R. W. COUSINS.

MAGNETIC SEPARATOR.

APPLICATION FILED SEPT. 11, 1908.

1,094,125.

Patented Apr. 21, 1914.

5 SHEETS—SHEET 1.

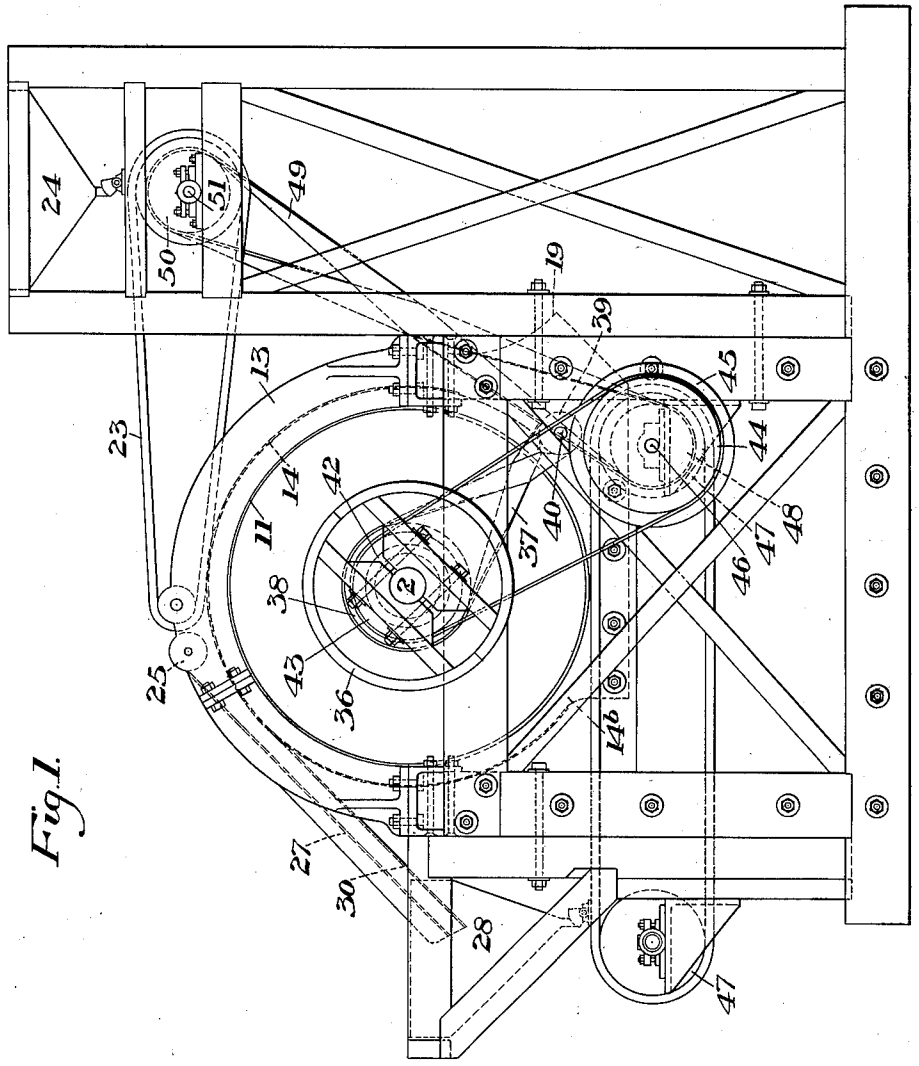


Fig. 1.

WITNESSES

W. W. Swartz

R. A. Baldeson

INVENTORS

R. W. Cousins

by Bakewell, Byrnes & Parmelee, their Attys

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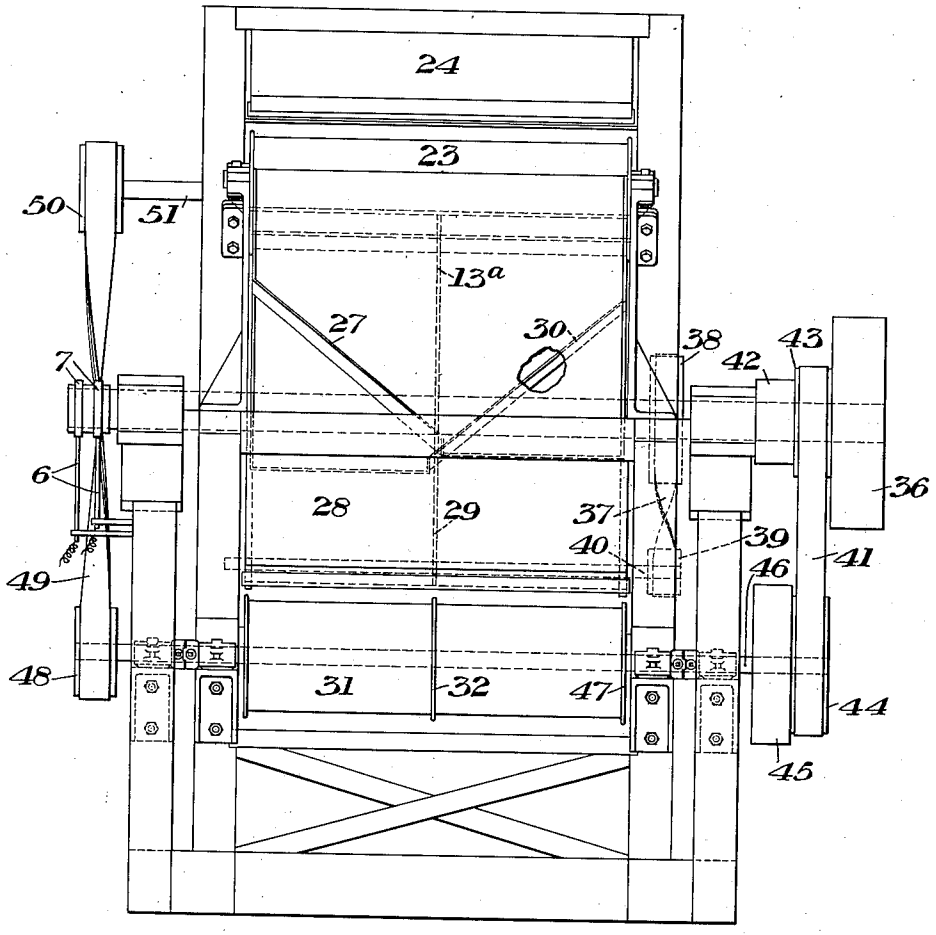
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5 SHEETS—SHEET 2.

Fig. 2.



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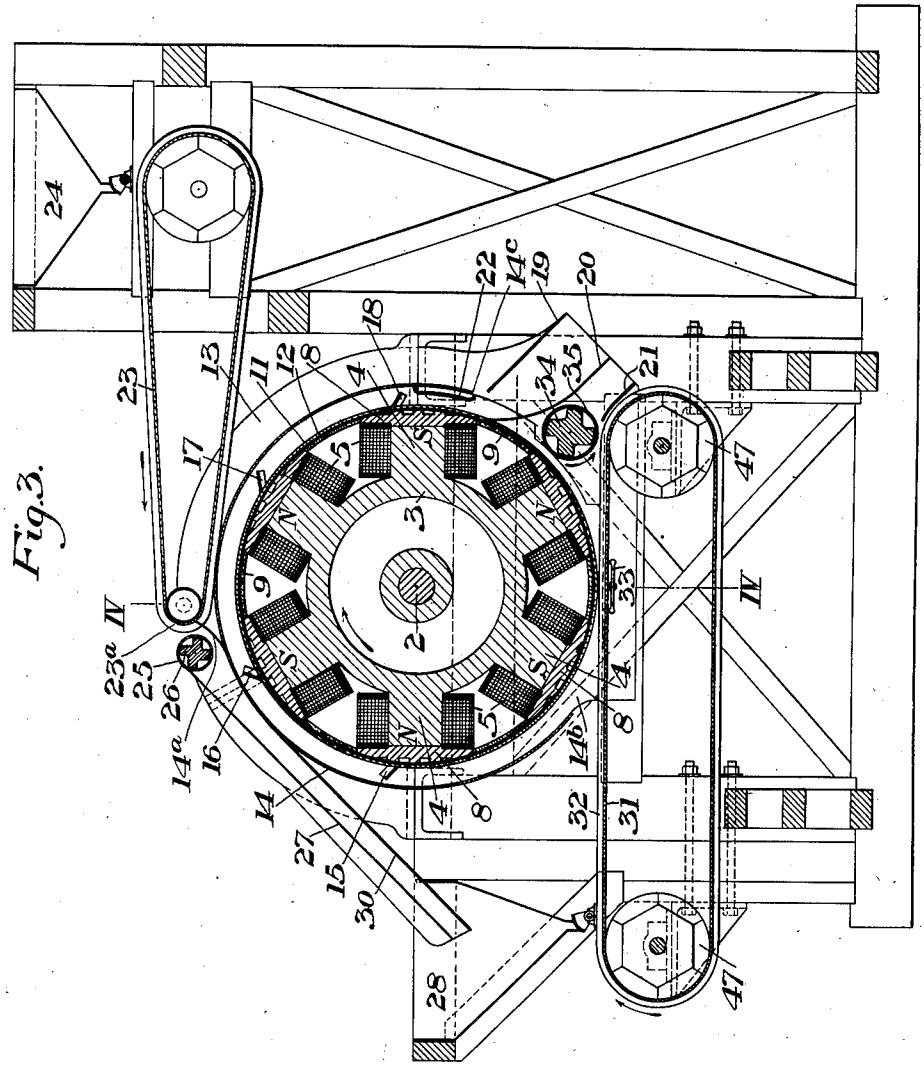
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5 SHEETS—SHEET 3.

Fig. 3.



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R. A. Balderson

INVENTOR

R. W. Cousins,

by Bakewell, Byrnes & Parmelee.
their Attys

R. W. COUSINS.

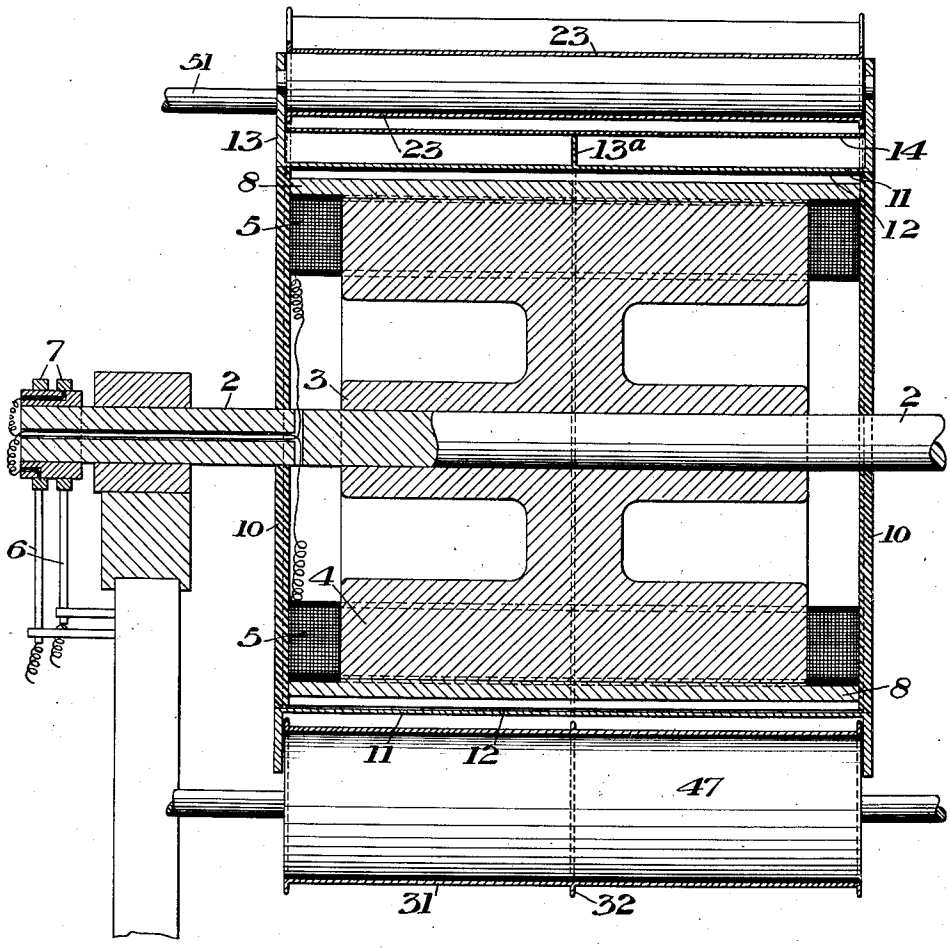
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5 SHEETS—SHEET 4.

Fig. 4.



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R. A. Balderson

INVENTORS

R. W. Cousins

by Bakewell, Byrnes & Parmelee, their Attys.

R. W. COUSINS.

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5 SHEETS—SHEET 5.

Fig. 5.

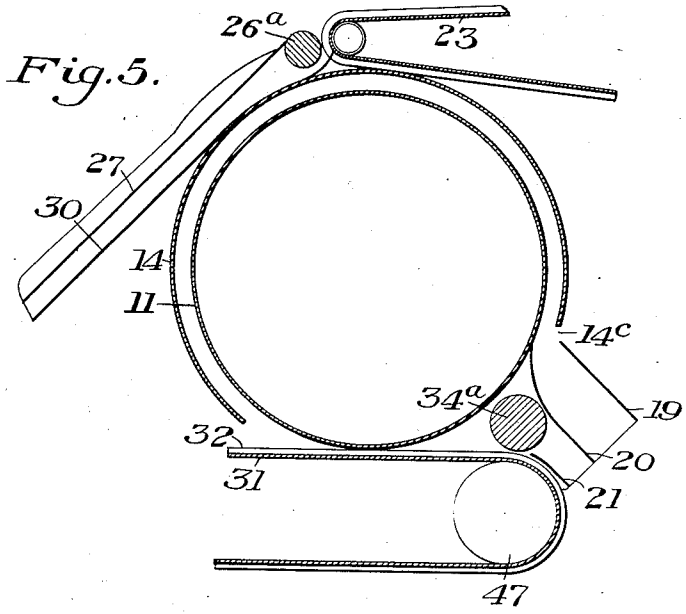
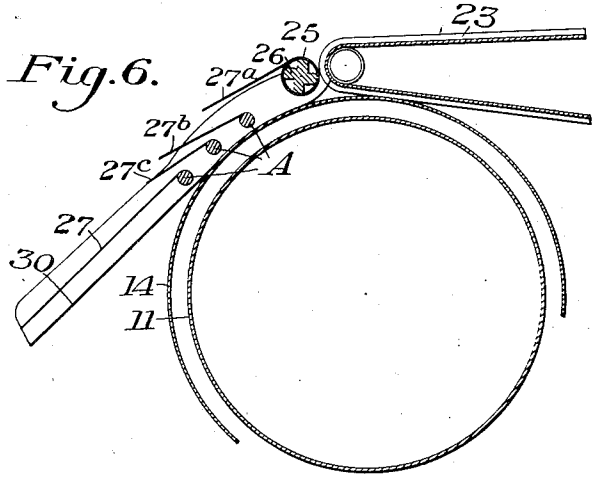


Fig. 6.



WITNESSES

R. A. Balderson.

Walter Famariss

INVENTOR

R. W. Cousins,

by Bakewell, Byrnes & Parmelee.

his Attys.

UNITED STATES PATENT OFFICE.

ROBERT W. COUSINS, OF CHICAGO, ILLINOIS.

MAGNETIC SEPARATOR.

1,094,125. Specification of Letters Patent. Patented Apr. 21, 1914.

Application filed September 11, 1908. Serial No. 452,584.

To all whom it may concern:

Be it known that I, ROBERT W. COUSINS, of Chicago, Cook county, Illinois, have invented a new and useful Improvement in Magnetic Separators, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a side elevation of one form of machine embodying my invention; Fig. 2 is an end view of the same from the left of Fig. 1; Fig. 3 is a longitudinal vertical section; and Fig. 4 is a transverse section taken on the line IV—IV of Fig. 3. Figs. 5 and 6 are views similar to Fig. 3 of modified forms, with a portion of the machine removed.

My invention relates to magnetic separation of material and is designed to provide a method and a machine of simple character by which a separation of magnetic from non-magnetic material can be rapidly, economically and effectively performed. The practicability of my invention has been thoroughly demonstrated by experiments.

My invention is of particular value for the treatment of comminuted blast furnace cinder and also for the treatment of the flue dust discharged from blast furnaces, but may be used to advantage for the treatment or separation of various other material containing iron or steel or any other magnetic material when combined with non-magnetic material.

The precise nature of my invention will be best understood by reference to the accompanying drawings, in which I have shown one embodiment thereof and which will now be described, it being premised, however, that various changes may be made therein by those skilled in the art, without departing from the spirit and scope of my invention, as defined in the appended claims.

In these drawings, the numeral 2 designates a shaft, which is supported in suitable bearings and is arranged to be positively rotated by any suitable driving means, such as hereinafter described. Rigidly secured to this shaft is a hub 3, of magnetic material, having a plurality of radially projecting core pieces 4 of magnetic material, each of which carries a coil or winding 5. These coils are wound in such manner as to give the projecting core pieces alternately a north and south polarity, when an electric current is applied to these coils by means of the brushes 6 and the collector rings 7. To each core piece there is attached a pole piece or shoe 8 of magnetic material, each having, as shown, a corrugated face. Filler blocks 9 of non-magnetic material are inserted between each pair of pole shoes 8. The filler blocks 9 and the pole shoes 8 form a cylindrical drum which completely incloses the revolving magnets. The ends of said drums may be inclosed with any suitable material, in order to exclude dust from the coils but preferably with cylindrical disks 10, made of fiber or brass.

A stationary cylindrical shield 11 of non-magnetic material, preferably of brass, incloses or surrounds the above described drum from which it is separated by an intervening air space 12. From the outer surface of each end of the cylindrical shield 11 vertical flanges 13 project, to which flanges a second cylindrical casing 14 of non-magnetic material is attached in such manner as to leave an air space of about two inches between the inner and outer casing. This air space or chamber is divided into two compartments by an intermediate partition wall 13^a. The casing 14 is continuous and incloses the casing 11 forming an air space between the casings, except at its lower side from 14^b to 14^c.

A plurality of bridges or baffles, such as 15, 16, 17 and 18 are attached longitudinally to the approximate upper half of the stationary cylindrical shield 11, which bridges project from its outer surface into the air space or chamber and in such manner as to leave a narrow opening between the outer edge of said bridges and the outer casing 14. These bridges form an acute angle with the direction of the rotation of the primary magnets 4. A partition plate 22, suitably shaped, is provided which divides the air chamber beyond the bridge 18 and between the casings 14 and 11 into two parts, the use for which being hereinafter described. A suitable curved plate 20 is attached at its upper end to the casing 11, upon which the magnetic material is discharged. A discharge plate 21 takes the material from the revolving magnet 34.

From a hopper or spout, or from any other suitable device, designated as 24, the material to be separated is fed on to the endless carrier or belt designated 23, which belt is suitably driven in the direction indicated by the arrow, in Fig. 3. At the point 23^a on the belt 23, an initial separation of the

material takes place and is effected in the novel manner hereinafter described. A shaft of magnetic material 25 supported in suitable bearings and carrying a plurality of longitudinally projecting arms, rotates in the direction indicated by the arrow, within the cylinder or casing 26, which is formed of non-magnetic material. The revolving shaft 25 and its projecting arms become secondary magnets, under the influence of the primary magnets 4.

At the point 23^a on the feeding belt 23, a portion of the magnetic material that is required to be separated from the non-magnetic under the influence of the revolving secondary magnet 25 is carried upward and around its non-magnetic casing 26, until it is deposited upon the inclined plate or chute 27, which material then travels down the inclined plates 27, under the influence of the force of gravity and the primary magnets, until it falls into one of the compartments of the hopper 28, which hopper is formed into two compartments by the vertical partition 29. The remaining portion of the magnetic, along with the non-magnetic material, falls upon the inclined plate 14^a, down which it travels and is deposited upon the outer non-magnetic casing 14, from which it is deposited upon the inclined plate 30, and thence it is discharged into the second compartment of the hopper 28. Upon the lower ends of plates or chutes 27 and 30, deflecting partitions are provided in order that the separated material may be deflected into its proper compartment in the hopper 28. (See Fig. 2.)

The material deposited by the inclined plates into each of the compartments of the hopper 28 is discharged on to the endless flanged carrier or belt designated as 31, which belt is suitably driven in the direction indicated by the arrow in Fig. 3. To the belt conveyer 31 is attached a vertical rib 32 longitudinally, which rib travels immediately under the vertical partition 29 of the hopper 28, and the vertical flange 13^a attached to the inner non-magnetic shield or casing 11, and this divides said belt into two parts by means of which the material which is deposited into each of the two compartments of the hopper 28 will be discharged on to separate portions of the belt 31 and thereby cause it to be thereafter treated separately in the two compartments, formed by the flanged partition 13^a in the air space between the inner case 11 and the outer case 14. A magnetic vibrator 33, composed of suitable material, supported and pivoted in the center, under the influence of the primary magnets 4, will be caused to act upon the lower side of the top portion of the belt 31 in order that the material carried thereon may not become compacted.

A shaft of magnetic material 34 supported in suitable bearings and carrying a plurality of longitudinally projecting arms rotates in the direction indicated by the arrow, within the cylinder or casing 35, which is formed of non-magnetic material. The revolving shaft 34 and its projecting arms become secondary magnets under the influence of the primary magnets; 34 is located above the rear end portion of the upper branch of the conveyer belt 31.

The moving parts of the machine may be driven in any suitable manner. In the machine illustrated in the drawing, I have shown the shaft 2 as having a driving pulley 36. A cross belt 37 from a pulley 38 on the shaft 2 drives a pulley 39 on the shaft 40 of the secondary magnet 34. A belt 41 from either of the pulleys 42 and 43 drives either of the pulleys 44 and 45 on the shaft 46 of one of the drums or rollers 47, which carries the feeding belt 31. The pulleys 48 on the shaft 46, by means of a cross belt 49, drives a pulley 50, carried by the shaft 51, of one of the rollers which carries the feeding belt 23.

The operation of the machine is as follows: The material to be separated is fed in comminuted or fine form from the hopper 24 on to the endless flanged belt or carrier 23, and is carried by it toward the revolving magnets 4. These magnets 4 are constantly rotating in the direction shown by the arrow, and they thus create a revolving secondary field in the magnetic material carried on the belt which has a tendency to raise and deposit such material on the top of the non-magnetic material and to rotate it in the direction of travel of the belt. Under the influence of the rotating secondary field of alternate north and south polarity, the magnetic particles are drawn together and built up into a large number of small thread-like bodies of varying length, which stand on end upon the surface of the belt in the lines of the radiating magnetic force of the primary magnets and these bodies of magnetic material are rotated or turned end for end, and also translated along in the direction of the belt, which motion results from a successive reversal of the polarity in the ends of the material next to the primary magnets. Each pole of the rotating primary magnets as it passes these threads of material forms therein a magnetic couple and thus turns them end for end, as the result of the polarity that was imparted to them by the preceding pole of the rotating magnet, which imparted polarity causes the following magnet to repel the ends of the bodies of material that are next this magnet, and in the direction of its motion, and to attract the opposite ends. The result of this induced revolving magnetic field is that the magnetic material travels on the belt in the direction of its motion, while the non-mag-

netic material remains at rest on the belt, which separates and aids the separation of the material. While this rotating field may be induced in the magnetic material by passing the carrier or belt over a series of stationary magnets arranged to have opposite polarity or by passing the carrier over stationary magnets having coils excited by an alternating current I prefer to use the arrangement which I have shown and described.

By the above described magnetic rotation the material on the carrier 23 is more or less completely separated into an upper layer of magnetic material and a lower layer of non-magnetic material when it reaches the point 23^a on the belt 23. A part of the magnetic material is then carried up on the outside of the casing 26 and deposited on the plate 27, which action is due to the revolving field induced in the magnet 25, by the primary magnets 4; it then moves down this plate by gravity and by the action of the revolving field and falls into one compartment of the lower hopper 28. A strong stationary magnetic field is produced in the space between the lower portion of the magnet 25 and the primary magnet 4, through which field any magnetic material that may fall upon the plate 14^a from the carrier 23 can not pass, which stoppage enables the secondary magnet 25 to take it up and deposit the greater part of such material on the plate 27. The non-magnetic material and any remaining magnetic material passes down the outside of the casing 14 on to the plate 30, and is deposited in the other compartment of the hopper 28. When the material moves over the plates or chutes 14^a and 30, and over the shield 14, its motion agitates it and while thus agitated, being subjected to the action of the rotating secondary field, its magnetic particles are drawn together and built up into small bodies by magnetic action, as hereinbefore described, which bodies of collected magnetic particles pass into the hopper 28 in a condition divided or separated from the non-magnetic portion of such material. This agitation sifts out and segregates the entangled magnetic particles from the non-magnetic, which aids and facilitates the future complete separation on the belt 31. The separate compartments to the hopper 28 and the longitudinal divisions of the belt or carrier 31, enable the two classes of material obtained by the first separation to be kept separate, and that portion which is largely non-magnetic to be again subjected to separating action, to remove therefrom any remaining magnetic material, or a large percentage thereof, and the portion which is magnetic to be again treated for further separation from any non-magnetic material that may remain after the first separation.

When the material is discharged from the hopper 28 upon the lower feeding belt or carrier 31, it is carried forward in the direction of the arrow, and a rotating secondary field is induced in the magnetic material which causes it to collect into small bodies like those formed on the belt 23, as above described, and to raise and form a layer thereof on top of the non-magnetic material and to rotate it in the direction opposite to the travel of the belt. The result of this induced revolving secondary field is that the magnetic material travels on the belt in an opposite direction to its movement, while the non-magnetic material remains at rest on the belt, which aids the separation of the material. As the belt 31 carries the material to the rotating magnets, the rotating magnetic material is lifted from the belt, by the revolving magnets 4 and is held by them against the shield or casing 11, whence it is carried into the separating chamber and up and around said shield in a manner hereinafter described. After the belt 31 has carried the remaining material past the lowest point of the casing of cylinder 11, the remaining magnetic material still continues to rotate, but toward the revolving magnets 4 and not away from them, as was the case before it passed such lowest point. This magnetic material is also drawn against the cylinder 11 and carried around the same by the revolving magnets into the separating chamber.

The following action takes place when the magnetic material is held suspended against the shield 11. The lines of magnetic force radiate from the rotating primary magnets and the magnetic material sets itself in such lines of force and the particles are caused thereby to stand on end, held against the shield 11, and formed into a large number of thread-like strings of material of varying lengths. This material which has set itself in radial lines of thread-like form, moves upward and along the outer surface of the cylinder 11, under the influence of its moving magnet within the cylinder, by sliding on the end of the thread that is in contact with such cylinder, whereby a vibrating motion is imparted to the material composing such threads, which causes the mechanically entangled non-magnetic material to be set free and to fall back on to the belt 31. The material in this thread-like form is carried upward and along the outer surface of the shield or cylinder 11, against gravity, as above described, until it reaches the first bridge or baffle 15, where the following described action results from the resistance offered to its further sliding movement by such bridge. Assuming that this material has been carried to this bridge 15, under the influence of a north pole of the revolving magnets 4, within the cylinder 11, it there

stops and is left by such revolving magnet as it passes on and leaves the material with a certain amount of the residual magnetism of south polarity on the inner end of the thread of material, and while in this magnetic condition, it is subjected to the repelling action of the approaching and following south pole, which south pole reverses the polarity on the inner end, which reversal of polarity causes it to form a magnetic couple and to revolve by repelling the inner end in the direction of the motion of the magnet and to attract the outer end of such material. During this change of polarity, and at the time when the material is being repelled and rotated by magnetic action, any non-magnetic material which may have been mechanically entangled and carried up the shield by the magnetic material is allowed to free itself and is thence carried down the inner side of the cover or casing 14, which acts as a chute therefor, and it finally falls back on to the carrier 31, whereby a further separation is effected. As the magnets continue to draw up material from the belt 31, and to deposit it at this bridge, the material thus held by the bridge 15 is gradually forced past and over the outer edge of such bridge and is then carried along the surface of the cylinder by the attraction of the revolving magnets until it reaches the succeeding bridge or baffle 16, where a separating action similar to the above described takes place. After passing the bridge 16 in the manner above described, the material is carried by the magnets to the bridge 17, where a similar attractive and repulsive action takes place, but at this point the revolving field set up in the magnetic material is in a reverse or counter-clockwise direction to that heretofore effected, thereby forcing the remaining non-magnetic material out over the outer edge of the bridge 17. A further and similar separating action takes place at the bridge 18. The non-magnetic material after passing over bridge 17 and the following bridges falls off against, but inside of the outer cover or casing 14 and passes down between the same and the partition plate 22 and is discharged at the lower end of this plate on to the discharge plate 19, and thence into any suitable receptacle arranged to receive it. The separated magnetic material which passes over the last bridge 18, is drawn back and held against the shield 11 under the influence of the revolving magnet, and thence passes down on the surface of such shield in the manner heretofore described until it reaches the plate 20, by means of which it is carried out of the machine as a finished product. Should any magnetic material fall behind the partition plate 22 and on to the plate 19, it will be rotated by the revolving magnets back into the casing at the upper end of the plate 19 in the manner above described. All of the magnetic material that is carried around the shield 11 is finally deposited or stopped where the discharge plate 20 joins said shield, which plate acts like the bridges or baffles above described, whereby a similar rotating motion is imparted to the magnetic material by the revolving primary magnets that was given to it at said bridges, and as this deposit increases, it will gradually pass down and fall from said plate into any suitable hopper or receptacle provided to receive the same. The discharge from the inclined plate 20 is assisted by the repelling action given to the material by the pole which follows that which has just deposited such material on said plate.

Any magnetic material carried by the belt 31, past the revolving magnets will be taken off by the secondary magnets 34 and this material is carried up on the outside of the casing 35, due to the rotating field set up in the magnet 34 by the revolving magnets 4. The vibrating action of the material mentioned in connection with the separation on the shield 11, takes place at this point also, and the material carried up by the secondary magnet will be thrown on to the plate 21, as the rotating field is reversed and is deposited into the same hopper or other receptacle, that receives the material from the plate 20. The magnet 34 may be rotated by the induced field set up therein by the rotating magnets 4, but I prefer the positively rotated, as shown.

The action effected by the corrugated pole pieces 8 is as follows: The corrugations of these pole pieces or shoes produce a magnetic field of unequal intensity on the face of the shoes, the lines of force being concentrated at the higher points of the corrugations, leaving weaker portions of the field at the depressed points between the same. As the magnetic material is drawn from the belt 31 and suspended against the shield 11, the particles of such material will set themselves in thread-like forms along and in the concentrated lines of magnetic force in the manner heretofore described, but when moved along the surface of the shield 11 by the revolving magnets 4, such threads of material will not pass from the stronger to the weaker magnetic field, or, in other words, such magnetic particles will not remain stationary on the shield 11 until they are taken up at and by the trailing pole tip, as would occur should a pole piece having a smooth face surface be used. As each line of concentrated magnetic force on the pole face thus carries its own complement of material up and around the shield 11, I prefer to use the corrugated pole pieces, as they permit of distributing the moving material over a greater area of the shield directly over the moving pole face, thereby

giving a more complete separation and a greater output of finished product.

The oscillating vibrator 33 by its action on the belt 31, agitates the material carried thereon which keeps it in a properly loosened condition thereby greatly facilitating a complete separation.

These processes result in a very complete and effective separation of the magnetic from the non-magnetic material. A further important advantage of my invention consists in the fact that, owing to the arrangement of the feeding devices and of the separating chambers over and through which the material passes, the magnetic material is kept in a magnetic field for such a length of time that its magnetic permeability is largely increased, which greatly increases the efficiency of the magnetic separating action. That is to say, before the material enters the separating chamber, its magnetic permeability has been increased to such an extent that practically all of the magnetic particles will be removed from the carriers by the secondary magnets. While the secondary magnet 34 may be omitted, its use largely increases the efficiency of the machine, its effect being to separate from the non-magnetic material a considerable portion of magnetic material, which would be otherwise discharged as waste.

The entire machine is simple in its construction and provides a practical and efficient device for rapid separation, but various changes may be made in the machine without departing from my invention, thus any suitable number of poles and any suitable method of exciting them may be employed for the primary magnets. The number of bridges or baffles may be varied according to the nature of the material being acted upon and the amount of foreign material to be separated therefrom. The construction and arrangement of the bridges or baffles and discharge chutes may also be changed, and the several parts may be driven in any other suitable manner. If desired, the material from the plate 27 may be removed from the machine as a finished product if the amount of non-magnetic material which it contains has been sufficiently reduced.

In Fig. 5 I have shown a modification in which the magnets 26^a and 34^a are stationary. As illustrated in this drawing, these magnets are not provided with a casing, although if desirable they may be inclosed with a casing similar to the casing shown on these magnets in Fig. 3. The magnetic particles will travel over these magnets by the secondary field induced therein.

In the modification shown in Fig. 6, the plate 27 does not extend to the casing 25 of the magnet 26. Running transversely at intervals over the casing 14, between the magnet 26 and the end of the plate 27 are three stationary magnets A. Projecting from the casing 25 of the magnet 26 and running transversely of the machine is a short plate 27^a, and running transversely of the machine below this plate 27^a and adjacent to the two upper stationary magnets A are the plates 27^b and 27^c. The lower magnet A resting against the upper edge of the plate 27. The magnetic particles which may remain in the material which has passed under the magnet 26 will be caused to jump to the secondary magnets A and travel over the surface of the same in a counter clockwise direction until they come to the plate 27^a, 27^b and 27^c where they will continue to move down the plates until they fall on the plate 27 and thence into its compartment of the hopper 28. The remainder of the material will pass on to the plate 30 and thence into its compartment of the hopper 28. The material from plate 27 may be removed from the machine as a final product and in passing through the machine for further separation. The material from plate 30 may then be distributed over the entire surface of the plate 31. The magnets A may be made to conform to the magnet 26 and also may be provided with a non-magnetic casing, and deposit the material on the plate 27. These magnets may be rotated by any suitable gearing from the main shaft.

Various other changes may be made by those skilled in the art without departing from the spirit of my invention.

I claim:

1. In a magnetic separator, the combination of a plurality of electromagnets, means for rotating said magnets, means for conveying material into the field of said magnets, whereby the magnetic material is partially segregated from the non-magnetic material, a secondary magnet located near the terminus of said conveying means, means for rotating said secondary magnet, a plurality of chutes extending from said secondary magnet, whereby the material is separated into grades of different contents of magnetic material, a conveyer having a partition thereon for receiving said material and keeping the different grades separate from each other, said conveyer passing through the field of said electromagnets, a pair of shells forming an annular passage around said electromagnets, whereby magnetic material is lifted from said conveyer and carried through said passage by the rotation of said electromagnets, a pair of chutes leading from said passage, and a secondary magnet near one of said chutes, whereby the magnetic material is attracted into said chute and further separated from the non-magnetic material, substantially as described.

2. In a magnetic separator, the combina-

tion of a plurality of electromagnets, means for rotating said magnets, means for conveying material into the field of said magnets, whereby the magnetic material is partially segregated from the non-magnetic material, a secondary magnet located near the terminus of said conveying means, means for rotating said secondary magnet, a plurality of chutes extending from said secondary magnet, whereby the material is separated into grades of different contents of magnetic material, a conveyer having a partition thereon for receiving said material and keeping the different grades separate from each other, said conveyer passing through the field of said electromagnets, a pair of shells forming an annular passage around said electromagnets, whereby magnetic material is lifted from said conveyer and carried through said passage by the rotation of said electromagnets, a bridge in said passage to facilitate the separation of magnetic and non-magnetic material, a pair of chutes leading from said passage, and a secondary magnet near one of said chutes, whereby the magnetic material is attracted into said chute and further separated from the non-magnetic material, substantially as described.

3. In a magnetic separator, the combination of a plurality of primary magnets having corrugated pole pieces, means for rotating said magnets, an endless belt for conveying material into the field of said magnets, whereby the magnetic material is partially segregated from the non-magnetic material, a rotatable secondary magnet located near said belt, whereby material from said belt will pass into the field of said secondary magnet, a plurality of gravity chutes extending from said secondary magnet, whereby the material is separated into grades of different contents of magnetic material, a conveyer for returning said different grades of material into the fields of said primary magnets, a pair of shells forming between them a passage extending around said primary magnets, a plurality of bridges in said passage, whereby, on rotation of said primary magnets, magnetic material will be carried from said conveyer through said passage and non-magnetic material will be separated from magnetic material at said bridges, a pair of chutes extending from said passage, and a rotatable secondary magnet located in proximity to one of said chutes, whereby magnetic material will be attracted into said chute, substantially as described.

4. In a magnetic separator, the combination of a plurality of primary magnets, means for rotating said magnets, a pair of shells having an annular passage between them and extending around said magnets, means for carrying material into the field of said magnets and into communication with said passage, a plurality of bridges in said passage, whereby, on rotation of said magnets, magnetic material will be carried through said passage, and on being brought into contact with said bridges non-magnetic material will be separated from magnetic material, and a chute communicating with said passage for delivering the separated magnetic material, substantially as described.

In testimony whereof, I have hereunto set my hand.

ROBERT W. COUSINS.

Witnesses:
C. G. KING,
B. G. BECK.