Aug. 16, 1932. W. A. HOMAN 1,872,591

IONIC SEPARATOR

Filed Aug. 13, 1927 3 Sheets-Sheet 1

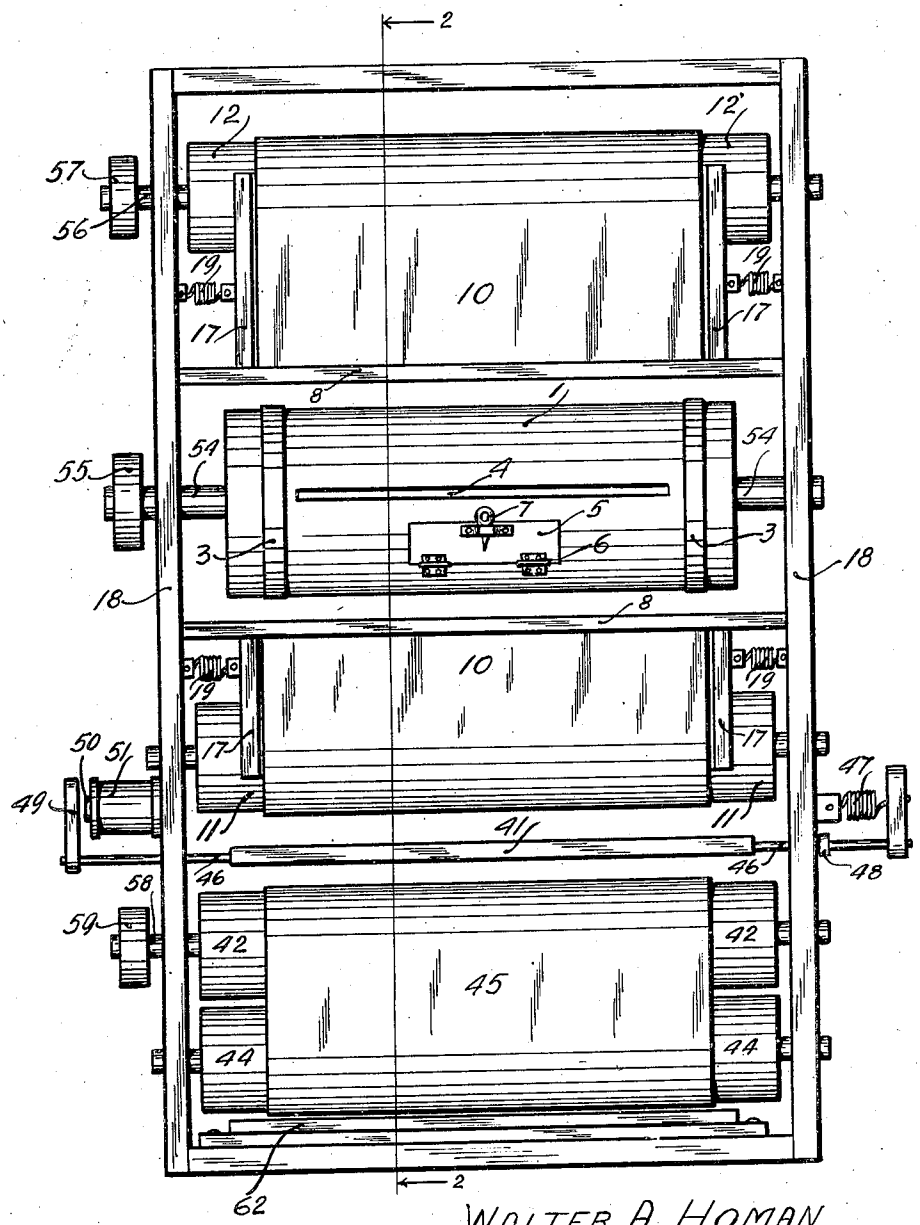


Fig. 1.

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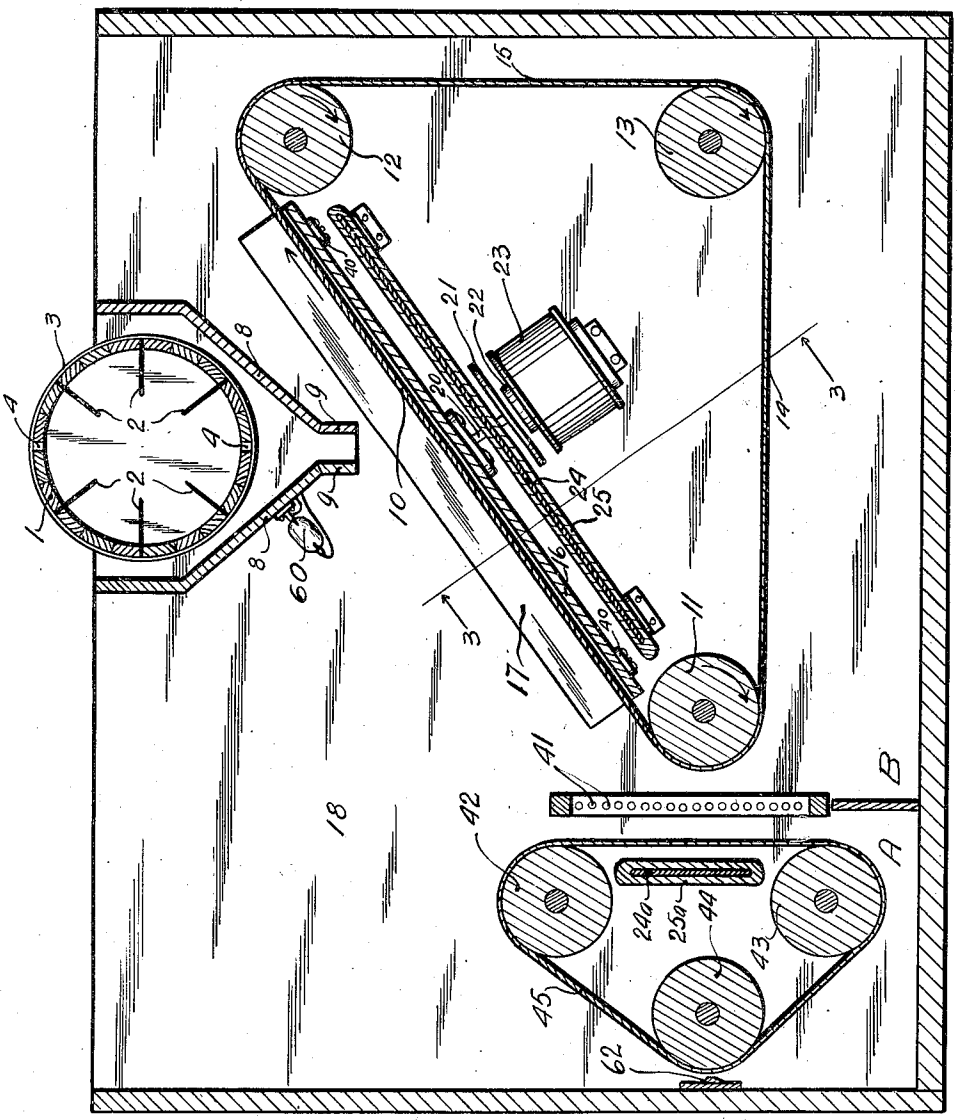


Fig. 2.

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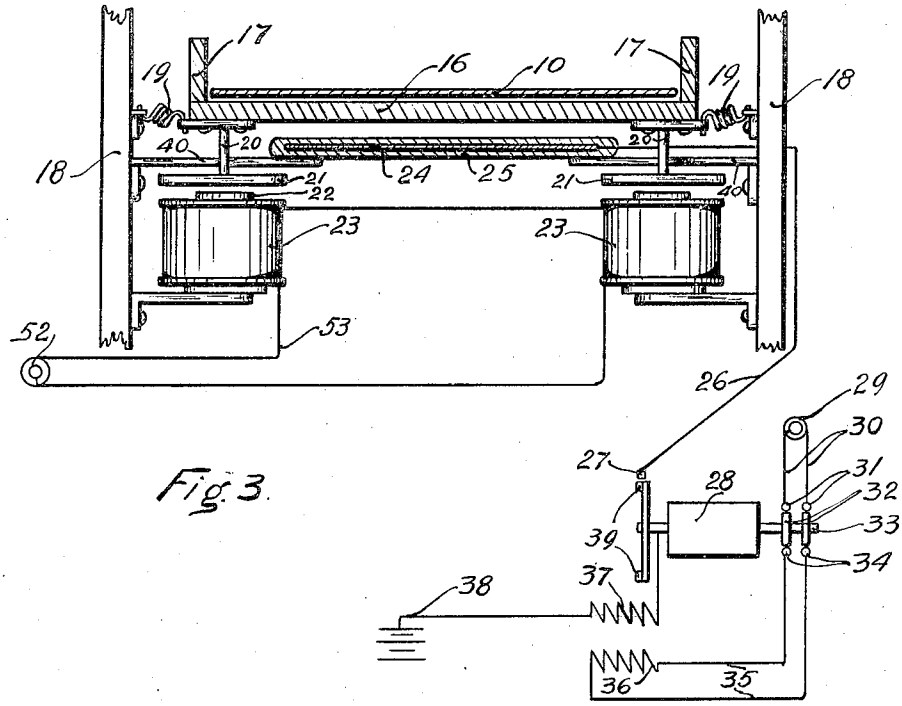


Fig. 3.

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UNITED STATES PATENT OFFICE

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IONIC SEPARATOR

Application filed August 13, 1927. Serial No. 212,749.

This invention relates to improvements in methods for the separation of materials having dissimilar electrical properties.

It is often desirable and necessary to separate different materials and various methods are used for different purposes. Where the materials to be separated differ in size, screens may be employed; where they differ in specific gravity the separation may be accomplished by means that takes advantage of this property and where the chemical properties are different, some chemical method may be employed.

It oftentimes happens, however, that the materials to be separated must be ground to substantially the same size and that they have such similar physical properties that the ordinary methods of separation cannot be successfully employed and for such materials my present method is especially well adapted.

It is well known that different substances have different electrical properties and can be arranged in accordance with these properties into a series in which any two elements, when brought into contact, will become dissimilarly charged, the difference of potential varying in accordance with the distance the materials are apart in this series. Gold and silver paper, the former coated on one side with copper foil and the latter with tin foil and placed together with their metallic sides outward and piled to the extent of several hundreds or several thousands in such manner that the copper of all pairs are turned in the same direction, will produce a dry pile capable of charging Leyden jars and of producing shocks.

It is well understood now that when any two bodies not exactly the same in both chemical constitution and molecular arrangement are brought into contact electrification will occur and one will become positive and the other negative.

It is not necessary to subject the materials to friction or rubbing to cause electrification but merely to bring them into intimate contact, such as will occur if the materials are put into a container and subjected to vibration.

The condition of the surface of the substances exercises an influence over their electrical properties and for this reason if a piece of polished glass is rubbed with a piece of rough glass, the former will become charged with positive electricity and the latter with negative electricity.

Electrification or ionization is also influenced by pressure temperature and other electrical manifestations such as ultra violet rays, etc.

It is well known that a body charged with positive electricity will attract a body charged with negative electricity and will repel a body charged with positive electricity. It is therefore evident that if a mixture of two dissimilar materials are ionized or electrified so as to make one positive and the other negative, and then passed through an electrostatic field adjacent a body charged with either positive or negative high potential electricity, that there will be a tendency to cause a separation of the differently charged particles. As the forces produced are small, the particles must be free to move and for this purpose must be in suspension as they are when falling under the influence of gravity or rising under the influence of a sudden impact.

My improved method, briefly described, consists in first reducing the material to be separated to small particles by some suitable grinding operation that separates the materials from each other, then subjecting the materials to the action of an agitator which causes them to come into contact with each other and to become ionized or electrified, one becoming positively charged and the other negatively charged, and then passing the ionized material through an electro-

static field in such a manner that the material will be in suspension and free to move in accordance with the forces produced.

My method can be carried out by a variety of specifically different apparatus, but for the purpose of this explanation I have illustrated an apparatus suitable for this purpose and which will now be described in detail and reference for this purpose will be had to the accompanying drawings in which the apparatus has been illustrated and in which:

Fig. 1 is a top plan view of the apparatus;

Fig. 2 is a longitudinal section taken on line 2—2, Fig. 1; and

Fig. 3 is a section taken on line 3—3, Fig. 2 and shows in addition the electrical apparatus employed.

In the drawings numeral 1 represents an agitator or ionizer which has been shown as consisting of a cylindrical drum formed from wood staves or of any other suitable nonconducting material. In the construction illustrated nonconducting plates 2 are placed between some of the wood staves and project inwardly towards the center of the drum in the manner shown in Fig. 2. The staves are held in place by hoops 3, of which there may be as many as are found to be necessary. The agitator drum is provided with one or more slots 4 which extend parallel with the axis on which the drum rotates. The drum is also provided with a door 5, which is secured to the outside of the drum by means of hinges 6 and which can be held in closed position by the latch 7 (Fig. 1). Door 5 serves to close an opening which can be opened whenever material is to be introduced into the interior of the drum.

Located directly beneath the drum is a chute which has inclined sides 8 that terminate in spaced parallel flanges 9 that form a slot or opening. When the material leaves the drum through one of the slots 4, it falls into the chute and is directed downwardly onto the upper surface of an inclined belt 10. This belt may be made of rubber or any other non-conducting material and has been shown as passing over rollers 11, 12 and 13 which are arranged so that the axes on which these rollers rotate are located at the vertices of a right angle triangle, whose base 14 is horizontal and whose adjacent side 15 is vertical. The side of the belt to which the numeral 10 is attached forms the hypothenuse of the triangle and is inclined, in the example shown, at an angle between thirty and forty degrees. The actual angle that the upper side of the belt makes with the horizontal is not of any particular importance, but is determined by experimentation so as to produce the best results for the material with which the device is to be used. A trough having a flat bottom 16 and spaced parallel sides 17 embraces the upper part of the belt in the manner shown in Figs. 2 and 3. This trough is supported from the side walls 18 by means of coil springs 19 of which there may be as many as desired. Secured to the under side of the bottom member 16 are two brackets 20 to the lower ends of which armatures 21 are connected. Located adjacent each armature is the pole piece 22 of an electromagnet 23. This electromagnet may be energized by means of an alternating or an interrupted current so as to exert a series of impulses that effect the armature 21 and causes the trough to vibrate. As the belt 10 rests on the upper surface of the trough, this vibration is transmitted to the belt with the result that it also vibrates. Means is provided for rotating the rollers 11, 12 and 13 in a clockwise direction as indicated by the arrows and this causes the belt to move upwardly along the bottom of the trough. Beneath the bottom 16 of the trough is a plate 24 of conducting material. This has been shown as enclosed on all sides by means of an insulating covering 25. In Fig. 3 I have shown the plate 24 connected by means of a conductor 26 to a stationary terminal 27. A synchronous motor 28 is connected to a source of alternating current 29 by means of conductors 30. These conductors terminate in brushes 31 that contact with slip rings 32 carried by the shaft 33. Another set of brushes 34 also connects with the slip rings and from these conductors 35 extend to the primary coil 36 of a transformer. The secondary coil of this transformer has been indicated by numeral 37 and has one end ground at 38, the other end is connected to a rotating commutator having one or more segments 39 that either contact with or come into close proximity to the stationary terminal 27 once during each cycle of the alternating current. This mechanism constitutes a rectifier that delivers unidirectional current to the plate 24 so that this can be maintained at a high potential of either positive or negative electricity as the case may be. The potential to which the plate 24 is raised is high and therefore there will be an electrostatic field surrounding plate 24 on all sides. As above pointed out a particle that is charged positively will be repelled by another conductor that is charged positively but will be attracted if the conductor is charged negatively. It is now apparent that if a plurality of particles are deposited on the upper surface of the belt and that some of these are charged with positive electricity, while others are charged with negative electricity, that either one or the other of these particles will be attracted by the charged conductor 24, while the others will be repelled. In the example shown, the plate 24 will be considered as carrying a positive charge so that any particles that carry a positive charge will be repelled, while particles carrying a

negative charge will be attracted. This assumption is made for the purpose of explanation only and the operation of the machine is exactly the same, regardless of the polarity of plate 24.

In Fig. 3 I have shown the plate 24 supported by means of brackets 40 which are preferably made of insulating material so as to prevent the escape of electricity. Located adjacent that part of the belt which passes around roller 11, is a metallic screen 41 that is supported in vertical position by any suitable means. To the other side of this screen are located three rollers 42, 43 and 44 which are preferably made of insulating material. The axes about which rollers 42 and 43 rotate are located in a vertical plane. A belt 45 of insulating material encloses the rollers in the manner shown. Located within the triangular space formed by belt 45 is a conductor 24*a* which corresponds to the conductor plate 24 and this is enclosed in an insulating cover 25*a*. Plate 24*a*, like plate 24, is connected by means of a conductor, not shown, to the conductor 26 so that conductor plates 24 and 24*a* will be charged with high potential electricity of the same potential and polarity. Screen 41 is attached to the side members 18 by means of rods 46 that pass through the side members and which permits the screen to be reciprocated in a longitudinal direction. A spring 47 is attached to the outer ends of one of these rods and tends to move the screen 41 towards the left, (Fig. 1) until the stop 48 engages the outer surface of the wall 18. One of the rods 46 on the lefthand side of the frame, Fig. 1, carries an armature 49 that is located close to, but is out of contact with the pole piece 50 of an electromagnet 51. This electromagnet, like electromagnets 23, is energized by means of an alternating current or by an interrupted current so that it will periodically exert a force on the armature 49 which will cause the screen 41 to reciprocate. In Fig. 3 I have shown an alternating current source 52 which is connected by means of conductors 53 with the electromagnets 23 and which may also serve to furnish electricity for the operation of magnet 51.

The drum 1 is rotatable about an axis 54 to the outer end of which is secured a belt wheel 55, roller 12 rotates about an axis 56 to the outer end of which a belt wheel 57 is attached, while roller 42 rotates about an axis 58 which carries a belt wheel 59. Power is applied to the belt wheels 55, 57 and 59, separately, so that the different parts can be rotated at any speed that may be found to be most suitable. The drum 1 may rotate in either direction as the direction of rotation of this element is immaterial. The power should be applied to belts 10 and 45 in such a manner that the upper surface of belt 10 moves upwardly while the vertical surface of belt 45 moves downwardly.

Let us now assume that the parts are assembled in the manner described and that magnets 23 and 51 are energized by means of an alternating current which causes the trough carrying the armatures 21 to vibrate and which also causes the screen 41 to vibrate in the manner described. Let us further assume that conductor plates 24 and 24*a* are energized by means of a very high potential positive current so that they are surrounded by a static field of great intensity.

Let us now furthermore assume that the drum 1 contains powdered material, such as oil shale ground to such an extent that the kerogen is freed from the clay. Oil shale is composed of kerogen and a species of clay. The kerogen carries the hydrogen carbon contents, while the clay has no particular value as far as the production of oil shale is concerned. I have found that, when a finely ground oil shale is agitated as it will be when drum 1 is rotated, this agitation will cause the particles of kerogen to be ionized or electrified to one polarity, whereas the clay will be electrified to the opposite polarity. For the purpose of this explanation, the kerogen will be considered as carrying positive electricity, while the clay will become charged negatively. When the particles of electrified clay and kerogen fall downwardly onto the moving belt 10, the clay particles will be attracted by the positive charge on plate 24, while the kerogen particles will be repelled. As the bottom 16 of the trough and the belt 10 which rests upon it are subjected to a high rate of vibration by means of the electromagnets 23, the particles will be continuously thrown upwardly and will therefore part of the time, be suspended in the air. During this period of suspension they will be acted upon by the mutual force between the charge plate 24 and the differently charged particles. This force will tend to repel the positive particles and attract the negative ones and the latter will therefore have a tendency to travel upwardly with the belt, while the repelled particles will take a downward course and finally reach the lower point of belt 10 adjacent the screen 41. If a thorough separation cannot be had on the inclined surface of the belt 10 alone, the particles that arrive at the bottom of the inclined surface will contain both positive and negatively charged particles. These particles will then be acted upon by a force due to the positive charge on plate 24*a*. This charge will tend to attract the negative particles and to repel the positive particles which will therefore separate. The negative particles will pass through the screen 41 and will finally be deposited in a chamber "A". The positive particles will not be attracted by the positive charge and will there-

fore pass downwardly into chamber B, but if positive and negative particles should adhere to each other, these groups will be separated by impact with screen 41 whereupon the negative particles will pass through the screen and the positive ones will fall into chamber B. In actual practice the bottoms of chambers "A" and "B" communicate with conveyors or chutes which conduct the material to proper receptacles where it may be stored. The material may be subject to as many different separations as may be desired, but the two steps shown are considered to be sufficient for the purpose of explaining this method, as the addition of more steps to the separation will merely be duplications of what has already been described. A scraper 62 is located in close proximity to the outer surface of belt 45 in the manner shown in Fig. 2. This serves to remove from the belt any material that may adhere to it.

From the above description it will be apparent that I have produced a simple method by means of which it is possible to separate materials of the same degree of fineness and which may have the same specific gravity and which would therefore not be suitable for separation by any of the ordinary means that depends upon screens or which utilize the momentum of the particles or their inertia.

As above intimated, this method is suitable for use in connection with any dissimilar materials, but is especially well adapted for use in connection with oil shale as by the employment of this method it becomes possible to separate the kerogen which carries the hydrocarbon from the inert matter of the oil shale and by so doing it becomes unnecessary to heat the large amount of inert matter in order to remove the hydrocarbon content from the kerogen. After the oil shale has been separated by means of the method and apparatus above described, the hydrocarbon content can be removed very quickly and with a comparatively small expenditure of heat.

The apparatus described above is merely illustrative of a type of apparatus which can be employed for the carrying out of this process and has therefore been shown more or less diagrammatically as the only object of presenting a drawing is to more clearly distinguish between the several elements and the several steps of the method.

Although I have shown and described a screen 41 this is not always essential. Where the particles have been highly electrified, they have a tendency to stick together so as to form a ball. When the vibrations of the belt 10 are insufficient to separate the particles, the screen 41 assists in attaining this separation.

It is also possible to entirely eliminate belt 10 and the rollers which cooperate with it and the conductor 24. In this case the vibrating trough 16 will increase the ionization and the separation will be effected by means of the belt 45 and the electrostatic field due to the conductor 24*a*.

If the belt 10 is omitted and the conductor 24 retained, a separating action will take place in the trough; the material that is electrified to the same polarity as the plate passing downwardly into chamber B, while the oppositely charged material is retained in the trough.

In the drawings belt 10 has been shown as formed into a right angle triangle, but this is, of course, unnecessary as the shape of the triangle is immaterial and as many rollers as desired may be used, but there is the minimum that can conveniently be employed for this purpose.

It is possible to ionize the material by means of ultra violet rays and thus to dispense with the agitator 1, which will then serve as a feeder, and in Fig. 2 I have shown a source 60 of ultra violet rays.

Although I have shown belt 10 as moving upwardly or in the direction of the arrow, I want to call attention to the fact that the direction of movement of this belt may be reversed, if desired. When the belt is moving in the direction shown, the material which is agitated by the belt will be agitated for a longer time than if the direction of movement s reversed and should therefore be employed with materials that are hard to separate but when the materials separate easily, the direction of movement of the belt can be reversed and the capacity thereby increased.

The belt has been shown as moving in the direction of its inclination, either upwardly or downwardly, but it can be made to run at right angles to the direction of its inclination as the important part is that there shall be an inclined movable surface that is vibrated so as to agitate the materials that are being separated.

Having now described my invention what I claim as new is:

1. The method of separating materials having different electrical properties which consists in reducing the materials to a powder, subjecting the powdered mixture to agitation whereby the particles become ionized, the particles of one material becoming charged positively and the particles of the other material negatively, causing said material to be suspended in the air for a short time and subjecting the material while so suspended to the influence of an electrostatic field of a given potential whereby the particles will be subjected to a force that tends to separate the positively charged ones from the negatively charged ones.

2. An apparatus for separating fine particles of materials having different electri-

cal properties comprising, in combination, means for ionizing the materials so that some particles will be positive and others negative, a conveyor of insulating material, means for directing the ionized particles onto the conveyor, an electrode of a given polarity located adjacent the conveyor and means for projecting the material into the air when it passes through the electrostatic field whereby the differently charged particles will be separated.

In testimony whereof I affix my signature.

WALTER A. HOMAN.