

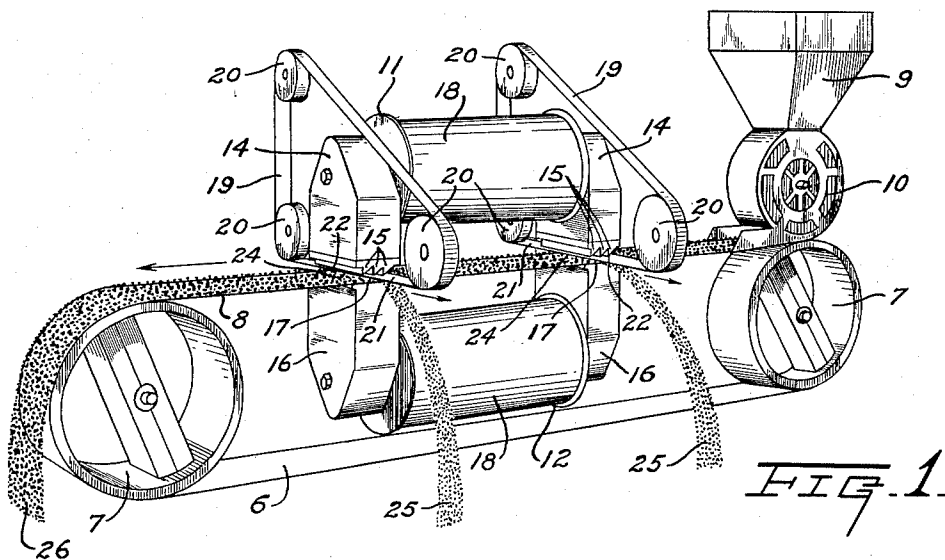
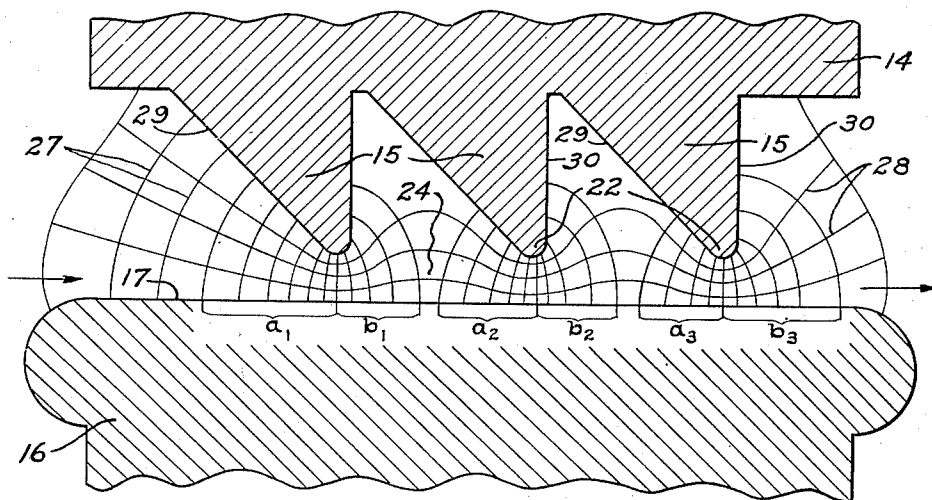
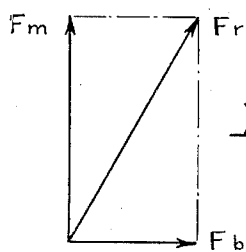
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K. A. BLIND

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CROSSBELT MAGNETIC SEPARATOR

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INVENTOR.
Karl A. Blind
BY
Lieber & Lieber
ATTORNEYS

UNITED STATES PATENT OFFICE

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CROSSBELT MAGNETIC SEPARATOR

Karl A. Blind, Thiensville, Wis., assignor to Dings
Magnetic Separator Co., Milwaukee, Wis., a cor-
poration of Wisconsin

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The present invention relates generally to improvements pertaining to the art of magnetic separation; and relates more specifically to improvements in the construction and operation of machines for effecting removal of magnetic particles from mixtures of magnetic and non-magnetic granular materials, while these mixtures are passing through zones of magnetic influence.

The primary object of my present invention is to provide an improved magnetic separator which is simple in construction and highly efficient in operation.

It has heretofore been common commercial practice to utilize so-called cross-belt magnetic separators for the purpose of removing magnetic from non-magnetic particles contained in an advancing stream of dry granular mixture of the materials, by constantly passing a thin layer of the mixture through one or several successive zones of magnetic influence produced by complementary sets of magnetized poles, each set comprising one pole provided with a flat face exposed to the zone and spaced from a symmetrical wedge shaped face of the other pole of the set. In these separators, the thin layer of bulk mixture is transported through each zone of magnetic influence by a main lower conveyor belt coacting directly with the flat upper pole face and advancing transversely beneath the corresponding wedge edge, while the magnetic particles are lifted out of the loose mass of mixture by the V-shaped magnetic pole and are projected upwardly against an upper auxiliary belt advancing along and directly adjacent to the edge of the wedge shaped pole face.

This type of separator has been quite successfully and extensively employed for many years, especially in the mining industry for the removal of magnetic ore from granular masses of mixture, but I have discovered that the symmetrical wedge or V-shape of the lifting poles is relatively ineffective since the symmetrical formation and the ordinary utilization of a single wedge surface at each separating zone, produces excessive concentration of the highly intensified and most effective flux tubes along a single central strip of each cross-belt, and does not distribute these tubes throughout the maximum available area of the separating spaces. This concentration of the flux tubes in the previous separators, not only results in objectionable local or mass pick-up of magnetic particles along a comparatively narrow central path on the cross-belt of each zone, but also causes considerable non-magnetic material to be entrained with the removed magnetic particles. I have found that the use of an asymmetrical apex or lifting face on the upper pole of each set, having a leading gradually inclined surface approaching the main conveyor in the direction of its advancement

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and also having a trailing face disposed perpendicular or more abruptly inclined relative to this conveyor, is far superior to the former symmetrical pole face; and that the provision of a succession of these asymmetrical lifting face formations distributed along each zone of magnetic influence, enhances the separating capacity and substantially reduces undesirable removal of gangue with the magnetic particles.

It is therefore a more specific object of the present invention to provide an improved cross-belt magnetic separator which more effectively removes the magnetic particles by eliminating the objectionable features of prior devices of this general type, above referred to.

Another specific object of the invention is to provide an improved pole face construction for the magnets of cross-belt separators or the like, which enables the flux tube to be most effectively utilized to extract the magnetic particles near the apex of the wedge face of each set of magnets, without undesirable concentration of the removed particles.

A further specific object of this invention is to provide an improved magnet assemblage for cross-belt magnetic separators, wherein the capacity of the machine is materially enhanced by providing each separating zone with a number of similar successive lifting apices distributed uniformly throughout the zone.

Still another specific object of my invention is to provide an improved cross-belt separator wherein the belt for removing the magnetic particles is more uniformly loaded than was possible with the prior assemblages, and in which undesirable local or mass pick-up of the magnetic particles is avoided.

An additional specific object of my present invention is to provide an improved magnetic separator for effecting removal of magnetic particles from an advancing stream or layer of dry granular mixture in a most effective and automatic manner.

These and other specific objects and advantages of the invention will be apparent from the following detailed description.

A clear conception of the features constituting my present improvement, and of the mode of constructing and of operating separators embodying the invention, may be had by referring to the drawing accompanying and forming a part of this specification and in which like reference characters designate the same or similar parts in the various views.

Fig. 1 is a diagrammatic perspective view of a typical two zone cross-belt magnetic separator in which the invention has been incorporated;

Fig. 2 is a considerably enlarged fragmentary section through a set of complementary magnetic poles forming one of the separating zones, and

showing the approximate disposition and formation of the flux tubes and of the equipotential lines permeating this zone; and

Fig. 3 is a force diagram illustrating the actual force attracting the magnetic particles toward and against the cross-belt of each separating zone.

While the invention has been shown and described as being especially useful and advantageously applicable to a cross-belt dry magnetic separator for removing magnetic ore particles from gangue or non-magnetic material in the mining industry, it is not my desire or intention to unnecessarily restrict the scope or utility of the improvement by virtue of this limited disclosure.

Referring to Fig. 1 of the drawing, the typical cross-belt magnetic separator shown therein comprises in general a main conveyor belt 6 co-acting with pulleys 7 and being constantly movable thereby to cause its upper stretch 8 to travel in the direction of the arrow; a granular material supply hopper 9 cooperating with a feed roller 10 to spread a thin layer of the mixed dry magnetic and non-magnetic particles upon the feed end of the advancing conveyor stretch 8; upper and lower reversely disposed horseshoe magnets 11, 12 respectively located one above the other on opposite sides of the main conveyor stretch 8, the upper magnet 11 having spaced poles 14 each of which is provided with a series of serrations or similar asymmetrical lower wedges 15 located somewhat above and spanning the belt stretch 8, while the lower magnet 12 has similarly spaced poles 16 each of which is provided with a flat upper face 17 coacting directly with the underside of the moving stretch 8; an electric coil 18 for energizing each of the magnets 11, 12; and a pair of auxiliary or cross-belts 19 coacting with pulleys 20 and surrounding the upper poles 14 of the magnet 11, each of the belts 19 having a lower pick-up stretch 21 spaced from the top surface of the conveyor stretch 8 and movable there-across in the direction of the arrows closely adjacent to the apices 22 of the corresponding pole wedges 15.

The main conveyor stretch 8 and the auxiliary belt stretches 21 are adapted to be constantly advanced in the directions of the arrows applied thereto in Fig. 1, by suitable power applied to the pulleys 7, 20 respectively, and the magnets 11, 12 may be energized with the aid of the coils in a well known manner so as to produce a magnetic field or separating zone 24 between each complementary set of magnet poles 14, 16. The constantly advancing upper stretch 8 of the conveyor 6 thus transports the dry granular mixture of magnetic and non-magnetic particles deposited thereon in the form of a thin layer extending throughout its entire area by the hopper 9 and feed roller 10, through a succession of the separating zones 24 beneath the cross-belt stretches 21; and magnetic particles of the progressing stream of mixture are lifted out of the mass and are picked up by the transverse belt stretches 21 and are delivered laterally of the conveyor 6 in the form of constant streams 25, while the non-magnetic particles are carried away from the magnetic zones 24 and are ultimately discharged as a stream 26 over the end of the conveyor stretch 8, as illustrated in Fig. 1. The main conveyor stretch 8 may be of any desired length and several successive pairs of magnets 11, 12 may be applied to this stretch depending upon the characteristics of the material being treated, and the degree of separation desired,

and the general construction and mode of operation of this cross-belt type of magnetic separator is well known to those skilled in the art.

It is also a well known fact that the gradients of the magnetic field at each separating zone 24, determines the intensity or force of the magnetic attraction acting upon the particles to be removed from the mass resting upon the belt stretch 8, and it is also recognized that flux tubes of short length and high intensity spanning the space between the magnet poles 14, 16 are most effective for magnetic separation purposes. It is a further fact that magnetic particles approaching the central planes of the upper lifting poles in the direction of travel of the conveyor stretch 8, will be picked more readily than those travelling away from these central areas, and in case a magnetic particle is not removed while approaching a wedge edge 22 it will remain magnetized but will not be lifted and will merely pass through a non-magnetic portion of the separating zone on the trailing side of the edge 22. From these known facts, it is desirable to utilize to the greatest possible extent, the lifting force available throughout the entire separating zone, and especially during the time that the particle is approaching the center of the magnetic field.

While the attractive force of a magnet is known to be proportional to the square of the induction so that ferro magnetic material subjected to the magnetic influence will move toward the magnet face while increasing the permeance of the magnetic path and thereby reducing the energy contained in the magnetic field, this theory may be somewhat modified as applied to practical cross-belt magnetic separation. For such purposes it may be considered that the intensity of the magnetic field or the magnetizing force in the magnetic zone or gap causes the magnetic particles to be attracted by a force F equal to

$$kH \frac{dh}{dx}$$

where k is the susceptibility of the particle, and H and

$$\frac{dh}{dx}$$

the strength and gradient of the part of the field occupied by the particle. In cross-belt separators, the lifting pole 14 of each set is provided with a wedge or V-shaped face in order to provide a rapid increase in field density with a resultant increase in lifting power or force tending to elevate the magnetized magnetic particles from the main belt stretch 8 to the cross-belt stretch 21.

Referring more specifically to Figs. 2 and 3 of the drawing, the separating zone 24 formed between the magnet poles 14, 16 is spanned vertically by a multiplicity of flux tubes 27 of which the shorter tubes have maximum intensity, and these tubes 27 may be crossed by equipotential lines 28 so as to subdivide the field into numerous approximate squares. The belts have been omitted from Fig. 2, but the direction of travel of the load carrying belt stretch 8 has been indicated by the arrows directed across the flat pole face 17, and the upper pole 14 is provided with three parallel depending asymmetrical wedges 15, each having a leading surface or face 29 directed downwardly in the direction of travel of the belt stretch 8, and also having an approximately upright trailing surface or face 30. The

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resultant force F_r which attracts each particle toward the cross-belt stretch 21, as the particle approaches one of the wedge edges 22 is indicated in the diagram of Fig. 3, and the component F_b represents the force acting in the direction of travel of the main belt stretch 8 while the component F_m likewise represents the force acting to lift the particle tangent to the flux tubes 27 at the flat surface 17. If the particle should fail to be removed prior to reaching a wedge edge 22 and passes beyond this edge, the horizontal component F_b will be reversed and the kinetic energy of the particle for lifting purposes will be lost since this reversal of the component is detrimental to the upward attraction.

Because of the fact that the trailing surface of each wedge 15 beyond the edge 22 is thus inactive and in fact has an effect detrimental to lifting of the magnetic particles, I provide an asymmetrical wedge 15 on the upper pole; and in order to more effectively and uniformly distribute the lifting force throughout each separating zone 24, a series of these wedges 15 of similar formation is provided at the zone 24. The widths of the effective pick-up localities resulting from this asymmetrical pole formation are represented in Fig. 2 by the distances a_1 , a_2 and a_3 , while the widths of the corresponding ineffective or dormant areas are represented by the distances b_1 , b_2 and b_3 ; and while the a distances gradually diminish as the b distances increase, the sum of the a values remains far greater than the sum of the b values. This fact indicates that the total pick-up area is considerably greater than the total detrimental area, and by providing a number of wedges 15 the pick-up area is distributed throughout the separating zone, and maximum pick-up or separating capacity results. The inclination of the leading wedge faces 29 is approximately forty-five degrees while the trailing wedge faces 30 are disposed approximately vertical to the corresponding lower pole faces 17, and while three wedges 15 have been utilized in the embodiment shown in order to uniformly distribute the pick-up areas throughout the separating zones 24, a single wedge 15 or more or less than the three wedges illustrated, may be advantageously utilized for the treatment of diverse materials.

From the foregoing detailed description it will be apparent that my present invention provides an improved cross-belt magnetic separator which besides being simple in construction, is also highly efficient in operation and provides for maximum capacity. The improved asymmetrical pole face enhances to a maximum the effective separating or lifting area and reduces to a minimum the ineffective area, and the enlarged effective area serves as an effective pre-magnetizer for the magnetic particles which are subsequently extracted from the mixture. If a magnetic particle is not in fact removed by the first wedge 15 to which it is presented, it will probably be pre-magnetized to an extent sufficient to insure removal thereof by a subsequent wedge 15; and by providing a succession or plurality of these wedges 15 at each separating zone 24, most efficient pick-up of all magnetic particles regardless of their susceptibility, is assured. The capacity of the improved separating unit is thus materially increased over that of machines utilizing symmetrical V-shaped pole faces, both because of the asymmetrical formation of the pole faces 29, 30 and due to the use of several of these

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specially formed wedges at each separation zone 24; and the improved assembly enables attainment of this improved result without increasing the size of the magnet energizing coils 18. The plural arrangement of the wedges 15 moreover uniformly distributes the load on the cross-belts 19 and eliminates objectionable mass pick-up of particles along a relatively narrow central area of these belts, and this feature is especially important when treating magnetic ores, as it avoids undue removal of gangue with the magnetic particles.

It should be understood that it is not desired to limit this invention to the exact details of construction or to the precise mode of use, herein shown and described, for various modifications within the scope of the appended claims may occur to persons skilled in the art; and it is also contemplated that specific descriptive terms used herein be given the broadest interpretation consistent with the novelty of the invention.

I claim:

1. In a cross-belt magnetic separator, a main conveyor deck constantly movable to transport mixed magnetic and non-magnetic particles in one direction along a definite path, a magnet pole having a flat face extending locally across said path beneath said deck, an auxiliary conveyor deck spaced from the top of said main deck and movable across said path above said flat pole, and a complementary magnet pole above said auxiliary deck having a series of at least three parallel asymmetrical depending wedge projections extending across said path and cooperating through equal gaps with said flat pole face to lift magnetic particles from said mixture onto the bottom of the auxiliary deck, one face of each wedge being perpendicular to said decks and the other being inclined downwardly in the direction of advancement of the main deck approximately forty-five degrees.

2. In a cross-belt magnetic separator, a main conveyor deck constantly movable to transport mixed magnetic and non-magnetic particles in one direction along a definite path, a magnet pole having a flat face extending locally across said path beneath said deck, an auxiliary conveyor deck spaced from the top of said main deck and movable across said path above said flat pole, and a complementary magnet pole above said auxiliary deck having a series of at least three parallel asymmetrical depending wedge projections extending across said path and cooperating through equal gaps with said flat pole face to lift magnetic particles from said mixture onto the bottom of the auxiliary deck, one face of each wedge being perpendicular to said decks and the other being inclined downwardly in the direction of advancement of the main deck approximately forty-five degrees while the apex of each wedge is bluntly rounded.

KARL A. BLIND.

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