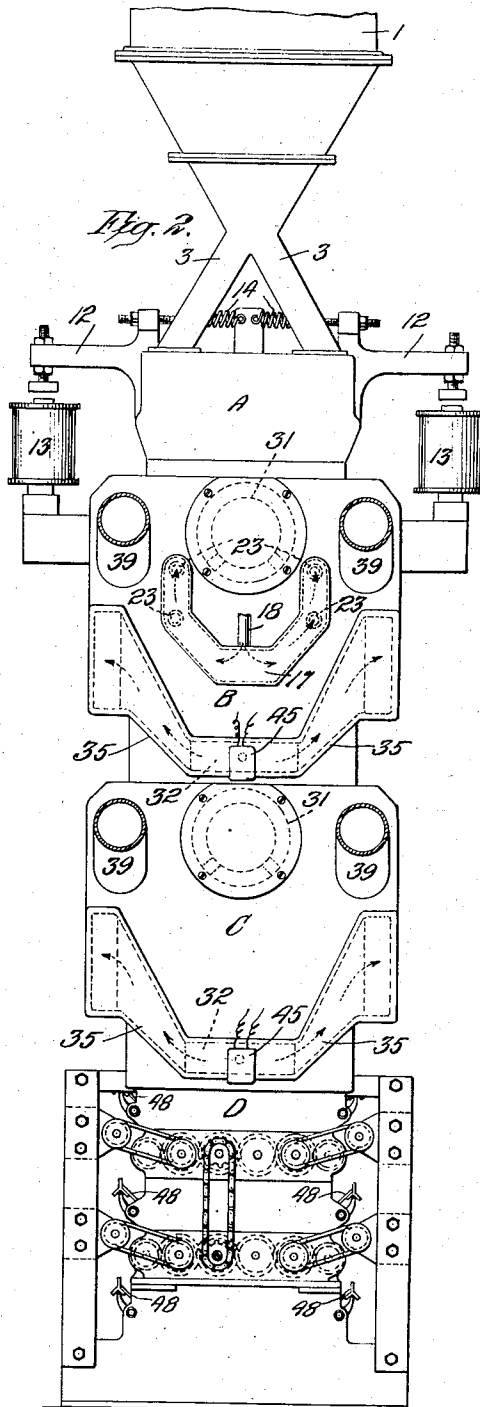
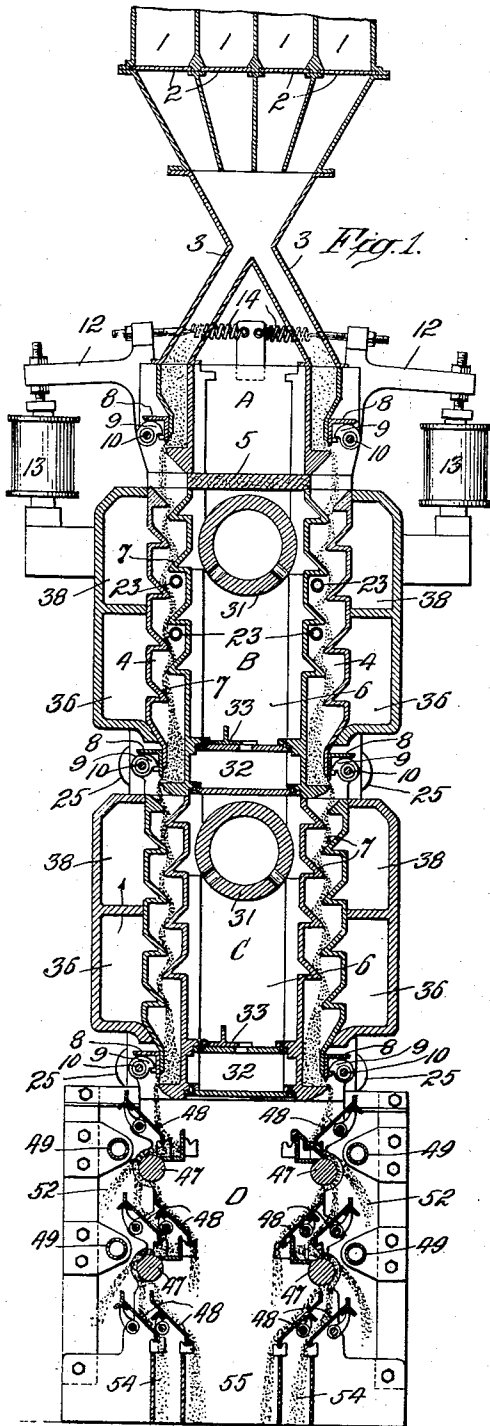


June 10, 1941.

F. R. JOHNSON
APPARATUS AND METHOD FOR CONDITIONING MATERIALS
FOR ELECTROSTATIC SEPARATION
Filed July 24, 1937

2,245,200

3 Sheets-Sheet 1



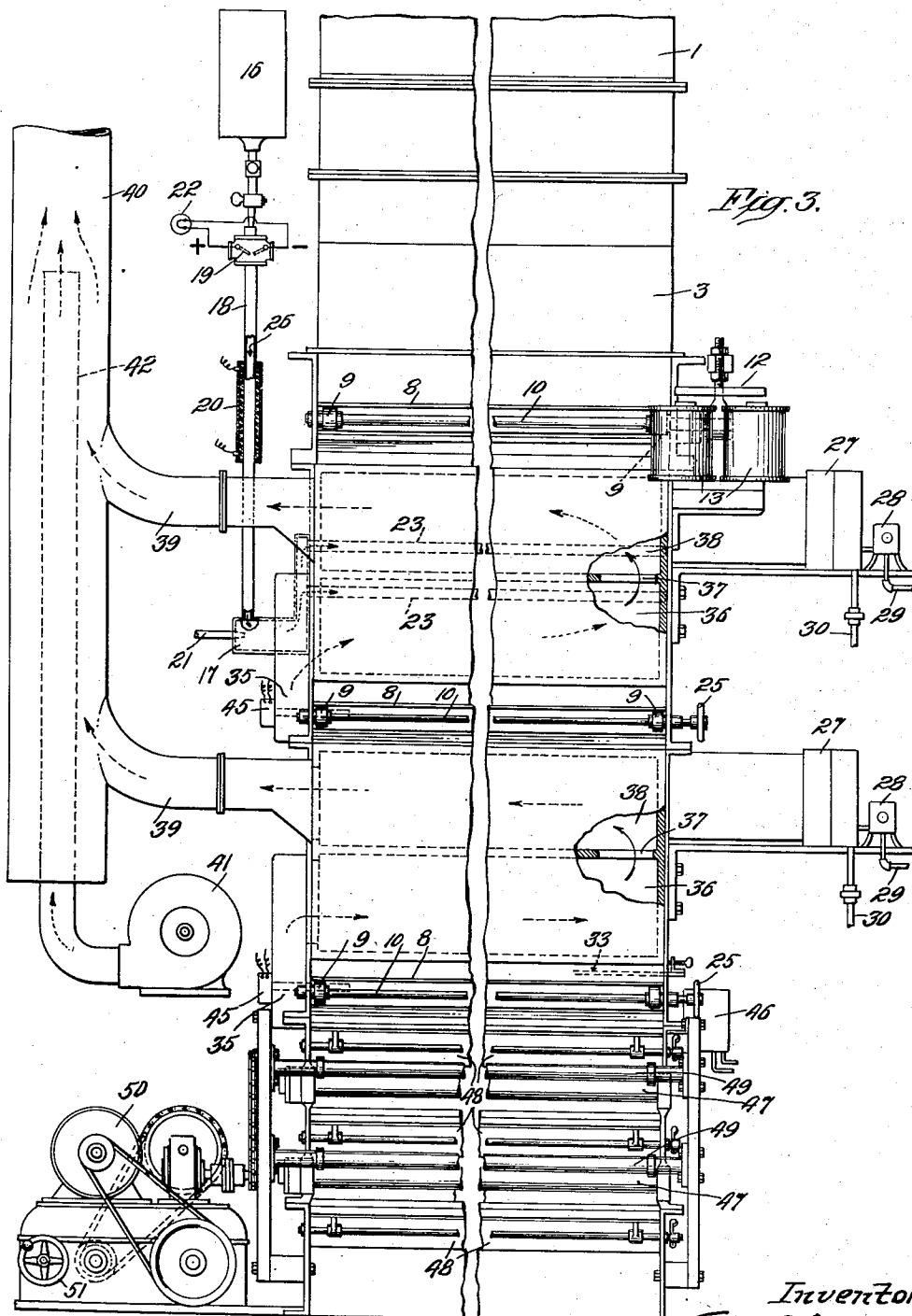
Inventor, Fred R. Johnson,
by Walter P. Geyer, Atty.

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3 Sheets-Sheet 2



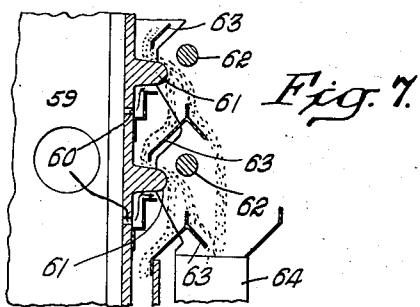
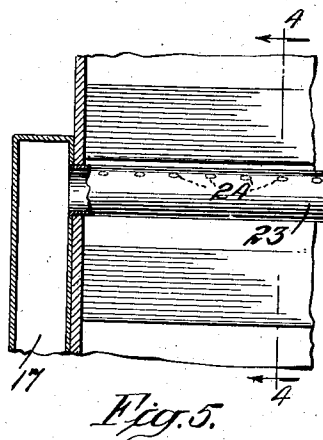
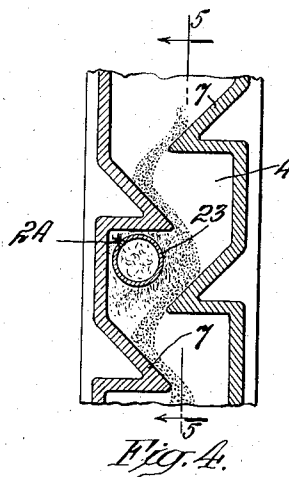
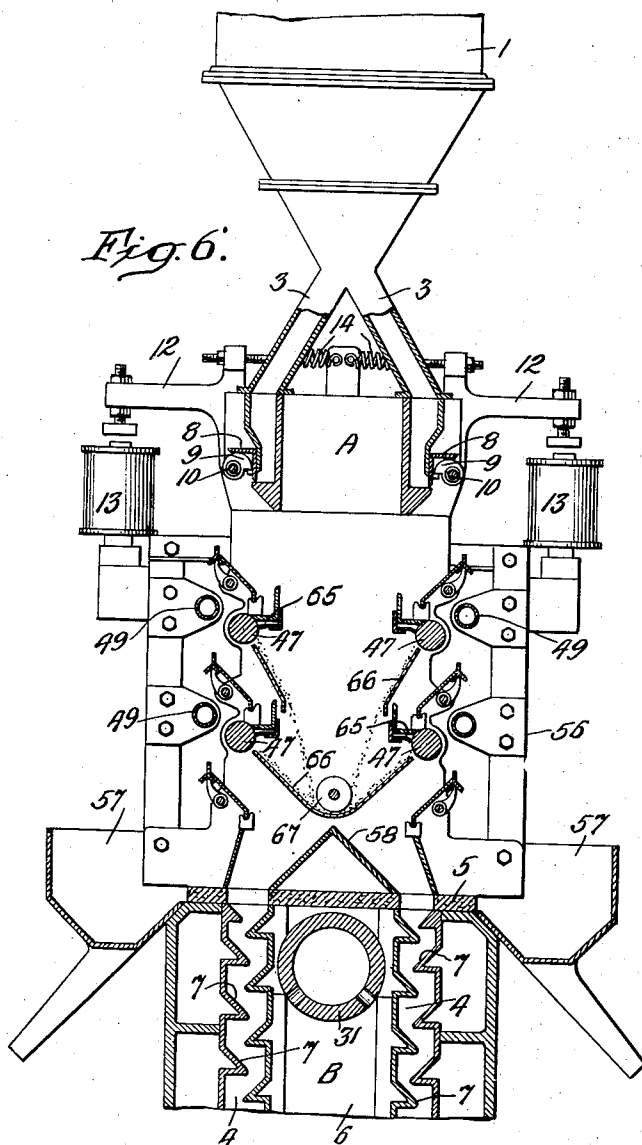
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2,245,200

3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,245,200

APPARATUS AND METHOD FOR CONDITION-
ING MATERIALS FOR ELECTROSTATIC
SEPARATION

Fred R. Johnson, Buffalo, N. Y.

Application July 24, 1937, Serial No. 155,495

4 Claims. (Cl. 209—9)

This invention relates generally to a method and apparatus for conditioning materials for electrostatic separation and is particularly adaptable for concentrating non-metallic minerals such as feldspar, pyrophyllite, olivene, talc, kyanite, zircon, etc., by the separation of undesired mineral substances whose physical and chemical characteristics are such that they cannot be removed by ordinary methods of treatment.

The principal object of the invention is to provide a simple and efficient method and apparatus for conditioning materials for electrostatic separation whereby the surface of the material to be separated is rendered conductive or non-conductive, as the case may be, to produce maximum selective action and efficient separation when the treated material is introduced into the electrostatic field of the separator.

Another object of the invention is to provide an effective conditioning treatment for materials undergoing electrostatic separation, which employs liquid or gaseous reagents, and where the material treated with said reagents is dried and then delivered to the separator in either a hot or cold condition as occasion requires.

A further object is to provide a novel means and method for introducing the conditioning reagent in such a manner that a uniform and effective distribution of the reagent is accomplished, and further to introduce the reagent at a higher temperature than the material to effect a thorough and comparatively quick condensation of the reagent on the material.

In carrying out this improved method of conditioning materials to increase their conductivity, or conversely their non-conductivity, and thereby increase to a maximum the selective action of the material when the same is introduced into the separating zone of an electrostatic field, most efficient and constant results are obtained by subjecting the material to be separated to the action of chemical reagents converted or sublimated to a fluid condition. The fluid reagent, in a gaseous or liquid state, is brought into intimate contact with the material and, depending upon the nature of the material and its reaction to a particular reagent, the material is given a surface conditioning which renders it either conductive or non-conductive to an electrostatic charge when delivered to the separator.

After treatment with the reagent, the material is then preferably dried in any suitable manner to remove any moisture or condensate, and the dry material is then delivered to the electro-

static separator which may be of any suitable type. An important feature of the present invention resides in the provision of a novel apparatus for performing the foregoing method in one continuous operation.

For purposes of illustration, the invention will be described as applied to the separation of free silica, usually in the form of quartz, from natural minerals such as feldspar, pyrophyllite, olivene, talc, kyanite and the like, having physical and chemical characteristics such that the separation of the silica by ordinary physical or chemical methods is unsatisfactory.

In preparing the foregoing or other materials or minerals for electrostatic separation to remove free quartz, for example, the mineral may be ground or crushed to small granules and then treated with an acid having a fluorine or chlorine radical, such as hydrofluoric acid or hydrochloric acid, at a temperature and for a period of time such that the granules are caused to have a different electrostatic susceptibility. This treating or conditioning step may be performed in a continuous operation in the apparatus hereinafter described. Following this conditioning treatment, the material is passed through an electrostatic separator wherein the free silica or quartz is caused to separate from the remainder of the mineral.

The method and apparatus of this invention may also be used to process graphic granite, pegmatite and other mineral mixtures, the constituents of which are differently susceptible to an electrostatic field after treatment; and various other liquid or gaseous reagents, such as chlorine, nitrate, bromine, sulphur dioxide, resorcinol, camphor, naphthalene, ammonium chloride, ammonium sulphate, sulphur, etc., may be used as the conditioning agent in the apparatus hereinafter described, depending upon the material to be treated. As examples of substances which may be electrostatically separated after preliminary conditioning treatment with reagents of this type, there may be mentioned kyanite from quartz and other impurities, manganese from free silica, phosphate rock from quartz and other impurities, and zircon from rutile and ilmenite. In connection with the separation of zircon from rutile, ilmenite and monazite an acid containing a nitrate radical, such as nitric acid has been effectively used as the conditioning reagent. In some instances, furthermore, it has been found that one ingredient may be removed from a mineral under certain conditions of time, temperature and volt-

age, while another ingredient may be removed under different conditions.

While the reason for the above-described selective action is not definitely known, it appears to be due to the formation of a surface layer, for example a surface layer of fluorine or fluoride on the mineral particles, which changes their electrostatic susceptibility. Whatever may be the exact explanation or the exact nature of the effect on the mineral particles, the separation has been found to be surprisingly effective under the conditions specified above.

The various features and advantages of the invention will be described in detail in connection with the particular apparatus shown in the accompanying drawings, wherein:

Figure 1 is a vertical sectional view of a machine constructed in accordance with the invention. Figure 2 is an end view of the machine. Figure 3 is a side view of the machine. Figure 4 is an enlarged section, taken on line 4—4 of Figure 5, illustrating the construction and arrangement of the acid fume distributing tubes. Figure 5 is a detail section taken on line 5—5, Figure 4. Figure 6 is a partial vertical sectional view similar to Figure 1 but illustrating a modification of the invention. Figure 7 is a sectional view of another modification.

Similar characters of reference indicate corresponding parts throughout the several views.

In the drawings, a set of bins 1 are adapted to receive different materials for treatment, for example feldspar or other non-metallic granules of different sizes. A set of gates 2 is adapted to control the discharge of material from said bins to chutes 3 which lead to the elongated treating or conditioning chambers 4 of the machine.

The machine shown herein for purposes of illustration comprises four connected units A, B, C and D which are mounted one above the other in the manner best shown in Figures 1 and 2 of the drawings.

The top unit A, which controls the feed of material from chutes 3 to the lower conditioning units, may be insulated from the uppermost conditioning unit B by a sheet of asbestos or other suitable heat insulating material 5 as shown in Figure 1. The units B and C are the conditioning units in which the acid and heating and drying treatment takes place as hereinafter described, while the unit D is the electrostatic separator. This construction makes it possible to vary the number of conditioning or other units in a machine and thereby correspondingly increase or decrease the time or extent of treatment of the material as required, although it will be understood that the machine may be constructed in any other desired manner.

The machine has two vertical conditioning chambers 4, one on each side of the central heating chambers 6 as viewed in Figure 1, and the inner walls of these conditioning chambers 4 are transversely ribbed or otherwise shaped to provide downwardly and inwardly inclined staggered chutes or baffles 7 to cause the material under treatment to be deflected from one baffle to another and constantly tumbled and turned from the time it enters the conditioning chambers until it emerges therefrom into the field of the electrostatic separator.

Feed of the material to the conditioning chambers 4 is controlled by vertically movable gates 8 which are mounted on the feed unit A as shown in Figure 1. The gates 8 are actuated by cams 9 which are mounted on opposite ends of shafts 10 extending laterally of the machine as shown in

Figure 3. Rotation of shafts 10 is controlled by armatures 12 of electromagnets 13, energization of these electromagnets causing their associated shafts 10 and cams 9 to rotate in a direction to raise the gates 8. When the electromagnets 13 are deenergized, springs 14 return the armatures 12, shafts 10 and cams 9 to their normal position and permit the gates 8 to descend so as to cut off the supply of material to conditioning chambers 4. In the position shown in Figure 1 the electromagnets 13 are energized and gates 8 are open, permitting the material to pass into the conditioning chambers 4.

The hydrofluoric acid or other reagent may be introduced into the conditioning chambers 4 in measured amounts from a receiver 16 containing a suitable float valve and connected to an inlet chamber or manifold 17 through an inlet pipe 18. Pipe 18 may contain suitable electrical contacts or electrodes 19 upon which the drops of liquid hydrofluoric acid or other reagent fall, thus completing an electric circuit which operates an electric light or electric counter 22 indicating or registering the amount of reagent used, and the pipe may also have a surrounding electrical heater 20 which heats the descending reagent or vapor during its passage to the inlet manifold 17. A baffle 26 is suspended in the center of pipe 18 just above the heater 20. This baffle, which is about $\frac{1}{8}$ " smaller than the inside diameter of pipe 18, prevents the drops of acid from falling through the pipe to manifold 17 and brings them in closer contact with the hot pipe. Hot air may be blown through a branch pipe 21 into the manifold 17 for admixture with the gaseous reagent as it enters the inlet manifold 17, this stream of air also creating a downward suction of the vaporized reagent in pipe 18. While the temperature of the entering gas may vary over wide limits, depending upon the reagent and the conditions of treatment, it may be stated that in the case of a hydrofluoric acid reagent employed in the treatment of feldspar it has been found satisfactory to maintain the temperature of the electrical heater 20 at about 250° F. and the air entering through branch pipe 21 at about 250° F. The acid fumes from inlet manifold 17, under low pressure, enter the conditioning chambers 4 through distributing tubes 23 which extend the full length of chambers 4 adjacent the top of said chambers as shown in Figures 1 and 2. The distributing tubes 23 are preferably mounted beneath the overhanging baffles 7 of the conditioning chambers and are provided with a plurality of closely spaced holes 24 extending lengthwise of the tubes and facing the corners of baffles 7, as best shown in Figures 4 and 5, so that the acid fumes from the tubes are forced or ejected into the corners of chambers 4 beneath baffles 7 and are thus sprayed or directed over the entire width of these chambers.

From the foregoing description it will be seen that the granular feldspar or other material passes downwardly through the conditioning chambers 4 by gravity, being tumbled about in a tortuous path from one baffle 7 to the other, and is intimately mixed with the fumes of the hydrofluoric acid or other reagent which are carried along with the descending material. If desired, the various conditioning units B and C of the machine may be provided at their lower ends with additional vertically movable gates 8 controlled by cams 9 carried by shafts 10 similar to the corresponding parts described above, although the shafts 10 controlling the gates 8 of

these conditioning units are preferably adjusted by means of handwheels 25 instead of by the electromagnetic means described above. Ordinarily the handwheels 25 are operated only when it is desired to adjust the gates to control the rate of feed from one conditioning unit to another, or from the lowermost conditioning unit to the electrostatic separator, at the beginning of a run.

In the machine shown herein for purposes of illustration the various conditioning units B and C are separately heated by individual oil burners 27 to bring the material to proper temperature for effective separation, each burner being equipped with the usual float valve 28, oil line 29 and air line 30, as indicated in Figure 3 of the drawings. These oil burners are provided with suitable combustion tubes or chambers 31 extending lengthwise of the central heating chambers 6 of the respective conditioning units as shown in Figures 1 and 3 of the drawings. The combustion gases from the tubes 31 circulate through the respective heating chambers 6 and then pass downwardly into passages 32 controlled by adjustable dampers 33 into branch passages 35 from which the combustion gases flow into the lower ends of jackets 36 which surround the conditioning chambers 4 at the sides of the machine as shown in Figures 1, 2 and 3. At the ends of jackets 36 remote from branch pipes 35 there are provided openings 37 leading into upper jackets 38 which surround the upper portions of conditioning chambers 4 of the respective conditioning units as best shown in Figure 3 of the drawings. The combustion gases from heating tubes 31 therefore pass downwardly through the respective heating chambers 6 into passages 32, thence through branch passages 35 into jackets 36, thence through openings 37 into jackets 38, and then out through pipes 39 to the stack 40 provided with a blower 41 and suction pipe 42 of any suitable type.

Although the temperature of the foregoing heated gases may vary within wide limits, depending upon the material being treated and the conditions of treatment, it may be stated for purposes of illustration that in the case of some actual runs on feldspar the temperature in heating chambers 6 has been around 400° F., while the temperature of the gases circulating through jackets 36 and 38 has been in the neighborhood of 150° F. The machine is preferably provided with suitable thermostats 45 associated with the heating chambers of the respective conditioning units, and with an associated protective mechanism or relay 46 for automatically controlling the oil burners 27.

It will be noted in Figures 1, 3, 4 and 5 of the drawings that the acid tubes 23 extend the full length of the conditioning chamber 4 and are disposed in juxtaposition to the upper portion of the adjoining wall of the companion heating chamber 6, whereby an even distribution of the acid fumes is effected over the layer of material passing through the conditioning chamber and the temperature of the acid-fumes is appreciably higher than that of the inflowing material with the result that the fumes condense on the surface of the material and cover the material quickly and thoroughly. For example, in practicing my invention I have introduced the material to be treated in a dry state at room temperature, say about 70° F., while the temperature to volatilize the acid reagent has been above 212° F. After this coating is effected, the material becomes hotter as it flows through the conditioner

and a more thorough chemical action takes place before it enters the heating or drying unit C, where the material is dried before entering the electrostatic field.

The treated material emerging from the conditioning chambers 4 of the lowermost conditioning unit C enters the electrostatic separator unit D which may be of any suitable construction. In the forms illustrated, the electrostatic separator comprises opposite sets of rotatable rolls 47 associated with a series of baffles or chutes 48 so that the material falls in succession from one roll of the vertical series to the next. The rolls 47 constitute one pole of the electrostatic separator, and the opposite pole may comprise companion rolls 49 which may be connected to a suitable source of high potential. The rolls 47 and 49 are operated by a motor 50 through a suitable reduction mechanism such as a Reeves variable speed drive having a handwheel 51 for varying the driving speed as shown in Figure 3 of the drawings. Assuming that the material treated in the machine described above is granular feldspar intermixed with free silica in the form of quartz, the treated particles of free silica are segregated toward the rods 49 of the electrostatic separator and will fall down in streams 52 which pass into the discharge at opposite sides of the machine as shown in Figure 1. The concentrated feldspar, reduced in silica, falls through chute 54 into any suitable collector. Tailings, which in the case here referred to would consist of mica particles, wood chips, etc., are discharged into a central tailings bin or receptacle 55.

In treating certain materials, for example, in treating certain grades of granular feldspar to remove free silica, it is sometimes desirable to give the material a preliminary pass through an electrostatic separator for the purpose of removing at least a portion of the mica before passing the material to the conditioner since excess mica in the feed seems to absorb hydrofluoric acid and therefore interfere with the separating action described above. In cases of this kind an electrostatic separator unit 56 may be mounted between the feed unit A and the uppermost conditioning unit B of the machine as shown in Figure 6 of the drawings. In the form shown, this electrostatic section 56 treats the material cold, and the mica, wood chips, etc., are discharged through the sides of the machine into chutes 57, while the remaining material comprising feldspar mixed with free silica is discharged towards the center whence it is directed by chutes 58 into the conditioning chambers 4 for the conditioning treatment described above. It will be noted that in the case of this preliminary separation the action of the electrostatic separator upon the material is substantially the reverse of that described above in connection with the electrostatic separator D. That is, in the preliminary separator 56 the material is treated cold and without previous conditioning the mica, wood chips, etc., are discharged at the sides of the machine while the main stream of feldspar is discharged inwardly; whereas the lower electrostatic separator D treats the material after it has passed through the conditioner and heater and the hot mica and other tailings are discharged inwardly. It will thus be seen that the action of the electrostatic separator varies according to the material being treated, and the conditions of treatment.

By the above described method and means for

conditioning minerals for electrostatic separation, the results produced are constant and efficient separation is assured. Furthermore, the action of the fluid reagents on the material increases the electrostatic susceptibility of the material with the result that the number of runs or passes of the material through the electrostatic separating zones is reduced to a minimum and the separating units may be accordingly reduced in size and thereby effect a material saving in installation and maintenance costs.

In cases where the materials to be separated may be inherently conductive or non-conductive, then by the foregoing method, one of the materials may be subjected to a surface conditioning by a reagent particularly adapted to such material so as to render it opposite in characteristics to the other material or materials.

While hydrofluoric acid is a very effective reagent for separating quartz from feldspar when run hot through the electrostatic field, hydrochloric acid as a reagent is very effective if the material is treated with the acid fumes while hot, then cooled by passing it through a cooling chamber or the like, and then in its cooled state run through the electrostatic field. In this case the feldspar is removed in front, that is, segregated toward the rods 49 of the electrostatic separator, which is an action reversed to that in the hot treatment of separation as heretofore described in using hydrofluoric acid as the treating agent.

In Figure 7 I have shown another modification for effecting the separation of mica, wood chips, iron-bearing minerals and the like from the material prior to its being introduced into the conditioning chambers, the numeral 59 indicating a hot air chamber in communication with a source of heat and having a plurality of outlets 60 in its side walls through which the hot air escapes into the path of the material flowing through an electrostatic field including the poles or electrodes 61, 62 and baffles or chutes 63. The electrodes 61 may be formed directly on the walls of the chamber 59, while the electrodes 62 may be independently mounted for rotation in the manner heretofore described. A receptacle 64 is provided below the lowermost electrode and chute for receiving the mica and other foreign matter, while the material to be conditioned flows on through the machine in the manner previously considered. By this arrangement, the hot air is directed against the flowing material, not only removing any moisture therefrom and drying it, but cooperating with the electrostatic field to divert the undesirable foreign constituents of the material, such as mica, etc., to one side and thence into the receptacle 64 from which it may be removed in any approved manner.

Should it be found desirable to run the material hot through the separator shown in Figure 6, then the mica and other foreign constituents in the material will be drawn inwardly and suitable felt brushes 65 are provided in contact with the electrode rollers 47 for removing the collected particles therefrom and directing them onto suitable chutes 66 into the path of a screw conveyor 67.

With this apparatus fluorspar ore has been effectively treated to separate it from other constituent particles contained in the ore, and in this treatment an acid of the cresyl radical, such

as cresylic acid, has been used to render the particles selectively susceptible to an electrostatic field to cause the fluorspar particles to segregate and be removed from the remaining constituents. Separation of the fluorspar particles is also effected by a similar treatment using pine tar oil, kerosene, gasoline or turpentine.

I claim as my invention:

1. An apparatus for conditioning materials for electrostatic separation, comprising a centrally-disposed heating chamber, conditioning chambers disposed at opposite sides of and in heat-conductive relation to said heating chamber, and each having an inlet at one end for the material to be treated and a discharge at its opposite end, jackets surrounding the outer walls of said conditioning chambers and in heat-communicating relation with said heating chamber, those walls of the conditioning chamber exposed to the heating chamber being ribbed in staggered fashion to provide baffles extending into said conditioning chambers, and ported tubes in said conditioning chambers and in juxtaposition to that wall thereof adjoining said heating chamber for heating and introducing a fluid reagent into said conditioning chambers for intimate contact with the material as it passes from the inlet to the discharge end of such chambers.

2. An apparatus for conditioning materials for electrostatic separation, comprising a heating chamber, a conditioning chamber for the material to be treated disposed alongside of and in heat conductive relation to said heating chamber, a combustion tube disposed in the upper portion of said heating chamber, the latter having a damper-controlled passage in its lower portion terminating in a jacket extending around the outer side of said conditioning chamber, and ported tubes in said conditioning chamber and in juxtaposition to that wall thereof adjoining said heating chamber for heating and introducing a fluid reagent into the conditioning chamber for intimate contact with the material as it passes through such conditioning chamber.

3. The method of concentrating minerals containing fluorspar which comprises treating the particles with an acid of the cresyl radical to render the particles selectively susceptible to an electric field, and then passing the treated particles through such field to cause the fluorspar particles to segregate and to be removed from the remaining constituents.

4. An apparatus for conditioning materials for electrostatic separation, comprising a heating chamber, a conditioning chamber for the passage of the material, to be treated disposed alongside of and having its side walls in heat conductive relation to said heating chamber, baffles projecting inwardly from the side walls of the conditioning chamber, and means for intimately mixing an acid reagent with the material during its passage through such chamber, said means consisting of one or more distributing tubes mounted in the conditioning chamber in juxtaposition to one of its side walls for heating the reagent to a temperature to cause its volatilization, each of said tubes being positioned beneath an adjoining baffle and having ports therein for directing the acid fumes against the adjoining wall of the conditioning chamber.

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