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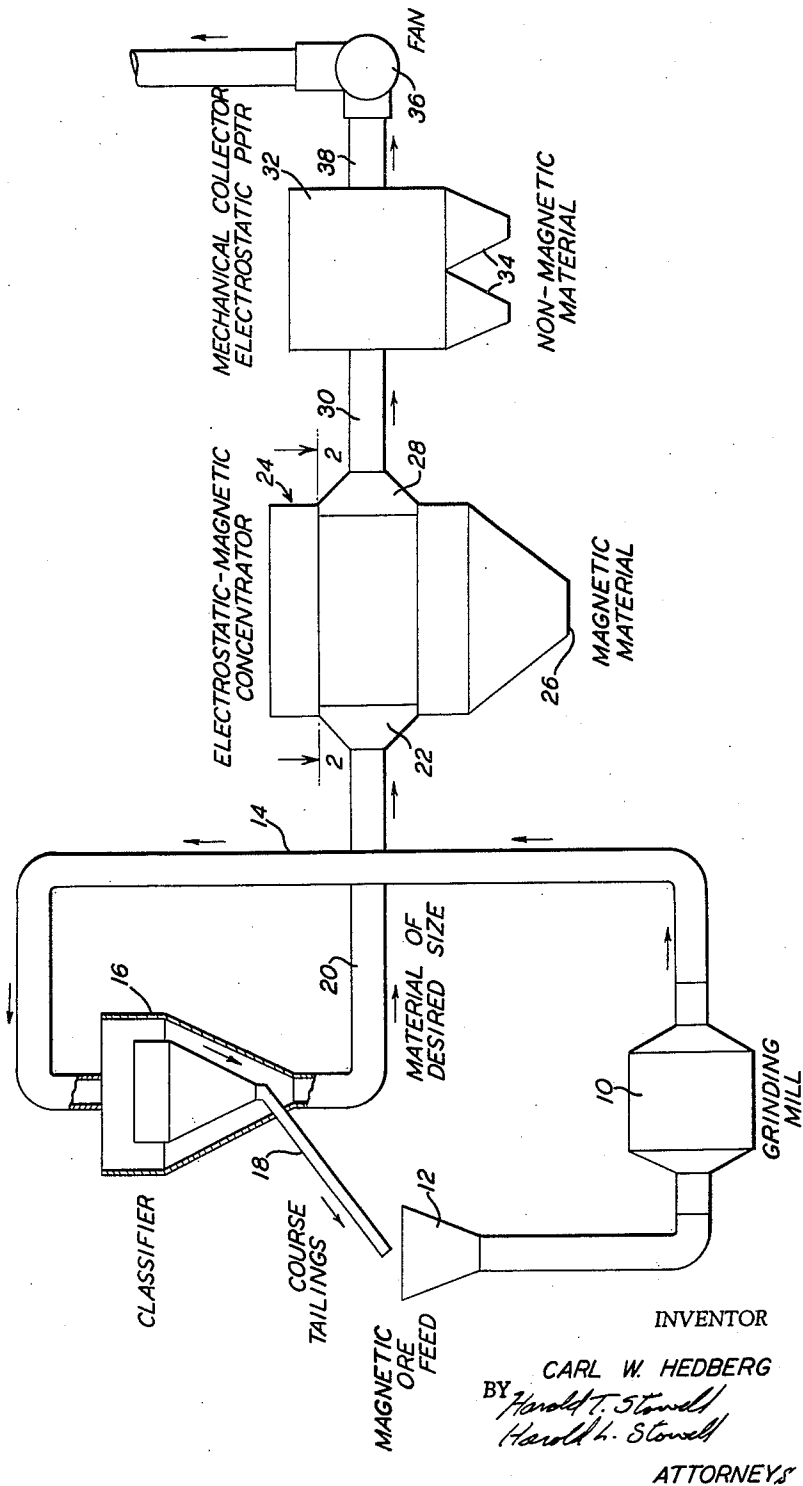
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ELECTROSTATIC MAGNETIC COLLECTING SYSTEM

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4 Sheets-Sheet 1

FIG. 1.



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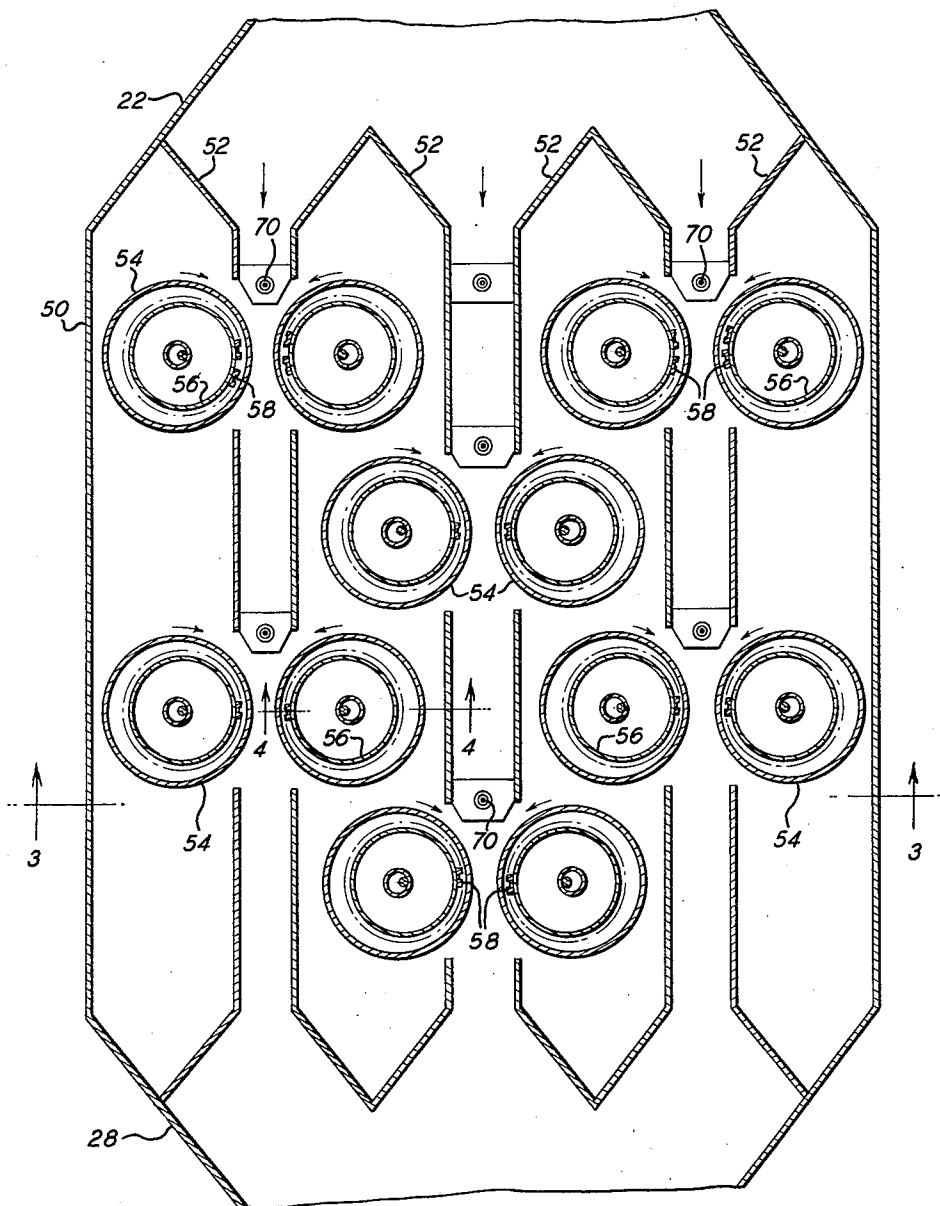
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FIG. 2.



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FIG. 3.

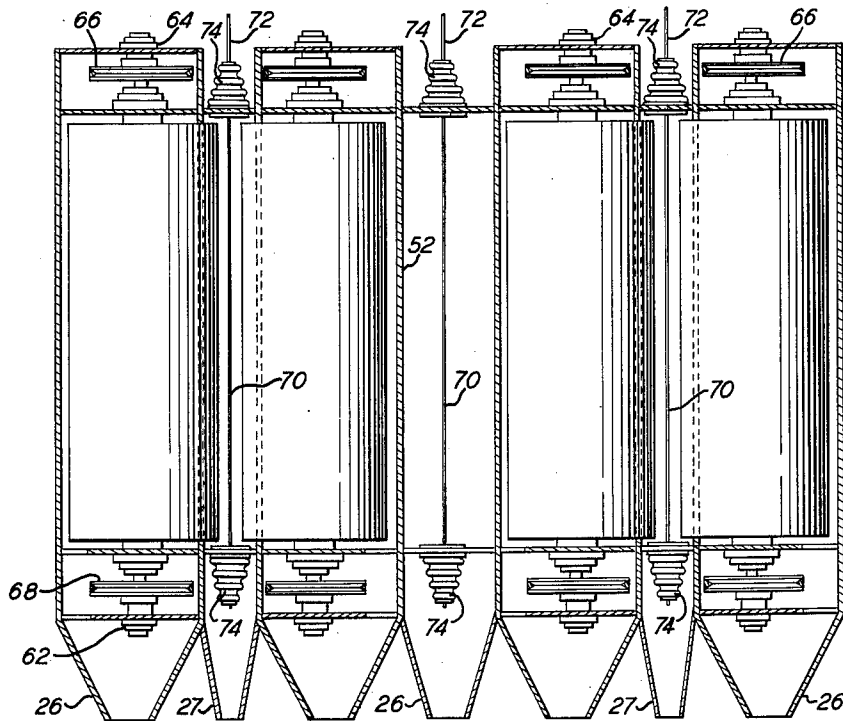
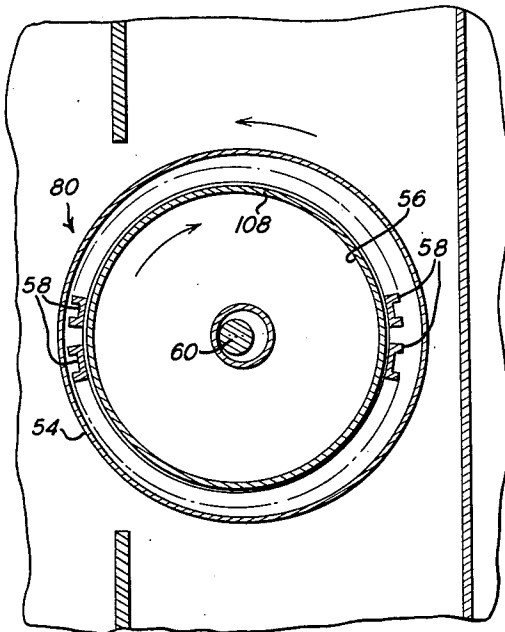


FIG. 4.

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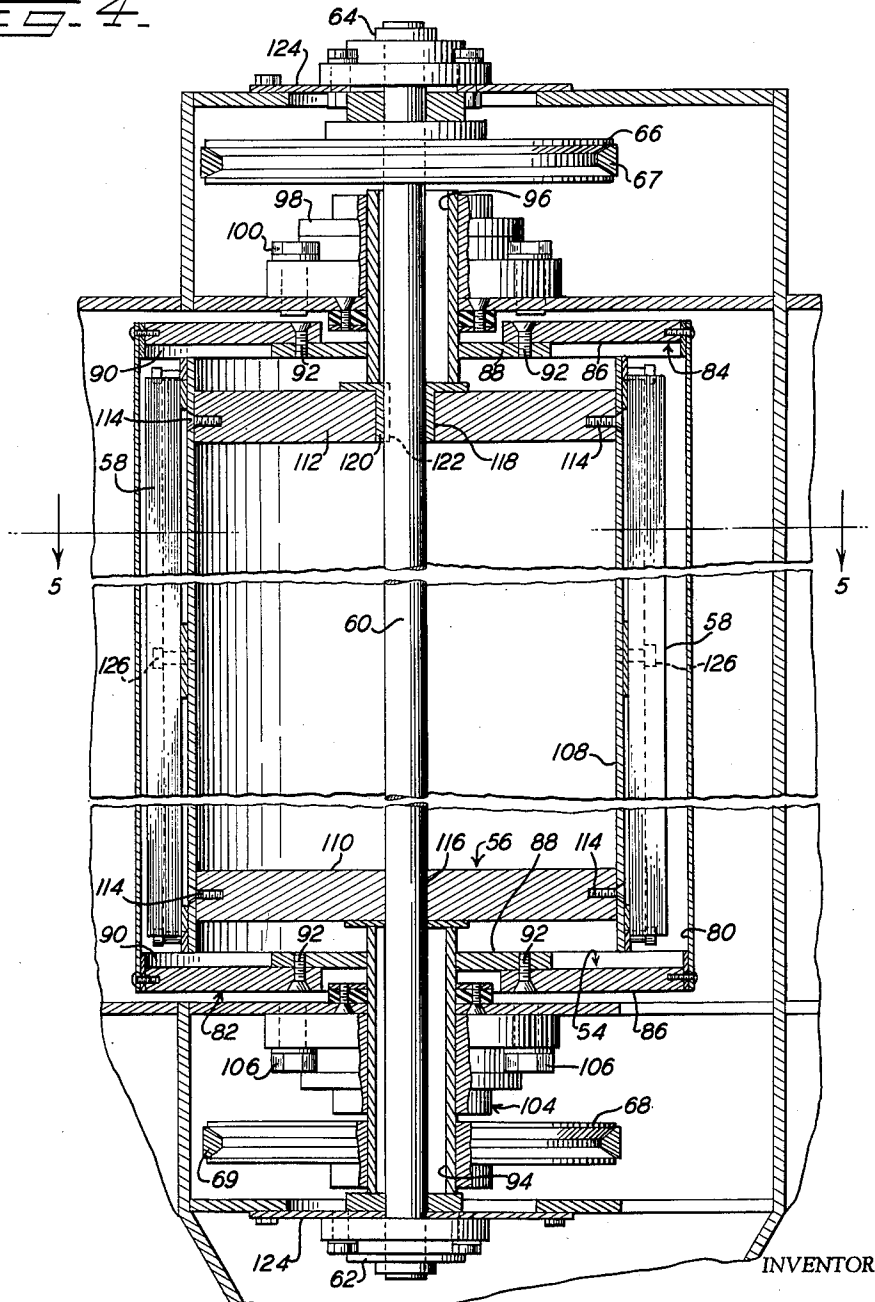
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ELECTROSTATIC MAGNETIC COLLECTING SYSTEM

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FIG. 4.



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ELECTROSTATIC MAGNETIC COLLECTING SYSTEM

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3 Claims. (Cl. 55—100)

This invention relates to electrical precipitation apparatus and, more particularly, to apparatus for combining magnetic and electrostatic fields for collection of gas-borne particulate materials.

In the beneficiation of the magnetic type iron ores such as the magnetic taconites, it is necessary to separate the magnetic portion of the ore from the gangue or tailings. In general, this is accomplished by pulverizing the ore and subjecting the pulverized mixture of magnetic material and gangue to a source of magnetism whereby the magnetic portion may be removed or separated from the gangue. Through the use of magnetic concentration of the ores, an ore containing from about 15 to 20 percent iron may be beneficiated to the extent that the treated material will contain as much as 65 percent iron.

Before the ore can be subjected to magnetic separation, it must be pulverized to a relatively small size by means of mills or grinders. In the case of dry mills where the ore is comminuted in a dry form, the mills are vented to magnetic separators within which the magnetic portion is removed from the tailings.

It is a primary object of the present invention to produce apparatus for combining magnetic and electrostatic fields for the separate collection of magnetic and non-magnetic materials whereby the beneficiation of iron ores of the magnetic type may be efficiently and economically carried out.

Another object of the present invention is to produce apparatus of relatively simple construction which will readily separate and individually collect materials of the magnetic and non-magnetic type.

A further object of the present invention is to produce a new and improved electrostatic precipitator apparatus including rotatable permanent magnetic structures associated with the collector.

These and other objects and advantages are provided by the electrical precipitation apparatus which generally includes a shell or housing, a gas inlet and a gas outlet in the housing, a plurality of concentrate ducts forming a plurality of gas passages within the housing, a plurality of discharge electrodes positioned along the gas passages, and a plurality of magnetic drums rotatably disposed within the ducts, a portion of the surfaces of the drums adapted to revolve through associated ones of the gas passages.

The principles of the present invention and other objects and advantages thereof will become more apparent from the following detailed description of the apparatus which will be more completely described with reference to the accompanying drawing in which:

FIG. 1 is a flow diagram of a system incorporating the present invention;

FIG. 2 is a sectional view of the electrostatic magnetic concentrator taken along line 2—2 of FIG. 1;

FIG. 3 is a vertical section of the concentrator shown in FIG. 2 taken along line 3—3;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3 showing the eccentric drums; and

FIG. 5 is a sectional view of eccentric drums taken along line 5—5 of FIG. 4.

Referring to FIG. 1, there is shown a flow sheet of a system embodying the present invention wherein 10 is a grinding device which may be of the ball, rod, tube or autogenous type. Very satisfactory grinding of the raw material fed into the grinding device 10 has been accom-

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plished through the use of conventional air sweep type mills. The ore to be concentrated is fed into the grinding mill 10 through an inlet conduit 12. Air entering the mill 10 through the inlet 12 picks up the material in the mill which has been reduced in size by the grinding operation and transports it therefrom through a conduit 14. It will be appreciated that the size and concentration of the material carried in suspension in the air stream in conduit 14 depends to a large extent on the flow rate of the air through the mill.

The air stream carrying the suspended particles is thence directed into a conventional classifier 16 wherein the particles suspended in the carrier air stream are separated into at least two fractions. One of the fractions comprises a substantial portion of fine particulate material and the other comprises primarily the coarser material.

From the classifier 16, the coarse materials or tailings are directed back into the inlet conduit 12 through a conduit 18. The fine particulate materials or that of the desired size is directed through a conduit 20 to a gas inlet 22 of an electrostatic-magnetic separator, generally indicated at 24, and described in greater detail hereinafter with reference to FIGS. 2—5.

The particulate materials entrained in the air stream passing into the separator 24 are separated into at least two fractions, one fraction consisting of magnetic materials and the other fraction consisting primarily of non-magnetic materials. The magnetic materials are caused to be collected by and discharged through the outlet 26. The non-magnetic materials are caused to be carried by the air stream through gas outlet 28 of the separator 24, through a conduit 30 to a collector 32, which may be either a mechanical collector or an electrostatic precipitator. The non-magnetic materials are collected or precipitated out of the air stream within the collector 32 and may be suitably discharged through the outlets 34 formed in the bottom region of the collector 32.

It must be understood that under certain conditions a portion of the non-magnetic material may be precipitated out of the transient gas within the separator 24. In these instances, the separator 24 is provided with separate outlets 27 for the discharge of the non-magnetic materials.

The air flow or stream within the apparatus thus far described is effectively maintained by a fan 36 which is connected to the air outlet side of the collector 32 through a conduit 38.

An illustrative embodiment of the electrostatic-magnetic separator 24 is illustrated in FIGS. 2 through 5. It will be noted that the separator 24 comprises an outer housing or shell 50 having an inlet 22 and an outlet 28. A series of concentrate ducts 52 is positioned within the housing 50 and extends in the direction of the gas flow generally from the gas inlet to the gas outlet and the assemblage of ducts define a series of gas passages. These ducts effectively divide the gas entering through the inlet 22 into a series of parallel paths as indicated by the arrows in FIG. 2.

A plurality of drums 54 are mounted for rotation within the ducts 52, and are adapted to rotate in the direction indicated by the arrows about axes which are substantially normal to the flow of gas. A portion of the drums 54 project through openings formed in their associated ducts 52 and thereby may revolve through the associated gas passage. It has been found to be preferable to dispose the drums 54 in counterrotating pairs, one on each side of a gas passage as is shown in FIG. 2. The positioning of these drums will be more fully described hereinafter. Associated with each of the drums 54, there is an eccentrically mounted inner drum 56, as illustrated in detail in FIGS. 4 and 5, which is adapted to carry a plurality of permanent magnets 58 on its outer cylindrical

surface. The assembly of the outer drum 54 and the inner drum 56 is mounted for rotation about a shaft 60 which is journaled at one end within a thrust bearing 62 and at the other end within an alignment bearing 64.

A sheave 66 is provided to drive the outer drum 54 and another similar sheave 68 is provided to drive the inner drum 56. Associated with each pair of drums 54, there is a discharge electrode 70 disposed in a downstream relation with respect to the gas flow. The discharge electrode 70 is connected to a source of high electrical potential through a conductor 72. The discharge electrodes 70 are electrically insulated from the separator housing 60 by a pair of insulators 74, as shown in FIG. 3.

The eccentric counter-rotating drums 54 and 56 and their associated components and structures will be more particularly described with reference to FIGS. 4 and 5 of the accompanying drawings. The outer drum 54 comprises a cylindrical shell 80 preferably constructed of stainless steel which has a low electrical conductive property. The stainless steel shell 80 is secured about the marginal edges thereof to drum heads generally designated 82 and 84. Each of the drum heads 82 and 84 includes an annular member 86 which may be constructed of stainless steel and a second annular member 88 which is preferably constructed of aluminum. To further reduce the flow of eddy currents established by the magnets on the inner rotating drum of the separator, a thin band 90 of non-electrical conductive plastic material is interspaced between the shell 80 and its supporting side flanges 82 and 84. The annular aluminum members 88 are secured by bolts 92 to the inner marginal portions of the outer annular members 86 and they are also secured to sleeves 94 and 96 at the respective ends of the drums. The sleeves are mounted concentric with the outer cylindrical shell 80. Sleeve 96 is rotatably mounted in a bearing block 98 secured by bolts 100 to a shell or housing 52 having dimensions slightly greater than the diameter of the outer cylindrical drum 54.

The sleeve 94 is rotatably mounted in bearing block 104 which is similarly secured by bolts 106 to the other side of the housing 52. The sleeve 94 extends axially outwardly of the bearing block 104 and has secured to said outer end a pulley 68 about which is trained a driving belt 69, whereby movement of the belt causes the pulley 68 to rotate bringing about the rotation of the sleeve 94 and the entire drum assembly 54.

Eccentrically mounted within the outer drum 54 is inner drum 56. The inner drum generally comprises a stainless steel cylindrical shell 108 which is secured adjacent the marginal edges thereof to drum heads 110 and 112 by bolts 114. Preferably the drum heads 110 and 112 are constructed of, for example, aluminum or other non-magnetic material.

Each of the drum heads 110 and 112 is axially bored as at 116 and 118. The bore 118 is slightly larger than bore 116 and is adapted to receive a flanged sleeve 120 which abuts in bearing relationship the sleeve 96 while the inner portion of the sleeve 120 is keyed as at 122 to the shaft 60 which extends through the sleeve 120 and the bore 116 in drum head 110 to project outwardly from each end of the barrel through sleeves 94 and 96. The extended ends of shaft 60 are rotatably supported in bearing blocks 62 and 64 secured by bolts to plates 124.

Between the outer end of sleeve 96 and the inner end of bearing block 64 is provided a pulley 66 which is keyed to the shaft 60. An endless belt 67 is trained about the pulley 66 and about a motor-driven pulley for rotating the inner drum 56 opposite to and at a different speed from the outer drum 54.

Secured to the outer surface 108 of the inner drum 56 are a plurality of permanent magnets generally designated 58. The arrangement and attaching means for the magnets 58 are more clearly shown in FIG. 5.

In the illustrated form of the present invention, each of the permanent magnets 58 comprises an elongate gen-

erally U-shaped magnet having legs which terminate in pole faces. The lower face of each magnet is concave in configuration and conforms to the radius of curvature of the inner drum shell 108.

The magnets are positioned on the outer surface of the inner drum shell 108 in an axial array and the spacing between adjacent magnets, at a radial distance from the drum shell 108 substantially equal to the height of the legs is substantially equal to a spacing between said legs whereby a substantially uniform sinusoidal magnetic field is established adjacent the surface of the outer drum shell 80. Further, the magnets are so arranged that the polarity of adjacent pole faces are opposite.

For convenience in manufacture of the magnets 58, each axial strip comprises a pair of identical magnets joined at the center of the drum by a single attaching bolt 126 shown in dotted lines in FIG. 4.

In the illustrated form of the invention the magnets are shown and described as being of the generally horseshoe type, however, other forms and shapes of permanent magnets may be employed on the outer surface of the inner drum without materially affecting the efficient operation of the separator. For example, the magnets may comprise bars, strips, rods or a plurality of small horseshoe-shaped magnets.

In operation of the apparatus, the motors for driving the plurality of drums 54 and 56 are energized so that they are rotated in the direction of the arrows shown in FIG. 5. The high tension discharge electrodes 70 are energized and a stream of gas carrying finely-ground magnetic susceptible and nonmagnetic materials is passed through the housing of the separator 24 from the inlet 22 through the gas treating zones between the ducts 52. As the gas streams carrying the magnetic and nonmagnetic particles pass through the treating zones, the suspended particulate materials are precipitated out of the gas stream and the particles are collected on either the outer surface of the drums 54 or on the walls of the ducts 52 which function as collecting electrodes. The magnetic susceptible particles are attracted to the outer surface of the drums 54 and are carried by the magnetic field established by the plurality of permanent magnets 58 into the concentrate compartment within the ducts 52. Within the ducts 52, the magnetic susceptible particles will fall from the outer surface of the drums due to the centrifugal force and the fact that the inner drum 56 carrying the permanent magnets 58 is spaced a greater distance from the outer drum 54, thereby reducing the magnetic field acting upon the magnetic susceptible particles. These particles are dropped into and collected by the outlet hoppers 26 disposed at the bottom of the concentrate compartment.

The non-magnetic particles which have been precipitated out of the gas stream are collected and may be satisfactorily discharged through the outlet hoppers 27 shown clearly in FIG. 3.

The non-magnetic portion of the particles which may have reached the surface of the drums 54 by virtue of the electrostatic forces will be thrown off of the drums by the centrifugal force of the rotating drums 54 and the gas flow.

A certain percentage of the non-magnetic particles which may remain in the transient gas stream and pass out of the separator 24 through the outlet 28 into a collector 32 which may be of either the mechanical or the electrostatic type. Manifestly, the need for a separator 32 is determined among other factors by the nature of the material being treated and the velocity of the gas stream.

In an illustrative example of the invention, 150,000 c.f.m. of air suspending about 150 tons per hour of magnetic and non-magnetic particles of size from about 14 mesh to about 400 mesh is passed through the system into the inlet 22 of the separator 24. An electrostatic field is established by connecting the discharge electrodes 70 to

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a source of direct current of about 50,000 volts. The inner drum 56 is rotated at about 250 r.p.m. and the outer drum 54 is rotated at about 250 r.p.m., the magnetic field created by the permanent magnets being about 1000 gauss in the collecting zone and decreasing to about 200 gauss in the discharging zone. Under these conditions, with each pound of suspended material entering the unit containing about 25% magnetic susceptible particles, concentrate containing about 65% magnetic particles is received from the hoppers 26.

From the foregoing description, it will be seen that the present invention has produced a new and useful apparatus for concentrating relatively low-grade magnetic susceptible ores, and while the invention has been described with specific reference to a particular form of apparatus and magnet arrangement, it will be appreciated that various changes may be made therein and the number of magnetic drums and separating stages may be varied and modified in accordance with and depending upon the particular ore being treated.

I claim:

1. A material separating apparatus including a housing having a gas treating zone therein, a gas inlet and a gas outlet for said housing, extended surface collecting electrodes and complementary discharge electrodes disposed within said gas treating zone, said collecting electrodes comprising a non-magnetic extended surface element having one face positioned in parallel spaced relationship to its complementary discharge electrodes and having at least one aperture formed in the surface thereof, a first cylindrical drum rotatably mounted within the aperture formed in said collecting electrode, a second cylindrical drum having a diameter less than the diameter of said first drum rotatably mounted within said first drum, the axis of said second drum being eccentric with the axis of said first drum, a plurality of permanent mag-

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nets secured in axial array to the outer surface of said second drum and extending across the face thereof, means for rotating said first drum about its axis, means for rotating said second drum to provide a differential speed between said first and second drums, means for directing particulate material including magnetic susceptible particles to the gas treating zone wherein at least the magnetic susceptible particles will be attracted to the outer surface of said first drum adjacent the zone of said drum where the attractive force of the magnets is greatest, and means for collecting magnetic susceptible particles adjacent the zone of said drum where the attractive force of the magnetic field is overcome by centrifugal force.

2. The invention defined in claim 1 wherein the gas treating zone is defined by a pair of said collecting electrodes positioned with their said one face in generally parallel spaced relation on opposite sides of their complementary discharge electrodes with the cylindrical drum receiving aperture of each of said pair of collecting electrodes being positioned in generally opposed aligned relationship.

3. The invention defined in claim 2 wherein the drum receiving apertures are positioned at least adjacent the said gas inlet of said housing.

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