

Jan. 17, 1961

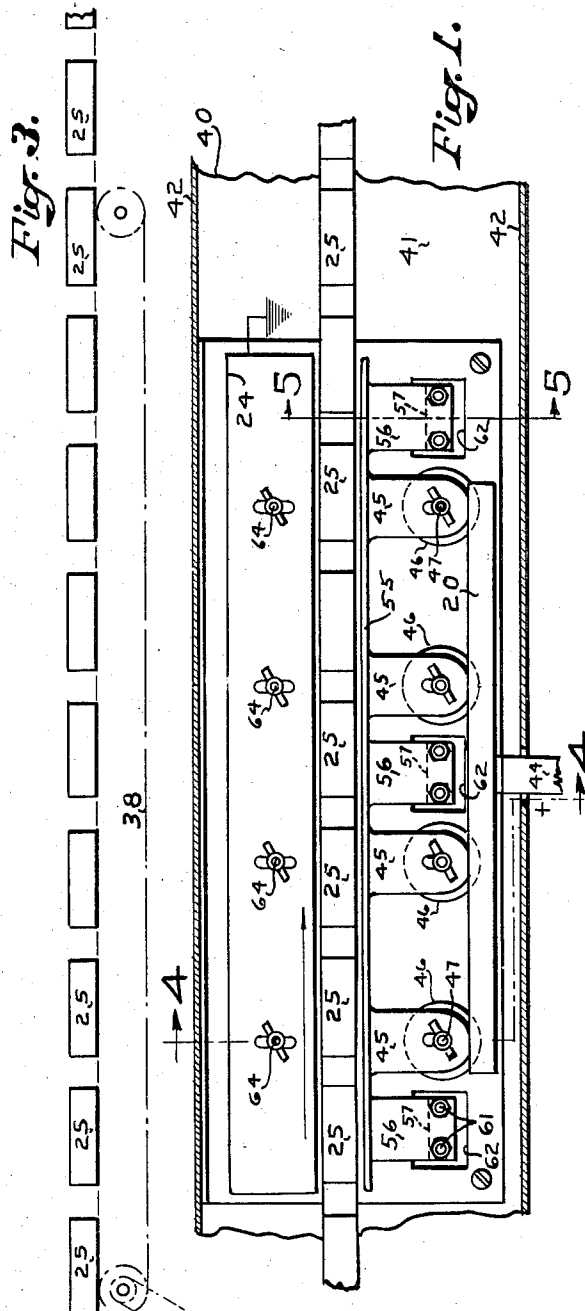
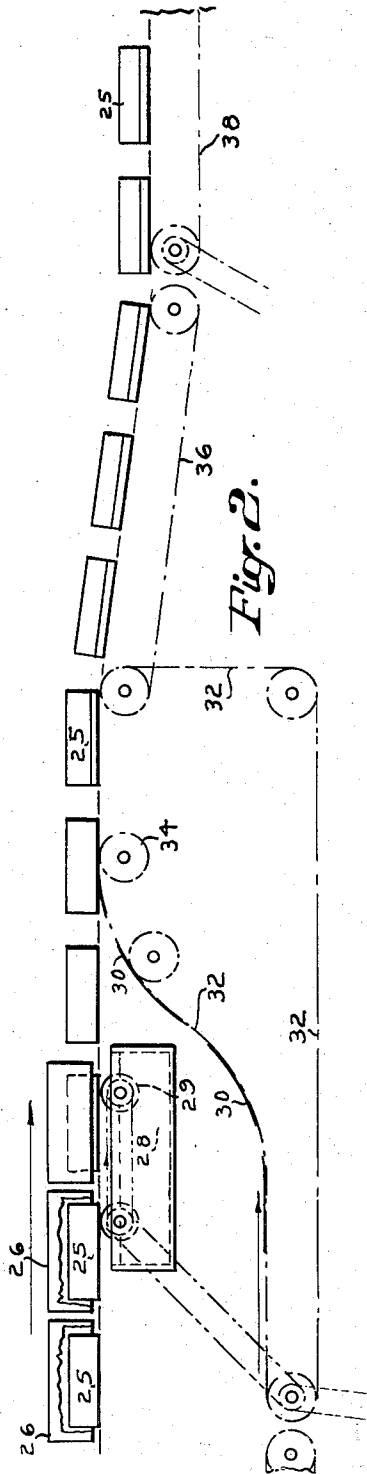
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2,968,336

DIELECTRIC HEAT SETTING OF A BOOK BINDING ADHESIVE

Filed Feb. 24, 1958

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

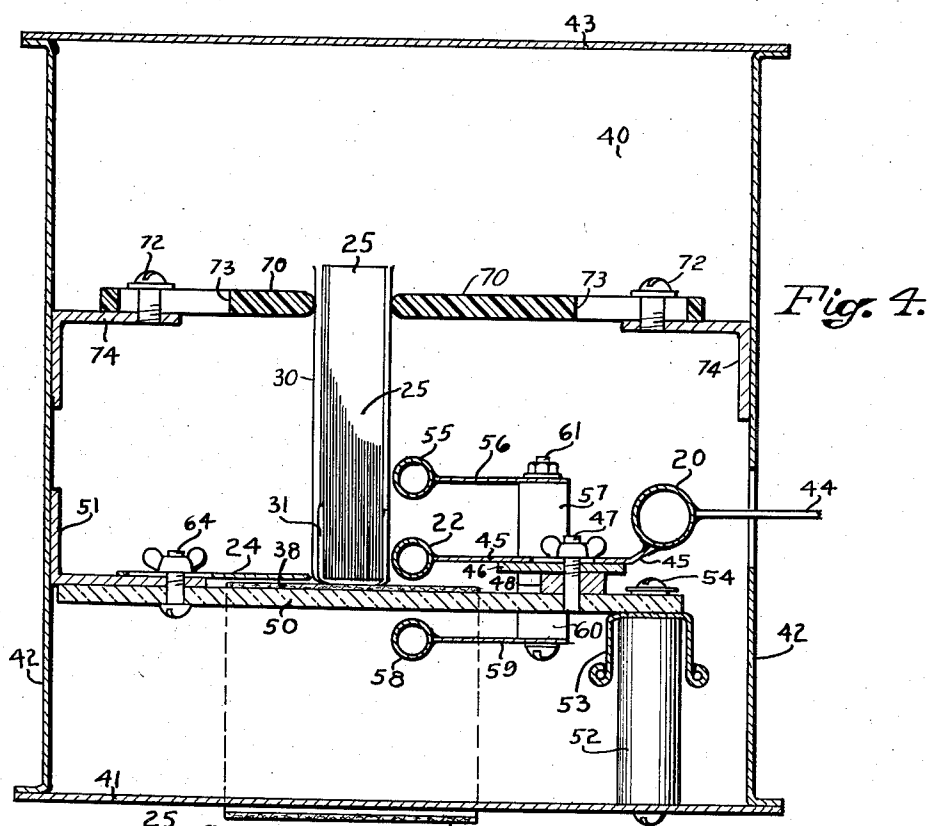


Fig. 4.

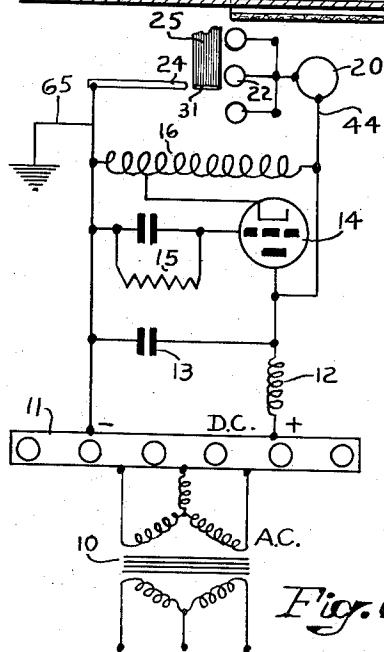


Fig. 6.

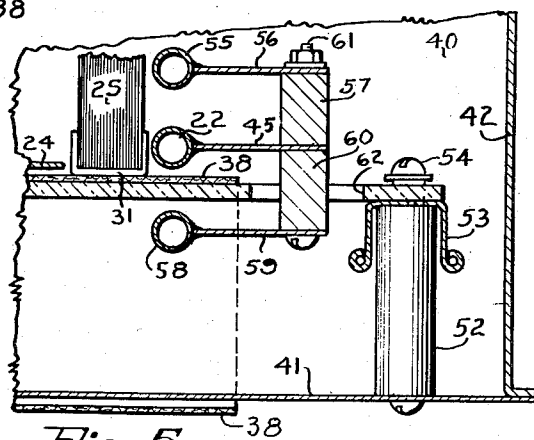


Fig. 5.

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DIELECTRIC HEAT SETTING OF A BOOK BINDING ADHESIVE

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5 Claims. (Cl. 154—41)

This invention relates to the manufacture of books, and more particularly to the art of securing by adhesive a backing or a strengthening strip to the back of a group of assembled signatures or book pages.

Heretofore, in the manufacture of one type of book, the signatures have been collected and carried forward in an upright position with their backs down by means of clamps on an endless conveyor system. The folded portions of the signatures are cut off by a sharp knife, leaving all of the sheets entirely separate in their assembly. This requires that the sheets be attached only by their edges to a flexible backing which permits opening the book and yet retains all of the sheets securely fixed to the backing. Hence, we have found that the individual book sheets are not secured adequately and that often some of the sheets may become dislodged and the book back may break because of an improper binding.

One object of our invention is to overcome such a problem and to bind all of the sheets securely in place. Accordingly, we coat the back edge of each sheet with a special adhesive which adheres strongly to the sheet, and a permeable flexible backing is applied thereto to insure that the individual sheets are bound in place. In this procedure, each book back is passed over a roller coated with liquid adhesive and finally into contact with either the back of a paper cover or a strip of crash or other strengthening material which is caused to adhere to the back of the book by the adhesive. In the standard procedure, the book with its wet adhesive is removed from the conveyor system and transported by truck to a dryer system where either artificial heat or the standard room temperature serves to dry out the moisture in the adhesive. This is a time-consuming operation which serves as a bottle-neck in the manufacturing line, as well as involving an unnecessary handling expense.

The primary object of this invention is to provide an apparatus and a method for binding a book in which the separate paper sheets are secured to a flexible backing by means of an adhesive which joins the paper sheets to that backing with a strength greater than that of the paper sheet itself.

Another object of this invention is to provide an apparatus and a procedure for drying and setting the adhesive while it is being transported by an endless conveyor system and thus obviating an intermediate handling operation and a slow drying stage. Other objects will be apparent in the following disclosure.

In accordance with this invention, we secure the individual book sheets to a flexible backing by means of an adhesive between the backing and the edges of the individual sheets which is an aqueous composition capable of adhering tenaciously to both the sheet edge and the pores or interstices of a backing and which is dried or hardened to a permanently flexible condition. To accomplish that drying operation, we propose to pass the books progressively through a high frequency high voltage electrostatic field and to set or dry a suitable adhesive

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applied to the back of the assembled book pages by a dielectric heating system where the heat is developed uniformly throughout the adhesive and provides a quick drying or setting operation.

Referring to the drawings which diagrammatically illustrate an apparatus suitable for the procedure:

Fig. 1 is a plan view of the heating section of the apparatus;

Fig. 2 is a view in elevation illustrating diagrammatically the forward movement of the book past an adhesive applying station and the subsequent application of a cover strip and its transportation by a conveyor belt system to the heating zone;

Fig. 3 is a diagrammatic elevation of the conveyor system which passes through the heating zone of Fig. 1;

Fig. 4 is an enlarged transverse sectional view on the line 4—4 of Fig. 1, showing the electrodes arranged for the dielectric heating of the book binding;

Fig. 5 is a sectional detail on the line 5—5 of Fig. 1; and

Fig. 6 is a diagrammatic illustration of essential portions of the electric circuit required for providing the high frequency high voltage field.

In accordance with this invention, we have provided a method of and automatic apparatus for binding a book whereby the separate sheets of a group of signatures are cemented permanently to a flexible backing or strengthening lining, such as a coarse and strong fabric, usually linen and commonly termed crash or super. The flexible backing may, for some purposes, be formed of paper of suitable quality and strength capable of both flexing repeatedly as the book is opened and closed and holding the individual sheets securely positioned. To this end, a set of signatures are assembled in their final book locations and their folded edges are cut away to form a book of separate disconnected sheets of paper. These separate sheets are held in their final locations by means of clamping boards, and each book is moved forward progressively in a series with the ends of the sheets to be attached to the backing held in an exposed condition. As the books are moved at a controlled rate, the edges of the sheets to be attached to each backing are coated with a heat responsive film of a resinous fluid adhesive which is dielectrically stable and capable of being dielectrically heat treated to form a strongly cohesive and adhesive flexible union between the edge portion of each sheet and the backing. Being a fluid, the adhesive penetrates the pores of each sheet and thus forms a band at that edge portion which, after it has been heat hardened, strengthens the sheet and makes it more resistant to a tearing force, so that each sheet is materially stronger at the binding than elsewhere. Moving forward progressively in a timed relation with the book, now consisting of the closely assembled sheets with their adhesive coating, is a series of backings, such as the crash or super lining or paper, and a backing is applied to the fluid adhesive on the back edges of each book. Then the books with their backings are passed serially at a controlled rate through a heating zone where the adhesive films are successively subjected to a rapidly oscillating dielectric heating field of high frequency which changes the fluid adhesive to a flexible substantially non-fluid and dry film and thus secures the back edge portion of each separate sheet securely to the flexible backing.

Our preferred method and apparatus therefor, as hereinafter described, serve for the dielectric heating and removal of water from a backing adhesive formed of an aqueous emulsion including polyvinyl acetate in an outer phase and thus drying the adhesive to a dry and flexible film. The adhesive is selected to have the essential properties of being a dielectrically stable material of low

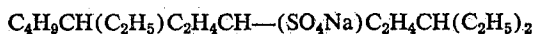
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electrical conductivity and low heat conductivity in both the wet film and the dry film state. The evaporation of water by the dielectric heating leaves the adhesive as a flexible film of strong internal cohesion capable of holding the book pages of the signatures firmly in position. the adhesive should have a low ionizable salt content, and its film in the wet stage should have sufficient viscosity and tackiness to serve adequately when the book is bound in a "Perfect" binding machine.

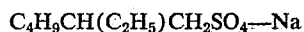
Of the various adhesives which serve the requirements, we may employ a viscous solution or emulsion including polyvinyl acetate in an outer water phase and cause the dielectric field to evaporate the water and leave the polymer in a position of adhering tightly to the adjacent book sheets and holding them firmly in place. A suitable resin emulsion formula for the dielectric curing adhesive may be compounded of the following substances in the following proportions by weight which may be widely varied.

	Percent
Aqueous emulsion of polyvinyl acetate or a copolymer of vinyl acetate with up to 5% of a polymerizable carboxylic monomer ----	60 to 80
A suitable plasticizer, either a polymeric or a monomeric type, such as dibutyl phthalate.---	0 to 20
Thickener and film-former (e.g., water-soluble gums, carboxymethyl cellulose, methyl cellulose, polyvinyl alcohol, starch) -----	0 to 10
Defoamer and/or wetting agent, such as a silicone composition -----	0 to 2
Added water, solvents, preservatives, as desired to give a suitable viscosity, according to the plasticizer used -----	Balance of 100

The resin substances are chosen for their dielectrically stable properties, and various carboxylic polymerizable substances may be copolymerized with the polyvinyl acetate. These comprise fumaric or maleic acids or their acid esters and methacrylic acid or crotonic acid, or their completely or partially neutralized derivatives. The polyvinyl acetate, as well as all of the indicated copolymers of vinyl acetate, are characterized by being thermoplastic resins. Thus, when the dielectric field removes the water from the emulsions of these resins, the heat melts the thermoplastic resins in situ to a substantially anhydrous, viscous fluid which is powerfully adhesive both to the sheets of the book and to the flexible backing, and which immediately upon removal of the heat congeals to a permanent bond. Hence, the rapid heating action provides a stronger bond of the paper to the backing than would be had if the water were evaporated in a slow drying procedure without softening the thermoplastic resin. For the wetting agent, we may use a fatty alcohol sulfate, such as is sold by E. I. du Pont de Nemours and Co. under the trade name of "Duponol." Another suitable wetting agent is one of the higher sodium alkyl sulfates, such as is sold by Carbide & Carbon Chemicals Corp. under the trade name of "Tergitol," two of which have the chemical formulas:



and



A suitable solvent is carbon tetrachloride, and a typical preservative is phenol. If the plasticizer is water soluble, an organic solvent is not usually needed. Otherwise, the organic solvent is used to hold the plasticizer in the system. The thickener and film forming agent is used to provide a suitable viscosity for the composition, and this viscosity modifying substance is proportioned, according to the other ingredients used and their proportions, so as to render the substance adequately adhesive for book binding and to form a strongly cohesive film. The dielectric heating action serves to remove the water phase and thus set the adhesive as a flexible film.

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A specific and preferred formula may comprise 78% by weight of an aqueous emulsion of polyvinyl acetate (55% by weight of solids), 9% of dibutyl phthalate, 1% of polyvinyl alcohol, a standard silicone defoamer 0.25% and added water to make 100% with the proportions above specified.

Dielectric heating to evaporate the water of the emulsion and set the adhesive is effected by means of an electromagnetic field of suitable radio frequency, which may be from five million to two hundred million cycles per second, but preferably is in the range of ten megacycles per second. The voltage may be as high as 15,000 volts, more or less. A suitable wattage may be from 5 to 10 kilowatts. By largely localizing an alternating field of these characteristics in the adhesive film applied to the book, the water is quickly removed while the book is traveling through the heating zone at a suitable rate coordinated with other book manufacturing stages. In this form of heating, the electric field permeates the entire band or film of adhesive and causes a substantially equal heating throughout, except as the outer layer may be slightly cooler due to conductivity or radiation. Since the adhesive is a comparatively poor conductor of electricity and heat, the field produces a dielectric hysteresis, eddy currents or other other effects, caused possibly by deformation or vibration of the molecules as the field polarity changes with the frequency. The voltage is limited to a point well below the flash-over point at which the adhesive and book materials could be punctured by an electrical discharge, and various safety measures within the knowledge of one skilled in the art are employed to insure a rapid but safe heating of the material and without endangering the machine operator. For example, co-axial cables serve to confine the electrical energy to the points of application.

This dielectric heating energy may be derived from a suitable circuit, such as that diagrammatically illustrated in Fig. 6, in which a power supply system comprises a suitable input transformer 10 arranged to convert the standard 60 cycle 220 volt A.C. to a required high voltage. This high voltage current is then rectified by a suitable rectifier tube system 11 to provide a D.C. current. An oscillator circuit includes a choke coil 12, a condenser 13, an oscillator tube 14, an associated condenser and resistance 15, tank coil 16 and other electrical parts which provide the high frequency high voltage current. This energy is applied to one terminal comprising a copper distributor tube 20 (Fig. 4) of suitable length which is directly connected to the copper tube electrode 22 arranged close to part of the adhesive on a traveling book back and parallel with the direction of travel of the series of moving books. A preferably narrow electrode plate 24, which is grounded, is spaced from the electrode 22 and so located as to serve as the second field terminal, and it is likewise arranged parallel with the direction of travel of the book series and near the adhesive films on several books 25 to concentrate the field therein and cause the adhesive to set.

An apparatus suitable for feeding books serially and progressively through this electric field is shown in Figs. 1 to 5 inclusive. The separate book signatures 25 may be carried between clamps 26 (Fig. 2) of a standard book conveyor system with their back portions projecting below the clamps. After the folded edges of the signatures have been trimmed away, the fluid adhesive 28 (Fig. 2) in a suitable container may be applied to the projecting backs of the projecting back edges of the sheets, herein termed a book, by means of the power driven rollers 29 which dip into the adhesive and carry the liquid into contact with the backs of the book sheets. These backs are to be covered with a paper cover 30 or a reinforcing super, such as a strip of cloth crash, paper, leather or other suitable material, herein termed a "backing." The backing 30 is shown as a paper cover

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in which the medial portion of the cover constitutes the flexible backing. To attach that medial portion to the separate assembled sheets, a set of covers is fed forward serially into contact with the adhesive film 31 applied on the back portion of the assembled book sheets. This backing may be fed into place by means of a power driven endless conveyor belt 32 (Fig. 2) onto which the book backings 30 are suitably laid in a properly spaced relationship. This belt 32 transports the backings 30 to a location beneath the wet adhesive on the book where the backing 30 is forced into adhering contact with the book by a belt supporting roller 34. If a crash lining or a super is to be applied, it is fed forward in the same manner so that it will be centrally positioned on the adhesive covering the back edges of the assembled book sheets. This crash or super may, likewise, extend for a short distance up the sides of the outermost sheets so as to make a satisfactory contact with the end sheets. The adhesive layer is suitably sized and positioned to insure that the adhesive is fully enclosed by the backing. Suitable folding mechanism serves to wrap the side portions of the backing 30 (shown in Fig. 4 as a full sized paper cover) around the side faces of the book. The adhesive film 31 has been applied only to the back of the book sheets, and if desired a short distance up the sides, so that the adhesive film extends only a short distance up the side of each book as well as across the back. Thereafter, the book is transported by a supplemental endless conveyor system 36 (Fig. 2) to another power driven conveyor 38 which transports the books serially to and through the heating zone.

The heating zone is preferably enclosed in a tunnel-like structure 40 (Figs. 4 and 5) made of aluminum metal and substantially enclosing the traveling books so as to serve as a shield for the electric field. This tunnel structure comprises a bottom 41, side walls 42 and a removable top 43. A suitable lead 44 connecting one terminal of the electrical high frequency generator to the current distributor tube 20 passes through a hole suitably provided in the side 42 of the tunnel. This distributor 20 (Fig. 4) is connected to the middle copper tube 22 through a set of spaced transverse brass distributor plates 45 which are welded at each end to the tubes 20 and 22. The plates 45 are slidably and adjustably mounted on metal discs 46 by bolts 47 located in elongated slots in the plates 45, so arranged that the field transmitting tube 22 may be adjustably positioned close to books of various thicknesses. Each disc 46 is mounted on a block 48 supported by a fiberglass plate 50 suspended at the left hand end on an aluminum angleiron 51 suitably carried by the vertical wall 42. At its right hand end, the glass plate 50 is mounted on a porcelain support 52 and provided with a corona shield 53. The plate is suitably attached to the porcelain, as by means of a cap screw 54. The conveyor belt 38 rides over the glass plate 50.

The three field producing copper or brass tubes are held in a vertically spaced arrangement as shown in Fig. 5. The upper horizontal tube 55 has a set of spaced brass plates 56 welded thereto and supported on the tops of aluminum blocks 57 mounted between the central distributor discs 46 (Fig. 1). The lower horizontal field distributing tube 58 (Fig. 5) likewise has a set of spaced brass plates 59 welded thereto, and each plate 59 is supported beneath an aluminum block 60 by means of a bolt 61 passing through the assembled blocks 57 and 60. Thus, the upper and lower metal field tubes are supported by a set of these blocks 57 and 60 which are carried by the central distributor plates 45. Various other constructional details may be employed as desired. The spacing blocks 57 and 60 pass through holes 62 (Fig. 5) in the fiberglass plate, which are large enough to provide for the lateral adjustment of the field distributor tubes 22.

The single field collecting plate 24 at the left in Fig. 4

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is also adjustably mounted on the top of the fiberglass plate, as by means of a clamp bolt 64 passing through an elongated slot in the metal plate 24 and a hole in the fibre plate 50. Thus, this plate 24 may be laterally adjusted to accommodate various book sizes. As indicated diagrammatically at 65 in Fig. 6, the plate 24 is grounded.

After the books have left the clamp plates 26 (Fig. 2) they are held in the same vertical positions by means of horizontal guide plates 70 of insulating material (Fig. 4) which are suitably mounted for adjustment toward and from the book, as by means of clamping screws and washers 72 carried in elongated slots 73 in the plates. These plates 70 are mounted on brackets 74 carried on the side walls 42 of the tunnel 40. These are suitably spaced so that the book may slide readily therebetween but be held in a vertical position as indicated. It will be appreciated that by a suitable arrangement of the construction the books may be presented to the field in a horizontal position or with the adhesive film vertical. The adhesive layer 31, as indicated diagrammatically in Fig. 4, may extend up the side of each book cover for a short distance and the middle one (22) of the three field terminals is preferably arranged opposite that side adhesive, while the upper and lower field terminals are well above and below the adhesive. The opposite terminal plate 24 is arranged substantially opposite the bottom portion of the adhesive on the back of the book sheets. This arrangement of the three field terminals at the right and the single terminal 24 at the left is such as to concentrate or localize the field in substantially a triangular zone which insures a fairly even distribution of the heating effect throughout all of the adhesive. The various electrical parts are suitably made and assembled in accordance with the knowledge of one skilled in the art.

This apparatus and the related method, therefore, serve to present a series of books progressively to the dielectric heating field, which is generated by a device including high voltage high frequency oscillators employing electronic tubes to obtain output frequencies ranging from 5 million to 200 million cycles per second and an adequate voltage of at least 10,000 volts and preferably at least 15,000 volts. The expression "dielectric heating" as herein used is intended to cover the production of such an oscillating field and subjecting the book adhesive to the drying or setting action thereof. The oscillating field is so located according to the selected position of the electrodes that the maximum effect is transmitted transversely of the adhesive on the book back and is so confined as to minimize heating other portions of the book. Thus, the books travel progressively through this elongated field which, as shown in Fig. 1, is acting on several books simultaneously as they are progressively introduced to and removed from the field. Hence the drying and setting action is progressive, and the electric field may be so controlled relative to the rate of book movement as to limit the heat input and insure that the heating effect takes place gradually and progressively without any explosive action which might result from too fast a drying operation. The frequencies employed are those allocated by the Federal Communications Commission and are operated within the government restrictions which prevent interference with radio apparatus.

It will be appreciated that various modifications may be made in this construction and the method. For example, the adhesive may be applied to the back of the book by means of a pneumatic spray nozzle or other device. The voltage of the field and its frequency may be widely varied within the requirements of evaporating the water and setting the adhesive during the time within which the traveling book is within the dielectric field. Also, the rate of the conveyor system, and especially the belt 38, is coordinated with the length of the heating

zone terminals and the conduction of heat in the dielectric field so that the adhesive is fully set during the period in which the book is traveling through that field. This is best effected by increasing the length of the terminals, if the conveyor speed is to be increased. Many other variations in both the apparatus and the procedure may be adopted within the scope of this invention, and the specification is to be interpreted as setting forth a preferred method and embodiment of the apparatus, and a suitable and preferred adhesive composition; but the claims are not to be construed as limited to the disclosure except as required by their phraseology.

We claim:

1. The method of binding the sheets of a book comprising the steps of assembling a set of separate paper sheets as an unbound book, coating the back edge portion of each sheet of the book with a fluid film of a dielectrically stable thermoplastic resinous adhesive which penetrates the pores of the edge portion of each sheet and is capable of forming a flexible strongly cohesive and adhesive union between the edge portions of the book sheets and a backing, applying a permeable and flexible backing to the adhesive on the book, subjecting the adhesive film on the book to a rapidly oscillating dielectric heating field of high frequency and progressively drying and heat softening the adhesive film, while controlling the heat input of the electric field to dry the film and avoid disruption of the film substance, and thereafter cooling and hardening the film.

2. A method according to claim 1 in which the adhesive comprises an aqueous emulsion of a polymeric resin including polyvinyl acetate, a plasticizer therefor, and a viscosity modifying substance which insures adhesion of the backing to the back of the book during the wet stage of the adhesive, and wherein the rate of movement of the book is coordinated with the period of heat application to evaporate the water and soften the resin during the dielectric heating stage.

3. The method of binding the sheets of books comprising the steps of assembling signatures and providing a set of unbound books of separate paper sheets, feeding the books forward under a lateral clamping pressure and with the back edge portions of the sheets exposed, progressively coating said edge portions of the moving books with a fluid film of a dielectrically stable thermoplastic resinous adhesive which penetrates the pores of said edge portions and is capable of forming a flexible strongly cohesive and adhesive union with said edge portions and a permeable backing, applying a permeable and flexible cloth backing to the adhesive coating on each book, pass-

ing the books serially through a heating zone and there subjecting the adhesive film of each book to a rapidly oscillating dielectric heating field of high frequency and progressively removing the water and softening each film, while controlling the heat input of the electric field relative to the rate of book movement to dry and soften each film and avoid disruption thereof during the period of travel through the field, and then cooling and hardening the thermoplastic film.

4. Apparatus for binding a set of separate sheets as a book comprising a conveyor system including sets of clamps for holding the book of assembled sheets and feeding it progressively forward with the back edge portions of the sheets exposed, means for applying a fluid film of a dielectrically active resinous adhesive to the back edge portion of each sheet of the book, means for feeding forward a flexible backing and positioning it in contact with the adhesive on the book in its final position, means for passing the book with its applied backing through a dielectric heating zone, and a dielectric heating device comprising means for generating a high voltage high radio frequency oscillating field in said zone and spaced electrodes near the traveling book which extend in the direction of book travel and are arranged to localize the field within the adhesive on the book in said zone, the extent of the electrodes being coordinated with the rate of book travel so that the application of heat by the field insures a gradual but non-disruptive drying of the adhesive as it passes through the heating zone.

5. Apparatus according to claim 4 in which the adhesive comprises a viscous aqueous emulsion including a polyvinyl acetate adhesive and a plasticizer therefor which is capable of adhering to the back of each book and forming a flexible coherent film.

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