

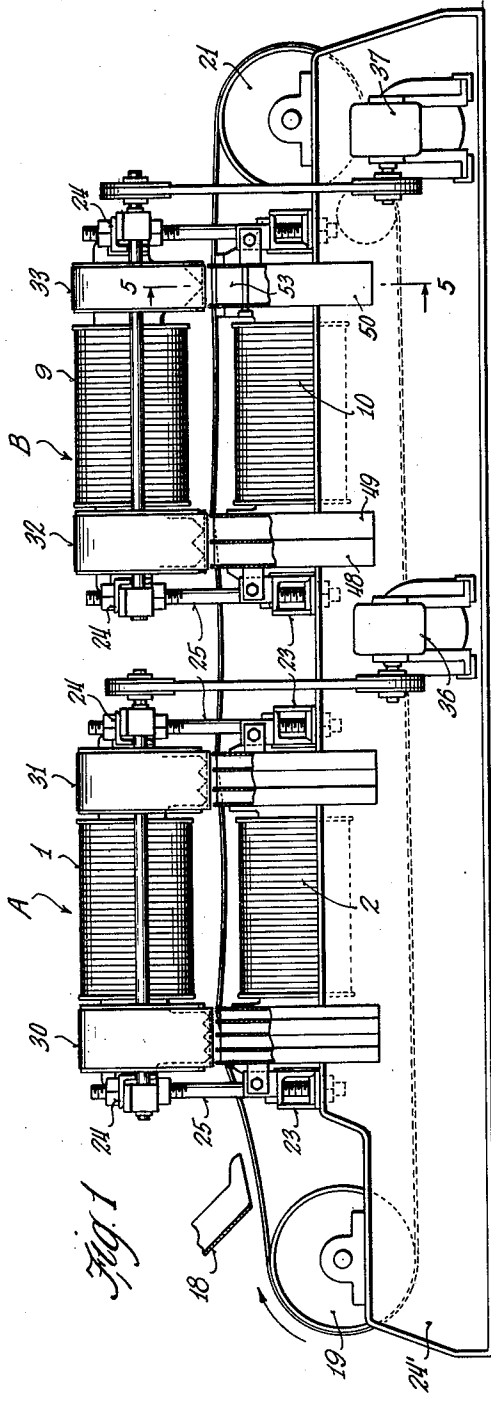
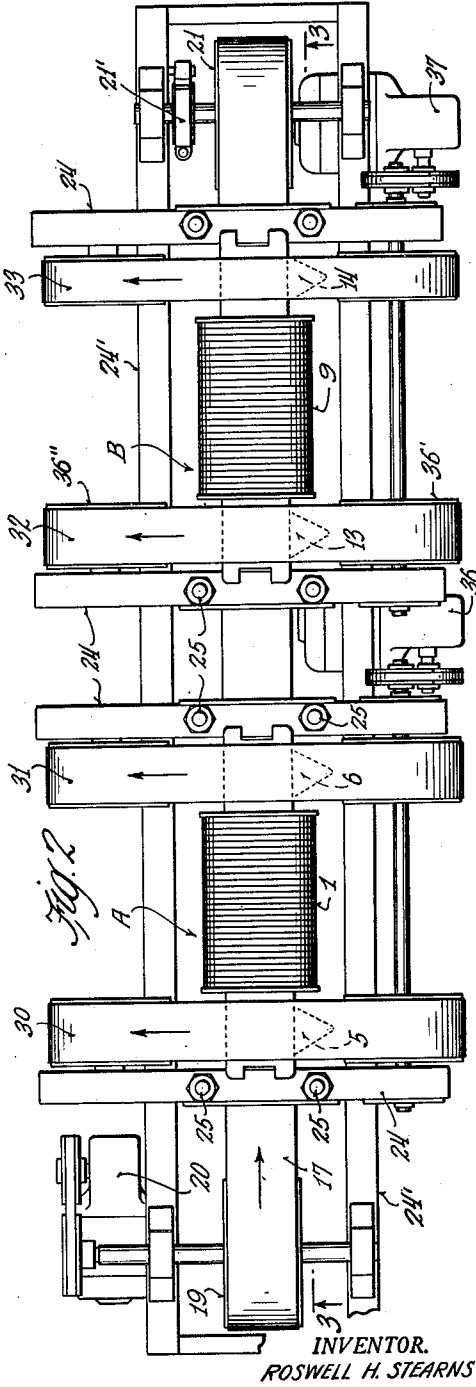
June 13, 1950

R. H. STEARNS
MAGNETIC SEPARATOR

2,511,484

Filed April 26, 1945

2 Sheets-Sheet 1



INVENTOR.
ROSSELL H. STEARNS

BY

Arthur P. Trovack
ATTORNEY.

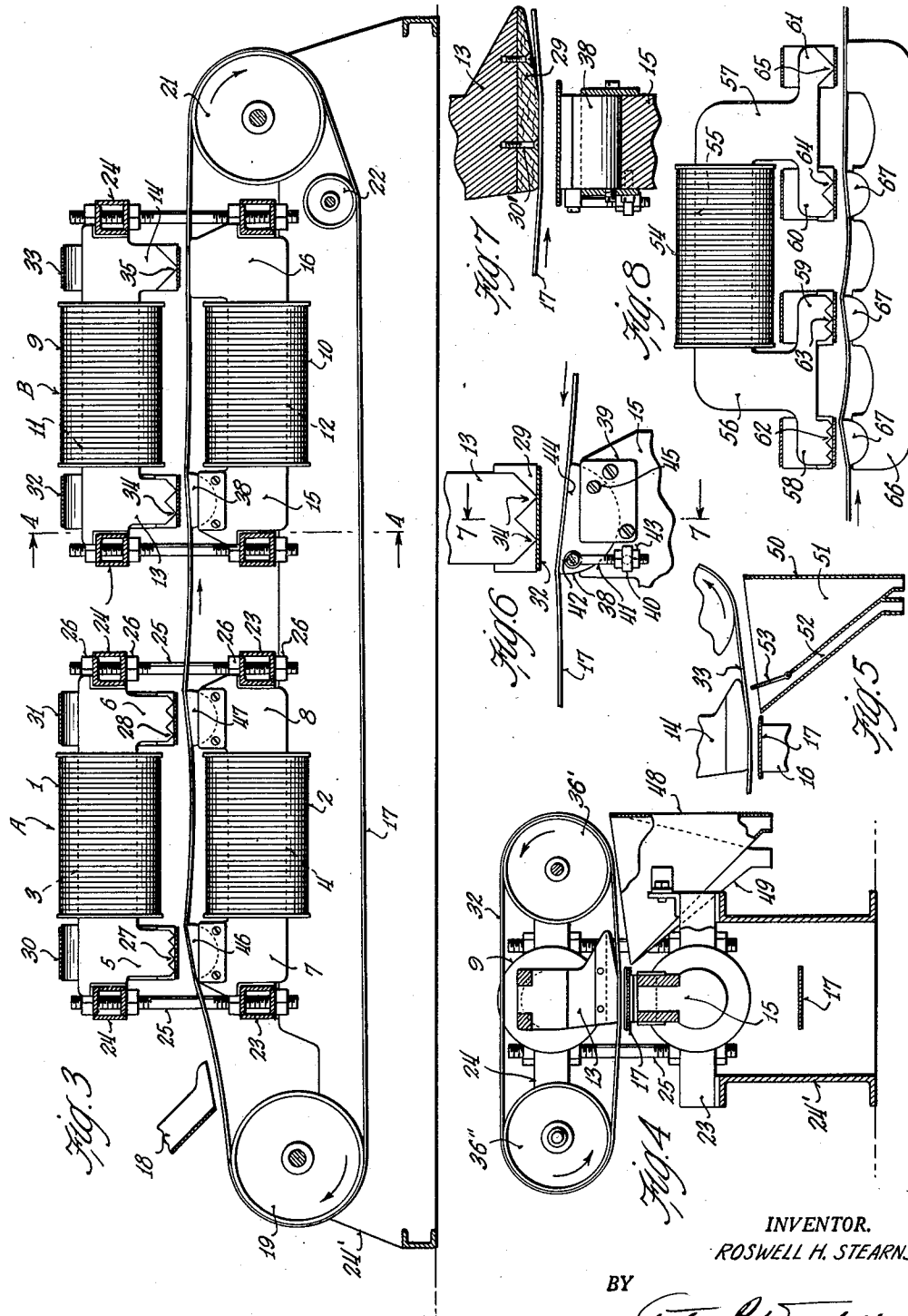
June 13, 1950

R. H. STEARNS
MAGNETIC SEPARATOR

2,511,484

Filed April 26, 1945

2 Sheets-Sheet 2



INVENTOR.
ROSWELL H. STEARNS

BY

Arthur R. Woodfolk
ATTORNEY.

UNITED STATES PATENT OFFICE

2,511,484

MAGNETIC SEPARATOR

Roswell H. Stearns, Wauwatosa, Wis., assignor to
Stearns Magnetic Mfg. Co., Milwaukee, Wis., a
corporation of Wisconsin

Application April 26, 1945, Serial No. 590,368

7 Claims. (Cl. 209-223)

1

This invention relates to magnetic separators designed for concentration of ores and minerals by the lift method; and is especially directed to a magnetic separator for separating highly complex mixtures of materials varying in magnetic permeability to a greater or lesser degree or being of substantially equal permeability but varying in specific gravity.

Objects of this invention are to provide a magnetic separator which has one or more magnetic assemblies, each providing a pair of air gaps through which the material passes, which is so arranged that a plurality of graded separations are obtained at each air gap and with a single passage of the material therethrough, so that the separator provides not only a plurality of different separated products for each magnet assembly but also provides a plurality of different separated products for each main magnetic field at each air gap.

Further objects are to provide a magnetic separator in which a plurality of zones of separation are provided at each air gap, in which the total intensity for all of the zones at any air gap may be simultaneously adjusted and in which the relative intensity between successive zones at each air gap may be adjusted to thereby provide any degree of differential separation desired for each air gap, and also to control the total intensity at the air gap for all of the zones.

Further objects are to provide a magnetic separator in which a plurality of different zones are provided at each air gap and are arranged in increasing intensity so that as the material is passed through an air gap the magnetic material is premagnetized as it passes from zone to zone and a certain interval of time is allowed for the travel of the material through one zone to thus allow time for premagnetization of the magnetic material before it passes into the next adjacent more intense zone.

Further objects are to provide a magnetic separator which will provide a greater range of separation of the materials for a given number of magnetic assemblies than has heretofore been possible, and in which each magnet assembly functions as a plurality of individual separators for securing a large number of graded, separated products from a single passage through the machine, the invention lending itself to greater flexibility so that one, two or any number of magnetic assemblies may be employed.

Further objects are to provide a magnetic separator having the above characteristics which is of relatively simple and inexpensive construction

2

and which is thoroughly reliable in its operation.

Embodiments of the invention are shown in the accompanying drawings, in which:

Figure 1 is a side elevation partly broken away with parts in section showing one form of the invention.

Figure 2 is a plan view of the structure shown in Figure 1.

Figure 3 is a sectional view on the line 3-3 of Figure 2.

Figure 4 is a sectional view on the line 4-4 of Figure 3.

Figure 5 is a sectional view on the line 5-5 of Figure 1.

Figure 6 is a detailed view partly broken away and partly in section taken from the side opposite that shown in Figure 3.

Figure 7 is a sectional view on the line 7-7 of Figure 6.

Figure 8 is a fragmentary longitudinal elevational view partly in section of a modified form of the invention.

The magnetic separator may comprise a single or a plurality of magnet assemblies. In the form chosen for illustration in Figures 1, 2, and 3, two magnet assemblies have been illustrated and are indicated by the reference characters A and B. The magnet assembly A is provided with a pair of energizing windings 1 and 2 wound about yoke or core portions 3 and 4 respectively. The core 3 is provided with pole pieces 5 and 6 and the core 4 is similarly provided with pole pieces 7 and 8.

Similarly the magnet assembly B is provided with energizing windings 9 and 10 wound about yoke or core portions 11 and 12. The core 11 is provided with pole pieces 13 and 14 and the core 12 is provided with pole pieces 15 and 16.

It is preferable to provide the usual means such as a rheostat, not shown, for adjusting the value of the current passing through the energizing windings of the magnet assembly. Also it is preferable to have a more powerful magnetic field for the magnet assembly B than for the magnet assembly A.

The pole pieces at each end of each magnet assembly are spaced apart to provide air gaps through which a continuous feed belt indicated by the reference character 17 passes. This feed belt is supplied with material to be separated by any suitable supply means such, for instance, as the chute 18. Any suitable means are provided for insuring a uniform, even spreading of the material upon the feed belt. The feed belt is driven from the left-hand end of the machine

3

as viewed in Figures 1, 2, and 3 adjacent the feed-
ing means or chute 18. For instance, the driving
pulley 19 is driven from a variable speed reduc-
tion gear motor indicated by the reference char-
acter 20. The other end of the feed belt is sup-
ported by the idler pulley 21 and a spacing pulley
22 is provided to hold the belt spaced sufficiently
downwardly to provide adequate clearance be-
tween the lower stretch of the belt 17 and the
overhanging portions of the machine. Attention
is particularly directed to Figure 3 and it will be
noted that the manner of driving the belt is con-
trary to the usual practice. Ordinarily the pulley
21 would be the driving pulley and would pull the
belt through the machine causing the upper
stretch to be tight. Instead the driving pulley
is the pulley 19. The reason for this is that the
lower stretch of the belt is held taut whereas the
upper stretch of the belt is allowed to sag slightly
for a purpose hereinafter to appear. In order to
increase this effect a brake 21' may be provided
to produce a slight braking action for the pulley
21. The lower magnet structure of each unit is
carried by transverse channels or box-like struc-
tural steel members 23 which are supported by
side frames 24, see Figures 3 and 4. The upper
magnet structure of each magnet assembly is
similarly supported by transverse channels or
box-like structural steel members 24. Each mag-
net structure is preferably secured in any suitable
manner, not shown, to the corresponding trans-
verse supporting members 23 or 24. The upper
members 24 are supported from the lower mem-
bers 23 by means of bolts 25. These bolts are of
nonmagnetic material such, for example, as stain-
less steel and are threaded for a considerable dis-
tance at each end. Nuts 26 are screwed on the
bolts and engage opposite sides of the members
23 and 24. By this means either or both ends of
the magnet structure may be adjusted to any de-
gree desired, either the same amount at both ends
or different amounts at opposite ends as sufficient
clearance is provided for the bolts 25. Obviously
if desired, the faces of the nuts 26 adjacent the
members 23 and 24 may be rounded and the
members 23 and 24 may be slightly socketed.
This construction, however, has not been illus-
trated as it is believed to be a well known me-
chanical construction.

The upper pole 5 of the magnet assembly A is
provided with a plurality of V-shaped projections
or sub-poles 27 and the pole 6 is similarly pro-
vided with a plurality of V-shaped projections
or sub-poles 28. These sub-poles 27 and 28 pro-
duce separating zones as will appear as the de-
scription proceeds. Take-off belts 30 and 31 are
provided for the sub-poles 27 and 28.

The magnet assembly B is similarly provided
with take-off belts 32 and 33. The pole 13 of the
magnet assembly B may be provided with a plu-
rality of V-shaped sub-poles 34 and if desired the
pole piece 14 of the magnet assembly B may be
provided with a single V-shaped sub-pole 35.

The arrangement is such that the first pole 5
has the greatest number of sub-poles and suc-
cessive poles 6, 13, and 14 have successively smaller
numbers of sub-poles. The final pole 14 may
have a single sub-pole if so desired and as shown
in the drawings. Obviously the exact number of
sub-poles for each upper pole piece may be varied
as desired.

The space between and on opposite sides of the
V-shaped sub-poles of each upper pole is filled by
wooden pieces. This construction is shown most
clearly in Figures 6 and 7 where the wooden

4

pieces are indicated by the reference character
29. These wooden members 29 are held in place
by means of nonmagnetic screws 30' which are
countersunk so that their heads are flush with
the bottom surface of the nonmagnetic filler
members 29. This construction is for the pur-
pose of providing a flat surface on the underside
of the upper pole pieces so that the take-off belts
indicated at 30 and 31 for the magnet assembly
A and 32 and 33 for the magnet assembly B will
ride flatly against the flat bottom surface of the
upper poles without any possible chance of cut-
ting the belt.

It is preferable to extend the upper pole pieces
laterally outwardly in the direction in which the
under stretch of the take-off belts travel. For
example, in Figure 4 where the take-off belt 32
and the pole piece 13 are illustrated it will be
seen that the pole piece is extended in the direc-
tion of travel of the lower stretch of the belt. It
is to be noted also that the lower stretch of the
take-off belts is the tight side of the belt and the
upper side is the loose side. For instance, in Fig-
ure 4 it is to be noted that the driving pulley is
the pulley 36', the belt passing over the pulley
36'' on the other side of the machine.

Each magnet assembly is provided with an
individual motor for driving its pair of belts.
These motors are reduction gear motors with a
mechanical adjustment to vary the speed of the
individual motor. The motors are indicated at
36 and 37 in Figure 1.

The lower poles of the magnet assembly A and
the first lower pole piece of the magnet assembly
B are each equipped with means arranged to pro-
vide an adjustment of the relative strength of the
successive zones for each air gap. This is shown
most clearly in Figure 6. From Figures 6 and 7
illustrating the construction for the pole pieces
15 as well as from Figure 3 showing the pole pieces
7, 8, and 15, it will be seen that each of these pole
pieces has an articulated portion. This portion
consists of a half-round magnetic member 38 ex-
tending transversely across the lower pole 15 and
socketed within a semicircular depression in such
pole piece. The pole piece 15 is provided with
end plates 39. A lug 40 extends laterally out-
wardly from one side of the pole 15 and loosely
carries an adjustable bolt 41 which is pivotally
secured as indicated at 42 to the half-round
transversely extending magnetic member 38. The
bolt 41 is adjusted by means of nuts 43 located on
opposite sides of the lug 40 so as to get a microm-
eter adjustment, so to speak, of the angle of tilt
of the upper flat face 44 of the half-round mag-
netic member 38. After the proper adjustment
is secured the nuts 43 are locked and a set screw
45 extending through one of the plates 39 is also
set so as to securely lock the half-round magnetic
member 38 in its adjusted position. The half-
round adjustable magnetic member for the pole
7 is indicated by the reference character 46 and
the half-round magnetic member for the pole 8
is indicated by the reference character 47.

It will now be seen why it was desirable to have
the upper side of the belt sag slightly. The pur-
pose of this as will be seen from reference to
Figure 3, is to cause the belt to lie flatly against
each of the flat angular disposed upper faces of
the magnetic members 46, 47, and 38 and to lie
flatly against the flat upper face of the pole 16.

It is preferable to adjust the member 46 so that
its upper flat face has the greatest slant and to ad-
just the member 38 so that its upper flat face has
the least slant. The upper flat face of the mem-

5

ber 47 is adjusted so that it has a slant intermediate that of the faces of the members 46 and 38.

In the operation of the apparatus it is apparent that the most highly permeable material will be attracted to the first of the sub-poles 27 of the pole 5 and other less highly permeable material will be attracted to the successive sub-poles 27 of the pole 5. Similarly for the pole 6 the still less permeable material will be successively attracted to the sub-poles 28 and again a similar operation will take place for the sub-poles 34 of the pole 13. Material of very low permeability will be finally attracted to the single sub-pole 35 of the pole 14. It is thus apparent that each of the poles 5, 6, and 13 secure a differential or graded separation of material at each air gap. By means hereinafter described, it will be seen that even with a single sub-pole as, for example, the sub-pole 35 of the pole 14, a multiple separation can be secured. However, returning to the poles 5, 6, and 13 it will be seen that the most highly permeable material will be held in the zone immediately below the first sub-pole and throughout the machine the successive sub-poles receive less and less permeable material. Thus it is apparent that the material is separated into zones due to the increasing magnetic intensity for successive sub-poles and the material so separated into zones is held against the underside of the take-off belts 30, 31, and 32, a single zone being formed on the belt 33.

In order to receive the graded and separated material, a plurality of hoppers are provided, one for each sub-pole. For example, as shown in Figure 4, two hoppers indicated by the reference characters 48 and 49 are provided in alignment with the sub-poles 34. It is to be noted also that each of the poles 5, 6, 13, and 14 project laterally towards the direction of travel of the under stretch of the take-off belts, see Figures 4 and 7. The result of this is that the material clings to the underside of the take-off belts and remains in its particular zone of separation. The projecting portions taper upwardly away from the take-off belts and consequently the separated material falls into its appropriate hopper when it is carried by the take-off belts past the influence of the separator poles.

As shown in Figure 5, it is possible to use a single V-shaped pole structure, for example the last pole 14, and yet secure a multiple separation. It is to be noted that the underside of the pole 14 is tapered upwardly away from the corresponding take-off belt 33. Thus as the material is gradually carried out of the influence of the magnet pole, the less permeable material will fall downwardly from the underside of the take-off belt 33 first and the more permeable material will fall off at a later instant. Consequently by dividing the chute 50, see Figure 5, into two portions 51 and 52 it is possible to have a multiple separation with only one projecting portion. The particular point at which the division between the separated parts is to be made is determined by means of an adjustable flap or divider 53.

It is to be noted particularly that this invention provides means whereby a plurality of separations is made at a single air gap, thus providing a machine which is extremely compact and of simple construction and which for each magnet assembly provides a large number of separations. It will thus be seen that this machine is adapted for use with a single magnet assembly if so desired but which is so arranged that a large number of separations is obtained even

6

though a single magnet assembly is employed. It will also be seen that any desired number of magnet assemblies can be employed two, for instance, having been shown in Figures 1, 2, and 3, thus increasing the total number of separations for one passage of the material through the machine.

It is to be understood that the construction shown in Figure 5 for the last pole 14 may be employed for each of the several sub-poles of the remaining poles if so desired.

The machine may take other forms. For instance, as in Figure 8, a diagrammatic illustration of a modified form is shown. In this figure a single magnet assembly is employed and is composed of the energizing winding 54, the core or yoke 55, and the main poles 56 and 57. These main poles respectively divide into branch poles 58 and 59 for the pole 56; and 60 and 61 for the pole 57. Each of these branch poles is provided with one or more V-shaped sub-poles. For example, the branch pole 58 is provided with four sub-poles 62, the branch pole 59 with three sub-poles 63, and the branch pole 60 with two sub-poles 64, and the branch pole 61 with a single sub-pole 65. The lower pole structure is indicated by the reference character 66 and is provided with a projecting pole adjacent and below each of the poles 58, 59, 60, and 61. At least the first three of these lower poles is provided with half-round magnetic member 67. A feed belt and take-off belts similar to those previously described are provided and are driven in exactly the same manner as described in connection with the first form of the invention.

In this modified form of the invention shown in Figure 8, it will be seen that there is a single energizing winding and that the main poles are divided or split up into several branch poles and the branch poles are provided with one or more sub-poles. The space between and just beyond the sub-poles is filled by nonmagnetic members, such as the wooden member corresponding to the member 29 of Figure 7. The same arrangement of hoppers is employed with this form of the invention as with that previously described and the component parts of the magnet assembly are supported in any suitable manner not shown.

Obviously the hopper construction associated with each of the sub-poles may be single hoppers or may be of the same construction as shown in Figure 5 and previously described.

If desired nonmagnetic spacers may be positioned above each of the flat faces of the articulated portions of the lower poles in any form of the invention in accordance with the usual practice.

In further explanation of the invention attention is called to the first form shown in Figures 1 through 7. It is to be noted that each magnet assembly can be individually adjusted to vary the space of the pole structures and to thus vary the flux distribution or intensity at the air gap, the adjustment of opposite ends of each magnet assembly being independent. This adjustment brings the poles closer together or spaces them farther apart and thus simultaneously varies the total intensity of the field at the poles and across the air gaps. The half-round adjustable magnetic members with flat upper faces are adjustable so as to adjust the angle of their upper flat faces against which the feed belt flatly lies. This angular adjustment of the upper flat face of each of the half-round members determines the degree of variation in magnetic intensity for each of the successive sub-poles formed on the upper

poles and consequently determines the relative degree of separation for successive sub-poles.

It is to be noted that by providing a plurality of upper sub-poles that it is within the realm of this invention to adjust the lower pole so as to have a horizontal, flat lower pole face. Even with this adjustment it is to be noted that a plurality of zones of separation are produced. Consider several particles of different reluctance. If the first particle is sufficiently permeable it will be picked up at the first sub-pole. The second and third particles will receive a certain degree of premagnetization from the first sub-pole but will not be picked up by the first sub-pole. When they arrive at the second sub-pole, assuming that particle number two is more permeable than particle number three, particle number two will be picked up by the second sub-pole and particle number three will receive a further degree of premagnetization. When particle number three arrives at the third sub-pole it will be picked up by the third sub-pole. Time to overcome the reluctance to magnetization is allowed by the passage through successive zones. Thus it is possible even with a flat, horizontal lower pole to secure differential separation at a single air gap.

It will be seen that a very simple and compact separator has been provided which has a relatively small number of parts and yet obtains a vast number of differently graduated, separated products.

Although this invention has been described in considerable detail, it is to be understood that such description is intended as illustrative rather than limiting, as the invention may be variously embodied and is to be interpreted as claimed.

I claim:

1. A magnetic separator comprising a magnet assembly including an upper and a lower pole spaced apart to provide an air gap and having flat opposed faces, said upper pole having a plurality of nonadjustable sub-poles of like polarity, the flat face of said lower pole being arranged for angular adjustment, a feed belt and a take-off belt arranged to travel through said air gap with the take-off and feed belts respectively flatly contacting the flat faces of the upper and lower poles, the angular adjustment of the flat face of said lower pole being arranged to vary the relative intensity of said sub-poles from equal values through any desired range.

2. A magnetic separator comprising a magnet assembly having a plurality of air gaps with upper and lower poles defining the air gaps, the upper poles having a plurality of downwardly projecting nonadjustable sub-poles and the lower poles comprising at least three rotatably mounted adjustable portions having flat faces arranged to be angularly adjustable to thereby vary the relative magnetic intensity of different portions in each of the several separating zones within a unified magnetic field in accordance with the degree of slant of the corresponding flat face, a feed belt and transversely extending superposed take-off belts passing through the air gaps, means for driving the take-off belts, and means for driving the feed belt and arranged to produce a slack in that stretch of the feed belt passing through the air gaps to cause said feed belt to lie flatly against the adjustable flat slanting faces of the lower poles in all positions of adjustment of the flat slanting faces of the lower poles.

3. A magnetic separator comprising a magnet assembly having a plurality of air gaps defined by upper and lower poles, said upper poles having

downwardly extending sub-poles and said lower poles having flat slanting faces located below said sub-poles, a feed belt having an upper stretch passing through said air gaps and having a lower stretch below said magnet assembly, a drive pulley and an idler pulley, respectively, located at the feed end and discharge end of said feed belt, feed means for feeding onto the upper stretch of said feed belt at a point after said feed belt has left said drive pulley, brake means on said idler pulley to hold the lower stretch of said feed belt tight while allowing the upper stretch of the feed belt to make full contact on the flat slanting faces of said lower poles, and take-off belts passing transversely of said feed belt through said air gaps.

4. A magnetic separator comprising a magnet assembly having an air gap defined by an upper and a lower pole, said upper pole having a plurality of downwardly projecting and tapering nonadjustable sub-poles arranged to form parallel ridges, said lower pole having a semi-cylindrical magnetic member socketed in said lower pole and having a flat upper face and adapted to be adjusted to vary the angularity of said flat upper face to thereby vary the relative intensity of the sub-poles, and an upper take-off belt and a lower feed belt arranged to travel through said air gap at right angles to each other.

5. A magnetic separator comprising a magnet assembly having an air gap defined by an upper and a lower pole, said upper pole having a plurality of downwardly projecting and tapering nonadjustable sub-poles arranged to form parallel ridges, nonmagnetic fillers between the said ridges to provide a flat lower face for said upper pole, said lower pole having a semicylindrical magnetic member socketed in said lower pole and having a flat upper face and adapted to be adjusted to vary the angularity of said flat upper face to thereby vary the relative intensity at the sub-poles, and an upper take-off belt and a lower feed belt arranged to travel through said air gap at right angles to each other.

6. A magnetic separator comprising a magnet assembly having an air gap defined by an upper and a lower pole, said upper pole having a plurality of downwardly projecting and tapering nonadjustable sub-poles arranged to form parallel ridges, said lower pole having a semi-cylindrical magnetic member socketed in said lower pole and having a flat upper face and adapted to be adjusted to vary the angularity of said flat upper face to thereby vary the relative intensity at the sub-poles, an upper take-off belt and a lower feed belt arranged to travel through said air gap at right angles to each other, and means for securing a micrometer angular adjustment of the flat face of said semicylindrical member.

7. A magnetic separator comprising a magnet assembly including an upper pole and a lower pole spaced apart to provide an air gap, a feed belt and a superposed take-off belt arranged to travel at right angles to each other through said air gap, said upper pole having a plurality of nonadjustable sub-poles forming parallel downwardly projecting elongated ridges extending transversely with respect to the feed belt and extending longitudinally with respect to the take-off belt, whereby material lifted from said feed belt will be arranged in parallel zones on the under side of said take-off belt, said lower pole having a flat face and being rotatably mounted and arranged to have the flat face slant upwardly towards the most rearwardly located sub-pole with reference to the direction of travel of said feed

belt, to thereby provide relatively different magnetic intensities at the separating zones of the nonadjustable sub-poles, said lower pole being at least coextensive in length measured in the direction of travel of the feed belt as said upper pole, and a plurality of hoppers arranged side by side to receive the material separated into the several zones on the take-off belt.

ROSWELL H. STEARNS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
807,517	Vance -----	Dec. 19, 1905
825,672	Moffatt -----	July 10, 1906
1,130,648	Ullrich -----	Mar. 2, 1915
1,310,802	Manegold -----	July 22, 1919
1,490,792	Woodworth -----	Apr. 15, 1924
1,935,075	Brubaker -----	Nov. 14, 1933