Aug. 9, 1955 M. V. MIELKE 2,714,959

WET ELECTROMAGNETIC SEPARATOR AND METHOD

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FIG. 1.

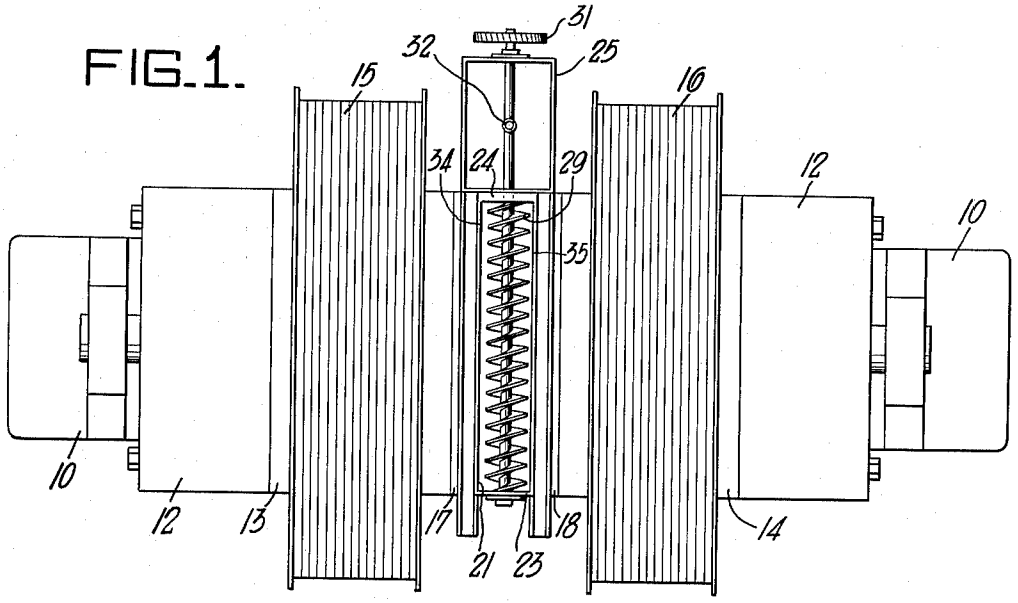
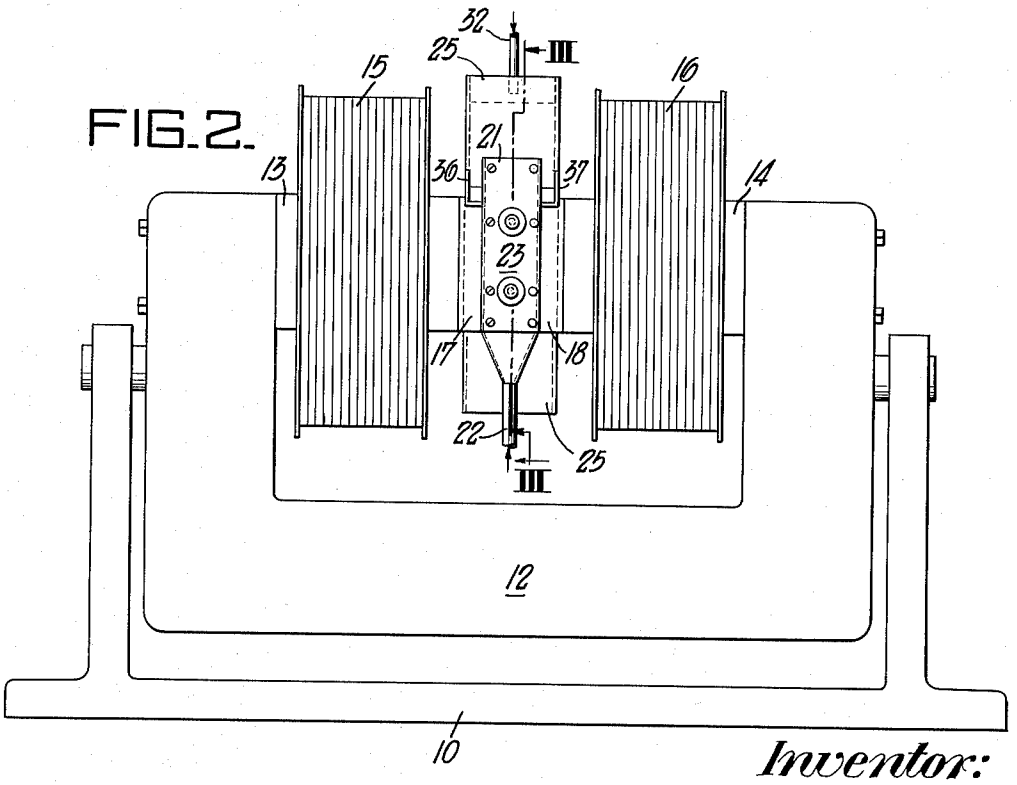


FIG. 2.



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FIG. 3.

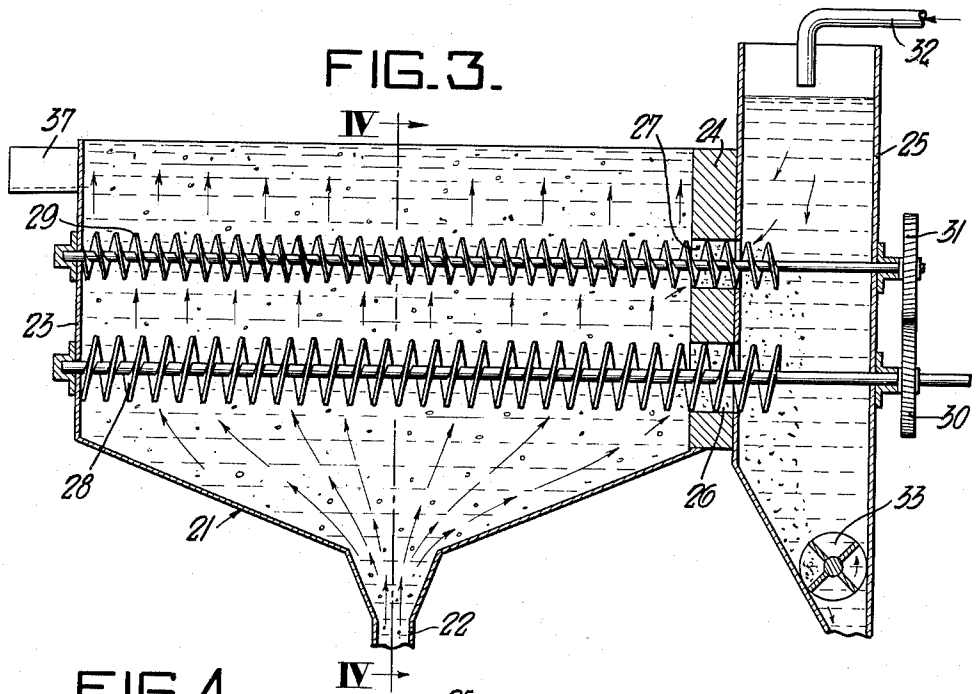
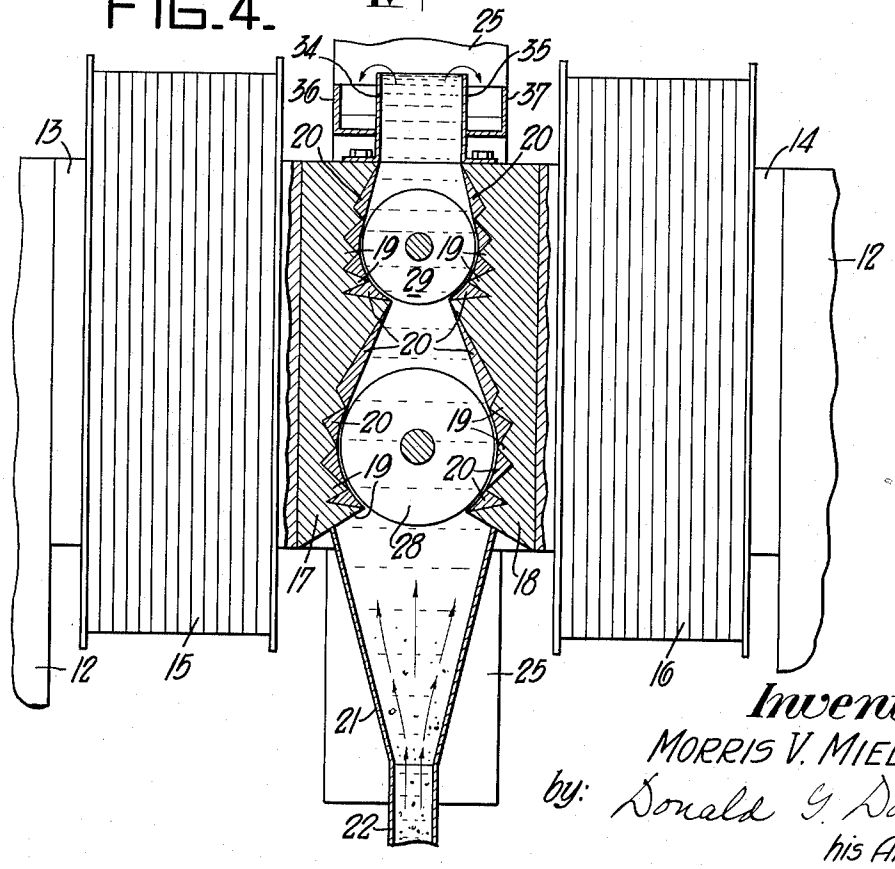


FIG. 4.



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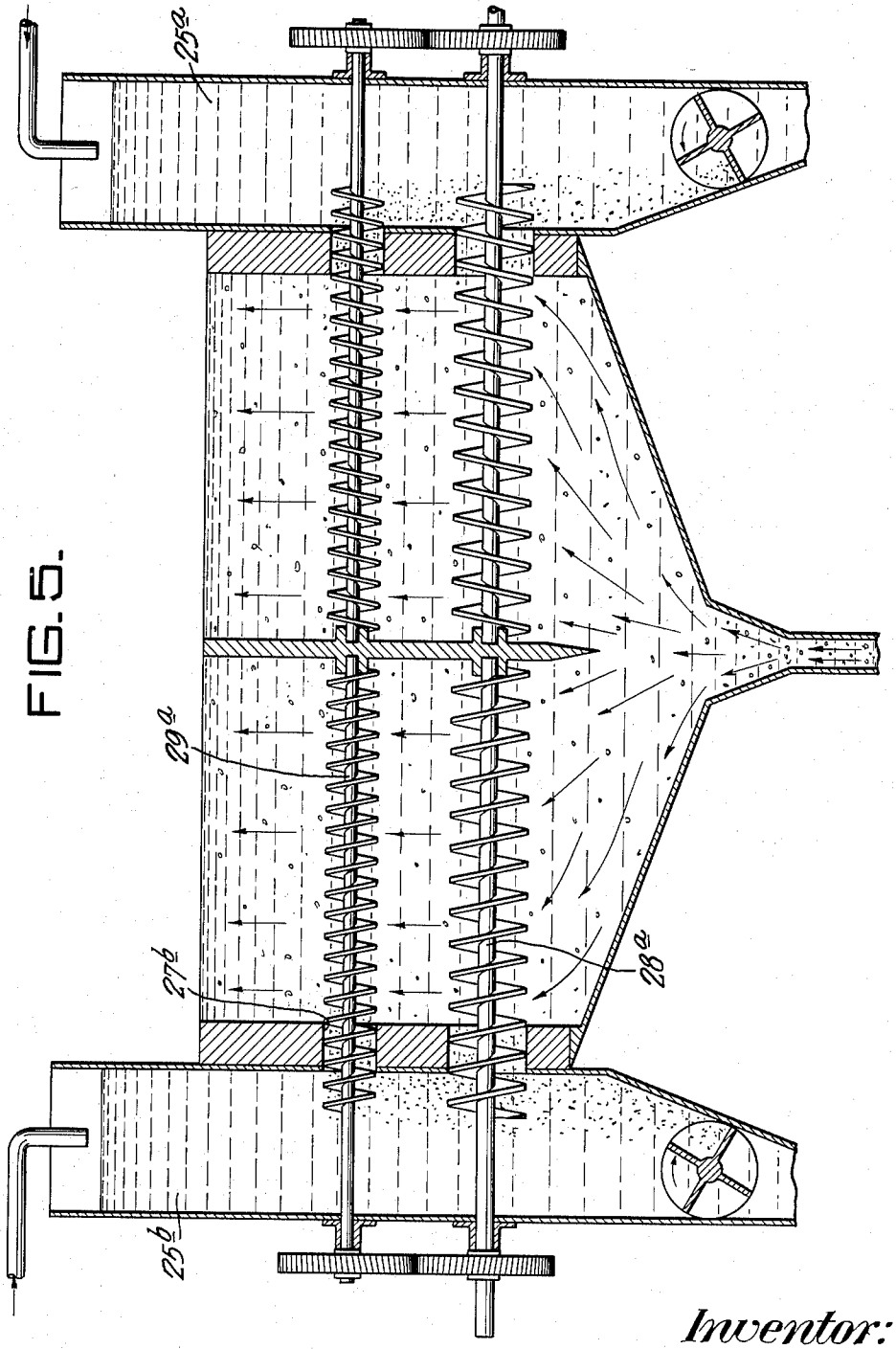


FIG. 5.

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United States Patent Office 2,714,959 Patented Aug. 9, 1955

2,714,959

WET ELECTROMAGNETIC SEPARATOR AND METHOD

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Application July 26, 1951, Serial No. 238,661

16 Claims. (Cl. 209—214)

This invention relates to improved wet electromagnetic separators and separation methods which subject an ore pulp to the combined actions of a magnetic field and a rising current of water.

An object of the invention is to provide an improved magnetic separator and separation method particularly suited for collecting ore particles which are only feebly magnetic.

A further object is to provide a separator and method which combine the action of a magnetic field and a rising current of water and thus collect both feebly and strongly magnetic particles, as well as heavier gravity particles not necessarily magnetic.

A more specific object is to provide a separator which has a high intensity magnetic field adapted to act on particles suspended in a rising current of water, thus retarding and collecting feebly magnetic particles, as well as more strongly magnetic particles and particles retarded by gravity, and means, such as a screw conveyor, for continuously withdrawing in a substantially horizontal direction the particles thus collected.

In accomplishing these and other objects of the invention, I have provided improved details of structure preferred forms of which are shown in the accompanying drawings, in which,

Figure 1 is a top plan view of an improved separator embodying features of the present invention;

Figure 2 is an end elevational view of the separator shown in Figure 1;

Figure 3 is a vertical longitudinal sectional view taken substantially on line III—III of Figure 2 with the pole pieces and fillers omitted to show more clearly the path of particles within the separator;

Figure 4 is a vertical cross sectional view taken substantially on line IV—IV of Figure 3; and

Figure 5 is a vertical longitudinal sectional view similar to Figure 3, but showing a modification.

As shown in Figures 1 and 2, the separator of the present invention comprises a suitable supporting structure, such as a base or stand **10**, a magnetic yoke **12** of U-shape in end elevation supported thereon, a pair of inwardly extending cores **13** and **14** at the ends of said yoke, and windings **15** and **16** on said cores. As shown in Figure 4, inwardly extending pole extensions **17** and **18** are fixed to the cores and thus furnish a pair of horizontally spaced apart poles of opposite polarity. Preferably these pole extensions have a number of high concentrating points **19**. Fillers **20** of non-magnetic material occupy the spaces between these concentrating points.

As best shown in Figure 3, a horizontally elongated feed distribution box **21** is fixed to the bottom of the pole extensions and has a pulp inlet **22** in its underside beneath the magnetic poles. End walls **23** and **24** are fixed to the upper edges of said box, the end wall **24** being somewhat thicker than the end wall **23**. A concentrate column **25** is fixed to the exterior of end wall **24**, which contains lower and upper concentrate tunnels **26** and **27** leading to said concentrate column.

Lower and upper screw conveyors **28** and **29** of non-magnetic material are mounted in suitable bearings in the end wall **23** and the exterior wall of the concentrate column **25** and extend into the concentrate column through the tunnels **26** and **27**. Conveniently said conveyors have helices of the opposite hand and they rotate in opposite directions, the speed of rotation being relatively slow. A suitable drive for the conveyors includes gears **30** and **31** on the respective conveyor shafts and power means, not shown, connected with either shaft. The two conveyors are spaced apart vertically. As best shown in Figure 4, the pole extensions and fillers partially surround each conveyor and conform in shape with the outside shape of these conveyors. The upper conveyor is of smaller outside diameter than the lower conveyor; hence the pole extensions are closer together and create a more intense magnetic field in the region of the upper conveyor than in the region of the lower conveyor.

An ore pulp consisting of a water suspension of finely divided solids, some of which are magnetic, is introduced to the separator via the inlet **22**. The pulp ascends between the pole extensions **17** and **18**, which are energized. Heavier gravity particles ascend more slowly in accordance with the familiar principles of a hydraulic classifier. The more strongly magnetic particles are retarded in their ascent and collect in the region of the lower conveyor **28**. The closer spacing of the poles in the region of the upper conveyor **29** creates a magnetic field whose intensity increases in the direction of flow, that is, upwardly. Consequently more feebly magnetic particles are retarded in their ascent and collect in the region of the upper conveyor **29**. The two conveyors carry the heavier gravity particles and the particles magnetically retarded toward the right, through the tunnels **26** and **27**, and into the concentrate column **25**.

As best shown in Figure 3, the upper portion of the concentrate column extends somewhat above the upper ends of walls **23** and **24** and has a water inlet **32**. The water in this upper portion forms a hydrostatic head which creates a counter-current water flow for washing the concentrate of slimes. The lower end of the concentrate column contains a rotating box valve **33** through which the concentrate is removed.

As best shown in Figure 4, the upper faces of pole extensions **17** and **18** carry overflow lips **34** and **35** over which flow the water and particles not withdrawn by the conveyors. Said lips support launder troughs **36** and **37** which carry away this overflow, normally a tailing product.

Figure 5 shows a modification in which the lower and upper screw conveyors **28***a* and **29***a* are divided at their mid-portions into helical sections of the opposite hand, whereby they remove magnetic material from both ends of the separator. The modified separator has concentrate columns **25***a* and **25***b* at its opposite ends to receive such magnetic material. This modification is particularly advantageous for treating a feed which contains substantial volumes of recoverable magnetic mineral, since it avoids crowding near the discharge end by dividing the recovered mineral between the two concentrate columns. Thus the modification increases the capacity of a separator of given size when used for feeds which have a high content of magnetic material. It is further seen that either embodiment of separator is well suited for use in multiples, either end-to-end or side-by-side.

In the separation method of the present invention, the feed ore can be any which contains both magnetic minerals and heavier gravity minerals that are to be separated from a non-magnetic, lighter gravity gangue. An example is taconite which can contain heavier gravity iron minerals including magnetite (magnetic), martite (feebly

magnetic), hematite (feebly or non-magnetic), and lighter gravity non-magnetic silicious gangue. Such an ore is crushed and ground approximately to liberation size, as known in the art, and mixed with water to form a pulp containing anywhere from 10 to 70 percent by weight of solids. This pulp is introduced to the separator via the inlet **22**. The pulp moves in a rising current between the magnetic poles, where, as already explained, it is subjected to the combined action of the magnetic field and the rising current. The field need exert only a slight retarding effect on a particle to hold it from rising with the water and thus to enable the screw conveyors **28** and **29** to withdraw it into the concentrate column.

Examples of other ores for which the separator can be used successfully are those which contain ilmenite, pyrrohotite and franklinite.

From the foregoing description it is seen that the present invention furnishes a separator that subjects ore particles to the combined action already described. Since only a slight magnetic force is needed to retard ascent of a particle, it is apparent that particles only feebly magnetic can be thus retarded. Consequently the separator recovers these feebly magnetic particles which would otherwise be lost, and it is capable of recovering all the types of iron minerals commonly occurring in taconites.

While I have shown and described only certain specific embodiments of the invention, it is apparent that other modifications may arise. Therefore, I do not wish to be limited to the disclosure set forth but only by the scope of the appended claims.

I claim:

1. A magnetic separator comprising horizontally spaced apart magnetic poles of opposite polarity, an inlet beneath said poles for introducing a pulp of finely divided ore particles suspended in water as a rising current which ascends in the space between said poles, means situated between said poles for horizontally withdrawing particles whose ascent is retarded by said poles, the direction of such withdrawal being parallel to the pole faces, and means above said poles for carrying away water and particles which ascend above the poles.

2. A magnetic separator comprising horizontally spaced apart magnetic poles of opposite polarity, an inlet beneath said poles for introducing a pulp of finely divided ore particles suspended in water as a rising current, a non-magnetic screw conveyor situated between said poles and rotatable on an axis parallel to the pole faces for withdrawing particles from the pulp retarded as the pulp ascends between the poles, and means above said poles for carrying away water and particles which ascend above the poles.

3. A magnetic separator comprising horizontally spaced apart magnetic poles of opposite polarity, an inlet beneath said poles for introducing a pulp of finely divided ore particles suspended in water as a rising current, lower and upper non-magnetic screw conveyors situated between said poles and rotatable on an axis parallel to the pole faces for withdrawing particles from the pulp retarded as the pulp ascends between the poles, a concentrate column into which said conveyors extend for receiving particles thus withdrawn, and means above said poles for carrying away water and particles which ascend above the poles.

4. A magnetic separator comprising horizontally spaced apart magnetic poles of opposite polarity formed with a plurality of high concentrating points and non-magnetic fillers between said concentrating points, an inlet beneath said poles for introducing a pulp of finely divided ore particles suspended in water as a rising current, a non-magnetic screw conveyor situated between said poles for withdrawing particles from the pulp retarded as the pulp ascends between the poles, said concentrating points and said fillers partially surrounding said conveyor and conforming in shape to the outside thereof, and means above said poles for carrying away water and particles which ascend above the poles.

5. A magnetic separator comprising horizontally spaced apart magnetic poles of opposite polarity, an inlet beneath said poles for introducing a pulp of finely divided ore particles suspended in water as a rising current, said poles being adapted to create a magnetic field whose intensity increases upwardly, means situated between said poles for horizontally withdrawing particles whose ascent is retarded by said poles, the direction of such withdrawal being parallel to the pole faces, a concentrate column for receiving particles withdrawn by said means, and means above said poles for carrying away water and particles which ascend above the poles.

6. A magnetic separator comprising horizontally spaced apart magnetic poles of opposite polarity, an inlet beneath said poles for introducing a pulp of finely divided ore particles suspended in water as a rising current, lower and upper non-magnetic screw conveyors situated between said poles for withdrawing particles from the pulp retarded as the pulp ascends between the poles, said upper conveyor being of smaller outside diameter than said lower conveyor, said poles partially surrounding said conveyors and conforming in shape to the outside thereof to create a magnetic field whose intensity increases upwardly, a concentrate column into which said conveyors extend for receiving particles withdrawn thereby, and means above said poles for carrying away water and particles which ascend above the poles.

7. A magnetic separator comprising horizontally spaced apart magnetic poles of opposite polarity, a feed distribution box fixed beneath said poles, end walls extending upwardly between said poles, an inlet in said feed distribution box for introducing a pulp of finely divided ore particles suspended in water as a rising current, a non-magnetic screw conveyor situated between said poles for withdrawing particles from the pulp retarded as the pulp ascends between the poles, a concentrate column outside one of said end walls, said last named end wall having an opening through which said conveyor extends into said concentrate column, and means above said poles for carrying away water and particles which ascend above the poles.

8. A magnetic separator comprising horizontally spaced apart magnetic poles of opposite polarity, a feed distribution box fixed beneath said poles, end walls extending upwardly between said poles, an inlet in said feed distribution box for introducing a pulp of finely divided ore particles suspended in water as a rising current, lower and upper non-magnetic screw conveyors situated between said poles for withdrawing particles from the pulp retarded as the pulp ascends between the poles, said upper conveyor being of smaller outside diameter than said lower conveyor, said poles partially surrounding said conveyors and conforming in shape to the outside thereof to create a magnetic field whose intensity increases upwardly, a concentrate column outside one of said end walls, said last named end wall having tunnels through which said conveyors extend into said concentrate column, and an overflow lip and a trough above said poles for carrying away water and particles which ascend above said poles.

9. A magnetic separator comprising horizontally spaced apart magnetic poles of opposite polarity, an inlet beneath said poles for introducing a pulp of finely divided ore particles suspended in water as a rising current, vertically extending end walls between said poles, a concentrate column outside one of said end walls, a non-magnetic screw conveyor situated between said poles for withdrawing particles from the pulp retarded as the pulp ascends between the poles, said last named end wall having an opening through which said conveyor extends into said concentrate column, an overflow lip and a trough above said poles for carrying away water and particles which ascend above said poles, said concentrate column extending higher than said lip to form a hydrostatic head for washing particles carried into

the concentrate column, and means for introducing water to the upper end of said concentrate column.

10. A magnetic separator comprising horizontally spaced apart magnetic poles of opposite polarity, a feed distribution box fixed beneath said poles, end walls extending upwardly between said poles, an inlet in said feed distribution box for introducing a pulp of finely divided ore particles suspended in water as a rising current, lower and upper non-magnetic screw conveyors situated between said poles for withdrawing particles from the pulp retarded as the pulp ascends between the poles, said upper conveyor being of smaller outside diameter than said lower conveyor, said poles partially surrounding said conveyors and conforming in shape to the outside thereof to create a magnetic field whose intensity increases upwardly, a concentrate column attached to the outside of one of said end walls, said last named end wall having tunnels through which said conveyors extend into said concentrate column, an overflow lip and a trough above said poles for carrying away water and particles which ascend above said poles, said concentrate column extending higher than said lip to form a hydrostatic head for washing particles carried into said concentrate column, means for introducing water to the upper end of said concentrate column, and valve means at the lower end of said concentrate column for removing particles.

11. A method of magnetic separation comprising introducing a pulp of finely divided ore particles suspended in water as a rising current between two magnetic poles of opposite polarity, horizontally withdrawing particles whose ascent is retarded in the region of said poles, the direction of such withdrawal being parallel to the pole faces and overflowing above said poles water and particles which ascend above the poles.

12. A method of magnetic separation comprising introducing a pulp of finely divided ore particles suspended in water as a rising current to a magnetic field whose intensity increases upwardly, horizontally withdrawing at two different levels particles whose ascent is retarded in said field, the direction of such withdrawal being parallel to the pole faces and overflowing above said field water and particles which ascend thereabove.

13. A magnetic separator comprising spaced apart magnetic poles of opposite polarity, an inlet beneath said poles for introducing a pulp of finely divided ore particles suspended in water as a rising current which ascends in the space between said poles, means situated between said poles for horizontally withdrawing toward both ends of the separator particles whose ascent

is retarded by said poles, the direction of such withdrawal being parallel to the pole faces and means above said poles for carrying away water and particles which ascend above the poles.

14. A magnetic separator comprising horizontally spaced apart magnetic poles of opposite polarity, an inlet beneath said poles for introducing a pulp of finely divided ore particles suspended in water as a rising current, lower and upper non-magnetic screw conveyors divided intermediate their lengths into portions of the opposite hand for withdrawing toward both ends of the separator particles from the pulp retarded as the pulp ascends between the poles, concentrate columns on opposite ends of the separator into which said conveyors extend for receiving particles thus withdrawn, and means above said poles for carrying away water and particles which ascend above the poles.

15. A method of magnetic separation comprising introducing a pulp of finely divided ore particles suspended in water as a rising current between two magnetic poles of opposite polarity, horizontally withdrawing in opposite directions particles whose ascent is retarded in the region of said poles, the direction of such withdrawal being parallel to the pole faces and overflowing above said poles water and particles which ascend above the poles.

16. A method of magnetic separation comprising introducing a pulp of finely divided ore particles suspended in water as a rising current between two magnetic poles of opposite polarity forming a closed field, continuously withdrawing mechanically from said field those particles whose ascent is retarded thereby, the direction of such withdrawal being parallel to the pole faces and overflowing above said field water and particles which ascend thereabove.

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