Jan. 30, 1940. C. Q. PAYNE 2,188,516

APPARATUS FOR MAGNETIC SEPARATION

Filed Jan. 10, 1938

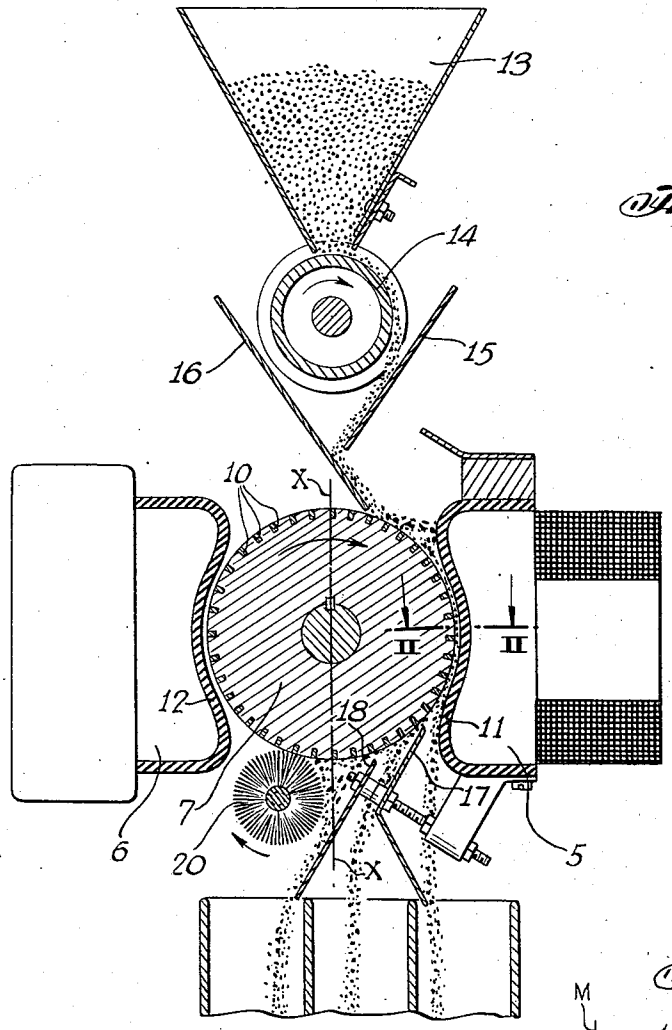


Fig. 1.

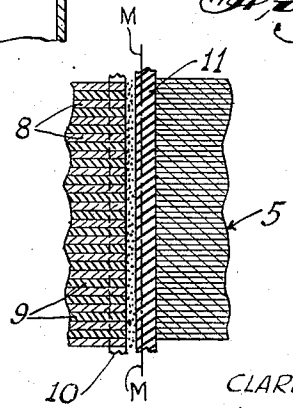


Fig. 2.

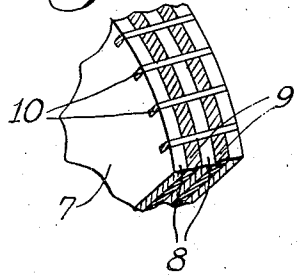


Fig. 3.

INVENTOR
CLARENCE Q PAYNE
BY
Raymond & Gillett
ATTORNEYS

Patented Jan. 30, 1940 2,188,516

UNITED STATES PATENT OFFICE

2,188,516

APPARATUS FOR MAGNETIC SEPARATION

Clarence Q. Payne, Stamford, Conn.

Application January 10, 1938, Serial No. 184,146

2 Claims. (Cl. 209—219)

This invention relates to the separation of finely divided ores and minerals containing strongly magnetic, partly magnetic and nonmagnetic particles. It utilizes centrifugal force, instead of gravity as the predominant means of separation. While the principle of the invention may be applied both to the wet and dry separation of such ores and minerals it is especially adapted to their dry separation at high speed with resulting greater capacity and economy of treatment.

While the force of magnetic attraction can be varied within wide limits by simply increasing the flux density of the magnetic field in which the separation takes place, the force of gravity is limited to the weight of the individual particles. This cannot be increased. As particles become smaller in size, other disturbing forces, such as adhesion, friction, and absorbed moisture interfere more and more with the free action of the force of gravity. With extremely small sized particles, such for example as pass a 100 mesh screen, these disturbing forces cause "clotting" and entanglement between the magnetic and nonmagnetic particles of the feed-stream. This reduces the freedom of the independent motion of the individual particles and separation by gravity alone is inefficient.

An important object, therefore, is to provide a magnetic separator in which centrifugal force rather than gravity is the main force used to act upon the nonmagnetic particles in removing them from the magnetic particles in effecting their separation and to act on the feed stream with enough centrifugal force to subdivide it into a fine spray. This enables the particles to be acted on individually by strong separating and also strong attracting forces while they pass through a restricted magnetic field-gap.

In the accompanying sheet of drawing which forms part of this description:

Figure 1 is a vertical cross sectional view of an apparatus embodying the principles of the invention taken through the disc-rotor and the opposing pole-pieces of an electromagnet, showing also a feed-roller and hopper placed above the rotor;

Figure 2 is an enlarged sectional view through a part of the field-gap taken on the line II—II of Figure 1; and

Figure 3 is a detail perspective view showing a construction of the rotor.

The ore is prepared for separation by crushing as fine as its mineralization may require to substantially unlock the separate minerals from each other. By thus crushing strongly magnetic ores comparatively fine so that the proportion of their middling particles is relatively small, employing a centrifugal force which may amount to five or ten times the gravitational force, and then spraying them in a thin stream against a nonmagnetic lining in the field it is possible to practically overcome all clotting or entanglement of the particles while undergoing separation. The enrichment of the magnetic concentrates is thereby carried so close to their chemical purity that they may be at once reduced to refined metal without the necessity of an intermediate process of furnace treatment to slag out any remaining impurities from their gangue minerals.

Two opposed stationary pole-pieces 5, 6 of a bipolar electromagnet together with an inductively magnetized laminated disc-rotor 7 which revolves in a constant and non-reversing magnetic field between the pole-pieces form part of the flux-circuit generated by the electromagnet. The pole-piece opposite which the rotor-surface moves downwardly forms with it a main or concentric field-gap in which the magnetic density is uniform. The concentric field gap of uniform width is relatively long, about 60° of arc, as shown in the drawing to give a considerable length of gap for the operation of separating strongly magnetic particles. Below this is a widening gap in which there is a diminishing magnetic density.

From a feed-hopper 13 and a feed-roller 14 above the rotor a regulated feed-stream is charged by means of guide plates 15 and 16 upon the rotor where the magnetic attraction is low. The high speed of the rotor then imparts enough centrifugal force to the feed-stream to subdivide it in a thin spray and drive the individual particles against the non-magnetic lining 11 of the pole-piece 5 from which they rebound and enter the upper part of the field-gap.

The principle involved will be quite clear if we consider the formula for centrifugal force exerted upon a particle fed with the feed stream upon the rotor. This formula is as follows:

$$F=\frac{Wv^2}{gr}$$

If the rotor is given a diameter of say six inches, and is made to revolve at a speed of 300 revolutions per minute, then the centrifugal force developed at its surface becomes F=7.65W, or 7.65 times the weight of each particle. If the speed of the rotor is increased to 350 revolutions,

the centrifugal force then becomes F=10.4W, and at 400 revolutions, it is F=13.6W.

By correspondingly increasing the attracting force it is thus possible to adjust two strongly opposing forces and to cause the practical elimination of the non-magnetic gangue particles from the magnetic concentrate. This is a result highly desired since a complete separation permits marked economies in the final metallization of the ore, which are not possible when the impurities must be removed by slagging them out.

Heretofore magnetic separation has been unable to make a practically complete separation owing either to insufficient crushing to unlock the separate minerals, or else to inability to overcome the effect of clotting and entanglement among very fine particles, which occurs when an ore has been crushed to completely unlock its separate minerals. By the method of this invention a strongly magnetic iron ore like magnetite, or roasted hematite, when properly crushed, can be enriched to a point where the non-magnetic residue in the concentrate does not exceed 1–1½%. Such an enrichment enables the concentrate to be reduced at once to sponge iron and then melted to steel in the open hearth or electric furnace. On the other hand magnetic concentrates such as heretofore produced contain usually 5–10% or more of "insoluble" or non-magnetic gangue minerals. Such an amount requires the concentrates to be smelted in a blast furnace, in order to slag out the gangue minerals by means of a limestone flux.

The invention therefore involves a difference in the relative intensity of the separating forces heretofore employed, which produces a new result. This result is a marked economy in the production of iron and steel.

The rotor armature may be constructed in the various ways, for example as shown in my United States Letters Patent No. 2,045,098 issued June 23, 1936. It may have a diameter of 5 or 6 inches in order to develop a strong centrifugal force at moderate speeds. The rotor is carried on a shaft and is truly cylindrical and balanced to run smoothly at high speed. The rotor shown is made up of interleaved magnetic and non-magnetic discs 8, 9 whose edges are provided with a series of longitudinal grooves which are filled with strips 10 of nonmagnetic material. The magnetic material at the surface is therefore in the form of a large number of insulated rectangular areas whose edges and corners are intensely magnetized as they pass through the magnetic field.

The opposed surfaces of the pole-pieces are covered with linings 11, 12 of nonmagnetic material, or preferably rubber on account of its resiliency, and resistance to wear from the impact of the particles of the material treated. The thickness may be from one-sixteenth to one-quarter of an inch or more. The lining occupies a space equal to or somewhat greater than half the width of the space at the narrow part between the surface of each pole-piece and that of the disc-rotor thereby restricting the field-gap as shown in Figure 2 of the drawing. The lining is extended upward above the narrow part of the field-gap where it serves as a nonmagnetic baffle against which the particles are driven by centrifugal force and any clots are broken up. As the particles descend through the field-gap they are thus kept out of contact with the pole-face.

The magnetic attraction of the magnetic particles binds them so strongly to the charged edges of the disc-rotor that they will not be detached by the centrifugal force but carried through the field-gap and over the edges of the division plates 17 and 18 at the outlet of the field-gap and discharged as they approach the neutral axis X—X of the rotor. The nonmagnetic particles on the other hand, descend through the field-gap under their impressed centrifugal force and are discharged at its outlet before they reach the first division plate thus effecting their separation from the magnetic particles.

While the finer an ore is crushed the greater is the degree of unlocking of its gangue, yet this is never complete even with ores crushed to pass 100 mesh screen or finer. It is, therefore, desirable to exert a sorting action upon the crushed ore in separating it so that a middlings or partly magnetic product is obtained in addition to the strongly magnetic and nonmagnetic products. Thus a richer final concentrate with greater efficiency of separation is possible than with only a two part separation. This three part separation into concentrate, middlings and tailings products is herein effected especially with strongly magnetic ores, with a single electromagnet and single rotor. By the use of the two division plates 17 and 18 whose distance apart can be regulated the amount of the intermediate product, or middlings, which falls in the space between the plates as the attracting force beyond the field-gap gradually diminishes, can be determined. The middlings product is then crushed finer and re-separated. The solid magnetic particles having the strongest holding power are carried farthest along by the disc-rotor until they approach the neutral axis of the rotor and pass beyond the second division plate. Here they are discharged since the polarity of the field reverses. To remove any permanently magnetic particles, such as minute pieces of steel, which may have introduced themselves into the feed-stream and will be carried past the neutral axis a revolving brush 20 is provided just beyond the neutral axis. This prevents such particles from accumulating on the rotor surface.

The foregoing particular description is illustrative merely and is not intended as defining the limits of the invention. Obviously modifications of the embodiment illustrated and various other embodiments of the principles of the invention may be developed without departing from the spirit of the invention, as defined in the appended clams.

I claim.

1. An apparatus for the separation of finely divided ores and minerals containing strongly magnetic, partly magnetic and nonmagnetic particles, which comprises an electromagnet, an inductively magnetized disc-rotor and a pole-piece spaced therefrom, in combination with a rubber lining of about one-half the width of the field-gap between the rotor and the pole-face, and means for driving a feed-stream of the particles from the rotor against the lining with a centrifugal force several times the gravitational force of the particles, and causing them to descend through the field-gap while keeping the particles out of contact with the pole-face.

2. In apparatus for the dry separation of finely divided ores and minerals containing strongly magnetic, partly magnetic and non-magnetic particles, which comprises an electromagnet, an inductively magnetized disc-rotor, an arcuate polepiece spaced concentrically around the rotor

for about 60° and a non-magnetic lining for the polepiece occupying throughout its effective length about one-half the width of said field gap, in combination with means for driving the rotor to carry a feed stream of said mixed particles through said field gap at a speed to develop a centrifugal force equal to at least five times the gravitational force of the particles, the non-magnetic lining being disposed so as to receive the impact of the particles driven thereagainst by centrifugal force and to cause them to rebound and to enter the field gap, and means for collecting the magnetic, the partly magnetic and the non-magnetic particles in separate receptacles at the end of the field.

CLARENCE Q. PAYNE.