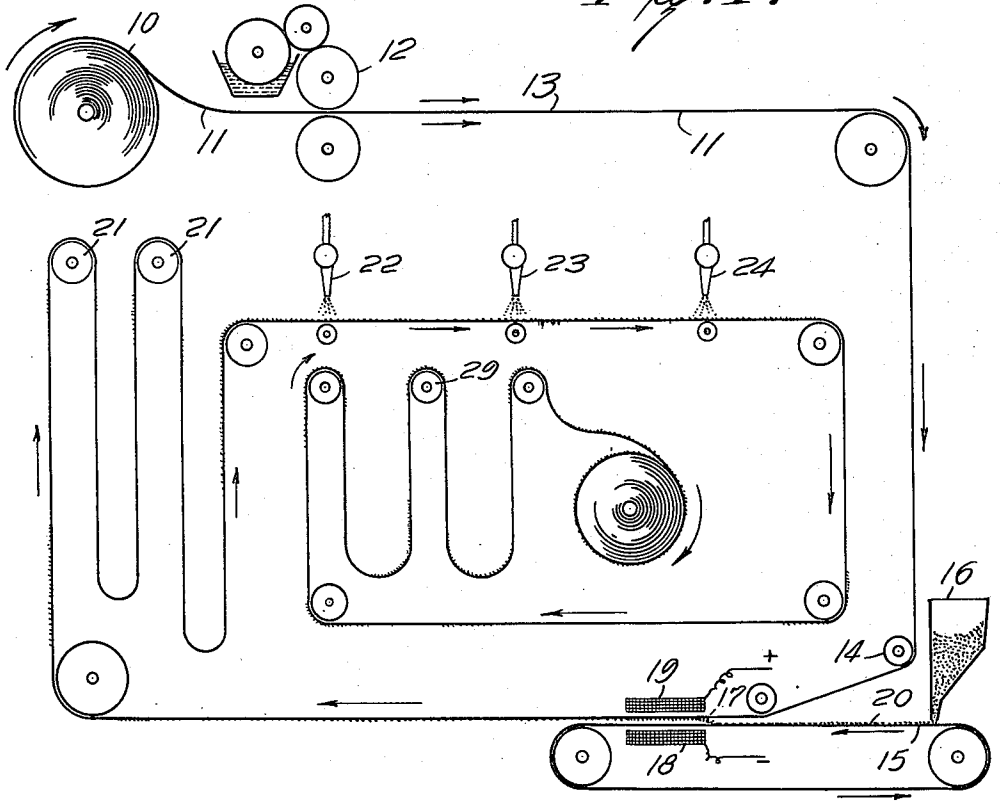
May 5, 1942. B. S. CROSS 2,281,558

MANUFACTURE OF ABRASIVE ARTICLES AND APPARATUS THEREFOR

Filed March 6, 1933 3 Sheets-Sheet 1

Fig. 1.



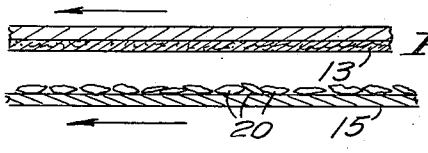
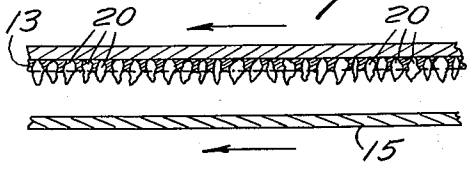


Fig. 2.

Fig. 3.



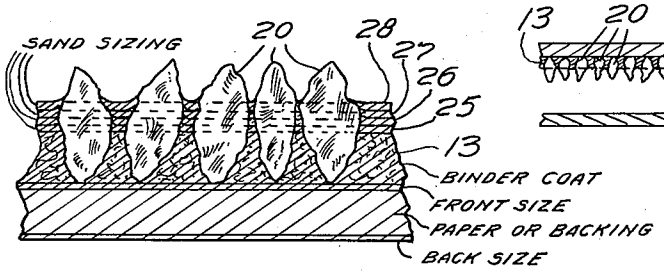


Fig. 4.

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May 5, 1942. B. S. CROSS 2,281,558

MANUFACTURE OF ABRASIVE ARTICLES AND APPARATUS THEREFOR

Filed March 6, 1933 3 Sheets-Sheet 2

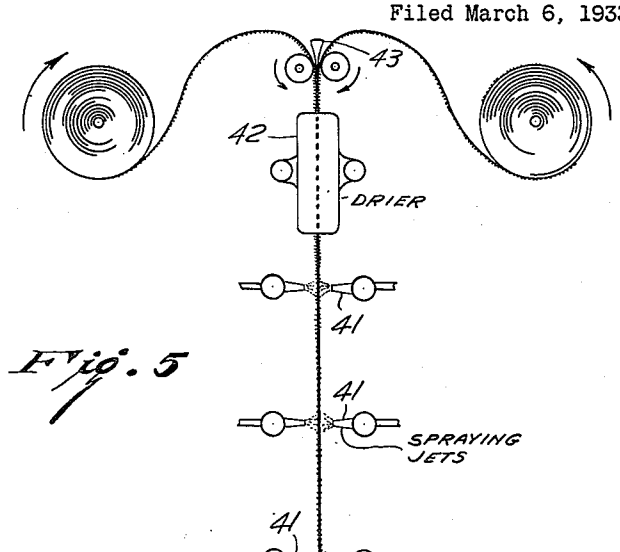


Fig. 5

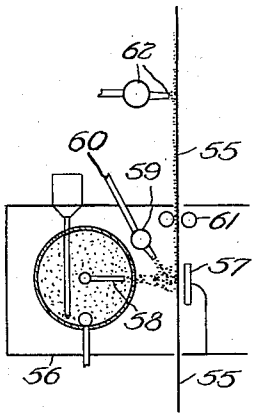


Fig. 7.

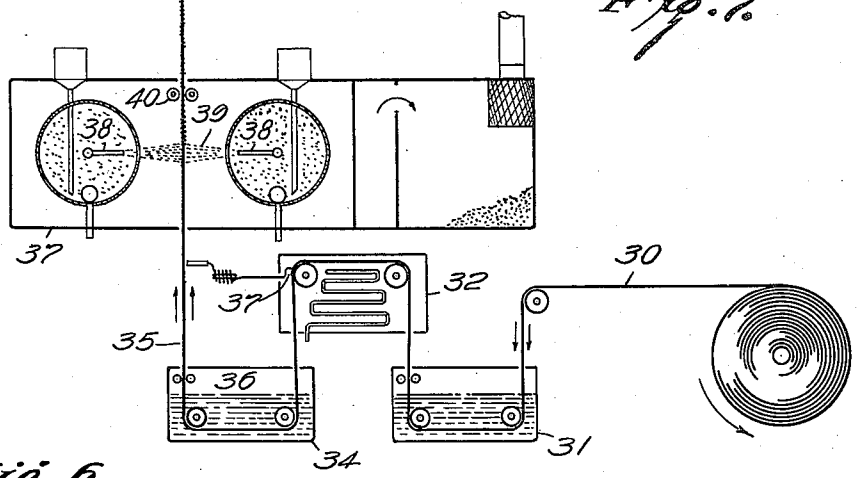
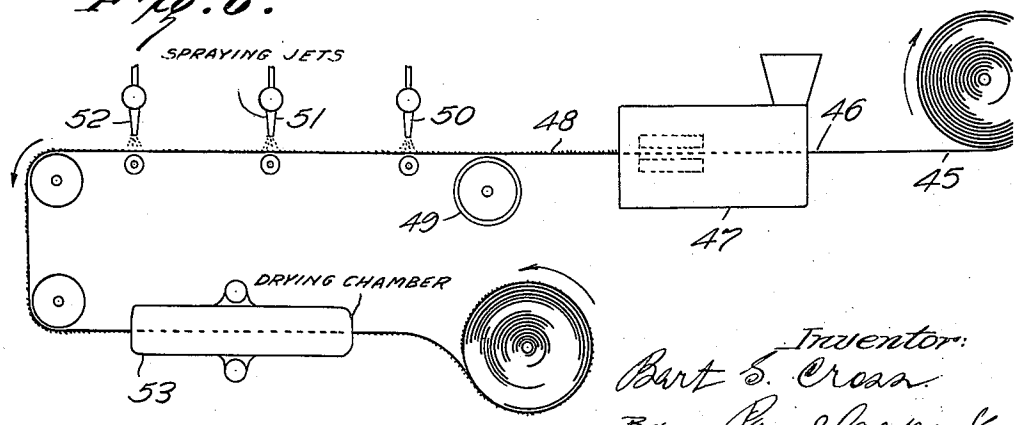


Fig. 6.



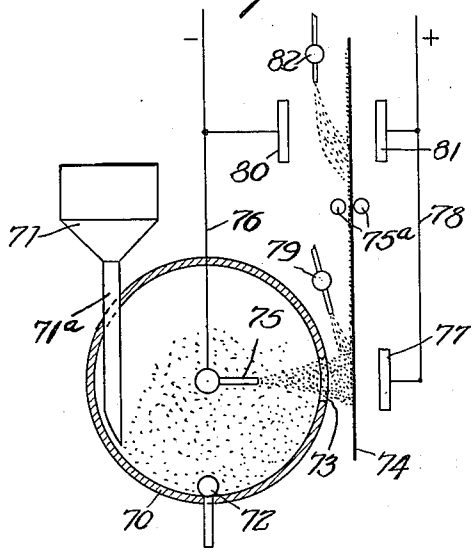
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MANUFACTURE OF ABRASIVE ARTICLES AND APPARATUS THEREFOR

Filed March 6, 1933 3 Sheets-Sheet 3

Fig. 8



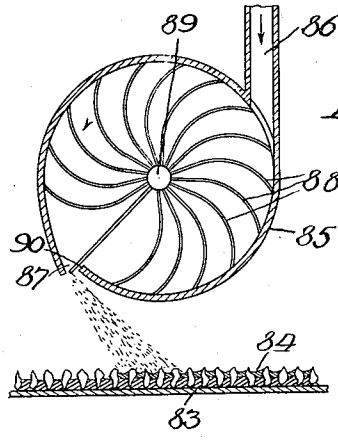


Fig. 9.

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Patented May 5, 1942

2,281,558

UNITED STATES PATENT OFFICE

2,281,558

MANUFACTURE OF ABRASIVE ARTICLES AND APPARATUS THEREFOR

Bert S. Cross, St. Paul, Minn., assignor to Minnesota Mining & Manufacturing Company, St. Paul, Minn., a corporation of Delaware

Application March 6, 1933, Serial No. 659,853

11 Claims. (Cl. 91—68)

This invention relates to the manufacture of abrasives, to abrasive articles, and more particularly to such articles in the nature of sandpaper and the like.

It has been proposed to prepare abrasive articles in the nature of sandpaper by positioning the abrasive particles so that the abrading edges of maximum abrading efficiency are exposed by acting upon a carrier including a grit or layer of abrasive particles, with the abrasive particles in a mobile state, with an electrical field which orients, positions or deposits the abrasive particles so that a more efficient abrading surface is provided resulting from an arrangement of the abrasive particles with their longest axes more or less perpendicular to the plane of the carrier or backing material, thus exposing the sharpest edges of the abrasive particles. Such process, and the abrasive made in accordance with this method, are generally described in the applications of Carlton, Serial No. 422,065, filed Jan. 20, 1930, and the patent to Smyser, 1,788,600, and may be effectively used for my purposes, though other methods for more erectly positioning the abrasive particles are also suitable for my purposes.

The method of making abrasive articles in accordance with the above mentioned applications and patent, in the preferred practice as known to me, involves providing a carrier, such as a web of paper, cloth or the like with a surface coating of an adhesive material, and while the adhesive is in the active condition, depositing a grit or layer of abrasive particles, and simultaneously with the deposition, or subsequent to the deposition, subjecting the carrier and grit so deposited to the action of an electrical field, which more desirably positions the abrasive particles, or orients the same, so that the sharpest edges will be exposed at the abrading surface, and generally the particles will be positioned with the longest axes of the particles arranged more or less perpendicularly to the plane of the paper or carrier. Following this operation, the backing material or carrier, together with the binding coat and grit are exposed to finishing operations which set the binder coat partially or completely. Thereupon, the abrasive surface is given a sand sizing coat to seal any crevices which may be formed in the setting of the binder coat or to supplement any binder which may be lost due to the absorption or shrinkage of the binder, and furthermore, to more securely anchor the abrasive particles to the backing material.

The sand sizing operation, under the present process, may be flowed over the abrasive surface in relatively thin solution of the size coating material, by a doctoring or transfer roll operation, and the excess material is then wiped off, or otherwise removed, by passing the web through relatively flexible squeeze rolls or other wiping devices. The abrasive sheet so prepared is then matured, depending upon the character of adhesive material and sizing coat that is used.

While the aforementioned process produces desirable results, certain disadvantages are experienced in the care that must be exercised, affecting the speed of production, and under certain conditions of operation, having a tendency to disturb or alter the predetermined desirable position of the abrasive particles. Furthermore, where the binder coat is preliminarily applied to the backing material, such as the web of paper, cloth or the like, the thickness of this layer is calculated to be sufficient to fully anchor the abrasive particles, to properly hold the abrasive particles which are influenced electrically or electrostatically carrying the binder and grit, before submitting the same to an electrical field. This latter mentioned phase of the process may have a tendency to decrease the clearance angles of the abrasive edges, as well as to retard the speed of the orienting process.

By the aforementioned process for depositing or positioning the abrasive grit or particles, utilizing the influence of an electrical field, resulting in more or less erectly positioning the abrasive particles upon the surface of the web, the influence of the electrical field does not become instantaneously effective and an electrical charge may persist for a short period of time after passing from the influence of the electrical field, after which condition it is desirable that the abrasive grit or particles remain somewhat mobile, until the entire influence of the electrical field becomes dissipated, to desirably position the abrasive particles in a more or less erect position. Under such conditions of operation in depositing and forming the grit or layer of abrasive particles, a mobile condition of the abrasive particles is desirable and the finishing operation involving the increase of the binder coat and the application of the sand sizing coat or coats, if accomplished under the conditions of operation to maintain this mobile position of the abrasive particles and without a movement deterring or disturbing influence, facilitates the formation of a desirable abrasive article, as contemplated by me.

Furthermore, by prior methods of making sandpaper which involve flowing (or brushing)

or mechanically distributing one or more sand size coats upon gravitationally deposited grit or abrasive particles with the material necessary for forming the sand size coat in excess, no particular difficulty is encountered in wiping away or otherwise removing the excess material necessary for forming the sand size coat. However, when utilizing the hereinbefore processes for more erectly positioning the grit or abrasive particles by the influence of an electrical field, flowing of the sand size material in excess and then removing the excess material not only has a disturbing influence upon the position of the abrasive particles where the binder coat is unset, especially so where the binder coat has not been completely matured or set, but also the sand size coat or coats formed by this method increases the clogging tendency of the sandpaper with the erectly positioned particles, by reason of the decreased clearance angle resulting from the deposition of the sand size coat material in excess and the difficulty in removal of this excess from the aforementioned positioned grit or abrasive particles.

It is contemplated by my present invention to materially increase the efficiency of sandpaper made in accordance with electrical deposition methods by combining therewith a method for applying a size coat or any number of size coats, which will be sufficient to finally anchor the abrasive particles in position, by applying the material forming the size coat or coats without disturbing the electrically or electro-statically deposited or oriented particles or submitting the particles to any stresses in applying the sizing coat, which may disturb the position of the abrasive particles upon the backing.

It is further contemplated by my invention to combine with existing methods for making an abrasive sheet which include preliminarily forming upon a backing material, including a binder and a grit or layer of abrasive particles, sizing coat or coats, a method for applying the sand sizing coat or coats which controls and limits the application of the sizing coat or coats and avoids the necessity for removing any excess by squeezing or wiping operations which may disturb the predetermined position of the abrasive particles.

It is a still further object of my invention to combine with methods heretofore used for forming an abrasive article in the nature of sandpaper, and the preliminary steps of anchoring a grit or layer of abrasive particles upon a web carrying a binding coat, a method for applying the requisite thickness of binder coat or sizing coat or coats by a spraying process which will permit the addition of the requisite thickness of binding coat or sizing coat or coats without excess, and without any tendency to disturb the predetermined position of the abrasive particles upon the backing material.

It is therefore, a still further object of my invention to provide a process which combines with the positioning of grit or abrasive particles upon a backing material or carrier operating under electrical influence, the application of a binder, sand size or plurality of sand size coats, while maintaining the mobile condition of the abrasive particles so that the effect of the electrical influence may be completely obtained and the sand size coat or coats be increased, without disturbing the particles or the influence of the electrical field upon the particles, until the requisite binder coat and auxiliary sand size coat or coats have been developed sufficiently, while in the finally matured article, results in an anchored abrasive material of proper abrasion resistance.

It is therefore still a further object of my invention to provide a method of depositing a size coat or coats upon an abrasive sheet including a binder coat having positioned thereon a grit or layer of abrasive particles more or less erectly positioned by the influence of an electrical field when the particles are in a mobile condition and building up the size coat or coats to the point sufficient to properly anchor the abrasive particles in the finally matured abrasive article, to resist the stresses in abrading operations and without excess which may objectionably increase the clogging tendency of the abrasive article, by atomizing or spraying the sand size coat or coats in extremely fine condition between the abrasive particles and upon the binder coat or underlying coats.

For the attainment of the aforementioned objects and such further objects as may appear herein or be hereinafter pointed out, and for a clearer understanding of the process herein involved, reference will be made to the accompanying drawings, forming a part hereof, in which—

Figure 1 is a diagrammatic illustration of one embodiment of my invention;

Figure 2 is an enlarged detail of a section of the web and belt before deposition of the abrasive particles;

Figure 3 is an enlarged detail of the same immediately after deposition;

Figure 4 is an enlarged detail in section, of a completed abrasive sheet as made in accordance with my process;

Figure 5 is a diagrammatic view of another embodiment of my invention;

Figure 6 is a diagrammatic view of a still further embodiment of my invention.

Figure 7 is a fragmentary diagrammatic view of a still further embodiment of my invention.

Figures 7 and 8 are fragmentary schematic views of alternative forms of a further embodiment of this invention, and Figure 9 is a sectional schematic view illustrating a still further alternative form of the invention.

Referring now to the drawings for purposes of illustrating one embodiment of my invention, 10 represents a roll of fabric material, such as paper, cloth or the like, which preferably has been given some sizing operation to waterproof the same. The web 11 then passes through applicating rolls 12, at which point a coating of binder material 13 is applied, of requisite thickness. Beyond this point, the web carrying the binder coat in a tacky condition is then reversely directed so that the adhesive surface 13 is downwardly disposed at 14, and passes above a traveling belt 15. This traveling belt is so formed as to receive a deposit or layer of abrasive particles from the hopper 16 containing the same. The traveling belt and web of paper are timed in synchronism and adjacent the point 17, when the web and traveling belt are in close proximity, the web and belt pass between electrodes 18 and 19 respectively. These electrodes are connected to a suitable source of electrical energy of any desired voltage and thereby create an electrical field and cause the particles of grit 20 to be directed against the web 11, carrying the binder coat 13.

The exact form of the electro-deposition and the details of the apparatus therefor are not par-

ticularly herein claimed and no further detailed description will now be made, but it will be sufficient to point out that in my preferred method, a uniform distribution of the abrasive particles upon the backing is accomplished approaching more or less a single layer, though with the finer grits of 100 to 200 mesh, this method includes a deposition of multilayers.

Abrasive particles as supplied in the trade are of unequal dimensions, the axes of which are unequal and have abrading edges of different sharpness. The effect of the electrical field upon the abrasive particles as just described will serve to more desirably position the abrasive particles for abrading operations such as by having the sharpest edges exposed, or the longest axes of the particles arranged more or less perpendicular to the surface of the paper or web.

For purposes of convenience, this desirable positioning of the particles herein referred to as positioning the abrasive particles by an electrical field will be referred to as erectly positioned abrasive particles, and by this term I mean to include the effect produced in so arranging the particles that their most efficient abrading edges or points are away from the surface of the paper, whether the action is electro-static, electro-magnetic, or caused by any other method of orienting the particles with their most efficient abrading edges exposed in the final abrasive surface.

After depositing the grit or layer of abrasive particles by the electrical field, as described, the web of paper **11**, carrying the adhesive surface **13** and the abrasive particles **20**, are passed over festooning racks **21**, to set the adhesive coating **13**, and to assure that in the subsequent handling of the abrasive article thus far formed, the abrasive particles will hold their predetermined desirable position.

The web of paper, as it leaves the electrical deposition apparatus is guided over guide rolls to the festooning racks **21**, as just described, so as to minimize any contact with the surface of the web carrying the abrasive. At such points where the surface of the web carries the abrasive, the guide rolls contact the web at the edge thereof.

The festooning racks as just described are particularly desirable in connection with a binder coat, using an adhesive material dissolved or dispersed in a volatile vehicle, such as, for example, a mixture of resin and drying oils, in a volatile solvent, such as a petroleum distillate, of which oleum spirits, naphtha are examples. The setting action may be accomplished by other means, depending upon the nature of the adhesive material, which will, for purposes of more fully illustrating applicant's invention, be hereinafter referred to and exemplified.

With an oil resin and solvent coating **13** and abrasive particles **20** as hereinbefore applied, the festooning operation may be continued for a period of about twenty-five minutes, or a period of time wherein the major proportion of the volatile solvent will be removed and the residuum become materially thickened, approaching a solid state. The nature of a binder of this character may be one made in accordance with the patent application of Okie, Serial No. 338,022, filed February 6, 1929, and may further include sufficient heating or baking treatment to ensure sufficient setting of the adhesive material.

The web as thus far prepared or, if desired, before partial drying by the festooning racks, is then brought in proximity to spray jets **22**, at which point a fine atomized spray of sizing material is deposited upon the web of paper carrying the abrasive particles. The plane of the paper at this point, in relation to the spray jets is such as to ensure the spray striking the web of paper substantially at right angles for the major area covered by the spray. The force of the spray is such as to give very little lateral action, or have any tendency to disturb the position of the abrasive particles, and to further ensure an even and uniform distribution of the sizing material between the particles of grit.

It will be understood that the spray jets shown at **22**, **23** and **24** may be connected to a single source of supply of coating material or may be connected to different sources so as to deliver subject to suitable control sizing coating materials of different degrees of hardness or flexibilty when dried in order to produce, if desired, an article having comminuted adhesive coatings of different degrees of hardness and/or other characteristics when set.

The spray jets may be arranged as shown at **23** and **24**, so as to increase the binding material between the grits to the requisite depth for properly anchoring the abrasive particles upon the web, with sufficient strength to resist displacement in abrading operations. The web may be passed beneath the spray jets to give any number of sizing coats, as more clearly illustrated in the enlarged detail shown in Figure 4, wherein **25**, **26** and **27**, and **28**, show successively, a plurality of sizing coats. The sizing coat or coats are applied to sufficiently anchor the abrasive particles upon the backing, to resist the stresses encountered in abrading operations, when the web is finally matured, but without excess, which may impair the clearance angles and abrading efficiency of the abrasive particles. This is accomplished by using an extremely finely atomized spray and the sizing material solidifying more or less in an extremely thin coat. This coating may be increased in number to require no removal of excess material. The web then passes to festooning racks or dryers **29** for maturing the web so prepared.

In another embodiment of my invention, as more particularly illustrated diagrammatically in Figure 5, the duplex web **30** of paper, cloth or the like, is fed into a vat **31**, which contains a coating composition in which there is disposed electrical conducting material. This may be finely suspended graphite, a bronzing powder, a water solution of some electrolyte, such as salt, or similar material. The web is then conducted into a drying chamber **32**, to set the preliminary coating and to take off any extraneous fluid. Adjacent the outlet of the drying chamber, the web makes contact with an electrode **33**. From the drying chamber, the web is passed into a second vat **34**, where the fabric is given a coating of adhesive material **35**. The excess adhesive material is controlled by the squeeze rolls **36**, which also adjust the thickness of the binder upon the web of material. The web then passes to the grit deposition chamber **37** of the character more particularly described in the patent to Smyser, No. 1,788,600.

In this embodiment of the invention, as the web with the adhesive still moist and tacky, passes between the electrodes **38**, the electrostatic discharge bombards the binder coating with electrically charged particles of abrasive material **39**. This operation serves to position

the particles of abrasive material upon the binder carried upon the surface of the web so that the most efficient abrading edges of the abrasive particles are exposed, and in general, the particles are oriented with their largest axes substantially perpendicular to the plane parallel to the surface of the paper. The speed of the movement of the web in relation to the points between the electrodes **38** determines, with a given size of abrasive particles, the character of coating. Though the coating may be one to provide plural layers of abrasive particles on the web of fabric, it is preferred by me to adjust the thickness of the adhesive layer, the speed of movement of the web in relation to the electrodes and the character of the particles of abrasive material so that substantialy a single layer of abrasive particles is coated upon the web, to produce an article in the nature of sandpaper.

With a web thus prepared, and while the adhesive is still moist, the web is passed through edge guiding rolls **40**. While the adhesive may be suitably set, in accordance with the prior embodiment, I may directly pass the web through a series of jets **41** arranged to spray the full width of the web of paper, at which point a finely atomized spray of sizing material is directed against the web coated with the abrasive surface. While the spray coat of sand size may be accomplished by a single spraying operation, it is preferred by me to apply successive coats of sizing material, to gradually increase the binding material between the particles of grit, until the size coatings are built up to properly anchor the abrasive grit or particles to the backing material, yet without excess which may interfere with the proper clearance angles and abrading efficiency of the abrasive particles. The web then passes through a drying chamber **42**, to partially set the web thus prepared.

After the web passes through the drying chamber, it is conducted adjacent to a knife **43**, wherein the web of paper is separated. The two branches of the web thus split are separately formed into rolls or they may be conducted to other apparatus for finishing the same, such as for applying a back size before the entire web is passed through a maturing process, depending upon the character of adhesive that has been used.

In the process as described, the web of fabric is made with an abrasive layer **39** on opposite sides of the web and this may, under one phase of my invention, be practiced in order that an equalized discharge be obtained. However, it will be readily understood that in the coating process for applying the adhesive, only one side of the web may be coated with the adhesive material, to thereby produce a single web of abrasive fabric.

In the formation of an abrasive in the nature of sandpaper, as aforementioned, the binder coat **35**, formed over a paper size coat or directly upon the backing, may be of a glue or protein base material, suitably waterproofed, if desired, by an insolubilizing or tanning operation, such as formaldehyde, tannin, potassium chromate, or it may be of a waterproofing material of oily or resinous constitution or combinations thereof, made and applied by way of example, in accordance with United States patents to Okie Reissue 17,593, Okie Reissue 17,584, Carlton 1,736,934 and Carlton 1,775,631 and others assigned to the Minnesota Mining and Manufacturing Company. The character of the binding coat, in one phase of my invention, determines the character of treatment to be given to this coat immediately following the deposition of the grit or abrasive particles, and preceding the application of the sand sizing coat or coats.

In order to more expeditiously practice the finishing of the sandpaper in accordance with my process, for purposes which will appear hereinafter, the binder coat that is applied before depositing the grit or abrasive particles, is of a thickness which will be just sufficient to hold the abrasive particles against gravitational displacement. This procedure not only reduces the time element in positioning the grit or abrasive particles by an electrical field, and permits the electrical field to more effectively orient the abrasive particles in the desirable position aforementioned upon the backing, but also provides a film which may be very rapidly set, to hold the grit or abrasive particles in the desirable position during the time that they are submitted to the spray coat of sand size. And I consider, as one phase of my invention, to deposit grit or abrasive particles upon a backing material carrying a binder coat of a minimum thickness to hold the grit or abrasive particles against gravitational displacement, followed by spraying of the sand sizing coat or coats, as this thin film of binder coat will respond more rapidly to the maturing treatment, and therefore more readily, firmly hold the abrasive grit in the desirable position resulting from deposition by an electrical field, and therefore permitting a more rapid application of the spray coats by a heavier and more powerful blast of spray, necessary for applying the sand sizing coat or coats.

In the embodiment illustrated in Figure 5, using a finely atomized, rapidly drying spray for applying the size coat, this size coat may be applied before the binder coat has set to any appreciable extent and, by proper adjustment of the spray, immediately following the electrodeposition of the grit or abrasive particles.

In the aforementioned methods and by the installation as described, reference has been made to partially or completely setting the binder coat before spray coating the sand size and that the character of the setting treatment would be dependent upon the character of the binder used. Thus, the binder coat may be a normally solid material which is sprayed in a volatile solvent, and setting or partial setting may be effected by partial vaporization of the volatile solvent. Furthermore, the spray coats issuing from the nozzles **41** may have different characteristics as to degrees of hardness or flexibility when finally set as hereinabove pointed out.

In another embodiment of my invention, as more specifically illustrated in Figure 6, a web of backing material, such as paper, cloth or the like, preferably after first sizing the same, is given a binder coating **46**, of heat responsive material, using substantially no volatile vehicle. Such material may be a properly heated shellac or resin, artificial resin, waxes or gums, which generally may be maintained fluid by heating, but which, upon cooling, rapidly solidify. Under these conditions, the web carrying the binder coat **46** is passed into a chamber **47**, which is kept at temperatures sufficient to maintain the binder layer **46** in a fluid or semi-fluid condition.

Under other conditions of operation, the heat responsive material may be one which sets, hardens or rigidifies on heating. Such materials, I may exemplify as albuminous adhesives of the character of egg albumen or blood albumen, and

other similar coagulable materials, such as, for example, latex, viscose containing a weak acid solution admixed therewith in noncoagulating proportions at ordinary temperatures. Under these conditions, using the heat coagulable material or materials rigidifying under increased temperatures, the chamber **47** is maintained at atmospheric temperatures.

Within the chamber **47**, the web with the adhesive coating **46** in its tacky consistency, is given a deposit of grit or abrasive particles **48** and is submitted to the process for erectly positioning these abrasive particles in accordance with any of the methods aforementioned and more specifically described, for purposes of example, in the application of Carlton, Serial No. 422,065, and the patent to Smyser, No. 1,788,600. The web then passes over a roller **49**, to rapidly set the binder coating. The roller **49** has provisions for being either chilled or heated. The chilling fluid is used where the binder coat **46** is of a nature which responds to a reduced temperature to rapidly set and solidify, and where materials, such as those hereinabove referred to, responding to reduced temperatures to rapidly set or solidify, are used. Where the binder material used is one which is heat coagulable, the roller **49** is connected with suitable heating means such as steam, to maintain the roller at a temperature sufficient to rigidify, coagulate or otherwise set the binder coating.

It will be understood that the time element of contact between the web as it contacts with the roller **49** may be such as to effect the purposes hereinbefore referred to, of rapidly setting, solidifying or stiffening the binder coating.

It is further understood that the nature of the binder as originally applied for my purpose, prior to the entry into the chamber **47**, is one that is sufficient for forming a binder coat for holding grit as made by a pure gravitational deposition method, but is insufficient, in the finally matured article, to hold erectly positioned abrasive particles, and for purposes of more rapidly passing from the grit deposition step to the sizing steps which will hereinafter be described, the binder coat is preferably applied of a thickness which will be the minimum necessary to hold the particles against any gravitational tendency to displace the same from the erect position previously referred to. This minimum coating up to the quantity found proper for an ordinary gravitationally deposited grit, is of value for purposes previously described and also shortens the time necessary for setting the binder coat, so that the web may be immediately subjected to the spraying process.

In the embodiment illustrated in Figure 6, the web, treated in accordance with the process just described, is subjected to a spray of sand sizing material by the jets **50**, **51** and **52**. These jets emit a fine, atomized spray of sand sizing material. The sizing material may be an ordinary glue-base material, where glue bond sandpaper is to be made, or it may be in the nature of a waterproofing material. Preferably, and by way of example, the flexible waterproofing materials made in accordance with the patents to Carlton and Okie, aforementioned, may be used so that a resinous, oil-resin, cellulose compound, such as nitro-cellulose, preferably modified by a polyhydric resinous material, cellulose acetate, may be used as the base. Those resinous materials which may be rendered liquid by heat are so used. In general, however, I prefer to use the materials in a volatile solvent or vehicle. Additionally, also, aqueous dispersions of rubber, such as latex and similar materials, halogenated rubber and isomers of rubber, such as described in the applications of Hatch, Serial No. 318,390 filed Nov. 10, 1928 and Hatch and Netherly, 418,148 filed Jan. 2, 1930, may be used.

The ingredients that are used for sizing the paper, formation of the binder coat and the sizing coat or coats, need not be of the same materials and flexibility and may be varied by use of a gradiently harder binder and sand size materials. In general, coating materials which are compatible with each other are used.

Where a rubber sized paper is used, a resinous material or rosin bond, oil and resin sand size are compatible. For an oil-resin binder coat, nitro-cellulose, preferably modified by a polyhydric resin in a common solvent, is compatible.

In using any of the coating materials, suitable adjustment is made of the temperature of the sizing material or the solvent used, so that an exceedingly fine spray may be deposited, and additionally, adjacent the point where the spray strikes the web of material, temperature conditions may be maintained so that the atomized particles strike the web in a more or less solidified or thickened condition, so that the binder or sizing coat or coats are almost in a fairly concentrated condition. Thus, with a hot liquid resinous material for the sand size, the web may be maintained approximately at a temperature at which the resinous material will begin to solidify, thicken, or concentrate to a substantial extent. For a sizing material including a volatile vehicle, temperatures adjacent the spraying zone may be raised to increase the volatilization of the vehicle.

In the application of the sizing coat or any number of successive coats by the jets **50**, **51** and **52**, no excess material will be applied and the spray coats may be controlled below that thickness at which the size coat would ordinarily interfere with the abrading edges of the abrasive particles, and serve to increase the clogging tendency of the abrasive article, when used in abrading operations.

To exemplify the conditions of operations where successive sprays of binder coats and sizing coats may be applied to leave the grains of abrasive particles well supported, reference will now be made to various conditions of operation. Where I have indicated sprays **22**, **23**, **24**, **41**, **62** and **59**, these sprays may be the spraying nozzle of a spray gun of a character known on the market as the No. 15 Apex Spray Gun, adapted to project a fan shaped spray about six inches wide and about one-half inch thick. With such type of apparatus, it is preferred by me to hold the nozzle about eight inches from the web to be treated and direct the same at an angle of approximately 90° to the work.

For purposes of projecting a glue binder upon a web, air pressure between 60–75 pounds is used, and discharged at about room temperatures of 62–68° F. The glue solution was preferably maintained at about a temperature of 150 to 180° F., though temperatures of 95–130° F. are operable. The concentration of the glue, using a hide glue, should preferably be below 10%, where hide glue of 105 millipoise is used. With lower grades of glue, however, of from 60 to 105 millipoise, concentrations as high as 15% may be used.

The conditions above given for glue, with the variables that may be encountered, are prefer-

ably maintained to work in the direction of the flood coat and a tendency for the sprayed particles to thicken upon deposition, yet below the limit where there is any tendency to form any caps upon the cutting edge of the grains, and the force of the spray, especially under the conditions above described, in addition to the force of the spray, tends to consolidate and unite the particles of spray into a unitary mass. Variables which cause such rapid solidification of the spray particles to an extent that the formation of round caps appears, is avoided.

While I have indicated that with compressed air and temperature conditions above indicated concentrations of glue as high as 10% may be used for the high grade glues and concentrations as high as 15% with low grade glues, still higher concentrations may be used. Under these conditions, however, steam at about 50–70 pounds pressure may be substituted for the compressed air, and utilize a glue concentrate of about 21%. This may be used without any evidence of glue caps on the abrasive particles.

It will be understood that the rate of evaporation, viscosity or concentration of the fluid, surrounding temperatures, humidity, distance of the spray from the work and the material used, are all variable factors which are varied from the conditions aforesaid and will require suitable adjustment, and the desirable condition of operation may be ascertained in a general way, maintaining the condition of the spray preferably between limits showing a definite concentration of the material sprayed and below the point where variations may cause the formation of caps.

For using a waterproof material and an organic solvent, clear lacquer of a base may be used. This is preferably thinned with an equal quantity of a thinner for the lacquer and a spray gun is operated at air pressures of from 45–60 pounds, though pressures as high as 75 pounds may be used. Again, the variables, such as the surrounding conditions, as above emphasized, may require adjustment of the spray to project a coating of more concentrated or thickened condition, the formation of caps upon the abrasive particles at their points being the limiting conditions in the direction of operating the spray for forming a more viscous or concentrated deposit.

With a glue base material of the character described, and operating conditions as described, approximately four coats may be given. With the waterproof type of lacquer, as many as ten coats may be given. It will be understood that the grit size and the character of grit and the other variable conditions indicated may also qualify the number and nature of the spray coats that may be applied.

By applying the size coat or coats in accordance with the method described, by a finely atomized spray of the size coat material and under the conditions which will cause the residuum carried in the spray to quickly solidify, a web of material carrying erectly positioned abrasive particles may be provided with the anchoring coat or coats, without an excess, which would ordinarily tend to increase the clogging tendency of the finally formed abrasive article.

After leaving the points at which the spray coats are applied, the web may then be passed over festooning rolls, or other means for partially or completely maturing the abrasive article, such as by passing the same through a drying chamber **53**, from which point it may be formed into rolls for more convenient handling, for subsequent complete maturing, or if sufficiently matured in the drying chamber, to be held for subsequent severance in the form in which the abrasive article will find its way on the market.

Though I have described in the embodiments illustrated, the application of a binder coat followed by the application of sand sizing coats for an embedded grit or abrasive particles which have been erectly positioned the method may include substantially simultaneous deposition of the binder coat and deposition of the grit by the influence of an electrical field and the apparatus diagrammatically illustrated in Figure 5 is admirably suitable for this purpose, as I may, adjacent the electrodes **38**, include spray jet or jets for simultaneously applying a binder material while the sheet is bombarded with abrasive particles. An extremely finely atomized spray material using either no solvent at all or a non-inflammable solvent is preferably used; in this form of operation, the binder coating operation may be entirely omitted or reduced to the minimum.

For purposes of illustrating the method briefly aforementioned, reference will be made to Figure 1. In this construction, a backing material **55** is conducted into a chamber **56**, of substantially the same character as that illustrated in connection with Figure 5. In this embodiment, the backing material need not be coated with an electrical conducting material, but is preferably surface sized, with a suitable sizing material compatible with the binding material hereinafter used. The right hand electrode **38**, illustrated in connection with Figure 5, may be omitted, and in its place there is substituted a grounded electrode **57**, disposed at a point opposite to the grit dispersing electrode **58**, of the same general construction as described in the previous embodiment shown in Figure 5. Adjacent the point between the electrodes **57** and **58**, there is positioned a spraying nozzle **59**, preferably to lead off from a line **60** connected so as to be operable with such spray nozzles of the character noted at **51** in the embodiment shown in Figure 5, or formed as part of a series of chambers, such as shown in Figure 7.

The operation for electrostatically bombarding the web of paper in accordance with the embodiment illustrated in Figure 7 is accompanied by simultaneously spraying the particles and the web of backing material **55**. The highly dispersed particles formed by the mist or spray of atomized particles of binding material do not interfere with the desirable position of the abrasive particles. The binding material as applied by means of the spray is preferably so adjusted that upon striking the backing material, the coalesced particles will reach a more or less thick liquid or semi-solid state, to effectively hold the particles of abrasive material in the predetermined, desired erect position.

After passing the point between the electrodes **57** and **58** and the spray nozzle **59**, the web is conducted between guide rollers **61**. These are preferably edge rollers which do not interfere with the surface coating of binder material and abrasive particles, though for purposes of compacting the surface, where a built-up layer is desired, the rollers **61** may be extended for the full width of the web.

It will further be observed that care is exercised to carefully insulate the rollers **61** so that discharge occurs between the electrodes **57** and **58**, and not from the paper through the rollers **61**.

After passing from the chamber, the web **55** and its coating of abrasive particles may be given one or more sizing coats by the spraying nozzle **62**. One or more of such nozzles may be used to build up the sand sizing coat, or the web may pass progressively through a series of chambers, such as **56**, to progressively build up any number of layers of abrasive particles, so that the web may have any desired thickness of abrasive particles, or the abrasive particles may be built up to any desired thickness upon the carrier, by moving the carrier at a relatively slow rate between the electrodes **57** and **58**, and the spray nozzle **59**, associated therewith.

In the embodiment illustrated in connection with Figure 7, novelty is attributed not only to spraying of erectly positioned particles upon a backing material, but the simultaneous deposition of the abrasive particles and the atomized binding material. The novelty of this embodiment of the invention I attribute not only to simultaneous application of the binder coat and the grit to more facilely permit of an erect positioning of the abrasive particles, but to an ability to continuously and progressively build up the layer of abrasive particles without waiting for the binder coat to set or dry, permitting either an additional coating or coatings of sand sizing material, or other abrasive particles and binding material to be applied.

Referring now more particularly to Figure 8, there is provided a container or chamber **70** conveniently cylindrical in contour similarly to the chamber shown in Figure 7. Comminuted abrasive material is supplied to the chamber **70** from a hopper **71** through a tube **71***a*.

An air blast may be introduced into the chamber **70** at **72** for creating a cloud of abrasive material therein.

At one portion of the container or chamber **70** I provide an outlet **73** and past this outlet **73** there is fed the fabric backing **74**.

Within the chamber **70** I provide an electrode **75** which is connected by conductor **76** to one side of a suitable source of high voltage and in substantial alignment axially with the electrode **75** I provide an electrode **77** back of the fabric **74** and connected by suitable conductor **78** to the opposite side of the source of high voltage.

It will be observed that the source of relatively high potential through the medium of the electrodes **75** and **77** establishes an electrostatic field of desirable strength between these two electrodes. It will be understood that to simplify the diagram the conductors **76** and **78** have been shown in parallel relationship, but it will be understood, of course, that these electrodes will be kept at a sufficient distance apart so that disruptive discharges cannot occur or other leakage of current which would tend to decrease the electrostatic field sought to be established between the electrodes **75** and **77**.

A spray nozzle **79** is provided arranged similarly to the nozzle **59** shown at Figure 7 and adapted to direct an atomized adhesive into the zone of the electrostatic field so that in addition to the mechanical deposition of the adhesive an electrical deposition of adhesive takes place. This prevents undue deposition of adhesive on surrounding parts of the apparatus and ensures that the major portion of the adhesive as desired reaches the sheet or backing **74** preferably simultaneously with the deposition of the abrasive thereon.

The fabric with the coating of adhesive and abrasive thereon then passes from the zone of the electrostatic field established between the electrodes **75** and **77** between edge guiding rollers **75***a* and thence passes between supplemental electrodes **80** and **81**. At the electrostatic field thus established between the electrodes **80** and **81** I provide an auxiliary nozzle **82** adapted to spray into the electrostatic field, but not toward the fabric **74**, an atomized stream of adhesive material which may be deposited by the action of the electrostatic field as a sizing coat upon the abrasively coated fabric **74**.

In view of the fact that the spray produced from the nozzles **79** and **82** is finely comminuted and of relatively low concentration as to conductive adhesive, it will be understood that the spray produced at this point both with respect to Figures 7 and 8 does not tend to materially reduce the strength of the electrostatic field, even where moisture containing adhesives, such as glue, are employed instead of non-conductive waterproof adhesives.

It will be understood that by disposing the auxiliary nozzle **82** at the angle shown, an improved dispersion of the finely divided adhesive particles is produced resulting in a more uniform distribution of the adhesive upon the web.

Referring now to Figure 9, here an alternative form of commuting means is disclosed for the treatment of the adhesive and for depositing the same on the web **83** containing the abrasive particles **84**.

In this form of the invention there is provided a drum **85** having an inlet **86** for delivering a fluid adhesive to the interior of the drum. The drum is provided with outlet **87** whose axis of discharge is directed toward the grit coated sheet **83**.

A brush having relatively stiff bristles indicated at **88** is arranged within the drum **85** so that as the brush is rotated in the direction indicated by the arrow the bristles will take up adhesive from the inlet **86** and as the bristles strike the edge **90** of the drum adjacent to the outlet **87** the adhesive in liquid form will be thrown as a fine spray on to the adhesively coated sheet.

It will be understood that this form of the invention may be adapted for use with any of the previous forms hereinabove described and, of course, in some circumstances, it will be necessary to mount the brush below the web, in which event appropriate modification may be made for supplying the adhesive under pressure sufficient to cause it to flow through the inlet **86** to a point adjacent to the bristles of the brush.

Thus, by the centrifugal force of the brush revolving the adhesive particles picked up by the bristles of the brush will be caused to be projected forcibly in a cloud form toward and on to the surface to be coated.

Not only does the spraying operation as above described penetrate between the particles of abrasive material, by reason of the use of the spray, but where an inert atmosphere is used, these particles also become electro-statically charged and more effectively impinge upon the web of backing material, and therefore more securely and effectively unite the abrasive particles.

In some cases it is desirable to employ a binder and sizing coats, materials which do not deform materially when set, and, therefore, do not, either by capillary action or in course of hardening to a flexible state, cause a displace-

ment of the grit particles from the desired oriented portions. For this purpose I have found to be suitable the phenolic resins and other synthetic or artificial resins, such as urea resins, oil resin mixtures wherein the maturing steps are conducted so as to prevent the displacement of the electrically oriented particles by controlling the viscosity during the interval of setting.

Having thus described my invention and illustrated its use, what I claim as new and desire to secure by Letters Patent, is:

1. The method of forming abrasive coatings upon a carrier, the steps which include simultaneously dispersing the abrasive particles upon the carrier and applying an adhesive material in a volatile vehicle in the form of a spray impinging upon the abrasive particles in transit to the carrier, while maintaining the spray of adhesive material under conditions tending to solidify and concentrate the same but below that at which a tendency to form caps of the adhesive material upon the abrasive edges of the abrasive particles is observed.

2. The process of applying coatings which includes the steps of dispersing and depositing a plurality of solid particles on a surface by the action of an electrical field, and depositing thereon in dispersed condition an adhesive material for binding said particles by the action of an electrical field.

3. In a coating apparatus, means for electrically projecting and dispersing a plurality of abrasive particles to form an abrading surface, and means in proximity converging with said first projecting means for mechanically and electrically applying and dispersing an adhesive material for retaining the particles in predetermined position on said surface.

4. In a coating apparatus, means for supplying abrasive and adhesive materials, and means for electrically projecting and dispersing simultaneously said abrasive and adhesive materials to form an abrading surface.

5. In a coating apparatus, means for supplying abrasive and adhesive materials, and means for electrically projecting and dispersing simultaneously said abrasive and adhesive materials to form an abrading surface, and means for supplementally electrically depositing and dispersing an adhesive material on said surface.

6. The process of producing an abrasive article which includes as steps thereof depositing and dispersing abrasive particles on a carrier by the action of an electrical field to cause the abrasive particles to assume oriented positions on said carrier with their major axes substantially perpendicular to the plane of the carrier, and simultaneously while intermingling with the dispersed particles of abrasive materials in transit to the carrier spraying an adhesive material upon the carrier to converge with the deposition of the particles in transit to the carrier, under conditions which cause a relatively rapid setting thereof for retaining said abrasive particles in their oriented positions on said carrier.

7. The method of making abrasive coated products which comprises as steps thereof directing a mixture of abrasive grains and a solvent free thermoplastic binder in finely comminuted form upon a backing moistened with an adhesive coating, to impinge the abrasive particles upon said adhesive coating and to cause said mixture to adhere to the backing, while said coating is adhesive and under conditions of plasticity of the adhesive and binder to cause the binder to adhere both to the grains, and the adhesive carried by the backing.

8. The method of making coated abrasive products which comprises applying to a backing a base coating of liquid adhesive, adding a thin layer of abrasive grains to the adhesive coated surface while said coating is in an adhesive condition and applying a sizing coating of substantially solvent free thermoplastic resinous adhesive material in comminuted form to adhere the same by impingement thereon, whereby the time necessary for setting the coated abrasive product by the thermal changes is reduced, and a substantial proportion of the abrasive grains thereon remain with exposed edges.

9. The method of making abrasive coated products which comprises attaching a thin layer of abrasive grains to a backing by a base coating of liquid adhesive, applying a sizing coating of a substantially solvent free thermoplastic resinous adhesive material in finely comminuted particle form, to supply a full quantum of binder for anchoring the grains and by the impinging movement thereof to cause said particles to become attached to the abrasive grains and to become united with the base coating of liquid adhesive.

10. The method of fabricating coated web material which comprises applying a base coating of liquid adhesive to a surface of the web, applying a layer of abrasive particles to the adhesively coated surface, moving the abrasive coated web into an electrostatic field, moving sizing material of solvent free material in finely comminuted form into said electrostatic field, electrically dispersing and projecting said finely comminuted sizing material onto the abrasive coated web prior to curing said base coating of liquid adhesive and thereafter curing both the previously applied liquid adhesive coating and finely comminuted sizing coat in one operation.

11. The method of manufacturing abrasive coated sheet material which comprises coating a surface of sheet material with a liquid adhesive, applying a layer of abrasive granules to the adhesively coated surface, projecting a layer of sizing material of solvent free material in finely divided form onto the abrasive coated sheet prior to setting the said liquid adhesive so that the sizing material becomes adhered to the liquid adhesive coating and thereafter curing both the layer of liquid adhesive and finely divided sizing material in one operation.

BERT S. CROSS.