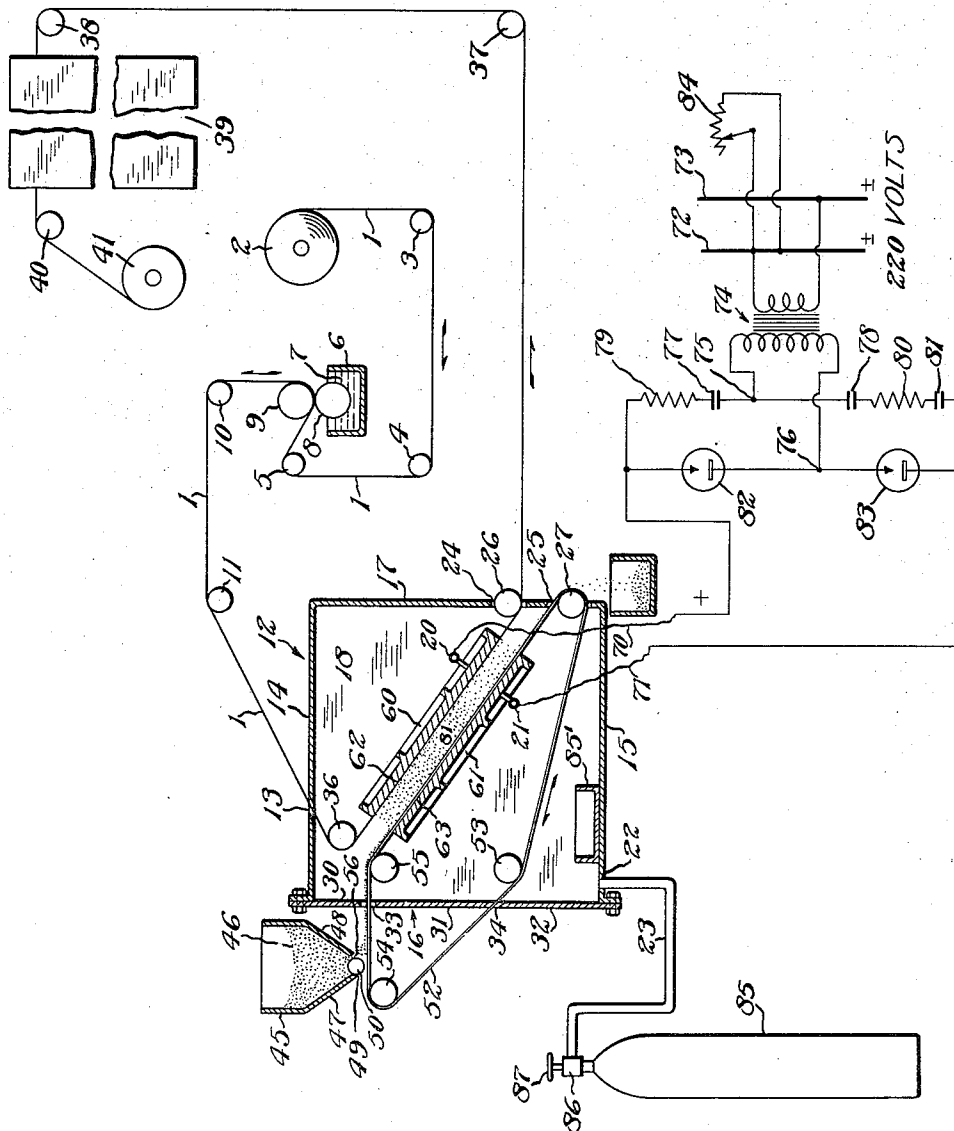


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ELECTROSTATIC COATING PROCESS

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ELECTROSTATIC COATING PROCESS

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The invention relates to an electrostatic coating process, and with regard to its more specific features to the manufacture of abrasive paper and cloth.

One object of the invention is to provide a process whereby the electrostatic coating of sheet material may be speeded up. Another object of the invention is to provide an improved method of electrostatic coating by means of which abrasive particles in the larger sizes may be more effectively handled. Another object of the invention is to provide an improved method of electrostatic coating permitting the manufacture of abrasive paper and cloth using larger and heavier abrasive particles than heretofore. Another object of the invention is to accelerate the production of sandpaper of the oriented abrasive particle type. Another object of the invention is to provide an electro-coating method and apparatus permitting the use of smaller electrodes.

Another object of the invention is to reduce the possibilities of short circuits or arcing over between the electrodes, especially when the field stress between the electrodes is close to the breakdown value. Another object of the invention is to reduce the possibility of short circuit between the electrodes when binders are used which are inflammable or are apt to cause explosive mixtures or when binders are used which have low flash points or when temperatures are used which cause rapid evaporation of inflammable binders. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts, and in the several steps and relation and order of each of said steps to one or more of the others thereof, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawing in which is shown one of various possible embodiments of the mechanical features of this invention, the single figure is a diagrammatic representation of electrostatic coating apparatus constructed according to the invention and by means of which the process may be carried out.

The invention is equally applicable to the coating of cloth with abrasive or other comminuted material and also paper with abrasive or other comminuted material, for the production of abrasive cloth and abrasive paper, respectively, and in fact may be applied to the coating of any sheet material and even material which is not flexible,

although it has special features of advantage when applied to the coating of flexible sheet material. It may be used for the application of comminuted material other than abrasive material to a surface, such as flock or piled surface products as used in the garment and shoe and textile industry. However, it will be more particularly described in connection with the manufacture of sheet abrasive material, of which abrasive coated paper, still familiarly referred to as "sandpaper," will be used as an illustrative example.

Referring now to the drawing, I provide a quantity of paper 1 initially in the form of a roll 2. The paper 1 is directed around a roller 3 and then around a roller 4 and up to a roller 5. I provide a glue trough 6 which may be suitably heated and in which is glue 7 or any other suitable adhesive for the manufacture of sandpaper or abrasive cloth. In the glue trough 6 and immersed in the glue 7 is a roller 8 above which is a roller 9. The paper 1 passes between the rollers 8 and 9 and then up to a roller 10. One or more of the rollers 3, 4, 5, 8, 9 and 10 are positively driven at a given peripheral velocity in order to feed the paper, this mechanism not being shown as it is well understood.

From the roller 10 the paper 1, now having a coating of glue on the upper side thereof, passes over a roller 11 and into a chamber 12. The paper 1 passes through a long slot 13 which is just wide enough to take the paper without contact between the paper or the glue thereon and the upper wall 14 of the chamber 12. The chamber 12 may take many different forms but as shown it is substantially a box-like structure, being a rectangular parallelepiped in shape and having the top wall 14 referred to, a bottom 15, back and front walls 16 and 17, a side wall 18, and an opposite similar side wall, not shown. The wall 18 and the opposite wall may be substantially imperforate excepting that insulating sleeves 20 and 21 may be provided for the introduction of electric potential, as hereinafter more particularly pointed out. The bottom 15 is preferably imperforate excepting for an opening 22 to receive a pipe 23. The front wall 17 may be imperforate excepting for openings 24 and 25 in which are mounted rollers 26 and 27 by means of any suitable journals, not shown. Preferably the back wall 16 is made in three detachable sections 30, 31 and 32 suitably fastened to the other parts of the chamber 12, in order that ready access may be gained to the inside of the chamber and so that the apparatus may be readily as-

sembled. This construction leaves slots 33 and 34 in the back wall 16 which are preferably narrow.

The paper 1 passes through the slot 13 and then around a roller 36 and through the chamber 12, passing around the roller 26, out of the chamber 12 and to a roller 37, then up and over a roller 38 to a drying chamber 39, thence over a roller 40 to the winding take-up roller 41. Abrasive is applied in the chamber 12.

The take-up roller 41 is driven at a varying angular velocity to wind the finished paper into the roll thereof 42 which increases in diameter, and one or more of the rollers 26, 36, 37, 38 and 40 may be positively driven, if desired.

I provide an abrasive hopper 45 supplied with suitable abrasive 46 therein. For the manufacture of sandpaper and abrasive cloth, I may use any suitable abrasive, such as silicon carbide, alumina, either fused alumina or any of the natural forms such as emery and corundum, also garnet and silica or sand. The bottom of the hopper 45 has inclined side walls 47 and 48 in between which is a bottom opening 49 with a delivery roller 50 which fits close to the wall 47 on the back side and has a somewhat larger opening on the front side, the roller 50 being positively rotated, for example in a clockwise direction, to deliver abrasive material at a fairly constant rate to a traveling belt 52. The traveling belt 52 is preferably a few inches wider than the paper 1 and it travels through the chamber 12 and outside thereof over and around the roller 27 and also rollers 53, 54 and 55 which may be located substantially as shown, the belt 52 passing through the slot 33 into the chamber 12 and through the slot 34 out of the chamber 12 to get the abrasive material which is deposited at 56. It will be seen that the belt 52 for a substantial distance runs parallel to the paper 1. Roll 27 is connected to a variable speed motor and acts as a driving roll for the belt. The belt speed can thereby be increased or decreased in order to feed more or less grain into the chamber 12 in order to control the sand weight.

I provide suitable electrodes which may be in the form of metal plates 60 and 61, for example made out of aluminum in order that they be not excessively heavy. These plates 60 and 61 may also have the rib-like construction shown, likewise for lightness, but preferably they have perfectly plane surfaces 62 and 63 which are parallel to each other and face each other. The paper 1 and the belt 52 pass between these surfaces 62 and 63, as shown. A conductor 70 passes through the insulating sleeve 20 and is connected to the electrode 60. A conductor 71 passes through the insulating sleeve 21 and is connected to the electrode 61.

I provide a source of electric current in alternating form, for example 220 volts at 60 cycles, in main line conductors 72 and 73. The line 72 and 73 is connected as shown to the primary of a transformer 74, the secondary of which is connected to terminals 75 and 76. Terminal 75 is connected to plates of condensers 77 and 78. The other plate of condenser 77 is connected to the conductor 70 through a resistance 79. The other plate of condenser 78 is connected to a resistance 80 which is connected to one plate of a condenser 81, the other plate of which is connected to the conductor 71. Two rectifiers 82 and 83 are connected in shunt across the conductors 70, 71 and to the terminal 76 as shown. The potential difference or coating voltage at the terminals 20 and 21 ranges from about 5,000 to 70,000 volts.

This voltage range is obtained by the insertion of a voltage regulator 84 into the 220 volt side of the transformer 74. This may be a rheostat, as shown.

The rectifier set as shown in the drawing supplies a unidirectional current to the electrocoating unit. This kenotron rectifier can be replaced by a thyatron converter set which supplies the electrocoating unit with alternating current, pulsating direct current or any desired form of current of definitely controlled characteristics.

As the conveyor belt 52 carries the abrasive over the electrode 61 which is preferably in contact with the belt 52, the abrasive receives a charge and, attracted by the electrode 60, and repelled by the electrode 61, it jumps the gap between the belt and the paper and becomes embedded in the glue or other adhesive on the paper. By reason of the electrostatic field with the abrasive particles having like charges of electricity, the abrasive material is evenly and equally spaced and, furthermore, is oriented so that the long axis of each particle is normal to the paper upon which it is deposited.

Electro-coating, as previously practiced, has been somewhat restricted due to the fact that air ionizes in a field of the intensity of about 30,000 volts per centimeter. The field intensity varies with the temperature of the barometric pressure. A practical formula for calculating the intensity at which air reaches the break-down value due to ionization is believed to be as follows. The formula is only accurate for flat electrodes and a spacing or sparking distance greater than $\frac{1}{2}$ ".

$$H = 81\sqrt{2} \times \frac{b}{273 + t}$$

H=maximum field intensity in kv./cm.

b=barometric pressure in centimeters.

t=temperature in degrees centigrade.

Since the force exerted in abrasive particles increases in proportion to the square of the field intensity, it is important to increase H as much as possible. Under substantially sea level conditions and room temperatures, the maximum value for air is around 30,000 volts per centimeter, as above stated. With greater field intensities the air is ionized and becomes a conductor, under which conditions the field intensity drops to practically zero.

The rate of production of sandpaper or abrasive cloth with a given apparatus is substantially a straight-line function of the speed of the material 1 through the apparatus. Therefore, it is desirable to achieve as high a speed as possible, other things being equal. For a given grade of sandpaper or abrasive cloth, there are particular specifications as to the amount of abrasive material to the square inch which have to be met as nearly as practicable. There are practical limits to the shortness of the gap 61 between the paper 1 and the belt 52 owing to the chance of actual contact of the glue with the belt which would interfere with the beneficial results achieved by the use of the electrostatic field involving equal spacing of the grains and orientation, and the fact that the abrasive particle should be allowed to jump a substantial distance in order to give it room enough and time enough in which to orient itself, as above specified, and also to allow several particles which may be bunched together to separate and space themselves properly. For all these reasons, in actual practice in the manufacture of sandpaper, it has

been found highly desirable and important to have the gap 81 at least $\frac{3}{4}$ " wide, and the closest gap which has heretofore been found thoroughly practicable has been of the order of $\frac{1}{2}$ ", whereas it is considered desirable in most cases to have a gap at least 1" wide. Furthermore, there are practical limitations on the length of the electrodes 60 and 61 in the direction of movement of the paper involving the use of a great deal of power if the electrodes have too large an area including greater opportunity for dielectric loss and because of space limitations and the desirability of applying the abrasive within a certain time limit following the coating of the paper with glue. As a practical matter, it has been found that with a gap of 1", the electrodes should be no longer than 6', that is to say the distance between the upper and lower rollers should preferably be not substantially greater than eight feet.

From the foregoing it will be appreciated that it has been desired to create a field intensity as great as possible but, as above explained, there have been definite limitations to the field intensity which could be employed and it should be noted that because temperature, humidity and barometric pressure vary, some margin has been heretofore provided in actual practice.

Referring to the attached drawing, I provide in the chamber 12 an atmosphere which ionizes at a substantially greater field intensity than air. There are many gases which have a greater break-down value than air. Many of them are dangerous, corrosive, or explosive. Others constitute a fire hazard. Among all the gases known for maximum stress higher than air, there are a number which are quite harmless. These gases may be used for our purpose of increasing the field intensity H between the coating electrodes. Among these gases are, for example, nitrogen (N_2), or nitrogen oxide (N_2O). On the other hand, I may use vapors of certain liquids in atmospheric air, for example vapors of methyl chloride (CH_3Cl) or carbon tetrachloride (CCl_4). Referring again to the drawing, I may provide a tank 85 containing the desired gas, fitted with the usual valve 86 connected to the pipe 23. By turning the handle 87 of the valve 86, gas is admitted to the chamber 12 in a steady flow so long as it lasts. Although there are various slots 13, 24, 25, 33 and 34 out of which the gas may flow, the direction of flow is substantially outward and the gas in the chamber 12 is substantially the gas provided in the bottle 85. I prefer to use such gases as nitrogen and nitrous oxide as they have little effect upon human beings in diluted quantities. I may provide suitable exhaust apparatus to convey away the gases as they escape. Satisfactory results are achieved even though the gas in the chamber 12 is not 100% pure nitrogen, nitrous oxide, etc., but contains a substantial quantity of air.

Figures for ionization of the gases mentioned, assuming 90% pure gas, 10% air, are substantially as follows:

$$\text{Nitrogen: } H = 133 \frac{b}{273+t}$$

$$\text{Nitrous oxide: } H = 152 \frac{b}{273+t}$$

or for $b=76$ cm. & $t=20^\circ$ C.

H max. for $N_2=34.5$ kv./cm.

H max. for $N_2O=39.0$ kv./cm.

As will be observed from the foregoing examples, it is possible with my invention to use a

higher field intensity than has heretofore been possible. The field intensity is measured in volts per centimeter and with my invention it is, therefore, possible to operate with a higher voltage per centimeter or per inch of electrode gap or spacing than has heretofore been possible. Stated in another way, this means that, with a given electrode spacing, it is feasible to use a higher voltage across the electrodes by employing my invention than has heretofore been possible. Therefore, a stronger force may be exerted upon the particles being applied in the gaseous media that I provide than has heretofore been possible with air. I am, therefore, able to coat a backing sheet with the usual particles of various kinds with greater speed, and I am also able to coat with heavy particles which could not heretofore be successfully deposited by the electrostatic method. The essence of my process is, therefore, the provision of an atmosphere which ionizes at a higher potential than air, combined, preferably, with higher field intensities than have heretofore been practical with air.

Further referring to the drawing, I may provide instead of the bottle 85 or even in conjunction therewith a pan 85' containing any one of the liquids mentioned or suitable equivalents, and under normal conditions of temperature and humidity there will be produced in the chamber 12 a fair concentration of vapors from the liquid. Naturally the results are more variable with this procedure but in practice I am enabled to achieve, using the various liquids mentioned, field intensity values of 36.2 kv./cm. and 56.8 kv./cm., respectively, for methyl chloride and carbon tetrachloride in the formula—

$$H = a \frac{b}{273+t}$$

a for $CH_3Cl=140$

a for $CCl_4=220$

the above being the given value for a in respective cases.

In the use of the apparatus and method of the invention, manufacture of sandpaper may be speeded up as much as 20%. Furthermore, larger grit sizes may be used up to $2\frac{1}{2}$ grit size. Furthermore, better results and better production can be achieved using the present apparatus and method because other factors including the size of the gap 81 and the length of the electrode 60 may readily be kept within safe limits, yet achieving a high rate of production.

Furthermore, gases or vapors may be used which will reduce fire hazards or prevent spark discharges or the sustaining of an electric arc between electrodes.

I mentioned in the above disclosure only a few gases or vapors as examples. There are many more which can be used and some are listed below:

Trichlorofluoromethane.....	CCl_2F
Dichlorotetrafluoroethane.....	$C_2Cl_2F_4$
Trichlorotrifluoroethane.....	$C_2Cl_3F_3$
Dichlorodifluoromethane.....	CCl_2F_2
Trichloromethane.....	$CHCl_3$
Trichloro acetyl chloride.....	CCl_3COCl
Dichlorofluoromethane.....	$CHCl_2F$
Dichloromethane.....	CH_2Cl_2
Chlorofluoromethane.....	CH_2ClF
Ethylene chlorohydrine.....	CH_2ClCH_2OH

Very effective are mixtures of nitrogen with some vapors or gases, for example, mixtures of

carbon tetrachloride, and nitrogen or dichloro-fluoromethane and nitrogen.

It will thus be seen that there has been provided by this invention a method and apparatus in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As various possible embodiments might be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawing is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. The method of coating with comminuted material such as flock, which comprises providing a gaseous atmosphere which ionizes at a higher electrostatic field intensity than air, creating an electrostatic field in said atmosphere of an intensity which would create a danger of ionizing air but lower than that which ionizes the atmosphere, locating the article to be coated in said field and introducing the comminuted material into the field adjacent the article.

2. The method of coating with comminuted material which comprises creating an electrostatic field, locating the article to be coated in the electrostatic field, feeding the comminuted material to the electrostatic field, providing an atmosphere in the electrostatic field which ionizes at a higher field intensity than air, and raising the intensity of the field to an intensity that would create a danger of arc-over or ionization in air but lower than that which creates such a danger in said atmosphere.

3. The method of coating sheet material which comprises coating the sheet material with adhesive on one side thereof, providing an atmosphere which ionizes at a higher electrostatic field intensity than air, creating an electrostatic field in

said atmosphere of an intensity at least as high as one that would create practical dangers of arc-over in an atmosphere of air but lower than one that would create practical dangers of ionizing said atmosphere, feeding the sheet material through said field and feeding comminuted material to the electrostatic field, the coated side of the sheet material being disposed in proximity to the comminuted material as it is fed into the field.

4. In the production of piled surfaces by passing pile forming material adjacent an adhesive surface foundation material positioned in an electric field, the steps which comprise introducing into the field an atmosphere conditioning gas which ionizes at a higher field intensity than air, and raising the intensity of the field above an intensity that would create dangers of arc-over or ionization in air but lower than that which would create such dangers in the atmosphere so conditioned by said gas.

5. The method of coating sheet material with comminuted material which comprises introducing into a substantially enclosed space, a gas or vapor having the characteristic of ionizing at a higher electrostatic field intensity than air and thereby creating in said space an atmosphere which ionizes at a higher field intensity than air, creating an electrostatic field in said atmosphere of an intensity that would create a danger of ionizing air but lower than that which ionizes said atmosphere, conducting adhesively coated sheet material through said electrostatic field, introducing comminuted material into the field adjacent the adhesively coated surface of the sheet material, and projecting the comminuted material onto the adhesively coated surface of the sheet material by an electrostatic force of greater intensity than would be possible in an atmosphere of air alone.

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