D. W. TROY.

METHOD AND APPARATUS FOR SEPARATING MATERIALS.

APPLICATION FILED APR. 24, 1911.

1,024,109.

Patented Apr. 23, 1912.

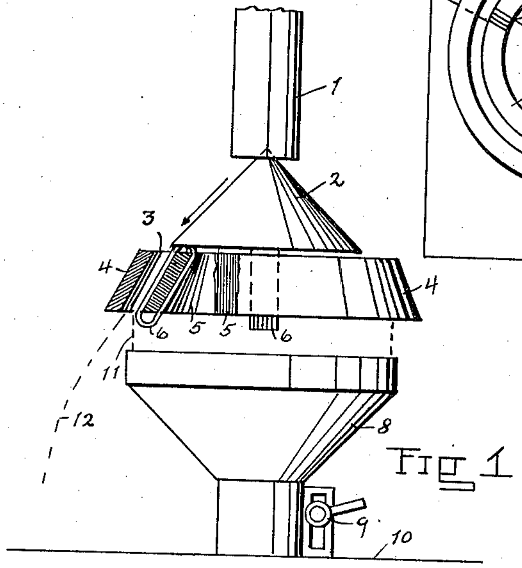

Fig 1

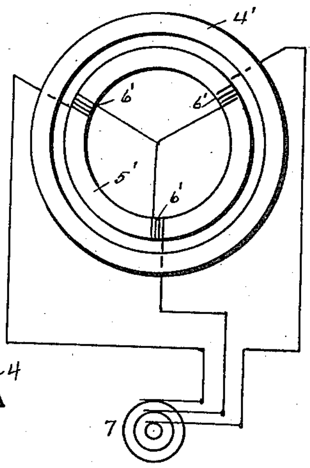

Fig 2

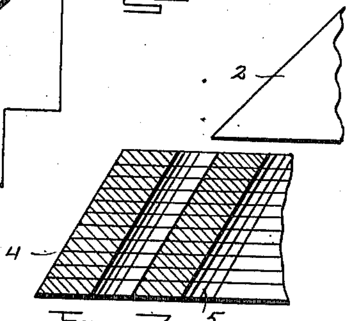

Fig 3

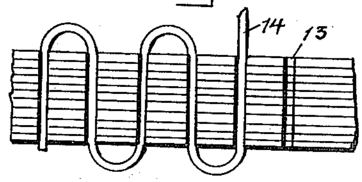

Fig 4

Witnesses

Thomas J. Scott

Daisy Jones

Inventor

Daniel W. Troy

COLUMBIA PLANOGRAPH CO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

DANIEL W. TROY, OF MONTGOMERY, ALABAMA.

METHOD AND APPARATUS FOR SEPARATING MATERIALS.

1,024,109. Specification of Letters Patent. **Patented Apr. 23, 1912.**

Application filed April 24, 1911. Serial No. 622,932.

To all whom it may concern:

Be it known that I, Daniel W. Troy, a citizen of the United States, and a resident of the city and county of Montgomery, State of Alabama, have invented certain new and useful Improvements in Methods and Apparatus for Separating Materials, of which this is a specification, reference being had to the accompanying drawing, forming part hereof.

The invention relates to the separation of materials with respect to their electrical conductivity and its object is to provide new and useful methods and means for employing this characteristic of materials to efficiently and economically disassociate the elements of mechanical mixtures, such as of ore and matrix, etc., as will be more fully pointed out hereinafter.

In the drawing, which is a diagrammatic illustration of the apparatus employed, except such types of crushers as may be used to grind the material to the required fineness and which form no part of the apparatus of the invention, Figure 1 shows a side elevation and partly sectional view of the separator; Fig. 2 is a diagram illustrating the electromagnetic elements; Fig. 3 is a sectional view (on a larger scale) of the magnet cores; and Fig. 4 shows a possible modification of core and core-winding.

The method consists broadly in causing mixed materials such as graphite and silica, in a more or less finely divided or granular condition, to be subjected to the action of a magnetic flux moving relative to the particles of material at what is in fact an enormous rate of speed. An essential of the invention is that the speed of the flux relative to the particles be as high as possible (or rather near the limitations which the hysteretic constants of the iron employed will permit). This will be readily understood from the description to follow. Assuming the mixed particles, say silica and graphite, to be freely falling through space, if they are engaged, for want of a better term, by this swiftly moving flux, Foucault or eddy currents will be set up in the graphite particles to an extent much greater than in the less conducting particles of silica. A moment's reflection, however, will satisfy an electrical engineer that the speed of relative motion of the flux, at least with such flux densities as known magnetic circuits permit, must be extremely high. The reason being that to induce one volt E. M. F. in the circuit formed by the peripheral portion of any particle 100,000,000 lines of force must be introduced (or removed) per second. With particles of substantial size, such as base-balls of copper and base-balls of mica, the area of cross section of which would include several square inches, a moderate speed could be employed to effect a substantial differentiation, but where the particles have a diameter something like a fraction of a millimeter or even smaller, it is at once obvious that the flux must move with a tremendous velocity to effect substantial E. M. F. tending to develop an eddy current in the particle.

In the drawing, Fig. 1 shows a combination of apparatus for effecting the separation in a practical manner.

1 is a pipe or discharge member for feeding the mixed granular material to the apex of a cone or spreader 2. The cone shape is a convenient and preferred form. At the base of the cone the particles, separated by the descent into a thin conical layer, drop in a more or less parabolic curve through an annular opening, also inclined more or less parallel with the slant of the cone, whence they are free to fall either in or out of a receiving bin 8. The annular opening 3 is the space between two concentric rings of iron or other magnetic material, see 4 and 5, of the figure, one of which forms the magnet and the other the armature of the electromagnetic system. Windings are represented by 6, 6, Fig. 1. Both rings are shown partly broken away and in section so as to clearly indicate their relative positions and the annular opening through which the mixed particles fall after leaving the spreading cone 2. In the diagram, Fig. 2 the outer ring is indicated at 4′, the inner at 5′ (the rings in this case being shown without slant and merely to illustrate the electromagnetic details).

6′, 6′, 6′, are three windings star-connected to a three-phase alternating circuit, as from the three-phase alternator 7. I do not confine myself to the use of two, three, or any polyphase current; the function of the out-of-phase windings is merely to produce a rotating field, which in the structure illustrated will set up two opposite fluxes between the inner and outer rings, opposite, however, only in position, as they will, of course, simply be the two air-gap portions of the same flux. By employing alternating currents of great frequency it is quite possible, especially with the dimensions of rings which will be adopted in practice, to produce a velocity of rotation of these two air-gap fluxes which, compared with mere mechanical rotational speeds may be aptly termed enormous. Taking the circumference, mean, as 30 feet, and the current as one of say 500 cycles, (although very much greater rate of alternation may be employed—existing dynamos being perfectly adaptable for this purpose) it is evident that the "flux-brushes," as we may term the two air gap portions of the flux, will rotate at a speed of 15,000 feet per second, and, as there are two of these air-gap fluxes, it follows that if a particle takes half a second to drop through the space between the rings it will be struck by a flux-brush many times before it can drop through. The limitation on the speed of travel of the flux-brushes is obviously to be determined by the hysteretic constants of the iron employed as there is no trouble in obtaining enormous speeds of alternation (see the special generators employed in wireless work.) Assuming the eddy currents thus generated in the particles it is at once evident that those particles having the greatest eddy currents will be dragged tangentially by the rotating flux and will take, in addition to their rate and direction due to gravity and the slant of the cone, an additional rate and direction due to this tangential drag, the effect being to cause these particles to fall beyond those not so dragged; in other words the particles acted upon will leave the cone (or rather the prolongation of the cone through the annular space 3) in much the same manner as if, while they had been falling or sliding down the cone, the cone had been whirling on its axis of figure. The non-conducting particles, however, not having the Foucault or eddy currents generated in them to any great extent, will not be acted on or dragged by the flux and will fall substantially as if there was no flux present.

At 11 and 12 I have attempted to illustrate the paths of the non-conducting and conducting particles respectively. At 8 is shown a receiver or bin adapted to catch the tailings, the concentrates being received on the floor 10 (which may be that of a suitable bin or other receiver). As the path of the tailings is apt to vary with different conditions of atmospheric moisture, moisture of the mixture, and other elements, I preferably provide means for varying the height of the mouth of the bin 8 (see the slotted member and clamping nut 9). Obviously a mere up and down adjustment of the bin 8 will suffice to cause it to form the base of the paraboloid of revolution or whatever the figure may be the surface of which is represented by the falling tailings.

It will be usually necessary to laminate the rings more or less in planes normal to the axis of rotation. Such a structure, while obvious to an electrical engineer, is shown at Fig. 3, the rings 4 and 5 being shown partly, in a sectional view, beneath the edge of the cone 2. Obviously a multipolar rotating field such as that in use in multipolar rotating field motors may be employed with certain advantages. Such a structure is indicated at Fig. 4, the laminated ring (only part of which is shown) being cut with winding slots as at 13, through which suitable windings (one shown at 14) may be threaded. It is needless to point out to those skilled in the art of constructing alternating current induction motors the manners in which a rotating magnetic field may be produced without the rotation of any mechanical parts. This separator is, in fact, what may be termed a squirrel-cage motor, the conducting particles forming the conductors in which currents are first induced and by which the conductors are dragged by the field. In principle it is precisely a squirrel cage or induction motor, but, as pointed out before, owing to the minute size of the conducting members the speed of rotation of the flux must be tremendous compared with any possible rates of mere mechanical rotation. This high rate of relative speed between conducting particles and flux has besides the essential characteristic noted an additional advantage, that is to say, the high speed of rotation directly increases the tangential drag on the conducting particles carrying eddy currents and by the very fact of the high speed of flux rotation a particle carrying, as all will, a minute current, will be dragged tangentially with a considerable force—the condition of successful operation with the particles which will be employed.

Little more need be said about the method as it is fully evident from the foregoing. In treating ores having greater conductivity than the matrix the ore and matrix is first crushed or ground, the machinery employed being that most convenient. The degree of fineness of the mixture will be determined by conditions of the particular ore—in general it must be sufficient to insure mechanical separation of grains of ore from grains of matrix or rock—in other words the system is unreliable where ore and rock are agglutinated or form a single compound grain or particle. The pulverized or granular mixture is fed by gravity or otherwise through the air gap and while passing through is operated upon by the swiftly moving flux. In operating upon gold bearing sands to extract the gold from the sands, or in other cases where the material is naturally in a granular or pulverent condition, the first step—the grinding—is of course needless. In other cases it forms an essential of the method.

As an alternative of the precise steps indicated the concentrates may be made to lag and the tailings be allowed to take the direction which gravity and the slant of the spreader may give them if the rings be formed as shown in Fig. 4 and wound with a single winding or its equivalents and the current simply alternated so as to reverse the flux directions through the falling particles without a movement of rotation of any sort. In this case it will generally be found necessary to alternate the flux at a high rate of speed and to increase the distance which the particles must fall through the rapidly reversing flux.

From the foregoing it will be seen that the essential element of this invention is the use of a flux speed of sufficient rate to produce not only an effective induction of eddy currents in the relatively minute particles which will be met with in practice but which will produce an appreciable drag upon these particles after such currents are induced; both of these factors making for a complete separation of the ore from the tailings. In the modification last described the essential is still an excessively high rate of reversal of magnetic field, but the function of the field is merely to produce the eddy currents and then by reason of its density to act as a drag or brake to check the downward velocity of the particle.

Having described my invention, what I claim is:

1. In apparatus of the class described, concentric rings of magnetic material forming parts of a magnetic circuit and separated by an inclined air-gap, means for feeding particles of non-magnetic material in a trajectory through said inclined air-gap, and a vertically adjustable receptacle beneath said air-gap adjustably adapted to intersect said trajectory, substantially as set forth.

2. The method described, consisting in feeding a mixture of non-magnetic particles of different electrical conductivities in a plurality of mutually divergent and substantially parabolic trajectories through the locus of a magnetic field, varying said field in said locus and setting up eddy currents in said particles to vary the trajectories of the differently affected particles.

3. The method described, consisting in feeding a mixture of non-magnetic particles of different electrical conductivities in a plurality of stubstantially parabolic trajectories through the locus of a magnetic field, varying said field in said locus and setting up eddy currents in said particles to vary the trajectories of the differently affected particles.

Witness my hand this 18th day of April, 1911.

DANIEL W. TROY.

In the presence of—
Daisy Jones,
Thomas J. Scott.