To all whom it may concern:

Be it known that I, Orrin B. Peck, Jr., of the city of Los Angeles, State of California, have invented certain new and useful Process or Method of and Apparatus for Magnetic Centrifugal Separation, of which the following is a specification.

My invention relates to separation or concentration of mixed solids when in a sufficiently crushed, or finely divided state, the component parts of which are definitely magnetic and non-magnetic substances, or are of substances which are magnetic in different degrees of intensity or strength, through the simultaneous use of opposing energy of centrifugal force, and magnetic force assisted by washing force of liquid while the latter is also forming a mobile medium for the movement of the substance under treatment, and between the separated strata of the respective products.

In the accompanying drawings, Fig. 1 is in part a vertical central section, and partly an outside elevation of my separator.

Fig. 2, is an enlarged fragmentary sectional detail of one side of the lower circumferential part of the separating vessel and also the core member which carries or forms the magnets, with one of such magnets partly in section and two of the same in elevation.

Fig. 3, is an enlarged fragmentary cross section of a part of Fig. 1 on line 3—3 of Fig. 1, looking in the direction of the arrows.

Fig. 4, is a fragmentary section of a part of the wall of the central rotor or magnet carrying member, showing one of such magnets mounted therein, illustrating a form of accretion of magnetic material on the magnet, substantially as it would form under certain undisturbed conditions.

Fig. 5, is similar to Fig. 4, but showing two magnets, and illustrating substantially a form of accretion of separated material collected on them by means of my apparatus under operating conditions.

As means for carrying out my process of separation herein described and claimed, I provide a suitable central rotor or core 2, which is preferably conical in form, of desired suitable size to serve the purposes required. It may be of any structure to form or carry suitable electromagnets and make up in association and operation with other parts of the apparatus.

In the drawings this rotor, or core, is illustrated as hollow, having circumferential walls of thickness to be recessed from its exterior, suitable to receive heads 3, serving as magnets. These heads have core parts 4 extending through the wall of the rotor, to receive windings of wire 5, in forming the magnets. In this structure the walls of the rotor are of non-magnetic material, and the recessing for the heads 3, is best when proportioned to let these heads in the core wall so they will be even with the peripheral surface of such wall, as shown.

One of these magnets in Fig. 2, shows the wire winding around its core in section, and the part 6, on the inner end of the core, serving to assist in retaining the wire in place.

As is illustrated in the drawings, in this construction, there are a multiplicity of magnets, the same being arranged in such relative positions and in such close proximity as will best serve the purposes sought. They may be connected in the manner desired, as hereinafter explained. Their form or structure may be varied so long as they serve the purpose intended, and in the claims I have termed this rotor or member as a magnetic core.

Surrounding the rotor with its magnets, is provided a rotatable conical shaped vessel or shell 7, preferably vertically positioned, and at its lower end it is provided with a head 8, having a hollow trunnion 9, which is both stepped and laterally journaled in a box 10, on a bed plate 11, of the separator.

The upper end of the vessel is provided with a head 12, having an extended hollow trunnion 13, by which it is journaled in a box 14 on a supporting bracket 15, which is mounted on the bed plate, as illustrated. On the upper end of the trunnion 13 is provided a pulley 16, through which the vessel may be rotated by a belt, not shown, from any suitable source of power.

The vessel is preferably of the same general shape as the exterior of the central core or rotor, but sufficiently larger in diameter to leave a desired channel 17, between them. This channel, which may be termed a separating channel, is of size or depth to be
within the effective magnetic field and meet the requirements of the separator, as will be further herein explained. It is preferably sufficiently narrow and of form to provide space for a comparatively shallow confined flow of liquid under pressure augmented by the action of centrifugal force.

The vessel has two circumferential enlargements 18 and 19 respectively, as illustrated, near its lower or discharge end, suitably spaced apart, forming interior pockets or channels, from which radiate comparatively small discharge openings 20 and 21. These openings may be made of size and form to serve as discharge passages while at the same time serving to retard or limit the discharge flow and retain a required amount of liquid in the vessel to properly function in the process of separation as hereinafter explained. The separating channel is kept full of liquid during operation, also preferably at least a small accumulation in the space in the vessel at each end of the core, as illustrated, due to the said openings 20 and 21 being contracted to suitably limit the discharge flow. The limited flow, keeping sufficient liquid in the vessel, results in internal liquid pressure caused by the action of centrifugal force. This pressure is important in the action of the separator as hereinafter described.

Around within the vessel near the enlargement 18, located and adapted to revolve with the vessel, having its lower edge attached thereto, is a dividing ring or member 22, the upper edge or portion of which extends out in the channel 17, and up in direction of the feed end of the separator, so that its shields or largely covers the chamber in the enlargement 18, and the waste discharge openings 20, serving as a divider in the channel, as illustrated. The material traveling along the circumference of the magnetized rotor, and the less magnetic or non-magnetic material traveling along the inner walls of the vessel. It also serves to hereby prevent remixing of separated products.

Located circumferentially around the enlargements 18 and 19, are troughs or launders 23 and 24, which are provided with annular circular openings in radial alignment with the discharge opening 20 and 21 respectively, suitably positioned to catch material and liquid discharged through such openings, and flow the same out at the spouts 25 and 26.

The rotor 2, is axially positioned to conform to that of the vessel, and in the drawings is illustrated as journaled at its lower end by an attached trunnion 27, entering the central opening of the vessel trunnion 9, and at its upper end, is journaled by an attached hollow shaft 28, passing through the hollow trunnion 13, of the vessel. This hollow shaft is provided with a pulley 29, through which the magnetic core or rotor may be revolved as desired by a belt, not shown, from any suitable source of power.

The rotor is vertically supported by a screw 30, on which its trunnion 27 rests, so the super-mounted rotor may be raised or lowered by means of the screw, to adjust the depth or size of the channel 17, if desired, which adjustment will result from such movement from the fact that both such members, the rotor and the vessel, are conical in form, there being necessary longitudinal clearance in the structure of the separator to permit of such movement.

The upper or feed end of the vessel is provided with a ring 31, which together with said end forms an annular feed channel, having feed openings 32, passing from it into the feed end of the vessel, so material for separation and liquid may be flown into the vessel by means of a suitable feed pipe 33, connected to any appropriate source of supply, not shown.

The wire used in making the coils of the several magnets may be connected so as to energize the magnets either in circumferential or vertical series, or otherwise, as desired to best serve the purposes of the operation. In Fig. 5 of the drawings, they are illustrated at 34 connected in vertical series and in Fig. 3 as connected at 35, in circumferential series, and the end or terminal portions 37 of the wires for conducting energizing current into the rotor to the coils, are properly passed into the hollow of the central shaft, as indicated in Fig. 1 by dotted lines and by solid lines through the broken portion of the upper part of the shaft 28, where they are connected to ordinary type slip, or take off rings 38, on the upper part of the shaft, between the magnetically charged rotor, and the less magnetic or non-magnetic material traveling along the inner walls of the vessel. It also serves to hereby prevent remixing of separated products.

This current should be of suitable desired intensity, and may be obtained from any appropriate source, and also may be controlled by any of the standard means which will serve the purpose of regulating or adjusting the strength of flow to the magnets.

In operation the magnet or magnets, of the central core or rotor, as has been already stated, are energized to the intensity required by suitable electric current supplied through the connecting wires 37, and the rotor is revolved at sufficient speed to develop the degree of centrifugal force necessary, assisted by the confined liquid wash, operating under pressure, to throw off the desired non-magnetic or weakly magnetic constituents, while the vessel is also preferably revolved sufficiently to develop the degree of centrifugal force on the material passing through the separating channel 17,
to best cause the separated non-magnetic constituents to lodge on its inner circumferential wall.

During this time material for separation suitably crushed and mixed with liquid, preferably water, of consistency to enable it to flow very freely, is introduced into the vessel through the pipe 23 in sufficient volume to pass down into the channel 17, and maintain such channel full of liquid and preferably partly fill the space between the ends of the vessel and the core, as has been hereinabove explained.

The fact that the liquid in the separating channel is confined and under pressure, as described, and therefore exerts a pressure on the accumulated bedded materials on both the periphery of the magnetic core and the inner wall of the vessel, renders it most effective, under the differential scrub in progressively dislodging and moving the constituents of the said accumulated beds along in comparatively parallel strata, towards discharge, each in its respective zone of greatest influence to magnetic attraction or centrifugal force.

The depth or width of the separating channel 17, is proportioned to best coordinate in separation, and is well within the effective field of the central magnetic core or rotor, and preferably to afford space for a confined shallow liquid flow, so that magnetic constituents in the material being fed to the separator, will as soon as they flow into the separating channel, be attracted to and collected in a strata or accretion, on the core, as indicated by the numeral 41, while the non-magnetic material will be precipitated outward mostly collecting on the inner wall of the vessel in a layer or accretion, as indicated by 42.

The magnetic constituents quickly collecting on the upper circumference of the magnetic core as it is introduced would very soon clog or block this part of the channel if there was applied no suitable agency of prevention. In part, therefore, for this important reason, the core and the vessel are revolved at different rates of speed to produce the frictional scrub operating under pressure or wash of liquid within the channel on both the accretion or strata of magnetic constituents collecting on the core and on the layer of non-magnetic material collecting on the inner wall of the vessel.

This liquid scrub is effective and potent throughout the length of the channel and should be of sufficient force, regulated by the volume introduced and velocity of differential rotation of the vessel and core, to keep at least the surface and preferably the larger portion of the magnetic layer on the core moving or scrubbing along on or close to the core with the liquid flow and under the influence of the magnetic force, towards the discharge end and to discharge through the openings 21, while the liquid scrub on the separated layer of non-magnetic material, will keep such material moving along towards the discharge end to pass out of the opening 20.

As the magnetic material first quickly collects at the upper end portion of the core, there will be more or less non-magnetic or relatively weakly magnetic material entangled with the accretion, but as the scrubbing current of liquid confined and thus operating under pressure, forces this deposit along the core towards discharge, while under magnetic force and under centrifugal force, the undesirable entangled material will be separated and projected out of the magnetic strata moving along the core, into the liquid in the channel to the inner wall of the vessel, where it will also be moved along towards discharge.

When it is desired to separate weakly magnetic constituents from those strongly magnetic, the speed of rotation of the core may be increased to develop as great a centrifugal force opposing the magnetic force as is required, acting with the liquid washing force, to make such separation.

When relatively highly and weakly magnetic materials are to be separated, and the relative intensity of the magnetic force, centrifugal force and liquid washing force are adjusted for such separation. In some instances it will follow that part of the weak magnetic constituents will be floated along in the liquid medium in the separating channel in the balanced zone of opposing centrifugal and magnetic forces, while part will be lodged by centrifugal force on the inner wall of the vessel, and move to discharge.

The dividing member 22 is positioned preferably with its upper end or edge in direction of the feed end of the vessel, terminating on a transverse plane near that of the upper edge of the enlargement 18, and in the free liquid body in the channel 17, as illustrated in Figs. 1 and 2, so that the layer of separated magnetic material next to the core will pass on one side of it to discharge while the non-magnetic material moving along on the inner wall of the vessel will pass on the other or outer sides of it to discharge, while such member also serves in part for preventing re-mixing of separated materials at this point.

The magnetic material moved along the core to its lower end will accumulate to some extent around this end near the discharge openings, as indicated at 43, Figs. 1 and 2, until there is sufficient quantity to bring its outer portion to a weaker part of the zone of magnetism and incidently stronger liquid wash, where the same will be forced to let go, when it will pass through the discharge holes.
In Fig. 4 there is illustrated a form in which magnetic materials are inclined to collect on the magnet, if undisturbed, but the liquid currents or deflects the same down substantially as illustrated, especially in Fig. 5, laying and leveling the extended filaments to an approximately even surface.

What I claim as new and desire to secure by Letters Patent is:

1. The process of separating mixed magnetic and non-magnetic solids while pulverized and mixed with liquid, which consists in simultaneously subjecting such mixture to the opposing action of centrifugal and magnetic forces in a liquid filled channel under confined pressure, and to washing force of such liquid, substantially as described.

2. The process of separating mixed magnetic and non-magnetic solids while pulverized and mixed with liquid, which consists in simultaneously subjecting such mixture to the opposing action of centrifugal and magnetic forces in a liquid filled channel under confined pressure, and to washing force of liquid under such pressure while moving the constituents in strata within such liquid to separate discharge, substantially as described.

3. The process of separating mixed magnetic and non-magnetic solids while pulverized and mixed with liquid, which consists in simultaneously subjecting such mixture to the opposing action of centrifugal and magnetic forces in a confined shallow body of flowing liquid under pressure, forming independent approximately parallel strata of the constituents thereof, while moving such separated strata progressively in the same direction with the flow of said liquid to separate discharge, substantially as described.

4. In a magnetic centrifugal separator the combination of a central hollow core carrying magnetic heads of electromagnets on its circumferential wall, a differentially rotatable vessel surrounding the magnets with a separating channel between the vessel and magnets surrounding the magnet, adapted to contain liquid, within the effective field of said magnets, and means for effecting independent rotation of the magnets and vessel, substantially as described.

5. In a magnetic centrifugal separator, the combination of a hollow rotor, carrying electromagnets provided with heads serving as magnetic poles, countersunk in the peripheral wall of the rotor, said heads having cores with wire windings extending into the rotor in formation of electromagnets, a surrounding rotatable vessel with a separating passage between the rotor and the vessel, encircling the magnets, adapted to contain liquid in operation under pressure, and means for effecting rotation of the vessel and core, substantially as described.

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