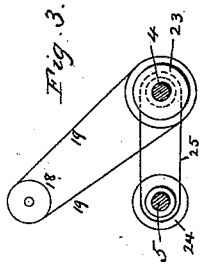


Fig. 2.

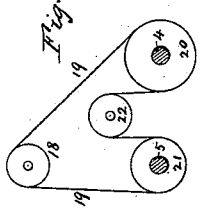
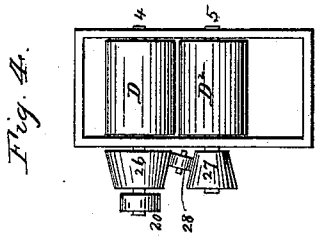


Fig. 4.



WITNESSES

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CLINTON M. BALL, OF TROY, NEW YORK, AND SHELDON NORTON, OF HOKENDAUQUA, PENNSYLVANIA.

PROCESS OF AND APPARATUS FOR SEPARATING ORES MAGNETICALLY.

SPECIFICATION forming part of Letters Patent No. 449,726, dated April 7, 1891.

Application filed June 30, 1890. Serial No. 357,206. (No model.)

To all whom it may concern:

Be it known that we, CLINTON M. BALL, of Troy, county of Rensselaer, and State of New York, and SHELDON NORTON, of Hokendauqua, county of Lehigh, and State of Pennsylvania, citizens of the United States, have invented certain new and useful Improvements in Processes of and Apparatus for Separating Ores Magnetically; and we do hereby 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.

This invention relates to a novel method or process and apparatus for separating iron or its crushed ore from the impurities with which such are generally found associated and for grading the separated products according to their character.

In United States Letters Patent No. 430,058, issued to us on June 10, 1890, we have shown and described a process and apparatus for separating iron or its crushed ore from impurities, in which the ore and gangue were passed through a magnetic field in such manner as to subject them to tangential inertia, and a deflector was interposed in the path of the ore, acting to separate the less magnetic from the more highly magnetic portions, and during such process the material was to be subjected to the action of a current of air opposite in direction to that taken by the material under the centrifugal impulse. Such process has been found in practice to operate to great advantage. We have discovered, however, that by using two or more sets of apparatus in series relation and causing the tangential inertia of the second set of apparatus to be higher than that of the first a great refinement of the process is attained.

Our present invention accordingly consists in passing the crushed or granulated mass through a consecutive series of magnetic fields, while impressing on the mass degrees of tangential inertia differing in the successive fields of magnetic force.

Our invention further consists in subjecting the crushed or granulated mass to the foregoing action simultaneously with submitting it to the action of a current of air adapted to carry away the dust and fine particles of gangue from the ore before its emergence from the magnetic field.

The invention further consists in the specific steps of the process and in the apparatus employed to carry such process into effect, all substantially as hereinafter more fully described and claimed.

In the drawings which form part of this specification, Figure 1 is a longitudinal vertical section of a practical form of apparatus intended to carry our invention into effect. Figs. 2, 3, and 4 are diagrams illustrating several modes of producing the variable tangential inertia in the successive fields of magnetic force.

The form of apparatus which we prefer to employ in carrying our process into practical effect is as follows:

The apparatus is constructed in the form of a chest having the sides 1, ends 2, top 3, and the bottom constructed in the form of several hoppers h h^2 h^3. In the upper portion of this structure we place two revolving drums D D^2, respectively, which are fitted on the respective shafts 4 and 5, which latter may conveniently be made hollow, so as to give access to the interior of the drum, the shaft being laterally perforated inside the drums for conveniently introducing the electrical conductors.

The drums D are preferably made of non-magnetic material—such, for instance, as brass or copper—or, more preferably still, of an electrically non-conductive material, such as indurated fiber, hard rubber, &c. Inside of each of the drums and upon its shaft is suspended a cylindrical segment of iron 6, having the sleeve 7, which forms the point of suspension for the segment on the shaft. Radiating from the lower surface of the segments 6 are a number of magnets 8, which extend almost into contact with the inner surface of the drums. These radiating magnets are wound with insulated wire, and by preference are connected into the exciting-circuit in such way as to make the successive poles alternately N and S. The weight of the structure 6 7 8 is such that the drum may be rapidly rotated around the same and out of contact therewith without disturbing

the normal position of the magnetic structure.

While we have given preference to the alternating character of the poles of the magnetic system, we wish to state that this is not essential to the carrying out of the process herein described.

In the top of the structure we arrange a hopper 10 between the drum D and the adjacent end of the chest for the introduction of the ore and gangue. Below this we place an apron 11, inclined toward the surface of the drum D, and we prefer to suspend this apron on a suitable pivotal point and provide it with the spring 12, whose tendency is to press the apron toward the drum, actual contact being prevented by the stop 13. The purpose of such spring suspension is that when the lump of ore or other matter happens to be too large to pass through the opening which we desire to maintain between the apron and the surface of the drum the apron yields sufficiently to permit the lump to pass through without injury to the drum and at once resumes its normal position. The direction of rotation of the drum D is, as indicated by the arrow, in a direction away from the apron 11 on the under side of the drum. The hopper *h* rises up to a point near the drum D on the side opposite that occupied by the apron 11 to a point not quite reaching the farthest of the series of magnets inside the drum.

The drum D^2 is arranged in the same position with reference to hopper h^2 that the drum D occupies with reference to hopper *h*. A combined deflector and apron 14 is arranged in a position under drum D^2 similar to that occupied by apron 11 with reference to drum D, but slightly farther advanced in the direction of rotation. The deflecting-edge of the apron 14 is about on a radial line with the upper edge of the last magnet-core in the drum D. Hopper h^2 has its breast rising to a point slightly beyond the last magnet in the drum D^2. We prefer to place the apron 14 slightly closer to drum D^2 than apron 11 is to drum D, and the space between the upper end of the breast of hopper h^2 and the drum D^2 is wider than the similar space between hopper *h* and drum D. These drums are both driven in the same direction and both the hoppers *h* and h^2 are provided with the automatic weighted traps *t* and t^2, which are constructed and operated on the same principles as set forth in our said Letters Patent No. 430,058. The chest structure is provided with a suitable air-inlet 15, and the outlet 16 for the concentrated ore also serves as an inlet for air, the proportions of the opening 15 being preferably made so as also to compel an inward movement of air through the opening 16. At the opposite end of the chest we place the pipe 17, which is connected to an exhaust-fan or similar device for the purpose of enforcing a movement of air from the distant end of the structure through the spaces existing between the two hoppers and their respective drums, all intermediate points of the structure being practically closed to further this object.

The gearing may consist of a variety of devices, a simple form of which is illustrated in the diagram Fig. 2, in which 18 is the driving-pulley, 19 the belt, 20 and 21 the pulleys applied to the respective shafts 4 and 5, and 22 an idler suitably journaled. Pulley 21 is smaller than pulley 20, and the arrangement is obviously such that a given speed of the driving-pulley 18 will impart the desired speed to pulley 20, and therefore to drum D, while a greater speed is imparted to the pulley 21, and therefore to drum D^2.

The operation will be as follows: Assuming, for example, that the drum D is given a speed of two hundred revolutions per minute, the drum D^2 might to advantage be given a speed of three hundred per minute. Under these circumstances it is obvious that if the magnetic field be of substantially the same strength in the two drums the tangential inertia which will be impressed upon the mass of material clinging to the drums by the magnetic attraction will be considerably greater on drum D^2 compared with that of drum D. The ore and gangue to be separated are passed into the hopper 10 and dropped from that onto apron 11. The ore and gangue passing down the apron 11 are brought into close proximity to the surface of the drum, and when the first magnetic pole is reached a powerful magnetic attraction is set up for the particles of ore, causing the same to cling to the surface of the drum. As the mass moves forward with the drum, as soon as the lower edge of apron 11 has been passed, the tangential inertia, together with the force of gravity, come into play, and the unattracted particles of gangue are violently thrown off the drum down into the hopper *h*, while the remaining particles adhere to the drum as it moves to the left. This operation continues upon the mass of ore and gangue as rapidly as it falls from the hopper 10, and when the hopper *h* has a sufficient quantity in it to cause the weighted trap to operate the latter will yield, permitting the gangue to pass away through trap *t* in proportion as it is received in the hopper *h*. As the drum D moves onwardly the adhering magnetic ore, finally passing the last magnet of the series inside the drum D, reaches a position where the tangential inertia which has been impressed upon it overcomes the attractive force of the magnet, and the entire mass is thereupon thrown off. This obviously will occur at a point where the tangential movement thus imparted will throw the entire body of ore which has reached this point over against the surface of the other drum D^2 and within the inductive influence of the series of magnets inside such drum, the two magnetic systems being so shaped and located relatively as to accomplish this purpose. Some of the ore thus projected against the drum D^2 is immediately held there

by the magnetic attraction, and such ore as is not directly held by the internal magnetic field falls upon the apron 14 and is by it guided into closer proximity to the drum, so that the material will be well spread out and every particle brought within the active range of the magnetic system inside drum D^2. As the drum D^2 revolves the layer of ore passes away from the lower edge of apron 14. The portions which are not rich enough in iron to cling to the external surface of the drum in spite of the increased tangential inertia which has now been impressed upon them fall into the hopper h^2, and this hopper may be considered as delivering at the trap t^2 a good grade of separated ore, but not the best. The latter, on account of its high relative percentage of iron, still clings to the surface of drum D^2 so long as it is within the inductive influence of the magnets inside, and upon passing out of their influence to a degree sufficient to overcome the attraction the tangential inertia becomes active, and the entire mass, which is then adhering to the surface of the drum, is projected over the wall of hopper h^2 into hopper h^3, where it falls and emerges at the opening 16 at the bottom. During this operation the current of air which has been introduced through the system by means of the exhaust-fan produces a powerful current of air at the opening between hopper h^2 and the drum D^2, and also a powerful current of air between the upper front edge of hopper h and the drum D, as indicated by the curved arrows, and at the same time a substantially horizontal current is established across the hoppers, as indicated by the straight arrows. The effect of these currents of air is to thoroughly cleanse the material operated upon of all the fine non-magnetic dust, which can be carried away along with the air discharged by the fan to any desired point. The result is that the immediate vicinity of the apparatus is clean and free from dust.

In operating the machine it is sometimes desirable to change the relative speeds of the two drums, so as to correspond with the grade of ore which is under treatment, so that in case the drum D^2 should be found to be running either too fast or too slow relatively to drum D the speed may be adjusted to the proper requirements. We have shown one means of doing this in the diagram at Fig. 3, where 4 and 5 illustrate the shafts of the respective drums. Drum D is driven at a definite speed from the driving-pulley 18 by the belt 19. The two shafts are fitted with the reversed cone-pulleys 23 and 24, respectively, which are connected together by means of the belt 25. By shifting the position of the belt 25 axially the relative speeds of the two shafts 4 and 5 may be changed to any desired degree. Another method of gearing for the same purpose is illustrated in the plan view, Fig. 4, where the shafts 4 and 5 are fitted with the reversed cones 26 and 27, respectively, and a friction-wheel 28 is interposed between the two, the faces of the respective cones being parallel with each other. In this arrangement the motion of the cone 26 is communicated to the cone 27 by the friction of the wheel 28. Obviously, by moving the wheel in the direction of its axis the speed of the drum D^2 may be changed within wide limits with reference to the speed of the drum D.

We claim as our invention—

1. The process of separating iron or its crushed ore from impurities and concentrating it, consisting in passing the ore and gangue through consecutive magnetic fields and at the same time impressing upon it differing degrees of tangential inertia in the consecutive magnetic fields.

2. The process of separating iron or its crushed ore from impurities and concentrating it, consisting in passing the ore and gangue through consecutive magnetic fields and at the same time impressing upon it tangential inertia increasing in force in the successive fields.

3. The process of separating iron or its crushed ore from impurities and concentrating it, consisting in passing the ore and gangue through consecutive magnetic fields, each composed of a number of alternate poles, and at the same time impressing upon it tangential inertia of differing degrees in the consecutive magnetic fields.

4. The process of separating iron or its crushed ore from impurities and assorting the separated products, consisting in passing the granulated mass of ore and gangue through consecutive magnetic fields, impressing upon it tangential inertia differing in degree in the successive fields, and separately collecting the portions which fail to pass through the respective fields.

5. An ore-separator comprising two or more magnetic fields, two or more non-magnetic screens moving in said fields, means for imparting different rates of speed to the screens, and guideways for feeding the ore to the screens successively, whereby different degrees of trajectorial momentum are imparted to the ore, for the purpose set forth.

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

CLINTON M. BALL.
SHELDON NORTON.

Witnesses as to Clinton M. Ball:
A. G. GOLDTHWAIT,
M. L. DAVIS,
Witnesses as to Sheldon Norton:
A. M. GLICK,
D. W. MCFETRIDGE.