March 28, 1933. H. B. ARDEN 1,902,938

MEANS FOR AUTOMATIC ELECTROMAGNETIC WET SEPARATION

Original Filed June 14, 1909 4 Sheets-Sheet 1

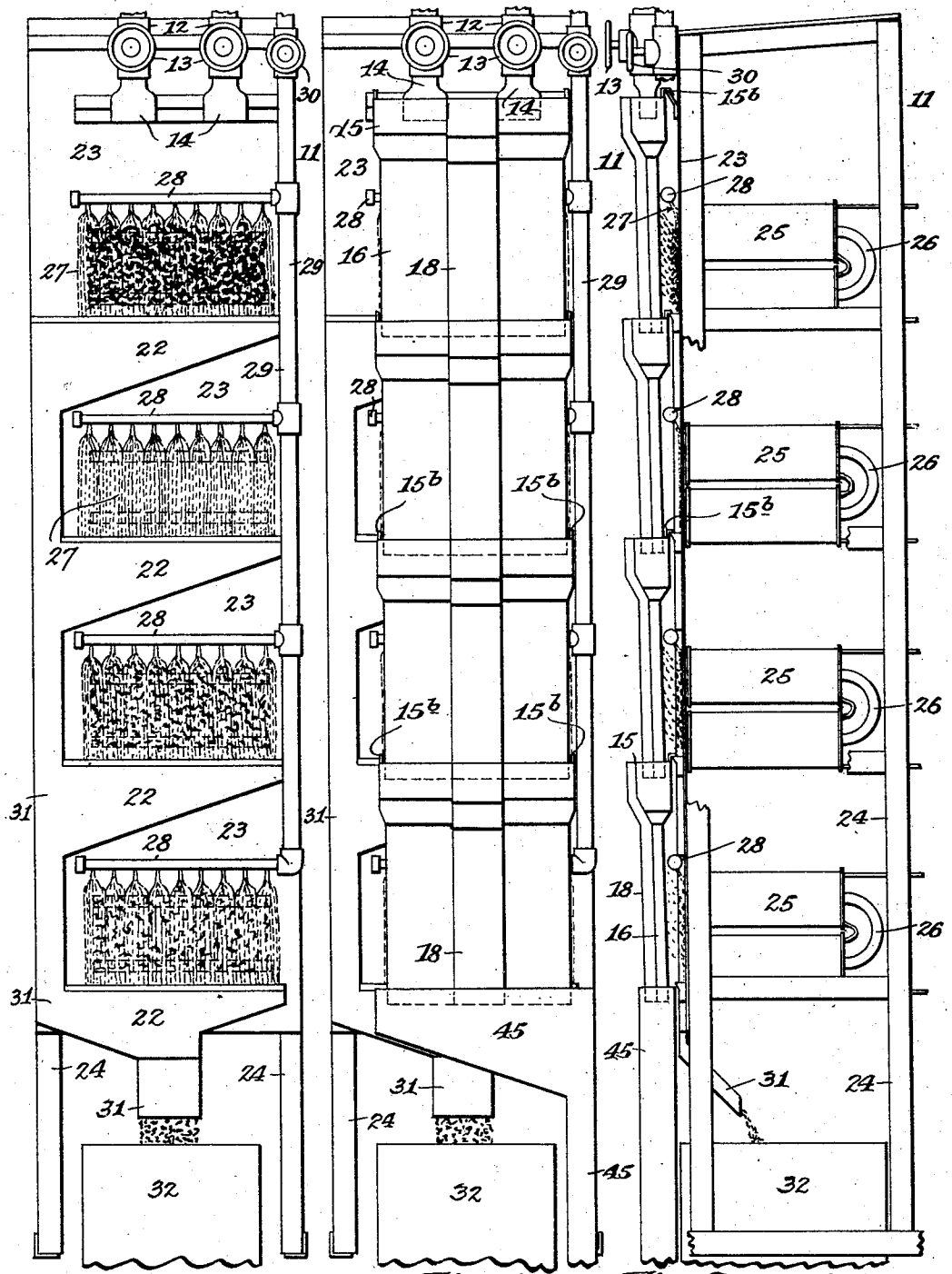

Fig. 2. Fig. 1. Fig. 3.

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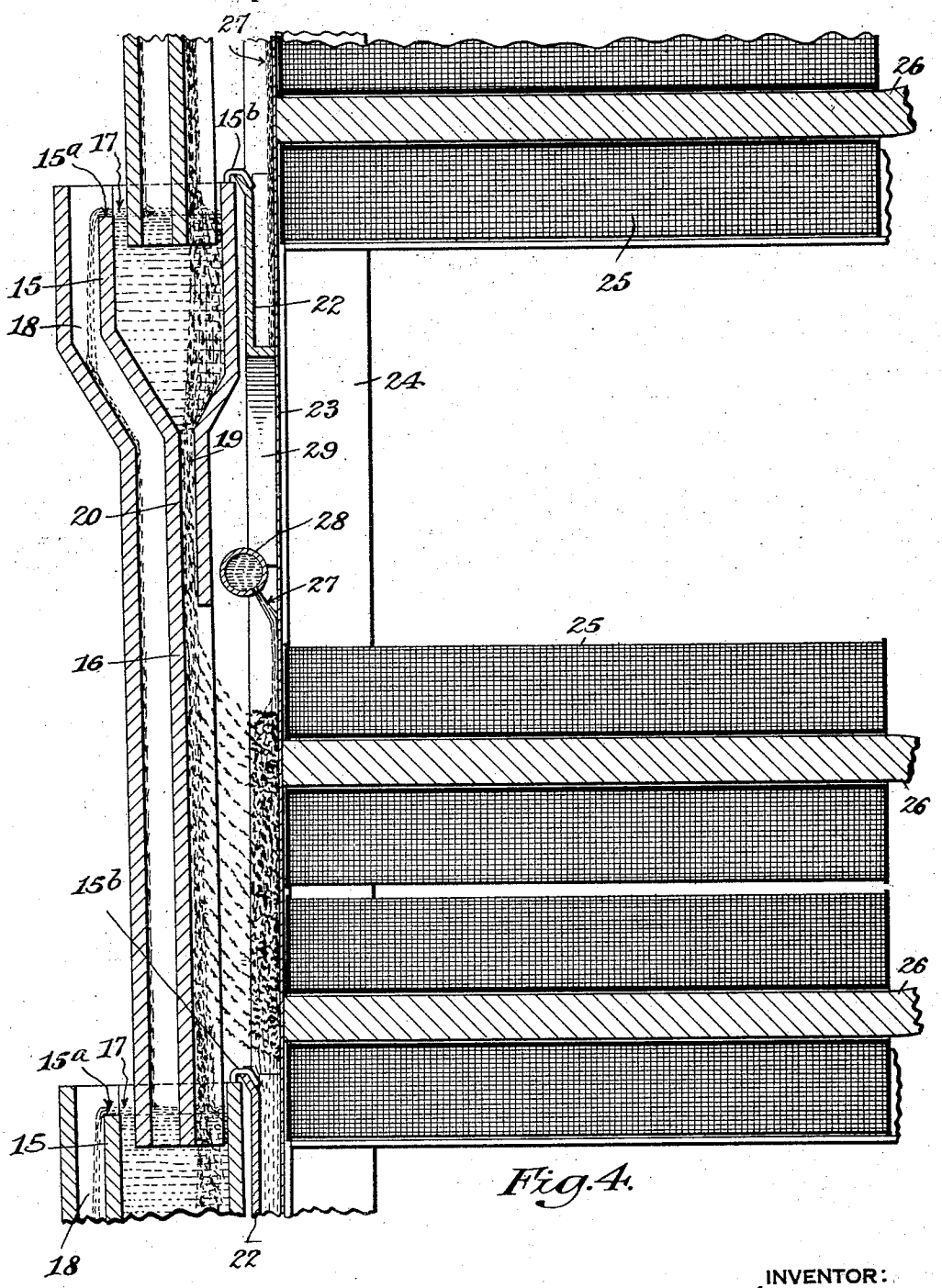

Fig. 4.

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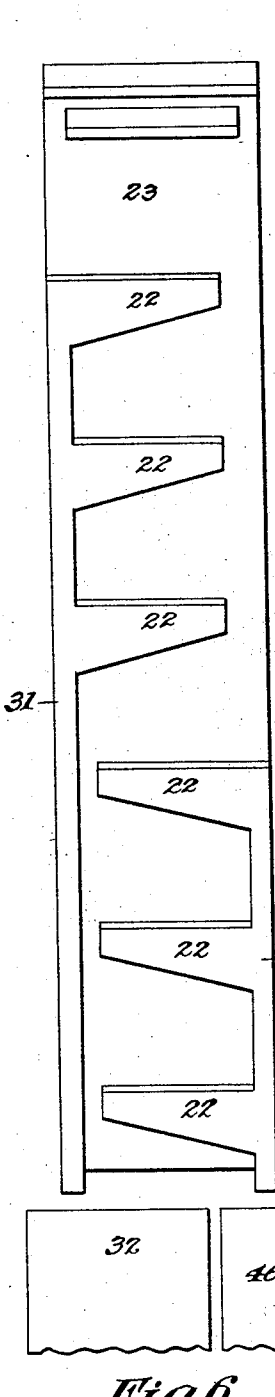

Fig. 6.

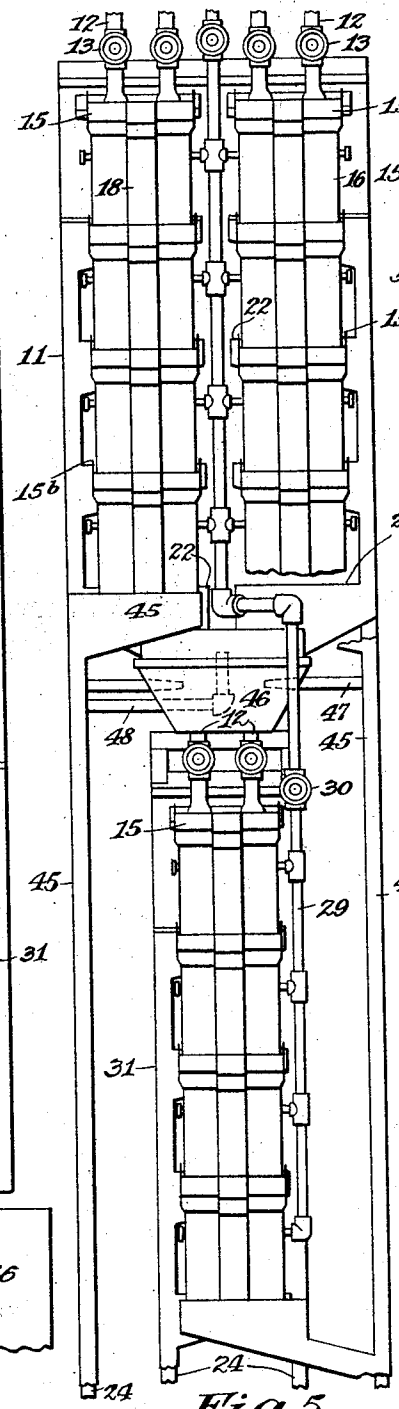

Fig. 5.

Fig. 7.

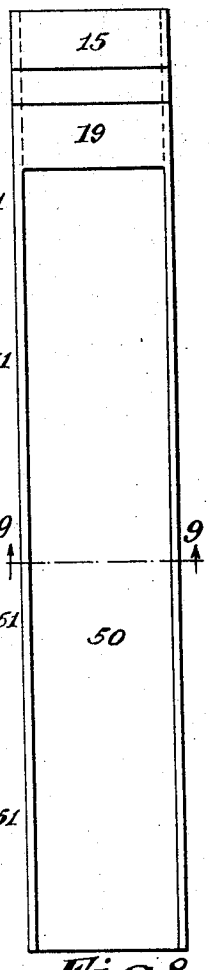

Fig. 8.

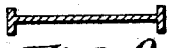

Fig. 9.

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MEANS FOR AUTOMATIC ELECTROMAGNETIC WET SEPARATION

Original Filed June 14, 1909 4 Sheets-Sheet 4

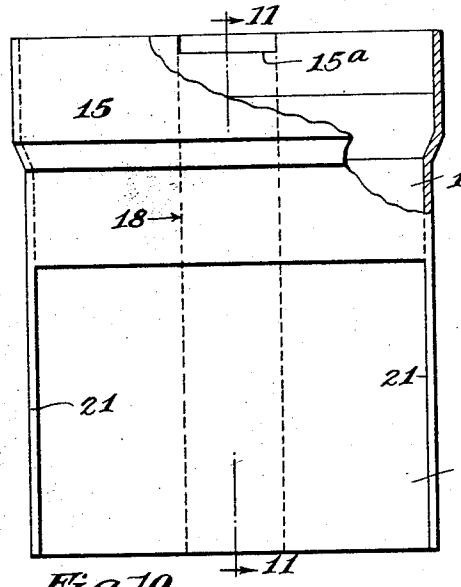

Fig. 10.

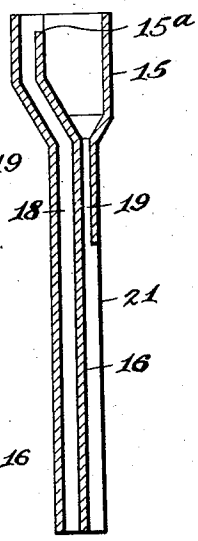

Fig. 11.

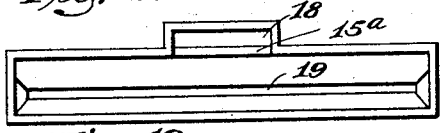

Fig. 12.

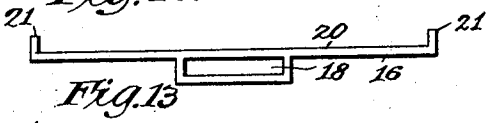

Fig. 13.

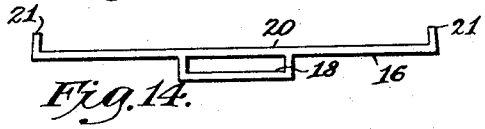

Fig. 14.

Fig. 15.

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Patented Mar. 28, 1933 1,902,938

UNITED STATES PATENT OFFICE

HARRY B. ARDEN, OF NEW YORK, N. Y.

MEANS FOR AUTOMATIC ELECTROMAGNETIC WET SEPARATION

Refile of application Serial No. 502,117, filed June 14, 1909. This application filed October 11, 1928. Serial No. 311,870. Renewed February 24, 1932.

The object of my invention is to provide an apparatus which may be used to separate the magnetic from the non-magnetic matter carried with a downwardly flowing stream of water. The magnetic substance may be in finely crushed ore, the magnetite of black sand deposits, or any other finely divided magnetic substance which can be carried within a stream of water. This and other objects are accomplished by my invention, some embodiments of which are hereinafter more particularly set forth.

For a more detailed description of my invention, reference is to be had to the accompanying drawings, forming a part hereof, in which

Figure 1 is a front elevation of one embodiment of my invention.

Figure 2 is a similar view with the feed hopper and stream guides removed.

Figure 3 is a side elevation of the structure shown in Figure 1.

Figure 4 is an enlarged sectional view of a portion of the apparatus shown in Figure 3.

Figure 5 is a front elevation of a multiple apparatus to be used for a double separation.

Figure 6 shows the front plate and ore ducts of a modification of the apparatus shown in Figure 1, which is to be used to segregate the strongly from the weakly magnetic substances.

Figure 7 shows a further modification wherein but one feed hopper is used with one long stream guide.

Figure 8 shows a front view of the hopper and stream guide shown in Figure 7.

Figure 9 is a sectional view, taken on the line 9—9 of Figure 8.

Figures 10 to 14 inclusive show details of my improved hopper and stream guide, Figure 11 being a sectional view, taken on the line 11—11 of Figure 10; Figure 12 is a top plan view of a hopper and Figures 13 and 14 are bottom views of stream guides, Figure 14 differing from Figure 13 only in having side walls converging slightly, as shown.

Figure 15 is a diagrammatic view of the electrical connections and circuits.

Throughout the various views of the drawings, similar reference characters designate similar parts.

My improved separating apparatus 11 is provided with a mixture 17 of water and magnetic ore bearing material, fluid enough to flow freely, which is supplied through the pipes 12 and is controlled in quantity by the valves 13, passing therefrom through outlets 14 into the top hoppers 15 and through narrow passages 19 at the bottom of the hoppers, which passages join the stream guides 16, which guide the stream down their inner surfaces and into the next lower hoppers 15.

The fluid mixture of ore and water from the outlets 14 into the top hoppers 15 should be in sufficient quantity to fill the hoppers so that an overflow will occur at the lips 15*a* into the overflow tubes 18 attached to the front of each hopper and stream guide, the surplus water going into the next lower hopper to compensate for magnetic substances withdrawn from the stream. This overflow should take place successively from upper to lower hoppers, thus maintaining an even pressure through passages 19, thus assuring a smooth, unbroken downward gliding stream of ore and water within the stream guides 16.

The passages 19 terminate and join with the stream guides 16 which are in the form of shallow troughs having front walls 20 and sides 21, the open backs being toward the magnetic source. These hoppers and stream guides are mounted so that the walls 20 are inclined slightly from the vertical, as shown in Figures 3 and 4, the object being to cause the falling stream of ore and water to impinge and flow in a smooth stream within the confines of the stream guides 16.

The walls of the hoppers 15 have hooks 15*b*, or other means provided for attaching them to the ore troughs 22, which are fixed to the front of shield plates 23 which are attached in vertical position to the frames 24 of the apparatus. These ore ducts each have a sloping floor sufficiently inclined to be self clearing when a stream passes over it. Back of the plate 23 are a series of electromagnets designated generically by the char-

acter 25 and specifically according to the systems in which they are connected, there being, in the embodiment shown, four of these systems numbered 1 to 4 inclusive, as shown in Figure 15. These magnets are also supported by the frame 24 in any suitable manner, but preferably with their pole pieces against the back of the plate 23, as shown, and they are rigidly mounted and separated from all water by this plate.

The support 24, the plate 23, the stream guide 16, the hoppers 15 and the overflow tubes 18, as well as the pipes 12, valves 13 and outlets 14 and all other parts, should be made of non-magnetic material, the only magnetic material that is employed in the apparatus being that of the cores 26 of the magnets 25.

Wash water 27 is supplied through suitable perforated pipes 28 from vertical pipes 29 governed by a valve 30 and one of these perforated pipes 28 is preferably located, as indicated in Figure 4, just above the level of the adjacent magnet 25, so that when the magnet is not energized the abundant flow of water will wash the ore, which is free, or substantially free of silica or other impurities, into the ore duct 22, from whence it is drained through drain pipes 31 into a suitable receptacle 32, where it is received and held ready for further treatment.

The magnets 25 are divided into four systems, in the embodiment shown, and each system is numbered 1 to 4 inclusive, as above stated, and supplied by electricity from any suitable source, as from a direct current generator 33 and this generator has one pole 34 connected to a wire 35 that runs to the lead in wires 36 of the respective magnets and the other pole 37 of this generator 33 is connected by a wire 38 to brushes 39 which bear on a commutator 40 which has its bars arranged in four series so that every fourth bar is connected to the first system, the next series has every fourth bar connected in the second system, the third series has every fourth bar connected and in a similar manner, the fourth series has every fourth bar connected, and so, in the embodiment shown, the commutator has segments in multiples of four all connected as indicated. The first system is connected to the proper part of the commutator by a wire 41 which runs to a lead in wire of the magnet 1. In a similar manner, the second series has a wire 42 which runs to the lead in wire of the magnet 2 and similarly the third system has a lead in wire 43 and the fourth system a lead in wire 44. The commutator is run in such a way that the magnets are properly energized beginning with 1, 2 and 3, then 2, 3 and 4, then 3, 4 and 1, then 4, 1 and 2, so that three are always energized and one is deenergized. The time of energizing each magnet will vary according to the flow and nature of the ore being treated and under the usual conditions of service the time each magnet will be energized will be substantially three-quarters of a second and it will be deenergized for one-quarter of a second. As long as each magnet is energized it will hold the ore adjacent thereto on the plate 23 and close to its pole pieces 26 and the instant it is deenergized the abundant stream of water 27 will cause it to fall into the ore duct 22, as above stated.

The advantage of having the magnets function in the order above described, is that at all times the material must pass through the magnetic field of an energized magnet and nothing will pass free thereof. If the magnets were energized in the opposite way, it might be that at times ore between systems 1 and 2 would pass free of all magnetism during the instant that the first system is deenergized and thereby permit loss of values.

The lowest overflow tube 18, as well as the lowest stream guide 16, drain into the outlet pipe 45 which carries away the tailings from the apparatus and also the excess water.

In view of the foregoing, the operation of this embodiment of my invention will be readily understood. Assuming that a flow of water is maintained through the pipes 29 and a flow of water and sand bearing ore through the pipes 12 and a suitable electric current passes through the magnets, as above set forth, the action is as follows. The hoppers 15 fill rapidly and immediately the mouths of the outlets 14 are submerged and an overflow into and through the overflow tubes 18 takes place. As the magnets 25 are successively energized, the ferrous or other magnetic material accumulates on the front of the plate 23 while non-magnetic material is carried into the next lower hopper 15 until the end of the apparatus is reached. The magnetic ore is released the instant the magnet is deenergized and is washed down by the stream 27 into the ore duct 22 from whence it is passed to the drain 31, as above set forth. If some of the magnetic material gets by the first magnet 25, it will be caught by one of the lower magnets in the manner just described, so that after the material has passed the last magnet its separation is practically complete under normal conditions. To further concentrate the separated material, the apparatus described below is employed.

In Figure 5 is shown a modification wherein there are two sets of hoppers 15 and stream guides 16 as well as overflow tubes 18, mounted side by side, all functioning precisely as above described, the waste water and gangue escaping by drain pipes 45, as above set forth. The ore which is caught in the upper ore ducts 22 is passed into a suitable tank 46 provided with agitating jets through nozzles 47 and the excess water is drained from the tank

46 by means of a suitable drain 48 which runs to a pipe 45. From the bottom of the tank 48, pipes 12 run precisely as above described, and the ore is further concentrated by this lower apparatus, precisely as shown in Figure 1.

In Figure 6 the ore and water pipes are omitted as well as the troughs 16 and attached parts and only the plate 23 is shown together with the ore ducts 22 which are divided into two series of three each, as appears on the drawings. The upper series is provided with magnets which function exactly as above described, so as to draw off the strongly magnetic material from the stream precisely in the manner above indicated, and this is drained through the pipe 31 into a suitable receptacle 32. The three lower magnets associated with the three lower ore ducts 22 have a much stronger magnetic flux, so as to recover the weaker magnetic material which otherwise would escape, and this drains into a receptacle 49. This embodiment of my invention is useful where it is desired to segregate weakly magnetic material carrying values other than that of iron.

In the embodiment of my invention shown in Figures 7 to 9 inclusive one long stream guide 50 drains the hopper 15 and instead of one plate 23 a series of short plates 51 are employed, each one overlapping the lower, as indicated, and these plates and the stream guide 50 converge towards the bottom of each plate by reason of the slope of the stream guide 50, so that the stream will follow an inclined surface and have a smooth, swift descent through the successive magnetic fields of the magnets. At the bottom the water and sand drain out through a pipe 45 and the ore passes with some water through another pipe 52.

The structure of Figure 14 shows converging side walls which more effectively confine the stream than the straight walls of Figure 13. The advantage is slight but substantial as all tendency of the stream to climb the side walls is thereby eliminated.

While I have shown and described some embodiments of my invention, it is obvious that it is not restricted thereto, but that it is broad enough to cover all structures that come within the scope of the annexed claims.

Having thus described my invention, what I claim is:

1. Means for automatic, electro-magnetic, wet separation which consists of means for passing downwardly a substantially vertical, smooth-flowing stream of magnetic ore and water through intermittent magnetic fields, and means for creating such fields whereby the magnetic material of the stream may be separated from the rest of the stream.

2. Means for automatic, electro-magnetic, wet separation which consists of means for passing downwardly a substantially vertical, smooth-flowing stream of magnetic ore and water through intermittent magnetic fields, means for creating such fields and holding magnetic material intermittently therein and means for washing down the ore when released.

3. Means for automatic, electro-magnetic, wet separation which consists of means for passing downwardly a substantially vertical, smooth-flowing stream of magnetic ore and water through intermittent magnetic fields, said passing means including troughs with inclined edges and means for creating such fields, whereby the magnetic material of the stream may be separated from the rest of the stream.

4. Means for automatic, electro-magnetic, wet separation which consists of means for passing downwardly a substantially vertical, smooth-flowing stream of magnetic ore and water through intermittent magnetic fields, said passing means being open towards the source of magnetic flux and means for creating such fields, whereby the magnetic material of the stream may be separated from the rest of the stream.

5. Means for automatic, electro-magnetic, wet separation which consists of means for passing downwardly a substantially vertical, smooth-flowing stream of magnetic ore and water through a succession of intermittent magnetic fields and means for creating such fields with a series of magnets, successively energized while the apparatus is in operation, whereby the magnetic material of the stream may be separated from the rest of the stream.

6. Means for automatic, electro-magnetic, wet separation which consists of means for passing downwardly a substantially vertical, smooth-flowing stream of magnetic ore and water through a succession of intermittent magnetic fields, and means for creating such fields composed of a series of magnets arranged vertically, one above another and energized successively from the bottom up, whereby the magnetic material of the stream may be separated from the rest of the stream.

7. Means for automatic, electro-magnetic, wet separation which consists of means for passing downwardly a substantially vertical, smooth-flowing stream of magnetic ore and water through a plurality of intermittent magnetic fields and means for creating such a plurality of magnetic fields, whereby the magnetic material of the stream may be continuously separated from the rest of the stream.

8. Means for automatic, electro-magnetic, wet separation which consists of means for passing downwardly a substantially vertical, smooth-flowing stream of magnetic ore and water through intermittent magnetic fields, means for catching and holding the separated ore and its accompanying water, means for agitating such mixture, and magnetic

means for further concentrating this mixture.

9. Means for automatic, electro-magnetic, wet separation which consists of means for passing downwardly a substantially vertical, smooth-flowing stream of magnetic ore and water through intermittent magnetic fields and means for creating such fields with different magnetic intensities, whereby magnetic material of one strength may be separated from a magnetic material of another strength.

10. A hopper terminating at its lower portion in a long and narrow passage, said passage having its front wall and side walls extended to form a shallow trough open toward the rear, an overflow opening at the top front wall of this hopper connecting with a tube attached lengthwise to the front of the hopper and the front wall of the shallow trough and means for supporting the hopper in an operative position.

11. A hopper terminating at its lower portion in a long and narrow passage, said passage having its front wall and side walls extended, the side walls being converged to form a shallow trough open toward the rear, an overflow opening at the top of the front wall of this hopper connecting with a tube attached lengthwise to the front of the hopper and the front wall of the shallow trough, and means for supporting the hopper in an operative position.

12. Means for automatic, electro-magnetic, wet separation which consists of means for passing downwardly, a substantially vertical smooth-flowing stream of magnetic ore and water through intermittent magnetic fields, means for creating intermittent magnetic fields and ore catching receptacles with inclined bottoms adapted to receive concentrated ore and water and drain the same and be self clearing.

13. Means for automatic, electro-magnetic, wet separation which consists of means for directing a falling stream of magnetic ore and water in a path inclined from the vertical and through the magnetic fields of a plurality of magnets mounted in vertical tier and successively and intermittently energized from the lowest up, means for so energizing said magnets, non-magnetic and waterproof means carried vertically in contact with the poles of the magnets and between them and the falling stream of ore and water, means between non-magnetic shield and falling stream for receiving magnetic material withdrawn from the stream and means for furnishing water for removal of said separated magnetic material.

14. Means for automatic, electro-magnetic, wet separation which consists in guiding and retarding means carried in position to direct a falling stream of ore and water through the successive magnetic fields of a plurality of magnets mounted in a vertical tier, means for successively and intermittently energizing said magnets, means for protecting said magnets against water and separated ore, means for furnishing water against one surface of said protecting means and means for receiving ore collected against and released from said protecting means.

15. Means for automatic, electro-magnetic, wet separation which consists of a surface and means for passing downwardly, on this surface, a substantially vertical stream of magnetic ore and water, a cooperating surface backed by a series of electro-magnets and means for energizing said magnets successively so as to cause a separation of magnetic material from the remainder of the stream.

16. Means for automatic, electro-magnetic, wet separation which consists of a surface and means for passing downwardly, on this surface, a substantially vertical stream of magnetic ore and water, a cooperating surface, adapted to receive magnetic ore, backed by a series of electro-magnets, means for energizing said magnets successively and means for washing the ore receiving surface so as to free it of magnetic material upon the release of the magnetism which holds it.

In testimony whereof, I have hereunto set my hand this 9th day of October, 1928.

HARRY B. ARDEN.