No. 655,433. Patented Aug. 7, 1900.

C. F. COURTNEY & R. BUTTERWORTH.

MAGNETIC SEPARATOR.

(Application filed Mar. 19, 1900.)

(No Model.) 3 Sheets—Sheet 1.

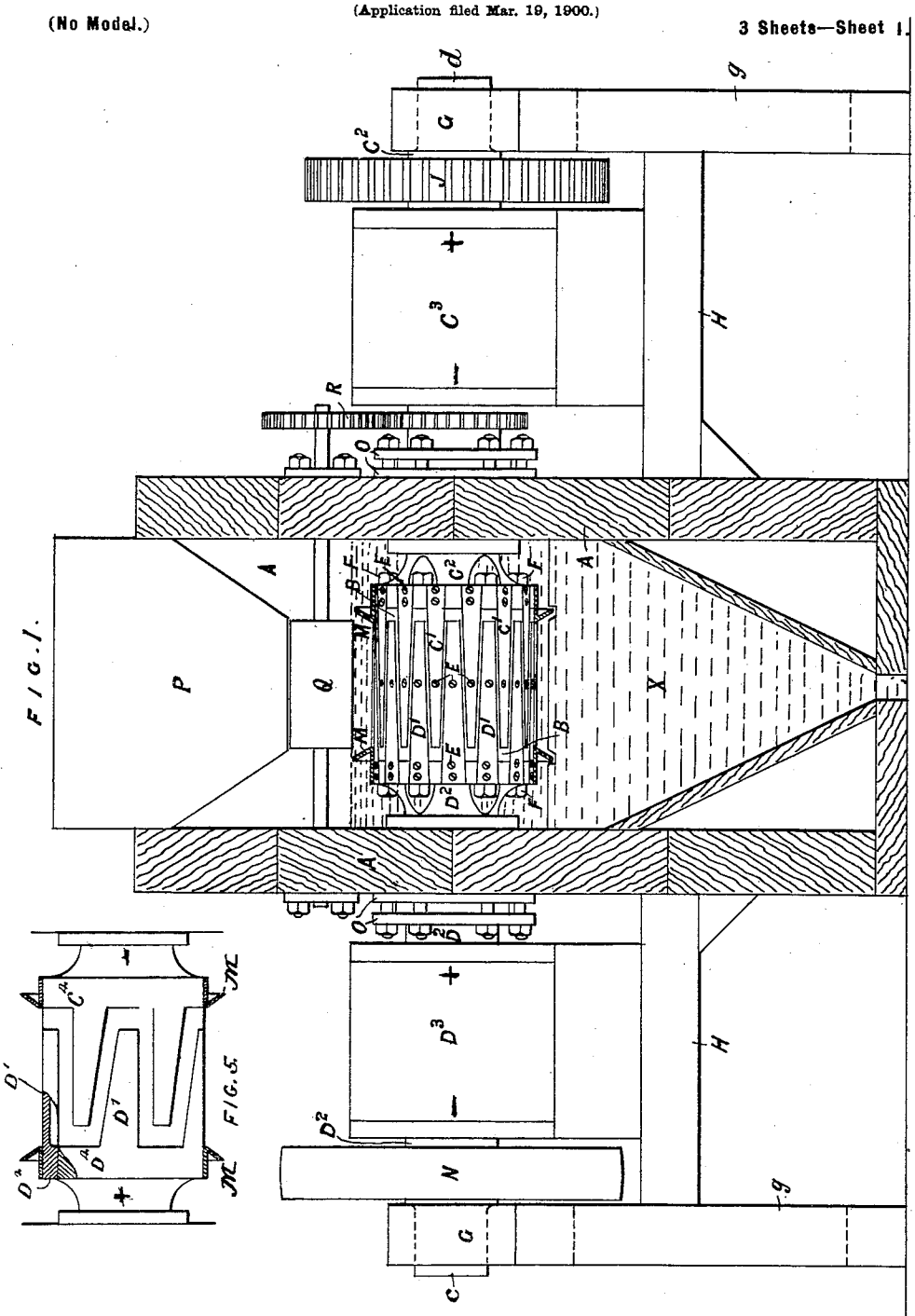

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FIG. 2.

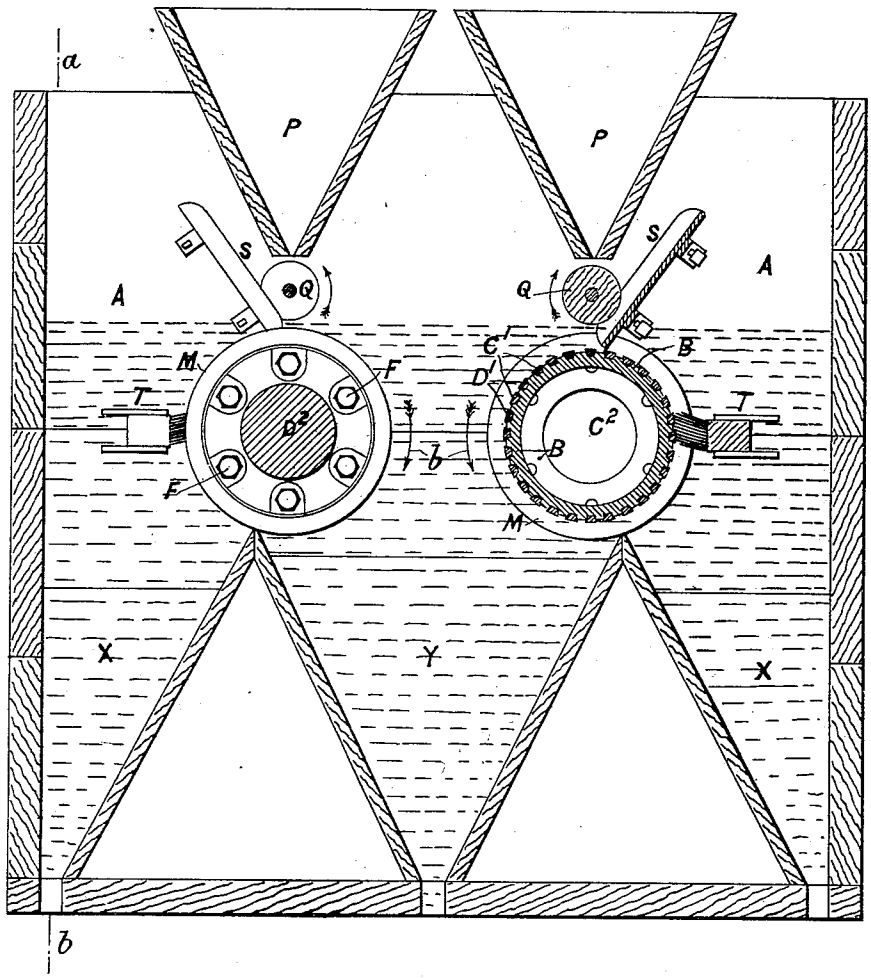
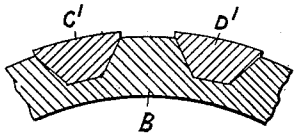


FIG. 4



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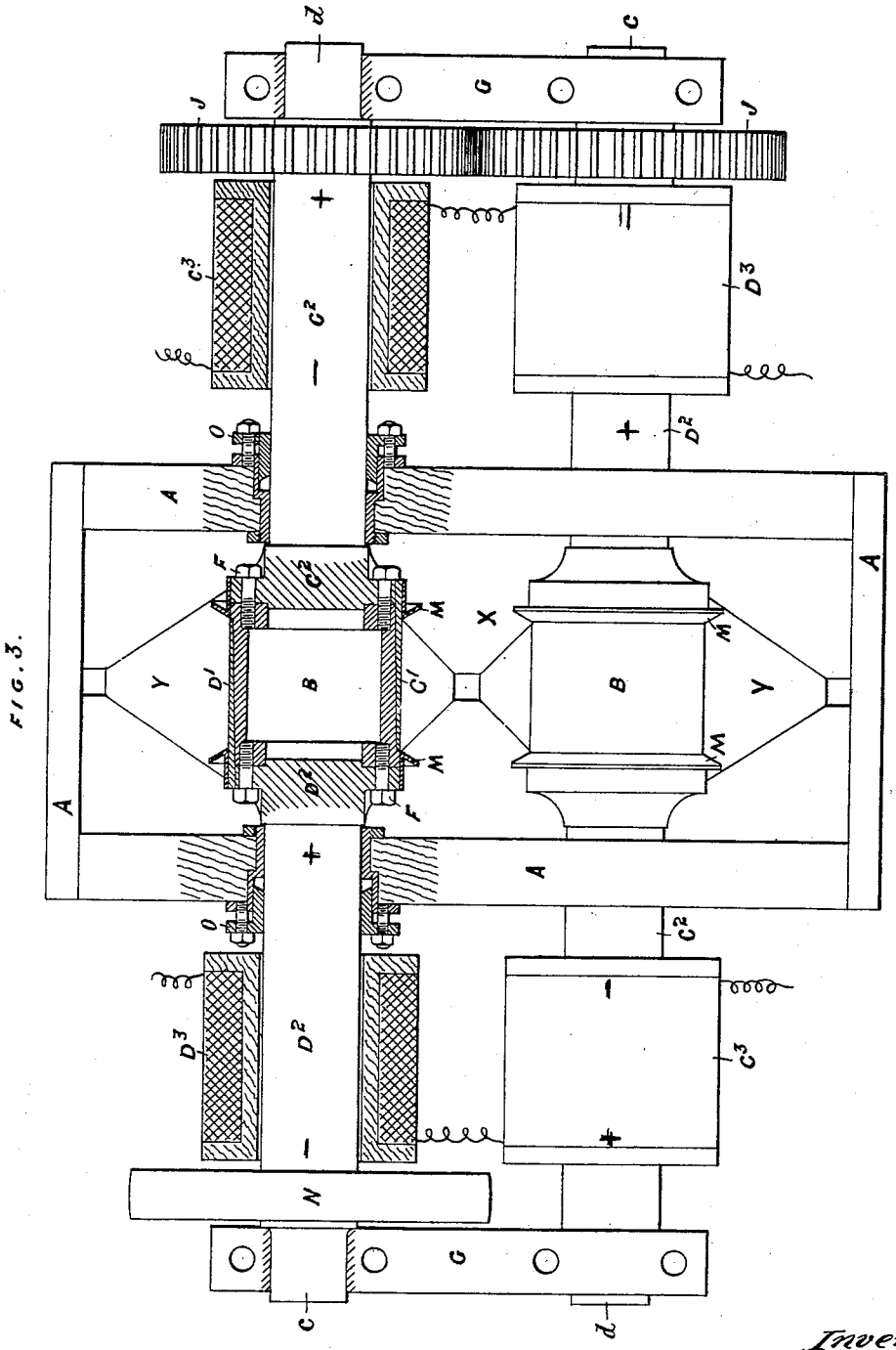

FIG. 3.

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UNITED STATES PATENT OFFICE.

CHARLES FREDERICK COURTNEY AND ROBERT BUTTERWORTH, OF BROKEN HILL, NEW SOUTH WALES.

MAGNETIC SEPARATOR.

SPECIFICATION forming part of Letters Patent No. 655,433, dated August 7, 1900.

Application filed March 19, 1900. Serial No. 9,285. (No model.)

To all whom it may concern:

Be it known that we, CHARLES FREDERICK COURTNEY, mine-manager, residing at Sulphide street, and ROBERT BUTTERWORTH, electrician, residing at Argent street, Broken Hill, New South Wales, subjects of the Queen of Great Britain, have invented new and useful Improvements in Magnetic Separators, of which the following is a specification.

Our invention relates to the industrial magnetic separation of paramagnetic substances, particularly those of low magnetic permeability, from ores and mixtures with which they are associated by passing said ores or mixtures in a comminuted state through a condensed or concentrated magnetic field.

The invention is more especially designed for the treatment of Broken Hill sulphide ores and tailings, and is particularly adapted for treating materials in the wet state, the object being to effect the separation in the most economical manner and without employing expensive or delicate apparatus, and especially without using belts or bands for feeding the material to the machine, the objection to the employment of belts or bands being, as is well known, that these appliances, besides requiring frequent renewal, do not readily lend themselves to operation with a wet process.

According to our invention the comminuted ore or other mixture is caused to pass through a highly-concentrated magnetic field in the form of a thin film, so as to avoid risk of the paramagnetic particles becoming prematurely detached from the magnetic poles and swept away by contact with the passing stream of matter of lower magnetic permeability with which they are associated. Further, by our invention the material under treatment is prevented from falling freely in space under the influence of gravity until the moment when the material enters the magnetic field, so that the paramagnetic particles contained in the mixture, however low their magnetic permeability, are not liable to become lost in consequence of their passing over or escaping from the magnetic poles under the influence of momentum acquired previous to their entrance into the magnetic field. From the moment of such entrance, however, and so long as the material remains within the magnetic field all the particles occupy a position wherein they are directly subjected to the influence of gravity acting in opposition to the magnetic attraction. Consequently since those particles which are paramagnetic or possess a higher degree of magnetic permeability are then retained by such attraction, while those particles which are diamagnetic or possess a lower degree of magnetic permeability are at the same time free to fall out of the magnetic field by their own weight, a practically-thorough separation is effected between these constituents of the ore or other mixture.

Our invention is also adapted to effect the separation of paramagnetic substances of different degrees of magnetic permeability, since by suitably regulating the intensity of the magnetic field and the time during which the material under treatment is permitted to remain within the influence of the magnetic attraction a substance having a certain degree of magnetic permeability may be separated from one contained in the same mixture, but possessing a lower degree of magnetic permeability.

The apparatus of our invention comprises an electromagnet having multiple pole-pieces, the positive and negative pole-pieces of the series being presented in alternation with one another around the periphery of a non-magnetic cylindrical drum, to which they are attached. The drum is mounted to revolve about a horizontal axis within a casing, the gudgeons or trunnions by which the drum is supported and rotated being constituted by the cores of the electromagnet, the pole-pieces of one sign being connected to the core forming the gudgeon or trunnion at one end of the drum and the pole-pieces of the contrary sign being connected to the core forming the gudgeon or trunnion at the opposite end of the drum. The apparatus further comprises a feed-hopper for the material to be treated provided with a distributing-roller and delivery-chute for feeding the material onto the upper part of the drum, a brush for removing such portion of the material as adheres to the drum, and independent bins for receiving the separated components of the

mixture. The apparatus so constituted may be combined together in pairs, as hereinafter described, each pair being contained within a single casing, so as to form a double machine.

In the accompanying drawings, forming part of this specification, Figure 1 is a side elevation of the apparatus forming one-half of a double machine, the casing being shown in section on line *a b*, Fig. 2. Fig. 2 is an end elevation of a double machine, the one drum and its appurtenances being shown in elevation and the other in section. Fig. 3 is a plan of the same, partly in section. Fig. 4 is a cross-section of two adjacent pole-pieces, drawn to a larger scale; and Fig. 5 is a detail of a modification with parts in section.

The two drums with corresponding hoppers, brushes, &c., shown in the drawings as contained within a single casing being duplicates of one another, it is only necessary that we should describe one drum with its associated apparatus.

B is the cylindrical drum, of non-magnetic material—such as brass, for example—mounted to revolve about a horizontal axis within a wooden casing A, the end gudgeons C^2 D^2, which support the drum and by one of which rotary motion is communicated thereto, being respectively constituted by the cores of an electromagnet or, as in the case illustrated, by one core of each of two electromagnets constructed as hereinafter described. The gudgeons are attached to the drum by screws F. The drum B carries a series of positive and negative pole-pieces C′ D′, of soft iron, whereof those C′ of the one sign are connected at one end to the gudgeon C^2, which supports that end of the drum, and those D′ of the contrary sign are connected at the other end of the drum to the gudgeon D^2, the pole-pieces of the one and of the other sign respectively alternating with one another around the periphery of the drum to whose axis they are placed parallel. The pole-pieces C′ D′ are partly countersunk in the wall of the drum, as shown in Fig. 4, and are attached thereto and to the cores C^2 D^2, to which they respectively appertain, by means of screws E. In order to obtain a highly-concentrated magnetic field, the pole-pieces project slightly beyond the surface of the drum, as shown, and are made to taper from their point of connection with the corresponding cores, so that the adjacent edges of adjoining pole-pieces are parallel to one another and expose between them a strip of the surface of the non-magnetic drum B. By this construction and arrangement the longitudinal side edges of the pole-pieces have greater length than would be the case if said edges of each pole-piece were parallel, and the magnetic field is therefore increased in extent. By the construction and arrangement as a whole the magnetic field produced is most intense between the edge of one pole-piece and the adjacent edge of the next pole-piece of opposite sign, the intensity being uniform throughout the length of the drum.

The gudgeons C^2 D^2, upon which the drum B rotates, pass out through stuffing-boxes O, in which they are journaled in the ends of the casing A, and thence through the bobbins C^3 D^3 of the electromagnet-coils, of which they respectively form the cores. The bobbins C^3 D^3 might be arranged to rotate with their respective cores C^2 D^2; but as this would involve the use of brushes to convey the current to the coils we prefer to keep the bobbins stationary, mounting them upon brackets H, fixed outside the casing A, and making the bobbins an easy fit upon their cores, so that the latter may rotate freely within them.

In a double machine, such as illustrated, two electromagnets are employed, one magnet being placed at each end of the machine and each magnet being connected with both drums, the positive and negative poles of the two magnets alternating with one another, as shown in the plan view, Fig. 3—that is to say, each drum is supported by the positive pole of the one magnet and the negative pole of the other magnet, the positive and the negative poles of the magnet which is at one end of the machine being respectively opposite to the negative and the positive poles of the magnet which is at the other end of the machine.

The cores C^2 D^2 of each electromagnet are coupled together by a yoke G, consisting of a bar of soft iron bored transversely to form bearings in which the outer extremities *c d* of the two gudgeons presented at the same end of the machine are journaled and supported, as shown in Fig. 3, the yoke G being bolted to a bracket or pedestal *g*, Fig. 1, of wood or other non-magnetic material. Upon one of the cores or gudgeons is keyed a pulley N, whereby rotary motion is communicated to the drum from some source of power, and in a double machine, as illustrated, the two drums B are geared together by spur-wheels J, of non-magnetic material, keyed on the respective gudgeons, the drums consequently rotating in opposite directions, as indicated by the arrows in Fig. 2. It will be apparent that the magnet-cores C^2 D^2 and coils C^3 D^3 form integral portions of the mechanism of the apparatus, while the pole-pieces C′ D′, being held in place by screws, are readily renewable, so that the maintenance of the efficiency of the apparatus involves no unnecessary waste.

Above the drum B is fixed a feed-hopper P, having a discharge-aperture consisting of a narrow slit, beneath which is mounted a horizontal distributing-roller Q, driven by geared wheels R from the gudgeon at one end of the drum. An inclined chute S is so placed as to receive from the roller Q the material to be treated and to deliver the same upon the upper part of the periphery of the drum B, which is provided at each end with an outwardly-

flaring guide-flange M, whereby the material is confined within the active portion of the peripheral surface of the drum—that is to say, within the lateral limits of the concentrated magnetic field.

T is a brush, of non-magnetic material, for removing from the drum such particles of the material under treatment as adhere to the drum by magnetic attraction, the brush extending between the flanges M M and being so placed that any point on the periphery of the drum after passing beneath the chute S will perform about three-fourths of a revolution before encountering the brush. A bin X is placed beneath the drum B at the same side as the brush T, so as to receive the particles removed thereby from the drum, while another bin Y is placed contiguous to X in order to receive those particles which fall from the drum by gravitation alone. The brush T is mounted in guides, so as to be adjustable for wear.

Our invention is adapted for treating either wet or dry material. We prefer to treat the material in a wet state, and the apparatus in the form illustrated in the drawings is specially designed for the wet system of treatment. To this end the casing A is made watertight and in operation is filled with water to such a level as to cover the drums and pole-pieces, the stuffing-boxes O affording freedom of rotation to the gudgeons C^2 D^2, while preventing the escape of water. The bearings of the spindle which carries the feed-roller Q are likewise provided with stuffing-boxes.

In operation the electromagnet-coils C^3 D^3 are supplied with current of a strength proportioned to the degree of concentration required in the product, and the drum B being rotated at a suitable speed the pulverized ore or other mixture is fed into the hopper P, whence it is received by the roller Q, which distributes it evenly upon the inclined chute S, whereby the material is gently delivered in a thin uniform film upon the upper part of the drum. By the revolution of the drum in the direction indicated by the arrow *b* the particles composing the film of material are at once subjected to the influence of gravity, acting in opposition to that of the magnetic attraction, and are eventually carried around to a point where those particles which are non-magnetic or possess a lower degree of magnetic permeability fall off the drum by their own weight and are received in the bin Y, whose edge is situated a little beyond the lowest point reached by the periphery of the drum in its rotation, so as to insure that no such particles as fall from the drum by gravitation alone shall find their way into the bin reserved for the more magnetic particles. Those particles which adhere to the drum by magnetic attraction are carried (by the continued rotation of the drum) beyond the range of the bin Y and thence upward until they are arrested and removed from the drum by the brush T, which deposits them in the bin X.

If it be desired to effect further concentration by a repetition of the above-described process, the contents of either or of both bins may be conveyed to a second apparatus in order to again undergo similar treatment.

The herein-described apparatus besides being adapted to the separation of paramagnetic from diamagnetic substances may also be used for the separation of paramagnetic substances possessing different degrees of magnetic permeability by suitably regulating the speed of rotation of the drum B and the strength of the electric current whereby the magnets are excited. The pole-pieces may be projected from rings D^4 C^4, so forming crowns, as represented in Fig. 5, and which will be shrunk onto the cores. Reverting to the pole-pieces C′ D′, we would have it understood that they may be run in with white metal or other non-conducting material in lieu of recessing them, as shown on Fig. 4, and also that a lesser number of such pieces may be employed than is shown on Figs. 1 and 2.

We claim—

1. A magnetic separator, comprising two cores, energizing-coils for said cores, a rotary separating-drum supported between the inner ends of said cores and having a series of longitudinal spaced pole-pieces connected alternately with the said inner ends of the cores, the said pole-pieces being tapered from those ends which are connected with the cores toward their free ends, the surface of the non-magnetic drum being exposed between the pole-pieces, and means for feeding the material to said drum.

2. A magnetic separator, comprising two spaced axially-alining rotary cores having flanges at their inner ends, stationary energizing-bobbins surrounding said cores, a rotary separating-drum of non-magnetic material arranged between the inner ends of said cores and secured to the said flanges, the said drum having a series of longitudinal spaced pole-pieces connected alternately with the flanges of said cores, the said pole-pieces being tapered from those ends which are connected with the cores toward their free ends, the said drum being provided at each end with a guide-flange to confine the material within the active portion of the peripheral surface of the drum, an adjustable brush extending between the said flanges, and means for feeding the material to the said drum, substantially as described.

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