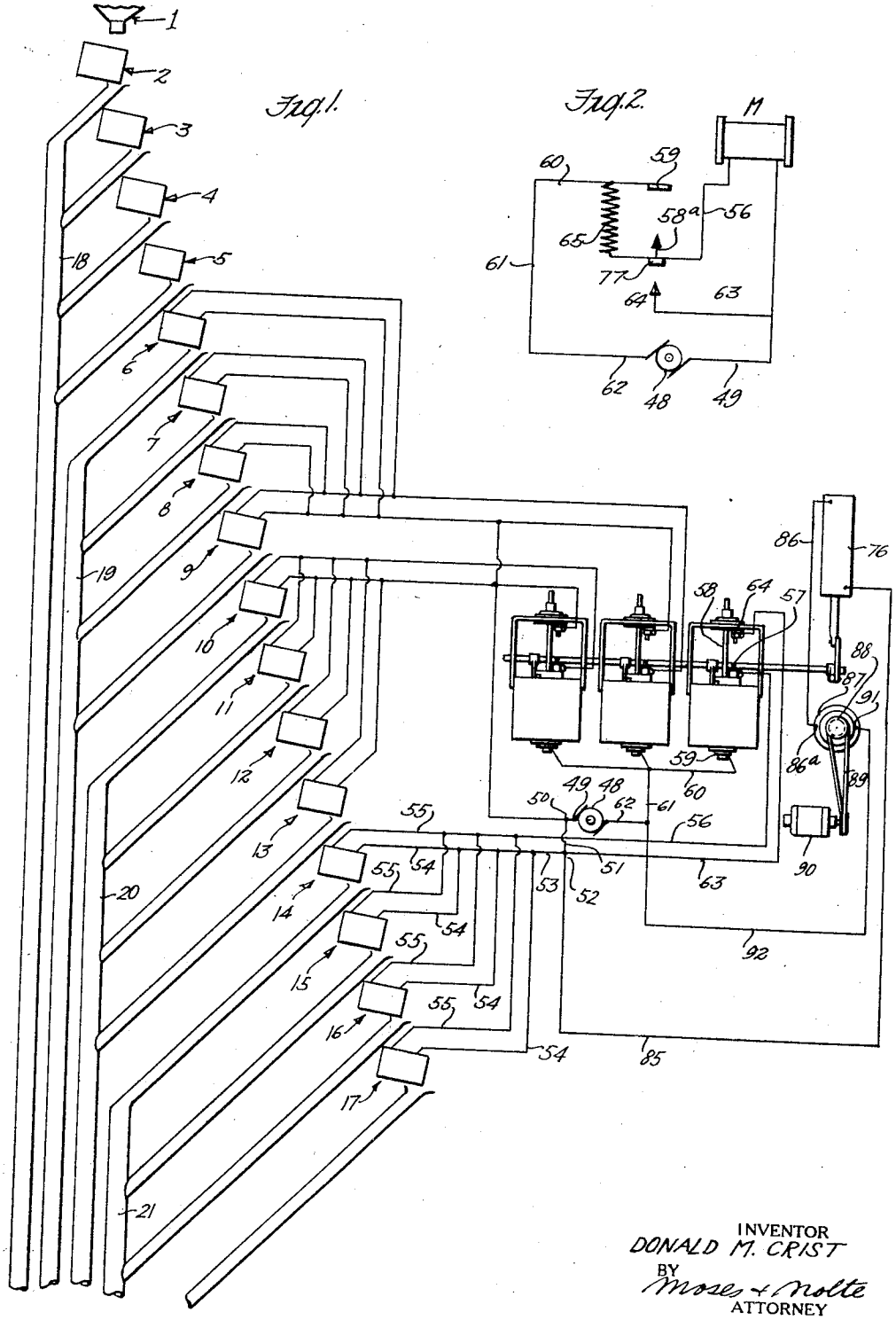
Jan. 24, 1939. D. M. CRIST 2,144,796

MAGNETIC ORE SEPARATOR AND CLASSIFIER

Filed Nov. 3, 1934 4 Sheets-Sheet 1



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MAGNETIC ORE SEPARATOR AND CLASSIFIER

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Fig. 3.

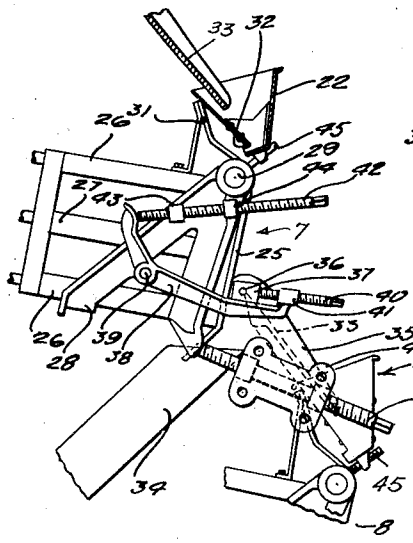


Fig. 5.

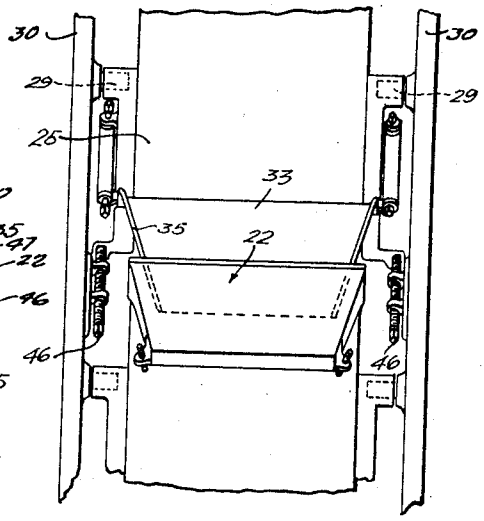


Fig. 4

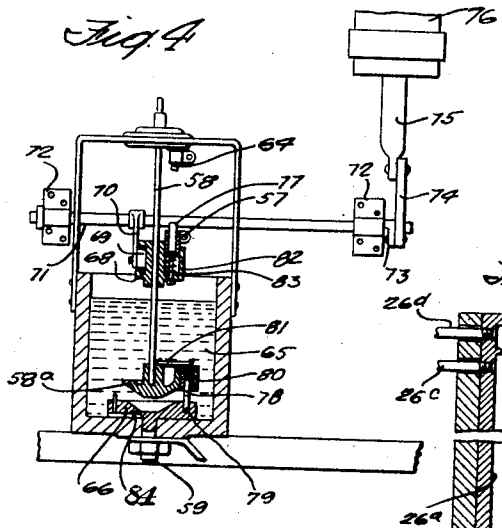


Fig. 6.

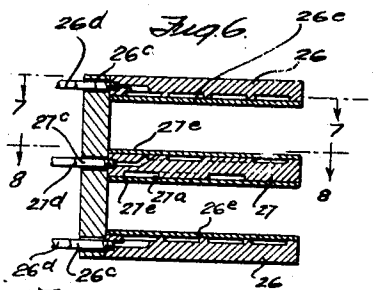


Fig. 7.

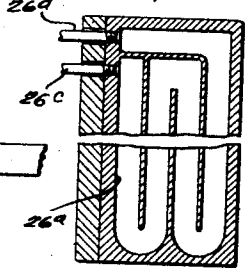
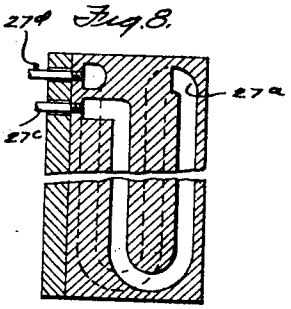


Fig. 8.



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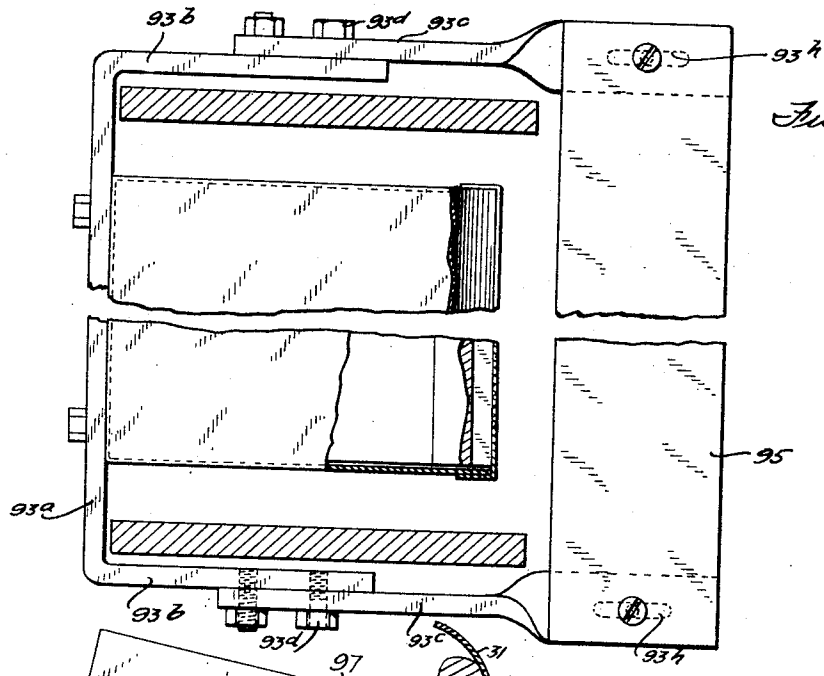


Fig. 9.

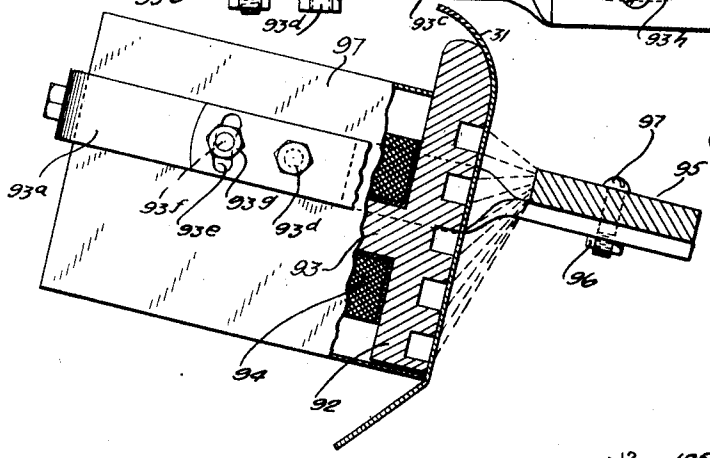


Fig. 10.

Fig. 11

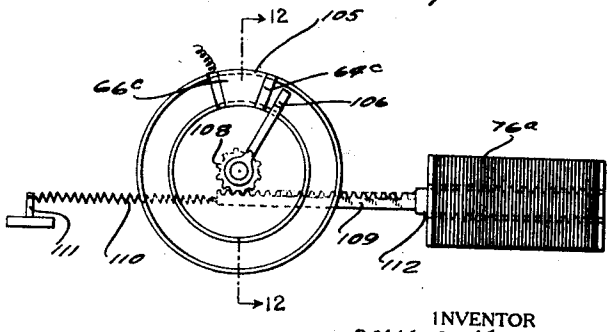
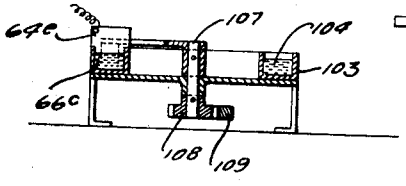


Fig. 12.



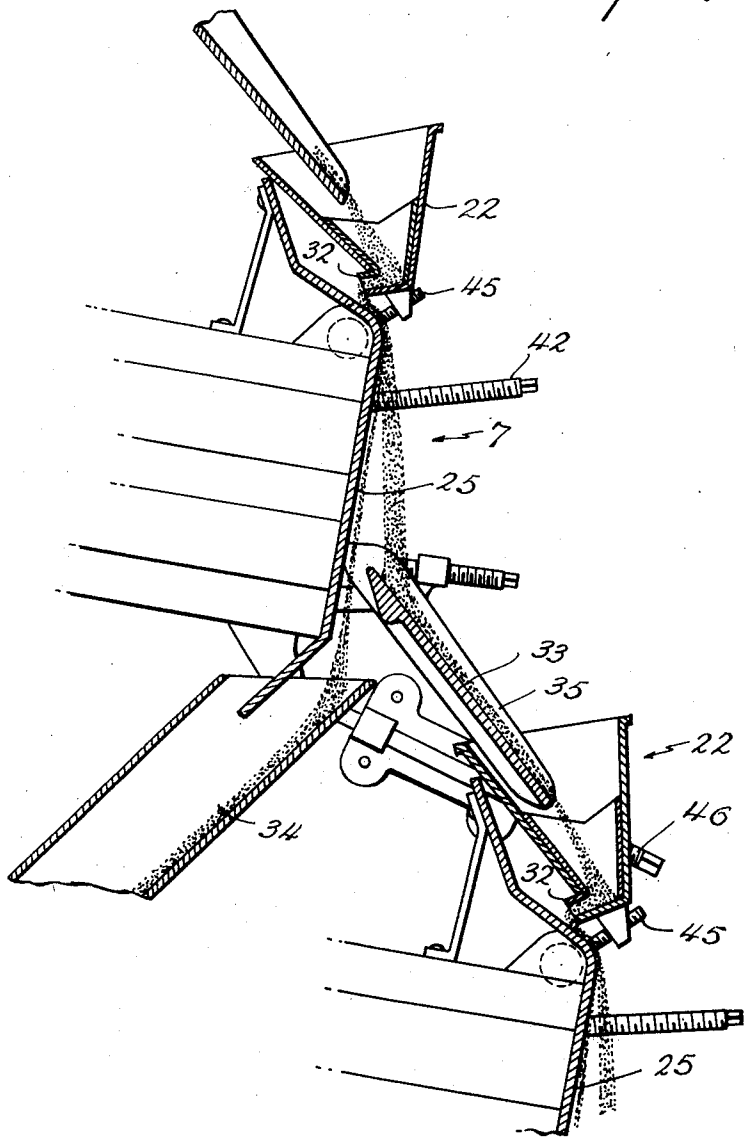
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Fig. 13.



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Patented Jan. 24, 1939 2,144,796

UNITED STATES PATENT OFFICE

2,144,796

MAGNETIC ORE SEPARATOR AND CLASSIFIER

Donald M. Crist, San Francisco, Calif., assignor to Titanium Steel Alloy Company, a corporation of Delaware

Application November 3, 1934, Serial No. 751,273

7 Claims. (Cl. 209—223)

This invention relates primarily to magnetic ore separators and has for an object to provide mechanism whereby several ore constituents of different magnetic susceptibilities may be separated and classified.

The invention also has to do with interrupter mechanism for intermittently interrupting the supplying of current to the electromagnets employed in the apparatus while avoiding objectionable back discharge of high voltage. Such means serves to prevent accumulation of ore against the faces of the electromagnetic units. The interrupter mechanism of the present invention is especially designed for this use but it is capable of use in other apparatus.

In accordance with a preferred embodiment of the invention, the electromagnetic units may all be arranged in stepped relation in a continuous upstanding series. These units are associated in groups, the units of each group being all connected to discharge ore to a common point and all having the same magnetic densities and characteristics. The units of the first group desirably comprise relatively weak magnets adapted only to attract and separate the ore constituent of highest magnetic susceptibility. The units of the second group employ more powerful magnets, capable of removing or recovering the ore constituent of next highest magnetic susceptibility but incapable of acting upon the less magnetic particles. There are as many groups as there are ore constituents to be separated and each group employs more powerful magnets than the next preceding group.

It is a characteristic of the ore separator of the present invention that the magnetic influence is applied while the ore particles (the ore being in a finely divided state) are falling freely under the influence of gravity and are not in contact with one another. In passing any unit, the ore constituents not responsive to the magnetic strength of that unit fall directly by gravity into a hopper and pass thence to the succeeding unit. The particles of the ore which are susceptible to the magnetic strength of the first unit are retarded in their fall and diverted by the magnetic pull, being caused to drop into a different receiver and to be transferred out of the system to a point of accumulation. The units are arranged in groups in order to make sure that the separation will be substantially complete and perfect, the several units of a single group being all designed for the separation of the same ore constituent.

It is a feature of the invention that the ore constituents are brought to a stop before reaching each unit, and hence are caused to pass each unit under the same gravitational force, there being no impairment of the effectiveness of the latter units because of any previously acquired velocity of the ore particles. The separation effected depends solely upon the magnetic characteristics of the ore particles and is independent of variations in the mass of the particles.

In effecting the separation of the ore constituents of low magnetic susceptibility, it is necessary to employ powerful electromagnets and these in turn require that many ampere turns of current be supplied to them. These electromagnets tend to hold the separated particles and completely to overcome the effect of gravity so that there is a tendency for the material to accumulate and choke the apparatus or impair the intended operation. Provision is accordingly made for temporarily interrupting the supply of current to the electromagnets at intervals. If the high density current supply were instantaneously cut off, there would be an inductive discharge transmitted through the system, originating at the electromagnets, which discharge would be of much higher voltage than the energy normally supplied from the generator or other source. Such back discharge has been found to be very destructive of insulation, damaging to the generator, and almost uncontrollable.

To overcome these difficulties interrupter mechanism is intermittently operated to gradually interpose an increasing resistance in each electromagnet circuit and finally to short-circuit the electromagnet. The inductive discharge originating at the electromagnet is confined to a loop circuit including the electromagnet and cannot reach the generator to affect it detrimentally.

Other objects and advantages will hereinafter appear.

In the drawings forming part of this specification and showing certain preferred embodiments of the invention,

Figure 1 is a fragmentary view in elevation and partly diagrammatic illustrating an apparatus embodying the invention;

Figure 2 is a diagrammatic view illustrating the circuit arrangement of a single electromagnet;

Figure 3 is a fragmentary view in elevation illustrating substantially a pair of successive units;

Figure 4 is a detail view in sectional elevation illustrating a portion of the interrupter mechanism;

Figure 5 is a view in front elevation of the mechanism illustrated in Figure 3;

Figure 6 is a transverse, vertical, sectional view illustrating certain features of one of the electromagnetic units;

Figure 7 is a horizontal sectional view taken on the line 7—7 of Figure 6 looking in the direction of the arrows;

Figure 8 is a horizontal sectional view taken on the line 8—8 of Figure 6 looking in the direction of the arrows;

Figure 9 is a plan view partly broken away illustrating another form of electromagnetic unit as employed in the last series of units;

Figure 10 is a fragmentary view in side elevation, partly broken away, showing features of the electromagnetic unit of Figure 9;

Figure 11 is a plan view illustrating a modified form of interrupter mechanism adapted to be used in place of that of Figure 4;

Figure 12 is a vertical, sectional view of the interrupter mechanism of Figure 11, and

Figure 13 is a fragmentary sectional elevation on a larger scale than Figure 3, but showing substantially the same part of the apparatus as Figure 3.

The illustrative magnetic separator comprises a supply hopper 1 from which the ore in finely divided form is discharged into the separating apparatus in a thin blanket. The ore passes successively through the units 2, 3, 4 and 5 of the first series. All of these units are identical and are designed for the separation of a single ore constituent of highest magnetic susceptibility. The magnets of these units are relatively weak magnets incapable of influencing any of the other ore constituents. The units of this series are all alike and are as illustrated in Figure 3.

The ore constituent of highest magnetic susceptibility is thoroughly separated out by the units 2, 3, 4 and 5 and the remaining ore then passes successively through the units 6, 7, 8 and 9. These units employ electromagnets which are more powerful than the magnets of the first series and are designed to separate out the ore constituent of next highest magnetic susceptibility. Similarly, the ore which remains unseparated passes through the units 10, 11, 12 and 13 to separate another constituent of still lower magnetic susceptibility, the units 10, 11, 12 and 13, being provided with more powerful magnets than the units 6, 7, 8 and 9. Finally, the units 14, 15, 16 and 17, which are provided with the most powerful electromagnets, separate out a further ore constituent of still lower magnetic susceptibility, these last mentioned units including the most powerful electromagnets of all.

The units 2, 3, 4 and 5 all discharge the separated ore into a common conduit 18; the units 6, 7, 8 and 9 all discharge the ore separated by them into a common conduit 19; the units 10, 11, 12 and 13 all discharge the ore separated by them into a common conduit 20; and the units 14, 15, 16 and 17 all discharge the ore separated by them into a common conduit 21.

The units of the first group may employ magnets which are simple, permanent magnets since very little magnetic force is required to exert the necessary influence upon the ore constituent of highest magnetic susceptibility. For the purpose of rendering the apparatus adaptable for different ore bodies, however, it may be preferable to employ in these units electromagnets of the same type employed in the second and third group as illustrated in Figures 3 and 6.

Mechanically, the units are all duplicates and the operation will be readily understood from the disclosure of Figure 3. This figure shows a pair of intermediate units which may be assumed to be the units 7 and 8. The ore material, which passes the unit 6 without separation, is collected in a hopper 22. Each hopper 22 is mounted to discharge ore onto the top of a non-magnetic plate 25 (preferably of brass) which is fastened to the pole plates 26 and 27 of the electromagnetic unit, the latter being in turn supported on brackets 28, pivoted at 29 to the frame 30.

The plate 25 extends across the front of and above the magnet, being rearwardly offset at its upper end 31. The hopper 22 is supported on this offset portion 31 of the plate so that the discharge spout 32 of the hopper which extends rearwardly and downwardly will discharge ore onto the plate 25 at a point above that portion of the plate which extends over the front of the magnet. The discharge spout 32 of the hopper is inclined down very slightly, being almost horizontal, so that any downward velocity of the ore particles is completely checked and the ore is caused to reverse its direction of flow before being delivered onto the offset portion 31 of the plate 25. The plate 25 does not extend vertically downward but is inclined slightly so that it overhangs a chute 33 and the mouth of a collecting chute 34. The ore which drops downward across the face of the plate 25 if permitted to fall freely and without deflection by the magnetic force would all fall onto the upper end of the guide chute 33 and be delivered thereby to the hopper 22 of the next unit. The particles of ore which are susceptible to the influence of the magnetic unit under consideration are slowed up, however, and drawn rearward toward or into contact with the plate 25 and clear of the upper end of the chute 33. This portion of the ore is therefore separated and caused to fall into the collecting chute 34. In this connection, it will be noted that the plate 25 extends downwardly and rearwardly and that its lower end is extended rearward and into the chute 34.

The chute 33 comprises a deflecting plate 35 which has its upper edge disposed close to the plate 11 at a point above and to the rear of the forward edge of the upper end of the chute 34, while the plate extends downwardly and forwardly so that its lower end extends into the hopper 22 for the next unit. The upper edge of the plate 35 is disposed rearward of the natural path of gravitation of the ore and is sufficiently spaced from the outer face of the plate 25 to permit magnetic particles separated from the ore to drop downward between said plates. The plate 35 narrows towards its lower end and forms a floor or bottom of the chute 33. Flange portions of the chute 33 are pivoted at 36 to blocks 37 which are slidably supported on rocker arms 38. The rocker arms 38 are pivoted intermediate their ends at 39 upon the bracket 28. Adjusting screws 40 are turned through screw threaded sleeves 41 carried on the outer ends of the arms 38 and are suitably connected with the blocks 37, so that when the screws are turned the blocks will be moved to carry the upper edge of the plate 35 toward or from the plate 25.

The arms 38 may be rocked on their pivots to raise and lower the deflecting plates 35. The means for rocking or adjusting these arms com-

located above the liquid. A movable contact member 106 normally stands in engagement with the block 66c. This maintains the electromagnets controlled by the device in a fully operative, normal condition. When it is desired to interrupt the supply of current, the contact 106 is swung away from the block 66c and it is finally brought into engagement with the block 64c to short-circuit the electromagnets. The contact 106 is fast upon a shaft 107, which shaft has fast upon it a pinion 108. A rack 109 meshes with the pinion 108 and is normally drawn toward the left-hand limit of its movement by a coil spring 110 which is secured to the rack bar and to a fixed frame member 111. The rack 109 forms a prolongation of the armature 112 of a solenoid 76a which is controlled in the same manner and for the same purpose as the solenoid 76 in Figure 1. When the solenoid 76a is energized, the contact 106 is swung away from the contact 66c through nearly 360° into engagement with the contact 64c. When the electromagnet 76a is de-energized, the spring 110 returns the contact 106 to its initial position.

The structure described can be used efficiently upon finely divided magnetic ore from any source. It has been found in practice to serve very advantageously for separating out the magnetic constituents of certain sea sand deposits which are rich in magnetic material. A single deposit may include, for example, magnetite, martite, chromite, ilmenite and rubies. All of these ore constituents are found in various degrees of purity in the original sand. No definite degree of magnetic densities can be specified, therefore, until the ores are tested, but it has been found that in any given deposit the several constituents are quite uniform and bear a substantially uniform relation to one another.

In a specific ore body if the magnetic density found to be required for the separation of magnetite may be taken as unity for the purpose of comparison with the densities of the magnets for separating the other constituents. The magnets of the first series, units 2 to 5 would all be designed alike and would all have this same density of 1.

Martite would then require for its separation magnets having a density of 1.7 to 2; chromite 3.57 to 4.3; ilmenite 5.7 to 6.43; and rubies or garnets up to 8.57. The magnets of the second series, that is 6 to 9, would be designed alike to have densities between 1.7 and 2; those of a third series to have densities between 3.57 and 4.3; those of a fourth series to have densities between 5.7 and 6.43; and those of a final series to have densities up to 8.57. The above figures are of course to be regarded merely as illustrative since it is possible to vary the number of stages or series and to design the magnets in accordance with the conditions found necessary by analysis of the ore body.

I claim:

1. In an ore separator, in combination, an electromagnet, a source of current, a circuit including the electromagnet and said source for supplying current from the source to the electromagnet, intermittently acting means for gradually increasing the resistance of said circuit, and means for shunting the source around the electromagnet and for short-circuiting the electromagnet when the maximum resistance is reached, comprising a body of conductive liquid, a first stationary contact submerged therein, a second stationary contact located at a substantial distance from the first, lower and upper movable contacts, the lower contacts being submerged and normally in engagement with the first stationary contact and the upper movable contact being located above the level of the liquid, and means for moving the movable contacts to separate the lower one from the first stationary contact and to carry the upper one into engagement with the second stationary contact.

2. In a magnetic ore separator, in combination, a succession of electromagnets of progressively increasing magnetic densities with associated current supply circuits, means for delivering ore successively past said electromagnets to separate and classify the ore constituents according to the magnetic characteristics thereof, and means for intermittently effecting a momentary reduction of the intensities of certain of the electromagnets to overcome adhesion of the ore, comprising means for first causing the resistance between the electromagnets and the source of current to be increased smoothly and then shunting the source current around the electromagnets.

3. In a magnetic ore separator, in combination, a succession of electromagnets of progressively increasing magnetic densities with associated current supply circuits, means for delivering ore successively past said electromagnets to separate and classify the ore constituents according to the magnetic characteristics thereof, and means for intermittently effecting a momentary reduction of the intensities of certain of the electromagnets to overcome adhesion of the ore, comprising means for first causing the resistances between the electromagnets and the source of current to be rapidly and smoothly increased and for then short-circuiting the electromagnets.

4. A magnetic ore separator comprising a frame, a plurality of magnets arranged one above the other in the frame, a support for each magnet pivotally mounted on the frame, an adjusting screw for each support mounted on the frame and bearing at one end against the support in such manner as to hold the support and magnet in adjusted position, said screw being disposed at the front of the separator, a rocker arm pivoted on each support, a metal plate carried by each support and extending in front of the magnets and above the support, a hopper supported on the upper end of each plate, one end of said rocker arm extending outwardly in front of the metal plate, a deflecting plate laterally adjustably supported upon the last named end of said rocker arm, means at the front of the metal plate for adjusting the deflecting plate, and means at the front of the metal plate for adjusting the rocker arm of each support.

5. A magnetic ore separator comprising a frame, a plurality of magnets arranged one above the other in the frame, a support for each magnet pivotally mounted on the frame, an adjusting screw for each support mounted on the frame and bearing at one end against the support in such manner as to hold the support and magnet in adjusted position, said screw being disposed at the front of the separator, a rocker arm pivoted on each support, a metal plate carried by each support and extending in front of the magnets and above the support, a hopper supported on the upper end of each plate, one end of said rocker arm extending outwardly in front of the metal plate, a deflecting plate laterally adjustably supported upon the last named end of said rocker arm, means at the front of the metal plate for adjusting the deflecting plate, means at the front of the metal plate for adjusting the rocker arm

of each support, and means at the front of the separator for adjusting said hopper relative to said plate.

6. In a magnetic ore separator, an electromagnet unit comprising pole plates, a winding on one of the pole plates, said pole plate having communicating grooves in the faces thereof forming a continuous channel, cover plates covering and closing the open sides of the grooves to form therewith a continuous passage, and means for delivering cooling fluid to one end of the passage and for discharging it from the other end of the passage.

7. In a magnetic separator, an electromagnet unit comprising a pole plate, a stem thereon, a winding on the stem, a smooth face plate of non-magnetic material on the pole plate, means for continuously effecting a free gravity feed of ore particles past the face plate, and a pole bar in front of the face plate at the opposite side of the ore path from the face plate adjacent the upper end of the face plate to concentrate the lines of magnetic force in the region where the ore velocity is low, and means for discharging the diverted, magnetic ore separately from the residue, the pole plate under the face plate being horizontally serrated to cause the magnetic flux to be distributed over the face of the plate.

DONALD M. CRIST.

prise screws 42 mounted in bearings 43 and 44, the bearings 43 being screw threaded. Ends of the screws 42 engage ends of the arms 38 in such manner that when the screws are turned in one direction the forward ends of the arms will be lifted, whereas on reverse movement of the screws the forward ends will be lowered. As the forward ends of the arms 38 are raised, the deflecting plate 35 will be moved upward and closer to the plate 25. The provision for bodily adjusting the plate 35 through adjustment of the screws 40 permits the setting of the plate 35 at the desired angle and position relative to the plate 25 and the other elements of the units. These adjustments are made to adapt the apparatus to the characteristics of the particular ore being treated and to the character of the separation desired. The hoppers 22 may be adjusted by means of adjusting screws 45. The screws 45 are mounted on the lower ends of the hoppers and are adapted to bear upon the plate 25 just where the plate curves around the upper end of the bracket 28. By means of this adjustment, the spacing of the discharge spout of the hopper from the plate 25 may be varied as desired.

To provide for adjusting the entire unit, the bracket 28 is swung on its pivot 29. This is accomplished by means of adjusting screws 46 mounted in brackets 47 fastened on the frame 30. Ends of these screws bear against the forward lower portions of the brackets 28. By turning the screws in one direction, the bracket 28 is caused to be pushed upward and rearward and the hoppers 22 and the deflecting plate 35, both with their associated elements, are likewise moved. Reverse adjustments may obviously be made by turning the screws 46 in the opposite direction.

These adjustments vary the inclination of the electromagnet 25 and provide for moving the electromagnet toward and away from the path of gravitation of the ore.

The adjustments can be quickly and easily made to adapt the elements of the several units for various kinds of separating operations, depending upon the class of work to be done and the characteristics of the ore to be treated. These adjustments further permit an arrangement of the elements of the units such that there will be no appreciable waste or loss and hence a greater yield of the desired ore constituents. The pole plates or cores for the electromagnets of the second and third series are provided with water passages 26*a* and 27*a* in order that these plates may be water-cooled. Leading to these passages from a suitable source of water supply (not shown) are pipes 26*c* and 26*d*, and 27*c* and 27*d*, for causing the circulation of the water through the passages of the pole plates.

The pole plates 26 have grooves formed in the inner faces thereof and the inner faces are covered by plates 26*a*. The water enters through a pipe 26*c* and leaves through a pipe 26*d*. The arrangement of the passages 27*a* is illustrated in Figure 8. The water enters through a pipe 27*c* and leaves through a pipe 27*d*. Cover plates 27*e* are applied to the upper and lower faces of the pole piece 27 to close the open sides of channels formed in the upper and lower faces of the pole piece so as to provide the continuous communicating passages 27*a* as illustrated.

This cooling of the pole plates and cores is desirable since the finely divided ore is usually quite hot when passing through the working zones of the magnetic separator, it being desirable to pass the ore through a drier before subjecting it to the action of the separator. The heat generated in the high density electromagnetic equipment together with the heat from the ore is apt to interfere with successful operation and to damage the magnets, and for this reason the water cooling of the poles is desirable.

In the units of the later series there is a tendency for the separated ore particles to adhere to and collect upon the faces of the plates 25 and it becomes necessary from time to time to release or remove the accumulation in order to prevent defective operation.

Current is supplied to all of the electromagnets from a suitable source of current such as a generator 48. One terminal of the generator is connected through a conductor 49 with a terminal 50. The terminal 50 is connected through a conductor 51 with a terminal 52 which in turn is connected with a trunk line 53 from which branch lines 54 run to the windings of the electromagnets of the last series. The current flowing through these electromagnets passes through branch lines 55 to a trunk line 56 which is connected to a terminal 57 of a circuit breaking mechanism. The terminal 57 is connected through a movable conductor 58 with a terminal 59 which in turn is connected through conductors 60, 61 and 62 to the opposite side of the generator. Through the circuit described, the electromagnets of the last series are normally fully energized, but when it is desired to release the accumulating ore on the faces of the plates 25 of the units 14, 15, 16 and 17, provision is made first to interpose an increasing resistance in the circuits of these units and then to short-circuit the electromagnets and shunt the generator around the electromagnets. To this end, the terminal 52 is connected through a conductor 63 with a contact 64, and the conductor 58 is moved to cause an increasing resistance to be interposed between the terminals 57 and 59.

The details of this mechanism are best illustrated in Figures 1 and 4. The conductive rod 58 carries at the lower end thereof a convex metallic contact block 58*a* which is constantly immersed in a conductive solution 65. Normally, the convex contact block 58*a* is in direct engagement with a concave contact block 66 mounted in the bottom of the vessel 67 which contains the conductive liquid 65. From time to time, however, and desirably at intervals of several seconds, the conductive rod 58 is moved upward to break the direct contact of the blocks 64 and 66 and to cause the resistance between them to be gradually increased. The rod 58 has fast upon it a conductive block 68 upon which the terminal 57 is carried. The block 68 has a slot in one side thereof which receives a roller 69 carried by a crank 70 fast on a shaft 71. The shaft 71 is journaled in brackets 72 fixed on the machine frame and includes an operating crank 73. The crank 73 is connected through a link 74 to the armature 75 of an operating solenoid 76. When the solenoid is energized, it pulls up on the link 74, swinging the shaft 71 to lift the rod 58 and thereby move the contact block 64 away from the contact block 66. This results in increasing the resistance between the blocks 58*a* and 66 without completely cutting off the current supply from the electromagnets. Finally, however, a contact 77 carried by the block 68 is moved into engagement with the contact 64 to short-circuit the electromagnets of the last series. At this

time the block 58a is still submerged in liquid so that the generator circuit is not interrupted but includes a high resistance because of the wide separation of the blocks 58a and 66. In the initial separation of the blocks 58a and 66 auxiliary contacts 78 and 79 carried by them are maintained in engagement so as to avoid too sudden an increase of the resistance. The contact 78 is carried by a plunger 80 mounted in a bore of the block 64 and the plunger is urged toward the lower limit of its movement by a leaf spring 81.

The contact 77 is carried by a plunger 82 which is mounted in a bore of the block 68 and is urged to the upper limit of its movement by a coil spring 83.

The blocks 58a and 66 are made convex and concave, respectively, in order that the trapped liquid may serve to cushion the relative approach of the blocks and thus prevent violent re-engagement of them when the solenoid 76 is de-energized. In order to prevent the liquid from interfering, however, with the complete re-engagement of the blocks, provision is made of a small bore 84 through which the liquid may escape from the cavity of the block 66.

The solenoid 76 is connected through a conductor 85 with the terminal 52. The opposite end of the winding of the solenoid 76 is connected through a conductor 86 with a stationary contact 86a. A disc 87 is driven through a pulley 88 and a belt 89 from a motor 90. The disc carries a contact which wipes across the stationary contact 87 periodically. The stationary contact 91 is in continuous conductive relation with the disc and the disc carried contact. The contact 91 is connected through a conductor 92 and conductor 62 to the generator. During the brief period of engagement of the disc contact with the stationary contact 87, the solenoid 76 is energized, the rod 58 is drawn upward quickly, the resistance of the generator circuit is increased and the ore separating magnets are short-circuited. As soon as the disc contact leaves engagement with the contact 91, the solenoid 76 is de-energized and the rod 58 together with the blocks 58a and 68 returns downward to the normal position. This entire cycle of movement requires only a small fraction of one second.

The electromagnets of the units 10, 11, 12 and 13 are similarly controlled and so also are the electromagnets of the units 6, 7, 8 and 9. Since the circuits of these electromagnets are in no way different from the electromagnet circuits already described, they will not be described in detail. Corresponding parts have been numbered with the same numbers but with the subscript *a* added in the case of units 10, 11, 12 and 13, and with the subscript *b* added in the case of units 6, 7, 8 and 9.

The electromagnets of the last series of units are mounted upon the frame in the same way as the electromagnets of the other units and are provided with similar means of adjustment. The electromagnets of the last series of units 14, 15, 16 and 17 are however desirably constructed in a somewhat different manner from the electromagnets of the preceding series. Such construction is illustrated in Figures 9 and 10 in this form. Each electromagnetic unit comprises a pole plate 92 whose face adjacent the plate 25 is serrated or notched in order to cause the lines of magnetic force to be distributed throughout the height of the plate. The plate 92 has a stem 93 on which a winding 94 is mounted. A U-shaped member 93a is bolted to the rear end of the stem 93 and has forwardly reaching arms 93b disposed outside the frame members. Further arms 93c are pivotally mounted upon the arms 93b by means of pivot bolts 93d. The arms 93c are provided with arcuate slots 93e concentric with the pivot bolts 93d. Threaded studs 93f carried by the arms 93c extend through these slots and receive upon their outer ends lock nuts 93g for fixing the arms 93c in selected adjusted positions. At their forward ends the arms 93c are twisted so that they are disposed flatwise and these flat portions are provided with slots 93h, which extend toward and from the pole plate 92. A pole bar 95 is adjustably mounted upon the arms 93c by means of bolts 97 and lock nuts 96. It will be observed that pivotal adjustment of the arms 93c is effective to raise or lower the pole bar 95 and the bodily adjustment is effective to move the pole plate to and from the path of falling ore. The pole plate 92 may be regarded as the positive pole and the bar 95 as the negative pole. The pole bar 95 acts to converge and concentrate the lines of force in front of the upper part of the plate 25 so that the ore particles are acted upon with great magnetic force while travelling at low velocity. It is important, however, that the pole bar 95 be adjusted to lie farther from the path of the falling ore than the directly opposed portion of the pole plate 92, since the pole bar 95 also tends to draw the magnetic ore particles to itself.

It will be noted that the pole plate 92 is in this instance extended upward into engagement with the sloping face 31 of the plate 25, so that the ore is subjected to the magnetic influence while actually in contact with the face 31. At this point the only particles remaining in the gauge which may be desirable are very slightly influenced owing to their low susceptibility by magnets of extreme magnetic density and it is found advisable to slow their gravitation as much as possible. This is feasible in the last stage since the ore particles which are to be rejected are non-magnetic and cannot, therefore, become attached to magnetized particles even when in contact with them.

The bar 95 is carried upon arms 96 being secured thereto by means of bolts 97 and nuts 98, the bolts being passed through slot 99 in the arms 96 so that the bar 95 can be adjusted at will toward and from the plate 25. The arms 96 are pivotally mounted at 97 and are adapted to be fixed in position by means of wing nuts 100 which are threaded upon stems 101 carried by the machine frame. The stems 101 pass through arcuate slots 102 formed in the arms 96 concentric with the pivots 97.

In Figures 11 and 12 disclosure is made of a modified form of interrupter mechanism. This mechanism is designed to be used in lieu of the solenoid operated mechanism of Figures 1 and 4. It has the advantage that the contacts to be separated for interposing an increasing resistance in the circuits of the ore separating magnets may be separated to a greater extent than would be feasible in the case of the blocks 58a and 66. This separator mechanism comprises an annular dish or vessel 103 of suitable non-conducting material, such as porcelain, which contains a conductive liquid 104. The trough or channel of this vessel has a partition 105 provided in it with a contact block 66c at one side of the partition submerged in the liquid and a contact block 64c at the other side of the dam