(No Model.) 4 Sheets—Sheet 1.

R. H. SANDERS & C. T. THOMPSON.

PROCESS OF MAGNETIC SEPARATION AND APPARATUS THEREFOR.

No. 499,253. Patented June 13, 1893.

FIG. 1.

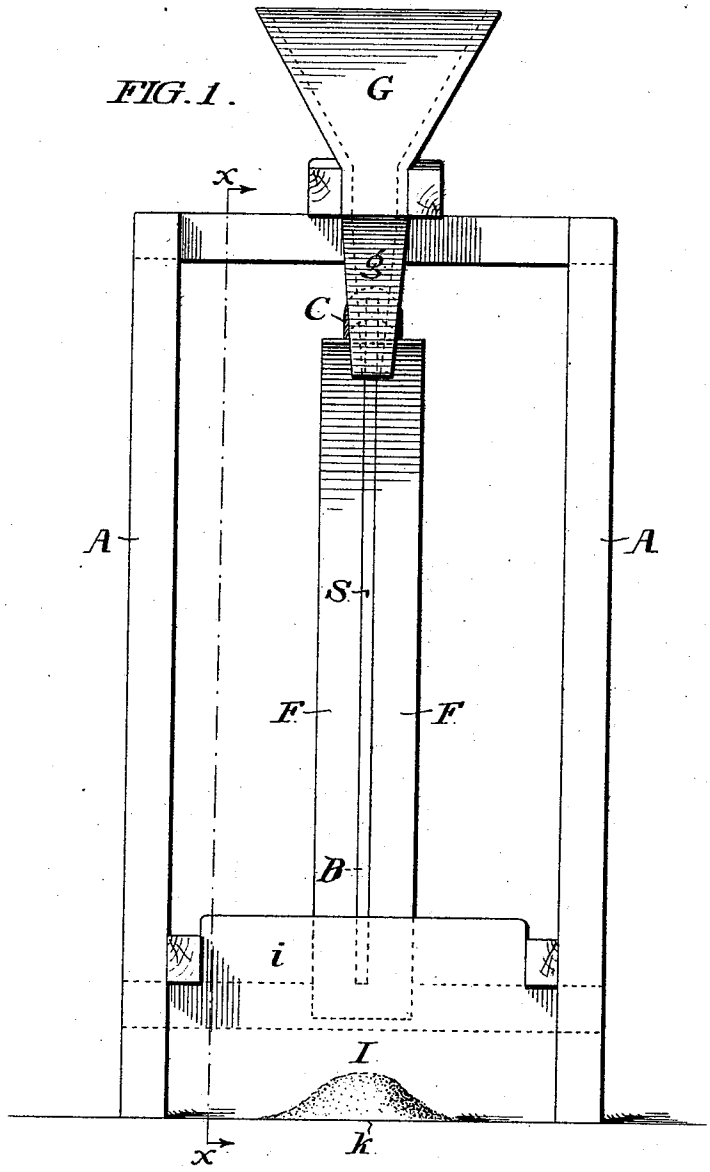
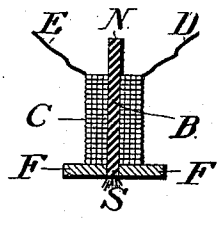


FIG. 3.



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(No Model.) 4 Sheets—Sheet 2.

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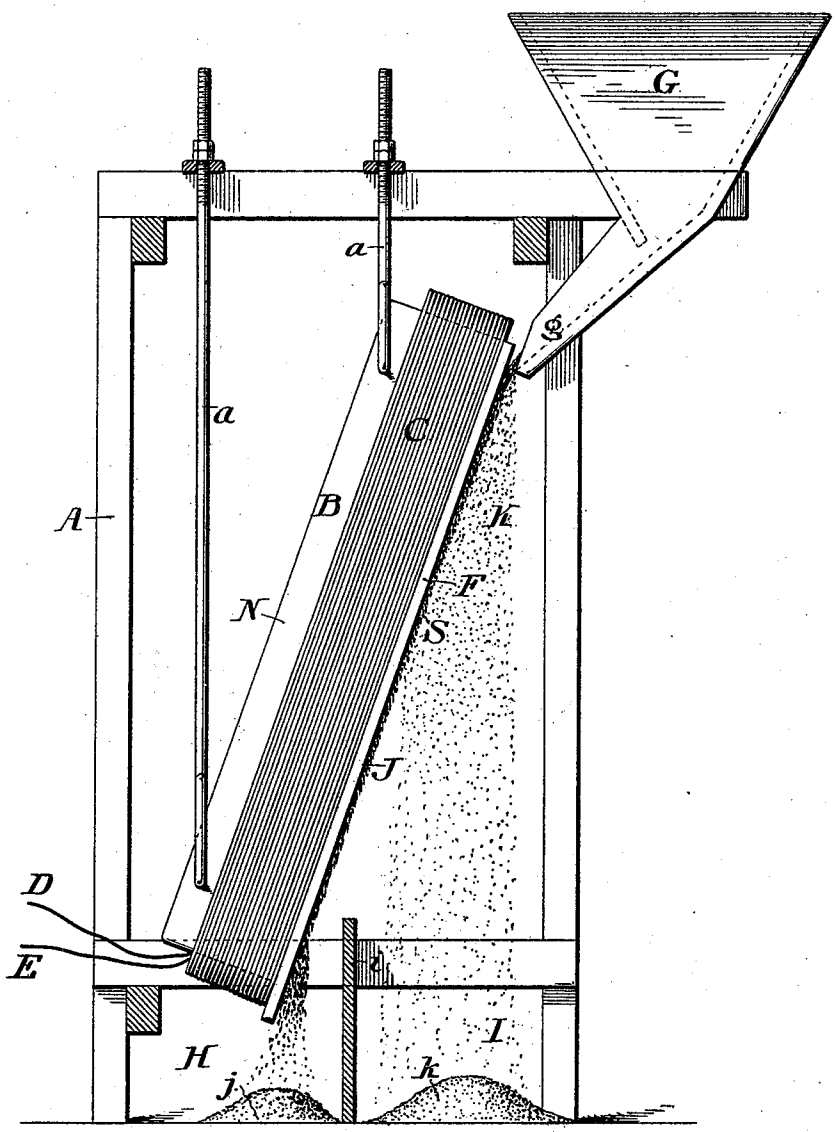
FIG. 2.



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PROCESS OF MAGNETIC SEPARATION AND APPARATUS THEREFOR.

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FIG. 4.

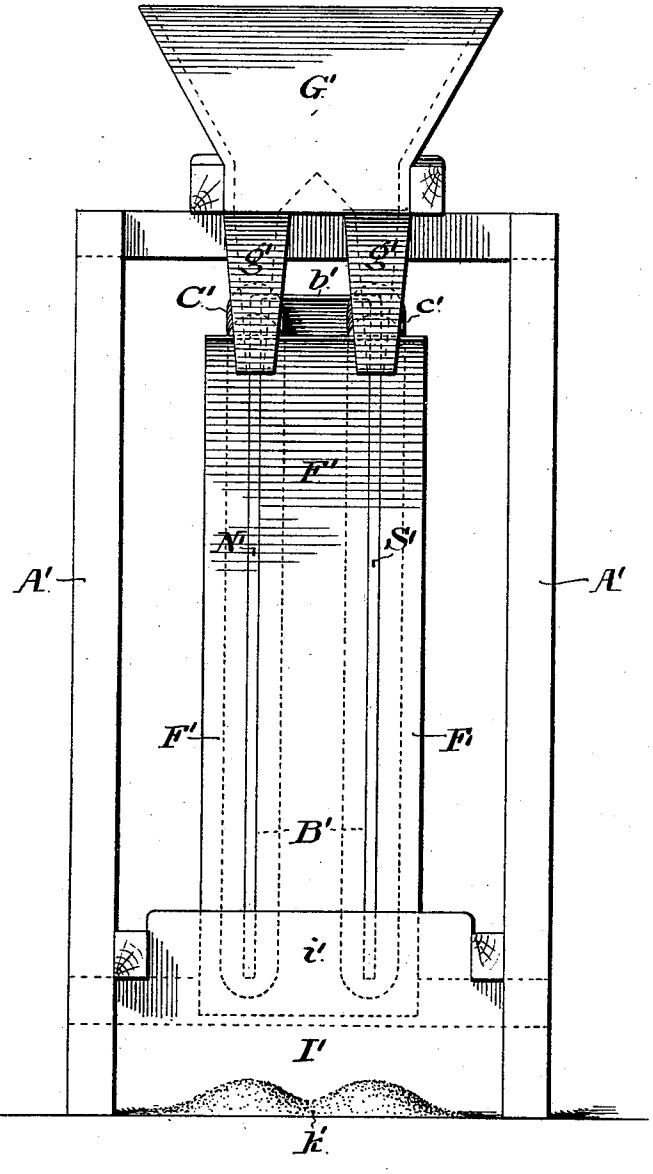
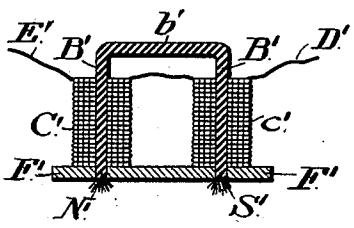


FIG. 5.



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(No Model.) 4 Sheets—Sheet 4.

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FIG. 6.

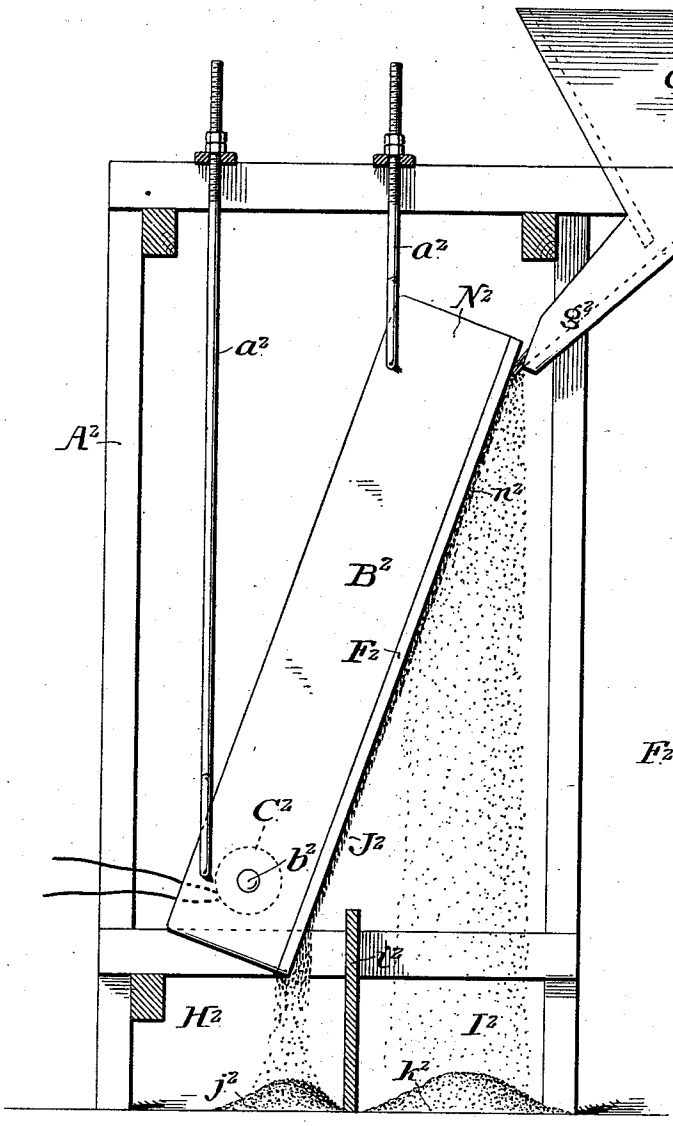


FIG. 7.

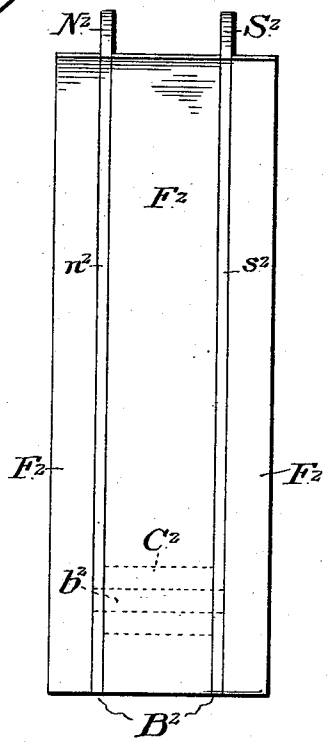
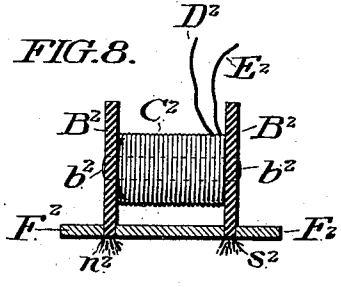


FIG. 8.



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UNITED STATES PATENT OFFICE.

RICHARD H. SANDERS AND CHARLES T. THOMPSON, OF PHILADELPHIA, PENNSYLVANIA.

PROCESS OF MAGNETIC SEPARATION AND APPARATUS THEREFOR.

SPECIFICATION forming part of Letters Patent No. 499,253, dated June 13, 1893.

Application filed December 27, 1892. Serial No. 456,434. (No model.)

To all whom it may concern:

Be it known that we, RICHARD H. SANDERS and CHARLES T. THOMPSON, of Philadelphia, in the State of Pennsylvania, have invented a certain new and useful Process of Magnetic Separation and Apparatus Adapted to the Conduct of Such Process, whereof the following is a specification, reference being had to the accompanying drawings.

Our invention is adapted to the separation of para-magnetic material, generally, from admixture with non-para-magnetic material, but as we contemplate its use primarily in connection with the separation of iron ore from its gangue, we shall use the terms ore and gangue in this specification as typical respectively of the two classes of material, the term stock being used to indicate the admixture of the two which are to be subjected to treatment.

Our invention is based upon the discovery of the peculiar behavior of are particles under the following conditions: If an elongated surface presenting a magnetic field of single polarity be inclined in the direction of its length so as to overhang, say at an angle of about seventy degrees to the horizontal, and ore particles be fed against said surface at the upper end of the incline, the particles will, if the intensity of the field be sufficient as compared with their individual weight, cluster upon the overhanging polarized surface adjacent to the point of feed. As new accretions are fed on at this same point the cluster or group of detained particles will grow downward until it has completely covered the polarized surface, to a depth depending, of course, on the strength of the magnet. When this depth is attained throughout, the polarized surface may be appropriately said to be charged; that is to say, the field is supplied with the maximum number of particles which it is capable of completely arresting in suspension, against the action of gravity. If now the feed of particles be continued at the same point as before, the new accretions will surcharge the polarized surface, and in so doing will displace from the point of arrival a substantially equivalent mass of particles previously in suspension. Instead, however, of completely dislodging the particles immediately adjacent to the point of feed, so that they will directly drop clear of the magnetic field, the following phenomenon will be observed: The superficial particles previously suspended nearest the point of arrival will move downward in a direction practically parallel to the polarized surface, displacing as they go, the next superficial particles previously suspended below them, and these in turn affect similarly the superficial particles next below them, so that a progressive displacement occurs down the entire face of the suspended group until the lower end thereof is reached, when the particles which for the time being have been suspended at the lowest point will upon displacement fall off and pass out of the field. If the feed at the top be intermittent, the phenomenon will take the form of a series of waves passing down the surface until the discharge from the bottom occurs; but if the feed be continuous, a constant stream of particles will appear to flow down the incline and discharge itself at the lower end thereof. It will furthermore be seen that as the particles descend, in the manner above described, they tumble over and over upon each other so as to undergo a thorough shaking up and exposure of new surfaces. If now, instead of feeding ore particles, or other para-magnetic material alone, against a polarized surface in the manner described, stock be similarly fed, a selective action will take place whereby the ore will be detained and diverted down in the general direction of said surface, while the gangue will drop out. The maximum escape of gangue will occur immediately adjacent to the point of arrival, but as the ore particles in their descent tumble over and over upon one another, in the manner just described, any remaining gangue, which has been mechanically detained within the cluster of adhering ore particles, will be permitted to drop out. If the gangue be under the influence of gravity alone (as distinguished from being acted upon by an air, or water current) it will of course fall vertically downward from the point of escape. For the practical conduct of this process it is necessary that the length of the polarized surface, as compared with the amount of its overhang, should be sufficient to afford an opportunity for the traveling ore particles to thoroughly cleanse themselves of

gangue; and this condition on the one hand, and mechanical convenience on the other, will suffice to determine practically the required length through which the polarized surface should extend.

It will be noted that in the foregoing description of our process, we have specified the use of a surface which exhibits polarity of only a single kind. By this we mean that said surface should be so isolated from its correlative polar surface, (either by distance, or by the interposition of a screen, between the two fields) that the sensible action of the correlative pole should not be sufficient to build the detained particles up in the form of closed circuits or chains, from pole to pole. In such case the particles assume the form of very dense and compact masses and their displacement will not occur to any substantial extent in the organized manner, which we have just described as characteristic of our invention. Hence while, as will hereinafter appear, we are able in some forms of apparatus to utilize both poles, or both legs of a magnet, they are to be understood as being really independent of each other and as having substantially no combined action upon the particles. Furthermore, we desire to note at this point that, although a continuous polarized surface constitutes the preferred type of apparatus for our invention, a series of surfaces possessing similar polarity may be so combined as to exhibit the action described, the particles appearing to fall from one surface to the next, when the latter are properly arranged with relation to one another. As, however, such arrangement is in reality nothing more than an aggregation of similar polarized surfaces, each one of which operates upon the material in the manner characteristic of our discovery, we do not deem it necessary to do more than allude to the possibility of such arrangement in order to prevent a misunderstanding of terms hereinafter used in the singular number.

We will now proceed to describe, by reference to the drawings, a typical or elementary apparatus, and some convenient variations thereof, for the conduct of our process.

In said drawings Figure 1 represents a front elevation of the elementary apparatus and comprises also a diagrammatic representation of the action thereof upon the material. Fig. 2 is a vertical section on the line *x x* of Fig. 1, and Fig. 3 is a transverse section through the magnet. Figs. 4 and 5 represent a modified apparatus, in which both poles of the magnet are separately employed, said figures being respectively a front elevation and a transverse section through the magnet. Figs. 6, 7 and 8 are, respectively, a vertical section, a partial front view and a transverse section through the magnet, in a third variety of apparatus, employing two separately-acting polarized surfaces.

Referring to the type shown in Fig. 1, A. represents an open rectangular frame work, in which is suspended, by means of the rods, *a a*, an elongated flat plate, B, of soft iron or steel capable of being magnetized by means of the coil, C, whose strands are wound at right angles to the shortest axis of the plate B. The terminals, D, E, of said coil are placed in circuit with a dynamo, or other suitable current generator. When energized the plate will of course have two polar surfaces, N, S, respectively, and it is so suspended as that the surface S shall overhang, as indicated in Fig. 1, at an angle of about seventy degrees to a horizontal line. We preferably apply along each edge of the overhanging polar surface, a shield, F, which may conveniently be made of wood, slotted to receive the projecting edge of the plate, B, and extending outward for some distance as indicated in Figs. 1 and 3, so as to protect the coil, C, from contact with ore, and limit the movement of particles in a direction back of the plane of the surface S. Such shield is, however, only a convenient adjunct which we do not regard as essential to the conduct of the process.

G represents a hopper to contain stock, terminating at its lower end in a spout, *g*, whose delivery orifice is immediately beneath and in close proximity to the upper end of the inclined polar surface, S, so as to deliver the stock directly to said surface.

At the bottom of the frame work, A, a transverse partition, *i*, divides the area beneath the polar surface, into two compartments or receptacles, H, I, respectively, the plane of said partition being such that if upwardly prolonged it would intersect the polar surface at a point quite near to the lower end thereof, as indicated clearly in the side elevation seen in Fig. 1.

The operation of the device is as follows: The magnet being energized, stock is fed to the overhanging polar surface at the upper end thereof and the phenomenon previously described occurs. The cluster of detained ore particles grows downward, as indicated at J, along the face of the pole, while the gangue particles fall off in a shower, indicated at K. By the time the ore particles, J, have traveled down the polar surface to a point coinciding with the plane of the partition, *i*, all, or substantially all of the gangue has dropped off and been received at *k*, in the compartment I. The ore particles, on the other hand, travel past the plane of the partition, *i*, and on reaching the lower end of the polar surface, S, are dislodged into the compartment, H, as indicated at *j*.

The device just described presents what may be called an elementary apparatus for the conduct of our process in that the surface employed is the actual pole of the magnet and that only one pole is utilized.

We will now proceed to describe, by reference to the remaining figures, an apparatus in which both poles of the magnet are independently used, and another in which the polarized surfaces utilized are not the actual

poles themselves. Thus in the type shown in Figs. 4 and 5 two plates, B′ B′, are employed, united by a back plate, b', so as to form in conjunction with the coils, C′, c', a horseshoe magnet having elongated overhanging poles, N′, S′, respectively, which may be appropriately provided with a shield, F′. The distance between the polar surfaces, N′, S′, is such that the ore within the field of one, is not sensibly acted upon by the other, and thus any permanent aggregation of particles in close circuits is prevented. The feed takes place, if desired, from the same hopper, G′, but by different spouts, g', each delivering in the proper relation to one polar surface, and the operation is precisely the same as that before described.

In the form of apparatus shown in Figs. 6, 7 and 8, a horseshoe magnet is employed, consisting of a pair of plates, B^2, B^2, connected by means of a transverse bar, b^2, at one end, said bar being wound with the coil, C^2. Instead of utilizing the extreme polar surfaces, N^2, S^2, as was done in the previous instance, we incline the legs of the magnet so that the edges, n^2, s^2, of each leg, instead of the ends thereof, shall constitute the overhanging polarized surface against which the stock is to be fed. The projecting shield, F^2, may be employed as in the previous instances, and the distance apart of the legs should be such as to prevent the sensible action of one upon the ore detained by the other. The stock being fed by independent spouts, g^2, arranged in the described relation to the polarized surfaces, n^2, s^2, the operation above set forth takes place and the ore and gangue fall respectively as indicated at j^2, k^2, on opposite sides of the partition, i^2.

Having thus described our invention, we wish to point out certain features which distinguish it from previously known processes of separation and apparatus employed therefor.

We are of course aware that it is not new to carry stock along an inclined magnetic field by means of a belt or other conveyer, and we are also aware that the use of horse shoe magnets in an inclined chute, or behind an inclined screen, is not new, these latter devices having been used to clean grain and similar material from accidentally mixed paramagnetic particles. Our invention, however, differs from the former type of apparatus in that we absolutely dispense with the use of a conveyer by reason of the new principle of operation involved in our discovery.

Our invention obviously differs from the latter type of apparatus, in which both poles of the magnet or magnets co-act upon paramagnetic material, in that we subject the ore to the action of but a single polarized surface and thus obviate the practically permanent clustering which takes place where closed circuits can be formed of the ore particles between two adjacent and co-operative poles. We desire also to note that although we prefer to feed the stock into direct contact with the polarized surface, yet we do not desire to exclude the use of a diaphragm covering said surface, provided such diaphragm does not substantially interfere with the projection of the lines of force from such polarized surface to form a magnetic field, in which the material can be subjected to the treatment above described. Hence in using the words polarized surface in our claims, we must not be understood as limiting ourselves to a process which involves the direct contact between the ore particles and the magnet itself.

We claim—

1. The hereinbefore described process of magnetic separation, which consists in feeding stock to the upper portion of an overhanging surface of substantially single polarity, whereby the ore is detained and gangue permitted to drop off; causing the ore to descend along said surface by new accretions fed at the upper portion thereof; permitting the remaining gangue to drop out during the period of descent; and finally causing the discharge of the cleaned ore by surcharging the polar surface; substantially as set forth.

2. The combination of a magnet having an overhanging elongated polarized surface; a shield arranged along each side of said surface; a feeding device arranged to deliver stock to the upper end of said surface; and separate receptacles, for gangue and ore, subjacent respectively to the upper and lower ends of said surface; substantially as set forth.

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CHARLES T. THOMPSON.

Witnesses:
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E. REESE.

Correction in Letters Patent No. 499,253.

It is hereby certified that in Letters Patent No. 499,253, granted June 13, 1893, upon the application of Richard H. Sanders and Charles T. Thompson, of Philadelphia, Pennsylvania, for an improvement in "Processes of Magnetic Separation and Apparatus Therefor," an error appears in the printed specification requiring the following correction, viz.: In line 21, page 1, the word "are" should read *ore;* and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed, countersigned, and sealed this 4th day of July, A. D. 1893.

[SEAL.]

JNO. M. REYNOLDS,
Assistant Secretary of the Interior.

Countersigned:

S. T. FISHER,
Acting Commissioner of Patents.