Jan. 4, 1944. B. S. FOLLOWILL ET AL 2,338,501

APPARATUS FOR MAGNETIC SEPARATION OF MATERIALS

Filed June 25, 1940 2 Sheets-Sheet 1

FIG. 1

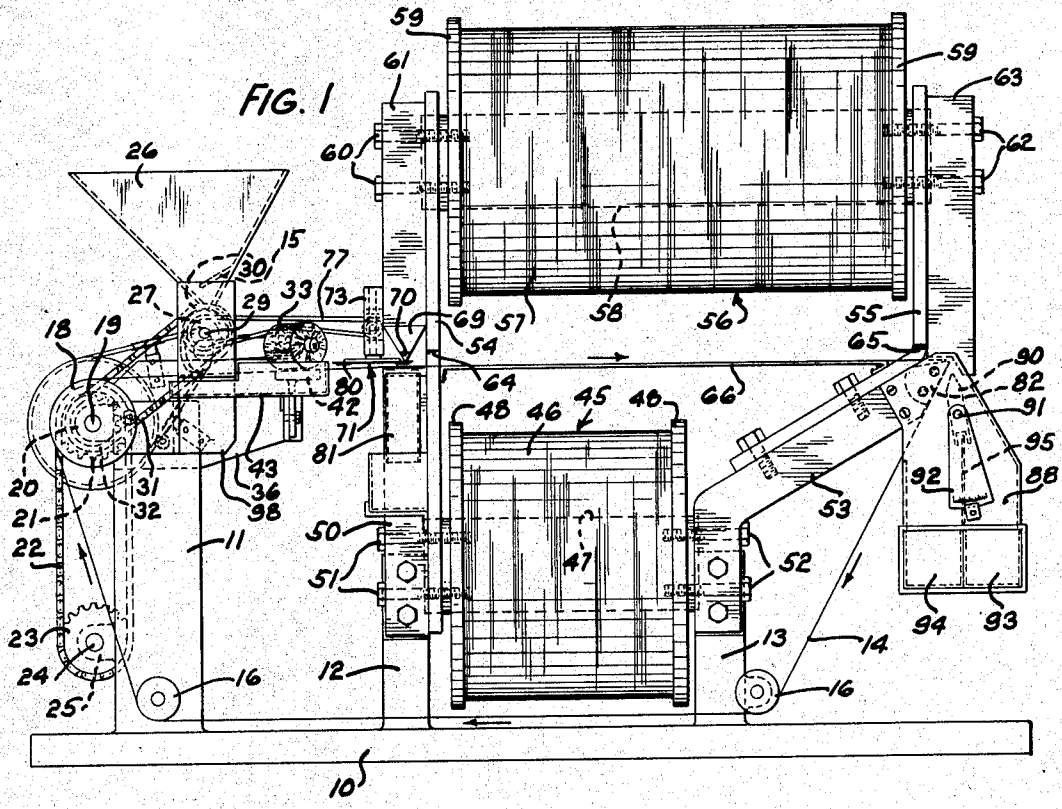


FIG. 5

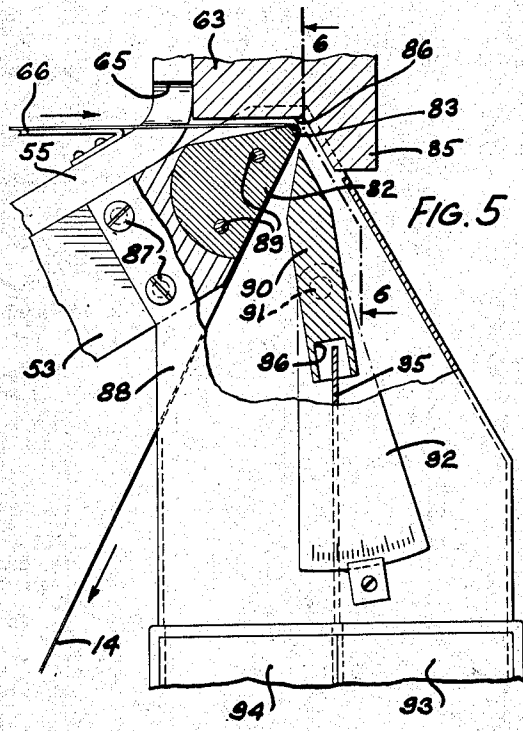
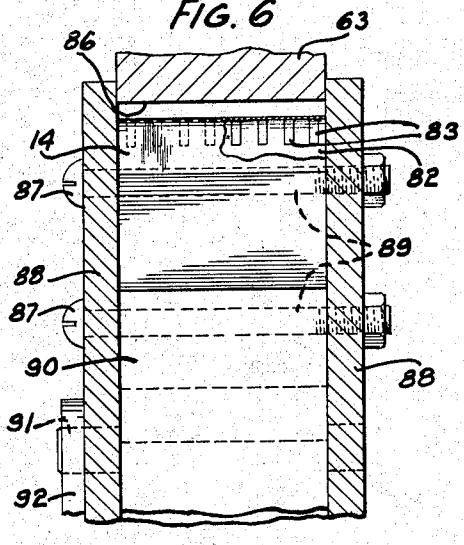


FIG. 6



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APPARATUS FOR MAGNETIC SEPARATION OF MATERIALS

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FIG. 2

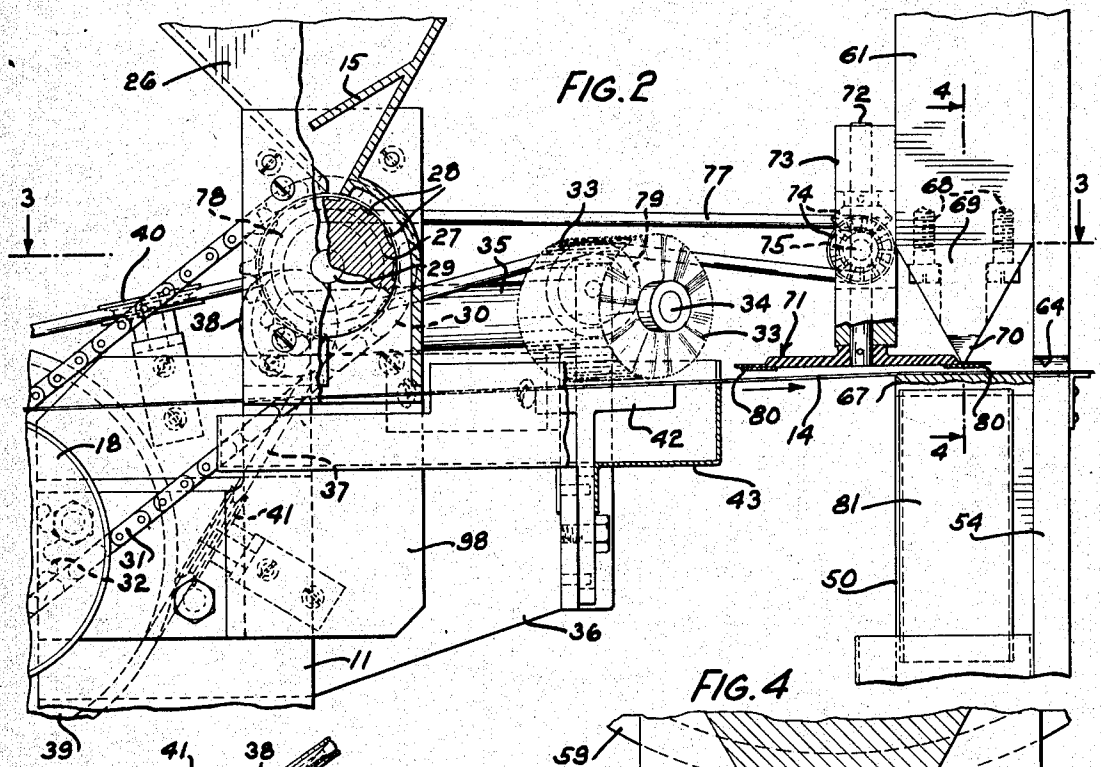


FIG. 4

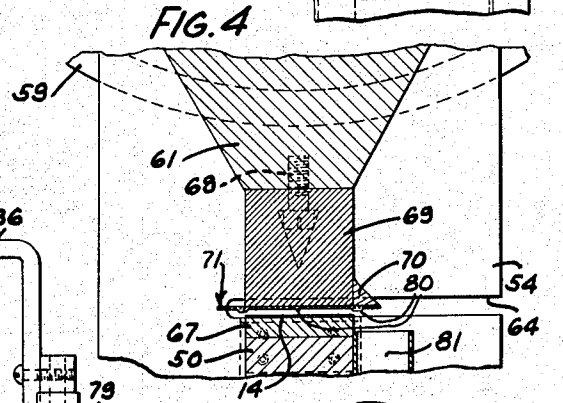


FIG. 3

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APPARATUS FOR THE MAGNETIC SEPARATION OF MATERIALS

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Application June 25, 1940, Serial No. 342,198

3 Claims. (Cl. 209—223)

This invention relates to apparatus for the magnetic separation of materials.

In certain types of electrical apparatus, such as communication equipment, it is customary to use small contact members made of precious metal. Gold, silver, platinum, palladium, iridium, and alloys of these metals, have been used for this purpose. The particular metal or alloy used in each instance depends upon individual service requirements and consequently a single installation often contains contacts made of a variety of metals and alloys. Whenever any of this equipment is withdrawn from service, it is, of course, desirable to recover the precious metals therefrom. Accordingly, all contacts are removed from discarded apparatus and accumulated for reclamation. The usual accumulation includes contacts of assorted sizes and shapes and a variety of compositions.

Reuse of these contacts, or any effective reclamation thereof, requires segregation of the contacts into their constituent metal or alloy groups. It is impossible to sort these contacts by visual inspection, because of their similarity of appearance, and it has not been considered practical to separate them magnetically, because of the very slight spread between the magnetic susceptibility of the metals and alloys of which the contacts are made. Previously, these contacts have been reclaimed by chemical methods, which are slow and costly and also usually entail some process loss of precious metal.

An object of this invention is the provision of an improved apparatus for rapidly and accurately separating articles made of precious metals and alloys; such as articles made of gold, silver, platinum, palladium, iridium, and their alloys, from a mixture of such articles.

In accordance with one embodiment of the invention, an apparatus is provided for sorting a mixture of contacts, including contacts made of palladium, platinum, and gold-silver-platinum alloy. The apparatus comprises a continuous moving belt on a horizontal bed onto which the contacts are deposited from a hopper and then carried between a pair of spaced pole pieces mounted in a magnetic circuit energized by electrical coils. Positioned between the belt and the upper pole piece is a rotating disc of non-magnetic material having projections on its under face against which the palladium contacts are attracted and held by magnetic force, moved by the disc out of the magnetic field, and dropped into a container. At the end of the horizontal belt bed are a second pair of spaced pole pieces mounted in the magnetic circuit. The belt passes over one of these pole pieces, changing its travel to a downwardly direction, and below this pole piece is a splitter blade for separating the alloy contacts, which fall from the belt at the end of its horizontal travel, from the platinum contacts, which are held against the belt, by the magnetic field set up by the energized pole pieces, during travel of the belt around the pole surface.

Following is a more complete description of the invention, taken in conjunction with the appended drawings, in which

Fig. 1 is a front elevation, partly in section, of a magnetic separating apparatus embodying certain features of the invention;

Fig. 2 is an enlarged view, in section, of a portion of the apparatus shown in Fig. 1;

Fig. 3 is a sectional view of Fig. 2, taken on the line 3—3;

Fig. 4 is a sectional view of Fig. 2, taken on the line 4—4;

Fig. 5 is an enlarged view in section of another portion of the apparatus shown in Fig. 1, and

Fig. 6 is an enlarged sectional view of Fig. 5, taken on the line 6—6.

The general arrangement of the apparatus is shown in Fig. 1. It comprises a rigid base 10, preferably made of metal, and three vertical legs extending from the base, on which the apparatus is mounted. One of these legs 11 carries a feeding and driving mechanism and the remaining legs 12 and 13 carrying the magnetic separating equipment. A continuous belt 14, supported on idler pulleys 16 and a belt driving pulley 18, extends through the feeding and separating mechanisms. The continuous belt is made of flexible, non-magnetic material, preferably muslin, cotton or other textile. The belt must be thin, so it is made without seams or ridges and the edges of the belt are impregnated with a rubber solution to prevent unravelling.

The belt driving pulley 18 is fixed to a shaft 19 rotatably mounted in a bearing 20 on the leg 11. Also fixed to this shaft is a sprocket 21 which is driven through a chain 22 from a sprocket 23 on a drive shaft 24 rotatably mounted in a bearing 25 on the leg 11. The drive shaft is connected to a suitable motor (not shown).

Mounted on a bracket 98, extending from the upper portion of the leg 11, is an open top hopper 26 formed of non-magnetic sheet metal which contains the mixed contacts. The bottom of

the contact containing portion of the hopper is formed by a rotating feed roller 27 of non-magnetic material (Figs. 2 and 3). This roller is mounted just above the belt and it has a series of indentations 28 in its peripheral surface, each dimensioned to receive and deliver a suitable volume of contacts. Inside the hopper, extending over the roller, is a baffle 15 to prevent the contacts from packing against the roller surface. The roller is supported on a shaft 29 which is rotatably mounted in the hopper wall. On this shaft is a sprocket 30 connected by a chain 31 to a sprocket 32 on the belt driving pulley shaft 19. Thus, as the belt pulley is driven to move the belt through the apparatus, the feed roller is also rotated by its chain to feed the contacts onto the moving belt in spaced arrangement.

To remove oversize contacts from the belt before they can enter the separator, a rotating cylindrical brush 33 is positioned a fixed distance above the belt. The brush is supported on one end of a shaft 34 which is rotatably mounted in a bearing 35 secured to a bracket 36 on the leg 11. The shaft and brush are rotated by means of a belt 37 running from a pulley 38 on the brush shaft to a pulley 39 on the belt driving pulley shaft 19 over idler pulleys 40 and 41.

To accurately position the belt below the brush, and thus establish the maximum sized contact that will pass under the brush, this portion of the belt is supported on an adjustable plate 42 mounted on the bracket 36. The lower surface of the brush is parallel to the plane of the belt and the brush shaft is positioned at an angle of about 30° to the longitudinal axis of the belt. Thus, whenever an oversized contact is deposited on the belt by the feed roller, it is engaged by the brush and swept into a container 43 positioned below the belt on the bracket 36.

As above stated, the separating equipment, or the magnetic circuit, is mounted on the legs 12 and 13, which arise from the base 10 (Fig. 1). These legs are both made of non-magnetic material, such as brass or bronze. Positioned between these legs is a lower coil 45, having a winding 46 of many turns of wire on a core 47 between coil heads 48 of non-magnetic material, such as wood or fibre.

The core is made of high purity iron and has a large cross section. Tightly secured to one end of the core (left end in the drawings) is a lower front pole piece 50 of high purity iron which is also firmly secured to the leg 12. To provide a close fit between the pole piece and the core, the end of the core is machined to a flat surface and positioned in a machined recess in the pole piece. These members are joined with heavy bolts 51 which pass through clearance holes in the pole piece and are threaded into the core. Similarly mounted on the other end of the core with bolts 52 is a lower rear pole piece 53 of high purity iron, which is also secured to the non-magnetic leg 13. Both lower pole pieces extend upwardly from the core with their upper ends near the belt.

Secured to the front lower pole piece is an upper coil supporting plate 54 and another upper coil supporting plate 55 is secured to the rear lower pole piece. These plates are made of non-magnetic material, such as brass or bronze.

Between these plates is an upper coil 56 that is similar in general construction to the lower coil, with a wire winding 57 on a pure iron core 58 between non-magnetic heads 59. Secured to one end of this core (the left end as viewed in the drawings) with bolts 60 in a front upper pole piece 61 of high purity iron and secured to the other end of the core with bolts 62 is a rear upper pole piece 63 of the same material. These upper pole pieces are mounted in the same manner as the lower pole pieces with the machined ends of the cores positioned in recesses in the pole pieces and the bolts drawn up tightly to provide good magnetic contact between cores and their pole pieces. Both upper pole pieces extend downwardly from the core and each terminates near the belt in alignment with a lower pole piece.

The cores in both coils pass through openings in the non-magnetic coil supporting plates and the plates are secured to all four pole pieces with screws to provide a rigid structure.

The two coils are connected in series to a suitable direct current source (not shown), to energize the pole pieces and establish a magnetic field in the gap between each pair of pole pieces.

In the supporting plate 54 is an opening 64 and in the plate 55 is an opening 65, through which the belt passes between each pair of pole pieces. Suspended between these plates and aligned with the plate openings is a horizontal bed 66 for supporting the belt through this portion of the apparatus.

On top of the front lower pole piece 50 is a brass plate 67 on which the moving belt is supported (Fig. 2).

Secured with screws 68 to the lower end of the upper front pole piece 61 is a pole member 69. This pole member is triangular in cross section and its body portion is formed of a cobalt-iron alloy. A 50–50 cobalt and iron composition gives best results, but both constituents can vary between 40% and 60%. Extending from the lower end of one triangular face of the body portion of the member and welded thereto is a triangular projection 70 of high purity iron (Fig. 4). The narrow end portion of this member is aligned with the center of the corresponding lower pole piece, and the projection extends beyond the belt and both the upper and lower pole pieces at right angles to the direction of belt travel.

Positioned above the belt in engagement with the lower end of the upper pole member is a horizontal disc 71. This disc is supported on the end of a vertical shaft 72 which is rotatably mounted in a bearing 73 secured to the upper front pole piece 61 (Figs. 2 and 3) so that there is a portion of the disc between the pole pieces and a portion of the disc outside of the pole end areas. This shaft and the disc are rotated through a pair of bevel gears 74 and a horizontal shaft 75 with a pulley 76 thereon by means of a belt 77 running from a pulley 78 on the hopper feed roller shaft 29 over an idler 79 on the bracket 36.

The disc is circular and made of non-magnetic material, preferably phenol fibre, with a thin peripheral flange in engagement with the upper pole member. Mounted on the lower face of the disc are a series of radial cleats 80 or projections which are made of non-magnetic material, such as brass, and which project below the lower surface of the disc.

When the contacts are carried between the front pole pieces by the belt, those having suitable magnetic susceptibility, as determined by the characteristics of the magnetic field set up by the pole pieces, are lifted from the belt by the action of the field and urged against the undersurface of the disc. When the apparatus is used to separate a mixture of palladium, platinum and gold-silver-platinum alloy contacts, the palla-

dium contacts are attracted against the disc. The attracted contacts are engaged by the cleats on the disc and rapidly carried out of the magnetic field by the rotating disc. As soon as the contacts leave the field, they fall under gravity balt and the balance substantially iron. In the from the disc surface into a container 81 mounted below the disc on the lower front pole piece.

At the end of the horizontal bed 66 (Fig. 1), is the lower rear pole piece 53 (Figs. 5 and 6). This pole piece has a concaved end surface fitted into which is a tapered pole member 82 (Fig. 5) having a rounded end surface on which the belt is supported after it leaves the bed. The belt in passing over this rounded surface changes its travel from a horizontal to a downwardly direction. This pole member is also made of the cobalt-iron alloy comprising from 40% to 60% corounded end surface, or nose, of this member are a plurality of spaced inserts 83 of non-magnetic material. These spaced inserts are parallel to the direction of belt travel and they extend through the end portion of the member, providing a series of spaced magnetic poles under and across the width of the traveling belt. It is convenient to provide these inserts by cutting grooves across the end of the pole member and filling the grooves with lead-tin solder, but other non-magnetic materials are satisfactory for this purpose.

Directly above the lower pole member, and spaced from the belt, is the upper rear pole piece 63. This upper pole piece has a lower end portion 85 which extends beyond and below the rounded nose on the lower pole member. Cut into the end surface of this upper pole piece is a recess 86 that is coextensive with the belt area at this point.

Secured to each side of the lower rear pole piece 53 with bolts 87 near the end of the pole piece is plate 88 of non-magnetic material, preferably aluminum. The pole member 82 is anchored between these plates with bolts 89.

The aluminum plates also support an adjustable splitter 90 which extends between the plates and has a wedge shaped upper end portion positioned closely to and below the nose of the lower pole member. The splitter is mounted on a pivotal shaft 91 supported in the aluminum plates, and fixed to the shaft on the outside of one of the plates is a graduated splitter adjusting arm 92. Below the splitter, and supported by the aluminum plates, are two containers 93 and 94 separated by a partition 95 which projects into an opening 96 in the bottom end of the splitter.

When the contacts not removed by the action of the front poles are carried by the belt over the end of the lower pole member they are subjected to the action of the magnetic fields between the rear pole pieces. The contacts that have the slightest magnetic susceptibility such as the gold-silver-platinum alloy contacts, fall off of the end of the belt under gravity as soon as the belt begins its downward travel. These contacts fall against the outer or right side of the splitter and are deflected into the container 93. Those contacts having relatively greater magnetic susceptibility, if paramagnetic such as the platinum contacts, are held against the belt, by attraction to the lower pole member, for a period of downward belt travel sufficient to carry them beyond the splitter. When these contacts reach a point where the magnetic field is sufficiently weak, they fall from the belt into the container 94. The splitter can be adjusted readily, by manipulation of the arm 92, to separate contacts of only slightly different magnetic characteristics, including both paramagnetic and diamagnetic materials.

An important feature of the apparatus is the combination of magnetic materials used in the magnetic circuit. The high purity iron used for the cores and pole pieces should have the following composition:

	Per cent maximum
Carbon	.015
Silicon	.003
Manganese	.025
Phosphorous	.004
Sulphur	.025
Total impurities	.072
Iron	Bal.

As stated above, the end members on the two pole pieces are made of a cobalt-iron alloy containing from 40% to 60% of either metal.

As stated previously, the upper and lower coils have the same general construction. The outside diameters of these coils are equal but the upper coil is about twice as long and has about twice as many wire turns as the lower coil. The structure is compact and economical of power. Introduction of a direct current of 3 amperes and 110 volts in the coils produces a flux density as high as 40,000 gauss in the pole tips and a field of 15,000 oersteds in the gaps between the pole pieces. The spacing, composition and contour of the poles adapt the field characteristics to the magnetic properties of the various contact compositions. The construction and operation of the apparatus insure accurate segregation of each contact composition even though the contacts having that composition may vary widely in size and shape.

The apparatus has been described as used with a mixture of three compositions; namely, contacts made of platinum, palladium, and gold-silver-platinum alloy. This mixture is placed in the hopper and the contacts of each composition are rapidly accumulated by the apparatus in their individual containers. If a mixture contains more than three compositions, it is first passed through the apparatus to remove two of the compositions from the mixture. In this operation one composition is extracted from the mixture by the rotating disc and another composition is removed at the rear pole pieces. The removed contacts are identified by their reactions to the magnetic fields, as determined by the apparatus setting. The residue, which is accumulated in either container 93 or 94, is then run through the apparatus again after the apparatus setting has been changed, by adjustment of the current, pole pieces, or splitter to accomplish a separation of the remaining compositions. This operation is repeated, with any necessary changes in apparatus settings between successive operations, until all of the compositions are identified. Thus, the apparatus is suitable for rapidly, economically, and accurately sorting a varied mixture of contacts, or other precious metal articles, into identified groups of individual composition.

It will be apparent that some modifications can be made in the specific embodiment of the invention described herein, and it is, therefore, to be understood that the invention is limited only by the scope of the appended claims.

What is claimed is:

1. In an apparatus for magnetically separating materials from a mixture thereof, a moving belt

made of non-magnetic material for supporting the mixed materials, a magnetic circuit, a lower pole piece of high purity iron positioned in the circuit with its upper surface just below the belt, an upper pole piece positioned above the belt in alignment with the lower pole piece, said upper pole piece having a body portion of triangular cross-section formed of an alloy comprising from 40% to 60% cobalt and the balance iron positioned with its narrow end surface adjacent to and spaced from the belt, and a triangular shaped member made of pure iron joined to the lower portion of one triangular end face of the body and extending therefrom with the lower surfaces of the body and member in alignment, a rotatably mounted disc of non-magnetic material positioned between the belt and the upper pole piece, means for energizing the circuit to establish a magnetic field between the pole pieces for attracting some of the material from the belt against the disc, and means for rotating the disc to remove the attracted materials from the magnetic field.

2. In an apparatus for magnetically separating materials from a mixture thereof, a moving belt made of non-magnetic material for supporting the mixed materials, a magnetic circuit, a lower pole piece of high purity iron positioned in the circuit below the belt with its upper surface extending across the belt, an upper pole piece made of an alloy containing 40% to 60% cobalt and the balance iron in the magnetic circuit, said upper pole piece having a triangular cross-section and being positioned with a narrow edge thereof adjacent to and extending across the belt coextensively with the upper surface of the lower pole piece, an auxiliary upper pole member of pure iron joined to one end surface of the upper pole piece and extending beyond the adjacent areas of the upper and lower pole pieces with its lower end surface in alignment with the lower end surface of the upper pole piece, a rotatable disc of non-magnetic material positioned between the belt and the upper pole piece, means for energizing the circuit to establish a magnetic field between the pole pieces and raise some of the material from the belt against the disc, and means for rotating the disc to remove the attracted materials from the magnetic field.

3. In an apparatus for magnetically separating materials from a mixture thereof, a moving belt made of non-magnetic material for supporting the mixed materials, a magnetic circuit, a lower pole piece formed of pure iron in the circuit having its upper end surface extending across the lower surface of the belt, an upper pole piece formed of an alloy containing from 40% to 60% cobalt and balance iron secured to the lower end of the upper pole piece, said upper pole piece having a triangular cross-section and being mounted with a narrow edge thereof extending across and spaced uniformly from the upper surface of the belt coextensively with the upper surface of the lower pole piece, an auxiliary upper pole member made of pure iron magnetically connected to the lower end portion of one triangular end surface of the upper pole piece, said auxiliary pole member being tapered in two directions and extending beyond the adjacent areas of the pole pieces and the belt with its bottom surface aligned with the bottom surface of the upper pole piece, a rotatable disc of non-magnetic material positioned between the belt and the upper pole member, means for energizing the circuit to establish a magnetic field between the pole pieces for raising a selected material from the belt against the disc, and means for rotating the disc to remove the selected material from the magnetic field.

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CERTIFICATE OF CORRECTION.

Patent No. 2,338,501. January 4, 1944.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, second column, line 19, before "view" insert --plan--; line 21, before "view" insert --elevational--; line 23, before "section" insert --vertical--; page 3, first column, line 6, strike out the syllable and words "balt and the balance substantially iron. In the" and insert the same after "40% to 60% co-" in line 18; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 25th day of April, A. D. 1944.

Leslie Frazer

(Seal) Acting Commissioner of Patents.