No. 810,841. PATENTED JAN. 23, 1906.

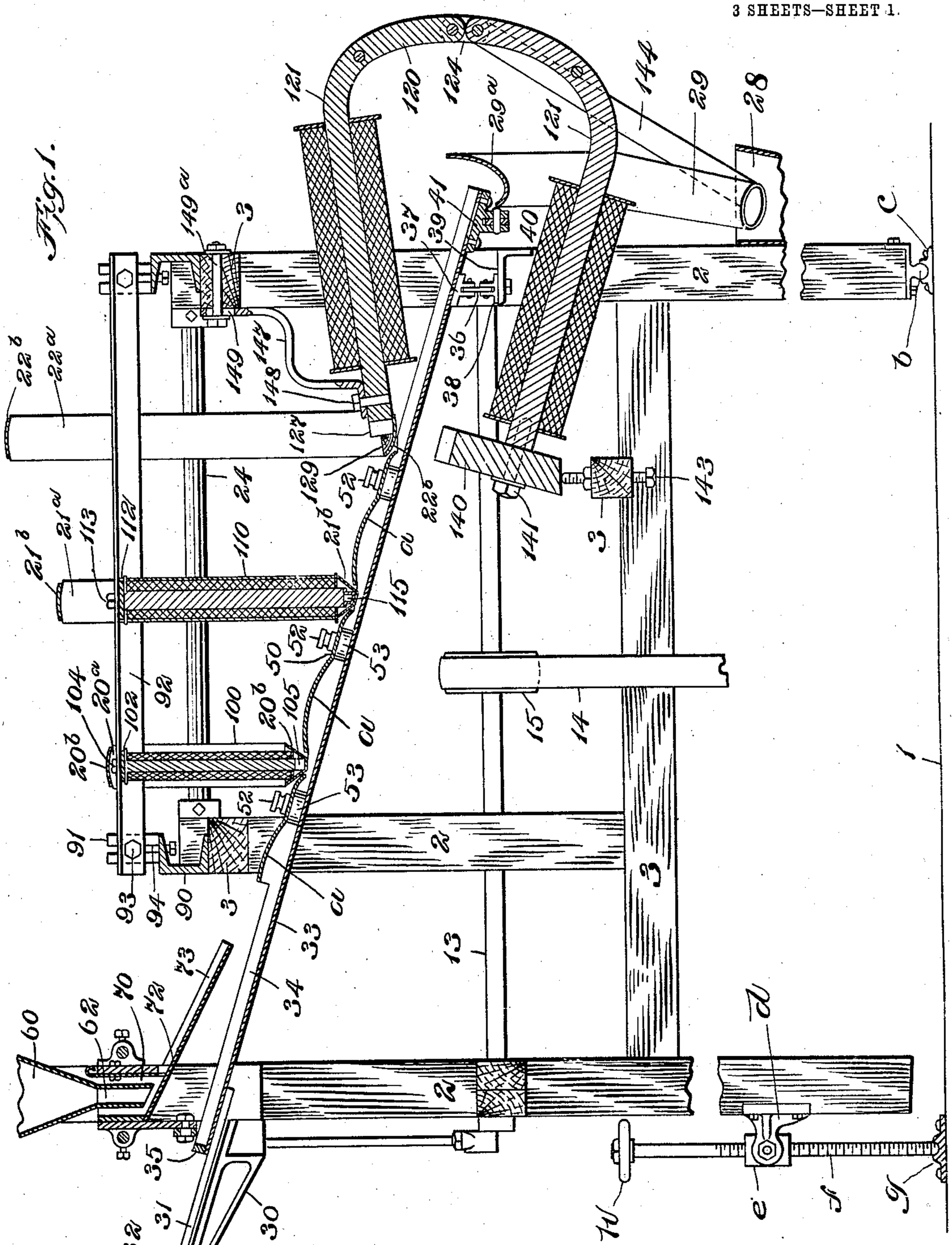
H. F. CAMPBELL.

MAGNETIC SEPARATOR.

APPLICATION FILED JULY 29, 1902.

3 SHEETS—SHEET 1.

Fig. 1.



Witnesses:
Walter F. Abell.
George Pezzeth

Inventor:
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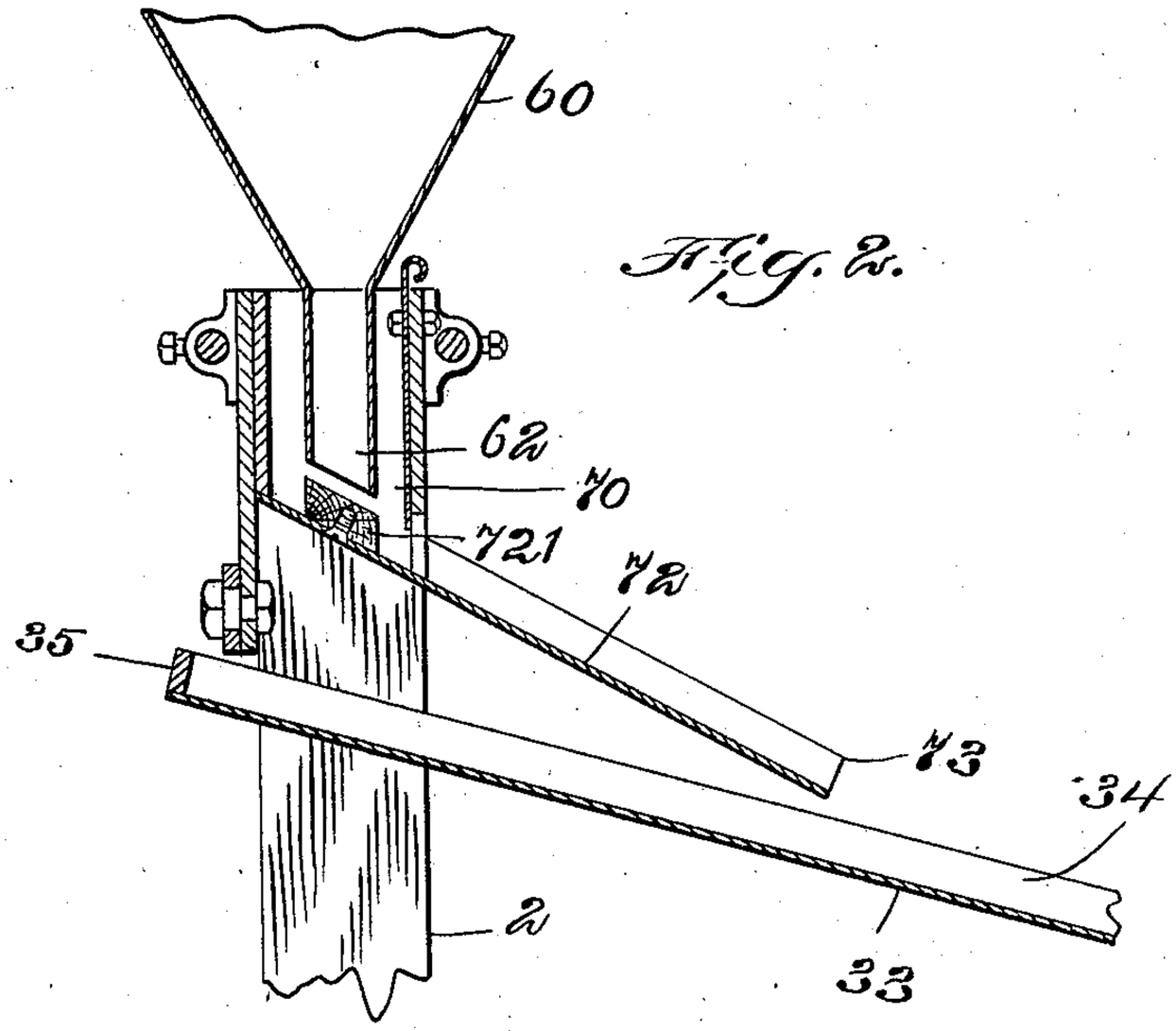

Fig. 2.

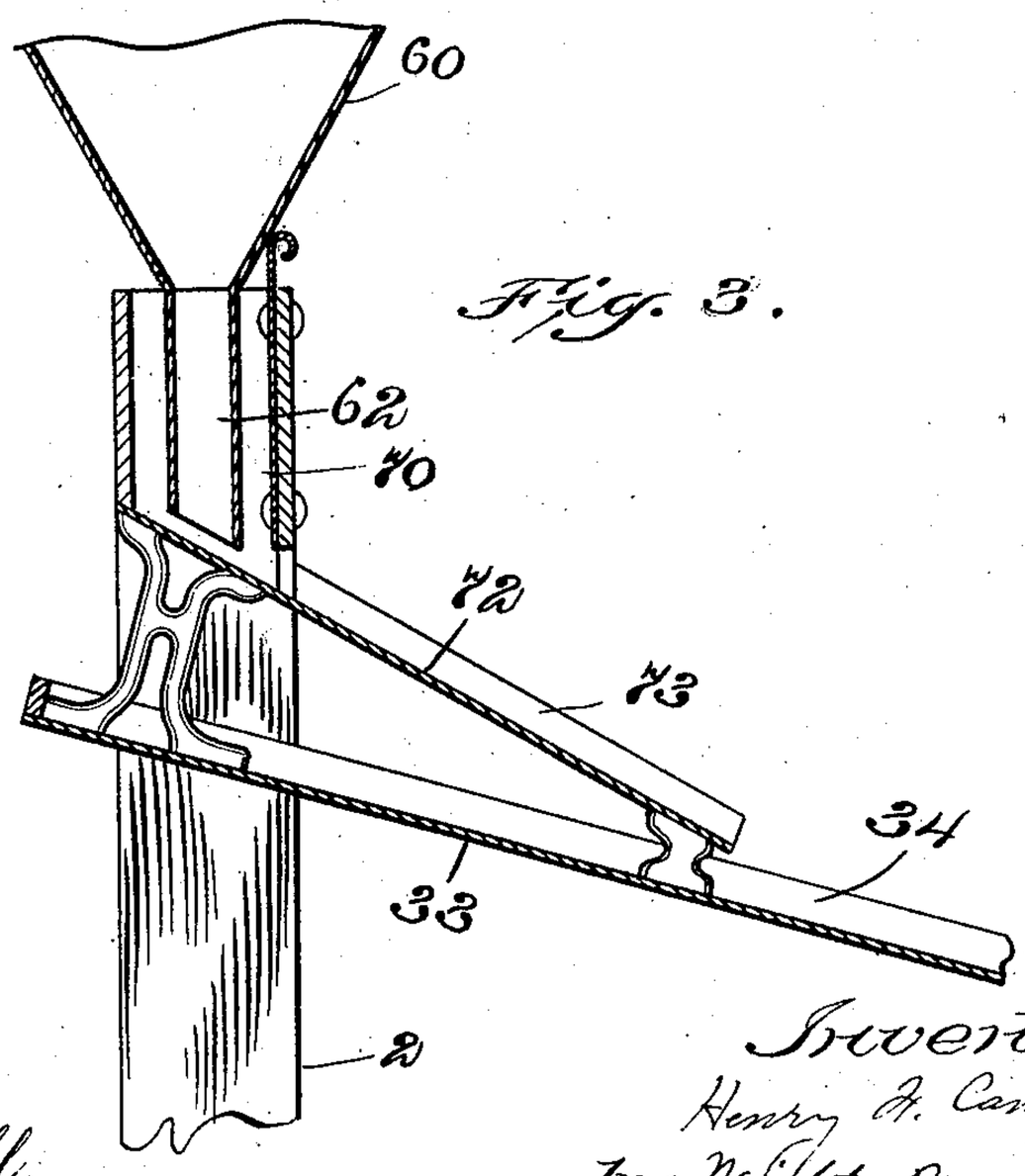

Fig. 3.

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3 SHEETS—SHEET 3.

Fig. 4.

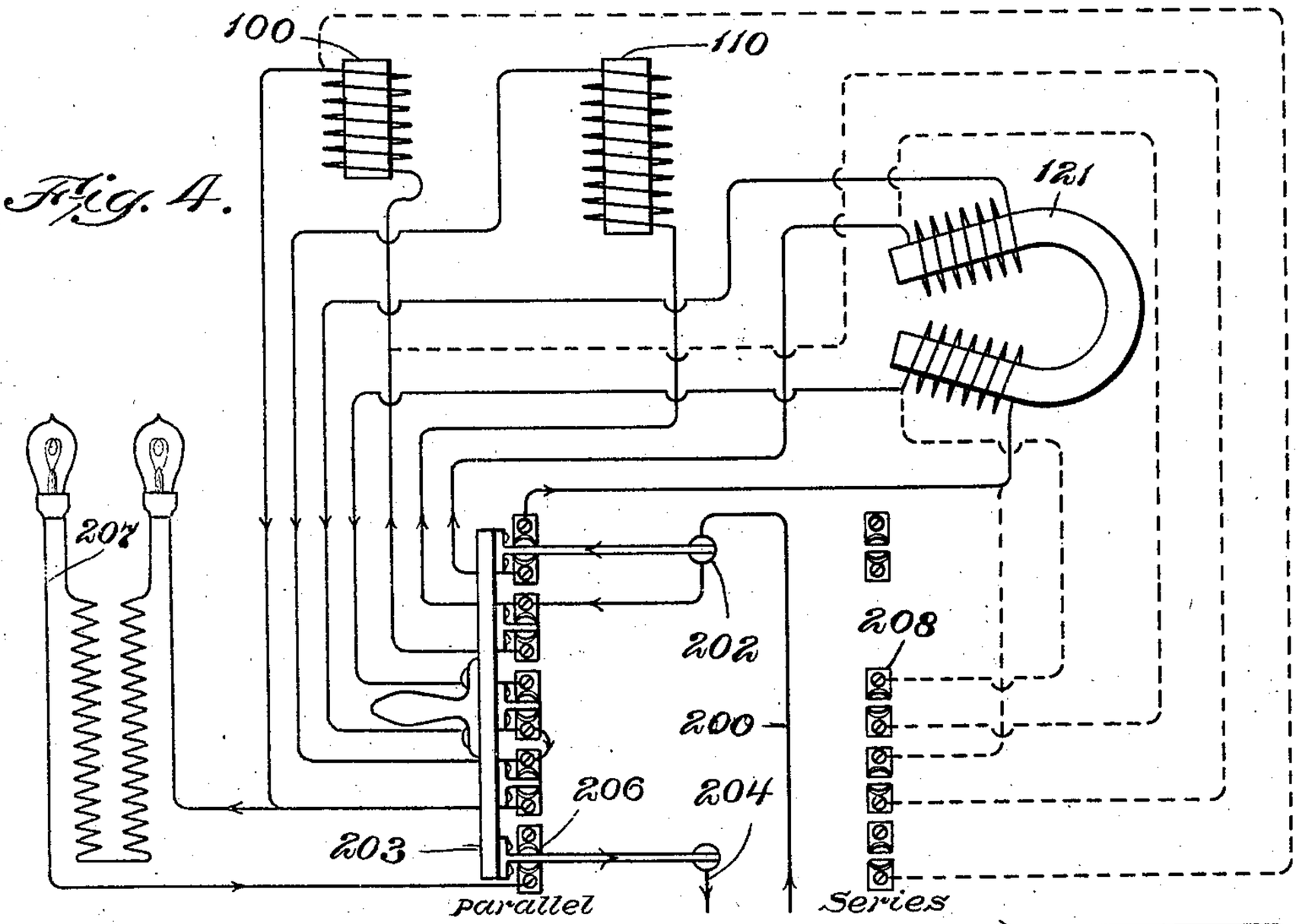
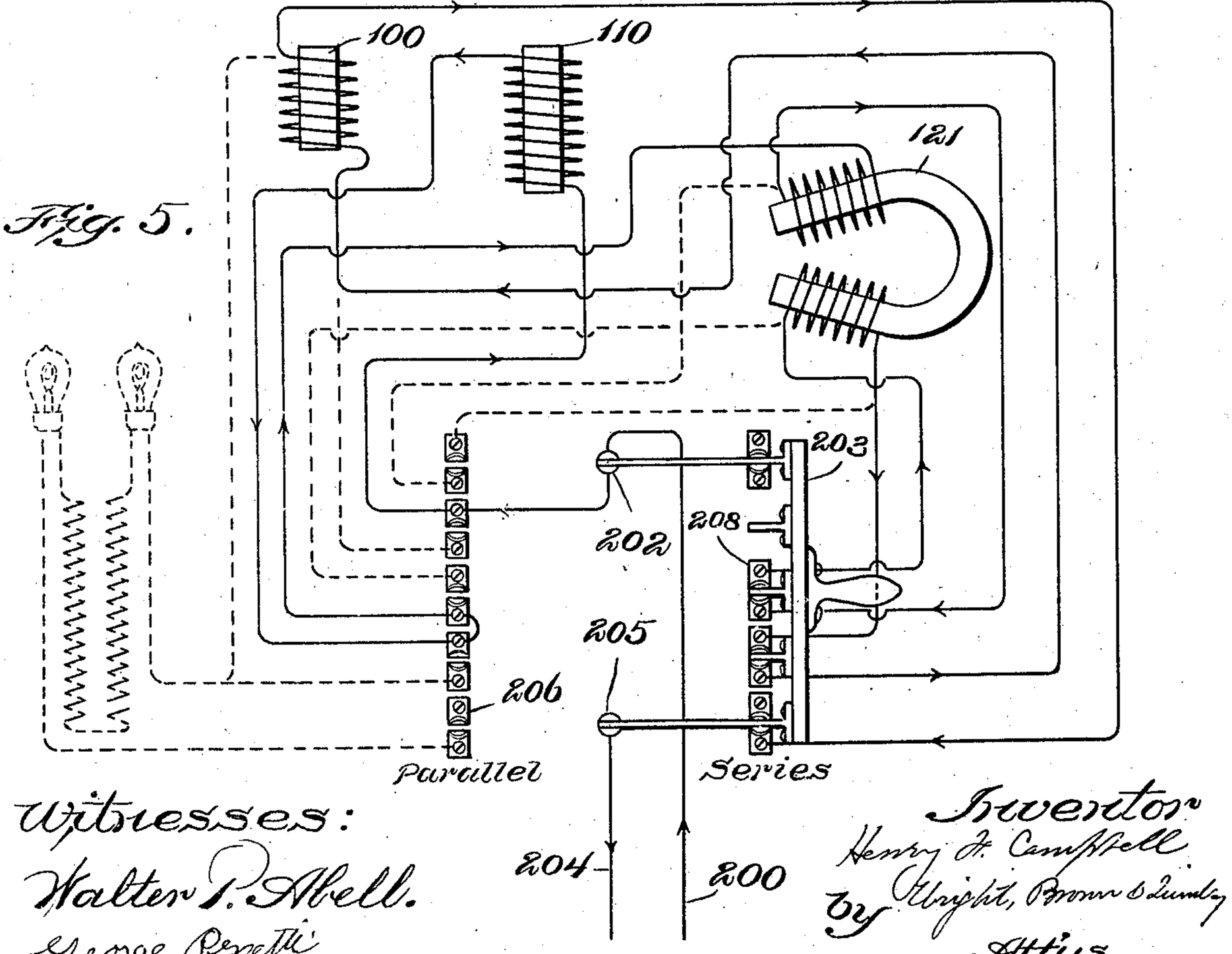


Fig. 5.



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UNITED STATES PATENT OFFICE.

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MAGNETIC SEPARATOR.

No. 810,841. Specification of Letters Patent. Patented Jan. 23, 1906.

Application filed July 29, 1902. Serial No. 117,564.

To all whom it may concern:

Be it known that I, HENRY F. CAMPBELL, of Melrose, in the county of Middlesex and State of Massachusetts, have invented certain new and useful Improvements in Magnetic Separators, of which the following is a specification.

This invention relates to apparatus for the extraction of magnetic particles from ore; and the particular object of the present invention is to provide a construction in which the tray or conveyer for conducting the ore past and in proximity to the magnet or magnets shall be not only non-oxidizable and non-magnetic, but also of a material so light that its inertia or momentum will not practically interfere to any extent with the rapid vibrations or shaking to which it is subjected.

A further object is to provide means for preventing the magnetic particles from leaving the tray or carrier prior to reaching the point where they may be lifted by the magnet or magnets into contact with a belt or other means for removing the magnetic particles aside from the tray or carrier; and a further object is the production of a machine as a whole which may be conveniently and readily adjusted to vary the inclination of the ore tray or carrier without effecting the adjustment of the magnets relatively to said carrier.

To these ends the invention consists in the construction and combination of parts, substantially as hereinafter described and claimed.

In the drawings, Figure 1 is a vertical sectional view of an ore-separator constructed in accordance with my invention. Fig. 2 is a detail view of a shaker and hopper shown in Fig. 1. Fig. 3 is a detail view of a modification. Fig. 4 is a plan view of the interchangeable circuits of the magnets, the switch being thrown to connect the magnets in parallel. Fig. 5 is a like view showing the switch thrown to connect the magnets in series.

The same reference characters indicate the same parts in all the figures.

Fig. 1 is similar in many respects to one figure of my application filed May 16, 1901, Serial No. 60,433.

The framework of the apparatus may be of any desired construction and is here shown as composed of uprights 2 and side pieces 3, the said uprights being supported upon a suitable base in a manner hereinafter described, said base being indicated in the drawings by the line 1. A shaft 13 is mounted in suitable bearings in the framework and is provided with a pulley 15, driven by a belt 14 from a suitable source of power. Mounted in suitable bearings at the upper portion of the framework is a shaft 24, upon which are secured three pulleys 20^a 21^a 22^a, said pulleys being of different sizes, substantially as indicated. It is to be understood that the machine carries another set of similar pulleys upon another shaft in the same plane as the shaft 24, and either one of these shafts is driven by suitable power, so that the belts or carriers 20^b, 21^b, and 22^b, which are mounted upon the said pulleys, may be suitably driven in order that the lower stretches of the pulleys or carriers which pass under the magnets, as hereinafter described, will also serve to deliver the magnetic material raised from the shaking-tray at one side of the magnets and tray.

The tray or carrier 33 for the ore, having side flanges 34 and a flange 35 at its upper end, is connected, by means of a spider 31, to a pivot or bolt 32, carried at the outer end of a bracket 30. Below the lower end of the tray or carrier is a gutter 29^a, which delivers through a spout 29 into a hopper 28, said hopper 28 receiving the non-magnetic particles. The lower end of the tray is supported so that it may receive a lateral oscillating shaking motion by means of links 36, pivotally connected with a lug 37 on the under side of the tray and with a lug 38, connected to a fixed cross-piece 39 of the frame. Lateral motion may be imparted to the lower end of the tray by any suitable means, such as a pitman connected at 40 to a lug 41 on the under side of the lower end of the tray. Suitable plates 50, preferably as many in number as the magnets and carrier-belts, extend across the tray and move therewith. A series of shutters or distributers 53 are connected to said cross-plates 50 by thumb-screws 52. A receiving-hopper 60, having a spout 62, is suitably supported by the framework above the upper end of the tray, said hopper discharging into a box 70 and over an apron 72, having side flanges 73, onto the tray or carrier 33. Cross-pieces 90, carried by the uprights 2 and extending over the

tray, are provided with slotted lugs 91. Two bars 92 (only one being shown in the drawings) are provided with bolts 93, arranged in the slots of the lugs 91. Adjusting-screws 94 pass up through the cross-pieces 90 and engage the under side of the bars 92, whereby said bars 92 and the magnets carried thereby may be simultaneously adjusted vertically. The upper or first magnet 100 is connected to the bar 92 by means of a plate 102 and bolts 104. This magnet, as in my other application hereinbefore referred to, is composed of a plurality or series of bars of magnetic material, the lower ends of which are connected by a plate 105, along and under which the lower stretch of the belt 20^b passes. The second magnet 110 is also supported by the bar 92 by means of the plate 112 and bolts 113. The series of bars of which this magnet 110 is also composed are also provided at their lower ends with a plate 115, extending lengthwise of the series. The carrier-belt 21^b passes along the under surface of said plate 115.

The horseshoe-magnet 120, consisting of two series of bars 121, which are hinged together at 124, is supported at one portion by means of a strut or struts 144, the lower ends of which are suitably connected to the framework. The upper bars 121 of this magnet are of different lengths, as described in said earlier application, the ends of the longer bars 121 being indicated at 127. A strip or plate 129 extends across or along the ends of the series of upper bars of the magnet, and the belt or carrier 22^b rides along and under said plate 129.

140 represents a keeper secured at the free ends of the lower bars 121 of the horseshoe-magnet, said keeper being secured to the said bars by bolts 141.

143 represents a set-screw passing through one of the portions 3 of the frame and bearing on the under side of the keeper 140, whereby the lower half of the magnet may be adjusted independently of any other adjustments of the apparatus.

147 represents a supporting-arm having its lower end connected to the upper arm of the horseshoe-magnet by a bolt 148. This arm 147 is formed at its upper end with a slot 149, through which a bolt 149^a passes into a portion 3 of the frame. By means of this slotted arm 147 the upper half of the horseshoe-magnet may be adjusted independently of any other adjustment.

As so far described the apparatus, as above stated, is or may be the same as in my application, Serial No. 60,433, above referred to.

The bottom or ore-carrying portion of the tray 33 is composed of a light non-oxidizable non-magnetic material, such as aluminium. Vulcanized rubber or indurated fiber board is essentially proof against the sulfids and oxidizing chemicals in the ore and of little weight. One of the chief requisites of the table is a surface that is smooth and offers little or no obstruction to the passage over it of the fine sharp particles of ore and which is not roughened by the same. It is possible that certain woods may be found which will measurably serve the purpose of a material for the table, especially if the same be treated with some filling, and such therefore would be within the scope of my invention. When desired, the bottom or carrying surface may be mounted upon some light structure, such as laminated wood, the purpose being to have the tray as light as possible, so that its inertia and momentum will not interfere with the rapid shaking thereof by suitable means connected with the lug 41, and, furthermore, a motor of less power is necessary to vibrate or shake the tray when the latter is made of such material as stated. Furthermore, this lightness of construction tends to confine the vibrations to the tray or carrier and its immediately-connected parts, and therefore does not tend to communicate vibrations to the carrier-belts, so as to have a tendency to shake the magnetic particles therefrom.

In the operation of the machine the ore is placed on the hopper 60 and falls therefrom over the apron 72 onto the rapidly-vibrating tray 33 and gradually moves downward along the latter between the distributers or shutters 53 to and from the lower end of said tray. During the passage of the ore under the magnets the magnetic particles are lifted from the ore against the carrier-belts and by means of the latter are discharged into suitable hoppers or receptacles, (not shown herein,) all as described in my said earlier application. To prevent magnetic particles from being lifted out of the mass of ore before the latter arrives under the carrier-belts, I provide a series of septums *a*. These septums are or may be of the same material as the tray 33. They are suitably supported by or connected with the tray, as by means of the same thumb-screws 52 which connect the shutters or distributers 53 to the plates 50. The lower edge of the septum extends under the edge of the carrier-belt which is toward the upper end of the tray, and from this point the first or upper septum extends sufficiently up the incline to entirely cut across or interrupt the magnetic field of the upper magnet 100. Each lower septum has its upper edge extending underneath the edge of the carrier-belt of the magnet next above it. In other words, a narrow space is left between the lower edge of the upper septum and the upper edge of the intermediate septum, through which magnetic particles may be lifted by the first magnet against the carrier-belt 20^b, and a similar space or passage is provided between the lower edge of the intermediate septum and the upper edge of the lower septum for the

upward passage of particles lifted by the intermediate magnet against the carrier-belt 21^b. The lower edge of the lower septum extends under the upper edge of the carrier-belt 22^b, so as to prevent the passage of magnetic particles around to the upper side of the strip 129. No septum is shown above the portion of the tray which is beyond or below the right-hand edge of the carrier-belt 22^b for the reason that none is needed at that point, because the power of the magnet 120 is such that any particles capable of being lifted out of the ore by any magnetic force are attracted directly against the carrier-belt 22^b. It will be understood that the series of septums practically constitute a cover for the tray, the spaces between said septums forming transverse openings which are parallel with and adjacent to the two carriers 20^b and 21^b, said openings being of less width than the width of the carriers, whereby magnetic particles are prevented from being lifted to either side of either of the magnets 100 and 110.

In order that the apparatus as a whole may be varied in its inclination, so that the speed of the material flowing down the tray 33 may be altered without varying the relative positions of the tray and magnets, I provide the lugs or uprights 2 at the right-hand end of the machine shown in the drawings with a strong hinged connection with the base 1. This hinged connection may provide a rib *b* at the lower end of each lug, said rib fitting in a socket *c*, suitably supported upon the floor or base 1. The other end of the machine is provided with one or more brackets *d*. One such bracket is shown as connected to one of the uprights 2 at the left hand of the figure. Pivotally supported in the bracket *d* is a nut *e*, through which a screw *f* passes, the lower mounted end of this screw fitting in a socket *g*, suitably secured to the floor or base 1. A hand-wheel *h* may be used for rotating the screw, and so raising or lowering the supply end of the apparatus bodily in a manner that will be readily apparent.

The apparatus as a whole is one in which the ore is caused to pass or flow in a lively dancing condition below the magnet or magnets. This animated movement below the magnets may be accelerated or diminished by means of the adjustment of the entire apparatus above described. I am therefore enabled to accurately adjust the operative speed capabilities of the apparatus according to the particular ore being treated. This is of particular advantage in an apparatus which embodies, as in this case, a plurality of magnets of varying powers, but having their poles at substantially equal distances above the tray or conveyer, for the reason that, as above stated, adjustment of inclination of the apparatus will not affect in any way the relative powers of the magnets, which are fixed in position relatively to the tray or conveyer.

The septum or septums above described aid in beating out or shattering the possibly-adhering masses of ore, because any such masses which may be drawn against the under side of a septum by the bar of the magnet toward which said mass is moving will be drawn with sufficient force to aid in breaking it up, while the violent agitation and shaking of the septum with the tray or carrier will immediately dislodge said mass and cause it to work gradually down to the carrier-belt next below that particular septum.

While most ores will be effectively treated by the magnets in series, certain refractory ores may require a greater magnetic intensity. In such case, the magnet-windings being such as to permit it, one or all of said magnets may be changed from series to multiple and from multiple to series at pleasure. Such change will, however, be seldom required save in case of the lower or most intense magnet.

In Figs. 4 and 5 I have shown an arrangement whereby the magnets may be used either in parallel or in series. 200 represents a wire leading from the source of power to one terminal 202 of the switch 203. 204 represents the return-wire connected to terminal 205. 206 represents a series of terminals connected by wires in parallel to the several magnets. In this parallel system is included a resistance device 207, composed of lamps and resistance-coils. 208 represents a series of terminals from which wires lead to the magnets in series. When the switch 203 is thrown to the position shown in Fig. 4, the current is applied to the magnets in parallel and the resistance device 207 is in operation. When the switch is thrown to the position shown in Fig. 5, the current is applied to the magnets in series and the resistance 207 is cut out. In Figs. 4 and 5 the live wires are represented in full lines and the dead wires in dotted lines.

The angle of the floor of the shaker is sharper than that of the table, so that the ore is thrown to the lowest point of the said shaker and against the gate and to the apertures. However small the quantity of ore in the shaker, the same result follows. It will be seen that the lower ends of the feed-pipes conform to the angle of the shaker-floor or to the block or boss 721 on the floor of said shaker. By this conformity and the oscillation of the shaker a self-determining or self-limiting feed of the ore is insured. A column of the ore is continuously by gravity pressing upon the floor of the shaker or the block or boss 721, fixed upon the floor of said shaker. The oscillation of the shaker determines the flow of said ore until the chamber of said shaker is partly filled with ore, when

the flow from the pipes momentarily ceases. As soon, however, as the flow from beneath the adjustable gate and through the apertures has slightly reduced the ore in the chamber there follows another flow of the ore from the pipes, which flow is obstructed by the ore in the chamber surrounding the ends of said pipes until the volume of said ore is again reduced and the flow succeeds. This intermittent flooding and cessation in the flow of the ore continues while the machine is in operation and ceases when the machine stops, with no danger of overflow. It is self limiting or determining. A nearly uniform depth of ore is maintained in the chamber, and, more important still, a uniform pressure of ore is maintained at the line where said ore issues beneath the gate through the several apertures and upon the apron of the shaker, thereby securing a flow of a predetermined film of uniform depth and constant in quantity upon the table of the separator and across its surface.

I have so constructed and arranged the upper poles of the horseshoe-magnet 120 that each is provided with sharp corners, the lower one of which is presented to the tray or conveyer and to the material passing over it. The face of each pole lies in a plane which forms an acute angle with the surface of the tray or conveyer. The effect of this arrangement is that the material in passing under the poles of the horseshoe-magnet travels through a magnetic field of gradually-increasing intensity. As the material enters the field of this magnet it is first influenced by the magnetic arc formed between the face of the poles 127 and the under poles. This is not sufficient to lift the magnetic particles from the tray. It serves to polarize them in advance of their arrival under the lower corner of the poles 127 and prepare them for the most effective work of the magnet. The lower corner being a sharp angle and nearest the tray creates the most intense portion of the arc, immediately beyond which the material leaves the magnetic field and the non-magnetic material is discarded. It is obvious that the lower poles of the magnet can be formed and arranged in a similar manner, so as to present a sharp corner nearest to the surface of the tray, and similar advantages would be thereby attained. I do not, however, herein claim a magnetic separating device arranged to remove magnetic particles from a mass of ore, a tray or conveyer arranged to conduct the ore, and magnets having a pole or poles arranged in relation to the tray, so as to form a magnetic field of gradually-increasing intensity across the path of the ore upon the conveyer and of greatest intensity at the point where the ore emerges from the magnetic field, as the same form the subject-matter of my application, filed February 12, 1903, Serial No. 143,012.

Having thus explained the nature of my said invention and described a way of constructing and using the same, although without having attempted to set forth all of the forms in which it may be embodied or all of the modes of its use, I declare that what I claim is—

1. The combination in a magnetic separator, of a magnet; a tray, presenting an unobstructed surface at a due distance below the magnet, for supporting and conveying the material spread in a film of substantially uniform thickness under and past the magnet, and through an uninterrupted field of such magnet, a cover for said tray for preventing the passage of magnetic particles to the sides of the magnet, and means for imparting a transverse shaking movement to the said support.

2. In a magnetic ore-separator, a magnetic separating device arranged to remove magnetic particles from a mass of ore, a tray or conveyer arranged to conduct the ore to the field of said device, magnets furnished with spools so wound that the current may be changed from series to parallel, means for making such change, and means for carrying aside the particles removed.

3. The combination in a magnetic separator, of a magnet; means, presenting an unobstructed surface at a due distance below the magnet, for supporting and conveying the material under and past the magnet, and through an uninterrupted field of such magnet, and to pass it, spread in a film of substantially uniform thickness on the surface beneath the magnet, a vibrating shaker for delivering the material to the said conveying means, said shaker having a boss, a hopper arranged over said shaker and having a pipe the delivering end of which terminates over and close to the top of said boss, and means for causing the particles of ore to be mechanically agitated under the magnet in a direction other than that of the travel of the ore.

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

HENRY F. CAMPBELL.

Witnesses:

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GEORGE PEZZETTI.