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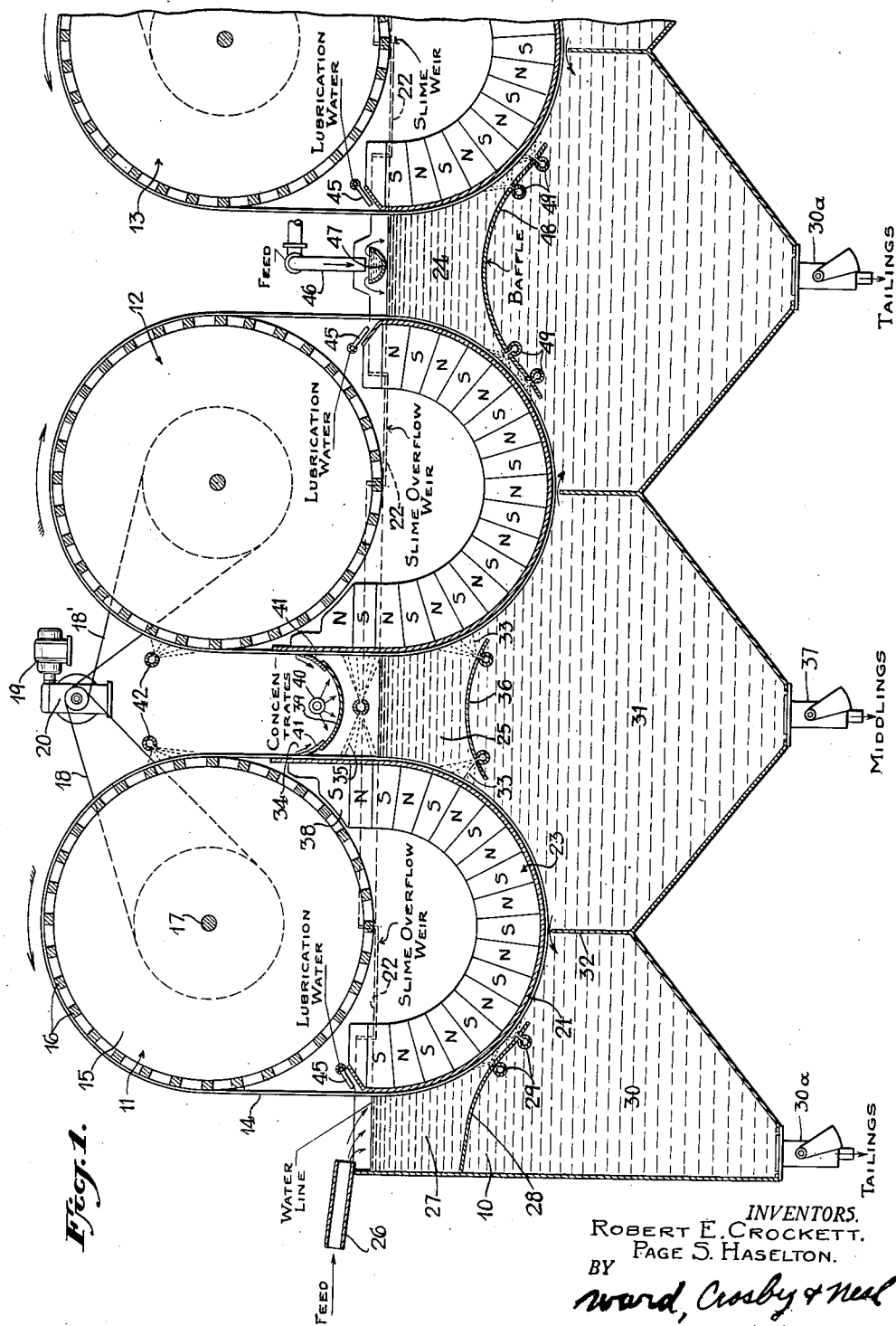
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2,559,565

MAGNETIC SEPARATOR

Filed Dec. 24, 1947

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Fig. 2.

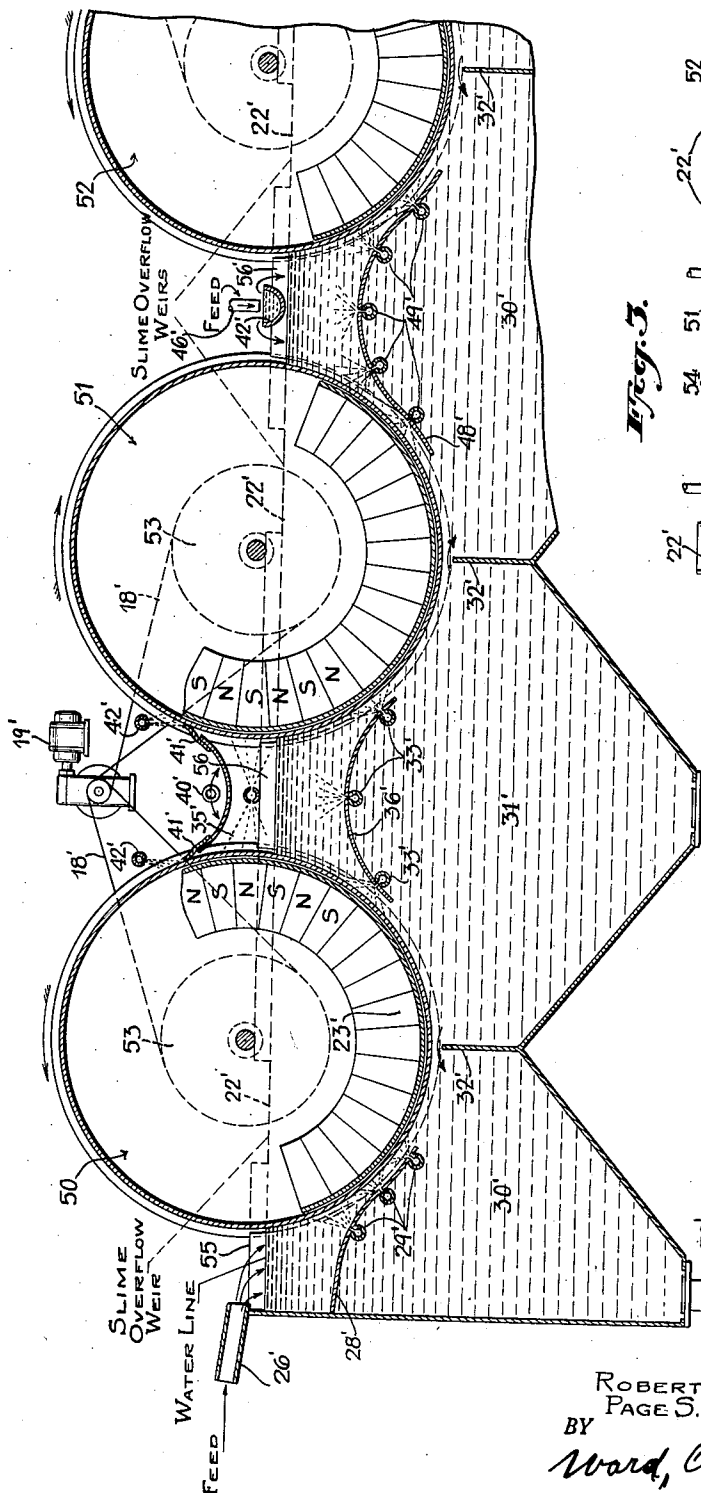
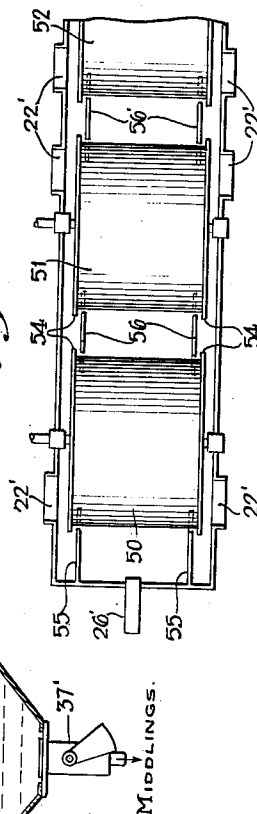


Fig. 3.



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2,559,565

MAGNETIC SEPARATOR

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6 Claims. (Cl. 209-232)

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This invention relates to magnetic separators and methods for separating finely divided magnetic particles from other material. It is particularly adapted among other possible uses, for the separation of magnetic ore particles, such as magnetite, from the gangue.

In our co-pending application Serial No. 488,668, filed May 27, 1943, (Patent No. 2,437,681, granted March 16, 1948) there is disclosed a magnetic separator comprising a succession of units, each including an elongated suspended belt loop, magnets being located within each loop and the units being suspended in a tank of water in an arrangement whereby material to be separated is fed against a downstretch of one belt loop, the material then passing around the loop on the belt to a concentrates take-off point at the upper part of the upward stretch. Also the belts of alternate loops of the series are preferably driven in opposite directions so that two downward or "feed" stretches may face each other as may also two upward or "take-off" stretches.

The present invention embodies various improvements and alternative arrangements and features for the above general type of separator, and more particularly improved feeding and "take-off" arrangements, and also features making possible more compact and efficient construction especially as adapted for the treatment of very fine ores. Also the present invention includes alternative constructions wherein the carriers which carry the ore being separated past the magnets, may be in the form of either drums or relatively short belt loops passing over arcuately arranged banks of magnets, while taking advantage of certain of the features of our said co-pending application.

Various further and more specific objects, features and advantages will more clearly appear from the detailed description given below taken in connection with the accompanying drawings which form a part of this specification and illustrate merely by way of example, preferred forms of the invention. The invention consists in such novel features, arrangements and combinations of parts as may be shown and described in connection with the apparatus herein disclosed and also such novel methods as are disclosed and described hereinafter.

In the drawings:

Fig. 1 is a side elevational view partially in sections, showing a gang separator, including several units constructed in accordance with a preferred example of the invention;

Fig. 2 is a similar view of an alternative form of the invention wherein the carriers are in the form of drums; and

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Fig. 3 is a somewhat schematic plan view of the embodiment of Fig. 2, certain parts being omitted for clearness.

In Fig. 1 a tank is shown at 10, within and above which a series of separating units as at 11, 12 and 13 are mounted. Each of these units comprises a belt as at 14 formed of suitable non-magnetic material in accordance with known practice. Each of these belts is suspended and driven by pulleys as at 15. Preferably the peripheral surfaces of the pulleys are made with a notch formation as at 16 to insure against slippage. The pulleys are mounted on and driven by shafts as at 17 connected as by belts 18, 18', so that alternate units are driven in opposite directions as by motors 19 which may operate through reducing gears as at 20. It will be understood that unit 13 and further additional units may be provided and driven in a similar way.

Each suspended belt loop extends down around and up again over the surface of a generally U-shaped member 21, formed of thin sheet material such as stainless steel or other non-magnetic material, this member being closed at its ends in any desired way to provide a water-tight magnet compartment with an arcuately shaped bottom and with the sides substantially tangential respectively to the belt stretches, which depend substantially vertically from the pulley 15. Although as shown the magnet compartments and pulleys are of substantially the same diameter, it will be understood that either one may be somewhat larger than the other, although it is preferred that they be of substantially the same diameter so that the upward running belt stretches will pass up substantially vertically out of the water within the tank 10. This tank may be kept filled with water up to a liquid level as indicated, which is determined by slime overflow weirs such as indicated at 22, preferably one of such weirs being positioned at some point adjacent each unit. As explained hereinafter, water is supplied to the tank by way of numerous washing sprays as well as along with the material fed into the system.

A series of magnets as at 23 is arranged in arcuate formation inside each of the magnet housings, alternate magnets having alternate polarities, preferably as indicated by the "N" and "S" notations. That is, corresponding magnets which face each other in successive units are preferably of opposite polarity so that within feeding regions such as at 24 between units 12 and 13, for example, and also in take-off regions such as at 25 between units 11 and 12, there will be fields of irregular shape, causing more or less violent agitation, and at the same time adequate

dispersion of the particles within these regions to insure unusually efficient separating action.

A mixture of water, magnetic and non-magnetic particles to be separated may be constantly fed to unit 11 in a feed trough 26 discharging into a pick-up region 27. There will be considerable turbulence in this region due to the discharge of the liquid mixture therein, and accordingly the mixture will be rather widely dispersed so that the magnetic particles will be free to be drawn up against the belt by the magnets without any extensive mass magnetism effects such as might cause masses of the non-magnetic particles also to cling to the belt. Beneath the region 27 a baffle 28 is positioned to insure that none of the mixture drops away from the belt without going close to the magnets. The more strongly magnetic particles will be promptly drawn onto the belt and carried out of the region 27 thereby, and while emerging from this region, the material on the belt is preferably subjected to the action of submerged jets of water as indicated at 29, which will act to dislodge non-magnetic particles. If at the same time magnetic particles are dislodged from the belt, the baffle 28 will retain them within the region of the strong magnetic field for immediate recapture on the belt. On the other hand non-magnetic particles will be washed down into the tailings chamber 30 past the baffle by the action of the jets. The tailings particles may be drawn off through an outlet 30a at the bottom of the tailings compartment in a manner known in the art. On the other hand any slime or slime-like material of low specific gravity which may float to the top of the body of water, will pass out at the slime overflow weir 22.

The belt as it passes the lower arcuate arrangement of magnets will carry both the strongly magnetic and weakly magnetic particles thereon into the middlings compartment 31, a barrier 32 preferably being provided to separate the tailings and middlings compartments, this barrier having at its top edge fairly close clearance with the belt so that there will be no opportunity for tailings to be carried by water currents into the middlings compartment. The water supplies are preferably so arranged that there will be a slight flow of water past the upper edge of the barrier 32 in a direction toward the tailings compartment.

The magnetic particles on the belt as they pass the pole pieces of alternate polarity, will be rapidly agitated to afford opportunity for non-magnetic particles to fall away from the belt. As the belt passes upwardly in the middlings compartment, the particles thereon may be subjected to the action of additional jets of water as at 33. These jets are preferably more powerful than those at 29 so that middlings particles will be washed off the belt, leaving thereon substantially only those particles which are so strongly magnetic as to be classified as concentrates, and carried up to a discharge point as at 34. The particles on the belt at the region 25 are washed not only by jets as at 33, but just as they emerge vertically up out of the water on the belt, they are further vigorously washed by spray jets at 35 to make doubly sure that all non-magnetic and weakly magnetic particles are washed off. Any concentrates which are washed off, however, will have ample opportunity for being recaptured on the belt by the action of the magnetic fields in the region 25 as above referred to, and these particles will be prevented from dropping down

to the middlings chamber by baffle 36. However, non-magnetic and weakly magnetic particles which may rest on the baffle 36 will be discharged by the turbulence around the jets 33, down into the middlings compartment and finally discharged therefrom through outlet 37.

The upper magnet as at 38 may be formed with an upwardly extended pole piece to insure that the concentrates will be carried on the belt to the discharge point 34, where in view of the absence of a further magnetic field, most of the particles will fall back from the belt into the trough 39 from which they may be washed to one side or the other of the machine as by sprays from pipe 40. The edges of the trough 39 adjacent the belt are provided with flexible lips 41 formed of rubber or some suitable resilient plastic material, so that these lips may rub against the particles on the belt and allow them to pass without dislodging them. Sprays as at 42 may be provided to clean from the belt all material which does not fall therefrom by gravity.

It will be noted that the particles on the belt pass up out of the water in substantially a vertical direction. This assures a very effective separating action as between the concentrates and any remaining non-magnetic material adhering thereto, inasmuch as the surface tension effects at the surface of the water tend to prevent the non-magnetic particles from passing through the surface of the water along the magnetic particles which are abruptly drawn straight up out of the water. Also it will be noted that the point of tangency of the vertical part of the belt with the arcuate portion thereof is substantially at the water level or closely adjacent thereto at a point slightly below, and that the take-off point is substantially as close as possible to this point of tangency, considering the space required for the spray jets 35. This arrangement insures that the vertical stretch portion of the belt will be as short as possible and thus all unnecessary drag and friction on the belt is avoided. It will be understood that with magnetic particles on the outside of the belt, the magnets tend to draw the belt quite firmly toward the magnets so that if the belt stretches are long, the friction may be considerable. This particular arrangement with short vertical stretch portions of the belt facilitates control of the alignment of the belt without subjecting the belt to strong tension and consequently with less friction and wear of the belt on the arcuate walls of the chamber 21. Since this apparatus is particularly adapted for treating ore mixtures which are quite fine and have strongly magnetic particles, any long extended vertical separating zone is not essential and consequently the arcuate wall of the chamber 21 may be positioned with its opposite upper edges extending up beyond the lowest point of the pulley 15, if desired, in the interests of compactness and the shortening of the belt.

In order to facilitate slippage of the belt around the arcuate portion 21, lubricating water may be introduced from a nozzle as at 45 positioned at the point where the belt is about to first engage the arcuate member 21. Further to insure free slippage of the belt, water may be introduced through the arcuate member 21 from pipes on the inside thereof at spaced positions in the manner disclosed in our above-mentioned co-pending application.

At the right hand portion of Fig. 1, a feed arrangement is shown common to the units 12 and 13. This may comprise a feed pipe 46 for the

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mixture to be treated, this pipe discharging into a trough 47 from the sides of which the mixture pours into the region 24 below which a baffle 48 may be positioned for purposes similar to the above-described baffle 28 and accompanied by pipes discharging jets of water as at 49 for purposes similar to the jets 29 above described.

Thus it will be apparent that with the arrangement of the units in a series with alternate units driven in opposite directions, it is convenient to provide at alternate gaps between the units, feeding means and take-off means respectively which are common to a pair of units. This not only enables a series of the units to be conveniently and inexpensively used in connection with a single tank, but also makes possible considerable saving of space due to the fact that each feeding and take-off unit (except for the initial feeding means and the final take-off means) is common to two units. Furthermore, due to the presence of magnetic fields from opposed units at the regions such as at 24 and 25, especially effective separating action is obtained in these regions with no substantial possibility of escape of any concentrates to the tailings or middlings discharge points despite the varied forms of agitation to which the particles may be subjected in regions 24 and 25, and further despite the fact that the particles may be well dispersed for easy separation in these regions in view of the presence of magnets along both sides of the regions. As to such details of construction of the machine of Fig. 1 as have not been hereinabove specifically referred to, reference may be had for a fuller understanding of the invention to our said co-pending application.

Many of the advantages of the arrangements of Fig. 1 may be achieved by the use of drum-type carriers in lieu of belt loops, as shown in Fig. 2. In Fig. 2 each unit comprises non-magnetic metal drums as at 50, 51, 52, which are rotated about fixed axes, alternate drums being rotated in opposite directions as indicated by the arrows, as by motor drive means the same as used for the pulleys in Fig. 1. That is, the drums may be carried on rotatable shafts having drive pulleys as at 53 outside the tank. The magnets within the drums may be mounted upon fixed shafts concentric with the rotatable drum shafts in conventional manner well known in the art of drum separators. Various parts in Fig. 2 which correspond to similar parts in Fig. 1 are identified in Fig. 2 by the same reference characters accompanied by prime marks.

As shown in Fig. 3, the drums may be formed with flanges 54 at their ends which, together with barriers as at 55, 56, 56' at each side of each feed and take-off zone, tend to keep the mixture in position for treatment on the drum surface and prevent it from flowing out at the slime overflow weirs.

So far as we are aware, drum-type separators as heretofore constructed as separately operating units have provided only for the separation of concentrates from the tailings without provision for middlings, except by treating the material first with one drum separator and then again with an independent drum separator. On the other hand, with the arrangement as shown in Fig. 2, it will be apparent that on each treatment of the ore, it may be separated into tailings, middlings and concentrates. At the same time the arrangement of Fig. 2 makes it possible with drum-type separators to take advantage of using feeding means and discharge means which are common to two drums, as well as the compact

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arrangement of a plurality of drums in connection with a single tank structure and with effective cooperative separating action between each succeeding pair of drums. The remaining features of construction and operation of the machine of Fig. 2 will be apparent from the above description of the machine of Fig. 1.

If desired, belts suspended as in Fig. 1 may be applied to the rotating drums of Fig. 2.

While the invention has been described in detail with respect to particular preferred examples, it will be understood by those skilled in the art after understanding the invention that various changes and modifications may be made without departing from the spirit and scope of the invention, and it is intended therefore in the appended claims to cover all such changes and modifications.

We claim:

1. A magnetic separator having in combination a pair of hollow drums, the surface portions of which are movable along an arcuate path downwardly, around and then upwardly, the upwardly moving surface portions of one opposing corresponding upwardly moving portions of the other with a separating region therebetween, means for supporting and driving said drums in opposite directions whereby such opposed surface portions will both move upwardly, a series of magnets arranged along a correspondingly curved path inside each of said drums, a tank constructed and arranged to receive a liquid mixture of magnetic and non-magnetic particles to be separated and to maintain such mixture with a liquid level such as to cause submersion of said downwardly and upwardly moving curved portions of the drums, said series of magnets extending along inside said upwardly moving surface portions to points just above such liquid level, whereby magnetic particles are caused to adhere to said opposed surface portions and be carried thereon up through the liquid surface, means above the liquid level and just above said region for conveying away magnetic particles from said drums, barriers substantially closing off the bottom of said region from the remainder of the tank except for clearance adjacent the drum surfaces, and water jets for agitating the mixture within said region.

2. A magnetic separator having in combination a pair of hollow drums, the surface portions of which are movable along an arcuate path downwardly, around and then upwardly, the upwardly moving surface portions of one opposing corresponding upwardly moving portions of the other with a separating region therebetween, means for supporting and driving said drums in opposite directions whereby such opposed surface portions will both move upwardly, a series of magnets arranged along a correspondingly curved path inside each of said drums, a tank constructed and arranged to receive a liquid mixture of magnetic and non-magnetic particles to be separated and to maintain such mixture with a liquid level such as to cause submersion of said downwardly and upwardly moving curved portions of the drums, said series of magnets extending along inside said upwardly moving surface portions to points above such liquid level, whereby magnetic particles are caused to adhere to said opposed surface portions and be carried thereon up through the liquid surface, and means above the liquid level for conveying away magnetic particles from said drums.

3. A magnetic separator having in combination a pair of hollow drums, the surface portions of which are movable along arcuate paths down-

wardly, around and then upwardly, the upwardly moving surface portions of one opposing corresponding upwardly moving portions of the other with a separating region therebetween, means for supporting and driving said drums in opposite directions whereby such opposed surface portions will both move upwardly, a series of magnets arranged along a correspondingly curved path inside each of said drums, a tank constructed and arranged to receive a liquid mixture of magnetic and non-magnetic particles to be separated and to maintain such mixture with a liquid level such as to cause submersion of said downwardly and upwardly moving curved portions of the drums, said series of magnets extending along inside said upwardly moving surface portions to points above such liquid level, whereby magnetic particles are caused to adhere to said opposed surface portions and be carried thereon up through the liquid surface, means above the liquid level for conveying away magnetic particles from said drums, feeding means for introducing the mixture along the downward portions of said paths, tailings hopper sections of the tank located beneath the latter portions, and a middlings hopper section of the tank located beneath said region.

4. A magnetic separator having in combination a tank constructed and arranged to receive a liquid mixture of magnetic and non-magnetic particles to be separated and to maintain such mixture with a substantially predetermined liquid level, a pair of carriers each with surface portions movable along substantially an arc having its center approximately at the liquid level, such surface portions being movable along said arc downwardly, around and then upwardly, such upwardly moving surface portions of one carrier opposing the corresponding upwardly moving portions of the other with a separating region therebetween, means for supporting and driving said carriers in opposite directions whereby said opposed surface portions will both move upwardly, a series of magnets arranged along a corresponding arcuate path inside each of said carriers, said opposed upwardly moving surface portions being positioned to converge more and more toward each other up to substantially the liquid level, said series of magnets extending along inside said upwardly moving surface portions to a discharge point above the liquid level, and means at such point for conveying away concentrates, the magnetic particles being caused to adhere to said surface portions and be carried thereon up through the liquid surface to such discharge point.

5. A magnetic separator having in combination a tank constructed and arranged to receive a liquid mixture of magnetic and non-magnetic particles to be separated and to maintain such mixture with a substantially predetermined liquid level, a pair of carrier belts each with surface portions movable substantially along an arc having its center approximately at the liquid level, such surface portions being movable along said arc downwardly, around and then upwardly, such upwardly moving surface portions of one belt

opposing the corresponding upwardly moving portions of the other with a separating region therebetween, pulleys for suspending and driving said belts in opposite directions whereby said opposed surface portions will both move upwardly, a series of magnets arranged along a corresponding arcuate path inside each of said belts, said opposed upwardly moving surface portions being positioned to converge more and more toward each other up to substantially the liquid level, said series of magnets extending along inside said upwardly moving surface portions to a discharge point above the liquid level, and means at such point for conveying away concentrates, the magnetic particles being caused to adhere to said surface portions and be carried thereon up through the liquid surface to such discharge point, and barrier means substantially closing off the lower portion of said region from the remainder of the tank except for clearance adjacent the belt surfaces.

6. A magnetic separator having in combination a tank constructed and arranged to receive a liquid mixture of magnetic and non-magnetic particles to be separated and to maintain such mixture with a substantially predetermined liquid level, a pair of carrier belts each with surface portions movable substantially along an arc having its center approximately at the liquid level, such surface portions being movable along said arc downwardly, around and then upwardly, such upwardly moving surface portions of one belt opposing the corresponding upwardly moving portions of the other with a separating region therebetween, pulleys for suspending and driving said belts in opposite directions whereby said opposed surface portions will both move upwardly, a series of magnets arranged along a corresponding arcuate path inside each of said belts, said opposed upwardly moving surface portions being positioned to converge more and more toward each other up to substantially the liquid level, said series of magnets extending along inside said upwardly moving surface portions to a discharge point above the liquid level, and means at such point for conveying away concentrates, the magnetic particles being caused to adhere to said surface portions and be carried thereon up through the liquid surface to such discharge point.

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