

May 30, 1939.

P. L. STEFFENSEN

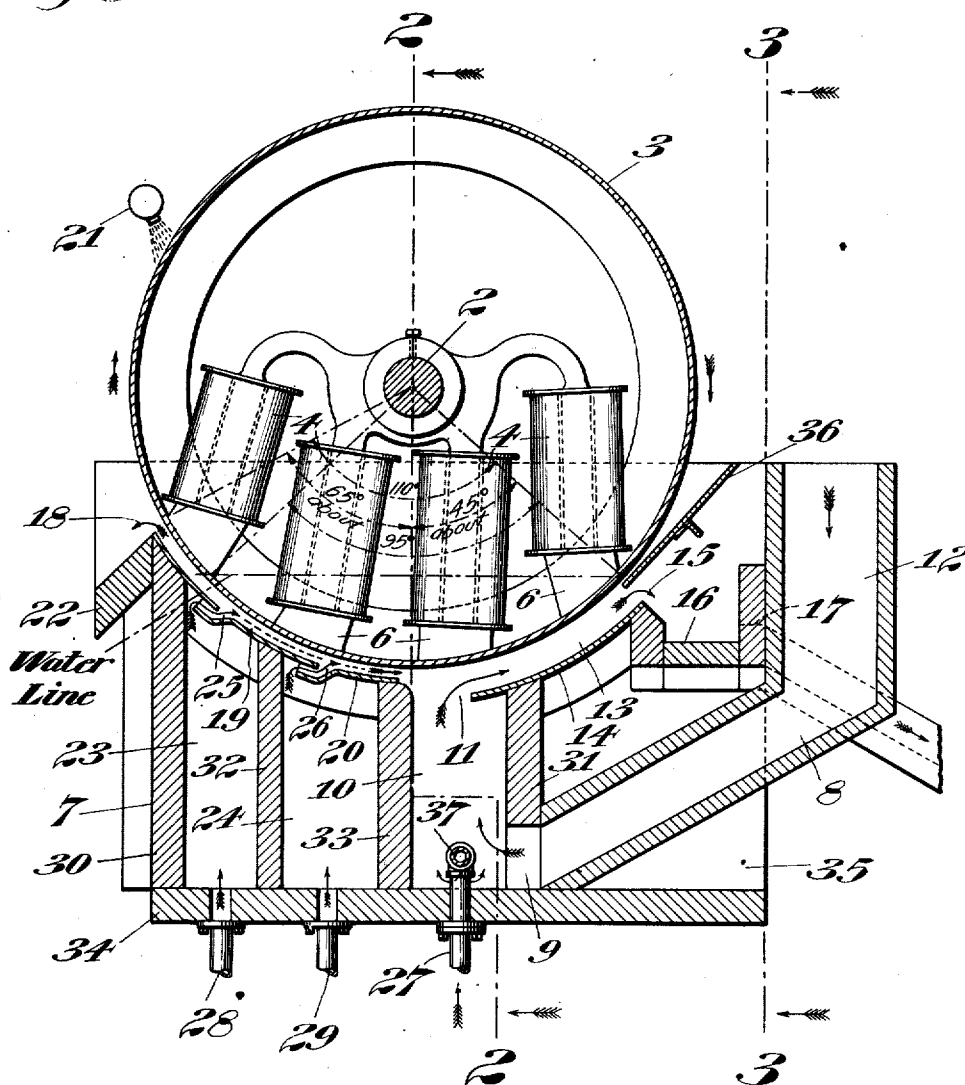
2,160,628

MAGNETIC SEPARATOR

Filed March 3, 1937

3 Sheets-Sheet 1

Fig. 1.



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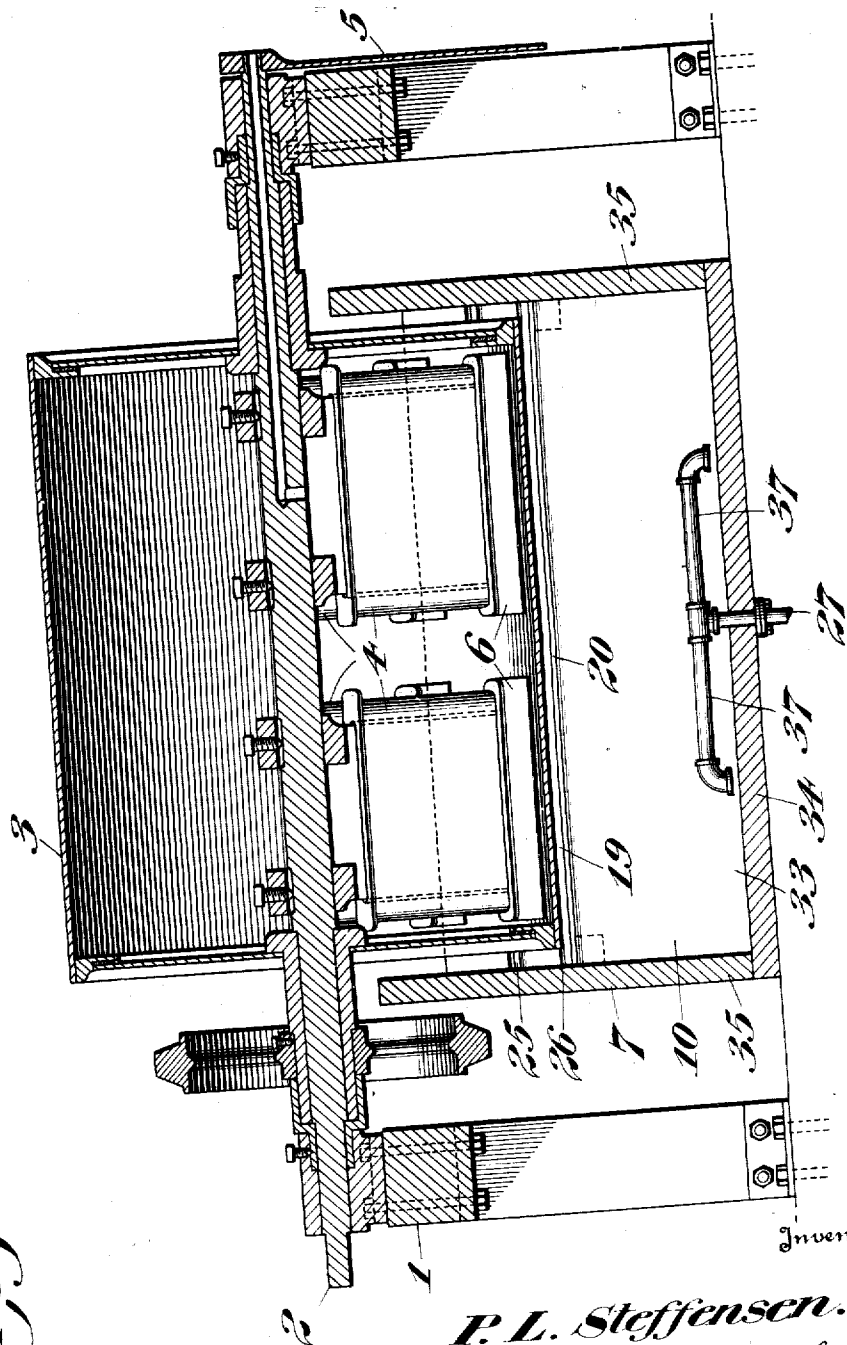
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3 Sheets-Sheet 2

Fig. 2.



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MAGNETIC SEPARATOR

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3 Sheets-Sheet 3

Fig. 3.

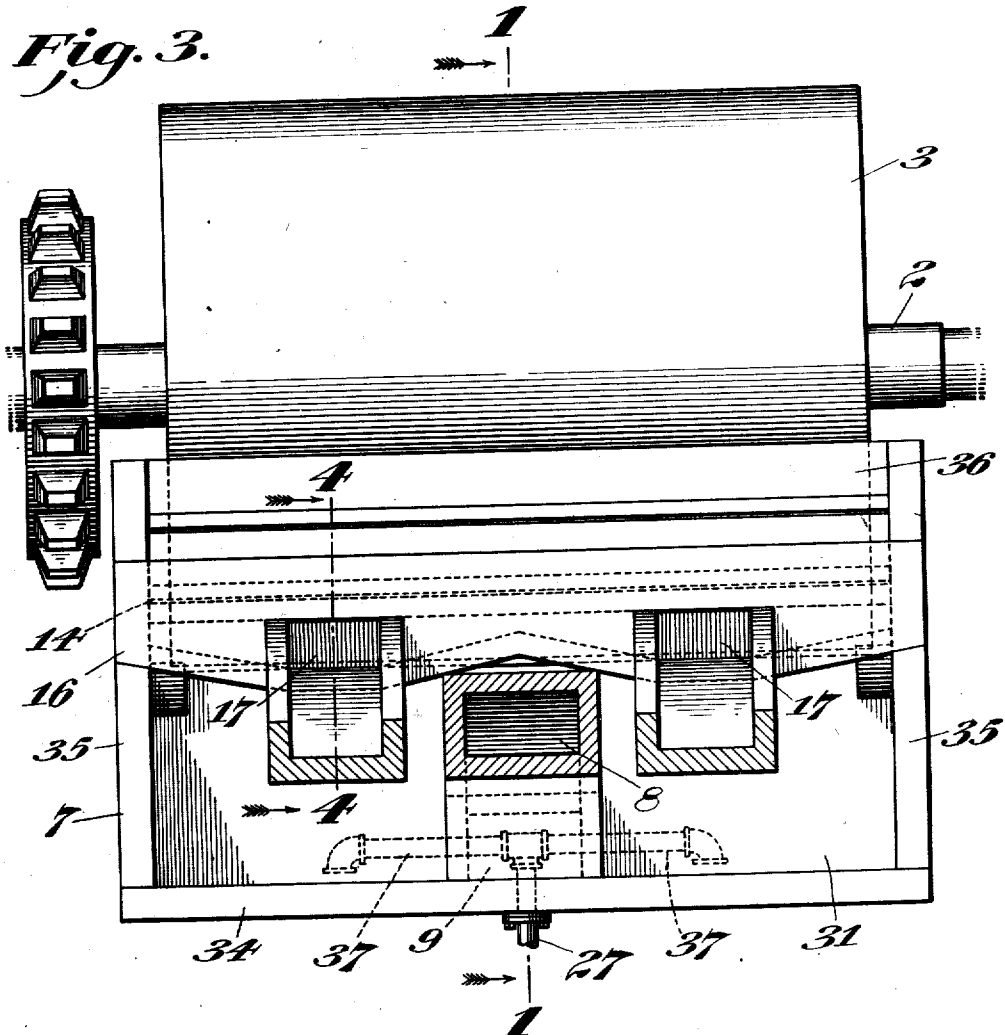
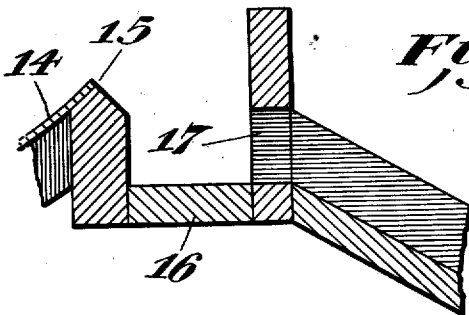


Fig. 4.



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UNITED STATES PATENT OFFICE

2,160,628

MAGNETIC SEPARATOR

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Application March 3, 1937, Serial No. 128,743

21 Claims. (Cl. 209—214)

This invention relates to improvements in apparatus and method for the magnetic separation of pulverized ores such as shown in Patent No. 946,394.

5 Magnetic separators of the above mentioned type are arranged with electro-magnets suspended in a fixed but adjustable position inside a closed revolving non-magnetic drum in such a position that the pole pieces are close to the inside bottom of the drum. The feed, a mixture of water and solids, enters one side of a box in which the bottom outside surface of the drum is in close proximity to the surface of the liquid, and passes over a bridge or wler located approximately at the vertical center line of the drum at a short distance from the outside bottom surface of the drum. In passing over the bridge or wler, the feed is brought within the field of the magnets inside of the drum and consequently the magnetic particles contained in the feed are attracted to and retained on the surface of the revolving drum, which carries them forward separating them from the non-magnetic material in the feed. When using a separator of this type it has become customary to employ two or more drums arranged in series to retreat the concentrates in order to obtain a satisfactory product.

I have modified and improved this arrangement so as to provide for treating finely ground feed, and obtaining in a single drum unit a clean concentrate and tailings very low in magnetic material, thus obtaining a highly efficient operation.

15 In this new type separator, which I have devised, the feed is introduced into the bottom of the feed box close to the vertical axis of the drum under sufficient hydraulic head to cause the feed pulp to flow freely upward and through the magnetic field of the machine without settling out solids. I have found that an inlet six inches to one foot above the level of the tailing overflow is sufficient under ordinary operating conditions. The actual head automatically adjusts itself, depending on the character and volume of feed and on the resistance to flow through the machine.

The feed flows upwardly toward the drum and through a narrow passageway in an elongated stream around the drum to the tailings overflow wler in a direction opposite the rotation of the drum. The magnetic material picked up by the drum is carried along as it revolves in passing from pole to pole of the magnets, the reversal of polarity of the poles causes the magnetic parti-

cles to move among themselves in the well known manner.

The rotation of the drum carries the concentrates away from the tailings discharge to the other side of the machine into a shallow concentrate discharge passage up and out of the magnetic field where they drop off or are washed off the surface of the drum with water sprays onto a discharge chute. Fresh water is supplied under slight pressure to the concentrate discharge passage counter-current to the movement of the concentrates for thoroughly washing the concentrates and diluting and replacing slime which may be carried with the concentrates. The wash water then mixes with the fresh feed for further treatment.

The novel features will be more fully understood from the following description and claims taken with the drawings, in which:

Fig. 1 is a sectional view taken on line 1—1 of Fig. 3.

Fig. 2 is a sectional view taken on line 2—2 of Fig. 1.

Fig. 3 is a sectional view taken on line 3—3 of Fig. 1.

Fig. 4 is a sectional view taken on line 4—4 of Fig. 3.

In the drawings, 1 is a supporting structure for the horizontal shaft 2, on which is revolved in the direction of the arrow a hollow drum 3 of non-magnetic material. Upon this shaft is secured, within the drum, a series of stationary electromagnets 4 so that they may be adjusted rotarily relative to the drum by means of lever 5. The magnet shoes 6 have a spread of approximately 110°, of which, about 45° constitutes the initial pick-up field, and the remaining 65° constituting the washing field for the concentrates. The actual magnetic field, however, is somewhat greater than the spread of the shoes. It will be noted that the bottom portion of the drum is submerged in the bath for about 95° of its circumference, all of which is within the magnetic field of the shoes, thus materially contributing to the high efficiency of the separator. Under the drum is a feed box 7. The feed, a mixture of water and fine solids into which the drum dips, enters one side of the box by means of conduit 8 which introduces the feed into the bottom of the box through opening 9 to a vertical chamber 10 having a restricted opening 11 at its upper end located close to the vertical centerline of the drum. The vertical portion 12 of the feed conduit being of sufficient height so as to produce a hydraulic head on the fluid in the

box thus causing the feed to flow freely upward through a curved pick-up passage 13 of considerable length formed by the surface of the drum and plate 14 to the tailings over-flow or wier 15 into launder 16, hence through openings 17 for disposal.

It will be noted that the outward flow of fluid through passage 13 is in counterdirection to the rotation of the drum. The dimensions of this passage may vary with different conditions of feed pulp. The passage extends through about 45° of the periphery of the drum, all of which is within the magnetic field. This relatively long time in the magnetic field provides ample opportunity for the magnetic material to be very completely removed from the feed.

The magnetic material picked up by the magnets and held against the surface of the drum is carried along by the drum as it revolves, and in passing from pole to pole of the magnets the reversal of polarity of the poles causes the magnetic particles to move among themselves. This movement allows non-magnetic material to drop out. A certain amount of magnetic or weakly magnetic material may fall off but before this can escape with the tailings, it must pass through the pick-up passage with new feed where it will again be picked up by the magnets and carried along with the concentrates. This arrangement in combination with only one outlet for tailings and that within or just beyond the magnetic field and only slightly below the concentrates discharge level 18 is an important feature of this separator as it largely prevents loss of magnetic material in the tailings.

In some previous types of separators part of the tailings are discharged through spigots at the bottom of the box. Any magnetic or weakly magnetic material which escapes from the magnetic field will pass through the spigots and be lost in the tailings since the spigots are beyond the magnetic field.

The rotation of the drum carries the concentrates away from the tailings overflow 15 to the other side of the box and into a relatively shallow but long concentrate discharge passage 19 formed by the under side of the drum and curved non-magnetic plates 20. This passage is also within the magnetic field and provides for cleaning the concentrates on the drum surface which carries them up and out of the magnetic field where they drop off or are washed off the drum by means of water sprays 21 on to discharge chute 22.

The plates 20, which form the bottom of the concentrate discharge passage 19, cover one or more fresh water boxes 23-24 to which fresh water is supplied under slight pressure. Openings 25-26 are provided between the edges of the plates for directing the water downwardly into discharge passage 19 in counter-current to the movement of the concentrates carried through the same passage by the drum. This counter-current flow of fresh water provides for thoroughly washing the concentrates, the fresh water diluting and replacing slime which may be carried with the concentrates. During this final washing, there is, of course, a tendency to wash off some of the magnetic particles but these particles have ample opportunity to be again picked up, combined with new feed, before being lost in the tailings. Fresh water is supplied to compartments 19, 23 and 24 through inlets 27, 28 and 29, respectively. These compartments are defined by the side walls 30 and 31 of the

box and partitions 32 and 33 with bottom 34 and end walls 35.

A guard plate 36 over the tailings overflow wier 15 prevents concentrates, which may be carried over the top of the drum, from falling into the tailings, as it will direct them into the magnetic field and again be picked up by the drum.

Branch pipes 37 are provided for injecting water under pressure into the bottom of chamber 10 so as to dislodge solids which might settle out of the feed pulp and thereby plug up the feed. This is used only when such a condition occurs.

While I have described the separator using a drum and magnets of the Grondal type, the principle of operation could also be used in any other form of wet magnetic separator which would permit the introduction of feed at some intermediate point in the magnetic field; the discharge of the tailings in one direction after the stream has passed through a part of the magnetic field counter-current to a means for conveying the magnetic material pulled out of the stream by the magnets; and the discharge of the magnetic material beyond the magnetic field on the opposite side from the tailings discharge and at an elevation only slightly higher than the tailings overflow level, after the concentrates have been thoroughly washed with clear water while still in the magnetic field. The mixing of the wash water with the incoming fresh feed renders this method of separation highly efficient because all dislodged material picked up in the washing operation undergoes repeated separation which cuts down magnetic loss in the tailings. By my method of separation, a clean and highly concentrated recovery may be effected in but one operation, in contrast to the two cycle separation commonly used.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. In a magnetic separator, the combination with a feed box, of a rotatable drum mounted in said box, a feed chamber for conducting feed to the bottom of the drum, means for supplying feed to said chamber, a tailings overflow positioned above and to one side of said chamber, a concentrates discharge positioned above and at the opposite side of said chamber, and passageways formed by portions of the drum and the box communicating with said chamber and said overflow and discharge.

2. In a magnetic separator, the combination with a feed box, of a rotatable drum mounted in said box, a feed chamber having a vertical discharge opening close to the bottom of the drum, means for supplying feed to said chamber under hydraulic head, a tailings overflow positioned above and in spaced relation to said opening, a concentrates discharge positioned above and at the opposite side of said overflow, and narrow passageways formed by portions of the drum and the box communicating with said opening and said overflow and discharge.

3. In a magnetic separator, the combination with a feed box, of a rotatable drum mounted in said box, a vertical feed chamber having a discharge opening in close proximity to the bottom of said drum, a tailings overflow positioned above and in spaced relation to said opening, a concentrates discharge positioned above and at the opposite side of the box relative to said overflow, an elongated passageway on each side of said chamber formed by portions of the drum and the box communicating with said chamber and

said overflow and discharge, means for supplying feed to said chamber under sufficient head so as to cause an upward flow of feed through one of said passages and over the tailings overflow, and means for rotating the drum counter to said flow.

4. In a magnetic separator, the combination with a feed box, a drum rotatably mounted in said box, a feed chamber having a discharge opening positioned close to the bottom of the drum, a tailings overflow and a concentrates discharge on respective opposite sides of said box, means for forming a pick-up passageway and a concentrates discharge passageway under the drum on respective opposite sides of said feed chamber and communicating therewith, means for supplying feed under hydraulic head to said chamber, and means for supplying fresh water under slight pressure to the concentrates discharge passageway in counter-current to the movement of the concentrates for washing same.

5. In a magnetic separator, the combination with a feed box, of a drum rotatably mounted in said box, a feed chamber having a discharge opening positioned close to the bottom of the drum, a tailings overflow positioned above and to one side of said chamber, a concentrates discharge positioned above said overflow but on the opposite side of said chamber, an elongated passageway on each side of said chamber formed by portions of the drum and box communicating with said chamber and said overflow and concentrates discharge, means for supplying feed to said chamber so as to cause an upward flow of feed through one of said passages and over the tailings overflow, means for rotating the drum counter to said flow, means for supplying fresh water under slight pressure to the other passageway in counter-current to the movement of the drum, and a guard positioned over the tailings overflow close to said drum for preventing concentrates falling into the tailings.

6. In a magnetic separator, the combination with a feed box, of a rotatable drum mounted in said box, a vertical feed chamber having a discharge opening positioned close to the bottom of the drum, means for supplying feed under pressure to the bottom of said chamber, a tailings overflow positioned above and in spaced relation to said opening, a non-magnetic plate for bridging the space between said opening and said overflow and in spaced relation to the outside surface of the drum, a concentrates discharge at the other side of the box relative to said overflow, a non-magnetic plate bridging the space between said concentrates discharge and said feed opening and in closely spaced relation to the outside surface of the drum, a water box under said last mentioned plate, an opening through said plate, and means for supplying water to said box and to said feed chamber.

7. In a magnetic separator, a feed box, a rotatably mounted drum partially submerged in the feed contained in said box, angularly adjustable fixed magnets within said drum, an elongated pick-up passage under said drum and within the field of said magnets and terminating in a tailings overflow at one side of the box, an elongated concentrates discharge passage under said drum opposite said overflow, said concentrates passage being within the magnetic field, means for producing a flow of feed through said pick-up passage around said drum in counterdirection to the direction of rotation of said drum, and means for supplying a stream of wash water to said con-

centrates discharge passage in counterdirection to the rotation of said drum.

8. In a magnetic separator, a feed box, a rotatably mounted drum partially submerged in the feed contained in said box, fixed means adjustably mounted within said drum for producing a magnetic field outside of said drum, means for producing an upward flow of feed around and close to the bottom surface of said drum through less than one half of said magnetic field and in a direction opposite to the direction of travel of the bottom of said drum to a tailings overflow whereby concentrates are picked up and carried by the drum, a narrow passage around and close to the bottom surface of said drum extending through the remaining portion of said magnetic field and through which the concentrates carried by the drum must pass, means for washing said concentrates in their travel through said passage, means for removing substantially all of said concentrates from the drum after emerging from said passage, and means for preventing concentrates not removed from the drum from escaping with the tailings.

9. In a magnetic separator, a series of stationary magnets associated with each other to produce a fixed magnetic field, successive sections of which have opposite polarity, a conveyor cooperable directly with the poles of said magnets and movable through said field to move a thin layer of mixed magnetic and non-magnetic particles along said field, a feed box containing a bath of feed pulp within which one end portion of said field is disposed substantially at the surface level of said bath and the other end of said field being disposed above said level, means for introducing said feed at a point intermediate of said field and causing same to flow in an elongated stream opposite to the movement of said conveyor, means for removing magnetic particles at one end of said field in the direction of travel of said conveyor, means for removing non-magnetic particles at the other end of said field in counter direction of travel of said conveyor, and means for washing said magnetic particles before removal from said bath.

10. In a magnetic separator, a series of angularly adjustable, stationary magnets associated with each other to produce a fixed magnetic field, successive sections of which have opposite polarity, a conveyor cooperable directly with the poles of said magnets and movable through said field to move a thin layer of mixed magnetic and non-magnetic particles along said field, a feed box containing a bath of feed pulp within which one end portion of said field is disposed substantially at the surface level of said bath and the other end of said field being disposed above said level, said conveyor contacting said bath for substantially 25 per cent of its periphery, means for introducing feed at the lowest point of said conveyor and causing same to flow around substantially 12 per cent of the effective surface of said conveyor in a thin stream, means for removing magnetic particles at one end of said field in the direction of travel of said conveyor, means for discharging non-magnetic particles at the opposite end of said field in counter direction of travel of said conveyor, means for washing said magnetic particles before removal from said bath, and means for mixing said wash with fresh feed at its point of initial contact with said conveyor.

11. In a magnetic separator, a series of angularly adjustable, stationary magnets associated with each other to produce a fixed magnetic field,

successive sections of which have opposite polarity, a drum cooperable directly with the poles of said magnets and movable through said field to convey a thin layer of mixed magnetic and non-magnetic particles along said field, a feed box containing a bath of feed pulp within which one end portion of said field is disposed substantially at the surface level of said bath and the other end of said field being disposed above said level, said drum being submerged in said bath for substantially 90 degrees of its circumference, means for supplying feed to said drum at its lowest point and causing same to flow upwardly and around substantially 45 degrees of its effective surface, means for removing magnetic particles at one end of said field in the direction of rotation of said drum, means for discharging non-magnetic particles at the opposite end of said field in counter direction of rotation of said drum, means for washing magnetic material carried by said drum with a thin stream of water before said material is removed from said bath, and means for introducing said wash water into fresh feed adjacent the point where the feed first contacts the drum.

12. The method of separating magnetic material from non-magnetic material, comprising producing a feed pulp of water and solids to be treated, passing said feed through a magnetic zone so as to separate the magnetic material from the non-magnetic material, collecting the separated magnetic material on a moving body and disposing of the non-magnetic material contained in said feed, removing the separated magnetic material from the zone of separation in concentrated form to another magnetic zone, passing said concentrates through a shallow stream of fresh wash water flowing in a direction opposite to the travel of said concentrates, then removing the concentrates from the magnetic zone and returning the magnetic material separated from the concentrates during the washing operation directly to the first separating zone and out of contact with the previously treated non-magnetic material for subsequent recovery.

13. The method of separating magnetic material from non-magnetic material, comprising producing a feed pulp of water and solids to be treated, flowing said feed through a magnetic zone so as to separate the magnetic material from the non-magnetic material, collecting the separated magnetic material on a non-magnetic moving body passing through said field and disposing of the non-magnetic material contained in said feed, moving the collected magnetic material in concentrated form to another portion of said magnetic zone in which the concentrates are washed by a shallow stream of fresh water flowing counter to the movement of the concentrates, then removing the washed concentrates from the magnetic zone and flowing said wash water uncontaminated by contact with the previously treated non-magnetic material directly to the first separating zone for recovery of the magnetic material contained in said wash water.

14. The method of efficiently separating magnetic material from non-magnetic material in a single operation, comprising producing a feed pulp of water and solids to be treated, flowing said feed through a magnetic field of fixed range so as to induce separation of the magnetic material from the feed, concentrating the separated magnetic material on the surface of a non-magnetic moving body passing through said field and disposing of the tailings at the feed end of said field, moving the collected material to another

portion of said field in which the concentrates are washed with fresh water flowing in counter direction to the movement of the concentrates and in an elongated stream held in intimate contact with said moving body, flowing said wash water uncontaminated by contact with the previously treated non-magnetic material to the initial field of separation for recovery of magnetic particles carried in said water, and removing the washed concentrates from the washing stream for final recovery.

15. The method of separating magnetic material from non-magnetic material, comprising producing a feed pulp of water and finely ground material to be treated, flowing said feed through a magnetic field so as to induce separation of the magnetic material from the non-magnetic material, collecting the magnetic material on a non-magnetic body moving through said field, disposing of the greater portion of the non-magnetic material produced by said separation in the form of fluid tailings, moving the collected magnetic material in concentrated form to another portion of said field and washing the concentrates by an elongated stream of fresh water flowing counter to the movement of the concentrate and in intimate contact therewith, mixing said wash water uncontaminated by contact with the previously treated non-magnetic material with fresh feed for further separation of magnetic material contained in the wash, and removing the washed concentrates from said washing stream for final recovery at the end of the magnetic field.

16. The method of separating magnetic material from non-magnetic material in a single operation, comprising producing a feed pulp of water and solids to be treated, flowing said feed through a pick-up zone of a magnetic field for effecting separation of the magnetic material from the non-magnetic material and collecting the magnetic material on a moving body passing through said field, disposing of the non-magnetic material separated from the magnetic material, transferring said magnetic material to another zone of said field devoted principally to a washing operation, washing the magnetic material with fresh water in said second zone and introducing said wash water uncontaminated by contact with the previously treated feed directly into said pick-up zone for further treatment in combination with fresh feed, and removing the washed magnetic material from the magnetic field for final recovery.

17. The method of separating magnetic material from non-magnetic material, comprising providing a feed pulp of water and solids to be treated, flowing said feed pulp through a zone in a magnetic field in a shallow, elongated path thereby separating the magnetic material from the non-magnetic material, collecting the magnetic material on a body moving through said magnetic field, disposing of the material not so collected, transferring said magnetic material into another zone in said field, washing said magnetic material with fresh water in said other zone, removing the washed magnetic material and transferring the wash water out of contact with the previously treated non-magnetic material to the first mentioned zone for further magnetic separation treatment.

18. The method of separating magnetic material from non-magnetic material, comprising providing a feed pulp of water and solids to be treated, introducing said feed pulp into a mag-

netic field at a point intermediate the ends of said field, flowing said pulp towards one end of said field, separating the magnetic material from the non-magnetic material, collecting the separated magnetic material on a body moving through said magnetic field in a direction opposite to the flow of the pulp, moving the collected magnetic material into another portion of said magnetic field, washing said collected magnetic material by means of a stream of water flowing in a direction opposite to that of the collected magnetic material and flowing the wash water out of contact with the previously treated non-magnetic material into the stream of feed pulp for further magnetic treatment.

19. In a magnetic separator, the combination with a feed box, of a rotatable drum mounted in said box, means for creating a magnetic field upon the bottom of said drum, a feed chamber for conducting feed to the bottom of the drum, means for supplying feed to said chamber, a tailings overflow positioned above and to one side of said chamber, a concentrates discharge positioned above and at the opposite side of said chamber, and passageways formed by portions of the drum and the box communicating with said chamber and said overflow and discharge.

20. In a magnetic separator, the combination

with a feed box, of conveying means mounted in said box, a feed chamber for conducting feed to the bottom of the conveying means, means for supplying feed to said chamber, a tailings overflow positioned above and to one side of said chamber, a concentrates discharge positioned above and to one side of said chamber, a concentrates discharge positioned above and at the opposite side of said chamber, and passageways formed by portions of the conveying means and the box communicating with said chamber and said overflow and discharge.

21. In an apparatus for separating materials, the combination with a feed box, of a rotatable drum mounted in said box, means associated with said drum for separating the desired material from the refuse associated therewith, a feed chamber for conducting feed to the bottom of the drum, means for supplying feed to said chamber, an overflow for refuse positioned above and to one side of said chamber, a discharge for the desired material positioned above and at the opposite side of said chamber, and passageways formed by portions of the drum and the box communicating with said chamber and said overflow and discharge.

PERCY LEA STEFFENSEN.

CERTIFICATE OF CORRECTION.

Patent No. 2,160,628.

May 30, 1939.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 5, second column, lines 6 and 7, claim 20, strike out the words and comma "a concentrates discharge positioned above and to one side of said chamber,"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 4th day of July, A. D. 1939.

(Seal)

Henry Van Arsdale
Acting Commissioner of Patents.

netic field at a point intermediate the ends of said field, flowing said pulp towards one end of said field, separating the magnetic material from the non-magnetic material, collecting the separated magnetic material on a body moving through said magnetic field in a direction opposite to the flow of the pulp, moving the collected magnetic material into another portion of said magnetic field, washing said collected magnetic material by means of a stream of water flowing in a direction opposite to that of the collected magnetic material and flowing the wash water out of contact with the previously treated non-magnetic material into the stream of feed pulp for further magnetic treatment.

19. In a magnetic separator, the combination with a feed box, of a rotatable drum mounted in said box, means for creating a magnetic field upon the bottom of said drum, a feed chamber for conducting feed to the bottom of the drum, means for supplying feed to said chamber, a tailings overflow positioned above and to one side of said chamber, a concentrates discharge positioned above and at the opposite side of said chamber, and passageways formed by portions of the drum and the box communicating with said chamber and said overflow and discharge.

20. In a magnetic separator, the combination

with a feed box, of conveying means mounted in said box, a feed chamber for conducting feed to the bottom of the conveying means, means for supplying feed to said chamber, a tailings overflow positioned above and to one side of said chamber, a concentrates discharge positioned above and to one side of said chamber, a concentrates discharge positioned above and at the opposite side of said chamber, and passageways formed by portions of the conveying means and the box communicating with said chamber and said overflow and discharge.

21. In an apparatus for separating materials, the combination with a feed box, of a rotatable drum mounted in said box, means associated with said drum for separating the desired material from the refuse associated therewith, a feed chamber for conducting feed to the bottom of the drum, means for supplying feed to said chamber, an overflow for refuse positioned above and to one side of said chamber, a discharge for the desired material positioned above and at the opposite side of said chamber, and passageways formed by portions of the drum and the box communicating with said chamber and said overflow and discharge.

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