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MANUFACTURE OF CELLULOSIC PRODUCTS

Filed Feb. 23, 1961

2 Sheets-Sheet 1

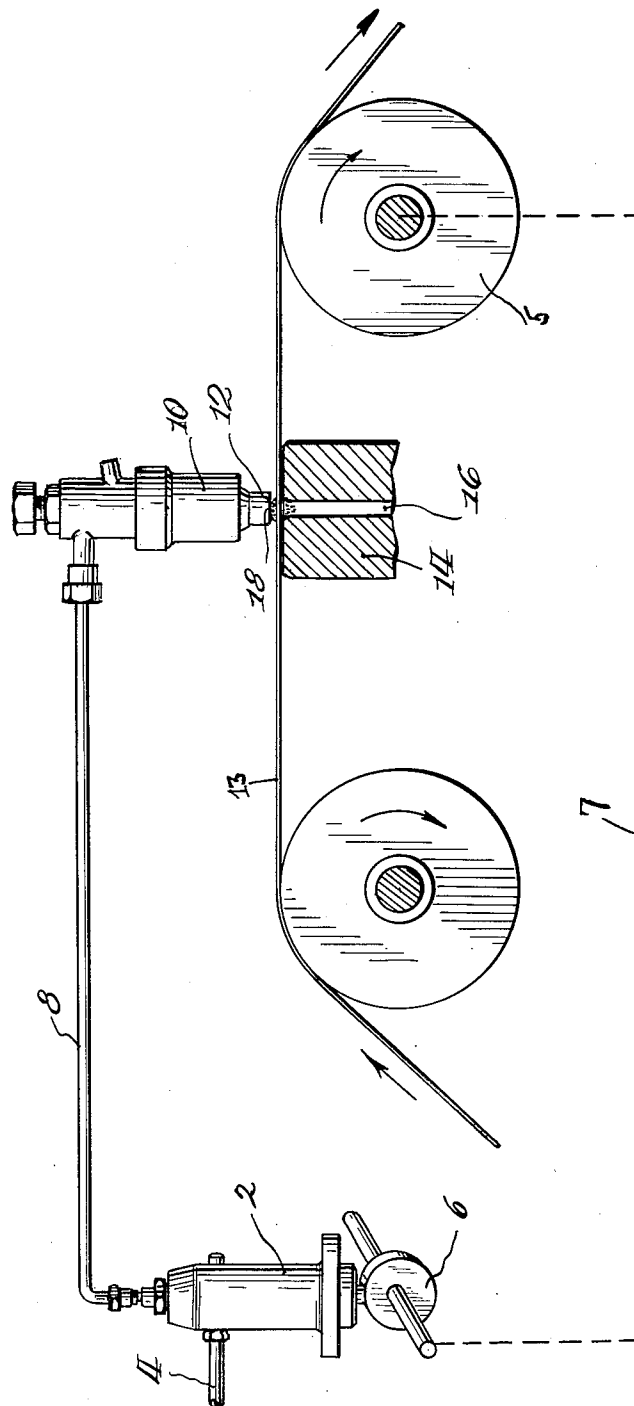


Fig. 1.

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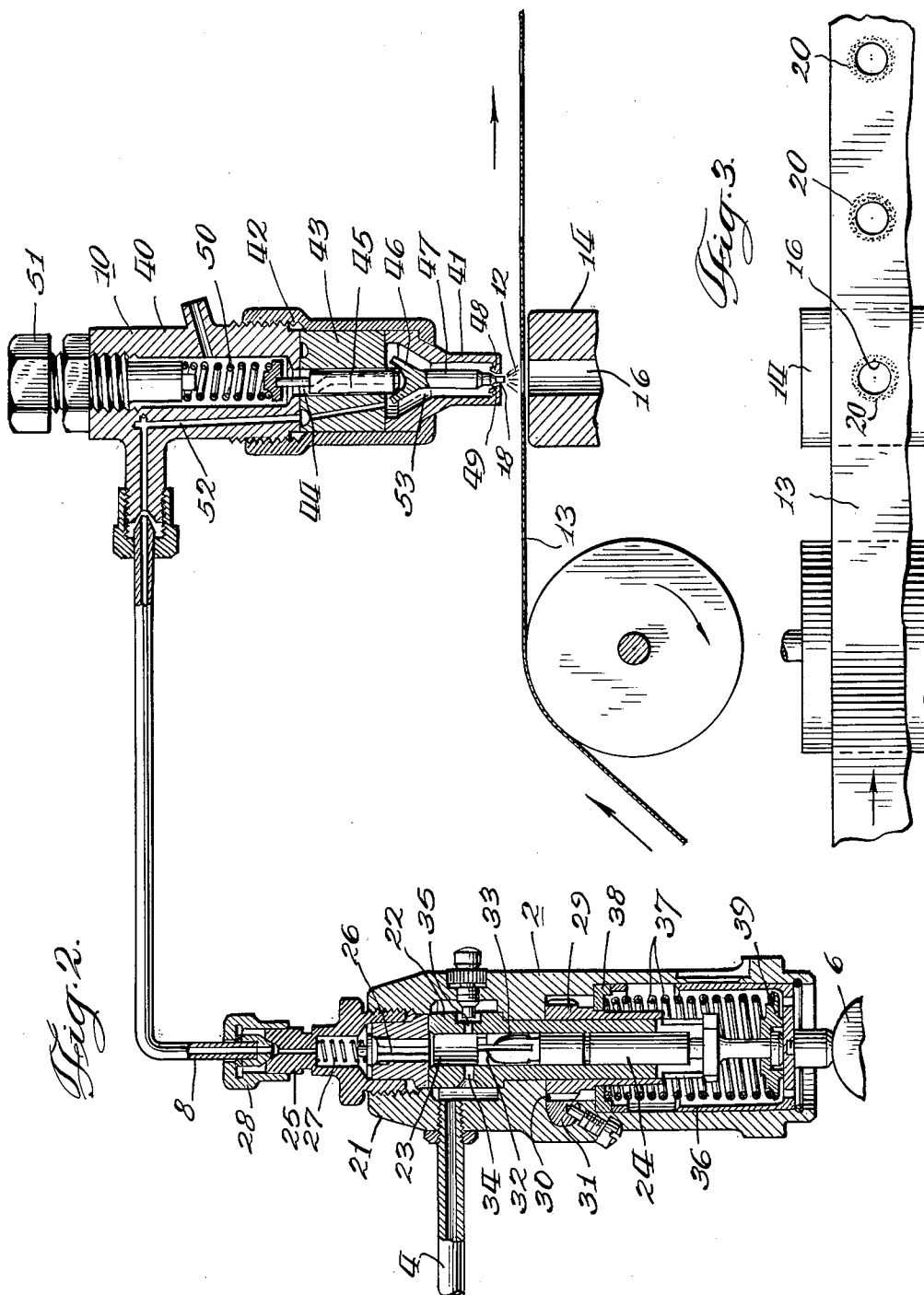
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2 Sheets-Sheet 2



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MANUFACTURE OF CELLULOSIC PRODUCTS

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This invention relates to methods of selectively perforating flexible webs or thin sheet stock, and the adaptation of hydraulic means therefor. More particularly, it relates to utilizing high velocity fluid injectors to perforate rapidly moving paper webs, and, as an adjunct thereto, to simultaneously incorporate a reinforcing material into areas of the web marginally defining the perforations thus obtained.

The invention is especially applicable to perforating selected areas of flexible webs, such as paper or similar sheet materials, while being handled at high speeds on a sheet cutter, printing press, or other web converting apparatus.

A major object of the present invention is to provide a method for perforating continuous webs with high pressure liquids, while said webs are moving at high speeds.

Another object is to provide a method of additionally utilizing the high pressure perforating liquid to impregnate and reinforce the web in an area immediately encircling and defining the perforations produced by said liquid.

A still further object is to provide improved means for perforating a continuously moving web and simultaneously reinforcing the web in an area adjacent to and encircling the perforations, while said web is traveling at high speed relative to said means.

Other objects and advantages will become readily apparent to persons skilled in the art upon examining the following descriptions and drawings as will various modifications, without departing from the inventive concepts defined in the appended claims.

In the drawings, in which like parts are identified by the same reference numeral:

FIG. 1 is a schematic illustration of an arrangement embodying the principles of this invention.

FIG. 2 is an enlarged view, partially in section and partially schematic, showing the details of a fluid injection device suitable for carrying out the invention, and its relative position with respect to a moving web on which it operates.

FIG. 3 is a plan view of the web showing holes punched into the web by the force of hydraulically-ejected liquid as the web moves under a fluid injector nozzle and over a cooperating apertured die member.

Heretofore, continuous web perforating operations commonly employed rotary punches in cooperation with rotary cavity-type dies. In such operations, it is necessary to align each punch with its associated die cavity, since even minor misalignment results in punch breakage or damage. Normal wear occurring between the punches and dies during high speed operation also contributes to misalignment, necessitating continual readjustment of the apparatus or frequent replacement of cooperating parts.

In accordance with the invention, a high pressure fluid injection device, including a pump and nozzle of a construction similar to those conventionally used in supplying fuel to diesel engines, is adapted to utilize a high velocity stream of liquid to perforate thin sheet stock. An injector nozzle is arranged in closely spaced relation to an apertured support member with the nozzle opening in registry with the aperture in said member. Thin sheet stock or a flexible web is interposed between the nozzle and apertured support member. Jets of high pressure liquid are then discharged through the nozzle to punch

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holes of predetermined size and configuration into the web. The web may be introduced to the perforating area in a step by step motion synchronously timed with the liquid jets, or, preferably, continuously and at high speed, again in synchronization with the liquid jets.

FIG. 1 schematically illustrates one arrangement for carrying out the invention wherein a substantially non-compressible fluid is supplied at low pressure to a fluid injection pump 2 through low pressure supply line 4. Pump 2, operated at a constant stroke by a cam or swash plate mechanism 6, supplies metered amounts of liquid in timed pulses through high pressure fluid line 8 to a high pressure fluid injector nozzle 10. Nozzle 10, which is preferably of the pintle type, ejects the liquid at high velocity and in the general shape of an inverted cone 12, against web 13 moving over a supporting member or die 14 provided with an aperture 16 in registry with nozzle opening 18. Pressurized liquid, as thus propelled against the moving web, punches a sharply-defined aperture therein in registry with orifice 16. Orifice 16 shown in FIG. 3, as circular, may of course be of any desired configuration. Margins of the web apertures thus produced are sharply-defined when the liquid stream is in cross sectional registry with orifice 16.

Injection pump actuating cam 6 is synchronously connected, as shown at 7, to a web driving roll 5 to insure desired linear spacing of the apertures punched in the web.

Any suitable substantially non-compressible fluid may be employed. It is preferred that non-corrosive, lubricous liquids be used, such as oils, plastic materials liquified by heat or by dissolving in a suitable solvent, or solvents themselves. Water, or various aqueous solutions containing hardenable materials, may also be used provided suitable provision is made to reduce the corrosive nature of the water. Hardenable plastic materials, are employed when, in addition to perforating the web, it is desired to reinforce the edges of the perforation simultaneously with the punching operation.

Under the conditions above stated for optimum aperture definition in the web, substantially all of the liquid passes through die orifice 16 along with the removed web material, but may be recycled through a suitable filter for removal of the entrained material, and re-used. By increasing the nozzle height above the web, the fluid stream of liquid is enlarged with outer portions thereof deposited on web marginally of die orifice 16 as shown at 20, FIG. 3. A fluid stream containing plastic material may be thus employed to effect marginal deposition of plastic material which may subsequently be hardened by carrier solvent removal or by heat removal to provide a reinforcing annulus marginally of the aperture and integral with the web.

Thus, the process of the invention is utilized, not only to punch holes of predetermined configuration into a rapidly moving web, but simultaneously to reinforce the web in the area surrounding the punched holes.

FIG. 2 shows in cross-sectional detail, one type of fluid injection pump and a cooperating injector nozzle and die arrangement, suitable for carrying out the invention. Pump 2 comprises pump housing 21, containing barrel 22 having bore 23 in which is mounted pumping plunger 24. Secured to housing 21 in alignment with barrel 22 is delivery valve holder 25 containing valve 26 and valve operating spring 27. Valve holder 25 is connected to high pressure fluid line 8 by coupling 28. Control sleeve 29 encircles lower portion of barrel 22 with a toothed pinion portion 30 in cooperating engagement with conventional toothed control rack 31. Rack 31 is utilized to adjust position of helices 32 and 33 on plunger 24 relative to fill opening 34 and fill and spill

opening 35 in barrel 22. Adjustable positioning of helices 32 and 33 within the barrel controls the amount of fluid metered by pump 2. Coil spring 37 in slidable plunger guide 36 presses against spring seats 38 and 39 to bias plunger 24 in open position in the usual manner.

Pump 2 delivers high pressure liquid through line 8 to high pressure fluid injector 10. Injector 10 comprises nozzle tip 41, nozzle holder 40 and intervening member 43 secured together by coupling 42. Valve stem 45 slidably mounted in central bore 44 of intervening member 43 engages cup-shaped portion 46 of pintle valve 47 and is biased by spring 50 to maintain pintle valve 47 closed in the absence of fluid pressure. Biasing pressure of spring 50 is adjustable by screw 51. Valve seat 48 in nozzle tip 41 is adapted to automatically seat and center tapered portion 49 of valve 47 to control flow of fluid through opening 18.

Nozzle 10 preferably is adjustable in both vertical and horizontal directions. Cooperating die 14 is also horizontally adjustable to maintain registry with nozzle 10.

In operation, a suitable liquid is delivered at low pressure by supply line 4 through fill opening 34 to inner bore 23 of pump 2 when plunger 24 uncovers fill opening 34 at the bottom of the plunger stroke. Actuating cam 6 (shown only in FIG. 1), driven in timed relationship with the movement of web 13, actuates plunger 24 to force liquid at high pressure through valve 26, and line 8 to injector 10. Liquid flows through valve 26 to injector 10 until spill opening 35 is uncovered. The resulting drop in pressure causes valve 26 to close and maintain residual pressure in line 8 until the next injection. Plunger 24 may be rotated in barrel 22 by control rack 31 to adjust length of time required for plunger helix 33 to uncover spill opening 35. Thus, the length of the effective plunger stroke and the amount of liquid injected thereby are effectively used to control the hydraulic pressure of the liquid delivered to nozzle 10.

The high pressure liquid travels through high pressure line 8 through channel 52 of nozzle holder 40 to bore 53 in nozzle tip 41. Hydraulic pressure forces open valve 47, to eject a conical spray 12 of high velocity liquid through opening 18 of nozzle 41. The ejected liquid instantaneously perforates moving web 13, in registry with underlying aperture 16 in die block 14. Substantially all of the liquid then passes through aperture 16 with the excised web material.

Synchronization of pump actuating cam 6 with web driving roll 5 may be adjusted to perforate the web at any desired linear spacing. An example of such spacing is shown by reference numerals 16 in the plan view of web 13, in FIG. 3.

Injection pressures generated by diesel injection devices usually range from 800 to 7,000 p.s.i. but may run as high as 25,000 p.s.i. For perforating paper webs in the manner herein taught, pressures in the range of 4500 p.s.i. to 6,000 p.s.i. have proved suitable. However, pressures are readily adjustable over a wider range to fit the particular characteristics of the material being worked.

The perforating device of this invention is adaptable for installation on most known web converting equipment including printing presses, sheeters, rewinders, interfolders, sheet collators and the like. The range of speeds for such equipment varies from 100 feet per minute to about 2000 feet per minute for printing presses, and as high as 5000 feet per minute for rewinders. High pressure fluid pumps and cooperating nozzles are capable of being operated at speeds which permit an almost unlimited range of spacing for the perforations. Additional flexibility in machine design may be obtained by arranging several ejector nozzles in parallel. The nozzles also may be spaced in any desired arrangement transverse of the moving web to provide still more variety in perforation patterns.

As previously noted, when the device is used only to perforate webs, the injector nozzle is spaced relative to the

web so that a cross section of the high velocity spray ejected by injector nozzle, taken at the plane of intersection of the moving web, is congruent with the configuration of the underlying die-opening. This arrangement produces perforations having especially sharp and well-defined edges. When it is desired to reinforce the perforations, the spacing of the nozzle above the web is increased to enlarge the area where the liquid intercepts the web. Any liquid striking the web outside of the unsupported area defined by the underlying die opening is absorbed into the web in that area. Thus, a hardenable resin may be included in the liquid to provide a reinforced area immediately surrounding the perforations as shown by shaded area 20 in FIG. 3.

Materials suitable for reinforcing purposes include resin in solvent combinations such as polyvinyl chloride in methyl ethyl ketone, cellulose acetate butyrate in methyl ethyl ketone or any of the below-mentioned thermoplastic materials in appropriate organic or mineral solvents. Thermosetting aldehyde resins, including water-soluble types, are also suitable.

Thermoplastic materials may also be used as the reinforcing media in which case the injection pump, nozzle, and fluid supply elements are heated to maintain the plastic in molten condition during application. After application the web is cooled to harden the plastic deposited in the reinforced areas. Suitable thermoplastic resins include polyethylene, polypropylene, polyvinyl chloride, polyvinyl acetate, copolymers of polyvinyl chloride and polyvinyl acetate, butyrates and the like. Various combinations of these resins, with or without added plasticizers are also effective.

It will be understood that more than one perforating nozzle may be mounted over selected areas of a moving web and that they may be supplied with liquid by individual pumps, or a single pump for several nozzles. The pump and delivery nozzle also may be combined, thus eliminating the high pressure fluid supply line or tube. The latter tubing, when employed, should be thick-walled, of smooth and uniform bore, and be made of material ductile enough to permit bending during installation, but of a ductility low enough to withstand the pressure pulses to which it is subjected in service. A suitable material is SAE 1010 steel with a carbon content not exceeding 0.05 to 0.15 percent, and with tensile strength on the order of 45,000 p.s.i. Suitable tubes range in size from $\frac{1}{4}$ " O.D. and $\frac{1}{16}$ " I.D. to $\frac{1}{2}$ " O.D. and $\frac{3}{16}$ " I.D.

The method and apparatus herein described is useful in converting punched sheets for loose leaf notebook refills, catalog sheets, magazine inserts, manual pages, multicopy paper and the like.

While one of the principal advantages of the invention is its adaptability to perforating webs moving at relatively high speeds, the principles of the invention are readily applicable to operations in which the movement of the sheet material acted upon is completely stopped while being perforated.

The method herein described is especially suitable for perforating paper webs but it is readily adapted to perforating other flexible webs such as non-woven bonded materials, woven fabrics, plastic films and the like.

It will be understood that modifications and variations may be effected without departing from the scope of the invention as set forth in the appended claims.

What is claimed is:

1. The method of perforating web-like sheet stock consisting of the steps of continuously moving said stock in sliding relation over a fixed apertured supporting member with said stock bridging the aperture while being supported in areas marginally thereof, and intermittently directing a high velocity liquid stream of predetermined shape against the aperture-bridging portion of said stock while said stock moves over said member to effect disintegration and removal of a portion thereof through the apertured member, and provide linearly spaced apertures

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in said stock of the same configuration as the shape of said liquid stream.

2. A method of aperturing flexible webs which comprises the steps of bridging a fixed selectively-apertured supporting member with a continuously moving flexible web, intermittently directing shaped high velocity jets of liquid at predetermined intervals against said moving web where said web bridges the apertures of said member, ejecting said jets against said web at sufficient pressure to excise shaped portions from said web at regularly spaced intervals along said web.

3. A method of perforating flexible webs comprising the steps of continuously moving a flexible web over a stationary aperture, maintaining said moving web in taut condition as it spans said aperture, intermittently ejecting at predetermined intervals a shaped jet of substantially non-compressible fluid at high velocity against the aperture-spanning area of said moving web, supplying said jet in a shape such that a cross section of said jet taken where it impinges against said web is of the same size and configuration as said aperture, ejecting said jet at a pressure and velocity sufficient to disintegrate and remove a portion of said web and obtain perforations therein of said configuration, and adjusting the speed of said web with the timing of the intermittent ejections of said jet to provide predetermined linear spacing between the shaped perforations thus-obtained in said web.

4. A method of simultaneously perforating and reinforcing flexible webs comprising the steps of continuously moving a flexible web over a stationary supporting member having an aperture of predetermined configuration, maintaining said web taut while moving over and spanning said aperture, intermittently directing a shaped jet of substantially non-compressible fluid containing a hardenable resin against said moving web in an area encompassing the aperture-spanning portion of said web and a portion of said web supported marginally of said aperture, the cross section of said jet taken where said jet impinges against said web being slightly greater in area than the similarly shaped aperture-spanning portion of said web, supplying said jet at sufficient velocity and pressure to excise and remove the aperture-spanning portion of said web while impregnating said web with said fluid in said supported portions marginally defining the excised portion of said web.

5. A method of simultaneously perforating and reinforcing flexible webs comprising the steps of continuously moving a web over a fixed supporting member provided with an aperture of predetermined configuration, maintaining said moving web taut while spanning said aperture, intermittently directing a shaped jet of substantially non-compressible fluid containing a hardenable resin against said web in an area encompassing the aperture-spanning portion of said web and a portion of said web supported marginally of said aperture, the cross section of said jet taken where said jet impinges against said web being slightly greater in area than the similarly shaped aperture-spanning portion of said web, supplying said jet at sufficient velocity and pressure to excise and remove the aperture-spanning portion of said web while impregnating the supported portion of said web with said fluid in an area marginally defining the excised portion of said web, drying said web, and curing the residual resin deposited therein to reinforce said web in an area marginally defining said excised portion.

6. A device for perforating flexible webs comprising a stationary apertured support member, means for continuously moving a flexible web over said member, a high pressure fluid injector spaced above said member and in registry with the aperture therein, a shaped nozzle opening in said injector, means for supplying highly pressurized liquid to said injector, means for intermittently ejecting said liquid through the shaped nozzle opening of said injector to effect perforation of said web while said web moves over said member, and means for timing said intermittent ejections of said liquid with the speed of said

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web to obtain shaped perforations of predetermined spacing in said web.

7. Apparatus for perforating flexible webs comprising a stationary apertured support member, a high pressure fluid injector spaced above said member and in registry with the apertured portion thereof, means for continuously moving a flexible web over said member and below said injector, means for supplying liquid under high pressure to said injector, means for the sequentially timed ejection of high pressure jets of liquid from said injector while said web moves between said injector and said member, means for shaping said jets to conform in cross section to the configurations of the aperture in said member where said jets intercept said members, and means for relating the sequential timing of said jets to the rate of movement of said web to obtain regularly spaced and shaped perforations on said web.

8. Apparatus for perforating sheet stock while simultaneously reinforcing said stock marginally of the perforations, said apparatus having in combination, a fixed support for said stock provided with an aperture of the configuration desired for said perforations, means for continuously moving said stock in slidable engagement with the apertured surface of said support member with a portion of said stock extending over said aperture, means arranged above said support including a high pressure nozzle in registry with the aperture of said support member for discharge of a resin-containing liquid in a predetermined shape toward said aperture to perforate said stock in the area thereof extending over said aperture while simultaneously depositing said resin-containing liquid onto said stock in a supported area thereof marginally defining the perforation thus formed.

9. In a device for aperturing thin sheet stock while simultaneously reinforcing areas thereof defining the aperture, an ejector including a pressure responsive nozzle for ejecting resinous material maintained in flowable condition within said ejector, a support member fixed in closely spaced relation to said nozzle and provided with an aperture in registry with said nozzle, means for continuously moving thin sheet stock across the apertured portion of said support member through a path bridging said aperture, and means associated with said ejector periodically to apply thereto pressure pulses of a magnitude momentarily to trigger said nozzle open and effect high pressure discharge of said resinous material against the sheet passing over the apertured portion of said support member, and means for shaping the pattern of the resinous material as ejected to be of the same configuration as and larger in cross section than the apertured portion of said support member where said material intercepts said member, whereby an inner portion of said resinous material simultaneously punctures said sheet material in the area defined by said aperture while an outer portion of said resinous material simultaneously impregnates said stock in an area marginally surrounding the aperture thus formed.

10. Apparatus for providing sheet stock with marginally reinforced perforations, comprising in combination, a fixed table-like support provided with an aperture of predetermined configuration extending therethrough, means for continuously feeding flexible sheet stock across the apertured area of said support, means for maintaining said sheet stock in snug sliding engagement with the surface of said apertured support, a high pressure nozzle spaced above said support in substantial registry with said aperture, a supply of resinous fluid in flowable condition, pump and valve means connected to said nozzle for the pulsed feeding thereto of said resinous fluid at a pressure sufficient to trigger said nozzle open momentarily and discharge a shaped high pressure stream of said fluid at least partially into the apertured area of said support to effect rupture and removal of the aperture-spanning portion of said sheet stock while simultaneously depositing a portion of said resinous fluid onto said sheet stock in sup-

ported areas marginally surrounding the perforation thus formed, means synchronizing said continuous feeding means and said nozzle actuating pulsed feeding means to effect regularly timed intermittent discharge of said resinous fluid against said continuously fed sheet stock to provide perforations therein at regularly spaced intervals, and means to harden said fluid in said sheet stock to provide a resinous reinforcement marginally of said spaced perforations.

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References Cited in the file of this patent

UNITED STATES PATENTS

720,593 Lindberg ----- Feb. 17, 1903

1,157,754
1,699,760
2,006,499
2,395,123
2,655,841
2,862,251
2,881,503
2,985,050
3,073,714
3,079,290

Benjamin ----- Oct. 26, 1915
Sherman ----- Jan. 22, 1929
Fourness et al. ----- July 2, 1935
Hutt ----- Feb. 19, 1946
Anness ----- Oct. 20, 1953
Kalwaites ----- Dec. 2, 1958
Johnson ----- Apr. 14, 1959
Schwacha ----- May 23, 1961
Shu-Tung Tu et al. ----- Jan. 15, 1963
Marshall ----- Feb. 26, 1963

FOREIGN PATENTS

Australia ----- Jan. 10, 1956

184,364