Oct. 6, 1942. R. G. WIDDOWS 2,298,243

MAGNETIC SEPARATOR

Filed June 23, 1939 2 Sheets-Sheet 1

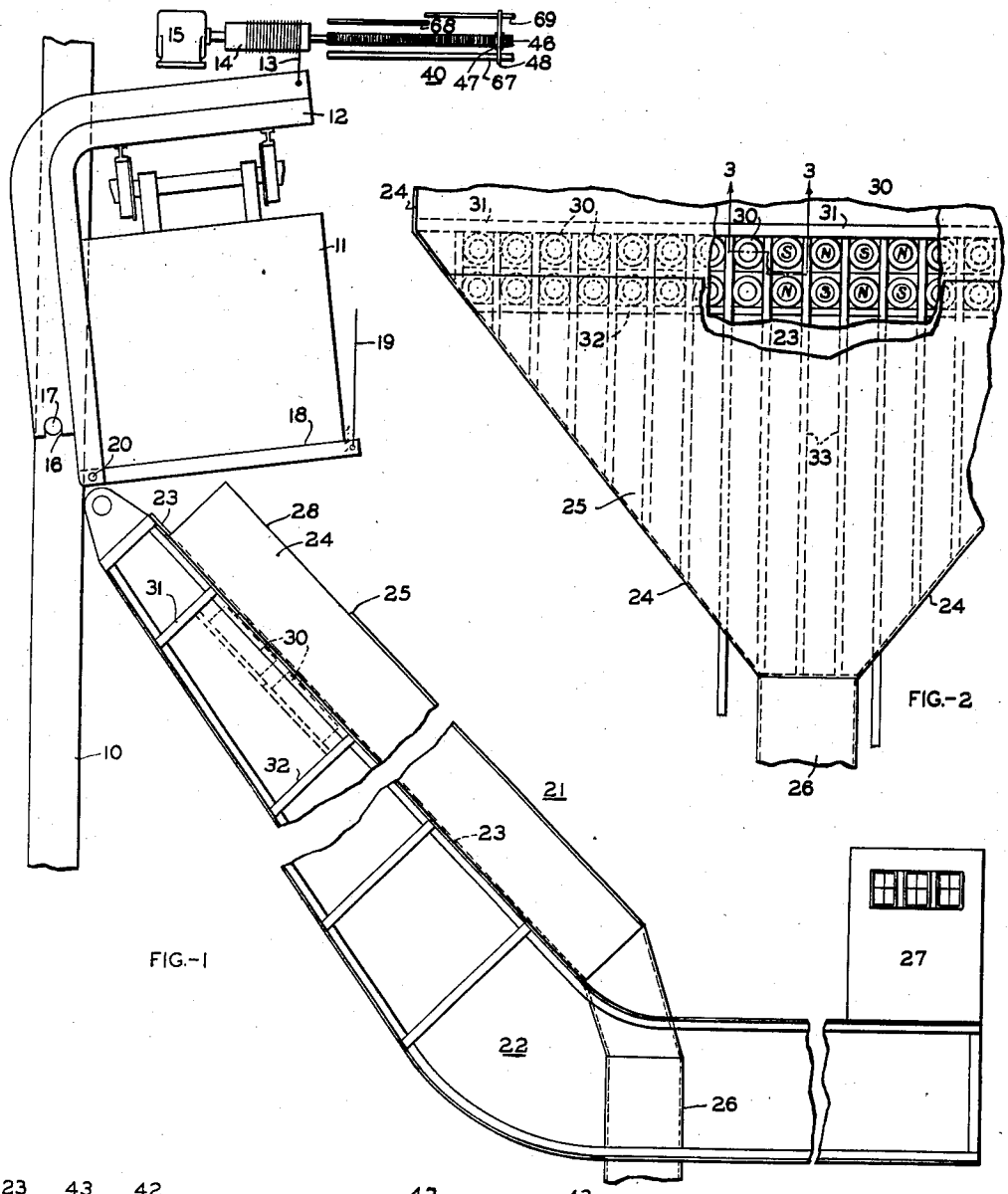


FIG.-1

FIG.-2

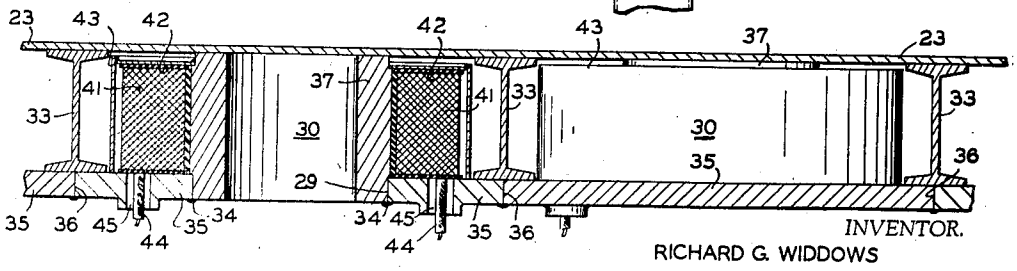


FIG.-3

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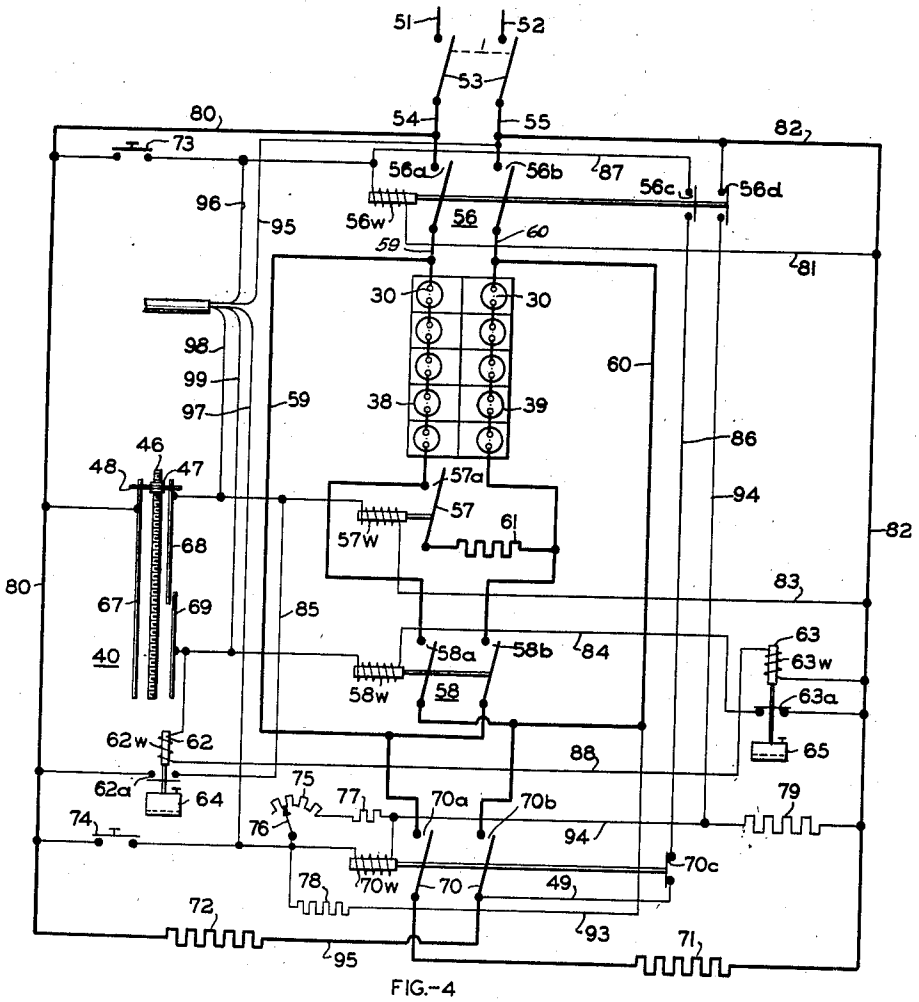


FIG.-4

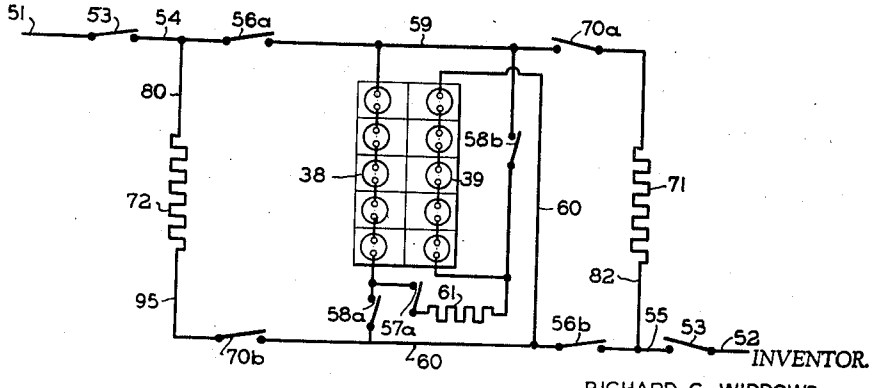


FIG.-5

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UNITED STATES PATENT OFFICE

2,298,243

MAGNETIC SEPARATOR

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Application June 23, 1939, Serial No. 280,827

12 Claims. (Cl. 209—214)

This invention relates to magnetic separation, and more particularly to the magnetic separation of stray pieces of magnetic material, such as bolts, rods, tools, and like tramp iron, from bulky materials of which quantities turbulently fall upon and slide or tumble over a plate through the field of a separator magnet at recurrent spaced intervals of time, as for example, the removal of iron from coal discharged from cars which are dumped in succession onto an inclined chute.

In car dumper chutes of this type, the bottom plates must be very strong and durable in order to resist the abrasive action of the falling material. Preferably, such plates should be made of iron or steel. Iron or steel plates, however, interfere with the creation of a strong flux in the path of the falling materials. Furthermore, the chutes are so arranged that only magnets of very limited size can be installed in connection therewith unless the chute is to be changed materially in construction. Because of these difficulties, attempts have been made to utilize more effectively the flux produced by small magnets. So far, no one has been able to do so without some material changes in the chute. The usual choice has been to replace the steel bottom plates of the chutes by bottoms made of alternate strips of iron and non-magnetic material, such as brass. The magnetic poles are then placed beneath the iron portions of such composite plates, or extended through openings therein, and the available flux utilized more effectively since it is prevented from passing from pole to pole through the bottom plate itself. While these non-magnetic strips provide a gap effective for this purpose, they are subject to rapid wear and deterioration. Consequently, this type of combination chute and separator is expensive both because of the special construction and because of its relatively short life and high maintenance cost. Oftentimes, too, additional changes were provided in the sides and cover of the chute so as to provide non-magnetic gaps between the poles.

The problem was presented, therefore, of providing sufficiently small magnets so that changes in the chute construction were not required and to avoid the use of the non-magnetic inserts, while at the same time obtaining sufficient available flux from the small magnets both to separate out the tramp material and to constrain the tramp material after separation from dislodgement by other material of the charge or of subsequent charges passing along the chute.

In accordance with the present invention, advantage is taken of the fact that the flux required to hold a piece of magnetic material against a pole piece of a magnet is less than that required to draw the material to the pole piece across an air gap. Further advantage is taken of the fact that in the use of chutes of this character, the material is dumped in successive charges spaced apart at somewhat uniform short intervals of time. Another fact is that a magnet may be over-energized and produce a great excess of flux for a relatively short interval of time without deleterious effects, whereas were such over-energization to be continued for a somewhat longer interval, the resultant heating would damage and rapidly deteriorate the magnet.

The present invention has to do with the new interrelation of these circumstances, phenomena, and structural limitations in a manner such that the desired results are obtained with a standard chute and while utilizing much smaller magnets than were heretofore thought practicable. This involves, directly, the conception that over-energization of the magnets for the relatively short intervals of time during which material is passing through the field thereof can be maintained, without danger to the magnet, at a degree such that an excess of flux over that required for saturating the bottom plate of the chute is produced, and that this over-energization must be reduced immediately after the passage of the charge of material through the field of the magnets, but only to a degree of energization of the magnets which provides a below-normal or holding flux which is adequate for maintaining the magnetic material directly against the bottom plate and constraining it from dislodgement by gravity, while permitting the magnets to cool. By virtue of this arrangement, the tendency toward excessive heat created during the alternate periods of over-energization and separating flux is dissipated during the alternate periods of under-energization and holding flux, at which time the magnets are subjected to but little heating effect.

Since the overenergization resulting from the application of increased voltage greatly increases the magnetic flux and completely saturates the iron or steel plate of the chute so that it does not act as a magnetic shunt for the additional flux, there is a great excess of flux in the turbulent mass of falling and sliding material, causing a strong pull to be exerted upon any stray magnetic pieces that are present. Also,

this greatly increased flux concentration during the time that the material is falling retains in position against mechnical impact any magnetic material which has been previously attracted to the bottom plate of the chute. The necessity of resorting to costly and complicated chute construction in order to obtain sufficient separating flux is therefore avoided.

An object of the invention is to obtain greater efficiency of separation of magnetic material from mixtures which pass a fixed point at successive, spaced intervals of time.

A further object of the invention is to provide a magnetic separator adopted to separate tramp iron from bulky material as quantities thereof turbulently fall upon and slide across a steel plate at successive, spaced relatively short intervals of time.

Another object of the invention is to provide a magnetic separator for use in conjunction with an inclined chute such as commonly used for transferring a quantity of bulky material from a dumped car to a transporting vehicle.

A more specific object of the invention is to provide a magnetic separator adopted to separate iron from coal as it falls from an inverted railroad car and which is more efficient and effective than those heretofore used.

Another object is to provide a separator magnet system for loads which pass the magnet at successive, spaced intervals of time and in which, while a load is passing, an extremely high voltage is applied to the system to over-energize the magnets and create a separating flux, and, while a load is not passing, a reduced voltage is applied to the system which causes under-energization of the magnets to create a holding flux which is less than the separating flux.

A further object is to provide a magnetic separator in which the magnets are placed beneath a continuous iron or steel plate and so energized that the plate is completely saturated and an extremely strong magnetic field created above the plate.

Other objects and advantages will become apparent from the following specification wherein reference is made to the drawings in which:

Fig. 1 is a diagrammatic side elevation of a portion of a car dumper and chute with the separator magnets in place;

Fig. 2 is a plan view of a portion of the car dumper chute shown in Fig. 1;

Fig. 3 is a sectional view taken on the line 3—3 of Fig. 2;

Fig. 4 is a complete wiring diagram of a controller for a plurality of separator magnets which may be used as part of the bank of magnets shown in Fig. 2; and

Fig. 5 is a simplified wiring diagram of a portion of the wiring diagram shown in Fig. 4, and particularly showing the power circuits for the magnets.

Referring to Fig. 1, a portion of the supporting structure of a car dumper is indicated at 10. In the operation of such dumpers, a railroad car 11 to be dumped is placed in a framework or cradle 12 and is raised in an upright position from the bottom of the car dumper to a point near the top by means of some form of hoisting mechanism shown as a cable 13 wound upon a drum 14 driven by a motor 15. When the cradle 12 reaches the height from which the car 11 is to be dumped, a slot 16 in the cradle 12 engages a cylindrical shaft 17 fastened rigidly to the car dumper structure 10. As the cable 13 continues to pull upward, the cradle 12 pivots about the shaft 17, and concurrently the rod-like members 18 controlled by the cables 19 pivot at 20 to hold the car 11 within the cradle 12 while the car 11 is being emptied. The particular structure and operation of the car dumper illustrated forms no part of this invention and therefore is not referred to in detail. The motor 15 also drives a limit switch 40, shown as of the traveling nut type, which controls the energization of the separator magnets in a manner to be described.

The uppermost portion of an inclined chute 21 is arranged directly below the inverted car 11. The chute 21 comprises a structural framework 22 supporting an iron or steel bottom plate 23. Iron or steel side panels 24 are arranged on each side of the bottom plate and a cover 25 encloses the chute for substantially all of its length leaving an opening 28 at the top through which the material may fall from the car 11 onto the plate 23.

As more clearly shown in Fig. 2, the plate 23 is substantially a triangle, having one side at the top and tapering in the direction of incline toward the lower angle. An opening which communicates with a flexible conduit 26 is left at the bottom of the chute by termination of the sides 24, top 25, and bottom 23. The conduit 26 can be moved at the will of an operator in the cab 27 to direct the flow of falling material.

Each of the magnets 30 comprises a square yoke 35 having a central opening 29 through which a hollow, cylindrical pole member 37 is inserted. The pole member 37 may be retained in position by welding as at 34. A winding 41 surrounds each of the poles 37. The windings 41 are insulated from the yoke and poles by means of insulating material 42, are preferably impregnated with an insulating compound to make them moisture-proof, and are enclosed in metal casings 43. The poles 37 extend above the casings 43 and abut tightly against the bottom plate 23. Electrical connections to the coils 41 may be made through conduits 44 which pass through openings 45 in the yokes 35.

The magnets 30 are placed beneath the portion of the plate 23 where the falling material strikes.

Referring to Fig. 2, two of the magnets 30 are arranged within each of the spaces between the transverse girders 31 and 32 and the longitudinal girders 33 which form part of the structural framework 22. The yokes 35 of longitudinally adjacent magnets abut tightly against each other to form a good path for magnetic flux and the magnets 30 are preferably of such size that the yokes of transversely adjacent magnets touch each other beneath the longitudinal girders 33, as shown in Fig. 3, thus making a good magnetic circuit transversely of the chute 21 as well as a good magnetic circuit longitudinally of the chute 21. The coils 41 of the magnets 30 are preferably wound so that alternate north and south poles occur in both the transverse and longitudinal directions as indicated.

When no material is passing through the chute, a comparatively low voltage is impressed upon the magnets 30 to create a holding flux. When the car 11 begins to tilt, the limit switch 40 completes electrical connections which cause the magnets 30 to be over-energized by a voltage in excess of their normal voltage to produce a separating flux. The limit switch 40 should be so adjusted in relation to the position of the car 11 that the magnets 30 are connected for over-ener-

gization a few seconds before any material begins to fall. This time interval permits the separating flux to reach its full strength before any material strikes the plate 23. The over-excitation normally continues until the car is unloaded and moved back into an upright position. In case the car is left in a tilted or inverted position for too long a time, a time delay arrangement operates to automatically reduce the over-energization of the magnets and apply a reduced voltage sufficient to create a holding flux.

Some features of the magnet controller now to be described are disclosed and claimed in Wright Reissue Patent No. 20,724, issued May 10, 1938 and in a copending application of Arthur L. Ward, Serial No. 173,817, filed November 10, 1937, now U. S. Letters Patent No. 2,195,017. Other types of automatic magnet controllers can be adapted in a similar manner to provide the desired control.

Referring to Figs. 4 and 5, a source of direct current supply is illustrated at 51 and 52 and a double-pole knife switch 53 is provided to connect the source of supply 51 and 52 to the conductors 54 and 55, which lead to an electromagnetic switch 56. The switch 56 has an operating winding 56*w*, normally-open main contacts 56*a* and 56*b*, and normally-open auxiliary contacts 56*c* and 56*d*. The separator magnets 30 are series connected in two groups 38 and 39 of five magnets each, and electromagnetic switches 57 and 58 control the connection of the magnet groups 38 and 39 between the conductors 59 and 60. The conductors 59 and 60 are energized from the source 51, 52 when the switches 53 and 56 are closed.

Two groups of five magnets each have been illustrated as controlled by one controller, but any reasonable number of groups having any number of magnets could be associated with a single controller if desired. Preferably the remaining magnets are arranged in similar groups and two or more of the groups controlled by a separate controller. The several controllers may be connected in parallel with each other in a manner to be described.

The switch 57 has an operating winding 57*w* and normally-open main contacts 57*a* and is arranged to connect the magnet groups 38 and 39 in series with each other and with a resistor 61 across the conductors 59 and 60. The switch 58 has an operating winding 58*w* and normally-open main contacts 58*a* and 58*b*. The contacts 58*a* and 58*b* when closed connect the magnet groups 38 and 39 in parallel with each other across the conductors 59 and 60.

The time delay arrangement which operates to automatically reduce the magnet energization in case the car 11 is left in a tilted or inverted position for too long a time comprises two time delay relays 62 and 63. The relay 62 has an operating winding 62*w* and normally-open contacts 62*a*, which are delayed in their closing movement by means of a retarding device shown as a dash pot 64. The relay 63 has an operating winding 63*w* and normally-open contacts 63*a* which are delayed in their opening movement by means of a dash pot 65.

An electromagnetic switch 70 having an operating coil 70*w*, normally-open contacts 70*a* and 70*b*, and a normally-closed auxiliary contact 70*c* is arranged to provide reverse voltage connections for the magnets 30 through the resistors 71 and 72.

A push button 73 controls the operation of the switch 56 and a push button 74 controls the operation of the switch 70. The operation of the switches 57 and 58 is controlled by means of the traveling nut limit switch 40 which is driven by the motor 15 of the car hoisting mechanism as shown in Fig. 1. The switch 40 comprises a screw 46 and a traveling nut 47 having a contact brush 48 attached thereto. The contact brush 48 is arranged to selectively electrically connect the segments 68 and 69 to a segment 67 as the screw 46 rotates.

To provide an adjustment of the operating characteristics of the reverse voltage switch 70, a resistor 75 having an adjustable connector 76 is connected in parallel with the winding 70*w*. A fixed resistor 77 is connected in series with the adjustable resistor 75. The resistors 78 and 79 are arranged to be connected in series with the winding 70*w* when the magnets 30 are discharging to reduce to a safe value the voltage applied to the winding 70*w*.

Controllers which are preferably duplicates of the one shown in Fig. 4 are provided for the other magnets, but are not illustrated, inasmuch as their construction and operation are apparent from the illustrated controller. The duplicate controllers are preferably connected in parallel with the controller shown so as to be operable from the push buttons 73 and 74 and the limit switch 40 by connecting a conductor 96 to one terminal of the operating windings of the switches of the duplicate controllers which correspond to the switch 56, a conductor 97 to one terminal of the operating windings in the duplicate controllers which correspond to the winding 70*w*, a conductor 98 to one terminal of the operating windings corresponding to the winding 57*w*, and a conductor 99 to one terminal of the operating windings corresponding to the winding 58*w*. The other terminals of each of the corresponding windings in the duplicate controllers are connected to a conductor corresponding to the conductor 82 of the illustrated controller in the same manner as in the illustrated controller, and that conductor connected to the source of power 51, 52 by means of a conductor 95 and the conductor 55.

As more clearly seen in Fig. 5, the series connected magnet groups 38 and 39 are arranged to be connected either in series or in parallel between the conductors 59 and 60. When a car is not being dumped, the switches 56 and 57 are closed to connect the magnet groups 38 and 39 in series with each other and in series with the resistor 61 across the energized conductors 59 and 60. With this connection the magnets are underenergized and produce only a holding flux. When the car 11 begins to tilt, the switch 58 closes. Closure of the switch 58 connects each of the magnet groups 38 and 39 directly across the conductors 59 and 60. Since with this latter connection, the magnets in only one group are now in series with each other and the resistor 61 is not in series therewith, a much larger voltage is impressed upon each magnet, and, as a result, the magnets are overenergized to produce a separation flux. Shortly after the switch 58 closes, the switch 57 opens to disconnect the resistor 61. It is essential, in order to avoid destructive induced voltages, that the switch 58 close before the switch 57 is opened so that the magnets 30 are not disconnected from the source of supply.

As a result of the overenergization of the magnets 30 during the time that the car 11 is being emptied, the steel bottom plate 23 of the chute 21

is magnetically saturated and a strong magnetic field is present in the path of the falling material to cause any iron that may be present to be attracted to the plate 23. Further, any material that has been attracted is retained in place against the impact of the falling material. After the car 11 is emptied, it is moved back to an upright position. During this operation, the switch 57 first closes to connect the resistor 61 in circuit with the magnets 30, and then the switch 58 opens to remove the high voltage from the magnets. The magnet groups 38 and 39 are now again connected in series with each other and with the resistor 61 across the source of power. The voltage impressed upon each magnet with this connection is preferably just sufficient to create a holding flux strong enough to constrain any attracted material in position against the pull of gravity.

The apparatus operates as follows:

If the knife switch 53 is closed, power from the source 51 and 52 is applied to the conductors 54 and 55, and if the push button 73 is operated to its closed position, an operating circuit is completed for the winding 56*w* of the switch 56 from the conductor 54 through a conductor 80, the push button 73, the winding 56*w*, and the conductors 81 and 82 to the conductor 55. Energization of the winding 56*w* causes operation of the switch 56 to its closed position to connect the conductors 54 and 55 to the conductors 59 and 60 respectively.

If the car 11 and the cradle 12 are at the bottom of the car dumper, the traveling nut 47 and its associated contact brush 48 will be in the position shown in Fig. 4. When in this position, the brush 48 completes a circuit from the energized conductor 80, the contact segment 67, the brush 48, the contact segment 68, the winding 57*w*, and a conductor 83 to the energized conductor 82. The resulting energization of the winding 57*w* causes closure of the contacts 57*a* of the switch 57. Power is now supplied to the magnets 30 from the energized conductor 59, through the magnet group 38, the contacts 57*a*, the resistor 61, and the magnet group 39 to the energized conductor 60. Since the magnets 30 are now all connected in series with each other and with the resistor 61, each magnet is energized by a relatively low voltage which is preferably just sufficient to create a holding flux strong enough to constrain in position against the pull of gravity any magnetic material that might be on the plate 23.

As the hoisting mechanism moves the cradle 12 and the car 11 upward, the contact brush 48 moves along the contact segments 67 and 68 toward the contact segment 69. When the car 11 begins to tilt, the brush 48 comes in contact with the segment 69 and completes a circuit from the energized conductor 80, the contact segment 67, the brush 48, the segment 69, the winding 58*w* of the switch 58, a conductor 84, and the normally-closed contacts 63*a* of the relay 63 to the conductor 82. In response to the resulting energization of its operating winding 58*w*, the switch 58 closes its main contacts 58*a* and 58*b* to connect the magnet groups 38 and 39 in parallel between the energized conductors 59 and 60. The windings 62*w* and 63*w* of the time delay relays 62 and 63 respectively are energized concurrently with the winding 58*w* when the brush 48 contacts the segment 69, but the contacts 62*a* and 63*a* remain in normal position. The circuit through the windings 62*w* and 63*w* is from the now energized segment 69, the winding 62*w*, a conductor 88, and the winding 63*w* to the conductor 82.

Further movement of the hoisting mechanism causes the brush 48 to leave the segment 68 and thus to interrupt the circuit to the winding 57*w*. As a result, the winding 57*w* is deenergized and the switch 57 opens its contacts 57*a* and leaves the magnets 30 connected in two parallel groups between the conductors 59 and 60. The switch 57 remains closed for an interval after the switch 58 closes to insure that the magnets are not completely disconnected from the source of supply. The elimination of the resistor 61 from its series connection with the magnets 30 and the fact that there are now only five magnets connected in series with each other results in a greatly increased voltage being impressed on each of the magnets 30. This increased voltage creates a large magnetic flux which completely saturates the plate 23 and also passes above the plate 23 into the air gap through which the falling material is to pass. As the car is turned to the inverted position, the brush 48 remains in contact with the segments 67 and 69, as shown in Fig. 1, and the magnets are overenergized to produce a separating flux during this entire time.

As soon as the car is emptied, the hoisting mechanism is reversed, and the brush 48 starts to move back towards the segment 68. When the car 11 approaches its upright position, the brush 48 again contacts the segment 68 to reestablish the circuit to the winding 57*w* previously traced. As a result, the switch 57 again closes. Upon further movement of the car 11, the brush 48 leaves the contact segment 69 to interrupt the circuit to the winding 58*w*. The switch 58 consequently opens, leaving the magnets 30 again connected in series with each other and in series with the resistor 61. The magnets 30 are now underenergized, but the holding flux produced is sufficient to retain in position, against the pull of gravity, any magnetic material that has been attracted.

As subsequent cars are moved onto the cradle 12 and hoisted and emptied, the same sequence of operations takes place. The increased energization during the time that the car 11 is being emptied insures that any previously attracted magnetic pieces are held firmly in place against the impact of the falling coal or other material and also that there is sufficient flux in the stream of the falling material to extract any additional tramp magnetic pieces.

After several cars have been emptied and an accumulation of magnetic material is present on the chute bottom 23, it is desirable to deenergize the magnets 30 to facilitate the removal of such material. The magnets 30 may be deenergized by closing the push button 74 and opening the push button 73. Closure of the push button 74 completes an energizing circuit for the winding 70*w* of the switch 70 from the energized conductor 80, the push button 74, the winding 70*w*, a conductor 94, the contacts 56*d* of the switch 56 to the energized conductor 82. The switch 70 in response to the energization of its operating winding 70*w* closes its main contacts 70*a* and 70*b* to set up reverse voltage connections for the magnets 30. If the push button 73 has previously been opened or is now opened, the winding 56*w* is deenergized, resulting in the opening of the switch 56. Opening of the push button 73 before the switch 70 closes has no effect upon the winding 56*w* because of an interlock circuit extending from the con-

ductor 80 through the resistor 72, the conductors 95 and 49, the contacts 70c, a conductor 86, the contacts 56c, a conductor 87, the winding 56w and the conductor 81 to the conductor 82. The purpose of this interlock circuit is to prevent deenergization of the magnets 30 by opening of the push button 73 without closure of the switch 70.

Closure of the main contacts of the switch 70 completes a magnet discharge circuit which extends from the terminal of the magnet group 38 which is connected to the conductor 59, through the conductor 59, the contacts 70a, the resistor 71, the conductor 82, the knife switch 53 to the source of supply 51 and 52 and thence back through the knife switch 53, the conductor 80, the resistor 72, the conductor 95, the contacts 70b and the conductor 60 to the terminal of the magnet group 39 which is connected to the conductor 60. If the switch 57 is closed at the time of operation of the closure of the switch 70, the discharge circuit is completed between the magnet groups 38 and 39 through the resistor 61 and the contacts 57a of the switch 57. If the switch 58 is closed at the time of closure of the switch 70, the discharge circuit previously traced is completed through the magnet groups 38 and 39 in parallel across the conductors 59 and 60 by means of the contacts 58a and 58b of the switch 58.

When the switch 56 opens in response to opening of the contacts 70c, the discharge voltage of the magnet is opposed to the supply line voltage, and, when the discharge voltage which may be twice or three times as much as the supply voltage at the beginning of the discharge, has reduced to a value equal and opposed to the supply voltage, the current in the magnets 30 becomes zero. Current now begins to flow in the reverse direction through the magnets 30 over one or the other of the previously traced reverse voltage circuits, depending upon which one is completed. The reverse current through the magnets 30 tends to cause the remaining flux to decrease to a zero value.

The original circuit to the coil 70w through the contacts 56d is interrupted when the switch 56 opens, but the coil 70w remains energized due to the discharge voltage of the magnet over a circuit which extends from the winding 70w to the resistor 78, the conductors 93 and 60, the magnet group 39, the resistor 61, the contacts 57a, the magnet group 38, the conductor 59, the contacts 70a, the resistor 71, the resistor 79 and the conductor 94 to the other terminal of the winding 70w. If the switch 58 is closed instead of the switch 57, the discharge voltage energizing circuit for the winding 70w is completed through the magnet groups 38 and 39 in parallel by means of the contacts 58a and 58b rather than in series through the resistor 61 and the contacts 57a.

When the discharge voltage reaches a predetermined value due to the reverse current, the winding 70w will be sufficiently deenergized to permit the switch 70 to open, thereby cutting off the current at the moment the magnets 30 are demagnetized to a predetermined degree. The adjustable resistor 75 is provided in the circuit of the coil 70w to permit control of the value of reverse current which permits operation of the switch 70 to its open position.

Should the car 11 be left in its inverted or tilted position for a period much longer than that normally required to empty it of its contents, the magnets 30 would be seriously damaged by overheating caused by the high current necessary to create the overenergization. To prevent this from happening, the time delay relays 62 and 63 are provided for automatically reducing the voltage applied to the magnets after a predetermined interval of time.

When the brush 48 engages the segment 69 to energize the winding 58w and close the switch 58, a circuit previously traced is completed to the windings 62w and 63w of the time delay relays 62 and 63 respectively. If the car 11 remains in a position such that the contact brush 48 completes a connection to the segment 69 for a period which is somewhat longer than that normally required to empty a car, the contacts 62a of the relay 62 close to complete a circuit from the conductor 80, the contacts 62a, a conductor 85, the winding 57w and the conductor 83 to the conductor 82. The winding 57w is therefore energized even though the brush 48 is not in contact with the segment 68, and, as a result, the switch 57 closes its contacts 57a to set up the series or reduced voltage connection for the magnet groups 38 and 39.

Although the windings 62w and 63w are simultaneously energized, the dash pot 65 is so adjusted in relation to the dash pot 64 that the contacts 63a do not open until after the contacts 62a close. After a lapse of this additional time, the contacts 63a open to interrupt the circuit previously traced to the winding 58w. As a result of the deenergization of the winding 58w, the contactor 58 opens its contacts 58a and 58b to remove the parallel or high voltage connection of the magnet groups 38 and 39, and since the switch 57 is closed, the magnets 30 are now connected in series with each other through the resistor 61 across the conductors 59 and 60. The voltage impressed upon each of the magnets 30 is thereby reduced and a holding flux created even though the brush 48 is still in contact with the segment 69. When the car is moved back to its upright position, the brush 48 leaves the segment 69 and thereby deenergizes the windings 62w and 63w and the relays 62 and 63 return to their normal position.

I claim:

1. In combination, a car dumping mechanism for successively inverting cars containing mixtures to be magnetically separated and for returning the cars to an upright position after the mixtures have fallen from the cars, a separator magnet fixed in proximity to the path along which the mixtures pass, means operated by the car dumping mechanism to over-energize said magnet to create a separating flux while the cars are being emptied, and means operated by the car dumping mechanism as it returns the cars to upright position to under-energize the magnet to create a holding flux, whereby the magnet is permitted to cool before the next successive car is dumped and attracted material is retained in attracted position during cooling of the magnet.

2. The combination with mechanism for handling and separating materials and wherein are provided means operable for causing quantities of the materials to pass along a given path at successive, spaced intervals of time and a separator magnet for creating a magnetic field in said path, of control means operated by the first means, when the first means is operated to cause passage of a quantity of material along said path, to connect the magnet for over-energization by a source of power, whereby the magnet

produces a separating flux while the material is passing along said path, said control means being operated by the first means, when the first means is operated to stop the passage of said material, to connect the magnet for under-energization by a source of power, whereby the magnet produces a holding flux while the material is not passing along said path.

3. The combination in accordance with claim 2 characterized further in that the control means comprises a limit switch and electromagnetic contactors operated by said limit switch to effect the magnet connections.

4. The combination in accordance with claim 2 characterized further in that the first means comprises a car dumping apparatus and the control means comprises a limit switch operated thereby.

5. The combination with a chute means defining a predetermined path of flow for mixtures to be magnetically separated, means to alternately permit and prevent the flow of said mixtures along said path, an electromagnet in close proximity to said path and energized to a predetermined value capable of separating and holding magnetic materials, of means operable, while said mixtures are not flowing along said path, to decrease the energization of said magnet from said predetermined value to a lower value capable only of holding the magnetic material after it has been separated, said last named means being rendered operative upon operation of said second mentioned means to prevent flow of material along said path.

6. A mechanism for separating magnetic materials, comprising an electromagnet adapted to be connected to a source of power, intermittently acting means for supplying materials to be separated to said magnet at successive, spaced intervals of time, switching means operable to change the effective resistance of said magnet whereby the field strength of the magnet can be increased and decreased, and means operatively connecting said intermittently acting means and said switching means to cause said switching means to effect a decrease in the effective resistance of said magnet just prior to and during the supplying of materials to said magnet and to cause said switching means to effect an increase in the resistance of said magnet during intervals when materials are not being supplied to said magnet.

7. The combination with a mechanism for handling and separating magnetic material from mixtures and wherein are provided means operable for causing quantities of the mixtures to be handled and separated to pass along a given path at successive, spaced intervals of time, and a separator magnet adapted to be connected to a source of power for creating a magnetic field in said path, of control means operated by the first named means, when the first named means is operated to cause the mixtures to pass along said path, to connect said magnet to a source of power for over-energization, whereby said magnet produces a separating flux while the mixtures are passing, and said control means being operated by the first named means, when the first named means is operated to stop the passage of said mixtures, to connect said magnet to a source of power for under-energization, whereby said magnet produces a holding flux while mixtures are not passing along said path, and means operative when said control means connects said magnet for over-energization for a predetermined interval of time to disconnect said magnet from over-energization.

8. The combination with a mechanism for handling and extracting magnetic material from mixtures, wherein are provided means operable for causing quantities of the mixtures to be separated to pass along a given path at successive, spaced intervals of time, a separator magnet for creating a magnetic field in said path, of control means operated by the first means, when the first means is operated to cause the passage of mixtures along said path, to connect said magnet for over-energization, whereby said magnet produces a separating flux while the mixtures are passing along said path, and said control means being operated by the first means, when the first means is operated to stop the passage of said mixtures, to connect said magnet for under-energization, whereby said magnet produces a holding flux while mixtures are not passing along said path, and means operative when said control means connects said magnet for over-energization for a predetermined interval of time to disconnect said magnet from over-energization and to connect the magnet for under-energization, whereby said magnet produces a holding flux regardless of the operation of said first mentioned means.

9. The combination with a mechanism for handling and separating magnetic material from mixtures and wherein are provided means operable for causing the mixtures to pass across the surface of a steel plate at successive, spaced intervals of time, an electromagnet beneath said plate and arranged to direct magnetic flux upwardly through said plate, of means operated by the first means, when the first means is operated to cause passage of mixtures across said plate, to connect said magnet for over-energization, whereby the magnet is energized to such a degree that the plate is saturated and a large flux passes above the plate into the path of the mixtures while the mixtures are passing across said plate, whereby magnetic materials are separated from the mixtures, and means operated by the first means, when the first means is operated to stop the passage of mixtures across said plate, to reduce the energization of the magnet only to a degre sufficient to retain any separated material on the plate against the pull of gravity while the mixtures are not tumbling across said plate, whereby cooling of the magnets between separating operations and consequent over-energization during separation periods are permitted.

10. The combination with a mechanism for handling and separating magnetic materials wherein are provided means operable for causing quantities of material to pass at successive spaced intervals of time along a given path, a plurality of electro-magnets having their poles in close proximity to said path, whereby the magnets can create a magnetic field in said path when the magnets are energized, of means operated by the first means, when the first means is operated to cause passage of materials along said path, to connect said magnets in parallel across a source of power which over-energizes the magnets while so connected and while the mixtures are flowing along said path, whereby magnetic materials are separated, and means operated by the first means, when the first means is operated to stop the passage of said materials, to connect said magnets in series with each other while they remain connected in parallel to said

source of power and then to disconnect said parallel connection, said series connection causing the under-energization of the magnets to a degree sufficient only to retain any separated material against the pull of gravity while the materials are not flowing along said path, whereby cooling of the magnets between separating operations and consequent over-energization during separating periods are permitted.

11. In combination, a car dumping mechanism operable with respect to a number of loaded cars to receive the cars, dump a load of material therefrom, and then discharge the cars, one at a time, successively, chute means for guiding the loads one at a time along a given path, a separator magnet positioned in close proximity to said path whereby the magnet can create a magnetic field intersecting said path when the magnet is energized, means operated by the car dumping mechanism to over-energize the magnet in a timed relation to the car dumping mechanism so that the magnet is over-energized while each load is passing along said path and through the magnetic field, whereby each load passes through a separating flux, and to under-energize the magnet in a timed relation to the car dumping mechanism so that the magnet is under-energized between periods of passage of the loads through the magnetic field, whereby a holding flux is created to retain any attracted material in attracted position.

12. The method of separating magnetic materials from a mixture containing both magnetic and non-magnetic materials which comprises alternately setting up a magnetic field of a predetermined value capable of separating magnetic material from the mixture when passed therethrough and decreasing the strength of said magnetic field to a value less than said predetermined value and capable only of holding all of the magnetic material after it is separated, passing a portion of said mixture through said magnetic field each time the field strength is at said predetermined value thereby separating magnetic material from each portion successively, discontinuing the passing of said mixture through the magnetic field each time the strength of said field is reduced to said lesser value and thereby holding at the point of separation the magnetic material separated from each portion until an accumulation thereof from successive portions is obtained.

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