Nov. 27, 1923. 1,475,394

F. A. JORDAN

MAGNETIC ORE SEPARATOR

Filed March 22, 1922 2 Sheets-Sheet 1

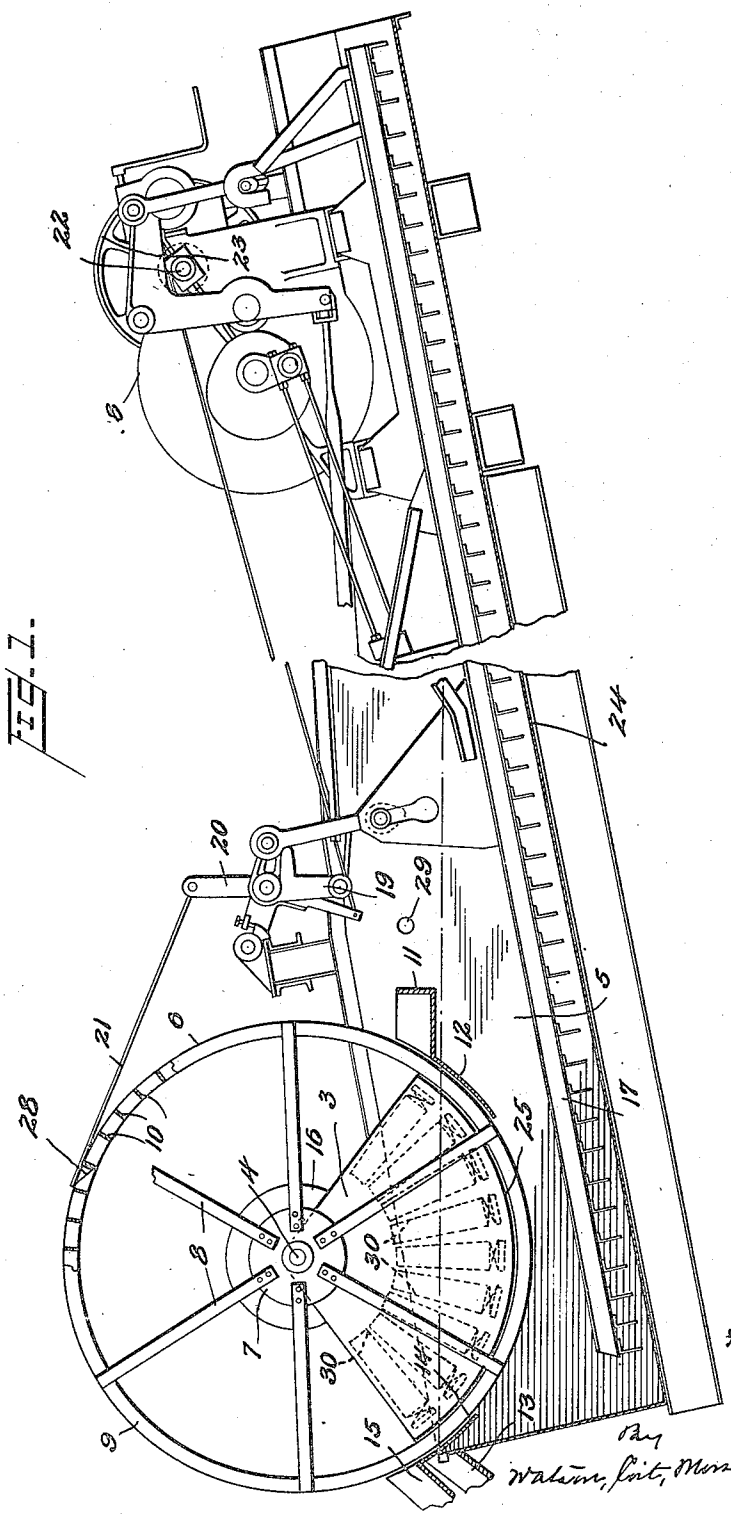


FIG. 1.

Inventor
Fred A. Jordan
By
Watson, Cole, Grindle
Attorneys

Nov. 27, 1923. 1,475,394

F. A. JORDAN

MAGNETIC ORE SEPARATOR

Filed March 22, 1922 2 Sheets-Sheet 2

FIG. 2.

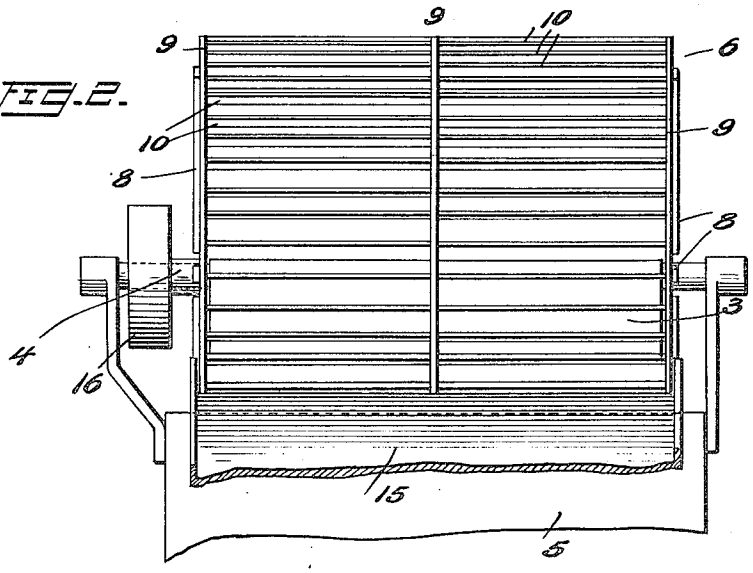
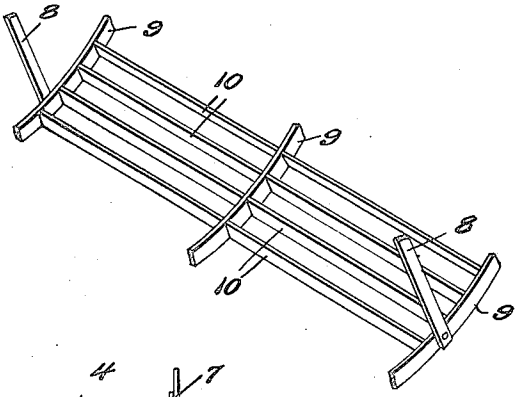


FIG. 3.



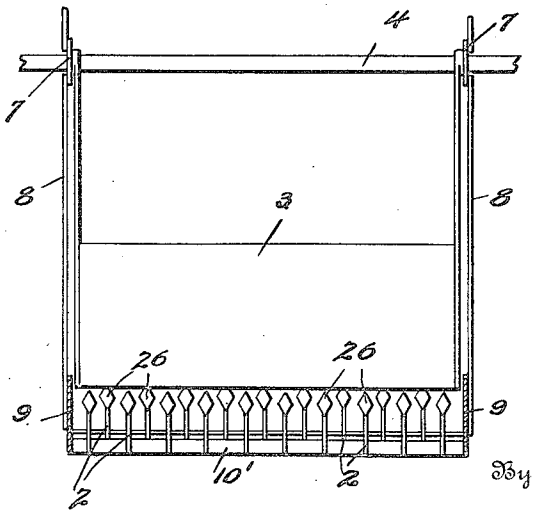


FIG. 4.

Inventor

Fred A. Jordan

By Malcom, Pitt, Morse & Grindle

Attorneys

Patented Nov. 27, 1923. 1,475,394

UNITED STATES PATENT OFFICE

FRED ALLEN JORDAN, OF DULUTH, MINNESOTA.

MAGNETIC ORE SEPARATOR.

Application filed March 22, 1922. Serial No. 545,804.

To all whom it may concern:

Be it known that I, FRED A. JORDAN, a citizen of the United States, residing at Duluth, county of St. Louis, State of Minnesota, have invented certain new and useful Improvements in Magnetic Ore Separators, of which the following is a specification.

In the use of magnetic separators to recover the valuable magnetic material in the ore separate from the gangue, it has been recognized for a long time that in causing the comminuted or ground ore to pass through the magnetic field in contact with the surfaces to which it is desired that the magnetic material shall adhere by magnetic attraction and from which it is desired that the gangue separate and fall by gravity, it is necessary or advisable to agitate the material more or less in order to secure efficient separation. This agitation has heretofore been produced by so winding adjacent magnets in the series generating the magnetic field to which the ore is subjected that their polarity will be opposite and thus through the resulting effect on the magnetic content of the ore there will be relative movement of its particles in effect stirring or agitating the material undergoing treatment permitting non-metallic particles to be detached from the magnetic and separate by gravity. I have found however that this means or method of operation does not produce such agitation of the material as will give the best results in the separation. I have discovered also that the proper agitation to get the best results may be produced mechanically and have discovered that the mechanical stirring and agitation does not result in the separation and loss of the valuable magnetic particles as one would naturally suppose. I have also made the additional surprising discovery that the mechanical stirring and movement of the material may be of such vigorous kind as will serve through a raking or scraping action to move the material along a stationary surface in the magnetic field without loss of valuable magnetic material but on the contrary accomplishing most efficient and complete separation of the gangue from the magnetic material. This mechanical agitation and movement of material undergoing magnetic separation I believe to be broadly new and it may be applied to practical uses in many ways and in many forms of devices and although for purposes of illustration I have shown the invention embodied in a specific form of separator it will be understood that the scope of the invention is not limited beyond what is specified in the claims. It makes it possible to produce entirely satisfactory magnetic separators of various kinds with no moving parts save the mechanical means for raking or moving the material being treated and the numerous and very valuable advantages of this will be apparent to those skilled in the art.

In the particular form of the invention shown for purposes of illustration the material being treated is mechanically moved by the raking or scraping action along and under a stationary surface having a magnetic field from the point of supply downwardly into water where the separation takes place and then upwardly above the water where the magnetic material drops from the surface by gravity beyond the magnetic field and the washing action of the water aids in the separation of the non-magnetic material. The novel features of the invention will be more fully understood from the following description and claims taken with the accompanying drawings. In the drawings:

Fig. 1 is a side view partly in vertical section of an apparatus embodying the invention;

Fig. 2 is an end view from the left in Fig. 1 partly broken away showing the upper edge of the tank, the supporting shaft for the magnetic separator and its rotary cage for stirring and moving the material;

Fig. 3 is a perspective view of a part of the cage for mechanically agitating and moving the material being treated; and

Fig. 4 is a partial longitudinal section of a modified form of cage and scraping means in place on the magnetic separator.

As will be seen by reference to Figure 1 of the drawings, the tank 5 which contains the water used in the operation, has an elongated inclined bottom 24 serving as a closure for one end and is of the type used as the settler tank in the well known Dorr hydraulic classifier. Rakes or scrapers 17 extend along the bottom of the tank and are reciprocated longitudinally and vertically with proper timing to move the coarse or large material in the tank along the bottom to

its upper end and to there discharge it stirring the water and causing the fine material therein to be suspended and to pass out of the tank through the spillway 13 as additional water is admitted to the tank. The means for imparting the reciprocatory motion to the rakes and scrapers is of the well known form used in the Dorr classifiers and needs no specific description. This hydraulic classifier receives the tailings discharged by the magnetic separator dividing and separating the material of different sizes and so far as the present invention is concerned may be of any of the known forms of classifiers in which the water is mechanically agitated. It forms a combination with the present magnetic separator similar to the combination formed with a different separator disclosed and claimed in a companion application signed and executed by me of even date herewith. In both cases the agitation of the water aids the action of the separator and serves to suspend in the water and discharge with the fine non-magnetic material such fine magnetic material as accidentally leaves the separator in the water and in addition separates and discharges the coarse material in the tailings in proper condition for use in making concrete.

The magnetic separator embodying the present invention is arranged across tank 5 near its lower and deeper end and at its discharge side it projects beyond the end of said tank and over a chute 15 into which magnetic material falls by gravity. The separator shown is of the drum type in that the surface along which the material passes within the influence of the magnetic field is on the curve of a cylinder although the surface does not extend entirely around the axis forming a complete cylinder or drum but extends only far enough to form the segment of a cylinder having the length of the magnetic field. It will be obvious however that the stationary drum could be in the form of a complete cylinder while still retaining the functional advantages of the present invention but the upper portion would in that case have little utility and it is preferably omitted as shown. The lower segment is the only operative part in affecting the separation. As shown, the cylindrical drum portion 25 is submerged in the water in the tank 5 between lines near its edges and has segmental end closures 3 making water-tight connection with it and rigidly connected at their upper ends to a fixed shaft 4 the axis of which corresponds to the axis of the semi-cylindrical portion 25. The casing formed by the semi-cylindrical portion 25 and its connections to shaft 4 is made of non-magnetic material such as copper and encloses a series of stationary magnets supported from shaft 4 and so arranged as to create a magnetic field throughout the surface of the semi-cylindrical portion 25 which faces downwardly and under which the material being treated passes. The particular structure and means for mounting the magnets in the casing constitutes no part of the present invention and will be understood by those skilled in the art. It will be seen from the dotted line illustration in Figure 1 that the magnets 30 are arranged radially below the shaft 4 and are rigidly connected to it and the outer ends of their cores are close to the inner surface of the segment 25 and are on the lines of a concentric cylinder.

The crushed ore to be treated containing magnetic material is fed by suitable means not shown to the feed box 11 supported from the sides of the tank 5 slightly above the water level at and parallel to the edge of the segment 25 and having an open side next to that segment with a guard flange 12 depending from the edge of the bottom of the box on a cylindrical curve corresponding to that of the segment 25 but spaced a fixed distance therefrom. The discharge chute 15 for magnetic material has a downwardly inclined bottom wall located beyond the end wall of the tank 5 at the opposite end of segment 25 from feed trough 11 and extending downwardly from the upper end of the bottom of this trough next to the segment there is a guard flange 14 on a cylindrical curve corresponding to the curve of segment 25 but spaced therefrom a distance approximately equal to that of guard flange 12.

The means for stirring and agitating the material undergoing treatment and for causing the crushed ore supplied by feed box 11 to move around the lower surface of the segment 25 through the magnetic field to effect the separation of the magnetic content from the balance of the ore consists of a cylindrical rotating cage 6 having rakes or scrapers moving close to the lower surface of segment 25 throughout its length and making engagement with such material as is on that surface. The cage has circular end supports or shrouds 9 composed of non-magnetic material connected to hubs 7 rotatably mounted on shaft 4 by the series of spokes 8 and in the form shown in Figures 1 to 3 there are longitudinally extending thin strips 10 of non-magnetic material acting as scrapers connected at their ends to the inner sides of the end supports or shrouds 9 at regular intervals around the circumference with their side surfaces in radial planes. The inner edges of the scraper strips 10 move in the path around the segment surface 25 and so close to it as to engage and move the fine material adhering to it as well as the coarse material. Their width is such that their outer edges move close to the adjacent surfaces of the flanges 12 and 14 whereby they will engage the material in

feed box 11 at its inner edge and move a layer of that material down the curved flange 12 and between it and segment 25 and by connection with flange 14 will prevent magnetic material discharged at the end of the magnetic field from accidentally entering the tank and will by the scraping action insure its discharge into chute 15. An additional circular support 9 may be used to connect and steady the scraper strips 10 midway between their ends as shown in Figures 2 and 3. This cage with its scrapers forms an endless conveyor for constantly moving the material being treated through the magnetic field in contact with the magnetized surfaces while the separation takes place. It stirs and agitates the material thus permitting perfect separation of the non-metallic material by the action of gravity.

In Figure 4 means is shown for agitating the material being treated and for moving it through the magnetic field which is different in some respects from that shown in Figures 1 to 3 above described. In this instance the end supports or shrouds 9 of the cylindrical cage like those of Figures 1 to 3 are made of non-magnetic material and have an interior diameter slightly less than the diameter of segment 25 thus slightly overlying its ends but unlike those of Figures 1 to 3 have an exterior diameter materially longer whereby they project a greater distance outwardly. The narrow strips 10′ of non-magnetic material are connected at their ends to the inner sides of shrouds 9 at regular intervals around the circumference with their side surfaces in radial planes and their outer margins substantially in line with the outer margins of the shrouds 9 but with their inner margins a material distance from the surface of segment 25. Rods or handles 2 are secured at regular intervals to strips 10′ and extend inwardly towards the center line of the cage, the inner end of each having a portion 26 flattened in a plane extending longitudinally of the cage forming a plow or scraper with its ends sufficiently close to the surface 25 to engage, agitate and move material adhering to that surface. The rods 2 and their plows or scrapers 26 on one strip 10′ are in staggered relation to those on the next strip 10′ in the series whereby the material will be effectively stirred and that on all parts of the segment 25 will be successively engaged and moved. It will of course be understood that when this arrangement is used the flange 12 on the feed box and the flange 14 on the discharge chute will be on a correspondingly greater radius and a distance from the axis of the cage greater than that shown in Figure 1 by an amount equal to the difference in the outer diameter of the shrouds 9 in Figure 1 and those in Figure 4.

It will be noted that the only moving parts of the separator are those carried by the cage which stirs and moves the material and that the drum surface of the separator along which the material being acted on moves and the magnets generating that field are stationary. This feature embodied in the drum type of separator has many very important advantages over the drum separators heretofore used in which a complete rotary drum surrounding stationary magnets or carried by rotating magnets was necessary. The drum must be comparatively thin and where it rotates its length and diameter is limited whereas with the parts stationary as in the present device more than half of the upper portion of the drum is unnecessary and is preferably omitted and the effective length of the segment remaining and thus the capacity of the machine may be greatly increased. The moving parts likely to get out of order are simple, easily replaced mechanical elements in full view and easily accessible. The thorough mechanical agitation of the material during treatment also secures a much more perfect and satisfactory separation of the valuable magnetic matter from the gangue than was possible heretofore. In the particular forms shown, the washing action of the water due to the mechanical operation of the classifier also aids in securing complete separation.

Rotary movement is imparted to cage 6 by any suitable means driven from any available source of power and that movement may be continuous or intermittent or a reciprocating movement in which the forward movement exceeds the reverse movement. If it is desired to rotate the cage continuously, power may be applied through belt pulley 16 which is connected to hubs 7 by sleeve 27 surounding shaft 4. In the form shown the cage is operatively connected to the mechanism for operating the rakes of the classifier whereby it will be intermittently moved a fixed rotary distance. The well known mechanism 18 for reciprocating vertically and horizontally the rakes 17 by power applied to belt pulley 23 on shaft 22 causes the bell crank lever 19 to oscillate on its horizontal pivot and this is used to move cage 6 by connecting rods 21 pivoted to the upper ends of the upwardly extending arms 20 of the bell cranks 19 and resting at their other ends on the cross strips 10 of the cage next to the shrouds 9 and each having a downward projection 28 forming a shoulder or abutment adapted to engage one side of a strip 10 in moving to the right in Figure 1. The lower surface of the projection 28 extends at an incline to the line of rod 21 to its tip end and this inclined surface engaging the upper edges of the strips 10 moving to the left in Figure 1 by wedging action lifts that end

of the rod and permits the projection 28 to pass over the cross strips 10 to the limit of its movement in that direction. In the reverse movement to the right in Figure 1 the shoulder engaging the strip 10 will draw the cage until that movement ceases.

The comminuted or ground ore to be treated is supplied to the feed box 11 either dry or wet and as it falls, the rear portion of the material next to the segment 25 will be on an incline downward due to gravity to the upper edge of the flange 12 and will travel by a sliding action down that flange into the magnetic field. Water is constantly supplied to the tank 5 by any suitable means at any suitable place such as by pipe 29 and at such rate as to maintain a constant water level indicated by the dot and dash line in Figure 1 and the surplus water constantly overflows through the spillway 13 carrying fine non-magnetic and any fine magnetic material which accidently becomes detached from the surface of the separator. This mixture of fine non-magnetic and magnetic material carried off is of substantially uniform size and may be collected and separately treated in a separator especially adapted for such work. The material passing down the guard plate 12 is engaged by the scrapers on the rotating drum 6 preventing any clogging or agglomerating and those scrapers then move the layer of material forward across the under surface of the drum section 25 with a rolling and tumbling action which thoroughly stirs and agitates the material and disintegrates any small masses adhering together bringing all of the non-magnetic material to the outer layer surface free to fall by gravity during some part of the travel. The washing action of the water also tends to insure perfect separation of the non-magnetic material although it is not necessary and without it the mechanical agitation gives very superior results. This mechanical agitation furthermore provides efficient means for causing those particles containing such a small percentage of magnetic matter as to be worthless or even objectionable mixed with the magnetic product to separate from the surface of the device before the takeoff for magnetic matter is reached. After the cage and its scrapers carry the magnetic material upwardly beyond the edge of the magnetic field it is no longer held magnetically and thus automatically falls by gravity and enters the discharge chute 15. The present invention therefore avoids the necessity for takeoff mechanism having movable parts.

Although one specific embodiment of the invention is shown for purposes of illustration it will be understood that it is not limited to the details shown beyond what is called for in the claims.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A magnetic separator comprising in combination a smooth surface in such position that unrestrained material at said surface will fall therefrom by gravity, means on the upper side only for creating a magnetic field for said surface causing magnetic particles to adhere thereto, means for passing material to be treated downwardly to said magnetic field near the lower side of said surface and means for mechanically stirring and agitating said material while passing through said field.

2. A magnetic separator comprising in combination a stationary smooth surface in such position that unrestrained material at said surface will fall therefrom by gravity, stationary means on the upper side only for creating a magnetic field for said surface causing magnetic particles to adhere thereto, means for passing material to be treated downwardly to said magnetic field near the lower side of said surface and means for mechanically stirring and agitating said material while passing through said field.

3. A magnetic separator comprising in combination a stationary smooth surface in such position that unrestrained material at said surface will fall therefrom by gravity, stationary means on the upper side only for creating a magnetic field for said surface causing magnetic particles to adhere thereto, means for passing material to be treated downwardly to said magnetic field near the lower side of said surface and means for mechanically stirring and agitating said material while passing through said field and for moving the magnetic material still adhering to said surface at the end of its travel through the magnetic field beyond the influence of said field and there discharging it.

4. The combination with a magnetic separator of the type in which the material treated is properly distributed along and continuously passes through the magnetic field in contact with a surface in said field to which the magnetic particles tend to adhere by magnetic attraction and from which the non-magnetic material tends to fall, of means comprising a series of connected plows or scrapers in staggered relation longitudinally for mechanically stirring and agitating all parts of the material adhering to said surface with substantial uniformity and continuously during the operation of the separator and for moving the separated magnetic material to a line beyond the edge of the magnetic field and collecting it.

5. A magnetic separator comprising in combination a stationary portion having a surface of material size adapted to serve as a contact slide for ground ore in such position that unrestrained material in contact with it will tend to fall by gravity, sta-

tionary means creating a magnetic field for said surface tending to cause magnetic particles to adhere to it, means for supplying a layer of material to be treated to said surface at one end of said magnetic field and mechanical means for moving along said surface from said supply to and beyond the opposite end of said magnetic field in succession a series of plows or scrapers in staggered relation on the line of movement in engagement with said material adhering to said surface thereby agitating it and moving it through the magnetic field along said surface.

6. A magnetic separator comprising in combination a stationary portion having a stationary segment of a cylindrical drum the longitudinal lines of which are horizontal and the axis of which is above its central portion, means creating a magnetic field for said segmental surface tending to cause magnetic material to adhere to it, means for supplying comminuted ore to and distributing it along said surface near one side edge and a series of connected plows or scrapers engaging the material adhering to said surface stirring and agitating it and moving it with regular timing from the point of supply across the lower surface of said segment to its opposite edge and there discharging the magnetic material remaining.

7. A magnetic separator comprising in combination a stationary portion having a stationary segment of a cylindrical drum the longitudinal lines of which are horizontal and the axis of which is above its central portion, means creating a magnetic field for said segmental surface tending to cause magnetic material to adhere to it, means for supplying comminuted ore to and distributing it along said surface near one side edge and a series of connected plows or scrapers engaging the material adhering to said surface stirring and agitating it and moving it with regular timing from the point of supply across the lower surface of said segment to its opposite edge and there discharging the magnetic material remaining the said drum segment having water-tight closures at its ends and being partly submerged in water in use.

8. In a device of the class described the combination with a tank of means for maintaining a substantially constant water level therein, a magnetic separator having a stationary downwardly facing surface the central portion of which is below the water level in said tank and the ends above said level, means above said surface creating a magnetic field therefor tending to cause magnetic material to adhere to said surface, an endless conveyor including spaced scrapers close to said surface from end to end engaging and moving material adhering to said surface along said surface and means for supplying comminuted ore containing magnetic material to said surface and conveyor near one end of said surface.

9. In a device of the class described the combination with a tank of means for maintaining a substantially constant water level therein, a magnetic separator having a stationary downwardly facing surface the central portion of which is below the water level in said tank and the ends above said level, means above said surface creating a magnetic field therefor tending to cause magnetic material to adhere to said surface, an endless conveyor including spaced scrapers close to said surface from end to end engaging and moving material adhering to said surface along said surface and means for supplying comminuted ore containing magnetic material to said surface and conveyor near one end of said surface, means for agitating the water in said tank thereby washing the material on the submerged portion of said surface.

10. The combination with a series of stationary magnets having cores arranged radially of a horizontal line extending downwardly therefrom with their lower ends in the lines of a segment of a cylinder having said horizontal line as its center, a stationary segment of a cylindrical drum extending across and close to said lower ends composed of non-magnetic material, a cage of cylindrical outline rotatable on an axis concentric with said horizontal line and having scrapers closely adjacent the surface of said segment agitating and moving material adhering to said surface.

11. The combination with a series of stationary magnets having cores arranged radially of a horizontal line extending downwardly therefrom with their lower ends in the lines of a segment of a cylinder having said horizontal line as its center, a stationary segment of a cylindrical drum extending across and close to said lower ends composed of non-magnetic material, a cage of cylindrical outline rotatable on an axis concentric with said horizontal line and having scrapers closely adjacent the surface of said segment agitating and moving material adhering to said surface, a water tank and means for maintaining a predetermined water level therein, the said drum segment being below the water level between its side edges.

12. The combination with a water tank having an overflow for maintaining a constant water level and means for supplying water thereto, a fixed shaft extending across and above said tank, a stationary drum segment below, suspended from and having a surface concentric with said shaft with its central portion below the water level in said tank the said segment being water-tight, a series of stationary magnets in said segment supported by said shaft and creating a mag-

netic field for said segment, a receptacle for material to be treated discharging towards said segment at one edge above the water level, a cage having a cylindrical outline rotating on said shaft and having scrapers arranged on longitudinal lines engaging, agitating and moving material on the surface of said segment from the supply to its other edge.

13. The combination with a water tank having an overflow for maintaining a constant water level and means for supplying water thereto, a fixed shaft extending across and above said tank, a stationary drum segment below, suspended from and having a surface concentric with said shaft with its central portion below the water level in said tank the said segment being water-tight, a series of stationary magnets in said segment supported by said shaft and creating a magnetic field for said segment, a receptacle for material to be treated discharging towards said segment at one edge above the water level, a cage having a cylindrical outline rotating on said shaft and having scrapers arranged on longitudinal lines engaging, agitating and moving material on the surface of said segment from the supply to its other edge, a downwardly inclined chute at said last mentioned edge for receiving magnetic material carried by said scrapers beyond the magnetic field.

14. The combination with a water tank having an overflow for maintaining a constant water level and means for supplying water thereto, a fixed shaft extending across and above said tank, a stationary drum segment below, suspended from and having a surface concentric with said shaft with its central portion below the water level in said tank the said segment being water-tight, a series of stationary magnets in said segment supported by said shaft and creating a magnetic field for said segment, a receptacle for material to be treated discharging towards said segment at one edge above the water level, a cage having a cylindrical outline rotating on said shaft and having scrapers arranged on longitudinal lines engaging, agitating and moving material on the surface of said segment from the supply to its other edge, a downwardly inclined chute at said last mentioned edge for receiving magnetic material carried by said scrapers beyond the magnetic field, the said discharge chute having a downwardly extending curved guard flange closely fitting the outer edges of said scrapers to aid in discharging the magnetic material.

15. The combination with an hydraulic classifier in which the larger size material is removed by mechanical means which stirs the water and the fine or small material passes off suspended in the overflow, of a drum type magnetic separator partly submerged in the water having a stationary drum surface and mechanical means for moving the material to be separated along the drum surface from the water level on one side to a point above the water level on the other side and stirring and agitating it as it moves.

16. The combination with a drum type magnetic separator partly submerged in water having a stationary magnetized drum surface and mechanical means for moving material to be separated along the drum surface from the water level on one side to a line above the water level on the other side, stirring and agitating it as it moves and discharging the magnetic material beyond the magnetic field.

17. A magnetic separator comprising in combination a smooth surface in such position that unrestrained material at said surface will fall therefrom by gravity, means for creating a magnetic field for said surface causing magnetic particles to adhere thereto, means for passing material to be treated through the magnetic field in contact with said surface and means for mechanically stirring and agitating said material while passing through said field, comprising a series of connected plows or scrapers in staggered relation on the line of movement.

18. A magnetic separator comprising in combination a stationary smooth surface in such position that unrestrained material at said surface will fall therefrom by gravity, stationary means for creating a magnetic field for said surface causing magnetic particles to adhere thereto, means for passing material to be treated through the magnetic field in contact with said surface and means comprising a series of connected plows or scrapers in staggered relation on the line of movement for mechanically stirring and agitating said material while passing through said field and for moving the magnetic material still adhering to said surface at the end of its travel through the magnetic field beyond the influence of said field and there discharging it.

19. A magnetic separator comprising in combination a stationary portion having a stationary segment of a cylindrical drum the longitudinal lines of which are horizontal and the axis of which is above its central portion, means creating a magnetic field for said segmental surface tending to cause magnetic material to adhere to it, means for supplying comminuted ore to and distributing it along said surface near one side edge and a series of connected plows or scrapers in staggered relation on the line of movement for engaging the material adhering to said surface stirring and agitating it and moving it with regular timing from the point of supply across the

lower surface of said segment to its opposite edge and there discharging the magnetic material remaining.

20. A magnetic separator comprising in combination a stationary portion having a stationary segment of a cylindrical drum the longitudinal lines of which are horizontal and the axis of which is above its central portion, means creating a magnetic field for said segmental surface tending to cause magnetic material to adhere to it, means for supplying comminuted ore to and distributing it along said surface near one side edge and a series of connected plows or scrapers in staggered relation longitudinally of the line of movement for engaging the material adhering to said surface stirring and agitating it and moving it with regular timing from the point of supply across the lower surface of said segment to its opposite edge and there discharging the magnetic material remaining the said drum segment having water-tight closures at its ends and being partly submerged in water in use.

In testimony whereof I hereunto affix my signature.

FRED ALLEN JORDAN.