No. 855,166. PATENTED MAY 28, 1907.

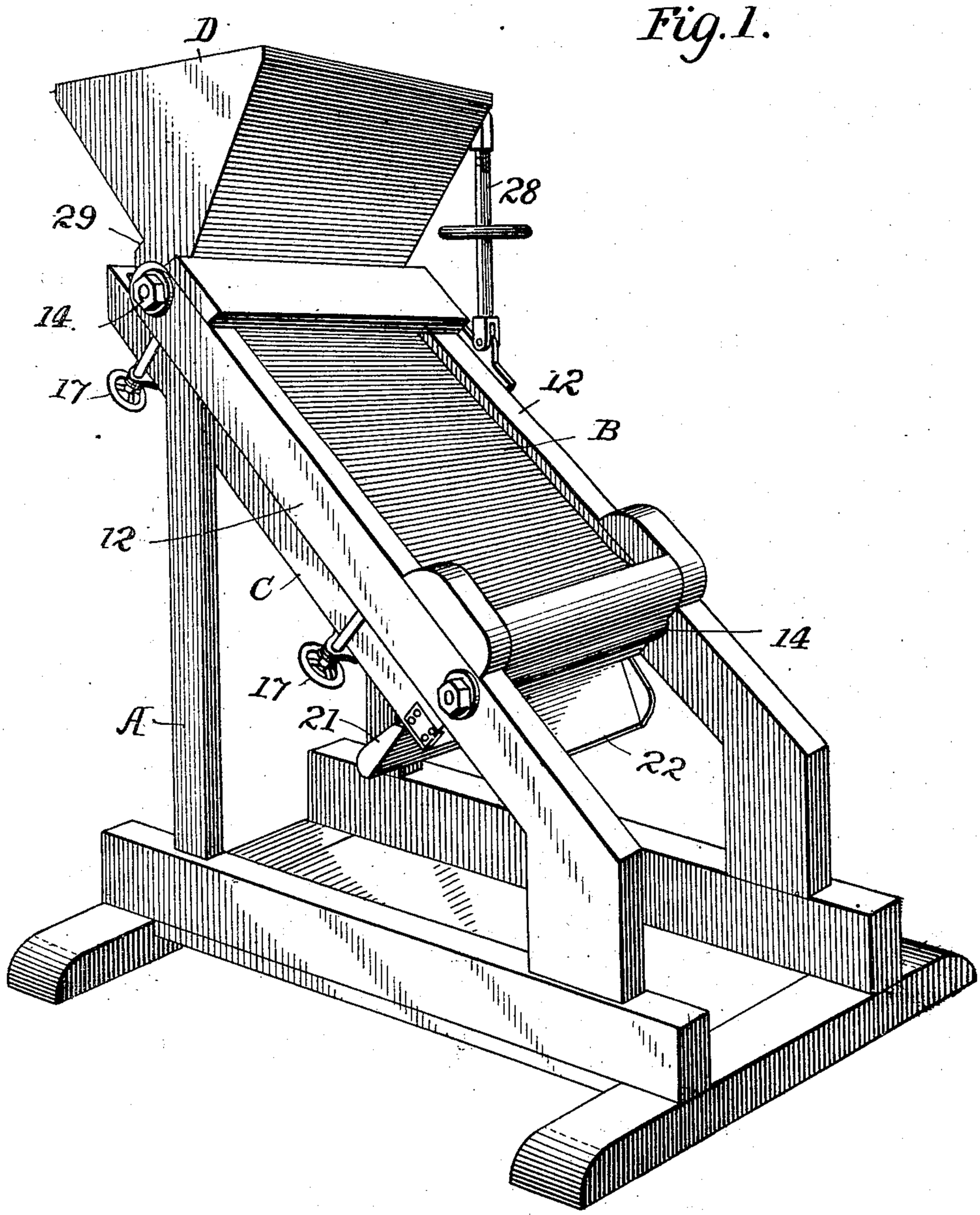
E. A. EDWARDS.

MAGNETIC ORE SEPARATOR.

APPLICATION FILED JULY 30, 1904.

3 SHEETS—SHEET 1

Fig. 1.



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3 SHEETS—SHEET 2.

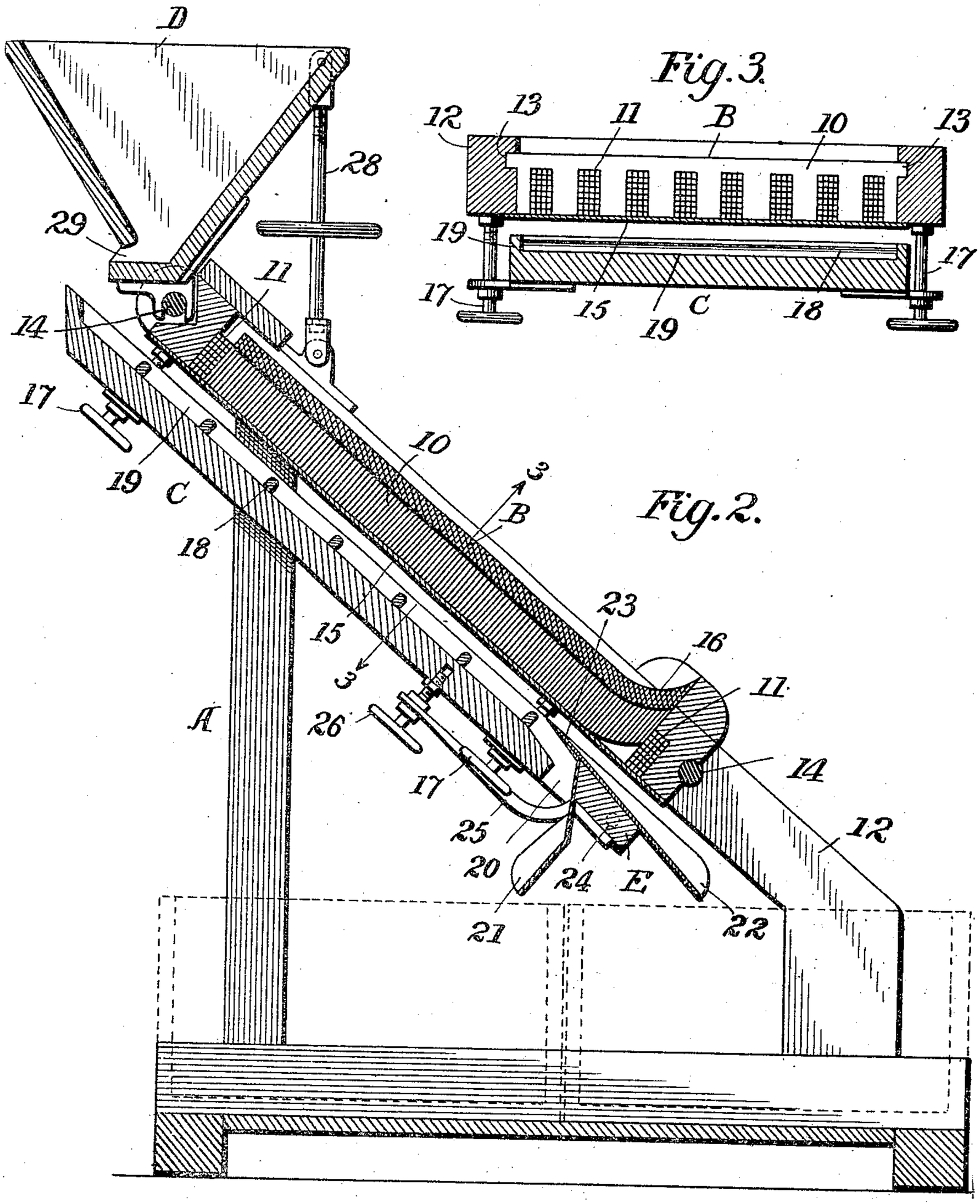

Fig. 2.

Fig. 3.

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3 SHEETS—SHEET 3.

Fig. 4.

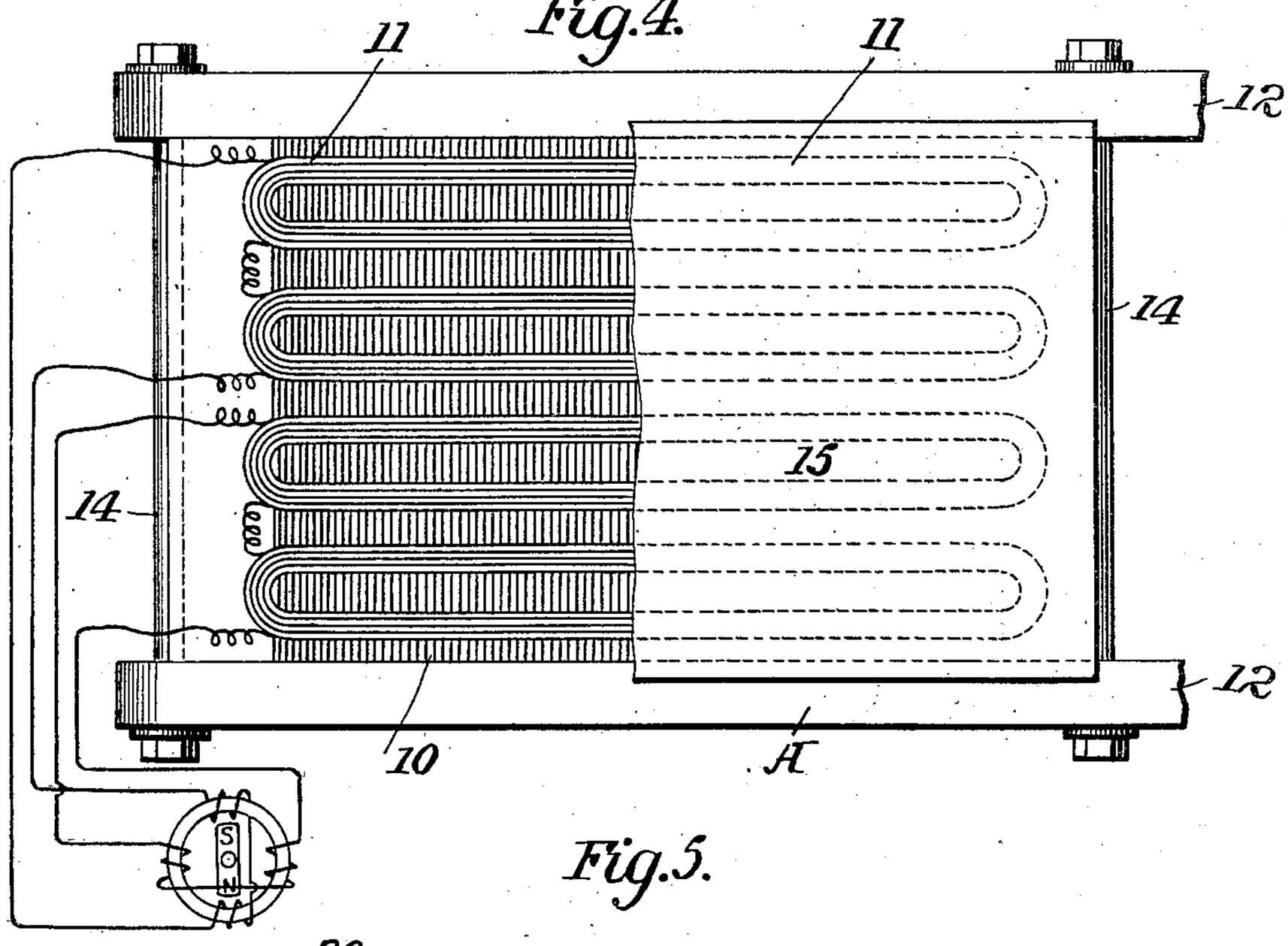


Fig. 5.

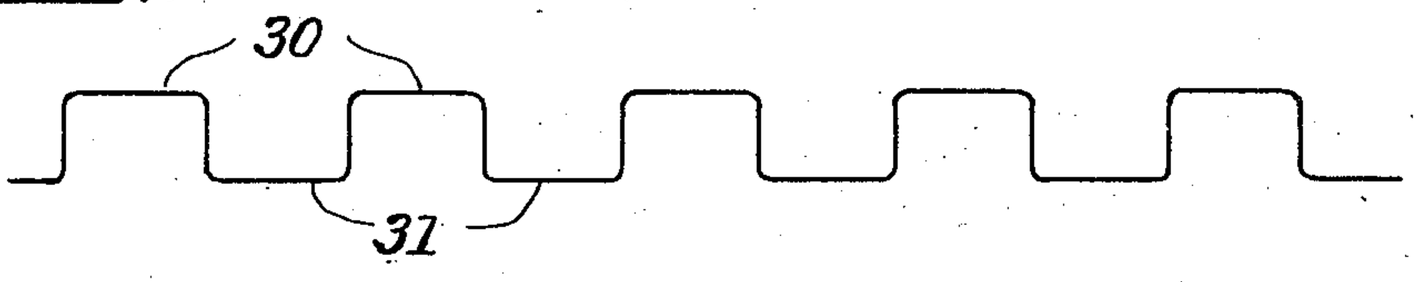
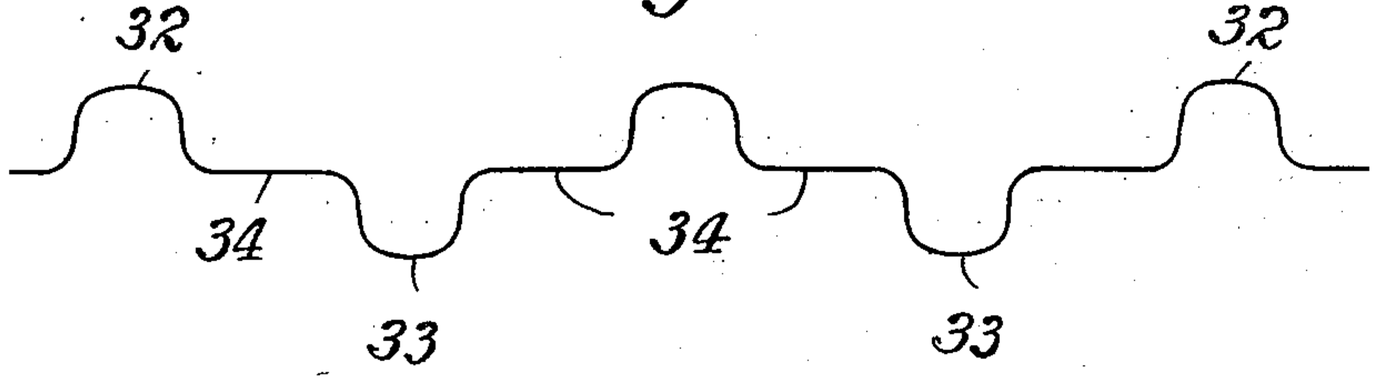


Fig. 6.



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UNITED STATES PATENT OFFICE.

EDGAR A. EDWARDS, OF CINCINNATI, OHIO, ASSIGNOR TO ALICE V. EDWARDS, OF CINCINNATI, OHIO.

MAGNETIC ORE-SEPARATOR.

No. 855,166. Specification of Letters Patent. Patented May 28, 1907.

Application filed July 30, 1904. Serial No. 218,793.

To all whom it may concern:

Be it known that I, EDGAR A. EDWARDS, a citizen of the United States, and a resident of Cincinnati, Hamilton county, State of Ohio, have invented certain new and useful Improvements in Magnetic Ore-Separators, of which the following is a specification.

This invention relates to improvements in electro-magnetic separators for separating magnetic from non-magnetic material, such for instance, as finely divided magnetic iron ore from sand and other non-magnetic material with which it is usually associated in natural deposits.

The invention will be described in connection with the accompanying drawing, in which,

Figure 1 is a perspective view of an electromagnetic separator embodying the invention Fig. 2 is a vertical sectional view of the same; Fig. 3 is a section on the line 3—3 of Fig. 2; Fig. 4 is a bottom plann view partly broken away of the electromagnetic element; Fig. 5 is a diagrammatic representation of an electric current adapted to the present invention; and Fig. 6 is a similar representation of another form of current;

The invention is designed chiefly for the extraction of magnetic iron ore from its associated impurities although it is adapted for the separation of any magnetic material from non-magnetic material. In the following specification we shall term the mixture of materials to be operated on as "stock," the iron or other magnetic material as "ore" and the sand or other non-magnetic material as "gangue". In carrying out the process the stock is fed in regulated quantity to the under surface of a magnetic element, which element is inclined at an angle at 40 degrees, more or less, to a horizontal plane. The magnetic element, which is an electromagnet, is alternately magnetized and demagnetized preferably in such a manner as to provide for periods of magnetic energy and alternate periods of rest. The ore separates from the gangue more or less immediately upon coming under the influence of the magnet, to which it is attracted. The ore however carries with it initially to the magnet a considerable quantity of gangue. As the magnetic element is alternately de-magnetized and magnetized the ore alternately drops by gravity a short distance and is again drawn to the magnet. The ore thus travels down the under face of the magnetic element being successively attracted and released, which gives it a vibratory movement resulting in the shaking off or out of all of the gangue, which drops by gravity. The ore in this manner follows the magnetic element to its lower end where it is discharged into a suitable receptacle.

By a period of rest is meant one during which the magnetization of the element is less than sufficient to retain the magnetic particles and consequently they fall away from the element. It will be obvious therefore that during a period of rest the element is not necessarily devoid of magnetization, but that the magnetization is below a certain value as described. On the other hand, the element may become totally devoid of magnetization without producing a period of rest, as, for example, where the element is excited by alternating currents of any of the usual commercial frequencies. There, although the magnetization of the element is zero for an instantaneous period, the successive impulses of current occur so rapidly that the magnetic particles are continuously retained and no period of rest occurs, as the term is employed in the specification. The same results would be obtained if a direct current circuit for energizing the element were made and broken with high frequency. Periods of rest might, however, be obtained with either the direct or alternating current arrangement if the frequency were made low enough so that the magnetic particles were not continuously attracted.

It may be remarked that in the apparatus shown the magnetic particles will not move from top to bottom of the element unless periods of rest occur, for the working face of the element is stationary and the field is longitudinally stationary, rising and falling in value but not moving longitudinally of the face. It will therefore be obvious that unless periods of rest occur when gravity can move the magnetic particles downwardly, there will be no movement of the particles along the element.

While the magnetic field does not move longitudinally of the element, that is, parallel to the flow of the magnetic particles, it

does, according to certain features of the invention, as hereinafter set forth, move transversely of the element.

The process above described may be carried out by means of an electromagnet in circuit with a direct electric current and provided with means for periodically interrupting the circuit at regular intervals, by means of which the magnetic element is alternately magnetized and de-magnetized. It is preferable, however, to use an alternating current having periods of rest between its positive and negative sine curves or loops which periods of rest are uniform and preferably substantially equal to the intermediate periods of action.

In carrying out the invention it is preferable to arrange a riffle board or tray beneath and substantially parallel with the operative surface of the magnetic element. The stock is fed onto the upper end of the riffle tray and it passes by gravity over the same, being at all times within the field of the magnetic element. As the stock travels over the tray it is caused to turn over by the riffles and thus, during its passage over the tray, all particles of ore are exposed to the influence of the magnet and withdrawn from the gangue. While the larger part of the ore is withdrawn at the upper end of the tray it is found that the stock must travel an appreciable distance over the tray before all of the ore is withdrawn and the length of the tray and the magnet are so proportioned that the separation of the ore from the gangue will be completed before the gangue is discharged from the lower end of the tray. The invention will now be described in detail.

Referring to the drawing A indicates the frame of the apparatus, B the magnetic element, C the riffle tray and D the hopper. The magnetic element B is built up of a series of soft steel plates 10 separated by suitable insulation and forming the poles. The plates 10 are toothed and provided with coils 11 surrounding the alternate groups of teeth as illustrated in Figs. 3 and 4. The plates 10 may be of any desired size, depending upon the desired capacity of the machine. As shown there are two pairs of coils, the coils of each pair being connected in series. It is preferred to arrange the coils in multiples of two for a purpose to be presently described. The plates 10 are suitably supported in a frame 12. As shown they are provided with shoulders 13 which engage grooves in the side bars of the frame and the side bars are connected by bolts 14, 14. The entire under surface of the magnetic element is covered by a non-magnetic plate, preferably of brass, which provides a smooth surface for the passage of the ore and covers the laminæ and coils of the magnet, and forms a working face for the magnet.

At the lower end of the magnet the plates 10 gradually recede from the face 15 of the magnet as indicated at 16, the object being to gradually reduce the force of the magnet and thus permit the ore to drop completely away from it.

The riffle tray C is adjustably supported below the face 15. As shown in Figs. 2 and 3 the tray is adjustably supported on the frame by screws 17 and it may be locked in any desired position by means of lock nuts or other suitable devices. The tray is provided at intervals with riffles 18 extending across its face and at the sides it is provided with flanges 19 to prevent the escape of the material.

At the lower end of the tray is a guide E adapted to direct the ore to one receptacle and the gangue to another. Between the lower end of the tray and the guide E is an opening 20 through which the gangue escapes and the guide E is preferably provided with a chute 21 to direct the gangue. On the upper side of the guide E is a second guide plate or chute 22 which receives the ore from the magnet and directs it to a place of deposit. The upper end 23 of the guide E overlaps the opening 20 to prevent any of the ore from dropping through said opening in case it is temporarily released from the magnet when passing said opening. The guide E is pivoted to the frame at 24 and is adjustable upon its pivot by means of an arm 25 and an adjusting screw 26.

The hopper D is arranged at the upper end of the magnet and tray and it is preferably adjustable to vary the feed. As shown this is accomplished by mounting the hopper pivotally on a bar or support, and connecting it with the main frame by an adjusting screw 28. The material is fed through a mouth 29 at the bottom of the hopper and the flow of material will depend upon the angle at which the hopper is set. The material discharged from the hopper falls upon the upper end of the riffle tray, as previously stated.

In Fig. 5 is indicated in diagram a direct electric current adapted to operate the apparatus. Any well known means may be employed to interrupt the current to produce periods of energy and rest as indicated at 30 and 31 respectively on the diagram, these periods being preferably of about the same duration. It has been found preferable however to use an alternating current having the peculiar properties indicated in Fig. 6 in which 32 indicates the positive sine curves or loops, 33 the negative sine curves or loops, and 34 intermediate periods of rest during which the magnetic element becomes demagnetized. The alternating current described effects alternate reversals of the magnetism of the magnetic element, and of the ore particles, with the result that the ore is more freely agitated in its descent over the face of the magnet and the separation of the

gangue greatly facilitated. Any well known means may be utilized for producing the alternating current described. In the operation of the apparatus the frequency of the alternating current must be comparatively low. It has been found that a frequency of from 6 to 8 cycles per second works well in actual practice although this may be varied with different conditions of ore and different proportions of apparatus. Similarly, the number of interruptions per second of the direct current when used should be adapted to the conditions of ore and apparatus prevailing.

The operation of the invention will be understood from the foregoing description and need only be briefly referred to. The apparatus operates continuously, it being only necessary to keep the hopper supplied with stock and to provide for the removal of ore and gangue. The stock falls in a continuous stream from the hopper onto the upper end of the tray and it flows by gravity down the tray and over the riffles. As it descends the riffles retard the flow and tend to turn the stock, presenting all of the particles in turn to the magnet. The ore, as presented to the magnet, is drawn away from the gangue and it travels down the face of the magnet, being alternately released and immediately reattracted before reaching the tray. Substantially complete separation of the ore and gangue is effected before the materials reach the lower end of the tray and the gangue then passes out through the opening 20 while the ore is carried over the guide E and delivered onto the chute 22.

It will be understood that any suitable means for feeding the stock continuously may be substituted for the hopper.

The adjustable riffle tray is an important feature of the invention. It is found that the tray must be adjusted with respect to the magnet to suit the particular material being operated on, some classes of material requiring the tray to be closer to the magnet than others. It is also found preferable in some instances to adjust the tray closer to the magnet at its upper end than at its lower end as the ore accumulates on the face of the magnet in depending masses or tufts which tend to lengthen toward the lower end of the magnet. In the operation of the machine these masses of ore descend along the face of the magnet step by step and at each period of rest in the magnet they open up and separate slightly thus freeing any gangue that may be carried with them and permitting it to drop to the tray.

It is preferred to couple the circuits in pairs as indicated in Fig. 4 and to so arrange the generator or commutator that the periods of rest in one-half of the circuits will be simultaneous with the periods of energy in the other half, thus rendering the load upon the motor substantially uniform.

Having described my invention what I claim and desire to secure by Letters Patent is,

1. In an electro-magnetic separator, the combination with an inclined magnetic element the under surface of which co-operates with the material under treatment, of a circuit therefor, a source of energy adapted to produce in said circuit an alternating current having periods of rest between successive alternations, and means for feeding stock beneath said element, substantially as described.

2. In an electro-magnetic dry separator, an inclined magnetic element having a laminated core the under surface of which co-operates with the material under treatment, means for alternately energizing said element positively and negatively and causing periods of rest between successive energizations, and means for feeding stock to the under surface of said element, the inclination of said element being such that the magnetic particles move along its under surface unaided except by gravity and magnetism, substantially as described.

3. In an electro-magnetic separator, the combination with an inclined magnetic element, of means for periodically energizing said element and causing periods of rest between successive energizations, an inclined stationary tray arranged beneath said element and adapted to convey the stock along the magnetic element, and means for feeding stock between said element and tray, the inclinations of said element and tray being such that the stock will travel along the same unaided except by gravity and magnetism, substantially as described.

4. In an electro-magnetic separator, the combination with an inclined magnetic element, of means for periodically energizing said element and causing periods of rest between successive energizations, an inclined stationary tray arranged beneath said element and adapted to convey the stock along the magnetic element, means for feeding stock between said element and tray, the inclinations of said element and tray being such that the stock will travel along the same unaided except by gravity and magnetism, and means for adjusting the tray to and from said element, substantially as described.

5. In an electro-magnetic separator, the combination with an inclined magnetic element, of means for periodically energizing said element and causing periods of rest between successive energizations, an inclined stationary tray arranged beneath said element and adapted to convey the stock along the magnetic element, means for feeding

stock between said element and tray, the inclination of said element being such that the stock will travel along the same unaided except by gravity and magnetism, and independent means at each end of the tray for adjusting the respective ends of the tray to and from the magnetic element, substantially as described.

6. In an electro-magnetic separator, the combination with an inclined magnetic element, of means for periodically energizing said element and causing periods of rest between successive energizations, an inclined tray arranged beneath said element and adapted to convey the stock along the magnetic element, means for feeding stock between said element and tray, the inclination of said element being such that the stock will travel along the same unaided except by gravity and magnetism, and a guide at the lower end of said tray adapted to direct the ore and gangue to their respective places of deposit, substantially as described.

7. In an electro-magnetic separator, the combination with an inclined magnetic element, of means for periodically energizing said element and causing periods of rest between successive energizations, an inclined tray arranged beneath said element and adapted to convey the stock along the magnetic element, means for feeding stock between said element and tray, the inclination of said element being such that the stock will travel along the same unaided except by gravity and magnetism, and a guide interposed between the tray and magnetic element, substantially as described.

8. In an electro-magnetic separator, the combination with an inclined magnetic element, of means for periodically energizing said element and causing periods of rest between successive energizations, an inclined tray arranged beneath said element and adapted to convey the stock along the magnetic element, means for feeding stock between said element and tray, the inclination of said element being such that the stock will travel along the same unaided except by gravity and magnetism, a guide at the lower end of said tray adapted to direct the ore and gangue to their respective places of deposit, and means for adjusting said guide, substantially as described.

9. In an electro-magnetic separator, the combination with an inclined magnetic element the under surface of which co-operates with the material under treatment, and with means for feeding stock to the under surface of said element, means for positively and negatively magnetizing the coils with periods of rest between energizations, and means for causing said field to shift transversely of the magnetic element, for the purpose set forth.

10. In an electro-magnetic separator, the combination of an inclined magnetic element having a series of coils arranged transversely to the flow of the magnetic particles along said element, a common source of current for said coils, means for feeding stock beneath said element, and means for successively energizing and de-energizing said coils, and producing periods of rest between successive energizations, the period of rest of one coil occurring when the adjacent coil is energized, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

EDGAR A. EDWARDS.

Witnesses:

HUGH M. STERLING,

JAMES A. WATSON.