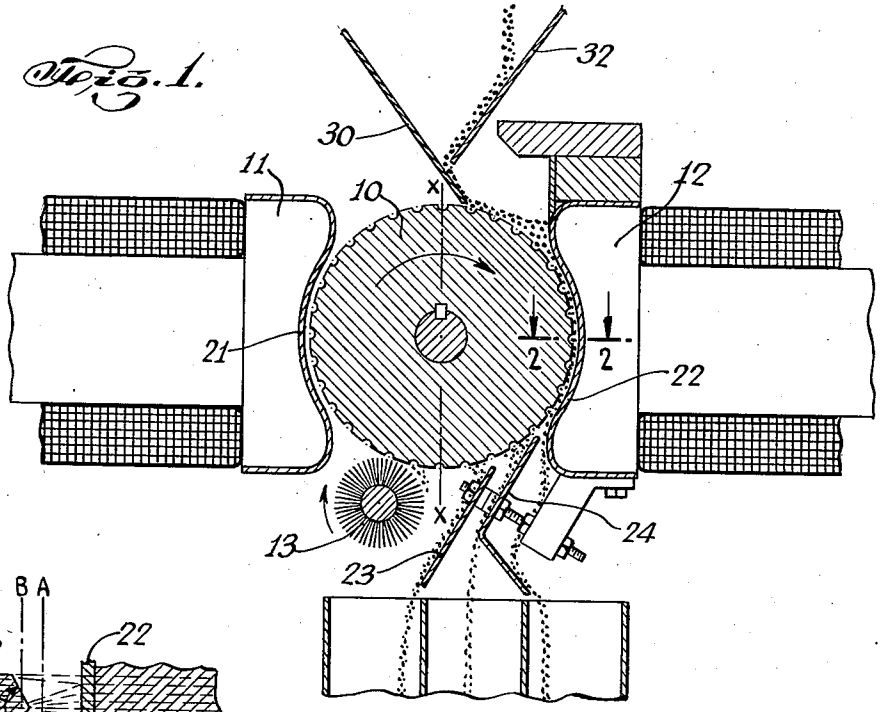
Jan. 30, 1940. C. Q. PAYNE 2,188,517

MAGNETIC SEPARATOR

Filed Nov. 22, 1938

Fig. 1.



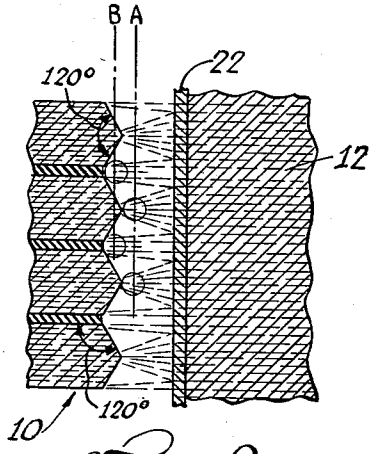
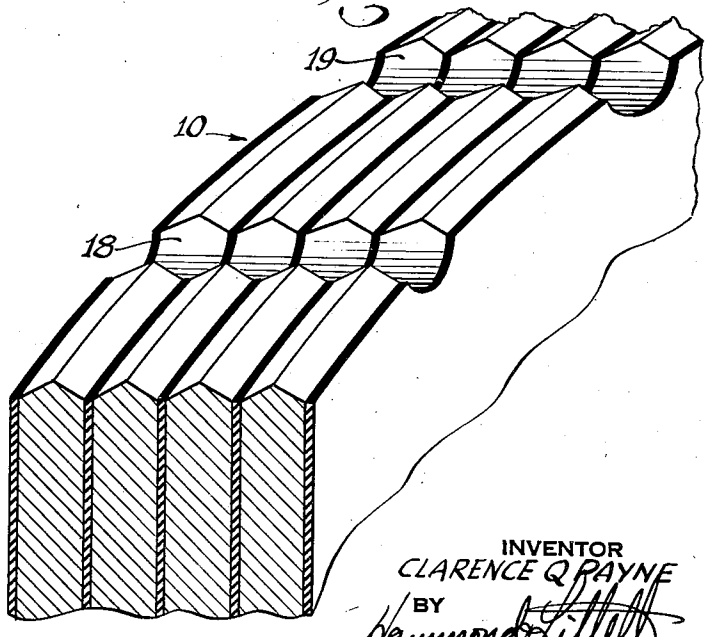


Fig. 2.

Fig. 3.



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MAGNETIC SEPARATOR

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Application November 22, 1938, Serial No. 241,720

4 Claims. (Cl. 209—219)

This invention relates to a new and improved method and apparatus for the magnetic separation of ores and minerals and is applicable to the separation of ores and minerals of all degrees of magnetic susceptibility.

Magnetic separators of this type utilize a direct current inductively magnetized disc-rotor which revolves between stationary pole pieces. In the prior constructions the magnetic discs of the rotor are normally interleaved with non-magnetic discs and all the disc edges are finished to provide a uniform cylindrical surface. Construction of this type provides two exposed edges to each magnetic disc. Since these edges present the only portions where there is any divergence of the lines of force, the flux density is increased at these edges and permits of the stronger attraction of the magnetic particles.

Rotors of magnetic separators of this type as well as others of the prior art are, however, not as efficient as they might be, as they are incapable of completely utilizing the full magnetic powers available when all the lines of force are directed to predetermined points on the periphery of the rotor. Rotors of this design partially control the direction of some of the lines of force by providing two exposed edges to every disc upon which the lines of force converge, but since the lines of force directed to the central surface portion between the exposed edges are practically all parallel, this portion of the disc does not exert any substantial attracting power upon feebly magnetic particles. These portions of the disc, therefore, represent "holes" or blank spaces in the field-gap of the separator which allow a certain percentage of the magnetic particles to escape without separation.

The object of my invention is to provide a magnetic rotor of such construction that it is possible to establish a complete control over the direction, or convergences of the lines of force within the magnetic field-gap and thereby more effectively make use of them.

Another object of my invention is to increase the active area of the magnetic rotors to a maximum.

A further object of my invention is to provide mechanical means for guiding the particles to be separated to those points on the rotor where the flux density, i. e., the magnetic attraction, is greatest.

A still further object of my invention is to increase the efficiency of the separator by eliminating the "holes" or blank spaces in the field-gap which permit a certain percentage of the particles to escape without separation.

Another object of my invention is to provide means on the magnetic rotor for effectively removing the magnetic particles from the magnetic field and preventing them from sliding back into the strongest part of the field as the rotor is carrying them into the weaker part.

I have found that it is possible to establish a complete control over the direction, or convergences of the lines of force within a magnetic field-gap by means of inclined surfaces therein. These cause a vast number of differences of magnetic density between the two sides of the field-gap and thus permit the number of points of attachment for the magnetic particles to be greatly increased, as well as their spacing in close relationship to the size of the particles. In this way "holes" or blank spaces along the attracting surface of the separator can be avoided and the efficiency of the separator greatly increased.

In the accompanying sheet of drawings, which illustrate one form of construction embodying features of my invention:

Figure 1 is a vertical cross-section through the operating portion of the apparatus which embodies the principles of the invention taken through the inductively magnetized disc-rotor and the opposing pole-pieces of an electromagnet.

Figure 2 is an enlarged sectional view through a part of the field-gap taken on the line 2—2 of Figure 1. It illustrates the wedge-shaped construction of the peripheries of the magnetic discs which are spaced closely together by means of thin non-magnetic discs. The broken lines in the field-gap indicate the positions of the reversed wedge-shaped lines of force which hold the attracted particles by differences of magnetic density along all three edges of each disc and at two levels.

Figure 3 is an enlarged perspective view of the circular wedge-shaped disc edges shown in Figure 2, with the addition of transverse grooves which cause point convergences at the disc intersections. These exert a very intense attracting force and assure the removal of magnetic particles even from the most strongly charged field-gap.

This invention is concerned with the type of magnetic separator which utilizes a direct current inductively-magnetized disc rotor 10 which revolves between stationary pole pieces 11 and 12 having arcuate shaped pole-faces. Its distinctive feature is the control which it exerts over the position or direction of the lines of force

throughout the field-gap. This is accomplished by giving the peripheries of the magnetic discs of the rotor a wedge-shaped contour. These discs are spaced quite closely together by means of very thin non-magnetic discs and the relative thicknesses of a preferred embodiment of my invention are indicated approximately by the sectional views illustrated in Figures 2 and 3. The central edge of each disc may be given a rather flat angle, preferably about 120°, so as to accumulate as much flux density as possible at the apex of each wedge. The apexes cause a wide double divergence of the lines of force and thus create great difference of density in the magnetic field-gap. This exerts great attracting and holding power upon the magnetic particles when brought in contact with them. By giving the central edge of each disc an angle of 120°, it is evident that its two side edges will also have interior angles of the same amount, viz: 120°. Each of these edges will individually also cause flux divergences of the lines of force and will attract magnetic particles to themselves, but not with quite the same degree of force individually, as the central edge, since the angle of their flux divergences available for attachment is less than in the case of the central edges. I have found, however, that when the magnetic discs are spaced quite closely together by means of non-magnetic discs having smooth cylindrical peripheries the adjoining lower side-edges of the former discs are able to act jointly and together attract and hold those magnetic particles large enough to span the gap between them and to rest on both of the adjoining charged edges. This is shown diagrammatically by means of spherical particles in Figure 2. Here, by greatly exaggerating the size of these magnetic particles and also the thickness of the wedge-shaped magnetic discs, while maintaining them in true relative proportions, it will be seen that not only the peak edges but also the valley edges of the discs can thus be made available for separation. This has the great advantage of giving the flux density in any unit of length of the field-gap a much greater efficiency than has heretofore been possible. The magnetic particles can thus be attracted and separated while occupying different levels on the separator surface, as shown by the arrows A, B in Figure 2.

As has been previously stated, it will be evident that if the peripheries of the discs are made cylindrically smooth, instead of wedge-shaped, and therefore parallel with the face of the pole-piece 12, then the lines of force in the field-gap will also be parallel except at the extreme edge of each disc where they diverge. The central portion of each disc edge will not therefore exert any substantial attracting force upon feebly magnetic particles. These positions thus represent "holes" or blank spaces in the field-gap of the separator which allow a certain percentage of the particles to escape without separation. On the other hand, by means of inclined or wedge-shaped edges on the disc rotor, all the lines of force in the field-gap are obliged to occupy divergent positions. This leaves no opportunity for the formation of "holes" or blank spaces in the field-gap along the surface of the disc-rotor and the instant a magnetic particle, fed upon the rotor, is carried into the field-gap it is seized and carried by one of the peak or two of the valley edges of the rotor discs as they revolve, until removed from the non-magnetic particles. The inclined surfaces of the wedge-shaped disc edges also assist mechanically in guiding the particles to their peak or valley edges where the magnetic particles are strongly held while undergoing separation. In this way, with a minimum number of passes through the magnetic field-gap, it is assured that one may obtain a complete separation of a great variety of ores and minerals from their associated non-magnetic particles. This greatly increases the economy of the separation.

A further important element in my invention consists in providing effective means for removing the magnetic particles from the magnetic field and discharging them from the disc-rotor. This, I find, can be accomplished by placing a series of shallow grooves along the circumference of the disc-rotor parallel with its axis. The position of these grooves is shown in Figure 1 and also in the enlarged perspective views at 18 and 19 in Figure 3. It will be evident that these transverse grooves form additional line and point convergences of the lines of force at each intersection with a magnetic disc. Without these transverse grooves, the continuous circular wedge-shaped projections on the edges of the discs would allow the magnetic particles attracted and held to their exposed edges to slide back into the narrowest part of the field-gap, which is also the strongest part of the field, as the rotor revolves. This would gradually choke up the field-gap and prevent any separating action. The transverse grooves, however, prevent any such reverse movement of the attached particles beyond the short distance between the grooves themselves. Since they cannot jump across the grooves, they are firmly held in place by the flux convergences at their points of contact until they are carried well out of the field, when they drop off. The necessity for these transverse grooves increases in the treatment of strongly magnetic material proportionately with its increase in magnetic susceptibility since it then becomes very active in an intense field.

In crushing and sizing ores in order to prepare them for separation, iron and steel particles are also frequently detached from the crushing surfaces and find their way into the feed stream. These, I find, should be further guarded against by covering the stationary pole faces 11, 12 with non-magnetic linings as shown at 21 and 22 in Figure 1. These linings may be preferably made of rubber on account of its resiliency and wear resistance. Highly magnetic particles like iron and steel are able by self-induction to develop highly condensed convergences of the magnetic flux at their point of contact, even in a field of uniform density. Such particles, once attached, are difficult to remove. The best remedy, therefore, is to protect the pole-faces by means of a non-magnetic lining.

In operating the separator embodying my invention as shown in Figure 1, the finely crushed ore flows along the inclined guide plate 30 of the hopper 32 onto the charged rotor 10 which revolves in the direction shown by the arrow in Figure 1. As the ore particles are passing through the field-gap between the pole piece 12 and the rotor, the magnetic particles are selectively separated from the non-magnetic and held to the rotor at two levels, as indicated by the arrows at A and B, constituting the peaks and valleys of the rotor surface until the polarity of the field reverses. This reversal in charge takes place as the rotor passes the X—X axis. In carrying out the actual operation, I find that it is advisable to make a three-part separation

even in treating finely crushed ore. This enables a middling or partly magnetic product to be obtained from the single rotor in addition to a strongly magnetic and a non-magnetic product. For this purpose, two division plates 23, 24 are provided along the lower portion of the disc-rotor, whose distance apart can be regulated. This enables the amount of the intermediate, or middlings product, which falls in the space between the plates as the attracting force beyond the field-gap gradually diminishes, to be determined. The middlings product can then be crushed still finer for a complete unlocking of its contained mineral and then reseparated. In this way, it is possible to secure an efficient recovery of the mineral while beginning the separation at a fairly granular size, which is also of advantage in separating it. When carried beyond the neutral axis X—X of the rotor, all the magnetic particles are discharged since the polarity of the field here reverses. But to insure the removal of any permanently magnetic particles, especially minute pieces of steel, etc., a rotary brush 13 is provided which revolves in the direction shown by the arrow. This prevents such particles from being carried completely around the rotor. The latter is thus able to present clean disc edges to the descending feed stream on its other side.

The foregoing description is illustrative merely and is not intended to define the exact angles of the wedge-shaped disc edges nor the limits of the invention generally. Various other embodiments of the principles of the invention may be developed without departing from the spirit of the invention as defined in the following claims.

I claim:

1. In a magnetic separator, an inductively magnetized disc-rotor and an arcuate pole piece having an air gap therebetween in which each of the magnetic discs of said rotor has an annular wedge-shaped projection which forms an angle of one hundred and twenty degrees, in combination with a series of grooves which transversely intersect said discs and which cause six point convergences of the lines of force at each of said disc-intersections.

2. In a magnetic separator an inductively magnetized disc-rotor composed of magnetic discs whose edges form annular wedges, the three adjacent interior angles, formed by surfaces of adjacent disks, being substantially equal each to each, said discs being spaced closely together by means of thin interleaved non-magnetic discs having smooth cylindrical edges and thereby enabling the adjoining edges of the magnetic discs to act jointly in attracting and holding those magnetic particles which span the intervening space and rest upon said adjoining edges, in combination with a series of transverse groove-intersections placed parallel with the rotor axis upon the outer surface of said disc-rotor.

3. In a magnetic separator the combination with an opposed pole electro-magnet of a rotor armature mounted between the pole faces of said electro-magnet, the surface of said armature comprising a series of annular circumferential alternate magnetic and non-magnetic areas in which the magnetic areas are of a wedge-shaped contour, the three adjacent interior angles, formed by surfaces of adjacent disks, being substantially equal each to each and the non-magnetic areas are of a smooth cylindrical contour and so thin that the adjoining edges of the magnetic discs act jointly in attracting and holding these magnetic particles which span the intervening space and rest upon said edges.

4. In a magnetic separator an inductively magnetized disc-rotor composed of alternate magnetic and non-magnetic discs, and an arcuate pole piece with an air-gap therebetween, in combination with means for securing a divergent arrangement of all the magnetic lines within said air-gap comprising an annular wedge on each magnetic disc edge so shaped that the peak edge and also the valley edges of said discs form angles of 120 degrees with each other, the latter being so disposed that they become jointly available for attracting and separating magnetic particles.

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