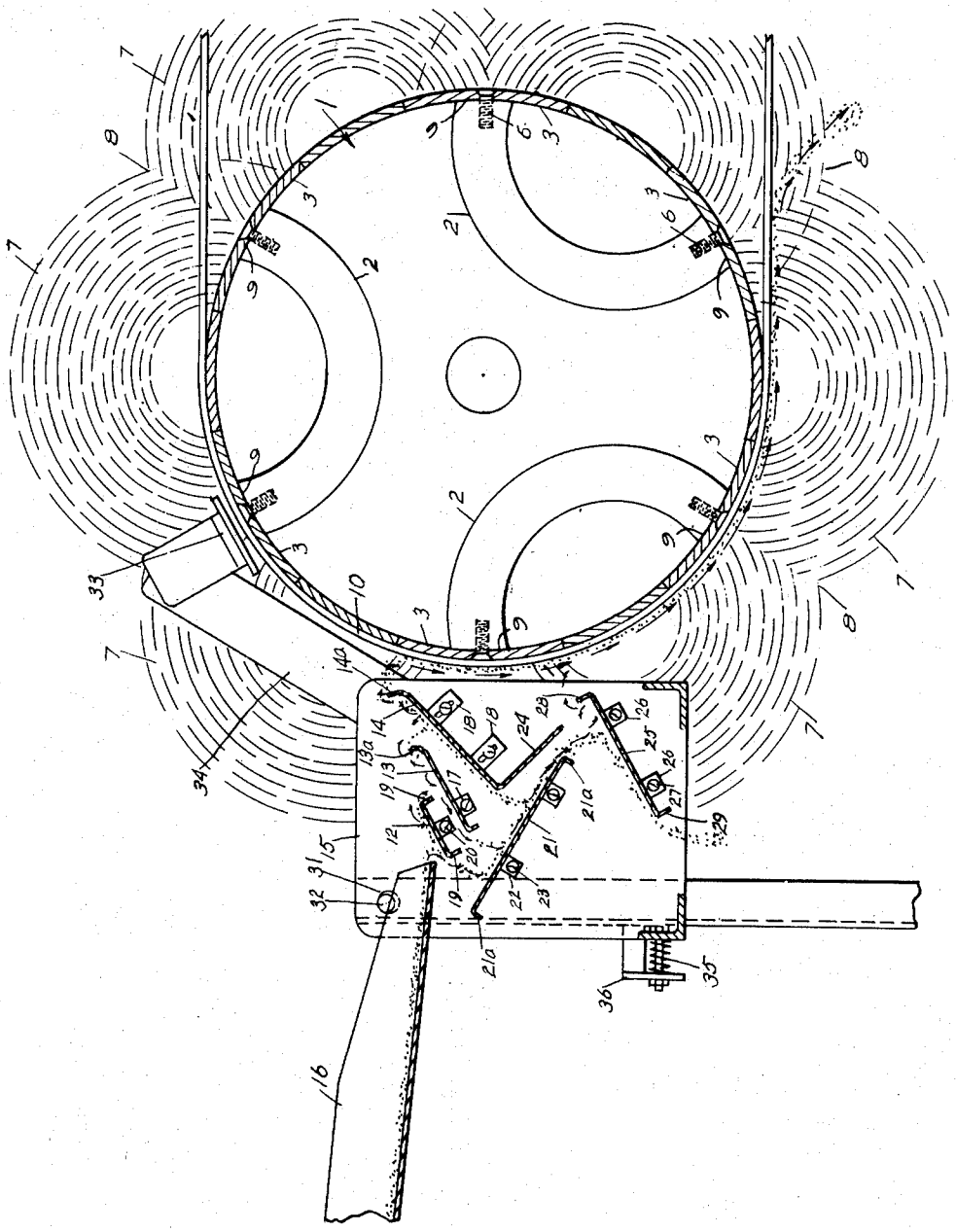
July 14, 1953 R. C. HOFF 2,645,348

APPARATUS FOR MAGNETIC SEPARATION OF MATERIALS

Filed June 25, 1949



INVENTOR
RONALD C. HOFF
BY
Florian S. Miller
ATTORNEY

Patented July 14, 1953

2,645,348

UNITED STATES PATENT OFFICE

2,645,348

APPARATUS FOR MAGNETIC SEPARATION OF MATERIALS

Ronald C. Hoff, Erie, Pa., assignor to Eriez Manufacturing Company, Erie, Pa., a corporation of Pennsylvania

Application June 25, 1949, Serial No. 101,432

14 Claims. (Cl. 209—218)

1

This invention relates generally to apparatus for the magnetic separation of materials and more particularly to the separation of non-magnetic materials from magnetic materials.

When the mixed materials to be separated contain a relatively high percentage of magnetizable material, for example, from five to ten or more per cent as compared to ordinary separation where the magnetizable particles are usually measured in parts per 1000, the magnetizable particles tend to be attracted to each other as well as toward and to the magnet. In the past, it has been the practice to pass such mixed materials over a drum type separator of the agitator type. In this drum type separator, a cylindrical shell is rotated around fixed magnets having alternating north and south poles around a portion of the circumference. The magnetic material being carried around the drum is caused to change polarity and a tumbling action results. This method depends upon the non-magnetic material falling away from the face of the drum by gravity and in wet separation processes, with the aid of a stream of water washing the surface of the drum in a direction opposed to its rotation.

This method has never been too successful particularly with materials in the dry state and with the finer non-magnetic materials since.

1. The finer non-magnetic particles tend to stick to the magnetic particles and to the surface of the drum and they become entrapped in the bunched strings of magnetic particles which have been attracted to each other;

2. The mixed dry materials are usually introduced to the drum at the beginning of a top quadrant thereof and gravity tends to remix the non-magnetic and magnetic materials until the horizontal center line of the drum is approached allowing only the lower quadrant of the drum for the non-magnetic material to fall free; and

3. It has never been possible to increase the separating efficiency of an agitator drum to any degree by the use of centrifugal force acting upon the non-magnetic materials since

a. Impingement of the material mixture on a rapidly revolving drum tends to throw the mixture away from the drum before it can become partially separated and therefore presenting more magnetizable groupings of magnetic materials; and

2

b. Passing the magnetizable materials through alternate poles of a magnet cause particles thereof to turn end over end and when the particles are standing on end, their attraction to the magnet is greatly decreased whereby centrifugal force at this time can readily throw it off.

On wet separation, a considerable volume of water is required.

It is, accordingly, an object of my invention to overcome the above and other defects in magnetic separation devices of the drum type and it is more particularly an object of my invention to provide apparatus for magnetic separation of materials which is simple in construction, economical in cost, economical in manufacture, and efficient in operation.

Another object of my invention is to provide apparatus for magnetically separating finely divided materials utilizing a rotating magnetic member with successive stages of magnetic pole pieces of opposite polarity around the periphery thereof.

Another object of my invention is to provide an inclined baffle between a material delivering device and a magnetic drum with a rotating field.

Another object of my invention is to provide apparatus for separating materials magnetically before reaching the face of a magnetized pulley comprising a series of inclined baffles, the baffles being inclined at different vertical angles from a horizontal plane passing through the axis of the magnetic drum.

Another object of my invention is to provide a series of inclined baffles in the path of materials to be separated and in magnetic fields of opposite polarity of a magnetic drum, in association with conveying baffles or aprons for conveying the non-magnetic material separated on the baffles from the magnetic material to a point adjacent the pulley for further separation.

Another object of my invention is to provide a series of baffles in a magnetic separating device between the delivery point of the material to be separated and a magnetic drum, the height of the baffles adjacent the drum being greater than those adjacent the delivery point.

Another object of my invention is to provide a series of inclined baffles between a delivery point of material to be separated and a magnetic drum

and means for pulsating or vibrating the baffles upon the rotation of the magnetic drum.

Other objects of my invention will become evident from the following detailed description, taken in conjunction with the accompanying drawing, in which

The figure of the drawing shows a more or less diagrammatic side elevational view of my novel apparatus for magnetically separating material with the magnetic drum shown in cross section.

Referring now to the drawing, I show in the figure of the drawing a magnetic drum 1 having circumferentially spaced, U-shaped magnets 2. The pole faces of the magnets 2 are engaged with pole pieces or shoes 3 disposed in spaced relation around the periphery of the drum 1. The magnets 2 are attached to the drum 1 by bolt and nut assemblies 6. It will be noted that by the use of three magnets symmetrically placed around the inner periphery of the drum 1, six equally spaced magnetic poles 9 of alternate polarity are provided around the periphery thereof. The magnetic fields 7 produced by the poles 9 are weakest adjacent the points of juncture 8 and strongest toward the central portion thereof as is well known in practice. The drum 1 has a non-magnetic belt 10 engageable therewith, the belt 10 engaging any suitable power pulley for rotating the drum 1, preferably in a counterclockwise direction.

Associated with the drum 1 are a series of baffles 12, 13, and 14 supported on a support plate 15 by brackets 20, 17, and 18. An inclined conveying trough 16 is provided for delivering material to be separated to the central portion of the first baffle 12. I preferably utilize a conventional vibrating conveying trough in order to evenly distribute the material to be separated movable therein. The angle of inclination of the baffles 12, 13, and 14 increases successively from the delivery trough 16 to the drum 1 as shown in the drawing. The baffle 12 has the least angle of inclination and it has depending flanges 19. The magnetizable material is drawn over the top side of the baffle 12 with the use of a comparatively small magnetic force provided by the magnets 2 in the drum 1. The non-magnetic material flows downwardly by gravity on the baffle 12 opposite to the direction of movement of the magnetic material onto a conveying apron 21 which is attached to the support plate 15 by means of brackets 22 and screw bolts 23. The ends 21*a* of the apron 21 are flanged downwardly. The apron 21 is inclined in a direction opposite to the inclination of the baffles 12, 13, and 14 so that the material flows by gravity downwardly thereon in the general direction of the drum 1. The baffle 13 receives the material that moves over the top of the baffle 12 and it has the upper end 13*a* thereof bent to a vertical position. After separation on baffle 13, the material that passes over the top thereof engages the midpoint of baffle 14 where further separation takes place. The upper end 14*a* of the baffle 14 is bent to an inclined position away from the drum 1 to minimize the amount of non-magnetic material carried thereover to the belt 10 surrounding the drum 1. The baffles 12, 13, and 14 are preferably arranged so that the material flowing thereon strikes approximately the midpoint thereof. The baffles 12, 13, and 14 preferably have successively greater angles of inclination in order that the finer non-magnetizable materials carried with the magnetizable materials over the baffles 12 and 13 will be shaken from the magnetizable material due to the more direct impingement on the succeeding baffles. The upper ends 13*a* and 14*a* of the baffles 13 and 14 are bent to more thoroughly agitate the material passing thereover whereby the non-magnetic material will be shaken loose from any bunched magnetizable particles. The baffle 14 has a right angled depending baffle portion 24 spaced from the apron 21 to provide a closed passage for the non-magnetizable material and to prevent any finely divided material from flowing through the air into the face of the belt 10 on the drum 1, the baffle 24 directing the non-magnetizable material towards a lower apron 25 which is inclined in a direction opposite to the direction of the inclination of the apron 21 and away from the drum 1. The apron 25 is secured to the plate 15 by means of brackets 26 and screw bolts 27. The end 28 of the apron 25 is bent upwardly at right angles to prevent non-magnetizable material from flowing toward the face of the belt 10 on the drum 1 and to thoroughly agitate any remaining magnetizable particles impinging thereon due to the strong attraction of the magnets 2 in the drum 1. The lower end 29 of the apron 25 is flanged downwardly at right angles to permit the free flow of non-magnetizable material therefrom.

The support plate 15 has an aperture 31 through which extends a support shaft 32, the diameter of the aperture 31 being greater than the shaft 32 to permit pulsating or vibratory movement of the support plate 15. An armature 33 is supported on an arm 34 which extends angularly upwardly from the upper end of the plate 15 and is secured thereto by welding or any other suitable means. The armature 33 is made of magnetizable material so that as it tends to close the magnetic circuit between the north and south poles 9 of the magnets 2, it is moved inwardly. Upon continued rotation of the drum 1, the armature 33 moves to a weak field and the spring 35 urges it outwardly. The armature 33 is thus moved inwardly and outwardly upon passage of each pair of poles 9 of the magnets 2, thereby causing pulsating movement of the support 15. The compression spring 35 is supported by a bracket 36 and it engages the lower side of the support plate 15 remote from the drum 1 to urge the armature 33 away from the drum 1. The vibrating or pulsating movement of the baffles 12, 13, and 14 permit the use of baffles with less inclination thereby providing better separation. The vibrations of the baffles 12, 13, and 14 permit the use of a baffle angle considerably less than the angle of repose of the non-magnetic particles thereby permitting the magnetizable particles to be walked up over the baffles end over end more easily, particularly on the more remote baffle 12 when the field is not as strong.

In operation, the drum 1 is rotated by the belt 10 and material to be separated is delivered to the first inclined baffle 12 at approximately the midpoint thereof by a conventional vibrating trough 16. The vibrating trough 16 agitates the material to be separated so that it is evenly distributed therein. The magnetic fields 7 of the magnets 2 of the drum 1 act upon the magnetizable particles in the materials to be separated when they reach a point near the end of the trough 16 in the preferable form of my magnetic separating device. The magnetizable particles tend to string or bunch together when they enter the magnetic fields of opposite polarity produced by succeeding poles 9 of the magnets 2. The mag-

netic fields of opposite polarity cause the magnetizable particles to string together and move end over end inasmuch as the field of one polarity magnetically induces the string of magnetizable material causing the more distant end of the string to be attracted by the approaching pole of opposite polarity. This action repeats as the drum revolves causing the particles to walk end over end into the face of the drum. By stringing together the magnetizable particles, the particles on the ends thereof have a greater amount of induced magnetism. When the material to be separated reaches the midpoint of the pulsating inclined baffle 12, the non-magnetizable material gravitates downwardly on the baffle 12 to the inclined apron 21 whence it passes to the apron 25 and to a suitable container. The magnetizable material is drawn upwardly over the upper end of the baffle 12, end over end, impinges on the second baffle 13 whereupon the magnetizable material moves upwardly thereon end over end and the non-magnetizable material carried with the magnetizable material is shaken loose by the impingement and agitation of the magnetizable particles drawn over the upper end 13a of the baffle 13 and gravitates downwardly on the baffle 13. Inasmuch as the baffle 13 is in a stronger magnetic field than baffle 12 because it is closer to the drum 1, the upper end 13a of the baffle 13 is bent upwardly to a vertical position to increase the agitation of the magnetizable particles to shake loose the non-magnetizable particles therefrom. When the remaining material leaves the upper end 13a of the baffle 13 and is drawn with increased force into the baffle 14, it is violently agitated by the impingement and non-magnetizable particles clinging to or held by magnetizable particles are shaken loose and they gravitate downwardly on the baffle 14 to the apron 21, the magnetizable material moving end over end upwardly thereon and over the bent upper end 14a thereof whereby it is drawn to and gathered on the face of the belt 10 on the drum 1. The angle of inclination of the upper end 14a of the baffle 14 is inclined away from the drum 1 so as to further increase the agitation of the magnetizable particles to throw off non-magnetizable particles clinging to or held thereby. The angle of inclination of the baffles 12, 13, and 14 increases progressively from the delivery chute 16 to the drum 1 to progressively decrease the angle of impingement and increase the agitation of the magnetizable particles to assure complete separation. All of the separated non-magnetizable material gravitating from the baffles 12, 13, and 14 pass to the apron 21 whereby they are directed to a point adjacent the drum 1. As it passes from the lower end of the apron 21 to the upper end of the apron 25 adjacent the drum 1, the material is again subjected to the strong magnetic forces of the magnets 2 of the drum 1 and any remaining magnetizable material is drawn upwardly, end over end, over the bent upper end 28 of the apron 25 and it is gathered on the belt 10 surrounding the drum 1. The magnetic fields of opposite polarity produced by the opposite poles 9 of the magnets 2 passing the armature 33 cause it and connected plate 15 carrying baffles 12, 13, and 14 to pulsate thereby causing the material to be agitated at all times so that it gravitates down the inclined baffles 12, 13, and 14 and aprons 21 and 25 continuously and the magnetizable particles are agitated so that the baffles 12, 13, and 14 may have a lesser inclination thereby minimizing the amount of magnetizable material gravitating with the non-magnetizable material to the apron 21. The non-magnetizable material gravitates from the apron 21 to the apron 25 which passes the non-magnetizable material to a point remote from the drum 1. The magnetizable material is gathered on the belt 10 surrounding the drum 1 and any remaining non-magnetizable material is thrown off therefrom by centrifugal force. The magnetizable material drops from the belt 10 when it reaches a point outside of the magnetic fields 7 of the magnets 2.

Any type of delivery trough may be used but I prefer to use a vibratory type because it provides an even uniform flow which gives uniform results. Although I show the baffles 12, 13, and 14 attached to one side of a plate 15, I show this for illustration only inasmuch as the baffles may be supported by plates on both sides thereof or by any other suitable supporting means. My magnetic separating device will operate without the pulsation of the support plate 15 although I prefer to pulsate the support plate and the baffles 12, 13, and 14 to assure the efficient flow of the materials with baffles having a minimum inclination. The armature 33 may be utilized for pulsating any accessory equipment in conjunction with the magnetic drum 1.

I prefer to use more than one inclined baffle although it will be evident that my device will operate with only one inclined baffle. I also prefer to increase the inclination of the baffles as they become more distant from the delivery trough and as they move into the strongest field of magnetization of the drum 1 because only the more finely grained non-magnetic material usually reaches the second and third baffles and increased obstacles causing greater impingement frees a maximum amount of non-magnetizable material. It will further be observed that the upper ends of each succeeding baffle from the delivery trough to the drum is spaced upwardly from the preceding baffle and the upper end of the baffles nearest to the pulley are inclined vertically or away from the drum 1 for increasing the obstacles over which the materials must pass thereby greatly increasing the agitation and the consequent throwing off of the non-magnetic materials.

The drum 1 has the magnetic pole pieces and air gap running parallel to the shaft supporting it so that when the drum revolves in front of the material to be separated or adjacent thereto, it causes the magnetic particles to tumble end over end in a pulsating action as the north and south magnetic fields intermittently magnetize the magnetic material as the drum 1 rotates.

It will be evident from the foregoing description that I have provided a magnetic separating device for separating magnetizable materials and especially materials containing an appreciable amount of magnetizable material wherein the material is run from a vibrating trough over one or more inclined separating baffles interposed between the delivery chute and the face of a belt on a magnetic pulley or drum, the magnetic drum providing a succession of north and south magnetic fields in which the baffles are disposed, the magnetizable material being drawn over the baffles to the pulley and the non-magnetizable materials gravitating downwardly thereon, which further separates any remaining magnetizable material which gravitates with the non-magnetizable material from the inclined baffles between the delivery chute and the pulley, which also separates non-magnetizable material from the mag-

netizable material by centrifugal force after it passes over the baffle to the belt on the drum, and which has novel means for agitating the baffles.

Various changes may be made in the specific embodiment of my invention without departing from the spirit thereof or from the scope of the appended claims.

I claim:

1. A magnetic separating device comprising a rotating member having magnets spaced around the inner periphery thereof and rotating therewith, said magnets having alternately progressive magnetic poles of opposite polarity around the outer periphery thereof, an inclined baffle spaced laterally from said rotating member within the magnetic fields of said magnets therein, and means for feeding the material to be separated onto the side of said inclined baffle in a direction towards the magnets of said rotating member, said baffle being inclined away and downwardly from said member whereby non-magnetic material is directed therefrom by gravitation and magnetic material is drawn over the top of said inclined baffle towards the outer surface of said rotating member.

2. A magnetic separating device as set forth in claim 1 wherein a plurality of successively spaced inclined baffles are spaced laterally from said rotating member, the angle of inclination of each successive baffle being greater than the angle of inclination of the preceding baffle in the direction of said rotating member.

3. In combination with a rotating member having magnets disposed around the periphery thereof providing magnetic poles of opposite polarity alternately and progressively around the periphery thereof, a plurality of spaced inclined baffles spaced laterally from said rotating member within the magnetic fields of said magnets, the angle of inclination of said baffles being away from said rotating member, and means for directing material to be separated into said inclined baffles toward said rotating member whereby magnetizable material is attracted by the magnets in said rotating member over the top of said baffles and non-magnetizable material gravitates downwardly on said inclined baffles away from said rotating member.

4. In combination with a rotating member as set forth in claim 3 wherein the upper ends of said baffles adjacent said rotating member are inclined away from said rotating member.

5. In combination with a rotating member as set forth in claim 3 wherein support means are provided for said baffles and an armature is mounted on said support means adjacent said rotating member for pulsating said baffles and baffle support means.

6. In combination with a rotating member as set forth in claim 3 wherein an inclined apron is disposed below said baffles inclined toward said rotating member to convey material gravitating from said baffles to a point adjacent said magnetic rotating member whereby further separation of said material takes place.

7. In combination with a rotating member as set forth in claim 6 wherein a second apron is spaced from the end of said first apron and inclined at an angle opposite thereto to direct non-magnetic material away from said rotating member.

8. In a magnetic separating device, in combination, a rotatable magnetic drum having magnets spaced around the periphery thereof with alternate north and south magnetic poles, a plurality of inclined baffles spaced laterally outwardly from said magnetic drum, said baffles being inclined away from said drum, means for delivering material to be separated into the baffle furtherest from said magnetic drum toward said rotating member, an apron disposed below said baffles inclined toward said rotating drum for directing the material gravitating therefrom towards said magnetic drum, and a second apron spaced from end of said first mentioned apron to direct said material flowing from said first mentioned apron away from said magnetic drum.

9. In a magnetic separating device as set forth in claim 8 wherein the angle of inclination of each of said successive inclined baffles is inclined at a greater angle than the preceding successive baffle from said material delivery means to said magnetic drum.

10. In a magnetic separating device as set forth in claim 9 wherein said baffles are disposed on a support member, and means are provided for vibrating said support member and baffles thereon.

11. In a magnetic separating device as set forth in claim 10 wherein the means for pulsating said support member and baffles comprises an arm secured to said support member having an armature adjacent said magnetic drum and in the rotating magnetic fields thereof.

12. In a magnetic separating device, in combination, a rotating member having magnets disposed around the periphery thereof within said rotating member defining alternate magnetic poles of opposite polarity, a deflecting member in the magnetic fields of said magnets spaced a predetermined distance laterally outwardly from the outer surface of said rotating member for deflecting the flow of material attracted to said rotating member, and an armature connected to said deflecting member disposed adjacent said rotating member in the magnetic fields of said magnets for pulsating said deflecting member upon rotation of said rotating member.

13. In a magnetic separating device, in combination, a pulley having magnets of generally U-shape disposed around the inner periphery thereof with the legs thereof transversely aligned around the periphery of said pulley defining progressive magnetic fields of alternate polarity around the outer periphery of said pulley, a non-magnetic belt trained on said pulley, a delivery chute for material to be separated having the delivery end thereof in said magnetic fields, an inclined baffle disposed between said chute and said pulley, said baffle being inclined away from said pulley, and a second baffle inclined oppositely to the direction of said first baffle to direct material gravitating therefrom towards and adjacent to said belt on said pulley, said material being fed by said delivery chute into said inclined baffle in a direction leading to said pulley.

14. In a magnetic separating device, in combination, a rotatable member having magnets therein spaced around the inner periphery thereof defining rotatable magnetic fields, an armature spaced from said rotatable member in said rotatable magnetic fields adapted to be moved inwardly by each successive magnetic field, a support member for said armature, and spring means on said support member for urging said armature away from said rotatable member upon passing each successive magnetic field, and an inclined baffle inclined away from said rotatable member in the path of material to be sepa-

rated passing toward said rotatable member to deflect the path of same, mounted on said support member for said armature.

RONALD C. HOFF.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
248,196	Muller	Oct. 11, 1881
411,899	Moffatt	Oct. 1, 1889
443,044	Finney	Dec. 16, 1890
449,726	Ball	Apr. 7, 1891
463,305	Hoffman	Nov. 17, 1891
500,604	Payne	July 4, 1893
634,356	Kreuser	Oct. 3, 1899
946,394	Ohrn	Jan. 11, 1910
1,529,970	Ullrich	Mar. 17, 1925
1,693,033	Hope	Nov. 27, 1928
2,187,637	Sutton	Jan. 16, 1940
2,466,839	Caldwell	Apr. 12, 1949

FOREIGN PATENTS

Number	Country	Date
103,310	Austria	May 10, 1926