Nov. 20, 1928. 1,692,590

R. H. STEARNS

METHOD OF AND APPARATUS FOR MAGNETIC SEPARATION

Filed May 28, 1924

Fig. 5

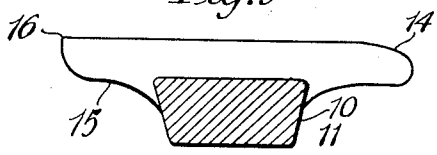


Fig. 1.

Fig. 3.

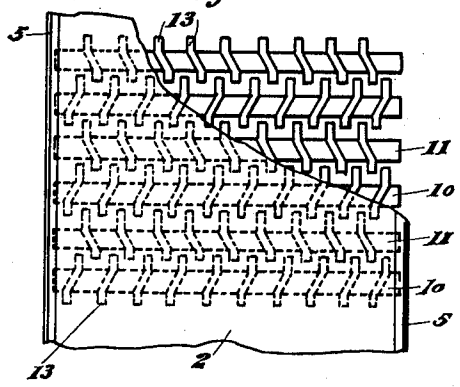
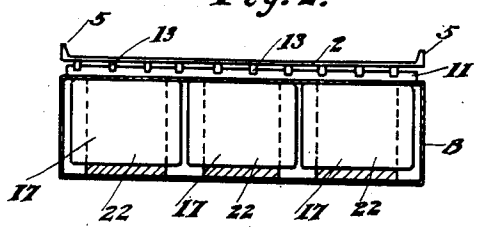


Fig. 2.



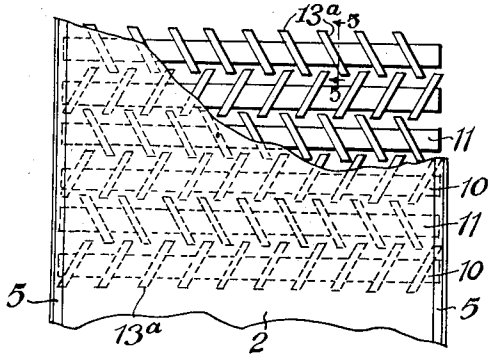


Fig. 4

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UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR MAGNETIC SEPARATION.

Application filed May 28, 1924. Serial No. 716,416.

My invention relates to improvements in methods of, and apparatus for, magnetic separation, and pertains especially to that art in which flowing water is utilized in a magnetic field to promote the separation and removal of non-magnetizable material from the magnetite.

One object of my invention is to provide an improved method of separation by subjecting the magnetite to short, quick magnetically induced movements transversely of the path of a stream of flowing water, while mechanically conveying it in opposition to the flowing stream, thereby releasing the non-magnetizable material from frictional or pressure contacts, and allowing the latter to be carried downwardly with the water to a point of delivery beyond the magnetic field.

Further objects are to provide means for establishing a magnetic field having zig zag magnetic zones of opposite polarity and spaced zig zag areas of maximum intensity into which the magnetite may move by mechanical conveyance in one direction and magnetic attraction in another direction; to provide means for delivering magnetized particles from the influence of one magnetic pole piece to another with minimum lag and a tendency to acceleration and re-arrangement of the particles of magnetite during such delivery; to provide an improved pole piece structure for an electromagnetic ore washer; to provide means for adequately protecting the electro-magnetic coils from the water; and to provide for adequate cooling of the housed electro-magnets of an ore washing, electro-magnetic separator.

In the drawings:

Figure 1 is a view of my improved magnetic separator in side elevation.

Figure 2 is a cross section on line 2—2 of Figure 1.

Figure 3 is a plan view of fragments of the conveyor belt and magnet.

Figure 4 is a view similar to Figure 3, showing a slight modification.

Figure 5 is a cross section on line 5—5 of Figure 4.

Like parts are identified by the same reference characters in all views.

My improved method is described as follows:—The material to be separated is conveyed upwardly in a thin stream along an inclined path through a magnetic field of varying intensity, and in opposition to a downwardly flowing stream of water. The material is delivered into the magnetic field before it is subjected to the action of the water, and the pressure of the water tends to wash out the non-magnetizable materials and carry them downwardly away from the magnetite. The latter is held to the conveying means by magnetic force and while it is being conveyed, it is subjected to varying magnetic attraction in directions transverse to the path of the conveying means, and it is preferably magnetically drawn in opposite directions along lines obliquely transverse to the line of mechanical conveyance, whereby entrained particles of sand or other non-magnetizable materials are released from frictional or pressure contacts with the magnetite, or with the conveying means whereby such particles may be more readily separated and moved downwardly by the water and by gravity. The magnetite is carried upwardly through and beyond the stream of water and then withdrawn from the magnetic field while supported in frictional contact with the conveying means.

The apparatus employed for carrying out the above described method will now be described.

The ore is fed through a hopper 1 to the surface of an upwardly moving conveyor, i. e. an inclined belt 2 which travels over end rollers 3 and 4. The margins 5 of the belt are raised to prevent lateral delivery of material therefrom, and above the point or transverse line along which the material is received by the belt, one or more batteries of spray nozzles 6 are provided. Each battery of nozzles 6 may comprise a water pipe 7 provided with nozzles or nozzle apertures 6, so arranged as to spray all the material, as it passes the nozzles, with a substantially equal flow of water to all the ore particles. The flow of water is sufficient, when added to the force of gravity, to enable the water to overcome the friction of such particles as are not magnetically held to the belt, and as soon as these particles start to move downwardly they are kept in motion by the water until delivered over the lower end of the conveyor into the receiver 8.

On the upwardly moving side, the belt travels over a series of electro-magnetic pole pieces 10 and 11 of opposite polarity. The pole pieces 10 and 11 are arranged in alter-

nation and are preferably parallel to each other and transverse to the conveyor belt.

Each pole piece 10, (or 11), is provided with a series of polar projections 13 which have their upper surfaces in close proximity to, or contact with, the under surface of the conveyor. These projections are narrow and are obliquely disposed in whole or in part, and extend from each pole piece 10, or 11, forwardly and backwardly toward the adjacent pole piece in staggered and preferably slightly interlapping relation to those on the adjacent bars. The oblique portions of the polar projections are oppositely inclined on successive pole piece, i. e. those of one pole piece extend obliquely to the right and those of the next obliquely to the left, whereby the magnetite carried by the conveyor is caused to travel in a zig zag path, and to move with a quick traverse from the interlapping ends of one set of pole piece projections to the next.

In Figure 3 only the central portions of the projections 13 are oblique. In Figure 4, projections 13^a are disclosed which are obliquely disposed throughout their length and at their rear or upper ends, the upper surface 14 is rounded or inclined so that at this end the polar projection diverges from the conveyor, with a gradual reduction in magnetic pull upon the magnetite. At the lower ends, the polar projections have their lower surfaces 15 rounded upwardly to a sharp shoulder at 16 thereby concentrating the magnetic lines of force at what may be termed the receiving end of the projection. The curved contours 14 and 15 are, of course, also applicable to the polar projections shown in Figure 3.

The pole pieces 10 and 11 are energized by electro-magnets 17 encased in a non-magnetic housing B having overhanging inclined end walls 19 and openings 20 underneath these overhanging walls to allow for air circulation. Each of said pole pieces is preferably energized by a series of small flat coils 22 between which the air can freely circulate. The overhanging walls 19 protect the windings from water, which might otherwise enter the openings and as soon as the temperature rises gravity circulation of air becomes pronounced, the inclination of the housing being such as to allow the heated air to rise freely.

As the magnetite passes over the upper end of the conveyor it tends to drop by gravity into the receiver 24. Any particles adhering to the belt may be washed off by jets of water delivered through nozzle apertures in the transverse pipe 25.

It will be observed that the hopper 1 is so disposed with reference to the conveyor that the material will be delivered to the conveyor above the lower pole pieces, or set of pole pieces. Therefore, none of the magnetite will be caried downwardly out of the magnetic field, if it is sufficiently magnetizable to be held by such pole pieces as lie below the point of delivery. But a considerable portion of the non-magnetizable material will be immediately separated and delivered downwardly. The entrained particles of such material will then be readily released as the magnetite moves upwardly and begins its zig zag travel from the polar projections of one pole piece to the next with quick transverse traverse across the gaps between the interlapping ends. It is well understood that the friction of rest is greater than the friction of motion, and therefore these movements of the magnetite are not only important in effecting their separation from the residue but in setting the particles of non-magnetizable material in motion and reducing the frictional resistance to motion, due to contact with the conveyor apron or belt.

A rubber belt will preferably be employed, and the sand is easily set in motion when the particles of magnetite change polarity, they usually reverse their position end to end in jumping transversely from a point above one pole piece projection to a point above another of opposite polarity.

I claim:

1. The method of magnetic separation consisting in moving finely divided material containing magnetite in a shallow stream of flowing water in opposition to the movement of the water, and magnetically attracting the magnetite transversely in a plane substantially parallel to the direction of flow.

2. The method of magnetic separation which consists in moving finely divided material containing magnetite upwardly along an inclined path, spraying water over said material and causing it to flow downwardly in opposition to the upward movement of the material, and subjecting the magnetite to magnetic attraction successively in different directions transversely of said path.

3. The method of magnetic separation which consists in moving finely divided material containing magnetite upwardly along an inclined path, spraying water over said material and causing it to flow downwardly in opposition to the upward movement of the material, and subjecting the magnetite, at successive stages of its travel to magnetic attraction in two directions, one of diminishing intensity and the other of increasing intensity and of differing polarity to produce abrupt changes in the position of the material.

4. The method of magnetic separation which consists in moving finely divided material containing magnetite upwardly along an inclined path, spraying water over said material and causing it to flow downwardly in opposition to the upward movement of the material, and successively subjecting the magnetite to the influence of magnetic poles laterally offset transversely of said path and of opposite polarity with diminishing in-

tensity of one, and increasing intensity of the next in the general line of movement of the material.

5. A magnetic separator having in combination, a multiple series of electro-magnetically energized polar projections arranged with those of one series in staggered relation to the next and of opposite polarity, means for conveying material containing magnetite over said projections in one direction, and means for delivering fluid against said material in the opposite direction.

6. A magnetic separator having in combination, a conveyor for material containing magnetite, means for supporting a portion of said conveyor for upward travel along an inclined path, a series of magnets over which said conveyor extends, an inclined casing for said magnets having open ends and walls overhanging the openings, and means for spraying water upon the material as it passes through the magnetic field.

7. A magnetic separator having in combination, a series of substantially parallel pole pieces disposed in an inclined plane, means for energizing said pole pieces, each opposite in polarity to the next, a conveyor extending across said pole pieces in proximity thereto, a feeder for delivering material containing magnetite into the magnetic field of said pole pieces, means for washing non-magnetizable material downwardly along said conveyor; said conveyor being adapted to otherwise convey material upwardly along said inclined plane, and means for causing the magnetite to move independently of the conveyor movement at different times during its traverse of the magnetic zone.

8. A magnetic separator having in combination, a series of substantially parallel pole pieces disposed in an inclined plane, means for energizing said pole pieces, each opposite in polarity to the next, a conveyor extending across said pole pieces in proximity thereto, a feeder for delivering material containing magnetite into the magnetic field of said pole pieces, means for washing non-magnetizable material downwardly along said conveyor; said conveyor being adapted to otherwise convey material upwardly along said inclined plane, and means for causing the magnetite to move independently of the conveyor movement at different times, and in opposite lateral directions.

9. In a magnetic separator a trough like conveyor adapted to convey material containing magnetite upwardly in an inclined plane, in combination with means for spraying water upon such material, and electro-magnetic means for holding the magnetite to the conveyor and actuating it repeatedly thereon independently of the conveyor movement.

10. In a magnetic separator a trough like conveyor adapted to convey material containing magnetite upwardly in an inclined plane, in combination with means for spraying water upon such material and electro-magnetic means for holding the magnetite to the conveyor and actuating it repeatedly thereon independently of the conveyor movement, and with abrupt movements and changing polarization.

11. In a magnetic separator, a set of electro-magnetic bar shaped pole pieces of alternating polarity each crossed at intervals by polar projections in staggered relation to the similar projections on adjacent bars, and means for conveying material containing magnetite across said bars.

12. In a magnetic separator a set of electro-magnetic bar shaped pole pieces of alternating polarity each crossed at intervals by polar projections in staggered relation to the similar projections on adjacent bars, and means for conveying material containing magnetite across said bars, the polar projections of one pole piece having their extremities between the similar projections of adjacent bars.

13. In a magnetic separator a set of electro-magnetic bar shaped pole pieces of alternating polarity each crossed at intervals by polar projections in staggered relation to the similar projections on adjacent bars, and means for conveying material containing magnetite across said bars, the polar projections of one pole piece having their extremities between the similar projections of adjacent bars, with the upper and lower surfaces of said projections converging upwardly at the end over which the material first passes, and converging downwardly at the other end divergently from the material.

14. In a magnetic separator, the combination with a conveyor apron of a series of sets of polar projections, each having a flat upper surface in close proximity to the apron, and an upper surface extending divergently from the apron at one end, said apron being adapted for movement over said surfaces in the direction of the divergent ends.

15. In a magnetic separator, the combination with a conveyor apron of a series of sets of polar projections, each having a flat upper surface in close proximity to the apron, and an upper surface extending divergently from the apron at one end, said apron being adapted for movement over said surfaces in the direction of the divergent ends, and said divergent ends being in interlapping relation to the pole pieces of the next set.

16. In a magnetic separator, a series of sets of electro-magnetic coils enclosed in an open ended casing of non-magnetic material, a series of induced magnets mounted on said casing, each over one set of coils, a conveyor extending over the induced magnets, and flushing means for removing non-magnetizable material from the magnetic field established by said induced magnets.

17. In a magnetic separator, a series of sets of electro-magnetic coils enclosed in an open ended casing of non-magnetic material, a series of induced magnets mounted on said casing, each over one set of coils, a conveyor extending over the induced magnets, and flushing means for removing non-magnetizable material from the magnetic field established by said induced magnets, each of said induced magnets having extensions projecting along the path of conveyor travel, and successive induced magnets being of opposite polarity and arranged with extensions in spaced relation to those of the others.

18. In a magnetic separator, a series of sets of electro-magnetic coils enclosed in an open ended casing of non-magnetic material, a series of induced magnets mounted on said casing, each over one set of coils, a conveyor extending over the induced magnets, and flushing means for removing non-magnetizable material from the magnetic field established by said induced magnets, each of said induced magnets having extensions projecting along the path of conveyor travel, and successive induced magnets being of opposite polarity and arranged with extensions in spaced relation to those of the others, said extensions having oblique portions.

19. In a magnetic separator, a series of sets of electro-magnetic coils enclosed in an open ended casing of non-magnetic material, a series of induced magnets mounted on said casing, each over one set of coils, a conveyor extending over the induced magnets, and flushing means for removing non-magnetizable material from the magnetic field established by said induced magnets, each of said induced magnets having extensions projecting along the path of conveyor travel, and successive induced magnets being of opposite polarity and arranged with extensions in spaced relation to those of the others, said extensions having oblique portions extending laterally in opposite directions from those of the adjacent magnets.

20. The method of separating magnetic material from non-magnetic material consisting of introducing said materials into a stream of water and conveying the magnetic material in a zigzag path opposed to the flow of said stream.

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