

July 28, 1942.

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2,290,892

WET MAGNETIC SEPARATION

Filed Nov. 15, 1940

2 Sheets-Sheet 1

FIG. 3.

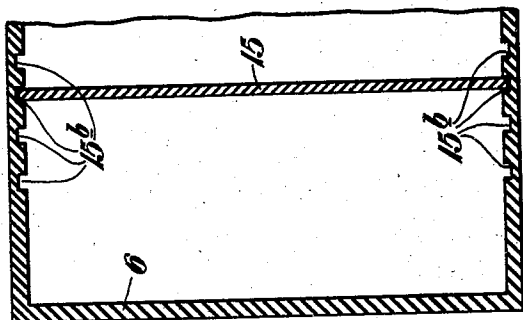
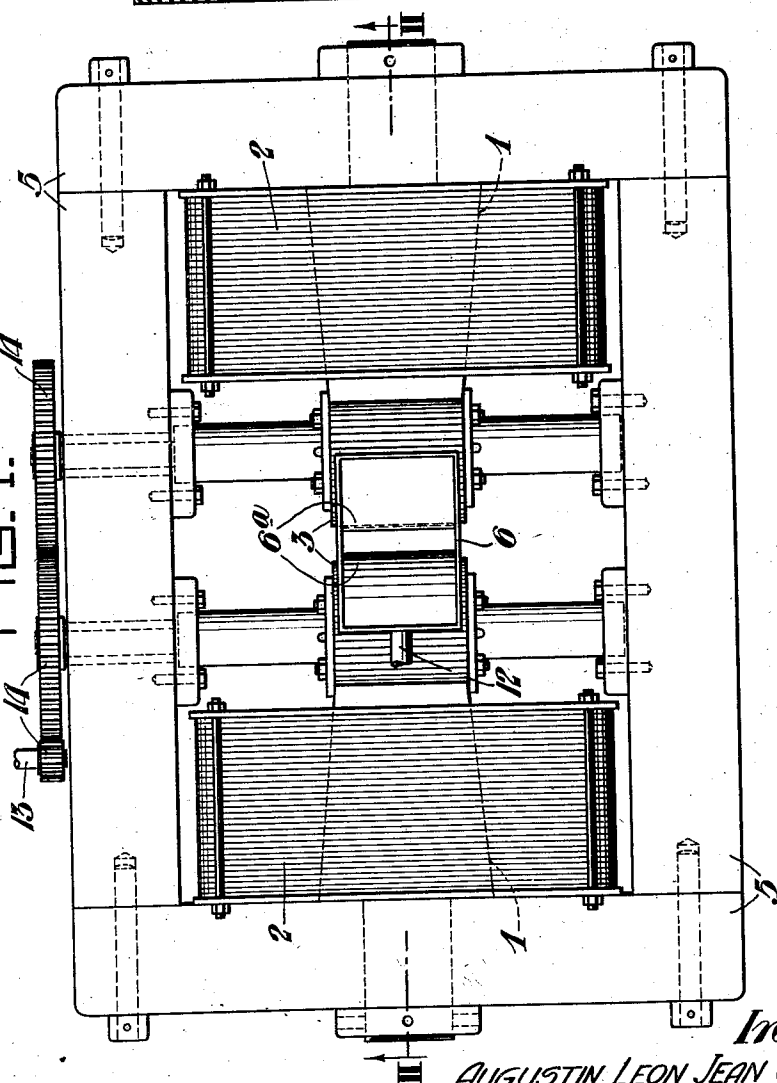


FIG. 1.



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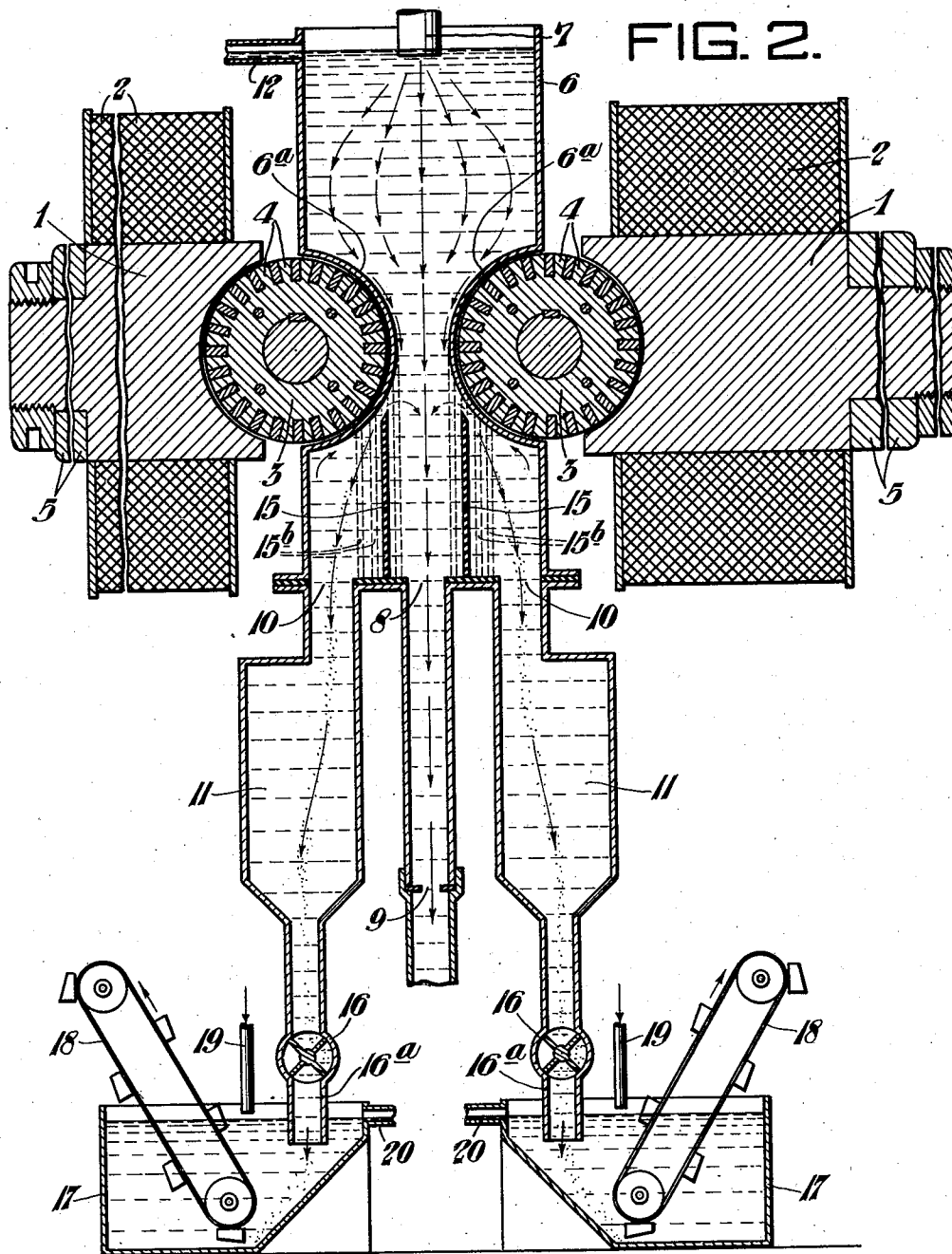
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WET MAGNETIC SEPARATION

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Application November 15, 1940, Serial No. 365,837

3 Claims. (Cl. 209—214)

This invention is particularly concerned with concentrating lean ore containing a feebly magnetic mineral such as hematite mixed with relatively nonmagnetic material, when the concentrating is effected by the wet magnetic separation of the feebly magnetic mineral from the relatively nonmagnetic material. However, the principles of the invention may be applied whenever the magnetic concentrates obtained by the wet magnetic separation method from a mixture of relatively magnetic and nonmagnetic particles include such a high percentage of the nonmagnetic particles as to render the separation impractical, it being obvious, however, that this problem is more troublesome when the relatively magnetic particles are of low magnetic permeability.

A specific example of a wet magnetic separator constructed to operate in accordance with the invention is illustrated by the accompanying drawings, the various figures being as follows:

Figure 1 is a top view.

Figure 2 is a vertical section on the line II—II in Figure 1; and

Figure 3 is an enlarged horizontal section of a detail.

More specifically, these drawings show opposed poles 1 magnetically energized by solenoids 2 and provided with revolving pole pieces 3 working in line with the magnetic field about horizontal axes and provided with radial extensions 4. There is a gap between the extensions 4 of the respective pole pieces 3, but except for this the magnetic circuit is closed by a yoke 5, the arrangement of the entire magnetic system being such as to produce a concentrated magnetic field between the opposing extensions of the respective revolving pole pieces, this field varying from a maximum when the extensions are substantially horizontal to a minimum when the extensions are substantially vertical.

A vertical separator box 6 extends down between the extensions 4 of the revolving pole pieces 3, this box having arcuate recesses 6^a in which the pole pieces with their extensions work, this arrangement permitting a relatively small gap between the extensions 4 and permitting the attainment of a magnetic field of the proper concentration to work on feebly magnetic material such as hematite. A wet pulp of the ore or other mixture to be concentrated is introduced to the top of the box 6 by way of an inlet 7, the bottom of the box below the magnetic field having a central outlet 8 through which the tailings constantly flow under the control of an orifice

plate 9, and side outlets 10 leading to concentrates-collecting chambers 11. The top of the box 6 is open and is provided with an overflow 12, the wet pulp being introduced at a rate respecting the rate of flow permitted by the orifice plate 9, to build up a head in the box 6 to the extent permitted by the position of the overflow 12.

In operation, assuming the wet pulp to be in the box 6 at a level dictated by the overflow 12, downward revolution of the pole pieces 3 effected in the case of the illustrated machine by driving the shaft 13 working the pole pieces 3 through a gear train 14, causes the relatively magnetic material to be drawn transversely outwardly from the pulp stream flowing through the gorge between the recesses 6^a and dropped oppositely outwardly, the tailings continuing to flow downwardly so as to eventually leave by way of the orifice plate 9. It is to be understood that this separation of the magnetic concentrates is effected by reason of the concentrated magnetic fields which revolve downwardly from the gorge through which the pulp flows and gradually decrease in strength until they reach a minimum sufficient to permit the concentrates to fall. Separation of the concentrates flows from the tailings flow is accomplished by baffles 15 which vertically divide the lower portion of the box 6 and extend to adjacent the recesses 6^a as required to leave adequate space for the concentrates flow.

In the operation of this separator and of other wet magnetic separators of an equivalent type, a problem is presented in that too high a percentage of the relatively nonmagnetic material separates from the pulp stream along with the relatively magnetic particles into the concentrates flow. Efforts have been made to exclude the nonmagnetic particles by introducing liquid to either the collecting chamber 11 or the lower portions of the box 6 inside the baffles 15, for the purpose of creating counterflows of liquid leaving the spaces between the tops of the baffles 15 and the recesses 6^a of the box, it thus being necessary for the concentrates to flow against this liquid counterflow. The idea is that this will exclude the relatively nonmagnetic particles so that more will be carried away with the tailings, as they should be. This practice has not met with success.

The present invention is characterized in that the liquid columns confined by the collecting chambers 11 and all other portions of the equipment up to the spaces between the tops of the baffles 15 and the box recesses 6^a, are maintained

static in the sense that no withdrawal of either liquid or concentrates is permitted which will produce an exiting flow, nor is any additional liquid introduced in the manner just previously discussed. However, the orifice plate 9 remains so that there is a gravitational pulp flow through the gorge of the box 6 with the static liquid columns to either side of this pulp flow and communicating with the latter by way of the spaces between the baffle tops and the box recesses, these spaces being hereinafter considered as entrances to the static liquid columns.

Now, when the pole pieces are revolved while the pulp is flowing through the box gorge under the influence of the head dictated by the overflow 12, magnetic concentrates are separated in the form of flows traveling through the entrances to the static liquid columns, the concentrates flows displacing the liquid, rendering the static columns dynamic and producing counterflows out from the entrances which, being restricted, function as orifices and most effectively exclude nonmagnetic particles since the liquid counterflows opposing the entrance of the concentrates flows to the previously static columns are of exactly balanced volume respecting the concentrates flows. Furthermore, by properly restricting the size of the entrances, as by adjusting the heights of the baffles 15, the areas of the entrances to the otherwise static columns can be correlated to the entering concentrates flows so that the liquid counterflows and the concentrates flows have the same velocities.

It might be mentioned at this point that the baffles 15 are removable so that they can be substituted by others of different heights, and their positions are adjustable horizontally as indicated by the broken lines in the drawings, the lower portion of the box 6 being provided with a series of grooves 15^b for receiving the baffles. The exact heights and horizontal position of the baffles 15 can be determined only by experience, their adjustment being but one of the many variables that can be adjusted in the case of the separator disclosed herein.

The other variables mentioned above include the pulp density, which is determined by the proportioning of the liquid and the ground ore or other mixture of materials; the velocity of the flowing pulp through the box gorge, which is determinable by the size of the orifice in the orifice plate 9; the speed of the downwardly and transversely outwardly revolving magnetic field which is determined by the revolving speed of the pole pieces 3; the correlation between the moving speed of the pulp as compared to the revolving speed of the magnetic field; and the concentration of the magnetic field, which is determined by the current in the solenoids 2 and the size of the magnetic gap between which the pulp flows. These are in addition to the adjustment of the horizontal positioning of the baffles 15 and their heights, the latter determining the sizes of the entrances to the static columns and hence determining the velocities of the counterflows when the static columns are rendered dynamic upon displacement of their liquid by the concentrates flows.

It is necessary from time to time to remove concentrates that have collected from the bottoms of the collecting chambers 11. In accordance with the invention, this is done so that as the concentrates are removed, equal volumes of liquid are introduced into the collecting chambers, whereby to preserve the balance between

the counterflows being ejected from the entrances into the pulp flows so as to travel with the tailings, and the incoming concentrates flow.

With the above in mind, the exits to the collecting chambers 11 are in the form of rotating box valves 16 emptying through pipes 16^a into liquid in tanks 17 from which the concentrates are ultimately removed by bucket conveyors 18 of the continuous type. Liquid is constantly introduced into tanks 17 by way of pipes 19, the liquid constantly overflowing through overflows 20 and the liquid levels thereby being maintained in the tanks 17. With this arrangement, rotation of one of the boxes of one of the valves 16 which is filled with concentrates causes these concentrates to dump through the pipe 16^a into the liquid in the tank 17, the liquid rising and filling this box so that when it is ultimately returned to a concentrates receiving position it is filled with liquid which is displaced into the collecting chamber with which the valve is in connection. In this way the two liquid columns on either side of the tailing flow are maintained under static conditions except for the liquid movement caused through displacement by the entering concentrates flow.

Experience has shown that once the various variables are set, the magnetic concentrates separate from the pulp with a much lower percentage of nonmagnetic particles of material which properly belong in the tailings than can possibly be attained when the counter flows are created by the constant introduction of liquid, regardless of what care is taken in regulating this introduction. However, it is conceivable that some of the advantages of this invention might be attained by carefully balancing the introduction of liquid as compared to the entering concentrates flow to provide a balanced counterflow for these concentrates. In practical work this balancing is impossible except by rendering static the columns of liquid into which the magnetic concentrates fall and permitting the counterflows to be caused solely by the concentrates displacing the liquid in these otherwise static columns.

I claim:

1. A wet magnetic separation method including producing a gravitationally flowing column of a mixture of relatively magnetic and nonmagnetic particles in liquid, producing a static column of liquid with an opening transversely communicating with said flowing column, magnetically drawing a magnetic concentrates flow from said flowing column through said opening into said static column and rendering said static column dynamic solely by allowing said concentrates flow to gravitationally displace liquid therefrom into said flowing column through said opening, thereby causing said concentrates flow to enter said opening through a liquid counterflow in substantial volumetric balance therewith, the size of said opening and the volume of said concentrates flow being correlated to cause said counterflow to exclude tailings from said concentrates flow through said opening.

2. A wet magnetic separation method including producing a gravitationally flowing column of a mixture of relatively magnetic and nonmagnetic particles in liquid, producing a static column of liquid with an opening transversely communicating with said flowing column, magnetically drawing a magnetic concentrates flow from said flowing column through said opening into said static column and rendering said static

column dynamic solely by allowing said concentrates flow to gravitationally displace liquid therefrom into said flowing column through said opening, thereby causing said concentrates flow to enter said opening through a liquid counterflow in substantial volumetric balance therewith, the size of said opening and the volume of said concentrates flow being correlated to cause said counterflow to exclude tailings from said concentrates flow through said opening, collected concentrates being removed from the second named liquid column while simultaneously substituting an equal volume of liquid.

3. A wet magnetic separation method for concentrating lean ore containing a desired feebly magnetic mineral and relatively nonmagnetic undesired material, said method comprising forming said ore into a wet pulp; producing a

gravitationally flowing column of said pulp, producing a static column of liquid with an opening transversely communicating with said flowing column, creating a concentrated magnetic field that repeatedly cuts said flowing column transversely and revolves downwardly through said opening while reducing in force, thereby drawing concentrates of said mineral through said opening into the second named column and producing a counterflow through said opening by displacement action, the second column being rendered dynamic solely by said displacement, maintaining said opening at a size causing said counterflow to have a velocity excluding tailings of said material therefrom and removing concentrates from the second named column while simultaneously adding equal volumes of liquid.

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