June 2, 1959 I. M. LE BARON 2,889,042

BENEFICIATION OF MINERALS

Filed Sept. 22, 1955 2 Sheets-Sheet 1

FIG.1

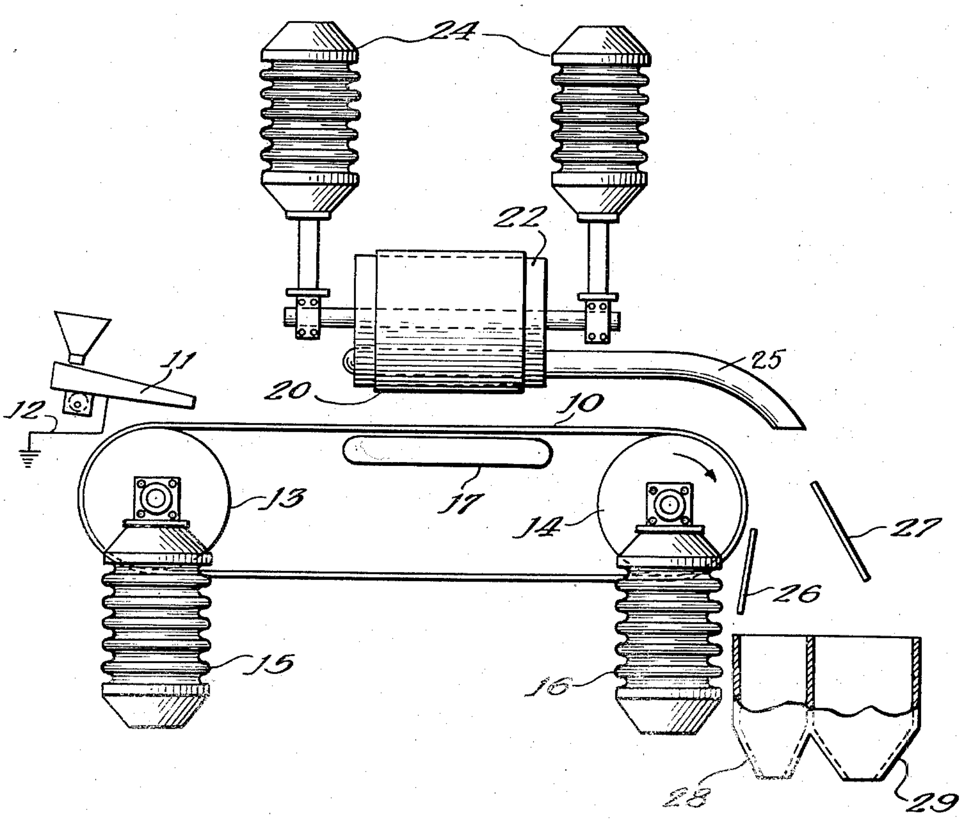

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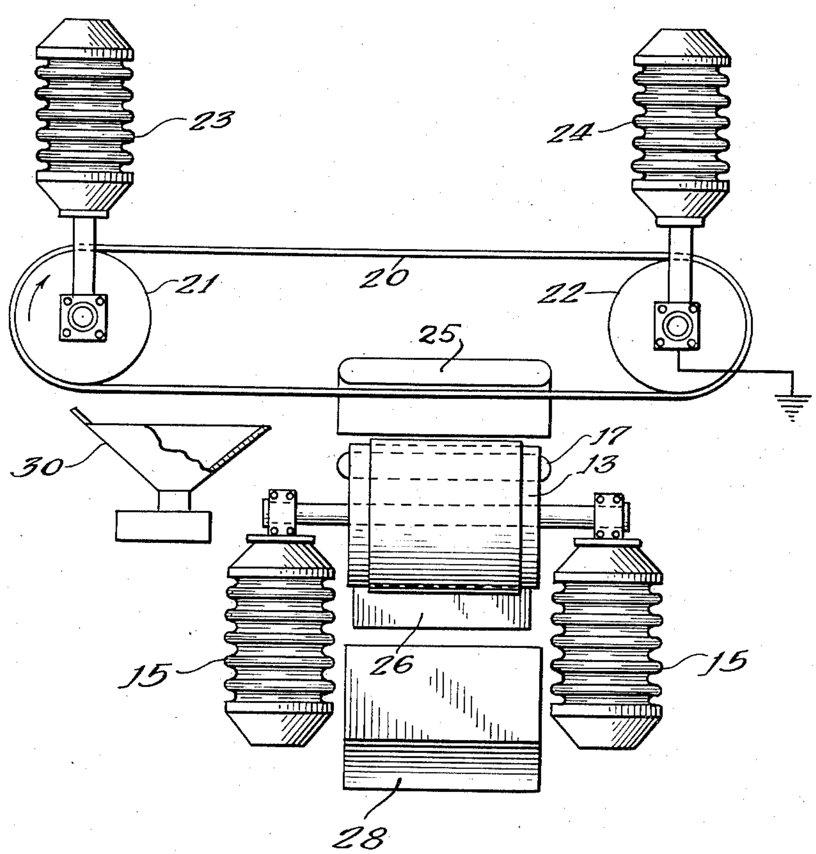
FIG. 2



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BENEFICIATION OF MINERALS

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4 Claims. (Cl. 209—127)

This invention relates to a method for concentrating mineral components. More particularly, it relates to the beneficiation of ore by the separation of the desired mineral from gangue material. Still more particularly, it relates to the beneficiation of phosphate and potash ores.

It has long been known that it is possible to beneficiate minerals by electrostatic methods. However, up to the present time, electrostatic methods have been successful from an economic and practical standpoint only in isolated instances. Generally, the apparatus has comprised essentially paired and opposited charged electrodes.

An essential problem in this field is the shortness of time during which the electrostatic field influences particles being separated. This short period of effective operation necessitates use of a multiplicity of stages for effective concentration. Electrostatic roll separators which separate particles according to their conductivity characteristics revolve at, for example, 6 r.p.m. and the particles are in the electrostatic field for about ⅙ of the circumferential length of a roll. When utilizing the method wherein the particles pass as freely falling particles through the electrostatic field, the force of gravity accelerates the speed of the particles to a point where multiple stages are markedly more effective than an elongated field.

It is a primary object of this invention to overcome the shortcomings and disadvantages of the prior electrostatic separation systems.

It is another object of this invention to provide a system whereby the time in the electrostatic field is under direct control.

It is a further object of this invention to provide apparatus for electrostatically separating materials in which the material is supported for the desired period in the electrostatic field and particles differentially charged move in diverse directions for separate collection.

These and other objects of the invention will be apparent to those skilled in the art from the following description.

In carrying out the instant invention, comminuted ore material is supported on a continuous non-conductor belt moving at a rate designed to give the desired holding time in the electrostatic field. Above and adjacent to this support belt and moving in a transverse direction is a second non-conductor belt. An electrostatic field is maintained in the area where the belts overlap. It will, of course, be understood that the electrostatic field area may be enlarged by the positioning of a multiplicity of belts in parallel in each direction.

The electrostatic field may be developed between electrodes positioned so that the belts are intermediate the electrodes or the belts themselves may be the electrodes if the belts are operating on the well known Van de Graaff system.

For effective separation, it is necessary that the particles be differentially charged before entering the electrostatic field. Differential charge in the instant process is an acceptance or divesting of electrons, as the case may

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be, so that at least one of the components of the mixture to be separated possesses a definite charge and is not merely polarized as in the case of pyroelectric crystals. Differential charging can be brought about by agitation of a proper character or by subjecting the material to contact with a source of free electrons such as is supplied by the earth, with or without the aid of heating. It is preferred, that the mixture or ore either while in a heated condition or while in a surface dry condition, be subjected to activity such as to bring about adequate differential charging thru one or the other or a combination of the above methods assuring that electron exchange will take place and that the particles will be charged as aforesaid.

Certain electrical conductive materials when grounded to the earth will facilitate the transfer of electrons to one or the other component of a mixture. In this regard, material comprising essentially carbon, for example, graphite is one of the best materials for donating electrons to heated phosphate ore gangue. Other useful materials for charging phosphate ore are zinc, galvanized iron, and brass. In addition to the above, aluminum is an excellent donor element for the charging of potash ore components. Such donor element may be a ground plate, chute, tray, hopper, rotating bowl or the like.

Heating of the particles may be carried out in suitable equipment such as an electric oven, heat exchanger and the like to reduce the granular material to dryness. Preferably the materials are heated to a temperature in the range between 150° F. and about 550° F. with a holding time sufficient to insure dryness. This material while at these temperatures or at any time before the particles pick up surface moisture are charged as hereinbefore described and passed thru an electrostatic field.

The efficiency of the process is to a degree dependent upon particle size of the materials being separated. The most satisfactory range from an economic standpoint is that obtained by grinding material to a size between about −4 and about 200 mesh. Particle size to which the material must be ground is of course dependent upon liberation of the components desired to be concentrated from the gangue. In the case of phosphate ore, grinding is usually carried to the point such that 90% of the material will be in the range of about −14/+150 mesh standard screen size. The same mesh size, is in general, useful for potash ores such as sylvinite and mixed ores, although a narrower mesh size range is preferred where practical, generally of the order of −8/+100 mesh.

It is preferred though not essential in the interest of economy, when benficiating ores to use indirect methods of heating such as hot air, electric furnaces, or electric heating.

In the instant process, due consideration must be given to the method of creating the electrostatic field to which the aforesaid charged ore is subjected. In this process, it is desirable to apply a system which will minimize the possibility of altering the previously described charge with corona discharge or normal induction such as is employed in substantially all conductivity electrostatic separators. The electrodes should be kept at a high direct voltage potential substantially free of alternating current components.

The strength of the electrostatic field which will effectively transfer ore particles from the supporting belt to the transverse removal belt will vary with the average particle size and the type of material. The field gradient or strength may vary from about 1000 to about 5000 volts per inch of distance between belts in separating materials of relatively fine particle size and from about 3000 to about 12000 volts per inch for beneficiating of coarser particles. In general, it is preferred to operate with total impressed differences of potential in the range between about 30,000 volts and about 250,000 volts. This voltage should be maintained in the form of direct current potential substantially free of alternating current components, i.e., filtered D.C. current low in so-called A.C. ripple. A steady supply of D.C. voltage may, for example, be obtained without expensive filtering apparatus by the use of such equipment as rectified radio frequency power supply.

The belts, i.e., the support belt and the transverse removal belt may be made up of any non-conductor material, for example, the belt may be made up of synthetic fiber material such as Dacron, nylon, or the like, as well as felt, velvet or satin.

It is to be noted that the instant process may be applied to minerals or mixtures of chemicals and different materials at various stages of commercially employed methods of beneficiating since no reagentizing is needed to effect separation. Thus the instant novel process has application to ground Florida phosphate pebble, deslimed phosphate waste debris, hard rock phosphate such as Montana and Tennessee phosphate ores, potash ores such as cylvinite, langbeinite and mixed ores, feldspar ores, chalcopyrite ore, fluorite ore, barite ore, and/or mixtures thereof, and the like to give but a few illustrations. The apparatus of the instant invention will be understood by reference to the drawings setting forth a preferred embodiment of the invention in which:

Figure I is a front elevational view depicting a simplified schematic diagram of the apparatus.

Figure II is a side elevational view of the same schematic apparatus illustration.

Referring to the drawings, the numeral **10** designates a support belt to which the feed is delivered by a shaking or vibrating feeder **11** such as Syntron feeder having an iron trough. This iron trough is grounded to the earth by electrical conductor **12**.

Belt **10** is a continuous belt supported by a head pulley **13** and a tail pulley **14**, said head pulley being driven at suitable speed by suitable drive means such as a belt. Each pulley is supported by insulator mounts, **15** and **16** respectively. Intermediate pulleys **13** and **14** is positioned an electrode **17** suitably connected by a conductor to a source of D.C. power not shown.

Mounted above and generally within about 1 to 5 inches of belt **10** is belt **20**, illustrated as being in the transverse position. Belt **20** is supported by head pulley **21** and tail pulley **22**, head pulley **21** being driven at suitable speed by suitable drive means such as a belt. Pulleys **21** and **22** are suspended by insulator mounts **23** and **24** respectively. Mounted so as to be shielded by belt **20** is an electrode **25** suitably connected by a conductor to the above mentioned source of D.C. power so as to be of opposite polarity from electrode **17** or to ground.

Material discharged from belt **10** may go directly to a storage collector or, as illustrated, the material may pass as freely falling bodies between a pair of fixed electrodes **26** and **27** between which there is imposed an electrostatic field. Material is collected in receivers **28** and **29** as middling and a concentrate of either the desired component or the gangue material.

Material pinned to belt **20** upon leaving the electrostatic field falls off the belt and is collected in a hopper for disposal.

The invention will be more fully understood by study of the following example which is given by way of illustration and without any intention that the invention be limited thereto.

EXAMPLE I

Florida pebble phosphate ore was hydraulically treated and screened to remove pebble material. Deslimed washer debris of a particle size in the range of −35/+200 mesh standard screen size was heated in an electric oven to about 300° F.

Hot dry solids were delivered to the support belt at a rate of about 500 lbs. per hour by means of a Syntron feeder having an iron trough grounded to the earth. The Dacron support belt, 8 inches wide and 12 feet long woven of 50 denier thread, traveled at the rate of about 330 feet per minute. The cross belt likewise was driven at a rate of approximately 330 feet per minute.

Electrodes at the cross over point of the two belts were maintained at a potential gradient of approximately 20,000 volts per inch of distance between electrodes.

Results are indicated in Table A.

Table A

	Percent weight	Percent BPL
Feed	100	29.5
Tail	45.7	3.2
Middling	36.9	45.0
Concentrate	17.4	66.0

EXAMPLE II

Mixed ore from Eddy County, New Mexico, was crushed, ground on a hammer mill and screened on a Hummer Screen to produce a comminuted material of −14 mesh size. The −14 mesh material was heated to 900° F. and cooled to about 300° F.

The cooled material was fed to the crossed Dacron belt separator described above at a rate of 300 lbs. per hour by a vibrating Syntron feeder equipped with a Lucite pan.

Electrodes were maintained at a difference of potential of about 20,000 volts, the electrode behind the upper belt being the negative electrode and the bottom electrode the positive electrode.

Results are indicated in Table B.

Table B

	Percent weight	Percent Langbeinite
Feed	100	37.5
Tail	5.4	14.8
Middling	24.8	30.0
Concentrate	68.8	43.0

Having thus indicated the nature of my invention, what I claim is:

1. The process of concentrating granular mixtures of chemically different materials which comprises inducing said granular material to accept differential electrical charges, delivering said charged material onto a continuous non-conductor moving support member, moving said charged material into an electrostatic field supported on said continuous non-conductor moving support member, moving transversely to said support member a second continuous non-conductor member adjacent to and above said moving support whereby the electrostatic field will cause one component of the mixture to transfer to said second non-conductor and separately collecting the materials from each continuous member.

2. The process of concentrating ore material which comprises delivering differentially charged comminuted ore onto a continuous non-conductor moving support, moving said charged ore into a vertically aligned electrostatic field on said continuous non-conductor moving support, moving a like non-conductor moving support through the electrostatic field transversely to the movement of the ore supporter, said transverse moving support being positioned adjacent to and above the supported material, collecting the material after passage through the electrostatic field as it is discharged from the moving support and collecting material removed from the electrostatic field on the transverse moving support as it is released by the support upon leaving the electrostatic field.

3. Apparatus for electrostatically separating mixtures of chemically different materials which comprises continuous

non-conductor moving belts arranged to move in directions transverse to one another having opposed faces one above the other, means for driving said moving belts, means for establishing an electrostatic field between said opposed faces, agitating and feeding means for delivering material to be separated onto the lower of said belts outside of said electrostatic field, and collection hoppers for separated material.

4. Apparatus for electrostatically separating mixtures of chemically different materials which comprises continuous non-conductor moving belts positioned one above the other and having opposed faces adjacent and transversely positioned relative to one another, means for driving said moving belts, electrodes positioned above the opposed face of the top belt and below the opposed face of the bottom belt, means for establishing an electrostatic field between said electrodes, agitating and feeding means for delivering material to be separated onto the lower of said belts outside of said electrostatic field, a collection hopper below the upper belt and adjacent the electrostatic field, and collection hoppers adjacent the end of the lower belt.

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CERTIFICATE OF CORRECTION

Patent No. 2,889,042 June 2, 1959

Ira Milton Le Baron

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 25, for "opposited" read -- oppositely --; column 3, line 22, for "cylvinite" read -- sylvinite --; line 65, for "example which is" read -- examples which are --.

Signed and sealed this 16th day of February 1960.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents