C. Q. PAYNE.

METHOD OF MAGNETICALLY SEPARATING ORES.

APPLICATION FILED MAR. 15, 1911.

994,871. Patented June 13, 1911.

2 SHEETS—SHEET 1.

Fig. 1.

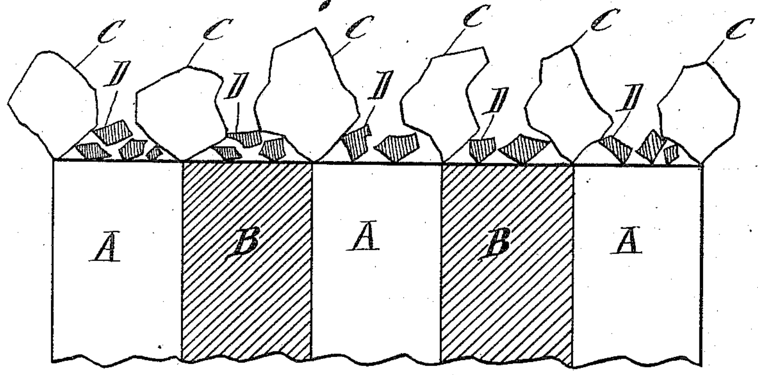


Fig. 2.

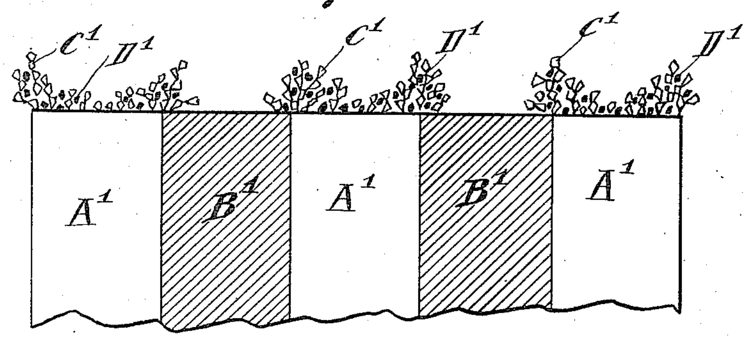


Fig. 3.

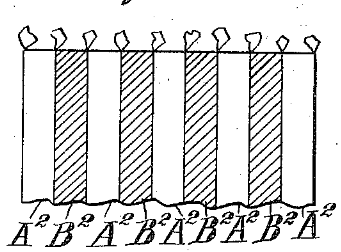
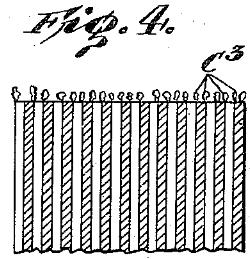


Fig. 4.



WITNESSES

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2 SHEETS—SHEET 2.

Fig. 6.

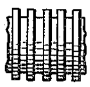


Fig. 5.

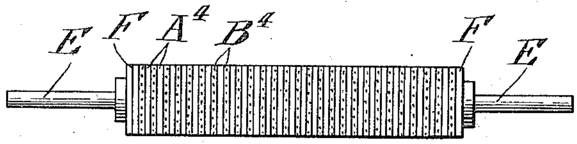


Fig. 7.

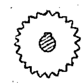
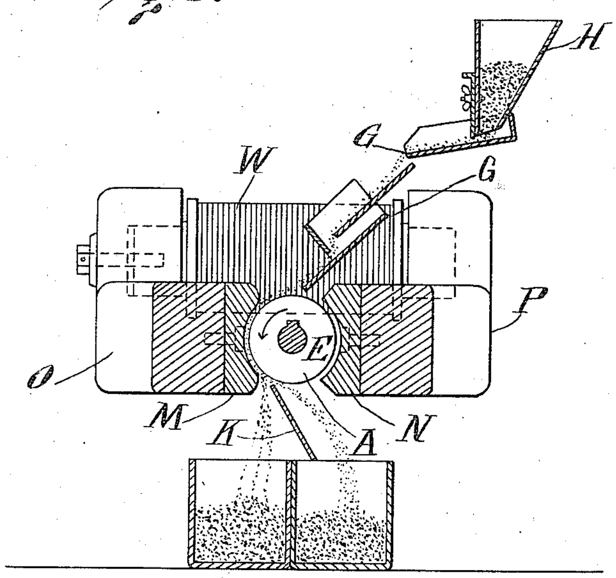


Fig. 8.



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METHOD OF MAGNETICALLY SEPARATING ORES.

994,871. Specification of Letters Patent. Patented June 13, 1911.

Application filed March 15, 1911. Serial No. 614,587.

To all whom it may concern:

Be it known that I, CLARENCE Q. PAYNE, a citizen of the United States of America, and residing in the borough of Manhattan, city, county, and State of New York, have invented certain new and useful Improvements in Methods of Magnetically Separating Ores, of which the following is a full and true description.

My invention relates to improvements in methods of separating substances of all degrees of magnetic susceptibility from one another or from non-magnetic substances with which they may be mixed.

It consists essentially in a method of overcoming mechanical interference or entanglement of the various particles of an ore mixture with each other while in a magnetic field, and whereby uniform conditions are provided for the attachment of the attracted particles.

I have found that mechanical entanglement is due to two principal causes, first, to the presence of particles differing greatly in size in an ore mixture, whereby the large particles when acted upon by magnetic attraction, wedge and hold the similar particles not so acted upon and prevent their free motion; and, secondly, to the unequal action of magnetic attraction, especially upon the smaller particles when they are afforded areal rather than lineal positions of attachment upon the separating surface.

I have succeeded in overcoming mechanical entanglement in a method of magnetically separating ores by dividing the ore mixture to be separated into groups by sizing it so that the particles in each group will be as nearly uniform in size as possible, and then treating each group independently upon a separating surface so formed that the particles acted upon by magnetic attraction are permitted lineal or independent positions instead of areal or massed positions of attachment, and will be free to respond to the forces of gravity and magnetic attraction to which they are subjected.

In my accompanying application, Serial No. 614,585, filed March 15, 1911, I have described and claimed a general method of separating ores which includes both a magnetic and an electrostatic method. I have also claimed in the said application the specific method of separation described therein as the electrostatic method. The claims of this application are limited to the modification of my general method described as the magnetic method.

I have previously sought, as shown in my Patent No, 791,494, dated June 6th, 1905, as well as in several other patents granted to me, to so control the positions of the lines of force in a magnetic field as to secure what may be called a "unipolar" field, *i. e.*, one in which the lines of force all pass in the same direction and do not reverse at any point. This I accomplish by causing the separation to take place in an air-gap of a magnetic circuit, between two opposing pole pieces. In this way a large amount of mechanical interference or entanglement of the particles undergoing separation is prevented, as compared with the use of a bipolar field in which loops or bridges of attracted particles are permitted to span the space between the adjacent poles, and thus surround and inclose a considerable amount of non-magnetic material. Notwithstanding the use of the unipolar field, a considerable amount of mechanical entanglement has heretofore still persisted. This mechanical entanglement it is the purpose of my invention to overcome, and at the same time to exert as uniform an effect as possible upon the attracted particles while they are undergoing separation.

In the drawing accompanying and forming a part of this specification, Figures 1, 2, 3 and 4 are detail views illustrating the principle of my invention, and show upon an enlarged scale sections of disks whose thickness bears a certain ratio or size relation to the diameter of the particles which they are respectively designed to act upon. Fig. 5 shows a separating cylinder made up of a series of magnetic and non-magnetic disks having smooth edge faces, placed alternately and mounted upon a shaft. Figs. 6 and 7 show disks having respectively projecting and toothed edges, and which may be employed in certain cases in place of disks having smooth edges. Fig. 8 shows a sectional view through a magnetic separator such as may be employed in carrying out my method of separation.

Referring in detail to these drawings to illustrate more clearly what is sought to be accomplished by my invention, I have shown in Fig. 1 in section upon a much enlarged scale a series of disks A A of soft iron or steel having smooth edge faces. These disks are alternately interleaved with a series of non-magnetic disks B B of the same diameter. If we convey upon these disk edges a series of particles which differ greatly in size such as C C and D D, and assume that the particles C C are magnetically permeable, and are therefore attracted and held to the edges of the disks A A when they are magnetized, while the particles D D do not so respond and are hence free to be removed by other forces, it is evident that in the positions in which the particles D D are placed, they are held or blocked by the irregular shape of the attracted particles C C, and their separation from the latter is thus prevented. This interference or mechanical entanglement of a certain percentage of one set of particles D D by another set C C, has the obvious disadvantage that the entangled particles D D are caused to pursue the same path of movement as the particles C C when they are finally released and discharged from their separating cylinder at the end of the field, instead of a diverse path of movement, thus causing a defective or inefficient separation. It is evident that if the smaller particles D D are removed from the larger ones C C by screening them out before the ore mixture is fed upon the separating cylinder A B their mechanical entanglement would be prevented. It is also evident that since the more highly charged edges of the disk faces largely determine the position of the attracted particles, the thickness of the disks should not be disproportionately great as compared with the diameter of the particles to be separated. For illustration if in Fig. 1 only particles of the size C C be treated upon the disks A B whose thickness bears to the diameter of the particles C C approximately the ratio 2:1, there will then be little or no mechanical entanglement between particles of such relative size while they are undergoing separation, and an efficient separation can then be made.

The ideal conditions for sized particles may be assumed to be realized when the thickness of the disks is just equal to the diameter of the particles to be separated. Each attracted particle then almost instantly finds a point of attachment when fed upon the cylinder made up of such disks, and the free distribution of the attracted particles upon the separating surface is thus aided. Such a size relation, however, is not feasible in practical work, and I have found that a ratio of the thickness of the disks to the diameter of the particles of 3:1, 4:1, or even somewhat greater, will give practical and efficient results, especially when the ore mixture is properly fed upon the separating cylinder.

In Fig. 2 is illustrated the effect of the disproportionate size relation between the thickness of a magnetized disk, and the diameter of the sized particles to be separated. Here the attracted particles C′ tend to form column-like attachments especially toward the edge of the disks where magnetic density is greatest, and considerable mechanical entanglement of the non-attracted particles D′ is thus caused among them. This can be largely prevented by using thinner disks for the small particles, as shown in Fig. 3 by A^2 A^2 and B^2 B^2, and by properly feeding the ore mixture upon the separating cylinder.

In Fig. 4 is illustrated an appropriate size relation in the case of still smaller ore particles C^3 C^3. I have found that the best results are obtained when thin disks are used for the separation of particles of small size, medium thick disks for medium size particles, and thick disks for coarser particles, in other words an approximately similar size relation should exist between the thickness of the disks and the average diameter of the particles of each group treated upon them respectively. The exact number of the group divisions into which an ore mixture should be subdivided, also the number of separating cylinders employed, and the precise ratio of the thickness of the disks of each cylinder to the average diameter of the particles of each group division will vary with the different ore mixtures, but it is evident that the sizing and disk variations may be carried to as great a degree of refinement as the value of a given ore and the resulting gain in efficiency will warrant.

In Fig. 5 I have shown a complete separating cylinder such as may be employed in carrying out my present invention. Here the separating surface consists of two series of disks mounted upon a shaft E, and held in place by means of compression flanges F F. One series A^4 A^4 is made of iron or soft steel, and the other series B^4 B^4 of a nonmagnetic material, such as fiber, etc. The disks have smooth edge faces and those of one series, are alternately interleaved with those of the other as shown in Fig. 5. In place of the interleaved nonmagnetic disks B^4 it is also possible to employ magnetizable disks A^4 alone, and to construct them with alternately projecting edges as shown in Fig. 6 or else to give their edges toothed outlines as shown in Fig. 7. The latter construction, especially when the disks are so assembled that the teeth are staggered or are out of alinement permits, in such cases where it is found desirable, a somewhat more intense localization of the magnetic attracting force than in the case of the interleaved disks with smooth edges. The latter, on the other hand, afford somewhat more uniform conditions under which the attracting force acts upon the magnetic particles of an ore mixture while being conveyed through the magnetic field.

It is obvious that the specific arrangements of disks shown in Figs. 5, 6 and 7 may be modified by those skilled in the art in practicing my invention without departing from the scope of my claims. It is essential, however, that the disks be so arranged as to secure magnetically exposed disk edges along the surface of the separating cylinder, in order that the attracted particles may be afforded as far as possible lineal positions of attachment while undergoing separation.

In Fig. 8 I have shown in sectional view a magnetic separator adapted for use in carrying out my invention. Here W represents the coil of an electromagnet which, when energized by an electric current, establishes a magnetic field betwen the pole pieces M N. The edges of the magnetizable disks which wholly or partly make up the armature-cylinder A then become charged with local condensations of magnetic lines of force when it is revolved through the field formed between the pole pieces M N. Those particles of the ore mixture fed upon the cylinder A from a convenient hopper H and guide plates G G, which are susceptible to magnetic attraction are held to the charged edges of the disks while they are being conveyed through the magnetic field, and are discharged from the cylinder at the end of the field in a different path of movement from those particles of the ore mixture which are not acted on by magnetic attraction, thus affecting a separation between them.

In carrying out my improved invention each ore mixture is first divided into several groups, preferably by screening it, so that the average diameter of the particles in each group differs respectively among themselves. These groups are then treated upon several separators of the type which I have shown in Fig. 8 and which differ among themselves in the thickness of the disks which are respectively used in the separating cylinders. The group containing the coarsest ore particles is then separated upon the cylinders containing the thickest disks, while the group containing the finest ore particles is treated upon the cylinder containing the thinnest disks. The greater the number of the groups into which an ore mixture is divided, and the more closely the thickness of the disks approximates to the size of the ore particles in each group the more perfectly can the mechanical entanglement of one set of particles with another set, during separation, be overcome, and the more perfect will the separation then become. While practical considerations based upon the value of a given ore and the expense involved in its treatment will necessarily modify the ideal conditions already referred to in connection with overcoming mechanical entanglement, it is evident that there must be at least two groups of particles into which an ore mixture must be divided, and that at least two separating cylinders must be employed having disks of different thicknesses in order to apply my method of separating to ore mixtures in accomplishing the purpose of my invention.

I am aware that the sizing of ore mixtures as a preliminary step to their treatment by various methods of separation is not uncommonly practiced, but it will be seen that the main feature of my invention consists in providing unobstructed positions of attachment for those particles in an ore mixture which are acted on by magnetic attraction, and as a further aid in thus overcoming mechanical entanglement, I have found that a preliminary sizing of the ore particles is of assistance.

I claim as my invention:

1. The method of magnetic ore separation which consists in dividing an ore mixture into a plurality of groups which differ respectively in the average diameter of their particles, and subjecting each of said groups independently to the magnetized edges of disks arranged in series, which disks vary in thickness with the average diameter of the particles acted on.

2. The method of magnetic ore separation which consists in dividing ore into a plurality of groups differing respectively in the average diameter of their particles, and subjecting each of said groups independently to the separating action of a series of magnetic charges spaced proportionately to the average diameter of the particles of the group treated, substantially as described.

3. The method of separating substances of all degrees of magnetic permeability from one another, or from non-magnetic substances with which they may be mixed, which consists in dividing such an ore mixture into a plurality of groups which differ respectively in the average diameter of their particles; feeding each group separately upon one of a plurality of cylinders each of which is provided with a series of magnetic and non-magnetic disks placed alternately which differ in their thickness, each series with respect to the others, acting upon each group by means of magnetic attraction as well as gravity and centrifugal force, and discharging two or more sets of separated particles from each cylinder along diverging paths of movement.

CLARENCE Q. PAYNE.

Witnesses:
WALTER S. JONES,
JOHN W. PETERS.