No. 668,941. Patented Feb. 26, 1901.

G. H. WARING.

METHOD OF MAGNETICALLY SEPARATING ORES.

(Application filed Apr. 21, 1900.)

(No Model.)

Fig. 1.

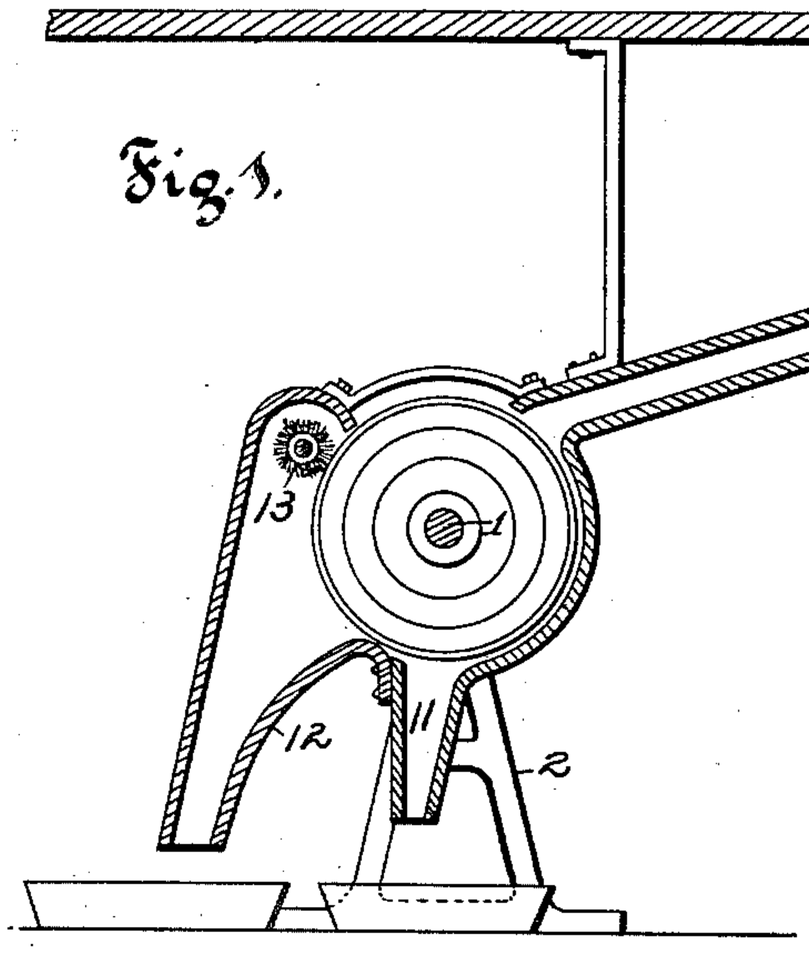


Fig. 4.

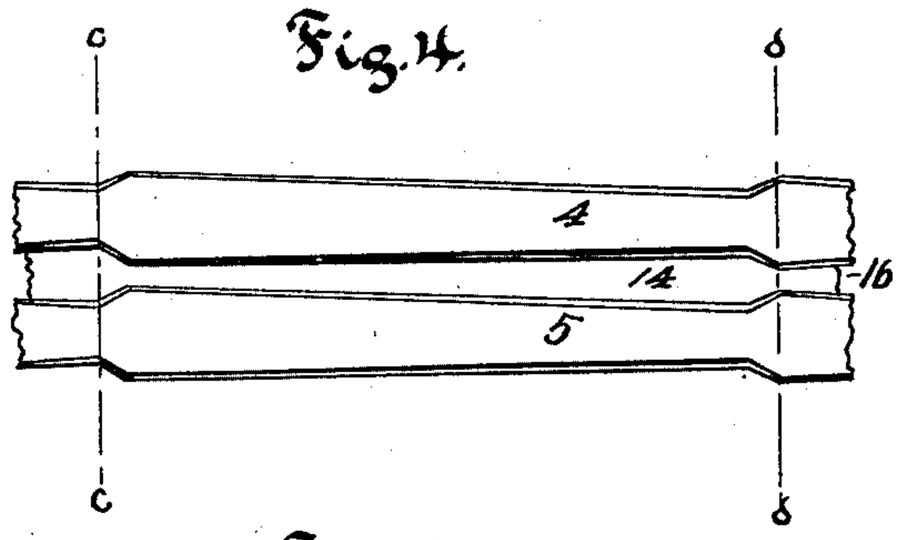


Fig. 2

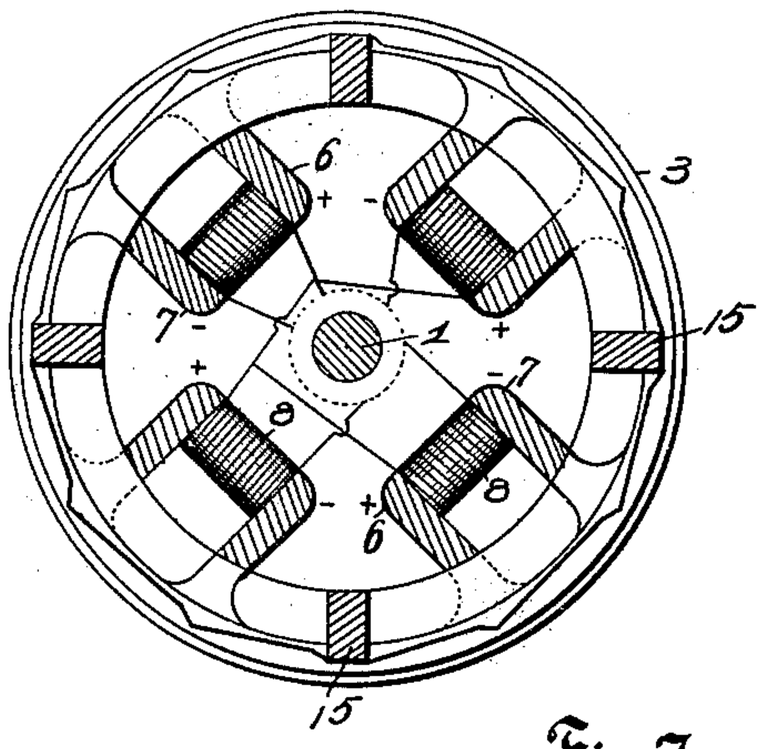


Fig. 3

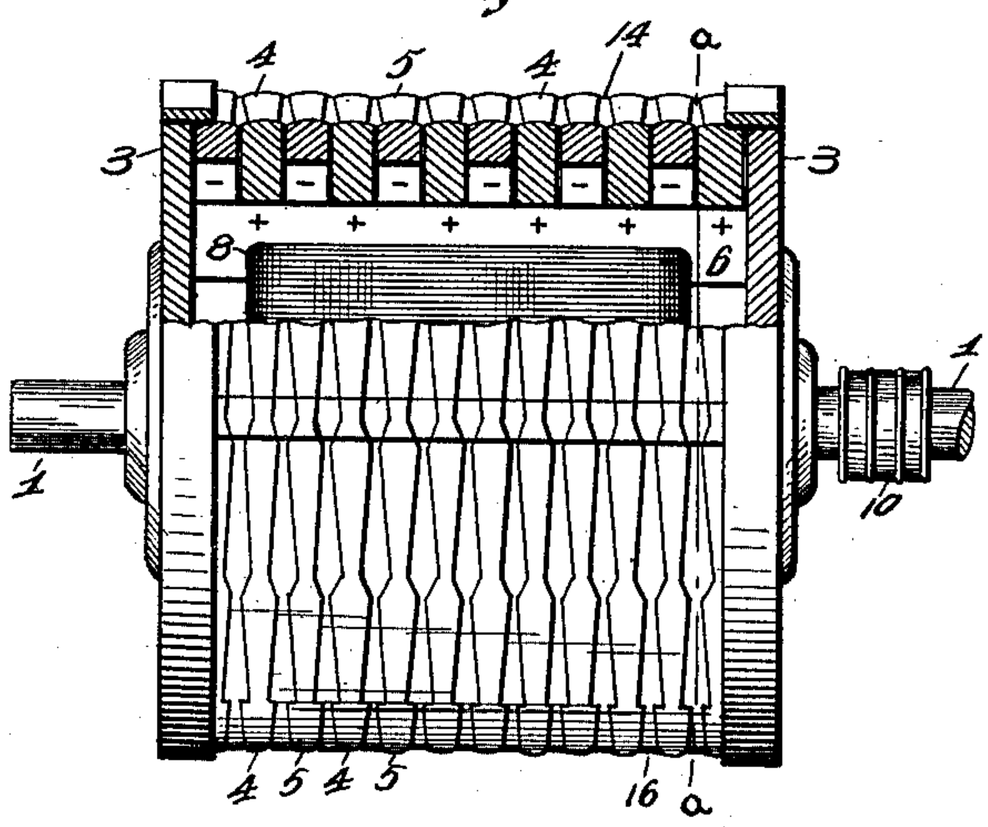


Fig. 7

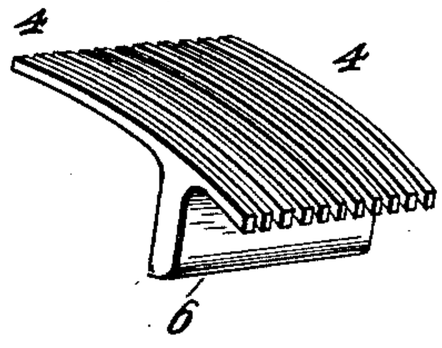


Fig. 5.

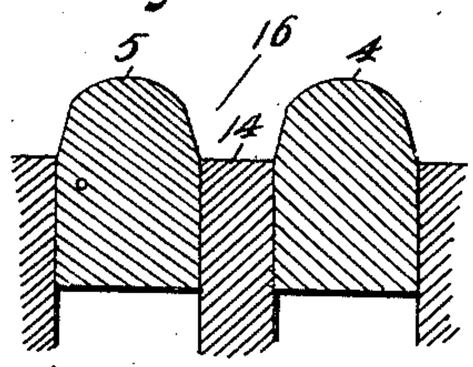
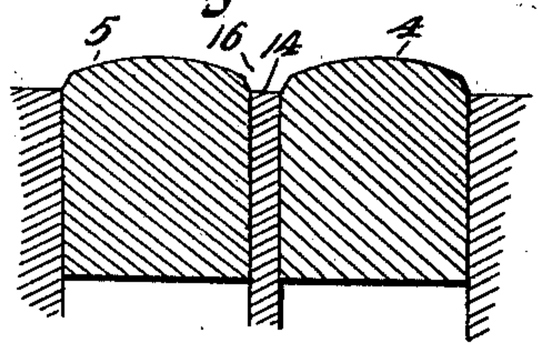


Fig. 6.



Witnesses
Alfred A. Eicker
J. H. Rippey.

Inventor
Guy H. Waring.
By Higdon & Longan, Attys.

UNITED STATES PATENT OFFICE.

GUY H. WARING, OF TYRONE, PENNSYLVANIA.

METHOD OF MAGNETICALLY SEPARATING ORES.

SPECIFICATION forming part of Letters Patent No. 668,941, dated February 26, 1901.

Application filed April 21, 1900. Serial No. 13,826. (No specimens.)

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 Methods of Magnetically Separating Ores, 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 the method of magnetically separating ores; and it consists of the novel features hereinafter described and claimed.

The object of this invention is to magnetically separate ore by submitting the material to be classified to zones of equally intense magnetic attraction so disposed upon the periphery of a rotating drum 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 pass the material to be separated through relatively similar channels or gaps of various widths and depths between surfaces of alternate polarity, so that particles of paramagnetic material of different sizes and shapes may move and assort themselves from the diamagnetic particles and freely arrange 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 a separate application for Letters Patent filed January 19, 1900, Serial No. 3,297, I have described and claimed certain improvements in a magnetic ore-separator having means for receiving and retaining paramagnetic particles of various sizes, whereby all the particles are tenaciously held regardless of size, the different particles assorting and arranging themselves within mechanically-graduated spaces, thereby resulting in greater efficiency and less loss than can be attained by passing the particles through uniform spaces in which the particles cannot move and assort themselves according to their longer diameter. The present application has to do with the process of separating different-sized particles by passing them through mechanically-graduated spaces inclosed by surfaces of opposite polarity, and by this process I employ substantially the mechanism described in the application above referred to.

Figure 1 is a view showing an ore-separator which is made use of in separating ores by my improved method, 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 the 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, of Fig. 4. 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 non-magnetic material 14—such as wood, indurated fiber, or hard rubber—and their abutting ends are separated 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 method by which I separate ores by means of this 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 drum 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 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.

The improved method of separating ores 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, so that a minimum amount of it will remain entangled with the latter. This also prevents the interference of the different-sized particles with each other and results in much greater efficiency and less loss than can possibly be accomplished by passing the material through uniform spaces. Repeated rearrangement and adjustment of the particles are permitted, and none of the paramagnetic particles are crowded away and forced out with the diamagnetic material. By practical experience I have found this to be one of the main obstacles heretofore; but by this improved process this difficulty is avoided, and this constitutes one of the main steps of the present method.

I claim—

1. The herein-described method of separating paramagnetic substances of various sizes from all diamagnetic substances, which consists in introducing the mixture into a magnetic field, having mechanically-graduated spaces of equal magnetic potentials, between surfaces of alternate polarity, within which spaces the particles may freely arrange, assort and move themselves in the line of magnetic flow according to the direction of their longer diameter, substantially as specified.

2. The herein-described method of separating magnetic substances of different sizes from all diamagnetic particles, which consists in introducing the mixture into a moving magnetic field, having mechanically-graduated spaces of equal magnetic potentials, between surfaces of alternate polarity, moving the paramagnetic substances along a path divergent from the path of the diamagnetic substances, and collecting the different particles in different receptacles at the ends of their respective paths of movement, substantially as herein specified.

3. The method of separating substances of any degree of magnetic susceptibility from all diamagnetic particles, which consists in introducing the mixture into a magnetic field, accumulating the paramagnetic particles within mechanically-graduated spaces of equal magnetic potentials between surfaces of alternate polarity within which spaces the particles may freely arrange, assort and move

themselves, in the line of magnetic flow, conveying the paramagnetic substances along a path divergent from the path of the diamagnetic particles, and collecting the particles in different receptacles at the ends of their respective paths of movement, 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.