No. 668,940. Patented Feb. 26, 1901.

G. H. WARING.

ELECTROMAGNETIC SEPARATOR.

(Application filed Jan. 30, 1900.)

(No Model.)

FIG. 1

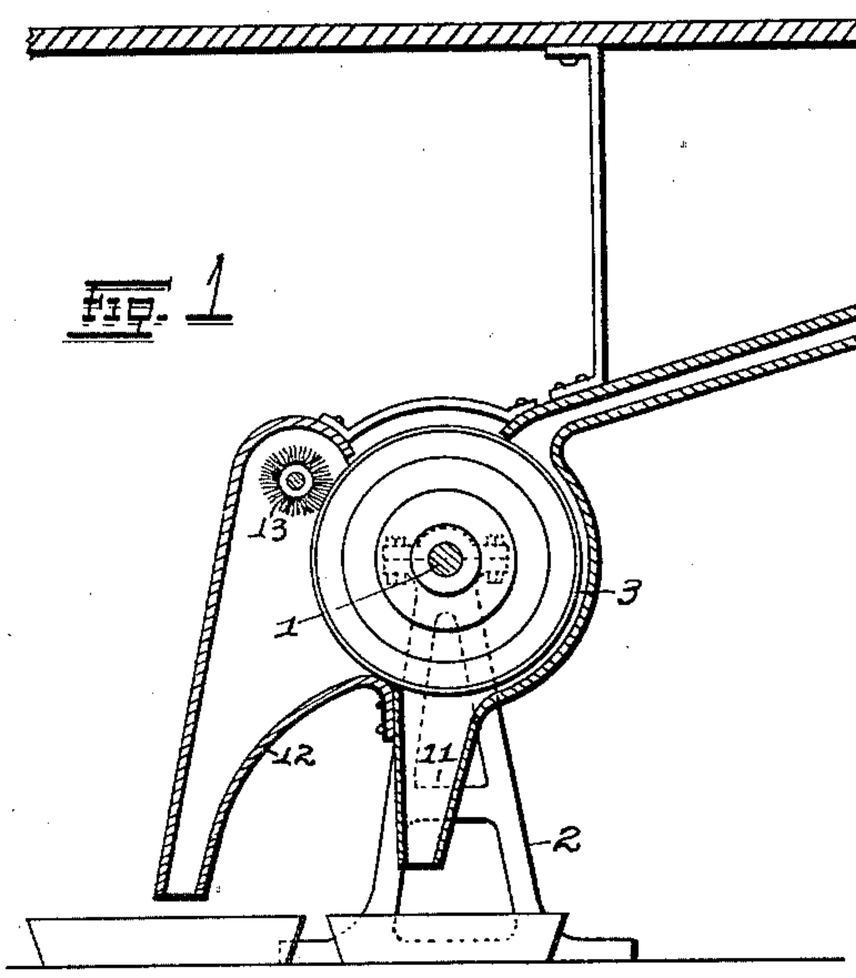


FIG. 4

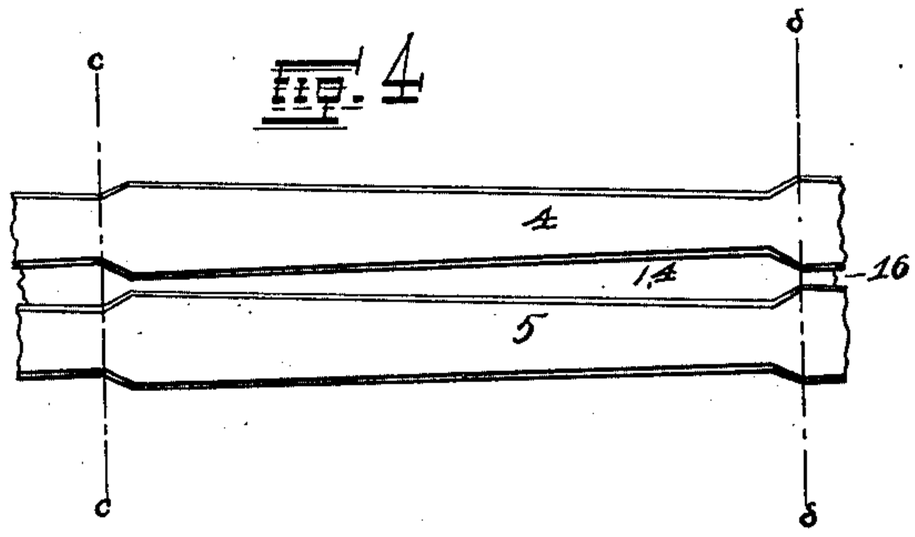


FIG. 2

FIG. 3

FIG. 5

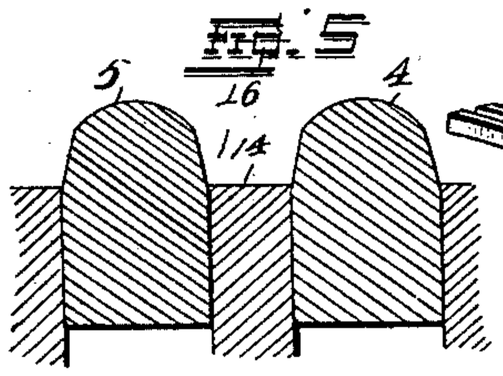


FIG. 7

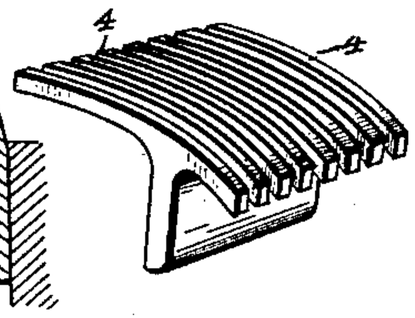
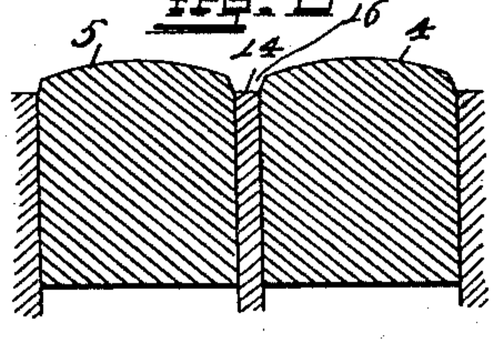


FIG. 6



Witnesses.
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UNITED STATES PATENT OFFICE.

GUY H. WARING, OF TYRONE, PENNSYLVANIA.

ELECTROMAGNETIC SEPARATOR.

SPECIFICATION forming part of Letters Patent No. 668,940, dated February 26, 1901.

Application filed January 30, 1900. Serial No. 3,297. (No model.)

To all whom it may concern:

Be it known that I, GUY H. WARING, of the city of Tyrone, Blair county, State of Pennsylvania, have invented certain new and useful Improvements in Electromagnetic Separators, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming a part hereof.

This invention relates to electromagnetic ore-separators; and it consists of the novel construction, combination, and arrangement of parts hereinafter shown, described, and claimed.

One object of this invention is to construct a magnetic ore-separator comprising a rotating cylinder having zones of equally-intense magnetic attraction so disposed upon its periphery that each particle of ore or other material to be operated upon magnetically shall pass equally with every other particle through one or more of such zones.

Another object is to so arrange the exterior attracting-surfaces of opposite polarity as to provide relatively similar channels or gaps of various widths and depths between such surfaces that particles of paramagnetic material of different sizes and shape may move and assort themselves from the diamagnetic particles and freely assort themselves in the lines of magnetic flow according to the direction of their longer diameters and the intensity of the force of attraction and at the same time have one or both extremities in direct contact with metallic magnetic surfaces. In the latter case the surfaces would be of opposite polarity, thereby permitting them to be attracted and held tenaciously in place until carried away from the material from which they are to be separated.

Figure 1 is a view showing the appearance of my improved ore-separator when in a position for use, a part of the appurtenances thereof being shown in section. Fig. 2 is a sectional elevation taken approximately on the line *a a* of Fig. 3. Fig. 3 is a detail side elevation of my improved ore-separator, showing in section the arrangement and disposition of the annular polar surfaces of alternate polarity over the periphery of the rotary cylinder or armature-drum, the said annular polar surfaces being separated by segments of electrically-non-conductive material—such as indurated fiber, hard rubber, wood, &c. Fig. 4 is an enlarged plan view of a part of a section of two annular polar surfaces, showing the separating non-conductive segment. Figs. 5 and 6 are enlarged cross-sectional views of the same, taken approximately on the lines *c c* and *d d*, respectively. Fig. 7 is a perspective of a part of one of the magnets.

Referring by numerals to the accompanying drawings, 1 indicates a suitable shaft to be supported in any desirable manner, as by brackets 2. Rigidly mounted upon the said shaft is a pair of electrically-non-conductive end plates 3, which are made to hold in suitable position the annular polar surfaces 4 5, each alternate polar surface 4 being integral with or attached to the (north) pole 6 of a magnet, while each intervening annular polar surface 5 is integral with or attached to the opposite (south) pole 7. The said annular surfaces are energized by an electric current transmitted through coils or helices 8, magnetizing the magnets, of which 6 and 7 denote the north and south poles, respectively, and through them the annular polar surfaces 4 5.

In Fig. 1 is shown a guide or apron 9, which may be used to guide the ore and gangue to be operated upon in a thin stream upon the periphery of the rotating drum.

The commutator 10 is arranged in any suitable position, so as to commute the electric current, allowing the polar surfaces to become magnetized at the time they pass under the stream of material to be electrically operated upon. After the diamagnetic particles have been allowed to pass through a suitable guide 11 of any desired construction and the paramagnetic particles have been carried beyond the said guide the current is cut off by the said commutator and the paramagnetic particles are allowed to fall down a suitable guide 12 and the particles still adhering are removed by means of a brush 13 or any other suitable means.

The annular polar surfaces are separated from each other by sections of electrically-

non-conductive material 14—such as wood indurated fiber, or hard rubber—and are separated annularly from each other by sections 15 of similar material.

The arrangement of the grooves 16 between the annular polar surfaces are each of various widths and depths in order that the material to be separated shall roll down the grooves until each paramagnetic particle may find a position in a magnetic field where it will be held by magnetic attraction until it is released by the cutting off of the current by the commutator 10. The magnets are arranged parallel to the axis of revolution of the drum and at points equidistant from the separating cross-pieces 15. By this arrangement fields of equal magnetic intensity are provided across the face of the drum, through which fields every particle of material to be separated must pass, as is hereinafter shown.

The operation of my improved ore-separator is as follows: The material to be magnetically classified having been previously prepared is fed by any suitable means in a thin stream across the periphery of the drums near the top and on the descending side, the annular polar surfaces being first magnetically excited at the upper point of their revolution. As the material descends over the excited polar surfaces of the slowly-revolving drum the paramagnetic particles are attracted into the grooves between the magnetic poles and are tenaciously held in position by magnetic attraction until after the lower point of revolution is passed and the current is cut off from the magnet, when the said paramagnetic particles are released automatically, or in case they are held by residuary magnetism until they are removed by a brush. On the other hand, the diamagnetic particles being repelled by magnetic repulsion when they reach the horizontal plane of the axis of revolution of the drum are drawn downwardly by gravity, and are thereby separated from the paramagnetic material, so that they can be collected in different receptacles.

In this description and in the drawings referred to the magnets are arranged to be carried by and rotate with the drum. However, stationary magnets may be used, in which case the commutator would not be necessary, but there would be a definite magnetic field in which the polar surfaces would be magnetically excited, and after rotating a certain distance would pass from the field of magnetic excitation and allow the paramagnetic particles to be automatically released or removed by means of the brush, as hereinbefore set forth.

A separator constructed in accordance with the above-stated principles will separate more perfectly than has been done heretofore all minerals or other substances which are at all subject to magnetic influence and those that can be made so by special treatment from those that are diamagnetic—as, for example, to separate iron ores, pyrite, gray copper, and many complex ores of silver, tin, &c., from such gangue and minerals as galena, zinc-blende, calc-spar quartz, clay, and all rock minerals, and all other diamagnetic substances. It avoids the contamination of the separated magnetic material with intermingled or entangled non-magnetic matter, and vice versa. Heretofore this has been an obstacle in the way of magnetic separation of minerals. This trouble is obviated by arrangement of polar surfaces and of zones of equal magnetic force, which permits repeated rearrangement of the material upon the periphery of the rotating drum, thereby facilitating the freeing of the diamagnetic from the paramagnetic matter, that a minimum amount of it will remain entangled with the latter.

I claim—

1. In a device of the class described, a rotating electromagnetic drum having annular polar surfaces of varying widths, and projecting at various distances from the surface of the drum, there being corresponding grooves or gaps of varying widths and depths between the said annular polar surfaces, substantially as specified.

2. The herein-described device comprising a rotary electromagnetic drum, annular polar surfaces of alternate polarity arranged upon said drum, there being gaps or grooves of varying widths and depths for receiving different-sized particles, between the said annular polar surfaces, the said gaps or grooves running in the direction of revolution, substantially as specified.

3. A magnetic ore-separator, comprising a rotary electromagnetic drum, revolving magnets arranged within said drum in such manner that their poles extend across the interior surface of the drum in planes parallel to the axis of revolution, annular polar surfaces carried by the said poles and being disposed over the surface of the drum, there being gaps of varying widths and depths between the said polar surfaces and sections of non-magnetic material arranged between the ends of the annularly-adjacent poles, substantially as specified.

4. In a device of the class described, a rotating armature or drum, electromagnets arranged within said drum, annular polar surfaces of varying widths disposed over the periphery of said drum, sections of non-magnetic material arranged between the annularly-adjacent poles, and means for allowing different-sized particles to arrange themselves within mechanically-graduated spaces on the periphery of the drum, substantially as specified.

5. An electromagnetic armature or drum, electromagnets within said drum, the poles of

said magnets being arranged annularly upon the periphery of the drum, and sections of non-magnetic material arranged longitudinally on the drum between the annularly-adjacent ends of the poles, there being gaps or grooves of varying widths and depths between the said polar surfaces within which particles of different sizes may freely arrange themselves during the operation of the drum, substantially as specified.

In testimony whereof I affix my signature in presence of two witnesses.

GUY H. WARING.

Witnesses:
A. M. MOORE,
M. A. HELM.