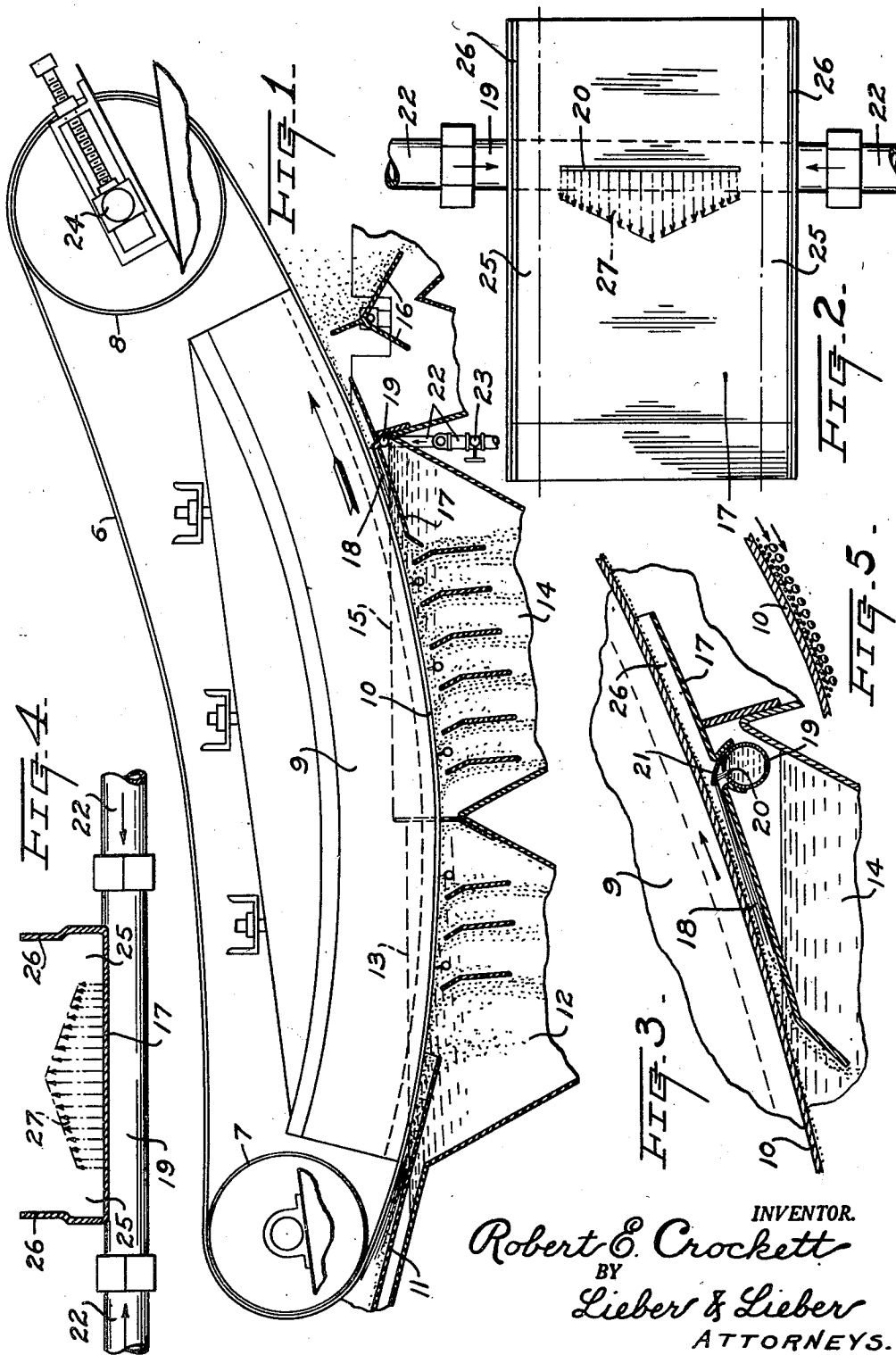


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MAGNETIC CONCENTRATE WASHING MEANS FOR  
SUBMERGED BELT MAGNETIC SEPARATORS  
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MAGNETIC CONCENTRATE WASHING  
MEANS FOR SUBMERGED BELT MAGNETIC SEPARATORS

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The present invention relates generally to improvements in the art of separating mixed materials having different characteristics, and relates more particularly to various improvements in the construction and operation of machines for effecting automatic separation of magnetic material from non-magnetic substances.

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

When separating granules of magnetic ore from a granular mixture of tailings, middlings and ore particles, it is a relatively simple matter to remove the tailings from the middlings and concentrates, but considerable difficulty may be encountered in effecting final separation of the concentrates from the middlings. Such magnetic separation has heretofore been accomplished with machines of the type shown and described in my copending application Serial No. 365,183, filed November 11, 1940, now Patent No. 2,410,601, dated November 5, 1946, wherein the mixture of magnetic and non-magnetic particles is conveyed by a moving belt through one or more liquid basins and from thence through a final washing and separating space extending at an oblique angle upwardly away from the basins and which is subjected to relatively strong magnetic influence. In this prior machine, the mixture of middlings and concentrates which is carried by the belt into the final separating space, is subjected to the washing action of a multiplicity of discrete and forceful jets of liquid which are projected across the space and against the layer of material being held against the travelling belt by magnetic force, and these jets have a tendency to gouge or plow into the layer thereby dislodging concentrates as well as middlings from the belt. In order to reclaim these concentrates, the final washing space or zone is limited in height so that all portions thereof are subjected to the strong magnetic influence, and the dislodged concentrates are thus quickly returned to the conveying surface of the belt. Most of the middlings which are removed from the belt by the forceful jets of washing liquid, however, remain within the strong magnetic field and a substantial portion of these middlings are also immediately recaptured by the belt with the returning concentrates, thus resulting in the production of final concentrates containing a considerable quantity of middlings.

It is therefore a more specific object of my present invention to provide improvements in magnetic separating machines of the above described general type, wherein more effective automatic

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separation of the magnetic and non-magnetic ingredients of a granular mixture, may be accomplished, and purer concentrates are thus obtained.

Another specific object of this invention is to provide a simplified and more reliable magnetic ore separating system, wherein the product is most effectively subjected to gentle final washing and cleansing without introducing excessive loss of magnetic particles.

A further specific object of the invention is to provide improved instrumentalities for effecting delivery of washing liquid to the final separating and cleansing space or zone of a magnetic separator, and for insuring prompt removal of the non-magnetic ingredients from the washing space.

Still another specific object of my invention is to provide various improvements in the construction and operation of endless belt magnetic separators whereby the structures are simplified and the operating efficiency is enhanced to a maximum.

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

A clear conception of a typical embodiment of my present improvement and of the normal functioning thereof, may be had by referring to the drawing accompanying and forming a part of this specification wherein like reference characters are employed to designate similar parts in the various views.

Fig. 1 is a somewhat diagrammatic and part sectional side elevation of a typical magnetic separator embodying the invention;

Fig. 2 is an enlarged top view of the pan or trough which cooperates with the conveyor belt to provide the final separating and washing space, with the water jet deflector omitted;

Fig. 3 is a similarly enlarged fragmentary central longitudinal vertical section through the elements forming the final separating and washing space;

Fig. 4 is a likewise enlarged vertical transverse section through the trough of Fig. 2, the water jet deflector also having been omitted; and

Fig. 5 is a somewhat schematic enlarged view for illustrating the operation of certain features of the invention.

While the invention has been shown herein rather diagrammatically and as being especially applicable to a magnetic ore separator of a particular type, it is not my desire to thereby unnecessarily restrict the scope of the claims or the utility of the improved features.

Referring to the drawing, the magnetic ore separator shown therein comprises in general, a constantly advancing endless non-magnetic conveyor or belt 6 coacting with lower and upper pulleys 7, 8 which are rotatable about parallel horizontal axes; an elongated arcuate bank of magnets 9 having lower pole-faces disposed in close proximity to and above the lower movable loosely sagging stretch 10 of the belt 6; a feed chute or tray 11 for feeding a granular mixture of magnetic and non-magnetic material to the lower face of the belt stretch 10 near the lower pulley 7; a tailings hopper 12 forming a liquid basin adjoining the feed tray 11 and having a relatively low liquid level 13 therein; a middlings hopper 14 forming another liquid basin adjoining the tailings hopper 12 and having a higher liquid level 15 therein; a magnetic material or concentrates discharge device 16 for delivering the final concentrates from the machine; a fixed plate or trough 17 interposed between the hopper 14 and the device 16 and coacting with the belt stretch 10 to provide a final separating and washing space 18 inclined upwardly away from the liquid level 15; a pipe or conduit 19 spanning the trough 17 and having an elongated slot 20 and a similarly elongated deflector 21 for directing a flat jet of liquid downwardly along the washing space 18; and means including pipes 22 and a valve 23 for admitting liquid preferably under substantially equal pressure to the opposite ends of the conduit 19.

Rotation is preferably imparted to the upper belt suspension pulley 8 so as to constantly advance the lower belt stretch 10 in the direction indicated by the arrows, and the pulley 8 may also be provided with suitable belt tension adjusting mechanism 24 for causing the conveyor stretch 10 to properly coact with the magnets 9. The magnets 9 are of somewhat less width than the belt 6, and are operable to create a relatively strong magnetic field along the mid-portion of the bottom surface of the lower belt stretch 10, in order to cause the magnetic material to adhere to this belt surface and to be thus transported through the hoppers 12, 14 and through the final separating space 18. The concentrates discharge device is located at the upper terminus of the magnetic field produced by the magnets, and the stationary trough 17 which provides the final separating and washing space 18 is formed and located so as to cause the entire mid-portion of the space to be constantly subjected to the strong magnetic field, while the opposite side zones 25 thereof indicated by the dot-and-dash lines in Fig. 2, are relatively free from magnetic influence. The plate or trough 17 may be provided with opposite side walls 26, and the lower ends of the plate and walls extend downwardly beneath the middlings basin water level 15, in order to prevent the loss of magnetic material to the hopper 14, at the same time allowing the non-magnetic material to be deposited within the hopper 14.

The wash water injecting conduit 19 and spray producing assemblage constitute an important part of the present improvement, and it is extremely desirable to have the washing liquid admitted under considerable pressure equally to both ends of this conduit 19 in order to produce a sheet-like jet having greatest intensity or volume and velocity along the central longitudinal region of the space 18 as indicated diagrammatically by the force vectors 27 in Figs. 2 and 4, the dot-and-dash lines and arrows representing jet intensity at the

indicated locations. This flat liquid jet which issues from the elongated straight slot 20 should also be directed downwardly in contact with the material conveyed on the upwardly traveling belt stretch 10 along the final separating and washing space 18, and this action is produced by the elongated deflector 21 shown in Fig. 3. The valve 23 is provided for the purpose of controlling the magnitude or intensity of the jet, and may be disposed within the common liquid supply piping system 22 which subsequently branches out and connects with the opposite ends of the slotted conduit 19 as illustrated in Figs. 2 and 4.

During normal operation of the improved magnetic separator, the belt 6 is being advanced by the pulleys 7, 8 so as to cause the loosely sagging lower stretch 10 thereof to travel through the elongated magnetic field created by the magnets 9, and the material which is to be treated is supplied to the lower surface of the loosely sagging belt stretch 10 by the feed tray 11 while the hoppers 12, 14 are filled with liquid to the levels 13, 15 respectively. Liquid under pressure should be admitted through the pipes 22 to the opposite ends of the conduit 19 and the liquid thus admitted will cause a sheet-like spray jet to be delivered from the slot 20 of the conduit 19 and this jet will be directed down along the space 18 in contact with the surface of the material on the belt stretch 10, by the deflector 21. The material entering the machine will be promptly separated by the magnetic force into gangue or tailings and more or less magnetic material, and the tailings will settle into the hopper 12 while the magnetic material including concentrates and middlings will adhere to the under surface of the belt stretch 10 and will be carried into the liquid basin within the hopper 14. While passing through the basins in the hoppers 12, 14, the layer of material adhering to the belt stretch 10 may be subjected to jet washing in addition to the washing action afforded by the liquid within these hoppers, and when the layer of material reaches the lower end of the trough 17 it will be in relatively clean condition. As the adhering and advancing layer of material is carried upwardly into the final separating space 18, it is subjected to the sweeping action of the flat sheet spray flowing at relatively high velocity down through the final separating space 18, and the sheet spray will promptly and effectively remove the retained middlings and gangue from the layer of concentrates, and will rapidly wash and, because of its greater central power or intensity, drive the removed middlings and gangue into the non-magnetic side zones 25 located on opposite sides of the strong magnetic field, which are relatively free from magnetic influence. The removed material and liquid will then flow quickly down the non-magnetic zones 25 into the middlings hopper 14 where the solids will settle for subsequent treatment. In this manner the concentrates are quickly and effectively purified and remain so and they will subsequently be released from the magnetic field at the upper end of the magnets 9 and will then be free to fall onto the deflector device 16 into a hopper.

When the liquid under pressure is admitted through the pipes 22 to the opposite ends of the conduit 19, the entering columns of liquid collide near the center of the slot 20 and thus produce a sheet jet having greatest intensity or volume and maximum velocity at the mid-portion of the slot 20 as illustrated by the vectors in the drawing, and this jet being directed downwardly along

in contact with but not directly against the layer of material carried by the belt stretch 10, will roll or sweep the middlings from the central portions of the layer and will carry these middlings toward the side non-magnetic zones 25 from which they are quickly discharged into the hopper 14 without being recaptured by the magnetic field. In order to produce a proper flat sheet jet 27 which is capable of thus quickly removing the objectionable particles from the layer, the pressure of the entering liquid at the opposite ends of the conduit 19 should be as nearly equal as possible, and the deflector 21 should be so formed and disposed that it will direct the flat sheet spray at a slight angle against the upwardly advancing bed of granular material. The flat jet will not gouge into the layer of material with sufficient force to disturb the stratification of the material on the belt wherein the smaller particles, generally concentrates, are close to the under surface of the belt stretch 10, and the coarsest particles, generally middlings, are on the lower surface of the sheet of material on the belt and are thus exposed to the washing and removing action of the sheet jet. Fig. 5 is an enlarged view of a portion of the belt stretch 10 at the region of the sheet-like spray, and indicating the approximate relationship which most of the middlings particles will generally assume in respect to the concentrate particles on the belt. That is, the small black dots represent the concentrate particles which are generally finest and closest to the belt, and the somewhat larger circles shown with partially blackened areas, are intended to represent the relatively larger middlings particles, i. e., particles containing both magnetic and non-magnetic material. Since these middlings particles are generally somewhat larger and do not contain as high a percentage of magnetic material, they are not generally attracted so strongly to the belt as the finer magnetic particles and are thus carried along in a position well adapted to be swept off by the sheet-like spray when applied in the direction of the arrow, as indicated in Fig. 5. The intensity of the jet may be readily varied by manipulating the control valve 23.

From the foregoing detailed description it will be apparent that my present invention provides an improved magnetic separator which is extremely simple and compact in construction, highly efficient in operation, and which is less expensive to build and to operate than the prior separators of this general type. The improved machine also produces a cleaner concentrate since the gangue and middlings are more effectively removed, and the flat sheet jet will also remove slimes and other foreign matter and actually consumes less water than was required with the multiple forceful spray jets previously used. By virtue of the fact that the direction of the flat sheet jet is in opposition to the direction of travel of the belt and is substantially parallel to this belt, the layer of ore deposited upon the belt stretch 10 will be restrained downwardly and held within the final washing zone for a longer period of time, thus also insuring more efficient final washing of the concentrates. The present improvement has proven highly satisfactory and efficient in actual commercial use, and has made it possible to eliminate objectionable features of prior magnetic separators of the belt and spray jet type, with simpler and more efficient automatically functioning equipment.

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 operation, herein shown and described, for various modifications within the scope of the appended claims may occur to persons skilled in the art.

#### I claim:

1. In a magnetic separator, means forming a liquid basin, a conveyor having a surface movable upwardly at an oblique angle away from the liquid in said basin, trough-like means extending along said conveyor surface to provide an inclined washing space extending upwardly away from said basin, magnetic means for creating a strong magnetic field extending along and through said space, said trough-like means projecting laterally beyond said field to provide side zones relatively free from magnetic influence, and means for directing a sheet-like jet of liquid downwardly through said space with greatest volume and velocity near the mid-portion of the space whereby non-magnetic material is washed toward said side zones.

2. In a magnetic separator, means forming a liquid basin, a conveyor belt having a lower flat surface movable upwardly at an oblique angle away from the liquid in said basin, trough-like means extending along and beneath said belt surface to provide an inclined washing space extending upwardly away from said basin, magnetic means disposed above said surface for creating a strong magnetic field extending along and through said space, said trough-like means projecting laterally beyond the opposite sides of said field to provide side zones relatively free from magnetic influence, and means for directing a sheet-like jet of liquid downwardly through said space with greatest volume and velocity near the mid-portion of the space whereby non-magnetic material is washed toward said side zones.

3. In a magnetic separator, means forming a liquid basin, a conveyor having a surface movable upwardly at an oblique angle from within the liquid in said basin, a series of magnets for creating a magnetic field extending along said conveyor to cause magnetic material to adhere to said surface, a trough extending along and in spaced relation to said surface to provide an inclined washing space extending upwardly away from said basin and to also provide side zones relatively free from magnetic influence, and means for directing a flat and wide jet of liquid downwardly through said space so that said jet has greatest volume and velocity near the mid-portion of the space whereby non-magnetic material is washed into said basin through said side zones.

4. In a magnetic separator, means forming a liquid basin, a conveyor belt having a lower flat surface movable upwardly at an oblique angle from within the liquid in said basin, a series of magnets above said belt for creating a magnetic field extending along the conveyor to cause magnetic material to adhere to said surface, a trough extending along and beneath and in spaced relation to said surface to provide an inclined washing space extending upwardly away from said basin and to also provide opposite side zones relatively free from magnetic influence, and means for directing a flat and wide jet of liquid downwardly through said space so that said jet has greatest volume and velocity near the mid-portion of the space whereby non-magnetic material is washed into said basin through said side zones.

5. In a magnetic separator, a hopper forming a settling basin, a belt conveyor having a lower sur-

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face movable upwardly away from said basin, magnets for creating a magnetic field sufficiently strong to cause magnetic material to adhere to said belt surface, a trough extending along and beneath said surface to provide an inclined washing space extending upwardly away from said basin and having opposite side zones which are relatively free from magnetic influence, and a conduit having an opening for directing a flat jet of liquid downwardly through said space approximately parallel to said surface in a manner whereby non-magnetic material is washed into said basin through said side zones.

6. In a magnetic separator, a belt stretch, hopper means for containing a body of liquid, means for supporting and moving said belt stretch to travel from a position in proximity to the liquid along an upwardly inclined path to a concentrates discharge position, magnetic means extending along above said belt stretch for causing magnetic particles to adhere to the underside of the belt, trough-like means extending along said inclined path in spaced relation to the belt at regions above the liquid level to form a washing space within the field of said magnetic means, said trough-like means also extending to zones alongside the belt which are beyond any strong influence of said field, and means for directing a sheet-like jet of washing liquid downwardly along the underside of the belt in said space, said jet having substantially greater velocity and volume at the mid-portion of the belt than at regions nearer said side zones, whereby particles embodying non-magnetic material are washed from the belt to the side zones and thence downwardly along the trough-like means.

7. In a magnetic separator, a belt stretch, hopper means for containing a body of liquid, means for supporting and moving said belt stretch to travel from a position in contact with the liquid along an upwardly inclined path to a concentrates discharge position, magnetic means extending along above said belt stretch for causing magnetic particles to adhere to the underside of the belt, trough-like means extending along said inclined path in spaced relation to the belt at regions above the liquid level to form a washing space within the field of said magnetic means, said trough-like means also extending to zones alongside the belt which are beyond any strong influence of said field, a conduit having a slot extending transversely of and opening into said space, and means for connecting sources of wash liquid under pressure to both ends of said conduit, whereby a sheet-like jet of wash liquid is projected from said slot downwardly along the underside of the belt in said space, the two sources of the wash liquid causing said jet to have greater velocity and volume at its mid-portion than at regions nearer said side zones to thereby cause particles embodying non-magnetic material to be swept from the belt to zones where the field is insufficient to cause substantial amounts thereof to be recaptured on the belt.

8. In a magnetic separator, a hopper forming a settling basin, a belt conveyor having a lower surface movable upwardly away from said basin, magnets for creating a magnetic field sufficiently strong to cause magnetic material to adhere to said belt surface, a trough extending along and beneath said surface to provide an inclined washing space extending upwardly away from said basin and having opposite side zones which are relatively free from magnetic influence, a conduit having an elongated slot opening into an upper

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portion of said space and formed to direct a flat jet of washing liquid downwardly along said space, and means for delivering liquid under pressure into the opposite ends of said conduit to cause said jet to have greatest intensity near its mid-portion and remote from said zones.

9. In a magnetic separator, means forming a settling basin, a conveyor having a lower surface movable upwardly away from said basin, magnets for creating a magnetic field adjacent to said surface, a trough forming a washing space extending along said surface and having its mid-portion within said field and opposite side zones relatively free from magnetic influence, a conduit formed to direct a flat jet of washing liquid downwardly along said space, and means for delivering liquid under pressure into said conduit to cause said jet to have greatest intensity near the mid-portion of said space and remote from said zones.

10. In a magnetic separator, means forming a settling basin, a conveyor having a lower surface movable upwardly away from said basin, magnets for creating a magnetic field adjacent to said surface, a trough forming a washing space extending along said surface and having its mid-portion within said field, a conduit formed to direct a flat jet of washing liquid downwardly along said space toward said basin, and means for delivering liquid under pressure into the opposite ends of said conduit to cause said jet to have greatest intensity near the mid-portion of said space.

11. In a magnetic separator, a belt conveyor having an inclined upwardly movable stretch, magnetic means arranged along the upper surface of said stretch for causing magnetic particles to adhere to the under surface thereof, trough-like means extending along beneath said stretch in spaced relation thereto, and means for projecting a sheet-like spray of washing liquid in a direction downwardly along a plane generally parallel to said stretch, between said stretch and trough-like means, said spray projecting means being so constructed and arranged that the spray along regions nearer an edge of the belt has less force than along regions more widely spaced from the edge of the belt, whereby particles dislodged from the belt by the spray tend to be swept to the side of the belt.

12. In a magnetic separator, a belt conveyor having an inclined upwardly movable stretch, magnetic means arranged along the upper surface of said stretch for causing magnetic particles to adhere to the under surface thereof, means for applying a liquid mixture of particles to be separated, to the under side of a lower portion of said stretch, trough-like means extending up along beneath said stretch in spaced relation thereto, and means for projecting a sheet-like spray of washing liquid having greatest intensity near its mid-portion, in a direction downwardly along a plane generally parallel to said stretch, between said stretch and trough-like means, at a region above the liquid level.

13. In a magnetic separator, conveyor means having an upwardly curved upwardly movable surface portion, magnetic means arranged along the upper side of said surface portion for causing magnetic particles to adhere to the underside thereof, trough-like means extending along beneath said surface portion in spaced relation thereto, and means for projecting a sheet-like spray of washing liquid in a direction downwardly along a plane generally tangent to said surface portion, between said surface portion and said trough-like means, said spray projecting means

being so constructed and arranged that the spray along regions nearer an edge of the surface portion has less force than along regions more widely spaced from such edge, whereby particles dislodged from the surface by the spray tend to be swept toward such edge.

14. In a magnetic separator, conveyor means having an upwardly curved upwardly movable surface portion, magnetic means arranged along the upper side of said surface portion for causing magnetic particles to adhere to the underside thereof, means for applying a liquid mixture of particles to be separated, to the underside of a lower portion of said conveyor means, trough-like means extending up along beneath said surface portion in spaced relation thereto, and means for projecting a sheet-like spray of washing liquid

having greatest intensity near its mid-portion, in a direction downwardly along a plane generally tangent to said surface portion, between said portion and trough-like means, at a region above the liquid level.

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