Nov. 5, 1946. R. E. CROCKETT 2,410,601

MAGNETIC SEPARATOR

Filed Nov. 12, 1940 3 Sheets-Sheet 1

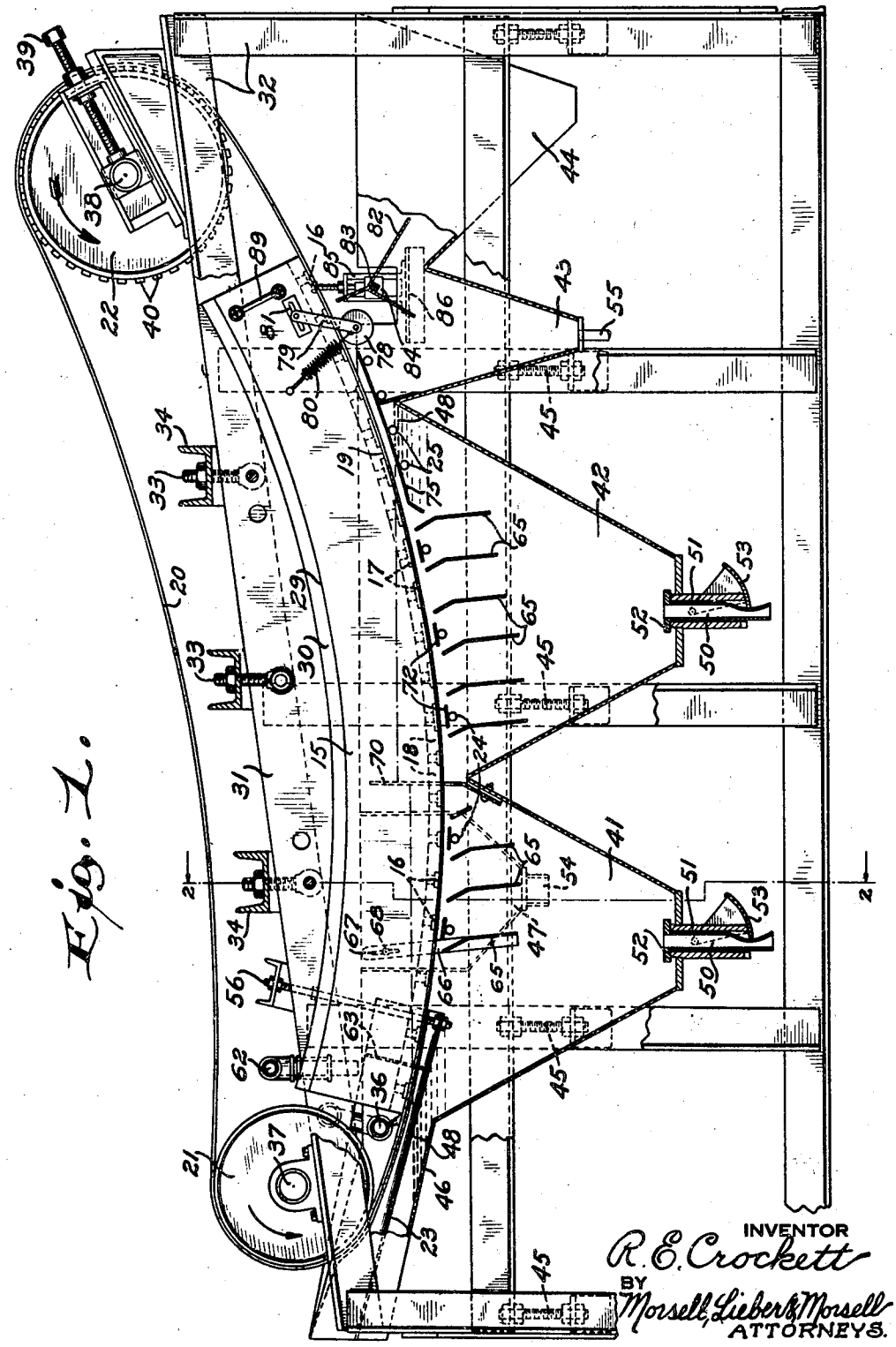

Fig. 1.

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Filed Nov. 12, 1940 3 Sheets-Sheet 2

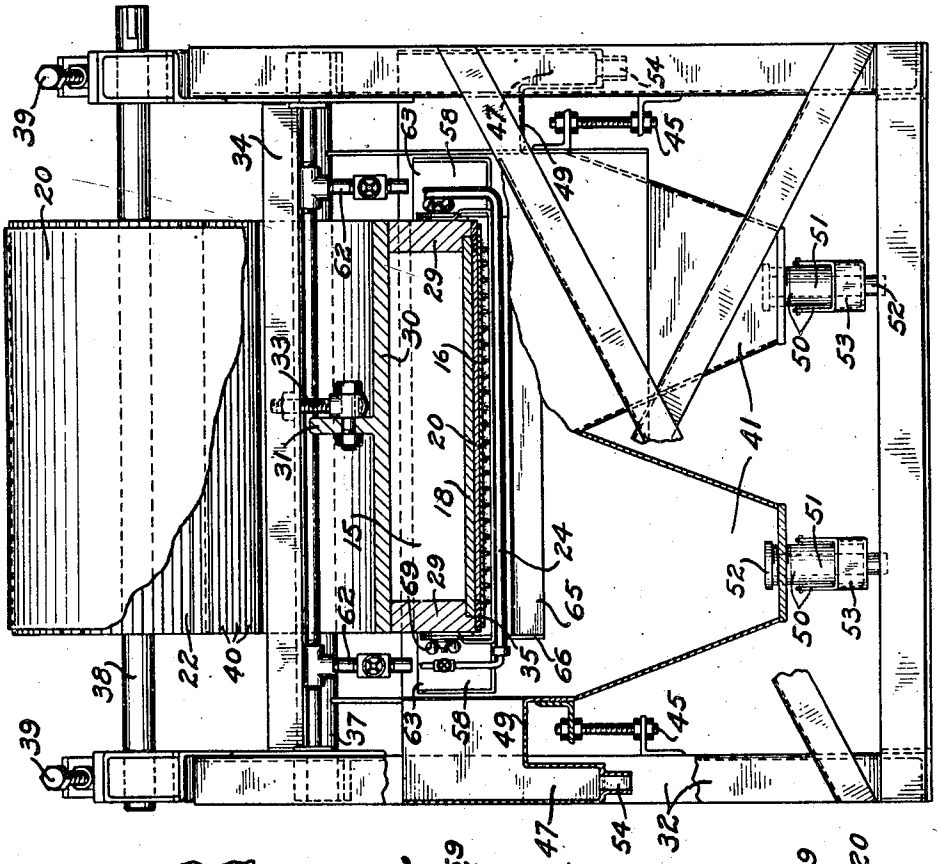

Fig. 2.

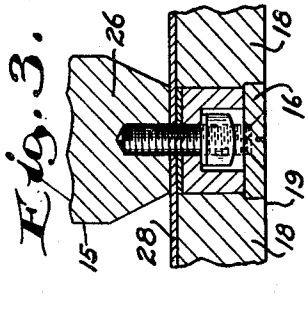

Fig. 3.

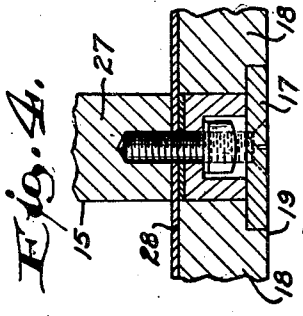

Fig. 4.

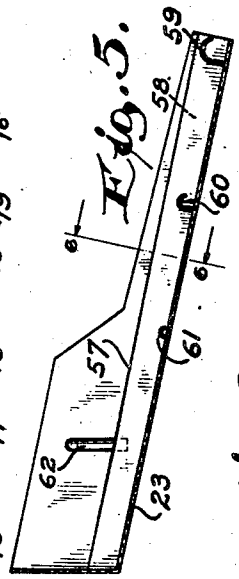

Fig. 5.

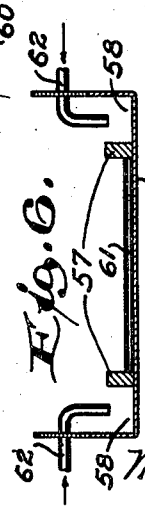

Fig. 6.

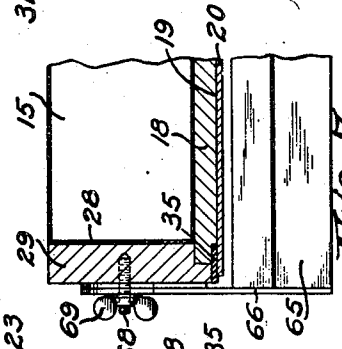

Fig. 7.

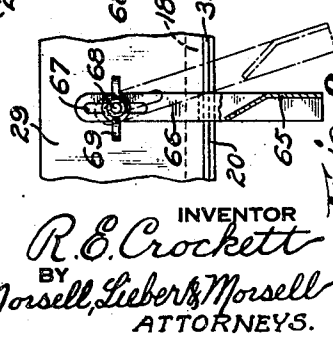

Fig. 8.

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MAGNETIC SEPARATOR

Filed Nov. 12, 1940 3 Sheets-Sheet 3

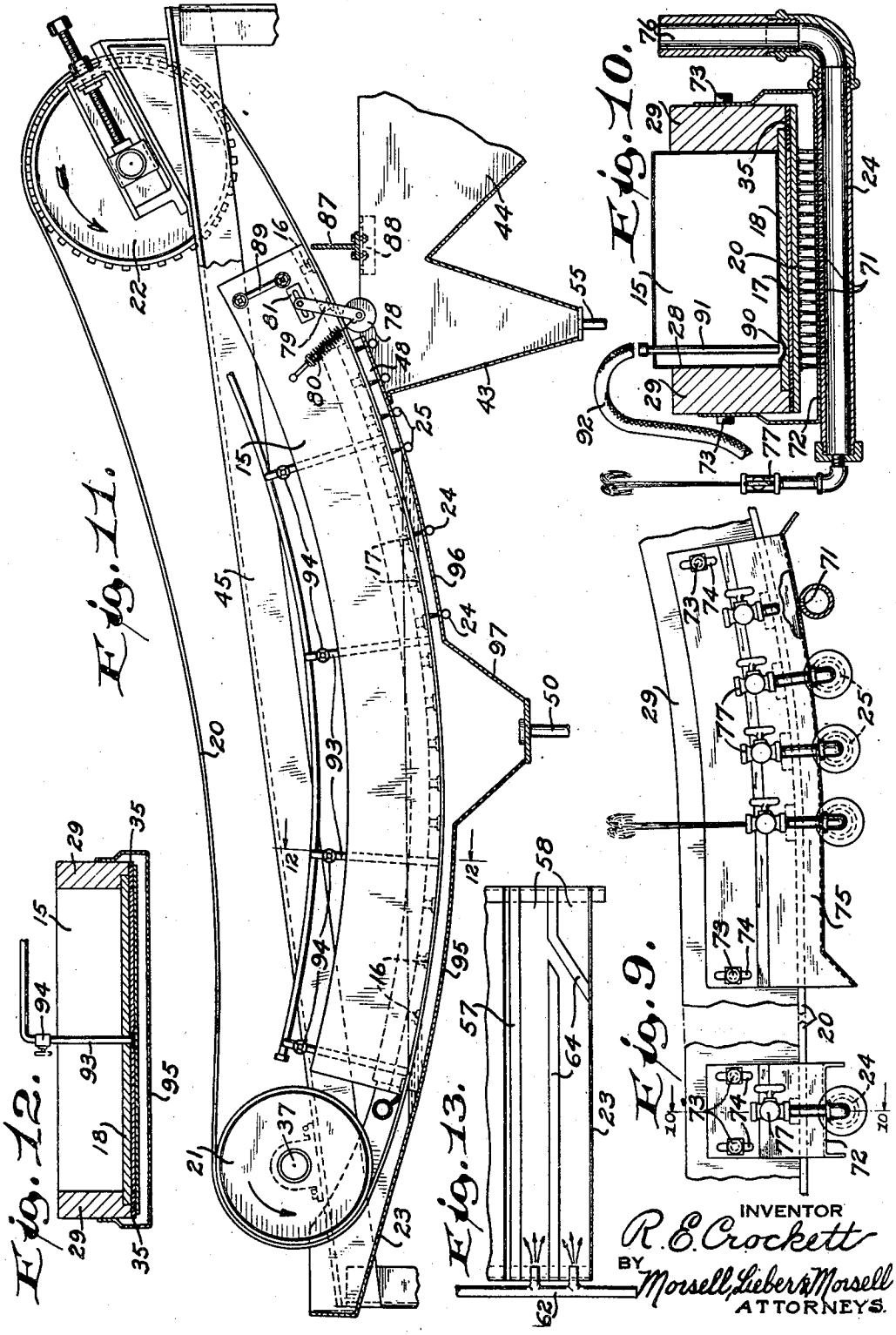

Fig. 11.

Fig. 10.

Fig. 12.

Fig. 13.

Fig. 9.

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Patented Nov. 5, 1946

2,410,601

UNITED STATES PATENT OFFICE

2,410,601

MAGNETIC SEPARATOR

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Application November 12, 1940, Serial No. 365,183

17 Claims. (Cl. 209—225)

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My present invention relates in general to improvements in the art of separating mixed solids having different characteristics, and relates more specifically to various improvements in the construction and operation of magnetic separators of the type shown and described in my prior Patents No. 2,003,430, granted June 4, 1935, and No. 2,090,112, granted August 17, 1937.

An object of the present invention is to provide a new and useful magnetic separator, which is simple in construction, flexible in adaptation, and highly efficient in operation.

Some of the more specific objects of my present invention are as follows:

To provide various improvements in the construction of magnetic separators of the general type shown in my prior patents above referred to, whereby the operation of such machines and the adaptability thereof to effectively meet various conditions, are vastly improved.

To provide an improved separator of the class wherein magnets coacting with one side of a travelling conveyor such as an endless belt, effect separation of magnetic from non-magnetic mixed particles brought in proximity to the opposite face of the advancing conveyor, and which is compact and durable in construction and automatic in operation.

To provide improvements in the construction and operation of the magnet assemblages for magnetic separators having magnets of considerable bulk and which are normally exposed to moist and gritty surroundings, whereby such magnets may be readily assembled and handled, and are thoroughly protected against damage from moisture and grit.

To provide improved means for safeguarding and for prolonging the usefulness of the material transporting conveyor or belt of a magnetic separator or similar assemblage.

To provide improved instrumentalities for feeding mixed materials to the advancing conveyor of a magnetic separator or the like, and for insuring most effective separation and removal of the products from the zone of separation.

To provide improved control means for regulating the supply of material to be treated to, and the discharge of treated product from, the separating zone of a magnetic separator or similar assemblage.

To provide improved means for controlling the delivery of liquid to a magnetic separator of the type wherein separation is effected in the presence of liquid, and for most effectively subjecting the material to the hydraulic action.

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To provide improved mechanism for effecting final separation of the ingredients from each other and from the advancing conveyor, and for expressing excess moisture from the finally separated product.

To provide other improvements in magnetic separator structures, whereby the cost of construction and operation thereof is reduced to a minimum, while the efficiency is enhanced to a maximum.

These and other objects and advantages of the invention will be apparent from the following detailed description.

A clear conception of the several features constituting my present improvements, and of the construction and operation of magnetic separators embodying the same, may be had by referring to the drawings accompanying and forming a part of this specification wherein like reference characters designate the same or similar parts in the various views.

Fig. 1 is a part sectional side elevation of one of the improved magnetic separators, showing a longitudinal vertical section through the feed and separating zones;

Fig. 2 is a part sectional end view of the separator of Fig. 1, the section through the lower structure having been taken along the line 2—2;

Fig. 3 is an enlarged fragmentary section through the pole-piece of one of the magnets in the pick-up tails and concentrates section of the machine;

Fig. 4 is a similarly enlarged fragmentary section through the pole-piece of a magnet in the middlings section of the machine;

Fig. 5 is a somewhat enlarged longitudinal section through a special feed tray or chute for initially introducing the mixed materials to the machine;

Fig. 6 is a transverse section through the tray of Fig. 5, taken along the line 6—6;

Fig. 7 is an enlarged transverse section through a fragment of the magnet and conveyor belt, showing one of the vertically and laterally adjustable baffles;

Fig. 8 is a side view of the assemblage of Fig. 7, showing the baffle in section;

Fig. 9 is an enlarged fragmentary part sectional side view of the liquid control and injecting mechanism associated with the separating zone of the machine;

Fig. 10 is a transverse section through the assemblage of Fig. 9, taken along the line 10—10;

Fig. 11 is a diagrammatic part sectional side elevation of a modified hydraulic magnetic sepa-

rator, the section having been taken longitudinally through the lower portion of the assemblage;

Fig. 12 is a transverse section through the machine of Fig. 11, taken along the line 12—12; and

Fig. 13 is a fragmentary top view of one side of a modified type of feed tray somewhat similar to that of Figs. 5 and 6.

While the various improved features constituting my present invention have been shown and described herein as being especially applicable to hydraulic magnetic separators for magnetic ore and of the type shown in my prior patents, it is not my desire or intent to thereby unnecessarily restrict the scope of the invention or the utility and possible application of the improved structures to other types of separators.

Referring to Figs. 1 to 10 inclusive of the drawings, the improved magnetic separator shown therein, comprises in general an elongated arcuate bank of material agitating magnets 15 having lower pole-pieces 16, 17 the bottom faces of which cooperate with spacers 18 to provide an approximately catenary shaped curved lower surface 19; an endless non-magnetic conveyor or belt 20 supported by pulleys 21, 22, and having its lower stretch movable along and in close proximity to the magret surface 19; an adjustable chute or tray 23 for feeding a mixture of magnetic and non-magnetic particles to the lower face of the belt 20 and into the magnetic field of the magnets 15; means including spray pipes 24, 25 for subjecting the material within the separating zone to a needle spray washing and jetting action, the latter to break up mass magnetism; and means for effecting final separation and grading of the treated product.

The magnets 15 which may be of any desired width, are of relatively well known structure, and alternate magnets of the series preferably are of like polarity, while the intermediate magnets are of opposite polarity, in order to provide successive magnetic fields having reversed polarity which will agitate the magnetic particles passing therethrough, to the maximum extent. As shown in Figs. 1 and 3, the magnets 15 at the feed and discharge ends of the separating zone, are provided with relatively narrow pole-pieces 16 and are of greatest intensity since the magnet cores 26 are rather heavy; whereas the magnets 15 at the middlings section of the separating zone, are provided with wider pole-pieces 17 and are of lesser intensity because the cores 27 are relatively light, as shown in Figs. 1 and 4. All of the magnets 15 are preferably housed directly within a liquid-tight casing 28 formed of sheet metal such as copper or stainless steel, and the cores 26, 27 and their energizing coils are preferably sealed within the casing 28 and are immersed in oil or the like. The enclosing casing 28 is protected at the bottom by the spacers 18 which may be formed of wood or the like, and the opposite sides of the casing 28 are likewise protected by heavy wooden or other non-magnetic slabs or plates 29. The top of the magnet bank has a curved backing plate 30 firmly but detachably secured thereto in any suitable manner, and this curved reenforcing plate may be formed of suitable metal and is provided with a central longitudinal stiffening and suspension rib 31 which may be pierced by openings to facilitate suspension and handling of the magnet bank.

As previously indicated, the lower curved surface 19 of the magnet assemblage is approximately a catenary curve, and the magnets 15 may be suspended from the main frame 32 of the machine, by means of eye-bolts 33 and removable cross-beams 34 in such manner that the lower catenary stretch of the belt 20 will travel closely adjacent to the pole-pieces 16, 17 but will not actually touch the same due to the injection of flushing and lubricating liquid between the belt and pole-pieces. The conveyor belt 20 may be of any desired width and formed of durable rubber impregnated fabric, and the opposite longitudinal edges of the lower belt stretch may be caused to coact with rubber sealing strips 35 secured to the lower edges of the side plates 29 as shown in Figs. 2 and 7. Lubricating and flushing liquid, preferably clean water, may be admitted to the area between the lower belt stretch and the surface 19 and between the strips 35, by means of a pipe 36 having orifices therein, as indicated in Fig. 1, and this liquid after being drawn under the magnet face between it and the belt, eventually flows outwardly between the belt 20 and strips 35 and prevents gritty particles from reaching the surface 19. The belt idler pulley 21 is mounted upon a shaft 37 near the lower feed end of the frame 32; and the driving pulley 22 which coacts with the higher discharge end of the belt 20, is mounted upon a driving shaft 38 which may be adjustable by means of adjusting bolts 39 as shown in Fig. 1, and may be rotated from any desirable source. Since the lower stretch of the belt 20 is constantly passing through liquid and may be moist and slippery when approaching the pulley 22, this driving pulley 22 is preferably formed with a plurality of parallel slats 40 on its surface, forming intervening grooves along which liquid may escape. With this construction, liquid adhering to the inner face of the belt 20 will be pressed into the intervening grooves by contact of the belt with the slats 40, and this removal of liquid will enhance the traction and will prevent slippage.

Supported upon the main frame 32 beneath the belt and magnet assemblages, is a series of hoppers 41, 42, 43, 44, of which the hopper 41 is a tailings collector, the hopper 42 is a middlings receptacle, the hopper 43 is a dewatering chamber, and the hopper 44 is a concentrate discharge chute. These hoppers may be adjustably suspended from the frame 42 by means of jack screws 45, and the tailings hopper 41 has a feed spout 46 at one end within which an independent feed tray 23 is adjustably confined, and is provided with liquid overflow compartments 47 at its opposite sides, see Figs. 1 and 2. The hoppers 41, 42 are normally filled with liquid 48 to the levels indicated in Fig. 1, and excess liquid will flow over dams 49 disposed between the hopper 41 and the compartments 47; and each of these liquid filled hoppers may be divided into two laterally adjoining sections each of which may be provided with a special material discharge spigot 50 such as shown in Figs. 1 and 2. Each spigot 50 may consist of an outer sleeve 51 secured to the bottom of the adjacent hopper 41, 42; a flexible and elastic tube 52 confined within the sleeve 51 and protruding from the lower end thereof; and a gate 53 swingably suspended from the sleeve 51 and being swingable across the lower sleeve end to kink or compress the tube 52 near its lower end and to thereby throttle the discharge, more or less. In order to completely shut off the discharge of material and liquid, the gates 53 may be swung to positions directly beneath the sleeves 51, thereby bending the tubes 52 which may be formed of rubber, to right angle

position. The overflow compartments 47 may be provided with lower liquid discharge passages 54, and the dewatering hopper 43 may likewise be provided with a liquid discharge pipe 55.

The raw material feed chute or tray 23 for delivering the mixed magnetic and non-magnetic particles to the separating zone beneath the liquid 48, may be constructed either as shown in Figs. 5 and 6, or as illustrated in Fig. 13; and this tray 23 is preferably made swingably adjustable as shown in Fig. 1, by means of adjusting rods 56 coacting with the lower end of the tray. The interior of the tray may be rubber lined, and as shown in Figs. 5 and 6, the tray is divided by partitions 57 into a central valley extending longitudinally thereof beneath the belt 20, and two opposite side channels 58 located outwardly beyond the path of the belt. The central valley formed by the partitions 57 may either be free from obstructions as in Fig. 1, or it may be provided with one or more flow retarding riffles 59, 60, 61 as in Figs. 5 and 6; and liquid may be supplied to the channels 58 by supply pipes 62 either as in Figs. 1 and 2 or as in Figs. 5 and 6. The side channels 58 may either be unobstructed as shown in Figs. 5 and 6; or they may be spanned by high dams 63 as in Figs. 1 and 2; or they may be sub-divided into divisions as in Fig. 13, by means of barriers 64. These several modified types of feed trays may be used advantageously under different conditions of operation.

The interior of the tailings and middlings hoppers 41, 42, adjacent to the zone of separation and beneath the liquid 48, is preferably provided with a series of baffles 65 having their upper ends directed toward the feed end of the machine, and some or all of these baffles 65 are preferably mounted for both vertical and lateral adjustment. In Figs. 7 and 8 is shown a means for effecting such adjustment, and each of the baffles 65 may be suspended from side arms 66 having slots 67 therein coacting with studs 68 secured to the magnet side plates 29, the studs 68 being provided with clamping nuts 69. With this assemblage, the baffles 65 may obviously be independently adjusted toward or away from the belt 20, or forwardly or rearwardly relative to the feed end of the machine, in order to secure most effective separation. In addition to the baffles 65 spanning the separating zone, barriers 70 may be provided between the hoppers 41, 42 beyond the opposite sides of the belt 20, see Fig. 1, and these barriers should also be made vertically and laterally adjustable.

In order to obtain thorough washing of the particles as they are conveyed along the separating zone by the belt 20 and while being agitated by the magnets 15, I have provided improved means for subjecting the conveying surface of the belt to pin sprays of liquid. This improved spray means comprises a series of transverse liquid supply pipes 24 located between some of the baffles 65 in the tailings hopper 41 and between others of the baffles 65 in the front part of the middlings hopper, and a subsequent group of liquid supply pipes 25 near the concentrate discharge zone, see Figs. 1, 2, 9 and 10. Each of the individual liquid supply pipes 24 has a series of pin holes 71 therein, and is provided with a transverse plate 72 disposed approximately parallel to the adjacent belt 20, and these pipes 24 and their plates 72 are adjustable toward and away from the belt 20 by means of bolts 73 coacting with the magnet side plates 29 and with slots 74 in the plates 72, see Fig. 9. All of the pipes

25 also have pin holes 71 therein, and are associated with a common plate 75 which is also adjustably suspended from the wooden side plates by bolts 73 coacting with slots 74. Liquid under pressure may be supplied to the pipes 24, 25 through flexible conduits 76 successive ones of which may be located on opposite sides; and the end of each pipe 24, 25 remote from the inlet thereof, is preferably provided with a valve controlled orifice 77 for indicating the pressure within the pipe, and hence the intensity of the jets issuing from the holes 71 thereof. These needle jets are directed at approximately right angles to the face of the belt 20 to break up mass magnetism, thus permitting most effective release of entrained waste materials, and the plates 72, 75 serve to prevent magnetic particles which may be dislodged by the jets, from falling out of the magnetic field or zone of separation. The open spaces between successive spray baffles 72 allow the immediate discharge of waste or middling material to the hoppers below.

It is desirable to remove at least the greater portion of the liquid from the concentrates, before the latter are discharged into the hopper 44, and in order to express this liquid, a roller 78 suspended from the lower ends of side links or arms 79, is provided. This roller 78 may be formed of soft rubber or the like, and is pressed against the lower face of the belt 20 by means of adjustable springs 80 coacting with the swinging ends of the arms 79 and with the wooden side plates 29. The upper ends of the suspension links 79 are adjustably pivotally confined in slotted plates 81 also secured to the side plates 29, and the roller 78 may thus be adjusted forwardly or rearwardly and may be caused to engage the belt 20 with more or less pressure due to the adjustability of the springs 80. The liquid expressed from the concentrates advancing with the belt 20, drops into the dewatering hopper 43, and in order to insure proper delivery of the final concentrates into the hopper 44, an adjustable dividing plate 82 such as shown in Fig. 1 may be employed. This dividing plate 82 is suspended from a cross-rod 83 which is rotatably adjustable in cross-heads 84, and the cross-heads 84 are vertically adjustable in slides 85 which are bodily movable along horizontal angle irons 86 at the opposite sides of the machine. With such an assemblage, the dividing plate 82 may be adjusted horizontally, vertically, and angularly in order to insure most effective discharge of the final product. The plate 82 may be replaced by a somewhat simpler dividing plate 87 adjustably supported on side angle bars 88 as shown in Fig. 11, and the plate 87 may be used either alone or in conjunction with a plate 82. The dividing plate 87 is preferably adjustably disposed in a zone starting midway between the last two poles and terminating just beyond the last pole-piece 16 as shown in Fig. 11.

The oil filled magnet housing 28 may be provided with an oil gage 89 near the highest end of the magnet bank and the oil may be positively circulated through the casing 28 for cooling purposes, and in order to remove heavy liquid such as water or moisture from the atmosphere which may accidentally enter the magnet housing 28, I provide one or more depressions 90 in the lowest portion of the casing 28 in which such heavy liquid may accumulate beneath the oil, see Fig. 10. Pipes 91 the upper ends of which are normally capped, have their lower ends disposed in these depressions, and upon removal of the closure caps,

siphon tubes 92 may be applied to the upper pipe ends in order to remove the accumulated water. Since the static oil pressure within the casing 28 is much greater than that of the liquid outside, any leakage of oil from within will prevent other liquid from entering the casing and damaging the coils, and such oil leakage may be readily detected with the gage 89. In order to insure more effective lubrication and expulsion of gritty material from between the belt 20 and seal strips 35, I may also provide a series of fresh water supply pipes 93 as shown in Figs. 11 and 12. These pipes 92 extend through the magnet bank to the slight space between the surface 19 and belt 20, midway between the sealing strips 35, and each pipe 93 may be provided with a control valve 94 for regulating the quantity of liquid admitted.

While the machine shown in Figs. 1 and 2 is relatively standard and adapted to meet a broad range of separation problems, it may in some cases be possible to omit the middlings production and reduce the size and weight of hoppers, by using a simplified thin trough such as shown in Fig. 11, which would be particularly applicable to fine material having the gangue separated as by crushing. In this modified magnetic separator, curved troughs 95, 96 are disposed forwardly and rearwardly of the tailings hopper 97 and closely adjacent to the lower face of the conveyor belt 20. The feed tray 23 is adapted to deliver the mixture of liquid and solids directly into the separating zone at the forward end of the trough 95, and the tailings hopper 97 is in open communication with the confined spaces between the troughs 95, 96 and the belt 20 at the rear end of the trough 95 and the front end of the trough 96. Water jet injection pipes 24, 25 may be provided along the rear trough 96 for the purpose of thoroughly washing the concentrates, and dewatering and concentrate collecting hoppers 43, 44 are provided at the delivery end of the trough 96. This modified assemblage may also be provided with a dewatering roller 78, a magnet suspension plate 30, and special feed troughs, such as previously described.

During normal operation of the improved magnetic separator shown in Figs. 1 and 2, the conveyor belt 20 is being constantly driven at an appropriate speed in the direction indicated by the arrow in Fig. 1, the magnets 15 are energized, and material and liquid are being delivered in regulated quantities through the feed tray 23 and the various supply pipes. As the material advances along the separating zone the magnetic solid particles are drawn upwardly against the lower face of the belt 20 by the magnets 15, and the tailings or non-magnetic particles are quickly removed by the washing and jetting action and the baffles 65 which may be set to insure such prompt removal. The opposite polarity of the successive magnets causes the retained magnetic particles which adhere to and advance with the belt 20, to be thoroughly agitated, and as this retained material passes over the spray pipes 24 it is subjected to thorough washing and agitation by the high intensity needle jets issuing from the orifices 71. Other non-magnetic material is thus removed from the belt 20 by the jets, and the open spaces between jets and the adjacent baffles 65 quickly direct this other material into the hoppers 41, 42. As the belt proceeds over the middlings hopper 42, some material containing magnetic particles may be washed from the magnetic separating zone, and these middlings may be treated for subsequent separation; and when the concentrates are being conveyed over the trough plate 75 they are finally subjected to a thorough washing and desliming action by the jets 25 before being subjected to the press roller 78. The roller 78 expresses most of the residual liquid, and the final high intensity magnets also remove some of the liquid, so that the final concentrates delivered into the hopper 44 over the diverter plate 82, are in relatively dry condition. The final high intensity magnets are designed also to carry the magnetic material across the dewatering hopper 43 without loss of mineral. It will therefore be apparent that the separation of the tailings and middlings from the concentrates is effected automatically and continuously, and the concentrates may be effectively dewatered before final discharge thereof.

While the operation of the machine shown in Figs. 11 and 12 is quite similar to that just explained, this modified assemblage is adapted to retain all material within the zone of magnetic influence for a longer period of time. The mixture of liquid and solids delivered to the separating zone by the feed tray 23 in this improved machine, is compelled to travel along a laterally and entirely enclosed flat conduit 95 and is thoroughly subjected to the magnetic influence which permeates the entire interior of this conduit, until the material reaches the open hopper 97. Here the tailings and non-magnetic materials are released and drop into the hopper, whereupon the concentrates are carried into and along another laterally enclosed conduit formed by the trough 96. In this latter conduit, the concentrates are finally thoroughly washed and deslimed by the relatively strong needle jets of fresh liquid delivered from the pipes 24, 25, and the final concentrates are thereafter dewatered and discharged as previously described.

It will thus be noted that the improved magnetic separators are adapted to automatically and effectively remove magnetic from non-magnetic materials, and to deliver the concentrates in relatively dry condition. The improved magnet structure wherein the magnets are confined in oil within a complete enclosure such as the housing or casing 28, and are provided with removable pole-pieces 16, 17, permits removal and replacement of these pole-pieces without disturbing the concealed magnet parts. The curved backing and suspension plate 30 for the magnet bank reenforced by the spine or spines 31, not only provides strong means for facilitating handling and convenient suspension of the magnets, but also enables the magnet cores 26, 27 to be properly disposed approximately perpendicular to the lower stretch of the belt 20. While the magnets are quite effectively cooled by the fresh water admitted to and circulating through the machine, the oil within the enclosing casing 28 may also be circulated to enhance the cooling effect, and water which may enter the casing 28 may be readily removed with the aid of the siphon tubes 91, 92. The use of the sealing strips 35 coacting with the belt 20, and the admission of fresh liquid to the surface 19 either through an end pipe 36, or several pipes 93, provides simple and effective means for cooling the magnets thus allowing the use of higher currents and consequently obtain stronger magnetic fields, and for keeping grit away from the belt surfaces. The ribbed pulley 22 insures proper driving of the belt 20 and avoids undesirable slippage, and the belt supporting pulleys 21, 22 can be readily adjusted

to position the lower belt stretch in snug engagement with the sealing strips 35.

The improved feed trough 23 is angularly adjustable to insure most effective delivery of the feed to the separating zone, and by utilizing barriers or riffles 59, 60, 61, the feed can be retarded as it enters the zone of separation and the solid particles are forced to flow upwardly toward the belt. The provision of the side chutes 58 with barrier partitions 64 therein for returning spillage to the separating zone, prevents loss of magnetic particles with the tailings, and the adjustability of the baffles 65 also enhances the efficiency of separation by quickly removing the non-magnetic particles from the separating zone. The improved spigots 50 not only make it possible to control the discharge of tailings and middlings, but also permit quick closing when the machine is shut down, and prevents complete drainage of the hoppers 41, 42.

The improved needle spray arrangement combined with the adjacent trough plates 72, 75 is very important since the strong jets of fresh liquid effectively spray the material being carried along the separating zone by the belt 20, and the plates prevent dislodged magnetic particles from dropping out of the zone of magnetic influence. The orifices 77 provide simple means for observing the pressure in the several pipes 24, 25 so as to obtain most efficient operation, and the press roller 78 and diverter plates 82, 89 enable the operator to thoroughly dewater the concentrates before final delivery thereof from the machine. These needle sprays and dewatering appliances are readily applicable to other types of separators wherein the materials are transported through a washing and separating zone by conveyors of other types. These various improvements have proven highly satisfactory in actual use, and provide a separator which besides being simple and compact in construction, is also flexible in use, and can be installed and operated at minimum cost considering the enormous capacity thereof. The use of oil under high static pressure head within the casing 28 not only provides effective insulation, but is also extremely important as a safety feature, since it positively prevents liquid from entering the casing 28 and thus damaging the coils, in case a leak occurs in the casing 28.

It should be understood that it is not desired to limit this invention to the exact details of construction or to the precise mode of operation, herein shown and described, for various modifications within the scope of the claims may occur to persons skilled in the art.

I claim:

1. In a separator, a conveyor belt having a lower stretch, a bank of magnets adjoining the top of said stretch, and a feed tray for delivering material beneath said stretch into the magnetic zone, said tray having a central valley and opposite side channels provided with barriers for catching overflow material on opposite sides of and above the magnetic field.

2. In a separator, an endless conveyor, a series of magnets on one side of said conveyor for creating a magnetic field along the opposite side thereof, and a roller resiliently engaging said opposite side of said conveyor near the discharge end of said field for expressing moisture from the concentrates within said field.

3. In a separator, an endless belt conveyor, a series of magnets on one side of said conveyor for creating a magnetic field along the opposite side thereof, a roller resiliently engaging said opposite side of said conveyor near the discharge end of the field for expressing moisture from the concentrates within said field, means for removing material from said conveyor beyond said roller, and a diverter plate coacting with said conveyor near the delivery end of said field beyond said roller.

4. In a separator, an endless conveyor, a series of magnets on one side of said conveyor for creating a magnetic field along the opposite side thereof, a resilient roller swingably suspended from said magnets near the discharge end of the field and resiliently engaging the opposite side of said conveyor for expressing moisture from the concentrates within said field, and means for swinging said roller toward and away from said conveyor.

5. In a separator, a conveyor belt having a lower stretch, magnets above said stretch for creating a magnetic field therebeneath, and a feed tray for delivering material into one end of said field beneath said stretch, said tray having a central valley beneath said stretch and opposite side channels beyond the sides of said conveyor provided with barriers for catching overflow material above the magnetic field.

6. In a separator, a conveyor belt having a lower stretch, magnets above said stretch for creating a magnetic field therebeneath, and a feed tray for delivering material into one end of said field beneath said stretch, said tray having a central valley within said field and opposite side channels beyond the sides of the field provided with barriers for catching overflow material escaping above said field.

7. In a separator, a conveyor belt having a lower stretch, magnets above said stretch for creating a magnetic field therebeneath, a feed tray for delivering material into one end of said field beneath said stretch, said tray having a central valley beneath said stretch and opposite side channels beyond the sides of said conveyor provided with barriers for catching overflow material above the magnetic field, and a dam spanning said valley.

8. In a separator, a conveyor belt having a lower stretch, magnets above said stretch for creating a magnetic field therebeneath, a feed tray for delivering material into one end of said field beneath said stretch, said tray having a central valley within said field and opposite side channels beyond the sides of the field provided with barriers for catching overflow material escaping above said field, and a dam spanning the delivery end of said valley.

9. In a magnetic separator, a pair of spaced pulleys, a carrier belt for running over said pulleys and having a lower reach suspended in loosely sagging position therebetween, means for feeding along the under side of said reach a liquid mixture of the magnetic and non-magnetic particles to be separated, a series of magnets on the upper side of said reach, said magnets having pole faces forming a series which extends along and is curved in substantial conformity with the upper surface of said lower reach, spacer means between such pole faces to form therewith a surface opposed to the upper surface of said reach, and a conduit opening into a slight space between said surfaces at a point spaced from the edges of the belt and spaced from the ends of the series of pole pieces, said conduit being constructed and arranged for connection to a source of water supply under pressure for injecting water to cause

said slight space to be maintained against the magnetic forces on the particles which tend to press said belt stretch against the pole faces.

10. In a magnetic separator, a pair of spaced pulleys, a carrier belt for running over said pulleys and having a lower reach suspended in loosely sagging position therebetween, means for feeding along the under side of said reach a liquid mixture of the magnetic and non-magnetic particles to be separated, a series of magnets on the upper side of said reach, said magnets having pole faces forming a series which extends along and is curved in substantial conformity with the upper surface of said lower reach, spacer means between such pole faces to form therewith a surface opposed to the upper surface of said reach, and a plurality of conduits opening into a slight space between said surfaces at spaced points respectively, said conduits being constructed and arranged for connection to a source of water supply under pressure for injecting water to cause said slight space to be maintained against the magnetic forces on the particles which tend to press said belt stretch against the pole faces.

11. In a magnetic separator, a pair of spaced pulleys, one substantially higher than the other, a carrier belt for running over said pulleys and having a lower reach suspended in loosely sagging position therebetween, the lower reach areas which are nearer the lower pulley sagging in approximate tangency to the horizontal while areas nearer the higher pulley are inclined more and more upwardly to a discharge point, means for driving the pulleys and belt in a direction for upward travel of said reach, means for feeding and conducting along the under side of said first named areas, a liquid mixture containing magnetic particles and non-magnetic material, a series of magnets on the upper side of said lower reach, such series extending along and being curved in substantial conformity with said areas, for causing said particles to be separated and carried on the belt, while the belt areas with such particles thereon travel from an approximately horizontal position, through a region of submergence in said liquid, and thence up to said discharge point, means at said region for projecting submerged jets of water against the belt for dislodging non-magnetic material, and means extending along adjacent the sources of said jets for preventing settling of magnetic material away from the belt, means providing a stationary surface extending up along and in spaced relation to said more inclined areas on the belt, to form a trough space subject to the effective field of said magnets above said region of submergence, and means for projecting a series of forceful sprays of water against the belt in said trough space, to thereby release remaining nonmagnetic material on the belt while said stationary surface retains any dislodged magnetic particles within said field for recapture on the belt, and said remaining material is washed back down the trough space by the spray water.

12. In a magnetic separator, a pair of spaced pulleys, one substantially higher than the other, a carrier belt for running over said pulleys and having a lower reach suspended in loosely sagging position therebetween, the lower reach areas which are nearer the lower pulley sagging in approximate tangency to the horizontal while areas nearer the higher pulley are inclined more and more upwardly to a discharge point, means for driving the pulleys and belt in a direction for upward travel of said reach, means for feeding and conducting along the under side of said first named areas, a liquid mixture containing magnetic particles and non-magnetic material, a series of magnets on the upper side of said lower reach, such series extending along and being curved in substantial conformity with said areas, for causing said particles to be separated and carried on the belt, while the belt areas with such particles thereon travel from an approximately horizontal position, through a region of submergence in said liquid, and thence up to said discharge point, means at said region for projecting submerged jets of water against the belt for dislodging non-magnetic material, means extending along adjacent the sources of said jets for preventing settling of magnetic material away from the belt, and means at said more inclined areas, subsequent to said region of submergence and in advance of said discharge point for washing remaining non-magnetic material from the belt.

13. In a magnetic separator, a pair of spaced pulleys, one substantially higher than the other, a carrier belt for running over said pulleys and having a lower reach suspended in loosely sagging position therebetween, the lower reach areas which are nearer the lower pulley sagging in approximate tangency to the horizontal while areas nearer the higher pulley are inclined more and more upwardly to a discharge point, means for driving the pulleys and belt in a direction for upward travel of said reach, means for feeding and conducting along the under side of said first named areas, a liquid mixture containing magnetic particles and non-magnetic material, a series of magnets on the upper side of said lower reach, such series extending along and being curved in substantial conformity with said areas, for causing said particles to be separated and carried on the belt, while the belt areas with such particles thereon travel from an approximately horizontal position, through a region of submergence in said liquid, and thence up to said discharge point, and means providing a stationary surface extending up along and in spaced relation to said more inclined areas on the belt, to form a trough space subject to the effective field of said magnets above said region of submergence, and means for projecting a series of forceful sprays of water against the belt in said trough space, to thereby release remaining nonmagnetic material on the belt while said stationary surface retains any dislodged magnetic particles within said field for recapture on the belt, and said remaining material is washed back down the trough space by the spray water.

14. In a magnetic separator, an endless belt having a lower material conveying reach, means for advancing said lower reach upwardly at an oblique angle, a series of magnets above and in close proximity to said advancing reach, means providing a stationary surface extending along and in spaced relation to the under side of said lower reach to provide a space subject to the effective field of said magnets, means for feeding magnetic particles and non-magnetic material mixed with liquid into a lower region of said space while maintaining said feed receiving region constantly submerged in liquid, means for projecting forceful jets of other liquid through the liquid within said region to dislodge nonmagnetic material from said lower reach while preventing settling of the magnetic particles, and means for effecting discharge of the mag-

netic particles at a point above said submerged regions.

15. In a magnetic separator, an endless belt having a lower material conveying reach, means for advancing said reach upwardly at an oblique angle, a series of magnets above and in close proximity to said advancing reach, a normally fixed plate having an upper surface extending along and in spaced relation to the under side of said lower reach to provide a space subject to the effective field of said magnets, means for effecting variation in the position of said plate relative to said conveying reach to vary the distance between said surface and said magnets, means for feeding a mixture of magnetic and non-magnetic materials into a lower region of said space, means for projecting forceful jets of liquid across said space to dislodge non-magnetic material from said lower reach while preventing settling of the magnetic particles, and means for effecting discharge of the magnetic particles from an upper region of said space.

16. In a magnetic separator, a pair of spaced pulleys, a carrier belt for running over said pulleys and having a lower reach suspended in loosely sagging position therebetween, a tailings hopper beneath a low sagging portion of said reach, trough means extending in upwardly inclined directions from each side of said tailings hopper

and along beneath said reach in spaced relation thereto and arranged together with the tailings hopper to maintain a body of liquid submerging a substantial portion of said reach, means adjacent one end of said reach for feeding into said trough means and thence along the under side of said reach toward said hopper, a mixture of the magnetic and non-magnetic particles to be separated, the concentrates discharge being adjacent the end of said reach opposite from said feeding means, a series of magnets on the upper side of said reach, said magnets having pole faces forming a series which maintains a field along said reach extending from the feeding means to the discharge position, and means between said hopper and discharge position for introducing jets of water into the trough space.

17. In a magnetic separator, a conveyor belt having a lower stretch, a series of magnets extending along the upper surface of such stretch, and a feed tray for delivering material along beneath said stretch into the field of said magnets, said tray having a central valley and opposite side channels provided with barriers for catching overflow of material on opposite sides of said central valley and for directing such overflow material into the magnetic field.

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