No. 731,042. PATENTED JUNE 16, 1903.

E. GATES.

DIAMAGNETIC SEPARATION.

APPLICATION FILED MAR. 19, 1900. RENEWED JAN. 13, 1903.

NO MODEL. 3 SHEETS—SHEET 1.

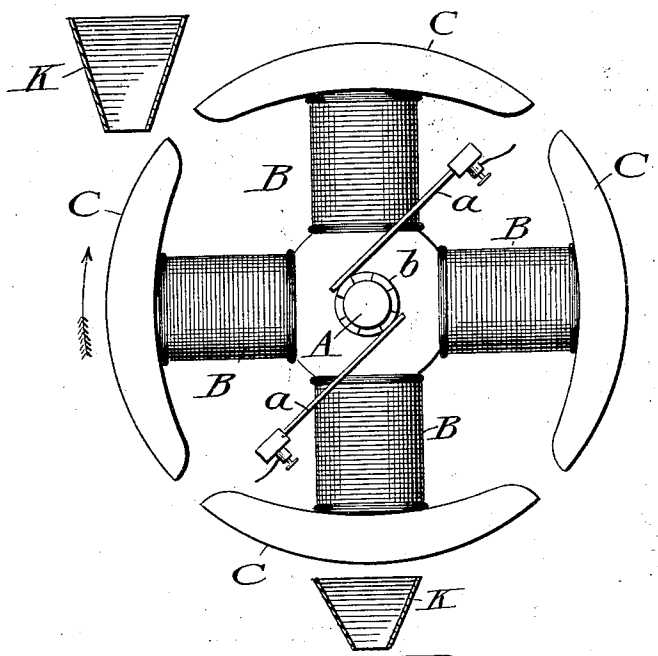

Fig. 1.

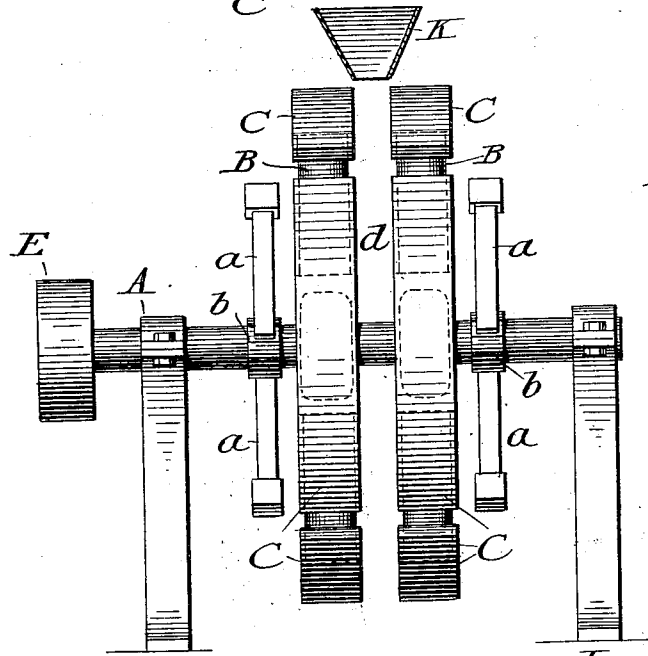

Fig. 2.

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NO MODEL. 3 SHEETS—SHEET 2.

Fig. 3.

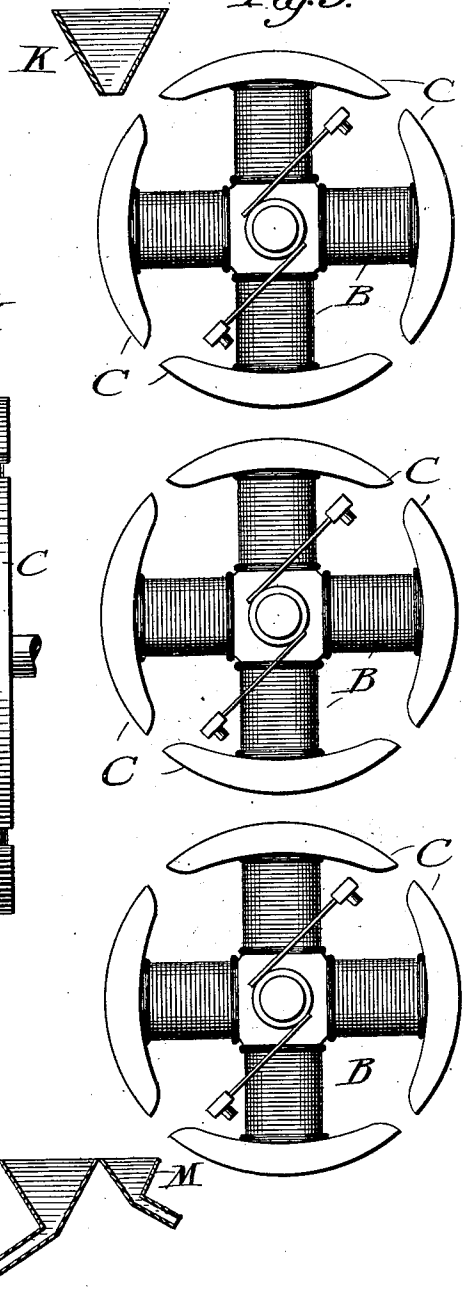


Fig. 4.

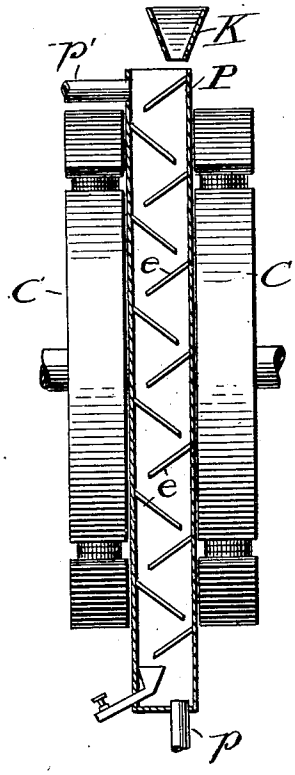
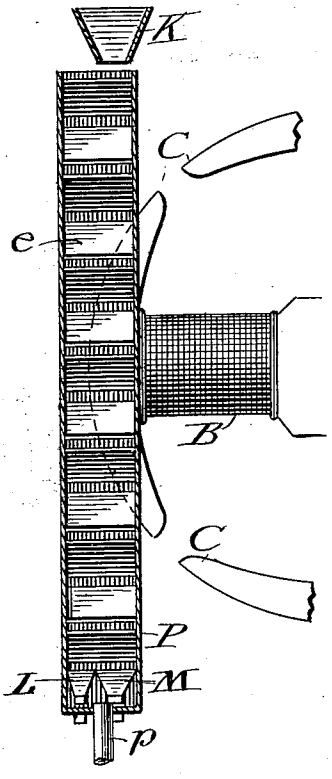


Fig. 5.



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NO MODEL. 3 SHEETS—SHEET 3.

Fig. 6.

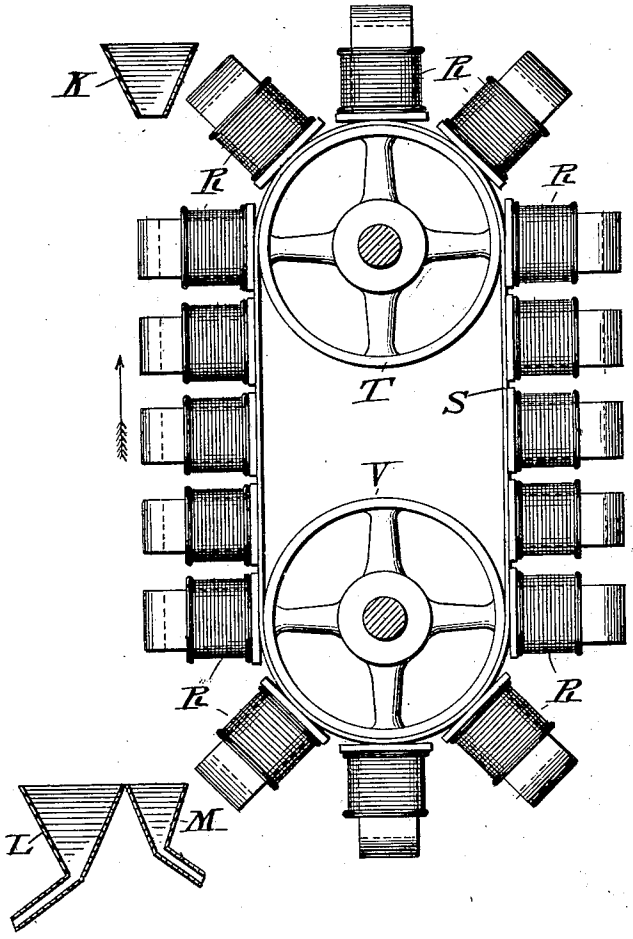
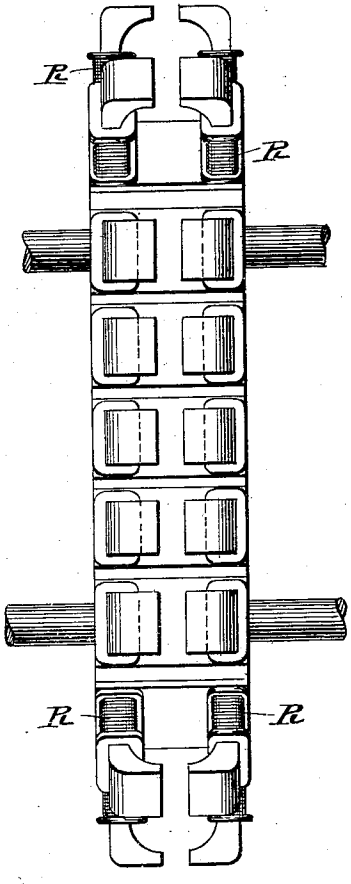


Fig. 7.



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No. 731,042. Patented June 16, 1903.

UNITED STATES PATENT OFFICE.

ELMER GATES, OF CHEVY CHASE, MARYLAND, ASSIGNOR TO THEODORE J. MAYER, OF WASHINGTON, DISTRICT OF COLUMBIA.

DIAMAGNETIC SEPARATION.

SPECIFICATION forming part of Letters Patent No. 731,042, dated June 16, 1903.

Application filed March 19, 1900. Renewed January 13, 1903. Serial No. 138,824. (No model.)

To all whom it may concern:

Be it known that I, ELMER GATES, a citizen of the United States, residing at Chevy Chase, in the county of Montgomery and State of Maryland, have invented certain new and useful Improvements in Diamagnetic Separation; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

In an application for Letters Patent of the United States filed by me September 26, 1899, Serial No. 731,762, I have described and claimed a method of separating diamagnetic particles from a mixture containing them, or diamagnetic particles of varying diamagnetic susceptibility from each other, by feeding the material into a relatively intense part of a magnetic field and continuing it in the magnetic field until the particles of greater diamagnetic susceptibility shall have moved out from the mass into a relatively weak part of the field, whereupon they are collected separately as heads.

My present invention is designed to supplement the diamagnetic action of the field upon the particles to be separated by rapidly moving the magnetic field in opposition to the falling particles. To this end I mount a series of electromagnets either upon a rotatory shaft or upon a traveling belt and supply them with current by means of contact-strips and brushes connected with any suitable source of electric energy. Such a series I denominate a "magnetic element," and I prefer to arrange a number of these elements one above the other, so that the particles diverted by the magnetic field of the upper element shall be still further diverted by the magnetic fields of the elements below.

In the accompanying drawings, Figure 1 represents an end elevation of a feed-hopper and a rotatory magnetic element of a kind adapted for the practice of my invention. Fig. 2 represents a side elevation thereof and shows a driving-pulley and standards for supporting the drive-shaft. Fig. 3 represents in side elevation the manner in which I contemplate arranging a number of the rotatory magnetic elements one above the other in the practice of my invention. Figs. 4 and 5 represent, respectively, front and side elevations of a modification of the invention. Figs. 6 and 7 represent, respectively, a side elevation and front elevation of a traveling-belt magnetic element.

Similar letters of reference indicate similar parts throughout the several views.

Referring to the drawings, K indicates a feed-hopper for supplying material to the magnetic field, M indicates a hopper for the tailings or material of low diamagnetic susceptibility, and L represents a hopper for receiving the heads or particles of higher diamagnetic susceptibility.

In the rotatory magnetic element of Figs. 1 to 3 the stationary brushes *a* supply an electric current to contact-strips *b*, fixed on the rotatory shaft A. The contact-strips *b* are insulated from each other and are arranged in pairs, each pair corresponding to one of the series of magnets. The members of each pair of contact-strips are located diametrically opposite each other on the shaft and are connected, respectively, to the ends of the coil of the corresponding magnet, so that when the brushes *a* are in contact with the contact-strips of any particular coil the corresponding magnet is energized, whereas at other times said magnet is out of service. I so locate the brushes that the magnets shall successively come into service as they cross the path of the falling particles.

B indicates the magnetic coils, and C indicates the elongated pole-pieces thereof, which, as indicated in Fig. 2, are spaced opposite each other in such manner as to form an interpolar space or series of interpolar spaces *d* of high density, through which the material to be separated is adapted to fall. The direction of rotation of the shaft A, and consequently of the polar pieces *c*, is indicated by the arrow in Fig. 1.

As the material drops from the hopper K it enters the intense magnetic field presented to it by the interval between the adjacent pole-pieces beneath the hopper, whereupon the diamagnetic particles tend to move outwardly into a weak portion of the field. The extent of the consequent deflection is due to the number of lines of force cut by the parti-

cles in a given unit of time, and by rapidly rotating the shaft A by means of the drive-pulley E or otherwise the number of lines of force thus traversed may be very greatly increased. The resultant effect is analogous to passing the same material through a long stationary magnetic field. In Fig. 3 I have shown a number of these magnetic elements located one above the other, which arrangement I prefer in practice, so that the particles deflected by the upper magnetic element shall be further deflected by the one next lower and still further deflected by the lowermost of the three or by any additional number that may be employed. I may conveniently and to advantage locate the second element slightly in advance of the position shown, and likewise the third remaining element still further in advance, so that they shall follow more closely the trajectory of the deflected particles, and thus cause them to separate still further from the main mass of inert material with which they are associated in the mixture.

In the form of apparatus shown in Figs. 6 and 7 a series of magnets R is mounted upon a traveling belt S, which passes over the pulley-wheels T V, one of which is a drive-pulley adapted to impart a rapid rate of travel to the belt and its magnets in direction opposed to the fall of the material through the magnetic fields. The current is supplied to the ascending magnet-coils by brushes and contact.

In some instances, as illustrated in Figs. 4 and 5, I may pass a current of liquid through the magnetic field in a direction opposed to the fall of the material. To this end I may conveniently insert within the field a box P having thin sides, and which serves as a conduit for an upward flow of water entering at *p* and having its constant overflow at *r*. The strength of the water-current may be so graduated as to bring the sand and floculent gold almost to a standstill and even hold it in suspension until said floculent gold has moved outwardly as desired, whereupon by decreasing the strength of flow the separated material will drop into their respective hoppers. Other portions of the gold, though not sustained by the upward flow, will drop through the field at a lessened speed than if such flow were absent and will be subjected for a correspondingly-longer period to the diamagnetic action. Instead of or in addition to the water-current I may employ as the retarding agent a series of inclines *e*, thereby compelling the material to travel for a longer distance through the magnetic field and causing it to turn over as it drops from one incline to the next of the series, thereby further facilitating the disengagement and free movement of the gold particles.

Having thus described my invention, what I claim is—

1. The method of separating diamagnetic substances from a mixture containing them, which consists in feeding the mixture into a relatively intense part of a magnetic field, rapidly moving said field in a direction opposed to the feeding of the material so as to increase the number of lines of force traversed thereby, and continuing the material in the magnetic field until the diamagnetic particles to be separated shall have moved outwardly so as to be separately collected as heads; substantially as described.

2. The method of separating diamagnetic substances from a mixture containing them, which consists in feeding the mixture into a relatively intense part of a magnetic field, rapidly moving said field in a direction opposed to the feeding of the material so as to increase the number of lines of force traversed thereby, and establishing a current of liquid flowing in a direction opposed to the feeding material so as to correspondingly detain the material during its movement through the field; substantially as described.

3. The method of separating diamagnetic substances from a mixture containing them, which consists in feeding the mixture into a relatively intense part of a magnetic field, rapidly moving said field in a direction opposed to the feeding of the material so as to increase the number of lines of force traversed thereby, and obstructing the descent of the material, so as to detain it correspondingly during its movement through the field; substantially as described.

4. The method of separating diamagnetic substances from a mixture containing them, which consists in feeding the mixture into a relatively intense part of a magnetic field, rapidly moving said field in a direction opposed to the feeding of the material, so as to increase the number of lines of force traversed thereby, and means for establishing a counter-current of fluid in the direction of the moving field for the purpose of retarding the movement of the material.

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

ELMER GATES.

Witnesses:
JOHN C. PENNIE,
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