(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 177 277
A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 85306852.6

(22) Date of filing: 26.09.85

(51) Int. Cl.4: D 06 C 23/04

(30) Priority: 28.09.84 US 656119
28.09.84 US 655967
28.09.84 US 655968
28.09.84 US 655966

(43) Date of publication of application:
09.04.86 Bulletin 86/15

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

(71) Applicant: MILLIKEN RESEARCH CORPORATION
Iron Ore Road P.O. Box 1927
Spartanburg South Carolina 29304(US)

(72) Inventor: Willbanks, Charles Everage
205 Greengate Lane
Spartanburg South Carolina 29302(US)

(72) Inventor: Love III, Franklin Sadler
1008 Seven Springs Road
Spartanburg South Carolina 29302(US)

(72) Inventor: Gilpatrick, Michael William
Route 4 Chesnee
Spartanburg south Carolina 29323(US)

(74) Representative: Bass, John Henton et al,
REDDIE & GROSE 16 Theobalds Road
London WC1X 8PL(GB)

(54) Method and apparatus for patterning substrates.

(57) A method for altering the surface appearance or texture of a textile or other substrate comprises impinging the surface of the substrate (25) with a high velocity fluid jet (18) with water being a preferred fluid. The substrate is placed against a support (20), and a fluid stream having a peak dynamic pressure in excess of about 2068 kPa (300 p.s.i.g) is directed onto the fabric surface. Various means are adopted to interrupt and re-establish contact between the stream and the surface in accordance with pattern information.

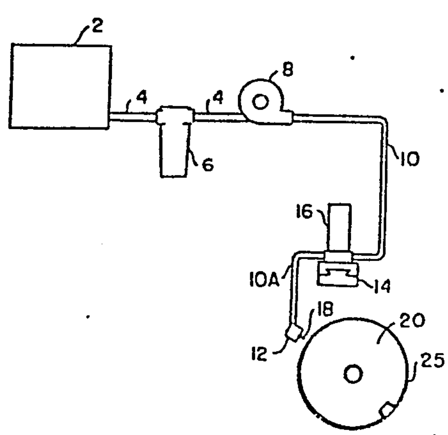

FIG. -1-

EP 0 177 277 A1

0177277

METHOD AND APPARATUS FOR PATTERNING SUBSTRATES

This invention relates to a method for patterning, or otherwise altering the surface appearance or texture of, woven, knitted, or bonded textile fabrics by directing one or more high velocity fluid streams onto the fabric surface, and to the products produced thereby.

The textile industry is constantly searching for commercially practical methods by which textile fabrics, especially woven or knitted flat or pile fabrics suitable for apparel or decorative use, may be patterned, textured, or otherwise made more attractive with greater economy or versatility than through use of existing methods, or methods by which such fabrics may be patterned or textured in unusual and attractive ways. Of particular value are methods which have one or more of the following characteristics:

1. capable of generating a variety of different pattern or texture effects, depending upon process conditions and the nature of the fabric being patterned;
2. capable of generating decorative pattern or texture effects on a variety of different substrates, e.g., woven fabrics, knitted fabrics, flat fabrics, pile fabrics, flocked fabrics, coated fabrics, etc.;
3. capable of simulating decorative weaving or knitting effects on textile fabric in web form at speeds in

excess of those associated with commonly encountered decorative weaving or knitting systems, and at dramatically lower cost;

4. capable of patterning or texturing textile fabric in web form at costs equivalent to or less than those associated with commonly encountered embossing systems;
5. capable of changing from one pattern or texture to another, completely different pattern or texture with a minimum of lost production time or expense;
6. capable of patterning textile fabric using electronically generated or stored pattern data, thereby permitting fabric patterning directly from digitally encoded pattern data;
7. capable of patterning textile fabric with a pattern having no conventional limitations on pattern repeat length.

The process disclosed herein, which embodies or makes possible all of the above capabilities, is one in which high velocity streams of a working fluid, for example, water, may be directed onto the surface of a fabric which is comprised of substantially continuous yarns which are interlaced in a repeating configuration to physically modify the surface appearance or texture thereof in a pre-determined pattern. By control of fluid stream size, stream velocity, nature of the fabric support surface, etc., many different and unexpected patterning effects may be achieved. For example, textural differences which mimic the effects of a Jacquard-type weaving process may be achieved, but with much greater speed and at much lower cost than is associated with such a specialized weaving process. Effects similar to the embossing effects obtained with various embossing roll or hot gas embossing systems are also obtainable, but without the necessity for heating the embossing medium and the costs associated therewith. Other effects will become evident upon a reading of the following description and inspection of the accompanying Figures. It should be noted that the use of various unheated gases as working fluids is also contemplated.

Furthermore, the process disclosed herein, when used in conjunction with various fluid stream manipulation means and methods disclosed herein, can be employed to pattern fabrics with patterns which are electronically stored or generated. By using such stream manipulation systems in association with the instant invention, patterned fabrics may be generated which have arbitrarily chosen pattern repeat lengths, and the patterns placed on the fabric may be changed without significant down time for the patterning apparatus and without the necessity of having an inventory of pattern "masters" which occupies significant storage space.

Further features and advantages of the invention will be apparent from a review of the following detailed description of the invention and the accompanying Figures, in which:

Figure 1 is a schematicized side view of an apparatus for practicing an embodiment of the instant invention wherein a pre-cut section of fabric is patterned or textured by a traversing liquid jet under solenoid or pneumatic valve control;

Figure 2 is a side view of one embodiment of an orifice assembly for a single jet;

Figure 3 is a schematicized side view of an apparatus for practicing an embodiment of the instant invention wherein a continuous web of fabric is patterned or textured by a traversing liquid jet under solenoid or pneumatic valve control;

Figure 4 is a schematicized plan view of the apparatus of Figure 3;

Figure 5 is a schematicized side view of an apparatus for practicing an embodiment of the instant invention wherein multiple jets, under individual solenoid or pneumatic cylinder control, are used to pattern or texture a web of fabric;

Figure 6 is a diagrammatic perspective view of the apparatus of Figure 5;

Figure 7 is a section view of an orifice assembly suitable for use in the apparatus of Figures 5 and 6;

Figure 8 is a schematicized side view of an apparatus for practicing an embodiment of the instant invention wherein a pre-cut section of fabric is patterned or textured by a traversing liquid jet situated opposite a stencil which is interposed between the jet and the fabric surface;

Figure 9 is a schematicized side view of an apparatus for practicing an embodiment of the instant invention wherein an array of liquid jets is placed inside a stencil in the form of a cylinder, which in turn is brought into close proximity to the fabric surface;

Figure 10 is a diagrammatic perspective view of the apparatus of Figure 9;

Figures 11 through 32 illustrate various apparatus configurations which may be used to practice the instant invention;

Figures 11 and 12 are elevation views, in section, of an apparatus which may be used to practice the instant invention, wherein a flexible reed 58 is urged into the path of a fluid jet by the action of piston 60;

Figure 13 is a partial section view of the apparatus of Figure 11, taken along lines XIII-XIII;

Figure 14 is an elevation view, in partial section, of an apparatus embodying the invention depicted in Figures 11 and 12, wherein generally opposed pairs of multiple reed arrays are employed to allow closely spaced multiple liquid streams;

Figure 15 is a perspective view of a multiple reed array as may be used in the apparatus of Figure 14;

Figure 16 is a section view of the apparatus of Figure 14, schematically illustrating the manner in which a reed may be urged into the path of a liquid stream to interrupt the stream;

Figure 17 is a section view taken along lines XVII-XVII of Figure 14, showing the staggered positioning of the generally opposed multiple reed arrays;

Figure 18 is a perspective view, in partial section, of an apparatus which may be used to practice the instant invention, wherein parallel grooves in the face of a flat block are used to form the streams, while generally opposed multiple reed arrays are used to interrupt such streams;

Figure 19 is a section view of the apparatus of Figure 18 taken along lines IXX-IXX, depicting in more detail that part of the apparatus concerned with initial formation of the fluid stream;

Figures 20 and 21 are elevation views of an apparatus which may be used to practice the instant invention, wherein the fluid stream is formed by projecting fluid through the bore of a stiff tube which is made to extend, in cantilever fashion, from the fluid manifold. A piston or plunger is used to deflect the free end of the cantilevered tube, which allows the stream formed by the tube to be directed either onto a target work piece, or against a barrier; Figure 21 depicts this blocking action;

Figure 22 is an elevation view, in partial section, depicting an apparatus which may be used to control a plurality of fluid streams, where the streams are formed by passing the fluid through the bore of stiff, cantilevered tubes;

Figures 23 and 24 are section views taken along lines XXIII-XXIII and XXIV-XXIV, respectively, of Figure 22;

Figures 25 and 26 are enlarged section views taken along lines XXV-XXV of Figure 24 which schematically depict the stream formation and stream blocking action resulting from the cantilevered tube configuration depicted in Figures 22-24;

Figure 27 is an elevation view, in partial section, of an embodiment of the invention depicted in Figure 22, wherein a multiple-tube array permits a greater linear density of streams along the roll axis 21;

Figure 28 is a section view taken along lines XXVIII-XXVIII of Figure 27, showing the offset positioning of tubes 136;

Figure 29 is a perspective view of an apparatus which may be used to practice the instant invention, wherein a transverse stream of a control fluid is used to interrupt the fluid streams formed in grooves 166;

Figure 30 is a section view taken along lines XXX-XXX of Figure 29;

Figure 31 is an enlarged section view of the inlet and discharge cavities of the apparatus of Figure 30, showing the effects of energizing the control stream;

Figures 32 is a section view taken along lines XXXII-XXXII of Figure 31;

Figures 33 and 34 are photomicrographs (1.9x) of the face of the patterned fabric of Example 1, using reflected and transmitted light, respectively;

Figures 35 and 36 are photomicrographs (10x) of the face of the fabric of Example 1, using reflected and transmitted light, respectively;

Figures 37 is photomicrograph (1.9x) of the face of the patterned fabric of Example 2, using reflected light;

Figure 38 is a scanning electron photomicrograph (17x) of the face of the fabric of Example 2, with the treated portion on the left;

Figures 39 and 40 are photomicrographs (1.9x and 10x, respectively) of the face of the patterned fabric of Example 3, using reflected light;

Figures 41 and 42 are photomicrographs (1.9x and 10x, respectively) of the back of the fabric of Example 3, using reflected light;

Figure 43 and 44 are photomicrographs (10x) of the face of the patterned fabric of Example 4, using reflected and transmitted light, respectively, with the treated portion near the top;

Figure 45 is a photomicrograph (10x) of the back of the fabric of Example 4, using reflected light;

Figure 46 is a photomicrograph (10x) of the face of the fabric of Example 5, using reflected light;

Figure 47 is a photomicrograph (1.9x) of the back of the fabric of Example 5, using transmitted light;

Figures 48 and 49 are photomicrographs (1.9x and 10x, respectively) of the face of the fabric of Example 6, using reflected light;

Figure 50 is a photomicrograph (10x) of the face of the fabric of Example 6, using transmitted light;

Figure 51 is a photomicrograph (10x) of the back of the fabric of Example 6, using reflected light;

Figure 52 is a photomicrograph (1.9x) of the face of the fabric of Example 7, using transmitted light;

Figures 53 and 54 are photomicrographs (10x) of the face and back, respectively, of the fabric of Example 7, using reflected light;

Figures 55 and 56 are photomicrographs (10x) of the face and back, respectively, of the fabric of Example 8, using reflected light;

Figure 57 is a photomicrograph (1.9x) of the face of the fabric of Example 9, using reflected light;

Figure 58 is a photomicrograph (10x) of the back of the fabric of Example 9, using reflected light;

Figures 59 and 60 are photomicrographs (1.9x) of the face of the fabric of Example 10, using reflected and transmitted light, respectively;

Figure 61 is a photomicrograph (10x) of the back of the fabric of Example 10, using reflected light;

Figures 62 and 63 are photomicrographs (1.9x and 10x, respectively) of the face of the fabric of Example 11, using reflected light;

Figure 64 is a photomicrograph (10x) of the face of the fabric of Example 11, using transmitted light;

Figure 65 is a photomicrograph (10x) of the back of the fabric of Example 11, using reflected light;

Figures 66 and 67 are photomicrographs (1.9x and 10x, respectively) of the face of the fabric of Example 12, using reflected light;

Figure 68 is a photomicrograph (10x) of the face of the fabric of Example 12, using transmitted light;

Figure 69 is a photomicrograph (10x) of the back of the fabric of Example 12, using reflected light;

Figures 70 and 71 are photomicrographs (1.9x and 10x, respectively) of the face of the fabric of Example 13, using reflected light;

Figure 72 is a photomicrograph (10x) of the back of the fabric of Example 13, using reflected light;

Figure 73 is a photomicrograph (1.9x) of the face of the fabric of Example 14, using reflected light;

Figure 74 is a photomicrograph (10x) of the face of the fabric of Example 14, using reflected light, with the treated portion to the left and above.

Figure 75 is a photomicrograph (10x) of the back of the fabric of Example 14, using reflected light, with the heated portion near the upper right;

Figure 76 is a scanning electron micrograph (15x) of the back of the fabric of Example 14, with the treated portion near the lower right;

Figures 77 and 78 are photomicrographs (1.9x and 10x, respectively) of the face of the fabric of Example 15, using reflected light, with the treated portion to the right;

Figure 79 is a photomicrograph (10x) of the back of the fabric of Example 15, using transmitted light, with the treated portion to the right;

Figure 80 is a photomicrograph (10x) of the back of the fabric of Example 15, using reflected light, with the treated portion to the right;

Figure 81 is a photomicrograph (1.9x) of the face of the fabric of Example 16, using reflected light;

Figures 82 and 83 are photomicrographs (10x) of the face of the fabric of Example 16, using reflected and transmitted light, respectively;

Figure 84 is a photomicrograph (10x) of the back of the fabric of Example 16, using reflected light;

Figures 85 and 86 are photomicrographs (1.9x and 10x, respectively) of the face of the fabric of Example 17, using reflected light;

Figure 87 is a photomicrograph (10x) of the back of the fabric of Example 17, using reflected light;

Figures 88 and 89 are photomicrographs (1.9x) of the face of the fabric of Example 18, using reflected and transmitted light, respectively;

Figures 90 and 91 are photomicrographs (10x) of the face and back, respectively, of the fabric of Example 18, using reflected light;

Figures 92 and 93 are photomicrographs (1.9x and 10x, respectively) of the face of the fabric of Example 19, using reflected light;

Figure 94 is a photomicrograph (1.9x) of the face of the fabric of Example 19, using transmitted light.

Figure 1 schematically depicts an apparatus which may be used to practice one embodiment of the process and generate the products of this invention. For purposes of discussion hereinbelow, water will be assumed as the fluid of choice, although other fluids may be substituted therefore. Pump 8 is a pump capable of pumping the water or other desired working fluid at the desired rate and pressure. If a single liquid stream is used, the pump should be capable of delivering a single stream having a minimum cross-section dimension within the range of about 0.003 inch to about 0.03 inch, at dynamic pressures ranging from about 300 p.s.i.g. to about 3000 p.s.i.g. (i.e., water stream velocities ranging from about 200 f.p.s. to about 667 f.p.s.), although stream sizes and stream pressures (or velocities) outside this range may prove advantageous under certain circumstances. Generally speaking, circular streams having diameters lying within the range of about 0.007 to about 0.03 inch are preferred. Such streams have a diameter which is generally less than twice as large as the spacing between adjacent yarns in most textile fabrics. Dynamic pressures in excess of about 1,000 p.s.i.g. are also generally preferred. Use of simultaneous multiple streams, as described hereinafter, will, of course, require increased pump capacity. As indicated in Figure 1, pump 8 is connected to a source 2 of the desired working fluid, e.g., water, via conduit 4 and filter assembly 6. Filter assembly 6 is intended to remove undesirable particulate matter from the working liquid which could clog the various orifice assemblies discussed in more detail below. Other, additional filters may be used, and are discussed below. The high pressure output of pump 8 is fed, via high pressure conduits 10 and 10A, to high velocity fluid orifice assembly 12. Orifice assembly 12, in simple form, may be merely a suitable termination of conduit 10A having a single orifice of the size which will generate a fluid stream of the desired cross-sectional shape and area, and which will operate safely at the desired pressure, as depicted in Figure 2. Conduits 10 and 10A may be any suitable conduit capable of safely accommodating the desired fluid pressures and flow rates, and having sufficient flexibility or rigidity to permit orifice assembly 12 to be positioned as desired with respect to the substrate to be treated.

Situated in close proximity to orifice assembly 12 is roll 20, over which the textile fabric to be patterned is placed. Generally, roll 20 has a solid, smooth, inflexible surface (e.g., polished aluminum or stainless steel); a roll having a specially treated or formed surface may be useful in achieving certain special effects on selected substrates. It has been found, for example, that use of a contoured roll surface may result in patterning effects corresponding to the roll surface contours on the substrate.

Associated with roll 20 is fabric 25, which may be in the form of a fabric section which is wrapped tightly about the circumference of roll 20 and securely attached at both ends, as depicted in Figure 1, or which may be in the form of a continuously moving web which is positioned against a portion of roll 20, depicted in subsequent Figures at 26.

In order to generate a pattern on fabric 25, contact between the fabric and the high velocity stream of fluid emanating from orifice assembly 12 must be established and interrupted in a way which corresponds to the desired pattern. Any suitable means for preventing a pre-formed high velocity stream of fluid from directly impinging upon the fabric surface may be employed. Preferred methods are depicted in Figures 1 through 31, and are discussed in more detail further below.

Looking first at stream interruption or control methods shown in Figure 1, Figure 1 shows a diagrammatic side view of a texturing and patterning system in which an orifice assembly 12, which produces a single high velocity fluid jet 18, is associated with a traversing table 14. Table 14 permits orifice assembly 12 to be moved, in a precisely controlled and reproducable manner, parallel to the axis of roll 20, around which is affixed a section of fabric 25, perhaps in the form of a sleeve or a short section of fabric which is securely fastened at both ends about the circumference of roll 20. Orifice assembly 12 may be constructed by installing a high pressure cap 13 having a single orifice of the proper size on the end of a suitable high pressure conduit 10A, as depicted in Figure 2. Of course, more elaborate orifice assemblies may be used as well, as will be discussed below.

Associated with conduits 10 and 10A is remotely actuated valve fluid 16, which valve is preferably installed in close proximity to orifice assembly 12 so as to minimize the length of conduit 10A between valve 16 and orifice assembly

12. Valve 16 may be actuated electrically, pneumatically, or by other means. In one embodiment, valve 16 comprises an electrical solenoid valve of the type marketed by the Skinner Valve Company, a division of Honeywell, Inc., of Minneapolis, Minnesota, as Model V52H. This valve is installed upstream of orifice assembly 12, in a conventional manner such as to control the flow of fluid in conduit 10A.

In operation, a working fluid, e.g., water, is pumped by pump 8 from fluid source 2, through filter means 6, to valve 16. If the portion of fabric 25 directly opposite orifice assembly 12 is to be treated, valve 16 is made to open, e.g., via an electrical or pneumatic command signal, and high pressure water is allowed to pass via conduit 10A to orifice assembly 12, where a thin, high velocity jet 18 of water is formed and directed onto the fabric 25. When the desired pattern requires that jet 18 not impact the fabric 25, an appropriate electrically or pneumatically transmitted instruction causes valve 16 to close. Positioning the desired areas of fabric surface under the jet 18 is achieved by proper coordination of rotation of roll 20 and translation of traversing table 14, which preferably may be accomplished by computer control.

Assuming that appropriate indicating means are used to specify, via a digital signal, the exact rotational position of roll 20 and lateral position of traversing table 14, a computer may be used to generate on/off instructions to valve 16 in accordance with pre-programmed pattern data. It is contemplated that roll 20 may be made to rotate continuously while traversing table 14 moves relatively slowly, in incremental linear steps, along the axis of the roll, or, preferably, roll 20 may be made to move intermittently, while traversing table 14 sweeps across the fabric face for each incremental rotational movement of roll 20. If the latter technique is employed, fabric 25 may be in the form of a web 26 traveling over roll 21, as shown in Figures 3 and 4, which better lends itself to commercial production methods.

It should be understood that, if desired, an orifice assembly which can generate a multiple jet array may be substituted for the single jet orifice assembly 12. In most commercial applications, this will comprise a preferred embodiment, particularly if computer control is available to control the actuation of the multiple valves necessary in such system, and will be described below.

As depicted in Figures 5 through 7, a multiple jet array orifice assembly 32 is situated in close proximity to the surface of fabric web 26, as web 26 passes over roll 21. Array assembly 32 may be sufficiently wide to extend entirely across web 26, or may comprise a fraction of the width of web 26. In the latter case, a traversing table or other means may be used, as discussed above, to obtain full-width coverage. Associated with each orifice in array assembly 32, and situated in the corresponding conduit 10A, is a separate remotely actuatable valve, designated at 16A, which serves to interrupt or control the stream of high velocity fluid emanating from its respective orifice in array assembly 32. As before, these valves can be of any suitable kind, e.g., electrical, pneumatic, etc., and may be installed in any satisfactory conventional manner which will allow safe and positive control of the pressurized fluid. Inserted between pump 8 and the array of valves 16A is a hydraulic accummulator or ballast tank 30. By using such tank 30, pump 8 may be specified at a somewhat smaller capacity than would otherwise be the case. Peak, short term demands for high pressure liquid, as when all jets are firing for a given short period of time, may be met by the capacity stored or accummulated in tank 30. Figure 7 depicts a section view of array assembly 32, taken perpendicular to the surface of roll 21 and bisecting the orifices in assembly 32. Orifice block 34 is drilled and fitted with tubes 35 which extend beyond block 34 and which are securely connected with respective supply conduits 10A. Orifice plate 33 is drilled with converging passages 36 which form collectively an array of jets.

In another embodiment of this invention, depicted in Figure 8, a stencil is interposed between a single jet or an array of jets and the fabric 25 to interrupt the liquid stream, in place of the valves disclosed above. In the form shown in Figure 8, a sleeve-type stencil 40, comprised of stainless steel, suitable plastic, or other suitable material which serves to mask areas of the fabric which are not to be treated, is placed in fixed relationship over the fabric segment 25 which is attached to roll 20. If desired, a traversing means 14 may be used to move the high velocity fluid jet or jets formed at assembly 12 or 32 across the face of the stencil 40 as the stencil and fabric are rotated together on roll 20. If a sufficiently wide multiple jet array is used, traversing means 14 is unnecessary. The fluid streams directly contact the fabric only where permitted by apertures in the stencil 40.

In an alternative, and preferred stencil embodiment, the stencil is configured to allow the fabric to be patterned to be in the form of a moving web. Figures 9 and 10 show a configuration whereby a cylindrical stencil 40A is arranged to accommodate a multiple jet array orifice assembly such as shown at 32 within the stencil 40A. In this configuration, orifice assembly 32 preferably comprises an array of jets which extends across the entire width of stencil 40A, which in turn extends across the entire width of fabric web 26. Orifice assembly 32 is preferably located in close proximity to the inside surface of cylindrical stencil 40A; the outer surface of stencil 40A is preferably located in close proximity to, and perhaps in direct contact with, the surface of fabric web 26. Means, not shown, are provided to achieve smooth rotation of stencil 40A in synchronism with the movement of fabric web 26. This may be achieved, for example, by an appropriate gear train operating on a ring gear which is associated with one or both ends of cylindrical stencil 40A.

It is also contemplated that a single or multiple jet array may be used which is made to traverse within cylindrical stencil 40A so that the entire width of fabric web 26 may be treated. Use of such traversing jet or jet array would preferably require incremental movement of fabric web 26, as discussed above. By inducing small, recipricating lateral motions to the jet or jets ("i.e., shogging"), more complete or even area coverage on the fabric may be achieved for a given jet size.

Other methods for selectively interrupting or otherwise controlling the impact of one or more streams of high velocity liquid on the fabric surface in response to pattern information are described hereinbelow.

Figures 11 through 13 depict various views of an apparatus which may be used to interrupt a thin, high velocity stream of fluid, e.g., water, in accordance with electrically coded command information. Conduit 10A supplies, via a suitable threaded connector, the water or other liquid at the desired pressure and flow rate to generally "U"-shaped orifice block 50. Within block 50 is threaded input cavity 52, at the end of which is drilled bore 54 which connects cavity 52 with the opposite face of block 50. Bore 54 is dimensioned and shaped in accordance with the desired stream cross section of the fluid to be controlled. Associated with orifice block 52 is spring-like reed assembly 58, comprised of a thin, flat section of flexible material such as metal shim stock, as depicted in Figure 13, secured at each end of the base portion of assembly 58 by bolts 56, only one of which is shown. Reed assembly 58 has a flat, proximal portion attached securely to the inside face of block 52 which carries bore 54, and an aperture 59 through which the fluid jet from bore 54 may pass without obstruction. Reed assembly 58 also has a flat, cantilevered portion which extends directly over and parallel to, and is aligned with, the path of the liquid stream formed by bore 54. Reed assembly 58 is positioned within orifice block 50 so as to permit the free or distal end of the cantilevered portion of reed assembly 58 to be urged into the path of the high velocity liquid stream emerging from bore 54, as by the action of plunger 60. When a liquid jet of relatively high velocity strikes the protruding free end portion of reed assembly 58, the jet does not appear to be deflected or diverted as a coherent stream, but instead appears to be completely disrupted — a dense mist is produced, and little semblance of a column of liquid remains. When plunger 60 is withdrawn the impact of the liquid on the free end of reed assembly 58 serves to restore it to its original position above the path of the liquid jet, with an extremely fast response time. Plunger 60 may be actuated by an electrically controlled solenoid 62 of the type used in impact printers, which may be actuated in accordance with electrically supplied pattern information. Of course, a pneumatic valve and air cylinder, associated with a means for controlling air pressure in response to pattern information, may be substituted for the solenoid. Set screw 63 is used to firmly position solenoid 62 within orifice block 50.

Directly opposite bore 54 is aperture plate 64, through which is drilled a hole 65 slightly larger than the cross sectional dimensions of the liquid jet at that point in the jet's trajectory. Aperture plate 64, secured to orifice block 50 by means of bolts 55, serves to form a containment barrier for the remnants of the jet resulting from the intrusion of the free end of reed assembly 58 into the path of the jet. When liquids are used, drain channels or other means to carry off the jet liquid, not shown, may be provided by any convenient means.

Figures 14 through 17 depict several embodiments of this apparatus wherein multiple jets may be formed and controlled by use of a plunger-activated reed which is urged into the jet path. In the embodiment shown in Figures 14 through 17, two separate arrays of reeds 81, 82 similar to that depicted in Figure 15 are mounted in generally opposed relation in control blocks 79, 80, forward of and on either side of a linear array of stream-forming bores or orifices 75 which are drilled or otherwise formed in orifice block 74. The flat, cantilevered portions of reed arrays 81, 82 are aligned with the respective streams formed by bores 75. Orifice block 74 is attached by conventional means, for example, by bolts 73, to liquid distribution manifold 70 which in turn is connected, via threaded inlet 72 and filter assembly 71, to a high pressure source of the desired working fluid, not shown. Upper and lower barrier plates 88, 89 are mounted in front of reed arrays 81, 82; a slot-like cut-out in plates 88, 89, shown in Figure 17, permits the liquid jets to strike fabric 25, roll 21, or other target, whenever the individual reeds in arrays 81, 82 are not engaging the respective jets formed by bores 75. As depicted in Figure 16, extension of plunger 84 causes respective reed 81 to intrude into the path of the liquid jet issuing from respective bore 75, thereby disrupting the jet and causing whatever remains of the jet to strike barrier plate 89.

As depicted in Figure 17, which is a section view taken along lines XVII-XVII of Figure 15, reed arrays 81, 82, as well as the individually command-actuated plungers 84 which are individually associated and aligned with each reed in arrays 81, 82, are positioned in staggered or alternating relationship on either side of the array of orifices 75.

Such arrangement allows for the interleaving of individual reeds in arrays 81, 82 from opposite sides of control blocks 79, 80 where two or more adjacent jets are to be nullified. Plungers 84 may be activated in a conventional manner by electromagnetic means, pneumatic means, etc., such as the solenoid disclosed above and shown at 86; preferably, plungers 84 are responsive to digitally encoded data supplied by an EPROM or similar source.

Figures 18 and 19 depict a variation of the apparatus shown in Figures 14, 16, and 17 which relates primarily to the manner in which the jet-forming bores or orifices are formed. Slot block 90, having a "U"-shaped cross-section, is used to form a fluid manifold 91 in conjunction with containment block 94. Along the broad upper face of block 90 nearest to reed arrays 81, 82 are cut a series of uniformly spaced parallel slots or grooves 92 having a depth, width, and profile corresponding to the cross-section of the desired liquid jets. Grooves 92 allow pressurized fluid to exit manifold 91 and strike roll 21, unless the fluid stream is otherwise interrupted by the action of reed arrays 81, 82. A flat containment block 94 is securely pressed against the top of block 90 by means of bolts 95 which extend through support block 98, forming a pressure-resistant, fluid tight seal. High pressure fluid, such as water, supplied via filter 71, is introduced into the manifold formed by blocks 90, 94 by way of a suitable conventional threaded coupling. Bolts 96, which may extend through support block 98, serve to align and secure blocks 90 and 94 against control blocks 79, 80, which collectively house arrays of reeds 81, 82, plungers 84, valves 86, and barrier plates 88 and 89, as in the embodiment of Figures 14 through 17 and as shown in Figure 19. Control blocks 79, 80 may be secured to support block 98 by means of bolts 99 or other suitable means.

Figures 20 and 21 depict various views of another apparatus which may be used to interrupt the impact of a thin, high velocity stream of fluid in accordance with externally supplied command information such as digitized electrical signals. In this apparatus, the thin stream of fluid is formed by passing the fluid through a stiff, cantilevered thin walled tube which is mechanically deflected by means of a piston or other means acting near the cantilevered end of the tube to direct the fluid against a barrier rather than against the fabric surface.

A conduit supplies the desired fluid (the "working" fluid) at the desired pressure and flow rate, via a suitable connector, to cavity block 110. Within block 110 is input manifold or cavity 112. A passage 114 is drilled or otherwise placed in the side of block 110; this passage is sized to accommodate a stiff, thin walled tube 116 which has a bore size and shape corresponding to the size and shape of the desired fluid stream to be produced. If desired, block

110 may be made in the form of two mating halves, so that the passage 114 may be formed by machining a groove in the face of one or both halves rather than by drilling a hole. Tube 116, which may be made of stainless steel or other suitable material, is inserted into passage 114 and securely affixed therein to assure that the high pressures associated with the working fluid will not dislodge the tube or cause leakage of the working fluid. Tube 116 is made to protrude from passage 114 in the direction of roll 21 a sufficient distance to permit the deflection of the free or distal end portion of tube 116 through a small angle without damage to tube 116. Closely associated with tube 116 is plunger 120, which is positioned near the cantilevered or distal end of tube 116 so as to cause a deflection of tube 116 whenever plunger 120 is extended. Barrier plate 118 is securely affixed slightly forward of the distal end of tube 116, and extends toward the path of the fluid stream far enough that the fluid jet formed by tube 116 strikes the upper portion of plate 118 whenever tube 116 is deflected by plunger 120, as shown in Figure 21. Whenever tube 116 is not deflected, the resulting jet passes over the upper portion of barrier plate 118, as depicted in Figure 20. If desired, the configuration of barrier plate 118 may be inverted so that the jet passes over the edge of barrier plate 118 only when tube 116 is deflected. Associated with barrier plate 118 are drains, not shown, for carrying the deflected liquid

away for disposal or recycling. Plunger 120 may be actuated in a conventional manner by an electrical solenoid, an air cylinder and pneumatic valve, or other means, depicted at 122. Optionally, the end of plunger 120 which makes contact with tube 116 may be formed to accommodate the contour of tube 116, i.e., may be formed to surround or grip, partially or completely, tube 116; it is preferred that, regardless of the contour of the end portion of plunger 120, the stroke of plunger 120 be adjusted so that plunger 120, when not deflecting tube 116, extends to a point closely adjacent to or in contact with tube 116, so that when plunger 120 is extended to deflect tube 116, little motion will be lost and unwanted oscillations will be minimized.

Figures 22 through 28 depict an apparatus related in operation to the apparatus of Figures 20 and 21, but suitable for controlling an array of jets formed in the manner depicted in Figures 20 and 21. Looking first at Figures 22 and 24, the working fluid is introduced into a generally cylindrical input cavity 132 formed along the length of orifice block 130, via high pressure conduit 10A (Figure 24) and a suitable threaded connector. Tubes 136, each having the desired inside dimensions and positioned generally perpendicularly to the surface of roll 21, are securely affixed to passages 134 in orifice block 130 which conform to the outside dimensions of tubes 136. By means of tubes 136 and passages 134, the fluid contained at high pressure within cavity 132 may be directed through tubes 136 in the direction of the surface of fabric 25, roll 21, or other target.

It is preferred, but not necessary, that tubes 136 extend through passages 134 to cavity 132. Tubes 136 may be secured within passages 134 by soldering the tubes directly to orifice block 130 by soldering a collar to the tube which fits snugly within a mechanical recess in block 130, or by other suitable means. Tubes 136 should be of such design, and should extend far enough from orifice block 130, so that deflections of tubes 136 through small angles by the action of plungers 140 will not cause undesirable deformation of tubes 136.

Securely positioned a short distance from orifice block 130 is deflection frame 138, through which are fed flexible deflecting plungers 140 sheathed by hollow plunger guides 141. Plungers 140 may be constructed of stainless steel or other suitable material; plunger guides 141 may be tubes of appropriate bore size, made of any suitable material having the necessary flexibility to allow for desired bending and shaping. Each plunger 140 and plunger guide 141 is associated with a respective individual tube 116 and is precisely aligned by deflection frame 138. Each plunger 140 is adjusted to make contact with its respective tube 136 even when that tube is in its undeflected position, as shown in Figures 23 and 25. By maintaining such contact, response time is increased, vibrations induced by impact between plungers 140 and respective tubes 136 are eliminated, and other vibrations or oscillations along tube 136 are dampened. Deflection frame 138 may also serve as a guide to align the movement of tubes 136 during deflection and recovery, as suggested in Figure 23. Plungers 140 are actuated by valves 142 which, because of their relative bulk, are situated somewhat remotely from the point at which plungers 140 act on tubes 136. For convenience, deflection frame 138, as shown in Figures 22 and 24, may be made to accommodate eight separate valve/plunger assemblies, and, together with a section of orifice block 130 containing eight tubes 136, may form a fluid control module which may be juxtaposed, as in Figure 24, to allow simultaneous treatment over a relatively wide roll surface.

In operation, as shown in Figures 25 and 26, when one of plungers 140 is unextended, i.e., when tube 136 is undeflected, the working fluid passes at high pressure through tube 136 from cavity 132 and strikes barrier lip 144, where the fluid jet is deflected and dissipated. By extending plunger 140 via corresponding associated valve 142 and plunger guide 141, as in response to pattern information supplied to valve 142, tube 136 is deflected slightly — not enough to cause undesirable deformations in tube 136, but sufficient to permit the jet formed by tube 136 to clear barrier lip 144 and pass on in the direction of roll 21, as depicted in Figure 26.

Figures 27 and 28 depict an apparatus similar to that disclosed immediately above, for use where increased jet density (i.e., number of jets per linear distance across the face of roll 21) is desired. In this configuration, twice the jet density of the apparatus of Figures 22 through 24 may be achieved. In this configuration, two parallel arrays of tubes 136, 136A, are inserted into orifice block 130A via passages 134, 134A and communicate with chamber or manifold 132A. The deflection frame 138, array of plungers 140, plunger guides 141, arrangement of valves 142, and placement of barrier lip 144 of Figure 22 have been substantially duplicated at 138A, 140A, 141A, 142A and 144A, respectively, to achieve an "over/under" apparatus which, in Figure 27, appears to be an almost mirror-image combination of the apparatus configuration of Figure 22. The opposing tube arrays 136, 136A and deflection frames 138, 138A, however, are offset, as shown in Figure 28, to permit uniform positioning of the additional jets in the direction of the axis of roll 21. It should be noted that, as deflected, the tubes 136, 136A from the upper and lower arrays of Figure 28 will not form a straight line along the axis of roll 21. This staggered alignment is intended to compensate for the non-normal orientation of the tubes 136, 136A to the surface of roll 21 in their deflected position. The small angle induced by the action of plungers 140, 140A will cause, upon proper adjustment of the overall distance to the surface of roll 21, the plunger extension length, etc., the jets emitted by the staggered tubes 136, 136A to strike the surface of roll 21, or a substrate 25 placed against the roll, in substantially perfect alignment.

Figures 29 through 32 depict yet another apparatus which may be used for the purpose of forming and interrupting the flow of a high pressure fluid stream, such as is used in the principal invention disclosed herein. As seen in the section view of Figure 30, a conduit 10A supplies, via filter 71 (Figure 29), a high pressure fluid to manifold cavity 162 formed within inlet manifold block 160. Flange 164 is formed along one side of manifold block 160; into the base of flange 164 is cut a uniformly spaced series of parallel grooves 166. Each groove 166 extends from cavity 162 to the forwardmost edge of flange 164 and has cross-sectional dimensions corresponding to the desired cross-sectional dimensions of the stream. Control tubes 170, through which streams of relatively low pressure air or other control fluid are passed on command, are arranged in one-to-one relationship with grooves 166, and are, in one embodiment, positioned substantially in alignment with and perpendicular to grooves 166 by means of a series of sockets or wells 172 in flange 164, each of which are placed in direct vertical alignment with a respective groove 166 in flange 164, and into which each tube 170 is securely fastened. The floor of each socket 172 has a series of small passages 174 which in turn communicate directly with the base of its respective groove 166. One configuration for passages 174 is a series of aligned circular apertures, as shown in Figure 32. Optionally, grooves 166 may be made wider and more shallow, and a single, larger passage may be substituted for small passages 174. As also shown in Figure 32, as well as Figure 29, the arrangement of the tube/socket combinations optionally may be staggered so that grooves 166 may be more closely spaced without adversely effecting the structural integrity of flange 164.

Positioned opposite inlet manifold block 160 and securely abutted thereto via bolts 161 are outlet manifold block 180 and containment plate 178. Containment plate 178 may be attached to outlet manifold block 180 by means of screws 179 or other suitable means. Within outlet manifold block 180 is machined a discharge cavity 182 and outlet drain 184. Discharge cavity 182 and outlet drain 184 may extend across several grooves 166 in flange 164, or individual cavities and outlets for each groove 166 may be provided. It is preferred, however, that cavity 182 be positioned so that passages 174 lead directly into cavity 182, and not lead into the upper surface of outlet manifold block 180 or containment plate 178. Discharge cavity 182 includes impact cavity 177 which is machined into containment plate 178. Bolts 183 and 185 provide adjustment of the relative alignment between inlet manifold block 160 and the combination of outlet manifold block 180 and containment plate 178.

In operation, a high pressure working fluid is fed into inlet cavity 162, where it is forced to flow through a first enclosed passage, formed by grooves 166 in flange 164 and the face of outlet manifold block 180 opposite flange 164, thereby forming the fluid into discrete streams having a desired cross-sectional shape and area. The pre-formed streams then traverse the width of discharge cavity 182, while being guided only by the grooves 166 in flange 164. It has been discovered that, so long as control tubes 170 remain unactivated, i.e., so long as no control fluid from tubes 170 is allowed to intrude into grooves 166 at any significant pressure, the streams of working fluid, may be made to traverse the width of discharge cavity 182 in an open channel formed only by grooves 166 without a significant loss in the coherency or change in the cross-sectional shape or size of the stream. After traversing the width of discharge cavity 182, the streams encounter the edge of containment plate 178, whereupon the streams are made to flow in a second completely enclosed passage, formed by grooves 166 in flange 164 and the upper end of containment plate 178, just prior to being ejected in the direction of roll 21. Where precise stream definition is necessary, this affords an opportunity to re-define the stream cross-section to exact specification, as defined by the cross-section of this second completely enclosed passage, at extremely close distances to the roll 21, thereby virtually eliminating any significant stream spreading, minimizing any alignment problems relating to slight non-parallelism in adjacent grooves 166, etc.

To interrupt the flow of high velocity fluid which exits from grooves 166, it is necessary only to direct a relatively small quantity of relatively low pressure air or other control fluid through the individual control tubes 170 into the associated grooves 166 in which flow is to be interrupted. As depicted in Figure 31, the control fluid, even though at a vastly lower pressure than the dynamic pressure of the working fluid (i.e., one twentieth or less), is able to lift the working fluid stream from the groove 166 and cause instabilities in the stream which lead to virtual disintegration of the stream. While, for diagrammatic convenience, Figure 31 indicates the liquid stream is merely deflected into the curved impact cavity 177 of containment plate 178, in fact the liquid stream appears to be almost completely disintegrated by the intrusion of a relatively low pressure control fluid stream as soon as the liquid stream is free of the walls of groove 166; it is believed impact cavity 177 and containment plate 178 serve principally to contain the energetic mist which results from such disintegration.

The streams of high velocity liquid employed in this invention have been used to pattern or texturize a variety of commercially available textile fabric substrates. Depending upon the nature of the substrate and the operating conditions chosen, many visually distinctive patterning and texturizing effects are possible using the teachings herein, as may be determined from the following illustrative examples, which are not intended to be limiting in any way.

EXAMPLE 1

An apparatus similar to that schematically depicted in Figure 1 was used, in accordance with the following specifications:

Fabric: 100% texturized polyester pongee, having a fabric weight of 2.16 ozs. per square yard. The warp yarns are 1/70/47 Dacron 56T false twist texturized polyester, and the fill yarns are 1/70/34 Dacron 92T false twist texturized polyester. The weave is a 2x1 twill, with a pick count of 88 and an end count of 92. The fabric was dyed with a mixture of basic and dispersed dyes to achieve a cross-dye effect.

Nozzle Diameter: 0.017 inch.

Fluid: Water, at a pressure of 1500 p.s.i.g.

Pattern Gauge: 20 lines per inch.

Source of Pattern Data: EPROM, with appropriate associated electronics of conventional design.

Fluid Jet Control: The apparatus depicted in Figures 20 and 21, using an electrical solenoid to activate plunger 120.

Roll: Solid, smooth aluminum, rotating at a circumferential speed of 10 yards/minute in same direction as warp yarns in fabric.

The fabric sample was secured, face side outward, to the carrier roll, which was rotated continuously at the specified speed. The jet nozzle was automatically traversed along the axis of the roll at a rate corresponding to the specified pattern gauge, using an apparatus arrangement similar to that shown in Figure 1. Impingement of the water jet with the fabric surface was interrupted by the action of the solenoid deflecting the stiff tube which formed the water stream in response to data being furnished by the EPROM. This procedure produced a visually similar pattern or effect on both sides of the fabric, as may be seen in the photomicrographs of Figures 33 through 36. Both the fill yarns and the warp yarns were displaced. Certain yarns, especially the fill yarns, were raised giving the fabric face a three-dimensional effect. Relative yarn tension within the fabric was redistributed, with some yarns made relatively tight, and others made relatively loose, compared with the untreated fabric. The water jet appeared to compress certain of the yarns, as well as opening certain other yarns. This latter effect is clearly observable in Figures 35 and 36.

EXAMPLE 2

An apparatus similar to that schematically depicted in Figure 8 was used, in accordance with the following specifications:

Fabric: A double knit polyester having a face comprised of 1/70/34 56T false twist texturized polyester, and a back comprised of 1/70/14 dacron 56T false twist texturized polyester, a construction comprising 74 courses and 45 wales, and a weight of 9 ozs. per square yard. The fabric was napped on the face.

Nozzle: Circular cross-section; 0.017 inch in diameter

Fluid: Water, at a pressure of 2000 p.s.i.g.,

Pattern Gauge: 20 lines per inch

Source of Pattern Data: Stencil carrying pattern outline

Fluid Jet Control: Stencil carrying pattern outline

Roll: Solid, smooth aluminum, rotating at a circumferential speed of 10 yards per minute

The fabric sample was secured to the carrier roll, face side outward, and was then covered with a cylindrical stencil carrying the outline of the desired pattern. The carrier roll was rotated continuously at the specified speed. The jet nozzle was automatically traversed along the axis of the roll at a rate corresponding to the specified gauge. Impingement of the jet with the fabric surface (face side) was interrupted by the interposition of the plastic stencil between the nozzle and the fabric surface. This procedure produced a visually discernible effect on both sides of the fabric, as may be seen from the photomicrographs of Figures 37 and 38. The treatment reduced the pile height by bending the free ends over and downward towards the base or substrate. There is a distinct two-level sculpturing effect, as well as a distinct difference in reflectivity between the treated and untreated areas. No significant penetration of pile yarns into or through the substrate was observed on the back of the treated fabric.

EXAMPLE 3

The procedures of Example 1 were followed, except for the following:

Fabric: A knit 100% polyester pile fabric, having a face comprised of 100/54 Dacron T56, and a back comprised 70/34 Dacron T57 polyester. The fabric construction is 47 courses, 27.5 wales, with an overall fabric weight of 13.8 oz. per square yard.

Fluid: Water, at 2400 p.s.i.g.

Pattern Gauge: 16 lines per inch

The water jet was directed toward the face of the fabric, i.e., toward the fabric pile. In the areas of the fabric impacted by the fluid stream, the pile was inverted, i.e., the free pile ends were driven through the backing material and protruded through the back of the fabric. In the treated areas on the fabric face, and only in the treated areas, the ground yarns were clearly visible. The effect can be clearly seen from the photomicrographs of Figures 39 through 42.

EXAMPLE 4

The procedures of Example 1 were followed except for the following:

Fabric: A 65/35 polyester/cotton poplin having a warp comprised of 25/1 polyester/cotton and a fill comprised of 25/1 polyester/cotton, a pick count of 52, an end count of 102, and a weight of 4.5 ozs. per square yard. The fabric was cross-dyed, with the polyester being dyed blue and the cotton being white.

Fluid: Water, at a pressure of 2200 p.s.i.g.

In this Example, the entire fabric surface was treated in a series of closely spaced lines, except for a small control area. The water stream was traversed across the fabric in the warp direction. The resulting effect on the fabric surface, both front and back, may be seen from examination of Figures 43 through 45.

On the impingement side of the fabric, the water stream appears to have opened the yarn. Free ended fibers were raised, and appeared to be entangled to a minor degree. A substantial number of free ends were driven through the fabric and appeared as raised fibers on the fabric back. Some breakage of the cotton fibers was observed. The yarns have been laterally displaced where the stream impacted the fabric.

EXAMPLE 5

The procedures of Example 1 were followed, except for the following:

Fabric: A knit 100% polyester, having a back comprised of 1/70/34 Cacron T26 flat polyester and a face comprised of 40/8 Dacron T55 flat polyester with a construction of 28 wales and 73 courses, and a weight of 3.3 ozs. per square yard.

Fluid: Water, at a pressure of 2400 p.s.i.g.

Pattern Gauge: 16 lines per inch

As can be seen from an examination of Figures 46 through 47, there was a lateral displacement of the wales on the face of the fabric. In nontreated areas, the fibers comprising the yarns were substantially parallel, while in the treated areas said fibers were not parallel. The lap yarns were also raised, and individual fibers appeared to be spread significantly.

EXAMPLE 6

The procedures of Example 1 were followed, except for the following:

Fabric: 100% polyester sateen, having a warp comprised of 2/150/68 Dacron 56T false twist texturized polyester, a fill comprising 1/135/54 Dacron 693T false twist texturized polyester, a pick count of 90, an end count of 90, a fabric weight of 6.08 ozs. per square yard, and a weave comprising a 1x4 filling sateen.

Fluid: Water, at a pressure of 2400 p.s.i.g.

The water stream was directed to the back of the fabric. The rotation of the roll corresponded to the fill direction. The effects of the patterning may be seen from an inspection of the photomicrographs of Figures 48 through 51. A Jacguard-like patterning effect was produced. As may be seen on the face of the fabric, while the water stream appeared to spread both the warp yarns and the fill yarns, the chief effect was a raising and spreading of the float yarns and fibers. On the back (Figure 51) individual fibers were displaced and opened to varying degrees, with localized areas wherein the degree of yarn crimp was changed.

EXAMPLE 7

The procedures of Example 1 were followed, except for the following:

Fabric: A 100% polyester sateen, having a warp comprised of 1/75/34 Dacron T56 non-textured polyester, a fill comprised of 1/150/34 Dacron 56T textured polyester, a pick count of 60, an end count of 160, a finished weight of 3 ozs. per square yard and having a weave of 4x1 sateen.

Fluid: Water, at a pressure of 2400 p.s.i.g.

The water stream was directed to the face of the fabric. The roll direction corresponded to the warp direction. The resulting patterned fabric may be seen in the photomicrographs of Figures 52 through 54. On the face of the fabric, there was a severe displacement of warp yarns, almost resembling a lace-like effect. Only minor spreading of fill yarns was observed, but fill yarn bundles were opened somewhat, i.e., they were made somewhat more bulky. The warp yarns were raised. In addition, there was distinct compaction of the weave and yarn structure surrounding the areas where the warp yarns were displaced. The displacement of the long float yarns tended to reduce the reflectance of the fabric. On the back of the fabric, a somewhat similar effect was observed; however, the absence of long float yarns significantly attenuated the effect.

EXAMPLE 8

The procedures of Example 7 were followed, except that the fabric of Example 7 was arranged so that the roll direction corresponded to the fill direction. The resulting patterned fabric may be seen in the photomicrographs of Figures 55 and 56. As may be seen, there was displacement of the fill yarns especially of the float yarns which were displaced somewhat further vertically than laterally. There was also a compaction of the weave and yarn structure surrounding the areas where the fill yarns were displaced. The warp yarns were opened to a significant degree. On the back of the fabric, a somewhat similar, but attenuated, effect was observed.

EXAMPLE 9

The procedures of Example 1 were followed except for the following:

Fabric: A 100% cotton Osnaburg, manufactured in the form of a black out cloth by being foam coated with an acrylic foam containing TiO_2, then being coated with an acrylic foam containing carbon black, and finally being coated with an acrylic foam containing TiO_2.

Fluid: Water, at a pressure of 2400 p.s.i.g., directed at the face of the fabric.

As can be seen from an inspection of the photomicrographis of Figures 57 through 59, the water jet removed the white coating and exposed the underlying black coating to provide a pattern having extreme contrast. It should be noted that there was some yarn displacement in the substrate.

EXAMPLE 10

The procedures of Example 1 were followed except for the following:

Fabric: A flocked fabric of unknown fiber content and construction was used.

Fluid: Water, at 2400 p.s.i.g.

The water stream was directed to the face of the fabric. The direction of roll rotation corresponded to the fabric warp direction. The water stream was directed at the face of the flocked fabric. A significant portion of the short pile was lost, while another significant portion of the pile yarns were laid down, and yet other portions of the pile yarns were bent over and driven through the substrate to the back. The substrate, as viewed from the back of the fabric, exhibited an opening and compaction of constituent yarns as well as expansion and compaction of the weave structure. On the face of the fabric, fibers which were initially substantially parallel prior to treatment were substantially disoriented following treatment, and the substrate fabric was exposed in many places. It is observed that the amount of substrate exposed is related to the velocity of the water jet used in the treatment. See Figures 59 through 61.

EXAMPLE 11

The procedures of Example 1 were followed except for the following:

Fabric: A 100% polyester fabric having a warp comprised of 1/70/47 56T false twist texturized polyester, a fill comprised of 1/70/34 Dacron 92T false twist texturized polyester, having a pick count of 88, an end count of 92, a finished weight of 3.6 ozs. per linear yard (63 inch width) and having a weave of 1 x 1 plain weave. The fabric was cross dyed.

Fluid: Water, at a pressure of approximately 1500 p.s.i.g.

The water stream was directed to the face of the fabric, with the roll direction corresponding to the warp direction.

The back of the fabric was treated in a similar manner in a subsequent step. The stream diameter was 0.008 inch; the nozzle was placed approximately one-eighth inch away from the fabric surface. The resulting patterned fabric may be seen in the photomicrographs of Figures 62 through 65. As may be seen, the warp yarns were separated and somewhat displaced and skewed. A similar effect was observed on the back of the fabric. The treatment resulted in both a reflected light and transmitted light effect (See Figures 63 and 64).

EXAMPLE 12

The fabric of Example 11 is processed as in Example 11, except that the orifice diameter is 0.017 inch. The resulting pattern fabric may be seen in the photomicrographs of Figures 66 through 69. There was a breaking up of the uniform arrangment of light and dark yarns by yarn displacement. It is observed generally that where a fabric exhibits a relatively tightly woven warp, the fluid stream tends to displace the fill yarns, and vice versa. It should be noted that the reflected and transmitted light photomicrographs (i.e., Figures 67 and 68) indicate that there was both a reflected light and transmitted light effect. Such effect, while discernable in the fabric of Example 11, was significantly more dramatic in this Example.

EXAMPLE 13

The procedures of Example 1 were followed, except for the following:

Fabric: A 100% cotton denim having a weight of 12.8 ounces per square yard. The warp yarns are dyed dark blue; the fill yarns are dyed white. The blue warp yarns are not dyed throughout, but carry dye only near the outer surfaces of the yarn, i.e., are ring or shell dyed. The resulting pattern fabric may be seen in the photomicrographs of Figures 70 through 72. Fibers from the outer layer of the warp yarns were torn away and portions of these fibers were driven to the interior of the fabric, portions were being displaced to the fabric back, and a significant portion was left on the fabric surface. There was fraying of the treated yarns, as well as opening of the yarns, which resulted in increased bulk.

EXAMPLE 14

The procedures of Example 1 were followed, except for the following:

Fabric: A 2X1 twill fabric, with an end count of 84, and a pick count of 46. The warp yarns are 14/1 polyester/cotton 65/35; the fill yarns are 14/1 polyester/cotton 65/35. The fabric has been napped on the back, and has a weight of 6.83 ounces per square yard. The resulting pattern fabric may be seen in the photomicrographs of Figures 73 through 76. The fabric has a two-tone effect. Most fibers comprising the nap on the fabric face have been pushed into the substrate. A significant portion of many of the fibers comprising the nap have been pushed through the substrate and form a nap-like surface on the back of the fabric. The path of the water jet which impacted the fabric may be seen on both the face and back of the fabric. There is little change in the light transmittance, but a significant change in the light reflectance between the treated and untreated areas.

EXAMPLE 15

The procedures of Example 1 were followed, except for the following:

Fabric: A 100% spun polyester jersey knit having a weight of 5 ozs. per square yard.

Pattern Gauge: Approximately 16 lines per inch.

The water stream was directed to the face of the fabric. The resulting pattern fabric may be seen in the photomicrographs of Figures 77 through 80. As may be seen, a multi-level effect has been introduced in the wales in the form of generally "U"-shaped grooves which form corresponding ridges on the opposite side of the fabric. Figures 78 and 79 show a compaction of the knit structure in the region of the grooves. Yarn bulking and spreading in the treated area of observed. There is a significant degree of fiber raising on the back of the fabric. (See Figure 80)

EXAMPLE 16

The procedures of Example 1 were followed, except for the following:

Fabric: A 65/35 polyester/cotton 2 x 1 twill having a warp and fill comprised of 14/1 yarn having 107 ends and 48 picks in a 1 x 1 weave, and having a fabric weight of 8.21 ounces per square yard.

Pattern Gauge: Five parallel "lines" or jet tracks, spaced approximately 0.067 inch apart and arranged in groups which are spaced approximately 0.37 inch apart.

Nozzle Diameter: 0.012 inch

Fluid: Water, at a pressure of 2000 p.s.i.g.

Roll: Circumferential roll speed was 5 yards/minute

The water stream was directed onto the face of the fabric from an array comprised of five separate nozzles. The resulting fabric is shown in the photomicrographs of Figures 81 through 84. As may be seen, there is a compaction of the weave structure in both the warp and the fill direction which results in buckling or puckering of the untreated fabric between adjacent groups of jet tracks. This buckling or puckering may be removed by drying the wet fabric under moderate tension. There is separation of adjacent warp yarns by each individual jet, and significant transfer of nap fibers from the face to the back of the fabric along the jet tracks.

EXAMPLE 17

The procedures of Example 1 were followed, except for the following:

Fabric: A 65/35 polyester/cotton sanded twill having a warp and fill comprised of 14/1 yarn having 85 ends and 54 picks in a 3 x 1 weave and having a fabric weight of 7.34 ounces per square yard.

Nozzle Diameter: 0.020 inch

Fluid: Water, at a pressure of 2500 p.s.i.g.

The water stream was directed onto the face of the fabric. The resulting fabric is shown in the photomicrographs of Figures 85 through 87. As may be seen, there is a raising of the yarns at corresponding locations on both the face and the back of the fabric, resulting in the formation of ridges on exactly opposite sides of the fabric which produce a slub-like appearance. There is an opening and a bulking of the yarn in the treated areas. Surface nap fibers are thought to be produced and displaced along the treated areas. Most of such produced nap fibers are pushed through the fabric and protrude from the fabric back surface opposite the treated areas.

EXAMPLE 18

The procedures of Example 17 were followed, except for the following:

Fabric: A 65/35 polyester/cotton 1 x 1 plain weave having a 25/1 polyester/cotton warp and a 25/1 polyester/cotton fill, with 98 ends and 56 picks, and a fabric weight of 4.92 ounces per square yard.

Fluid Jet Control: The apparatus depicted in Figure 29. The water pressure was maintained at 2500 p.s.i.g., the control fluid was air, which was varied in pressure from 2 to 85 p.s.i.g. in response to externally supplied pattern information. The fabric was positioned approximately 0.37 inch from the forward face of flange 164. Circumferential roll speed was 5 yards per minute. The resulting patterned fabric may be seen in the photomicrographs of Figures 88 through 91. As may be seen, there is a separation of adjacent warp yarns, as well as some bulking of the treated yarns. Surface nap fibers are thought to be produced and displaced along the treated areas. Most of such produced nap fibers are pushed through the fabric and protrude from the fabric back surface opposite the treated areas.

EXAMPLE 19

The procedures of Example 1 were followed except for the following:

Fabric: The fabric of Examples 11 and 12 was used.

Fluid Jet Control: The apparatus depicted in Figures 11 through 13, using an air cylinder to activate plunger 60.

The reed was fashioned out of stainless steel shim stock having a thickness of 0.003 inch. Deflection was via a deflector plate located approximately 0.5 inch from the exit of the water jet. The deflector plate was provided with a hole approximately 0.05 inch in diameter to allow the undeflected jet to pass therethrough and strike the fabric. Actuation of the reed was provided by a minature air cylinder distributed by Tomita Company, Limited, of Tokyo, Japan as Model Number 1C-0.10-NFS-0.197. The air cylinder plunger was spaced approximately 0.03 inch from the reed. The air cylinder was in turn controlled by an air valve distributed by the Lee Company, of Westbrook, Connecticut as Model Number LFAX0460900AG. Air pressure was maintained at 60 p.s.i.g. When used in conjunction with a supply of high pressure water (i.e., 1500 p.s.i.g.) a high velocity stream of water was projected onto the textile fabric substrate in accordance with pattern data supplied by an EPROM and associated electronics. The fabric was spaced about 0.75 inch from the exit point of the water jet; the circumferential speed of the roll to which the fabric was attached was approximately four inches per second. The resulting pattern fabric may be seen in the photomicrographs of Figures 92 through 94. There was a breaking up of the uniform arrangement of light and dark yarns by yarn displacement, with both a reflected light and transmitted light effect. Upon close inspection, the fabric effect appeared to be generally similar to that achieved in Example 12, and shown in Figures 66 through 69.

CLAIMS

1. A method for treating a substrate characterised by:
   a. placing the substrate against a support;
   b. directing at least one treating stream of fluid at the surface of the substrate under a peak dynamic pressure in excess of about 2068 kPa (300 p.s.i.g.); and
   c. interrupting and re-establishing contact between the stream and the surface in response to electrically encoded pattern information.

2. A method according to claim 1 for treating a textile fabric, said fabric being comprised of substantially continuous yarns which are interlaced in a repeating configuration, said method comprising:
   a. placing said fabric against a support member;
   b. directing at least one treating stream of fluid at the surface of said fabric, said stream having a cross section with a minimum dimension which is smaller than the minimum pattern detail desired;
   c. delivering said stream at a peak dynamic pressure in excess of about 2068 kPa (300 p.s.i.g.); and
   d. interrupting and re-establishing contact between said stream and said surface in response to electrically encoded pattern information to selectively displace yarns in said fabric.

3. The method of claim 2 wherein said stream of fluid displaces said yarns without substantial entanglement of said yarns.

4. The method of claim 1 or 2 wherein said support member provides a smooth, impenetratable surface.

5. The method of claim 1 or 2 wherein said stream has a diameter in the range greater than about 0.007 inch (0.18 mm).

6. The method of claim 2 wherein said textile fabric has a pile surface comprised of pile yarns, said method comprising:

a. placing said substrate against a support member with said pile surface exposed; and

b. directing at least one stream of fluid at the exposed surface of said substrate at a peak dynamic pressure in excess of about 2068 kPa (300 p.s.i.g.), said stream striking said pile surface with sufficient force to displace portions of said pile yarns into said substrate.

7. The method of claim 1 or 2 wherein said stream is comprised of water, wherein said water stream flows within an open channel, said stream being laterally confined within said channel, and wherein said stream is interrupted by means of a transverse stream of a control fluid which is directed into said water stream within said open channel from under said water stream, thereby lifting said water stream and interrupting the flow of said water stream within said channel.

8. A method for intermittently interrupting the flow of a first fluid stream within an open channel, which stream at

least partially conforms to and is laterally confined within said open channel, by means of a transverse stream of a control fluid which is directed into said first fluid stream from a point within said channel and under said first fluid stream with sufficient pressure to force said first fluid stream to leave the confines of said channel.

9. The method of Claim 8 wherein said stream of treating fluid is a liquid stream which substantially conforms to said open channel and is flowing within said channel at relatively high velocity, and wherein said transverse stream is comprised of a gas which has sufficient pressure to disrupt the flow of said liquid stream and cause said stream to dissipate.

10. The method of Claim 8 wherein said treating fluid stream is given a desired cross-section following passage within said open channel by passage through an aperture which is aligned with said open channel.

11. An apparatus for intermittently interrupting the flow of a first fluid stream within an open channel, which stream at least partially conforms to and is laterally confined within said open channel, by means of a transverse stream of a second fluid, said apparatus comprising:

a. means for supplying a stream of said first fluid in alignment with said channel;

b. means for directing a transverse stream of said control fluid into said first fluid stream from a point within said channel and under said first fluid stream; and

c. fluid supply means for supplying said control fluid to said directing means at a sufficient pressure to cause said first fluid stream to leave the confines of said channel.

12. The apparatus of Claim 11 wherein said directing means comprises a passage in the base of said channel directed outwardly from said base.

13. The apparatus of Claim 11 which further comprises a stream forming means for giving said first fluid stream a desired cross-section following the flow of said fluid stream within said open channel, said stream forming means including an aperture in substantial alignment with said channel.

14. An apparatus for forming an intermittent stream of fluid, comprising:

a. manifold means for containing a quantity of said fluid at the desired pressure;

b. stream forming means, in fluid communication with said manifold means, for forming a stream of said fluid;

c. reed means situated outside said manifold means and comprising a thin portion of stiff, resilient material, said reed means being positioned adjacent to the path of said stream formed by said stream forming means, said reed means being connected in cantilever fashion to said manifold means, thereby having a fixed, proximal end and a free, distal end, said distal end of said reed means being capable of resilient movement through the path of said stream;

d. reed actuation means for intermittently urging a portion of said distal end of said reed means into the path of said stream, said actuation means comprising a plunger which may be moved to an extended position and moved to a retracted position on command, and which contacts said reed means and moves said distal portion of said reed means into the path of said stream in one of said positions and allows said reed means to move out of said path in the other of said positions; and

e. containment means spaced from said stream forming means, and beyond but in close proximity to said distal end of said reed means, said containment means being positioned generally within the path of said fluid stream and comprising a barrier means having an aperture therein, said aperture being in alignment with said stream forming means, said alignment allowing said fluid stream to pass through said aperture whenever the distal portion of said reed means has moved out of the path of said stream.

15. The apparatus of Claim 14 wherein said reed means is an elongate strip of stiff metal, the distal end of which is bent at an obtuse angle, said strip being situated in parallel arrangement along the path of said stream so that when said plunger is extended, the distal end of said elongate strip is forced into the path of said stream.

16. The apparatus of Claim 15 wherein said stream forming means comprises means for forming a plurality of generally aligned bores, for simultaneously forming an array of fluid streams; said reed means comprises a plurality of reed means, positioned in two generally parallel arrays flanking said bores, with each of said bores having an

individual reed means corresponding thereto, said arrays being slightly laterally displaced to allow for interleaving of reed means from each array; said reed actuation means comprises a plurality of reed actuation means positioned in operable association with said reed means, each of said reed means having a corresponding individual actuation means associated therewith; and further including containment means spaced from said stream forming means, beyond but in close proximity to said distal portions of said plurality of reed means, said containment means comprising a barrier means having at least one aperture in substantial alignment with said plurality of bores, and allowing said fluid streams to pass through said aperture whenever the distal portions of said reed means are retracted from the paths of said streams.

17. An apparatus for forming a thin stream of fluid which intermittently strikes a target in accordance with externally supplied command data, comprising:

a. a manifold for containing and distributing said fluid at a desired pressure;

b. stream forming means in fluid communication with said manifold, said stream forming means comprising a relatively stiff section of tubing which is directed at said target and which is cantilevered from said manifold, said tubing being capable of undergoing moderate deflection without permanent deformation;

c. a barrier means extending beyond the proximal end of said tube and extending transversely to the direction of said stream path, said barrier means serving to intersect the path of said stream when said tube is in a first position, and positioned to allow said stream to pass substantially unchanged and strike the target when said tube is in a second position; and

d. tube deflection means comprising a plunger which, when extended, contacts said cantilevered tube and deflects said distal end of said tube.

18. The apparatus of Claim 17 wherein said tube is in said first position when said plunger is extended.

19. The apparatus of Claim 17 wherein said tube is in said second position when said plunger is extended.

20. The apparatus of Claim 17 wherein said stream forming means comprises an array of relatively stiff sections of tubing which are directed at said target and which are cantilevered from said manifold, said tubes being arranged in two generally parallel arrays, said arrays being laterally offset so that respective tubes from each array

are unopposed; said barrier means comprises a barrier means for each array extending beyond the proximal end of said tubes in each array; and said tube deflecting means comprises a plurality of plungers arranged in two generally parallel arrays, said arrays being laterally offset so that respective plungers from each array are unopposed, each individual plunger being associated with a corresponding cantilevered tube in said stream forming means.

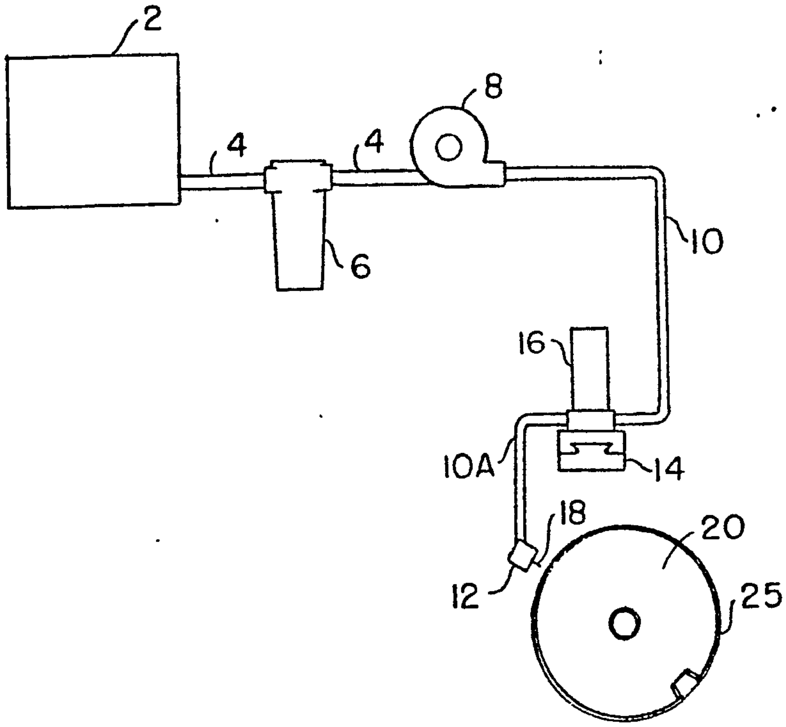

FIG. -1-

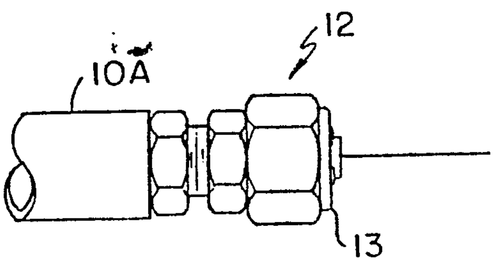

FIG. -2-

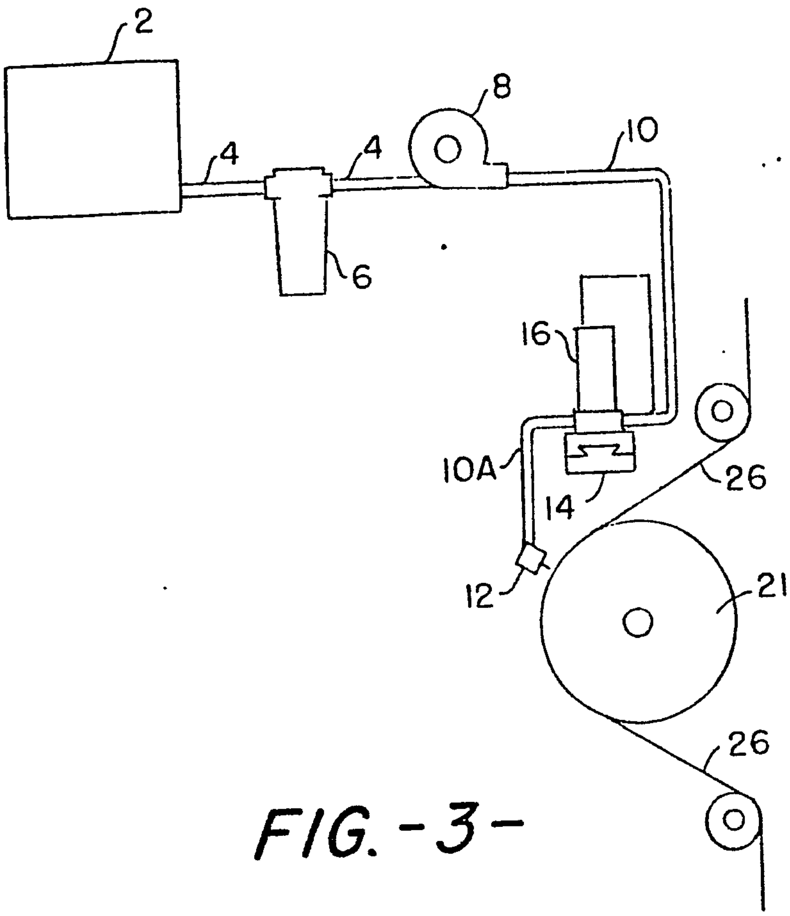

FIG. -3-

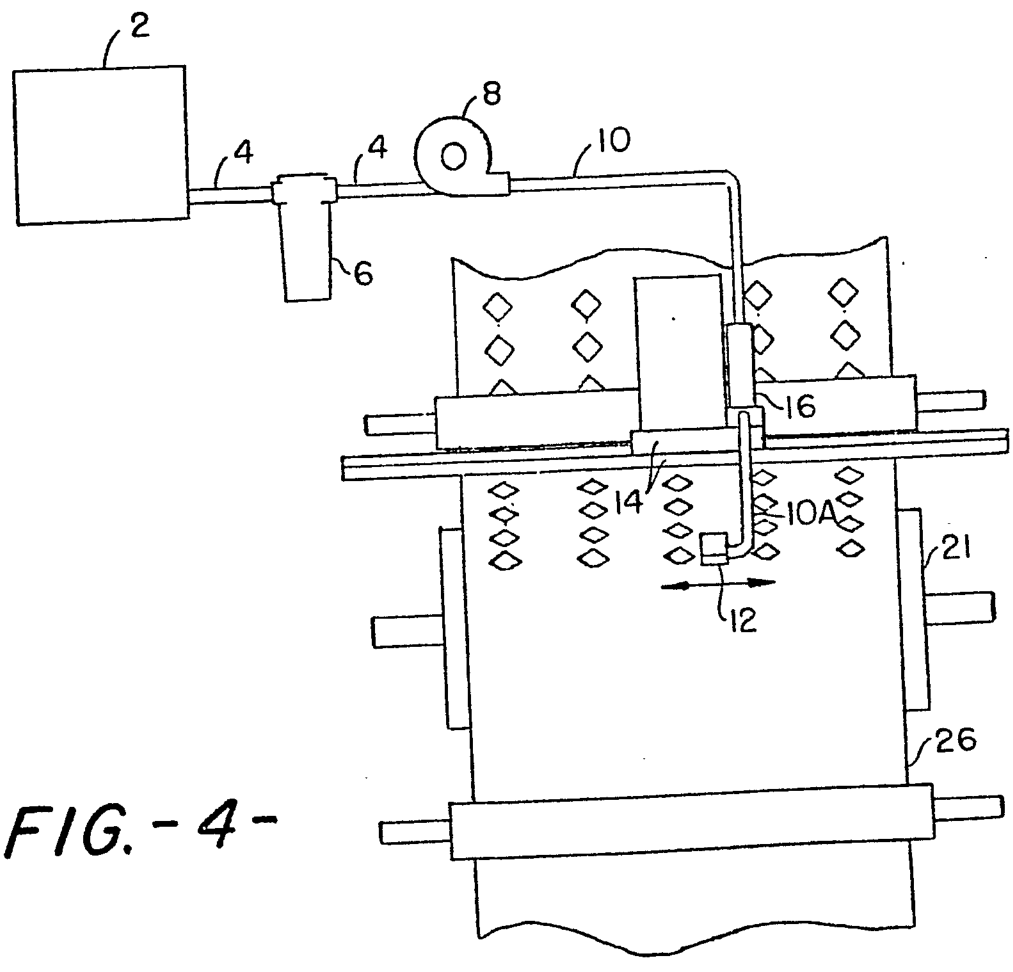

FIG. -4-

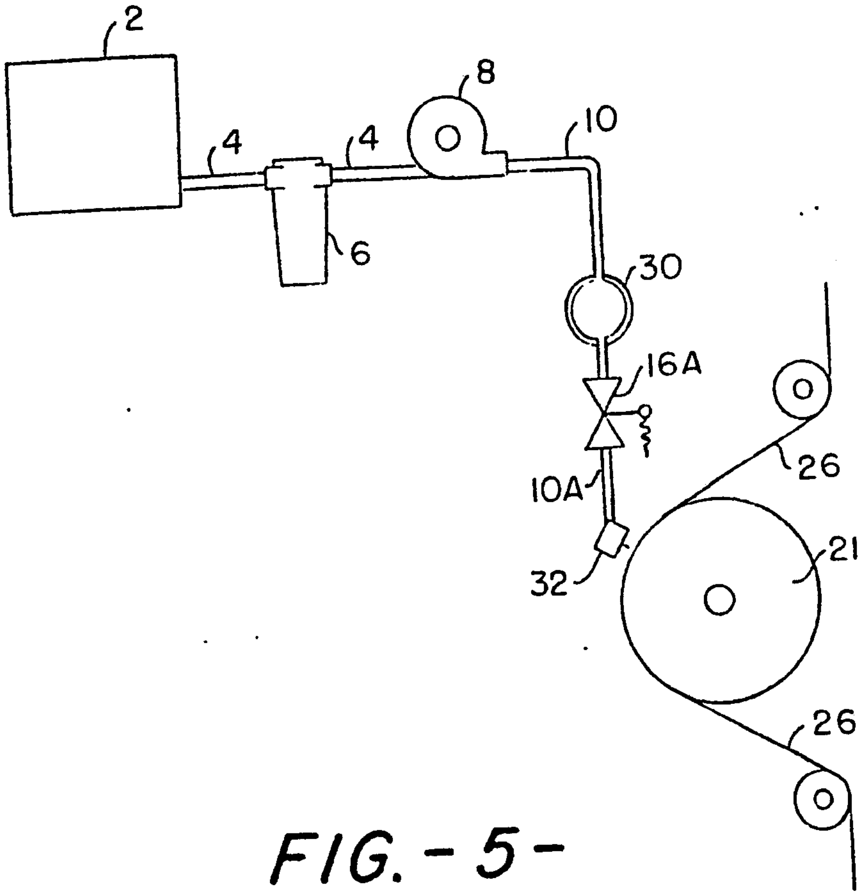

FIG. - 5 -

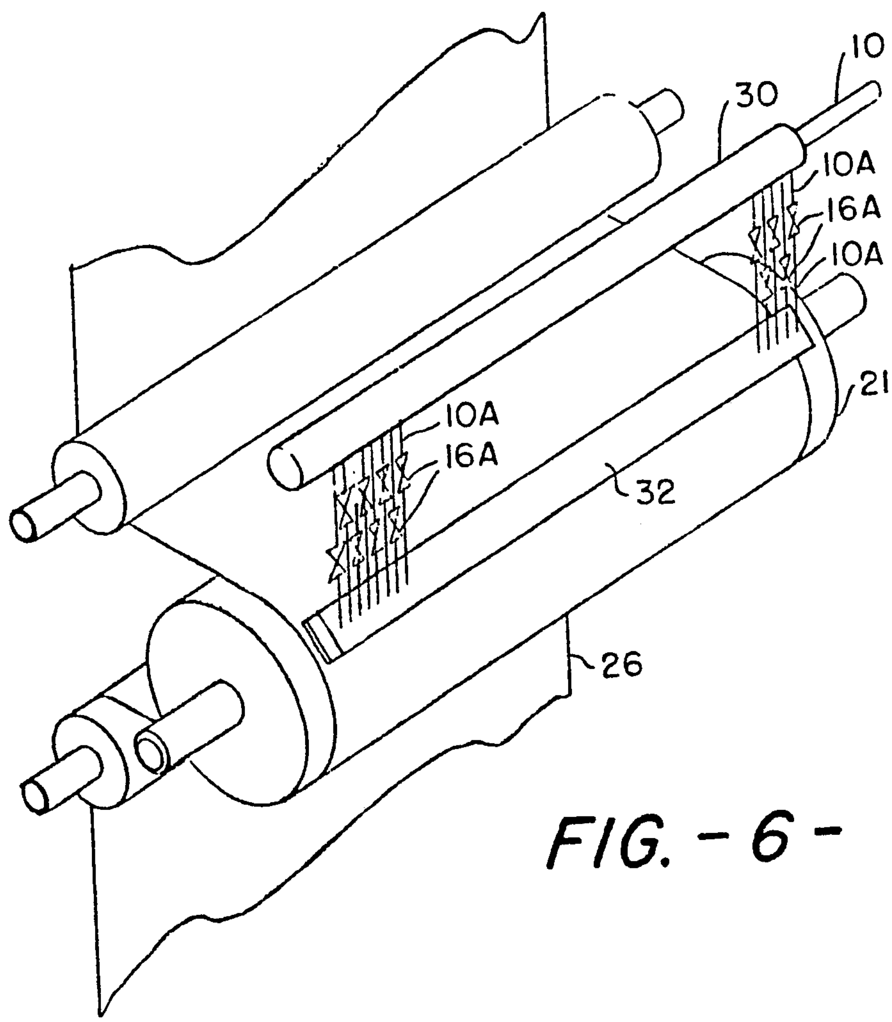

FIG. - 6 -

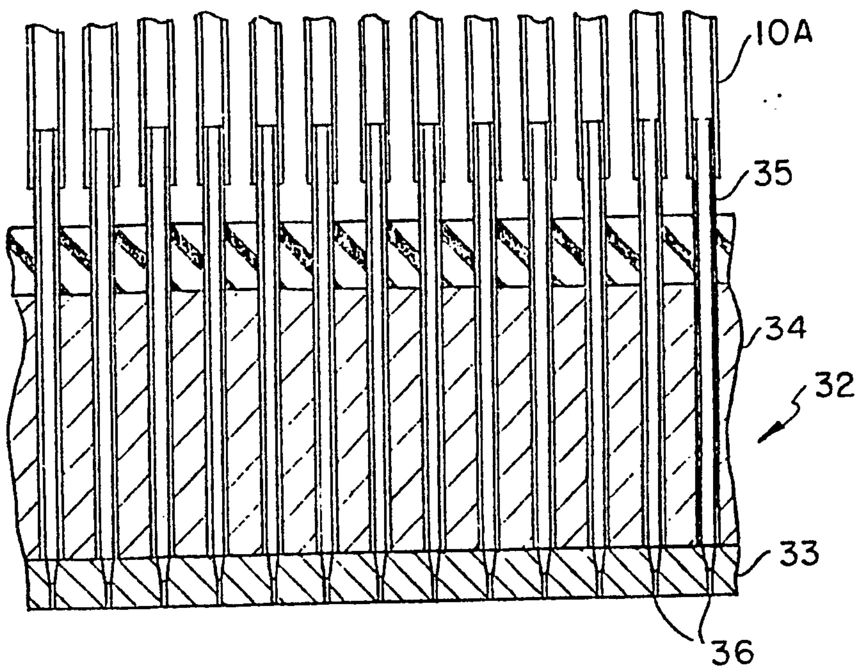

FIG. - 7 -

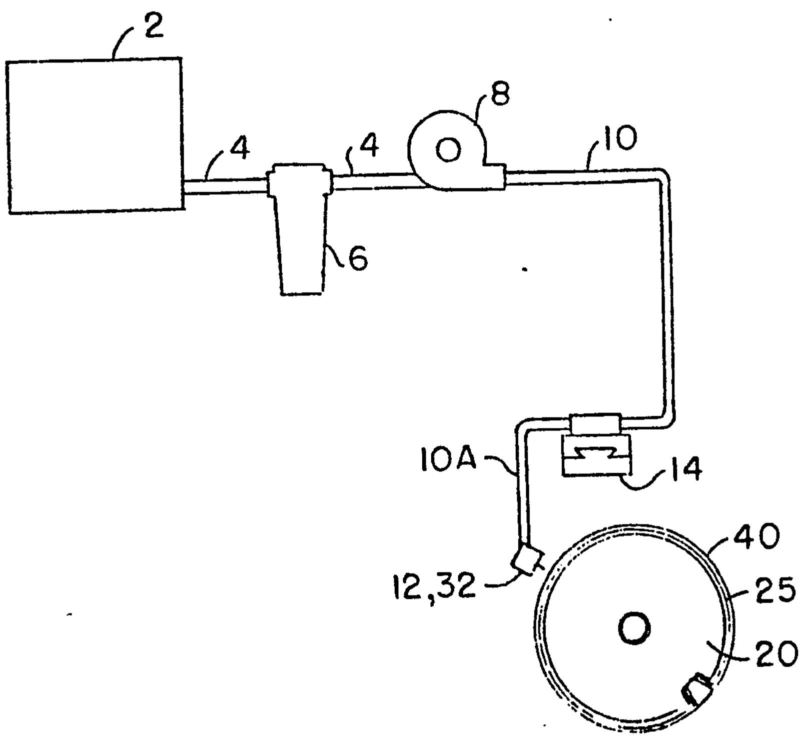

FIG. - 8 -

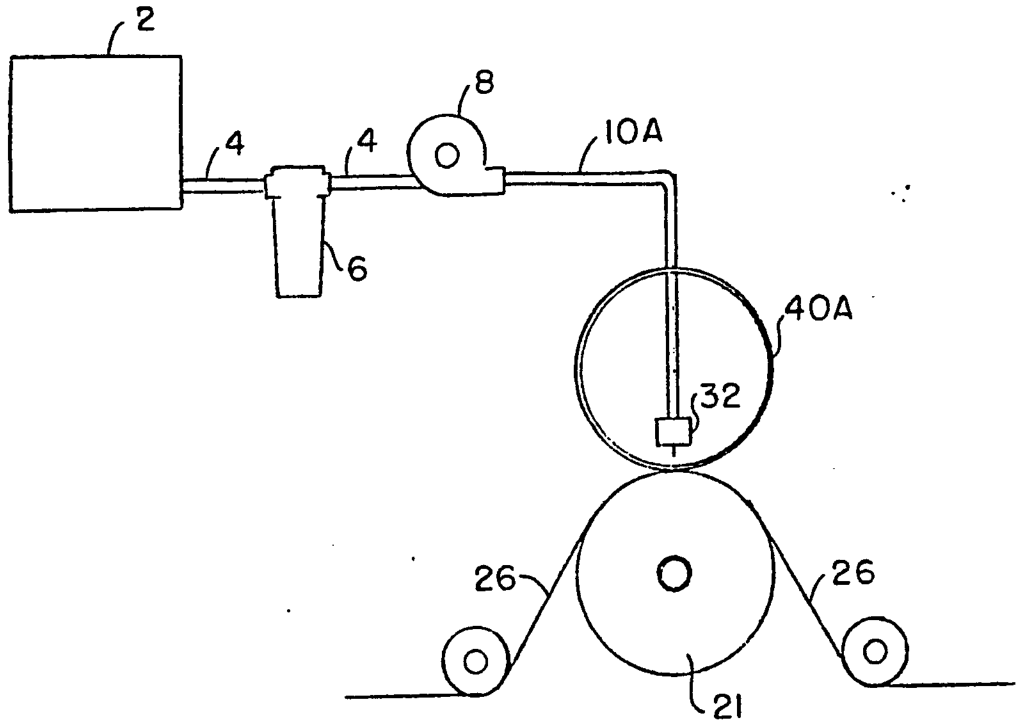

FIG.-9-

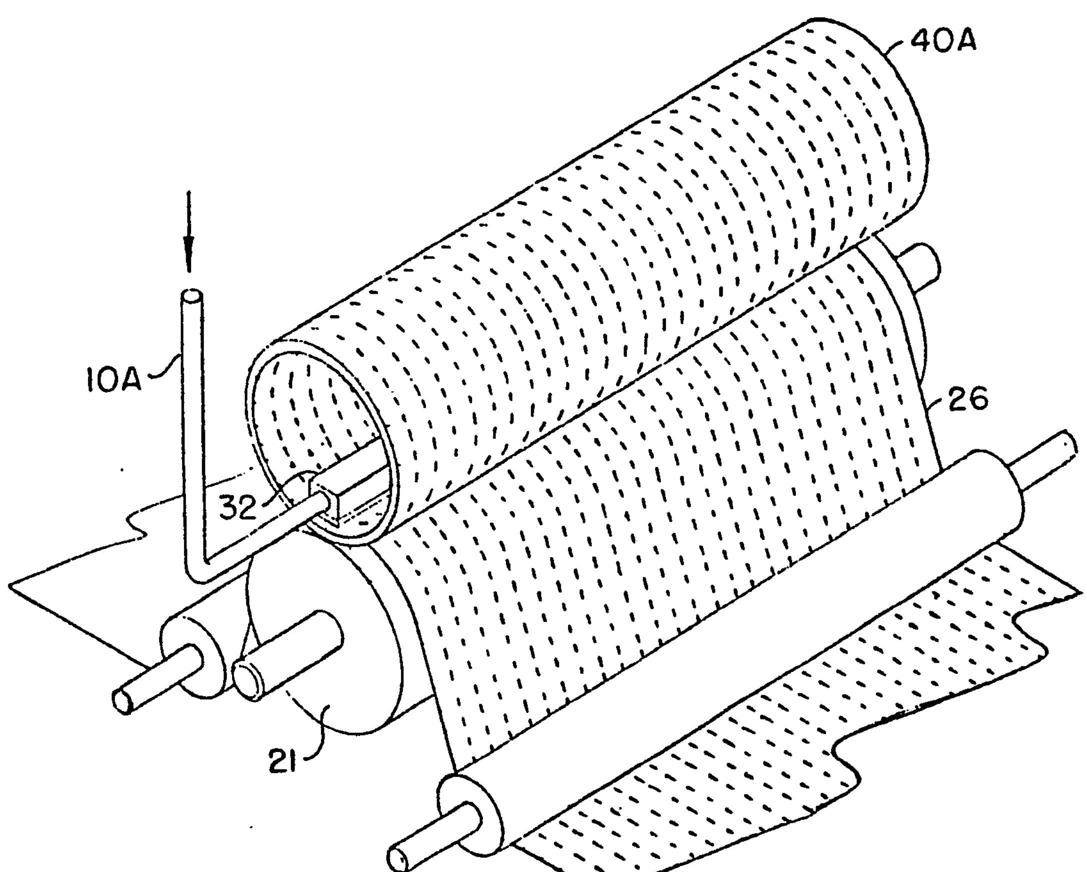

FIG.-10-

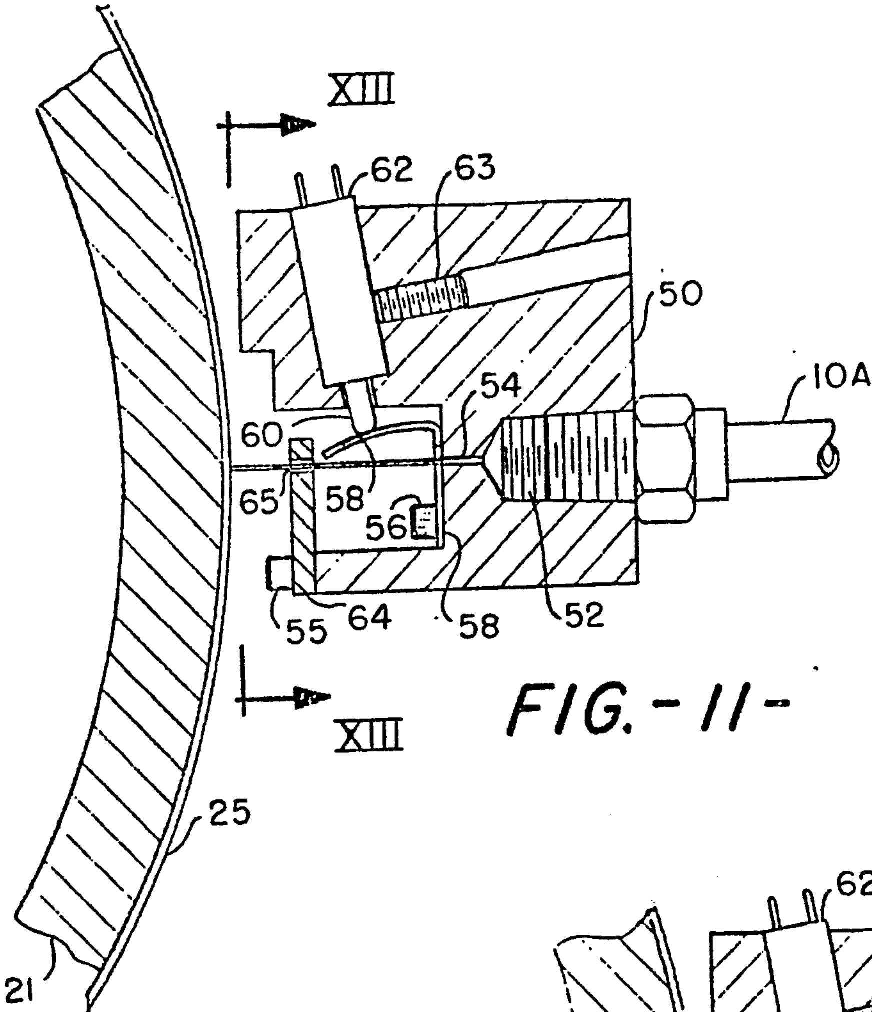

FIG. - 11 -

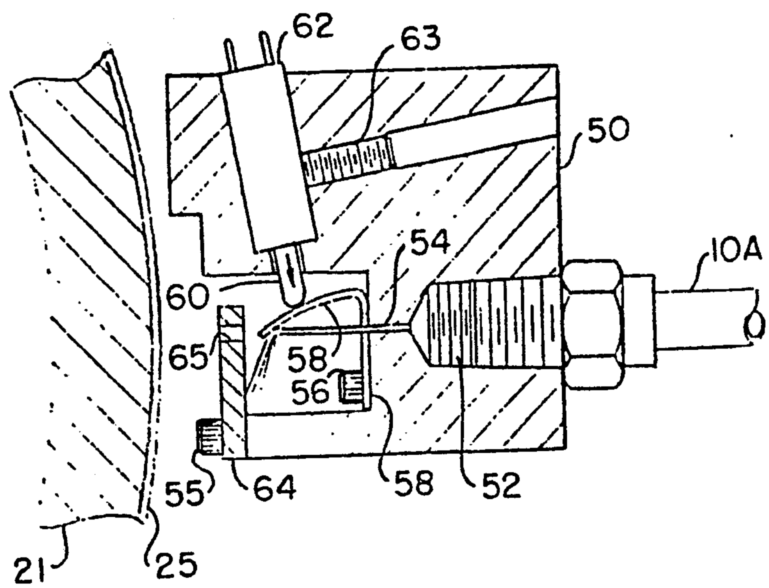

FIG. - 12 -

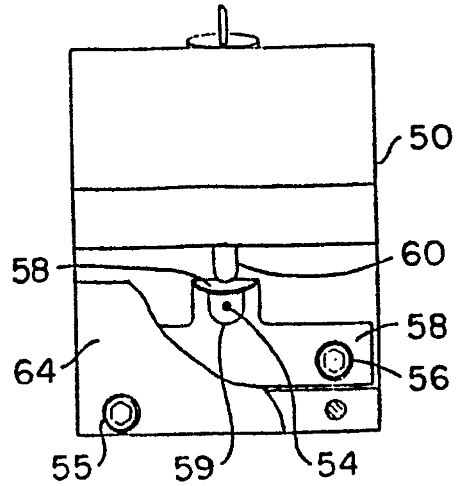

FIG. - 13 -

0177277

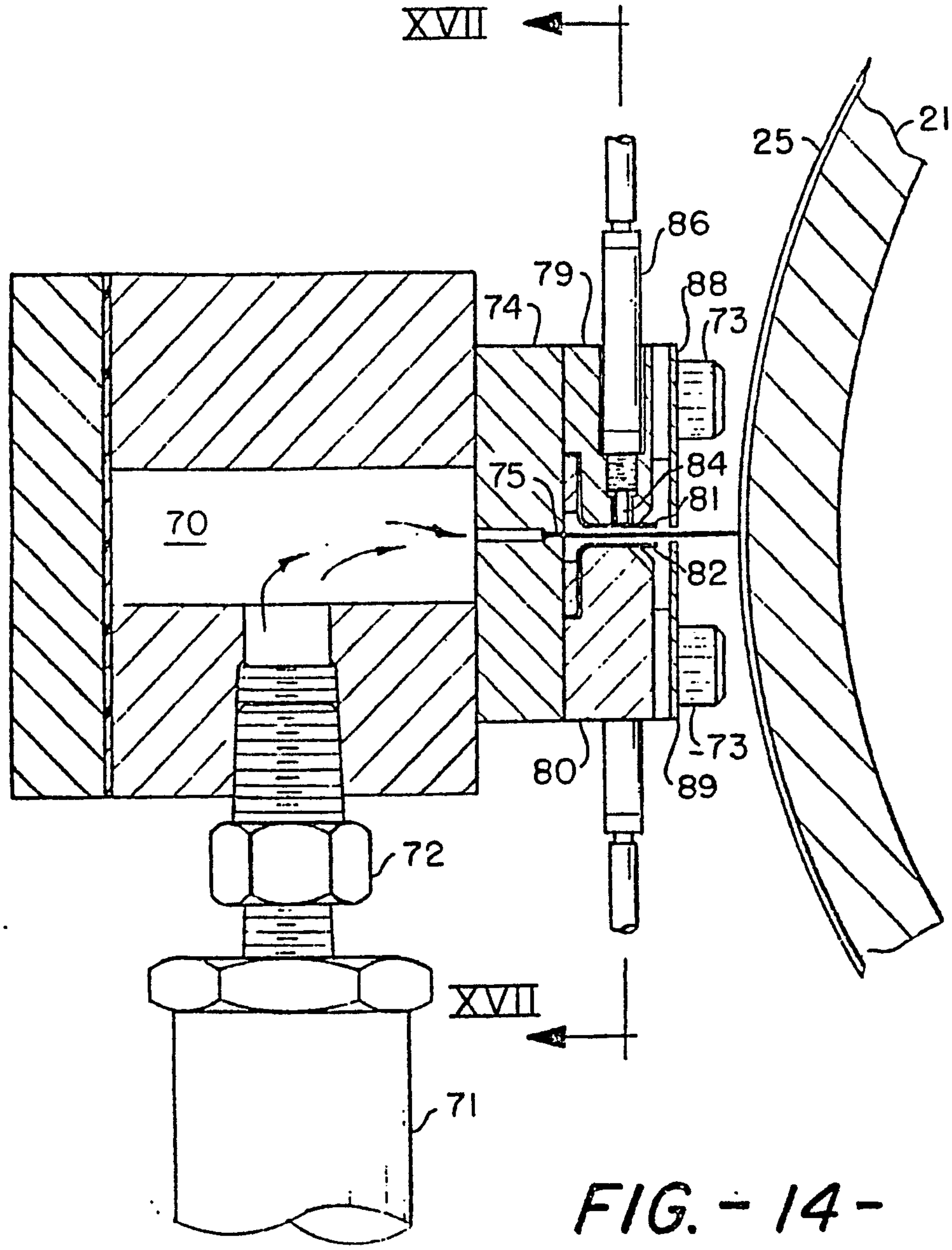

FIG. - 14 -

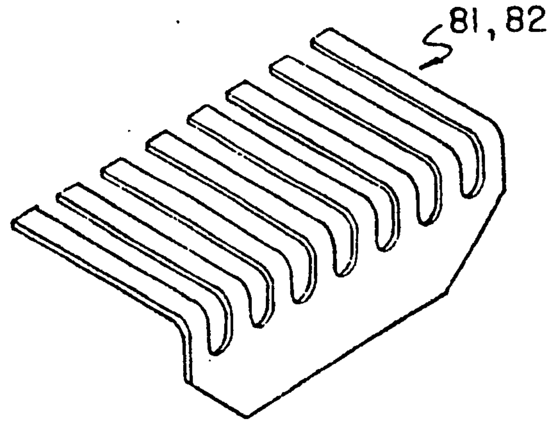

FIG. - 15 -

0177277

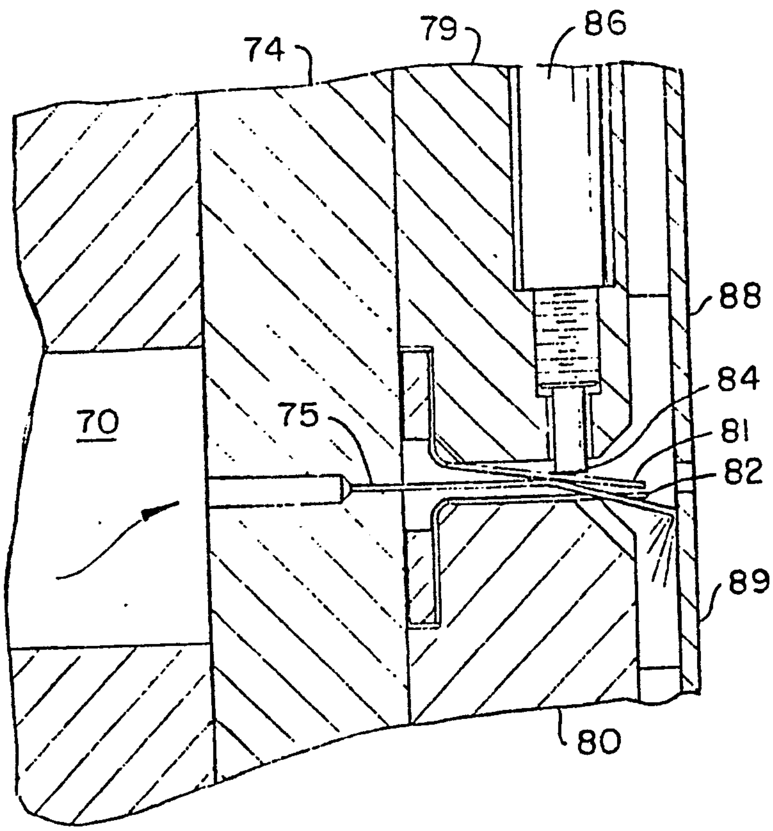

FIG. - 16 -

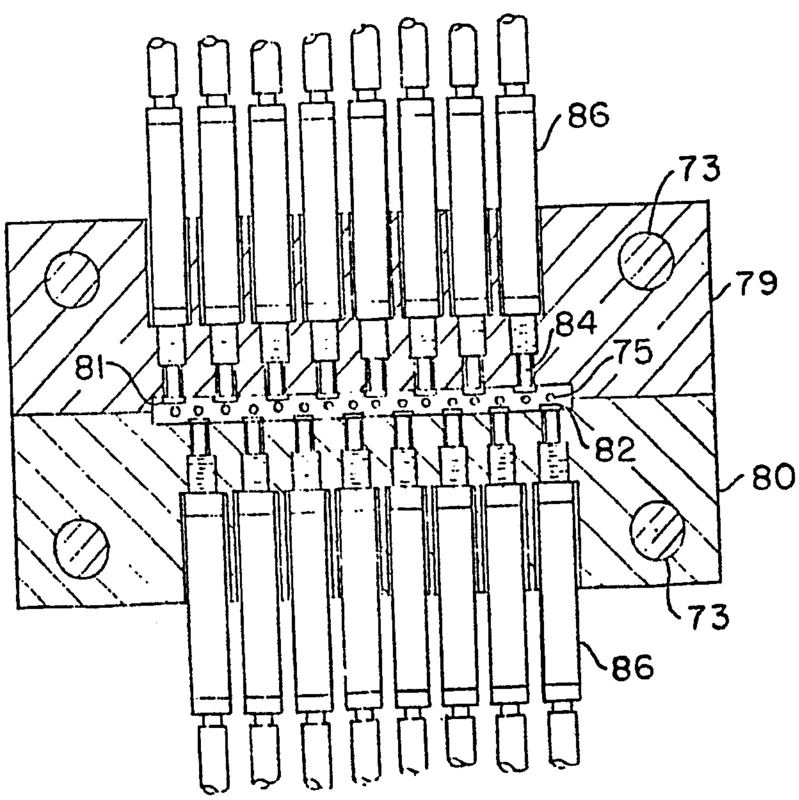

FIG. - 17 -

0177277

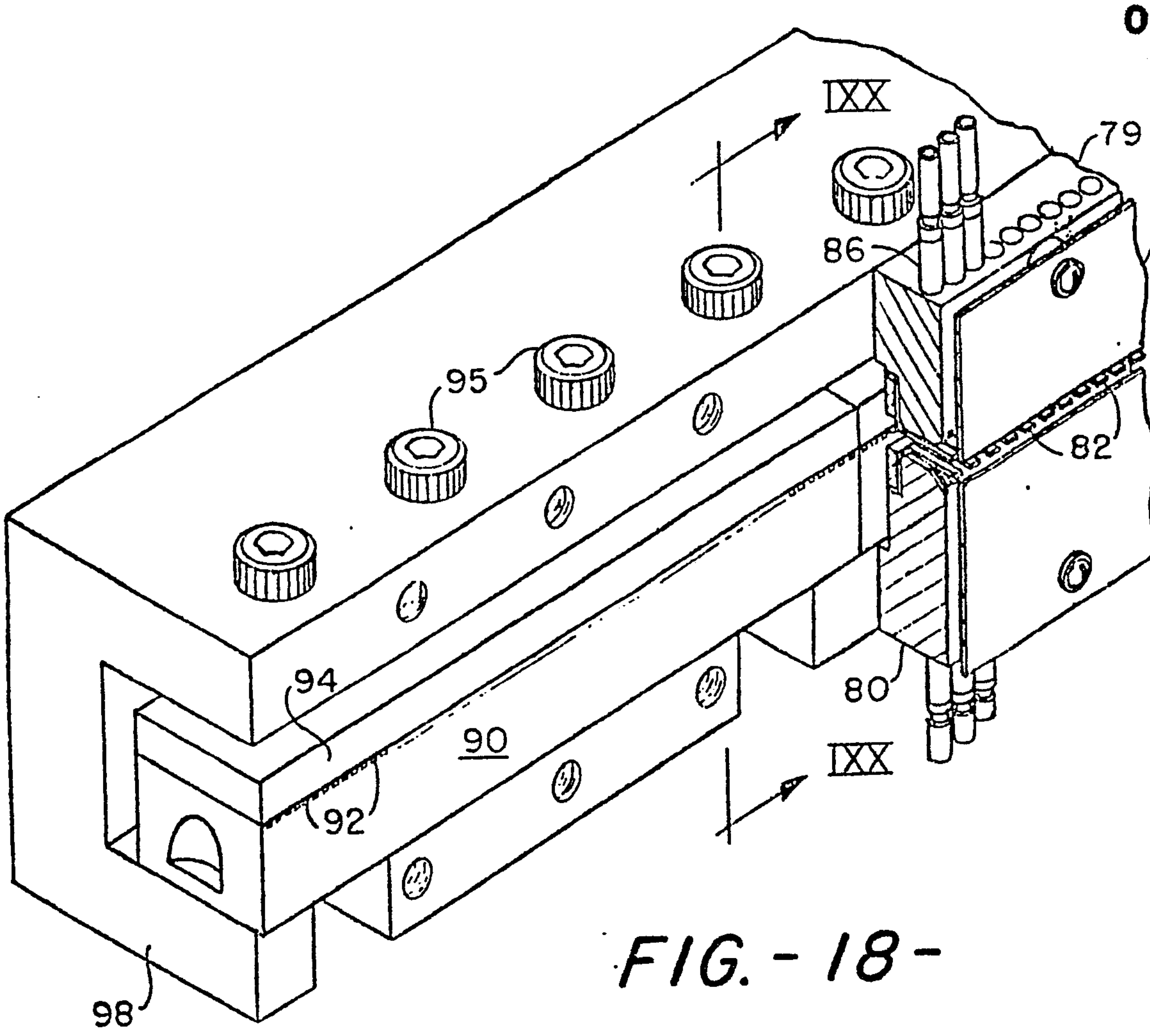

FIG. - 18 -

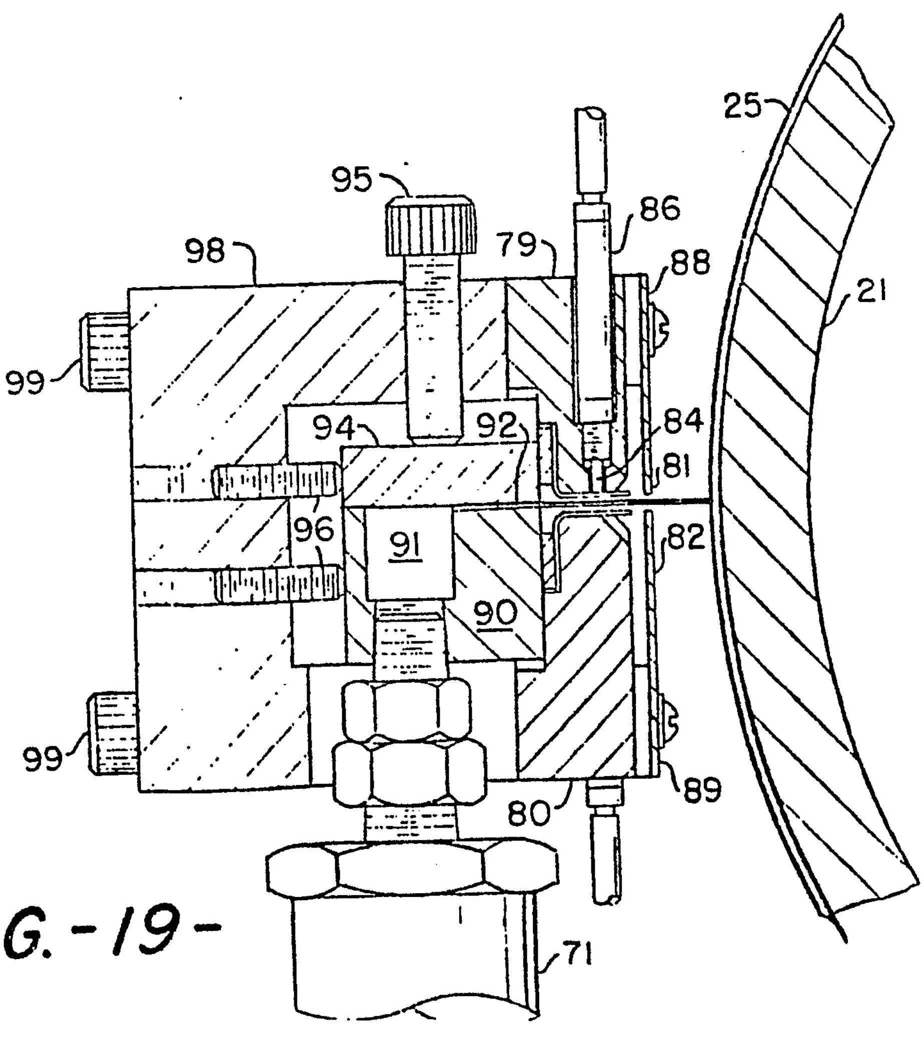

FIG. - 19 -

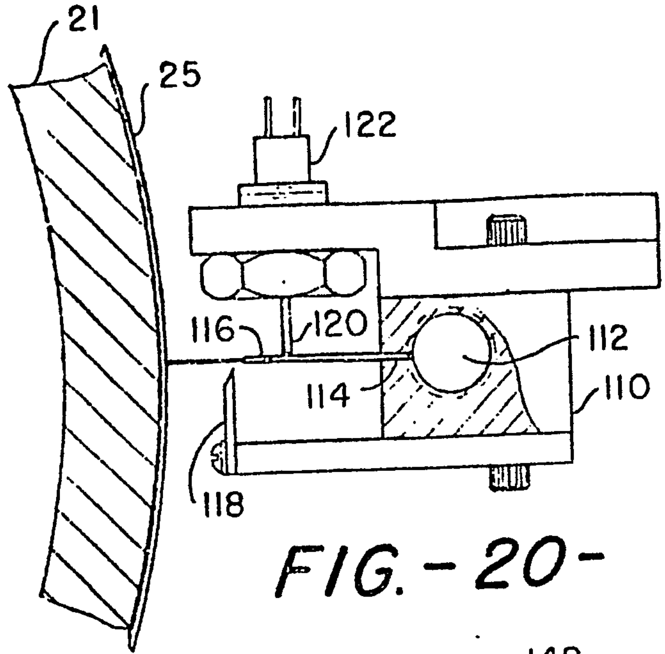

FIG.-20-

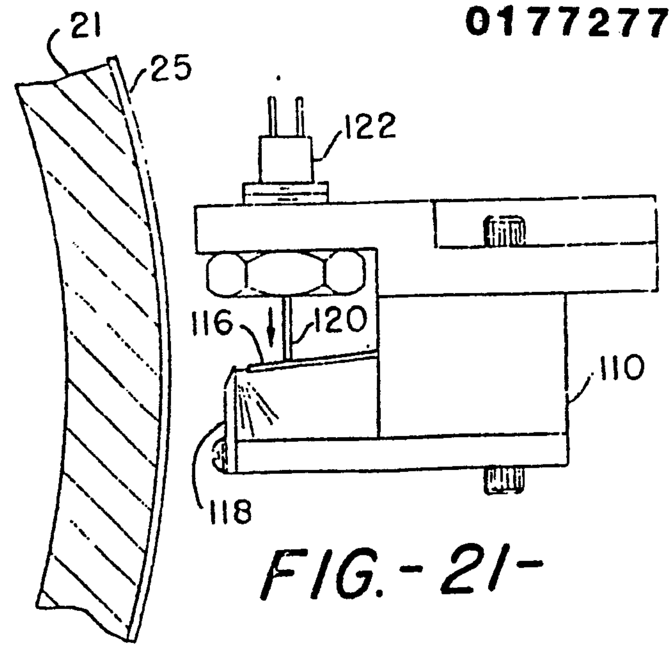

FIG.-21-

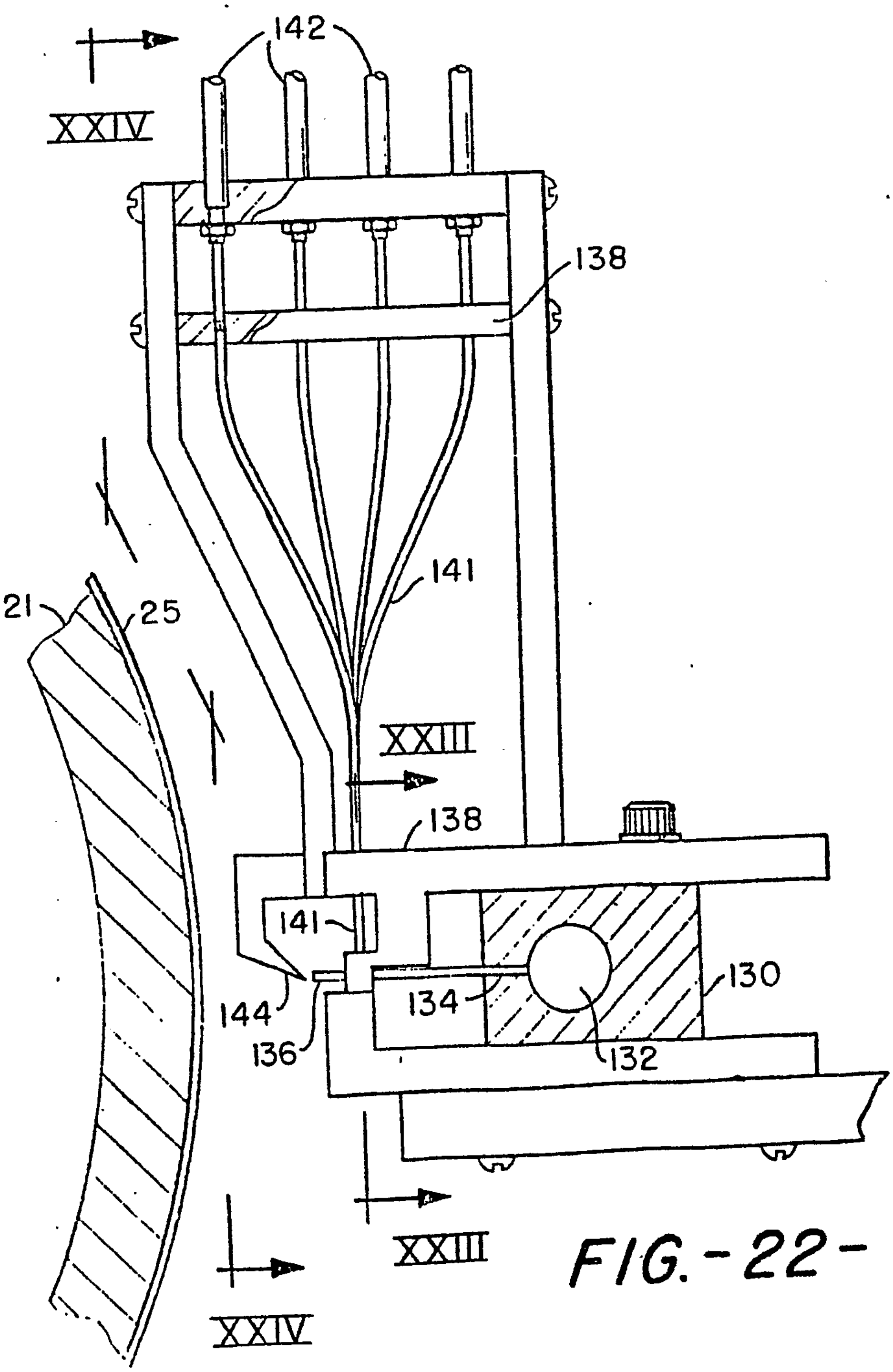

FIG.-22-

0177277

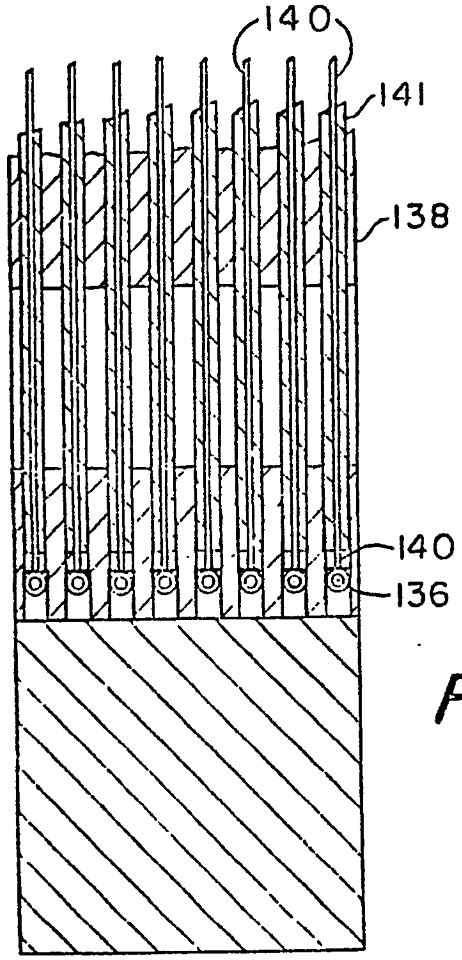

FIG.-23-

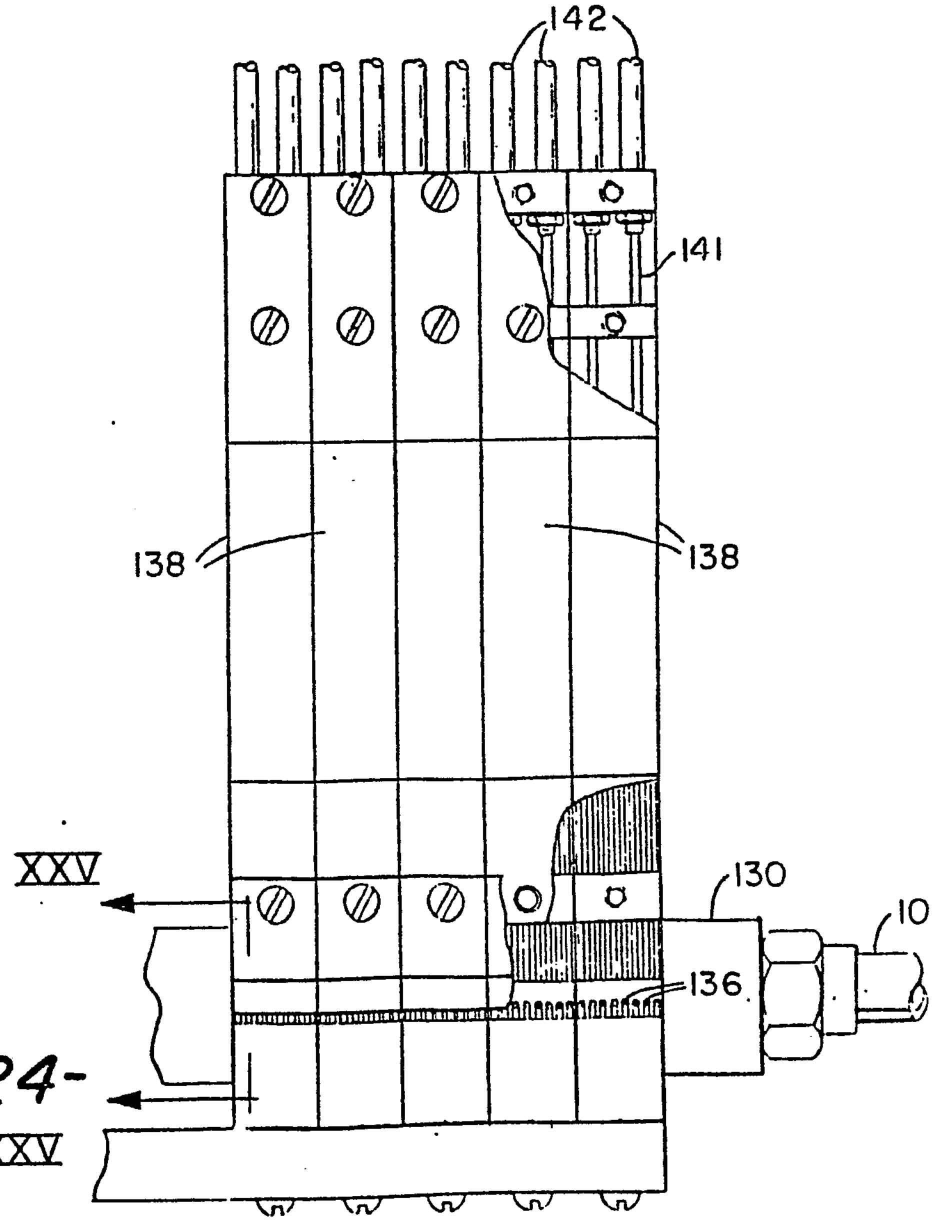

FIG.-24-

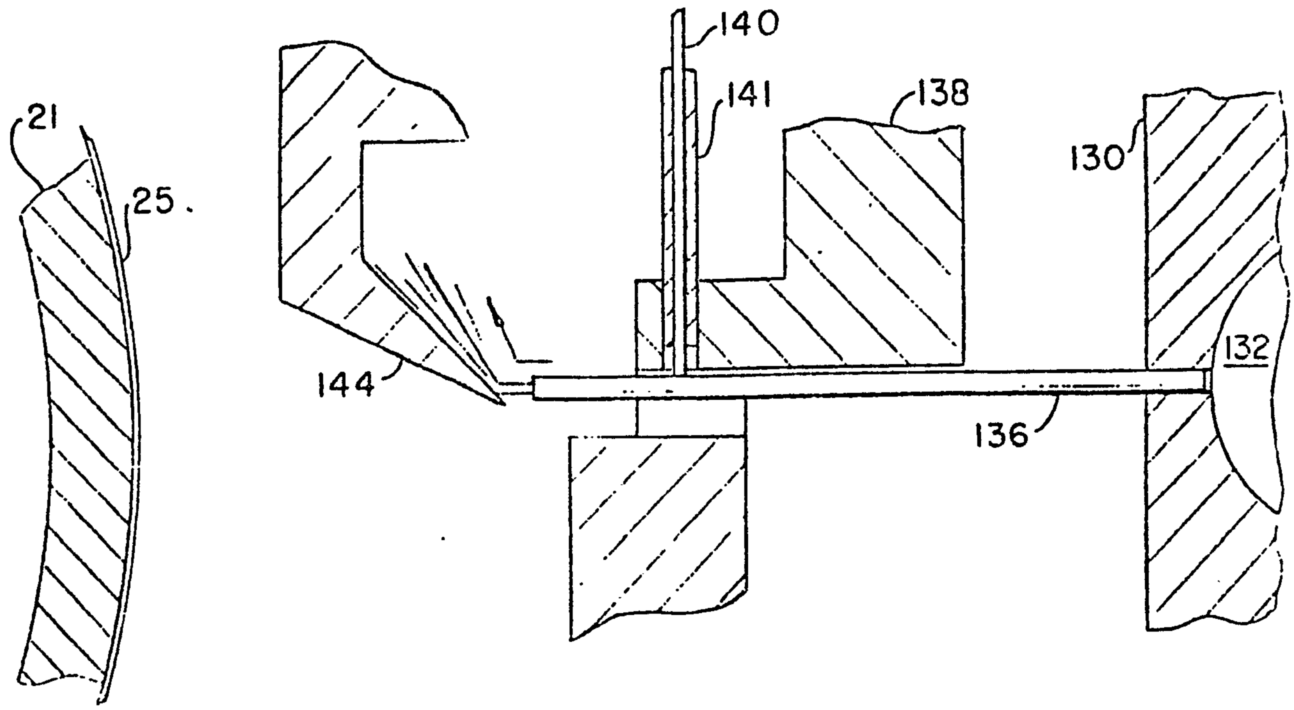
140
141
138
21
130
25
132
144
136

FIG. - 25 -

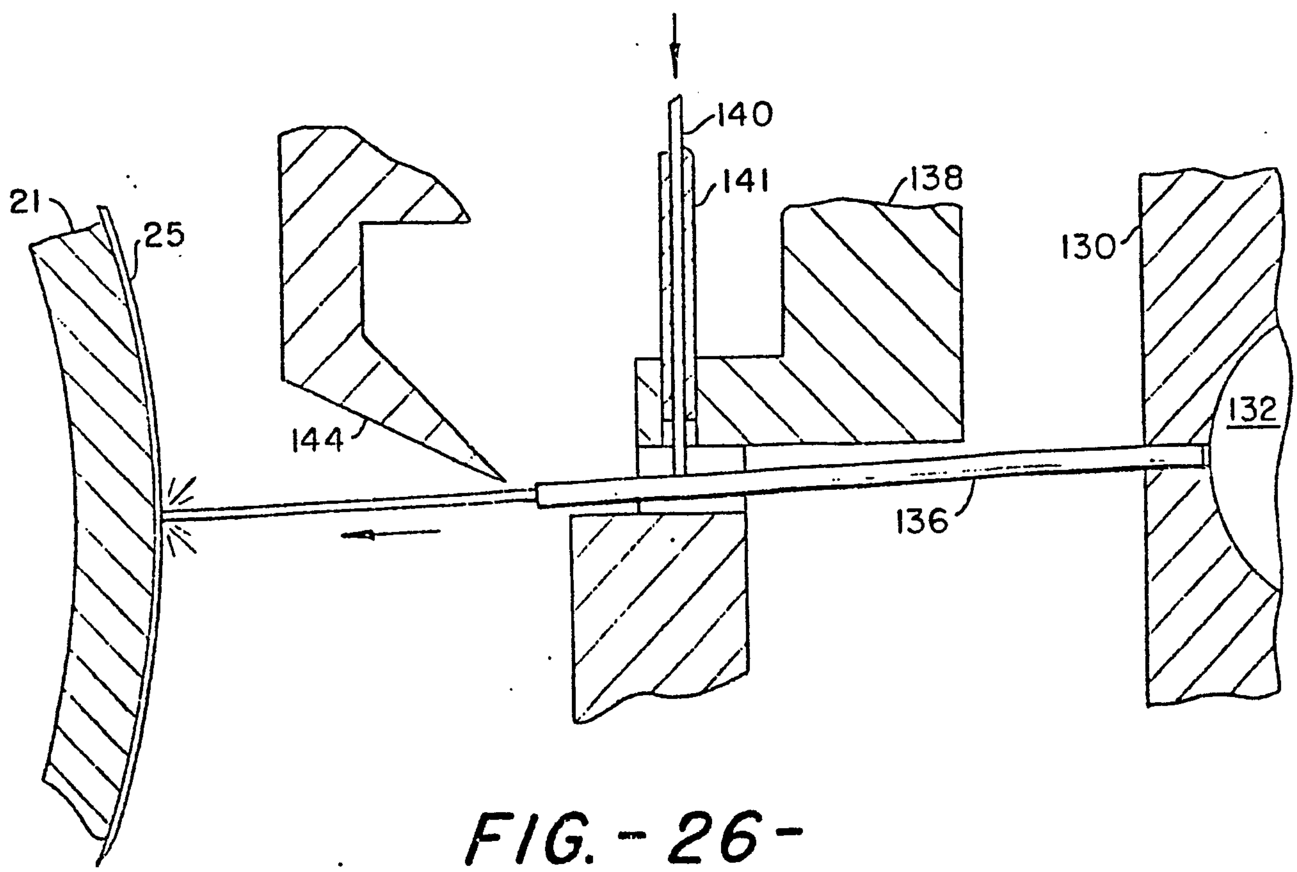
140
141
138
21
25
130
132
144
136

FIG. - 26 -

0177277

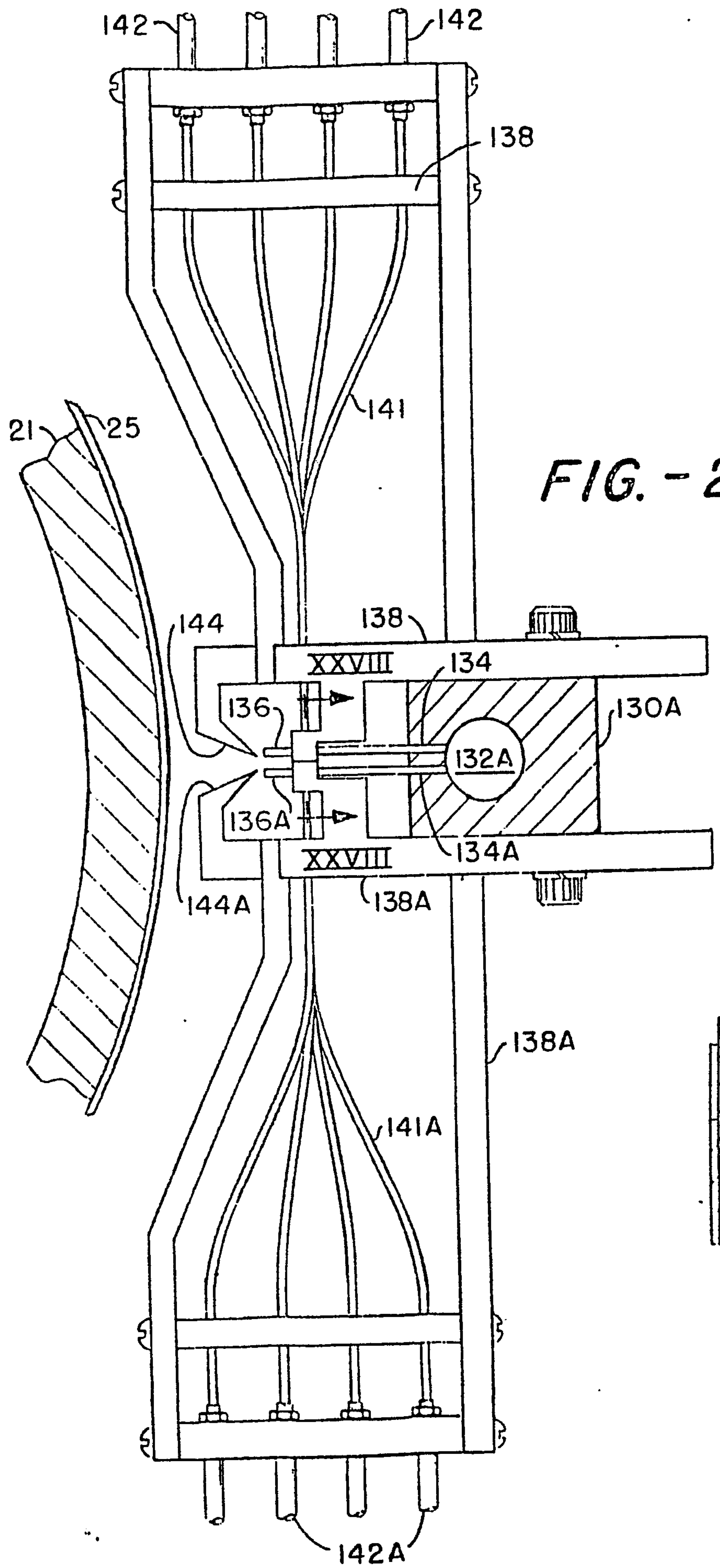

FIG. -27-

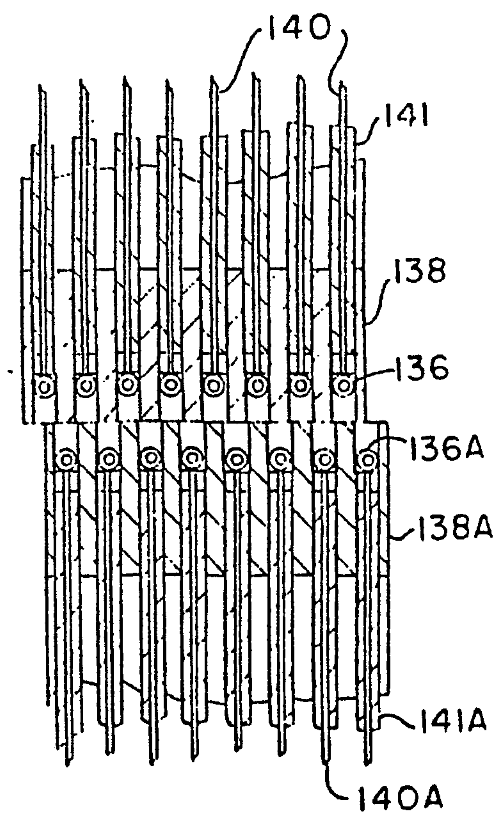

FIG. -28-

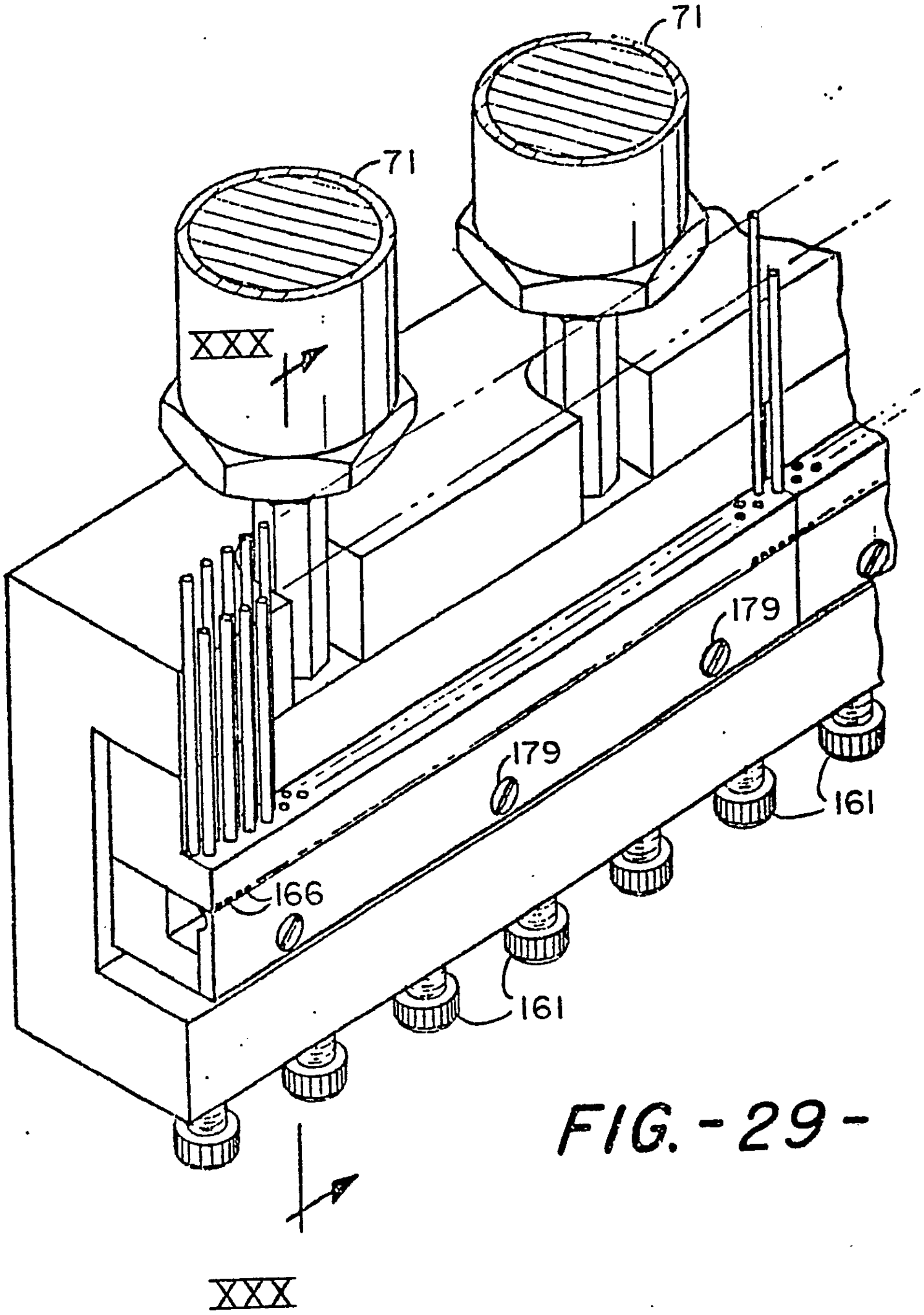

FIG.-29-

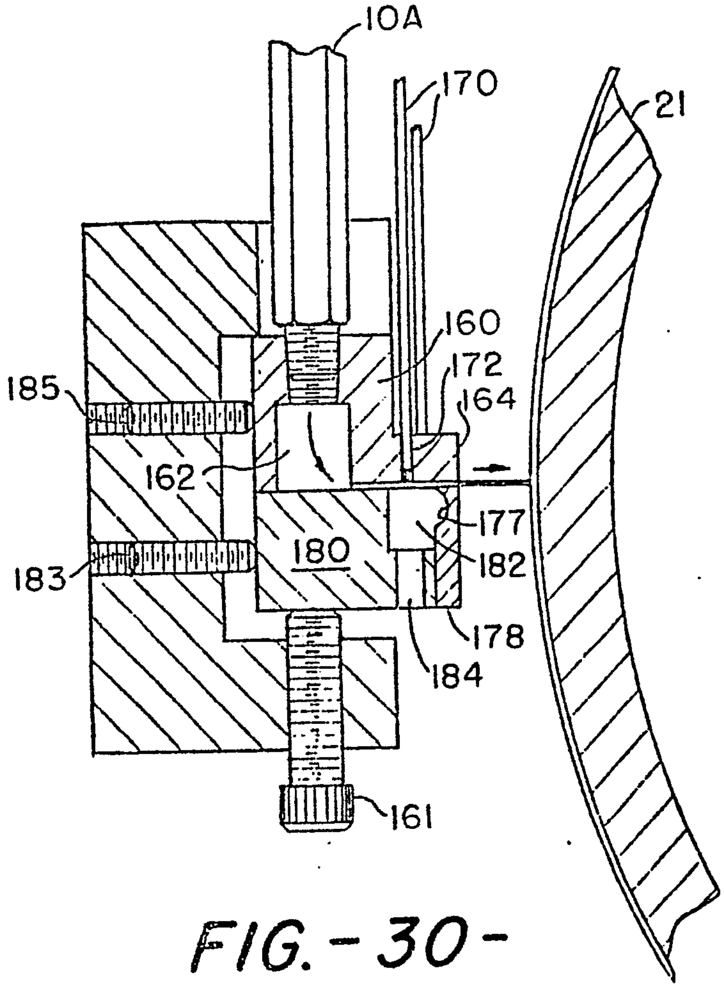

FIG.-30-

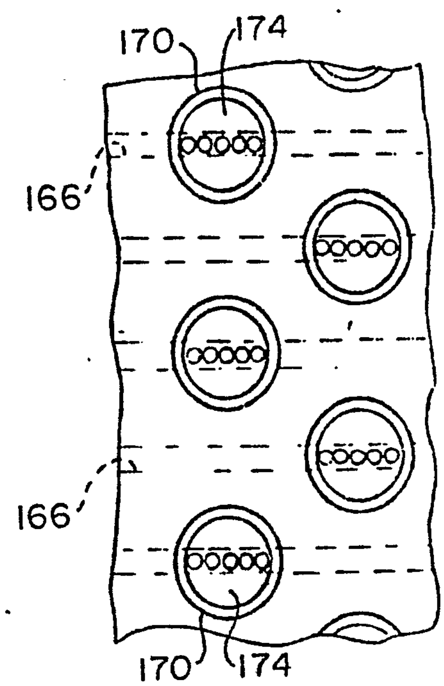

FIG.-32-

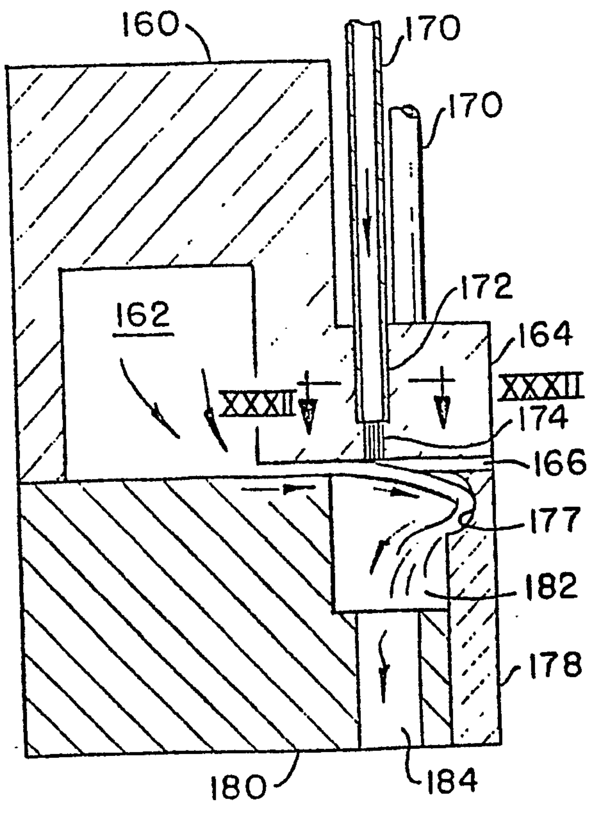

FIG.-31-

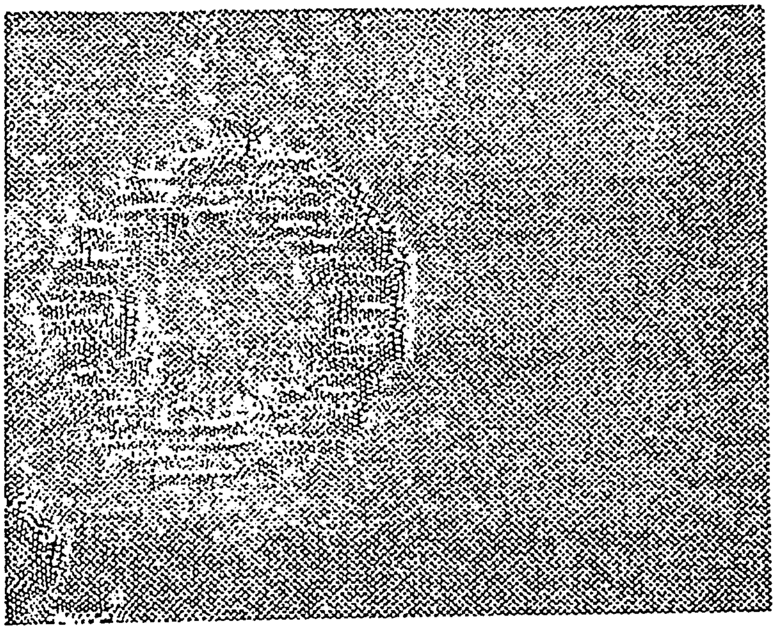

FIG. -33-

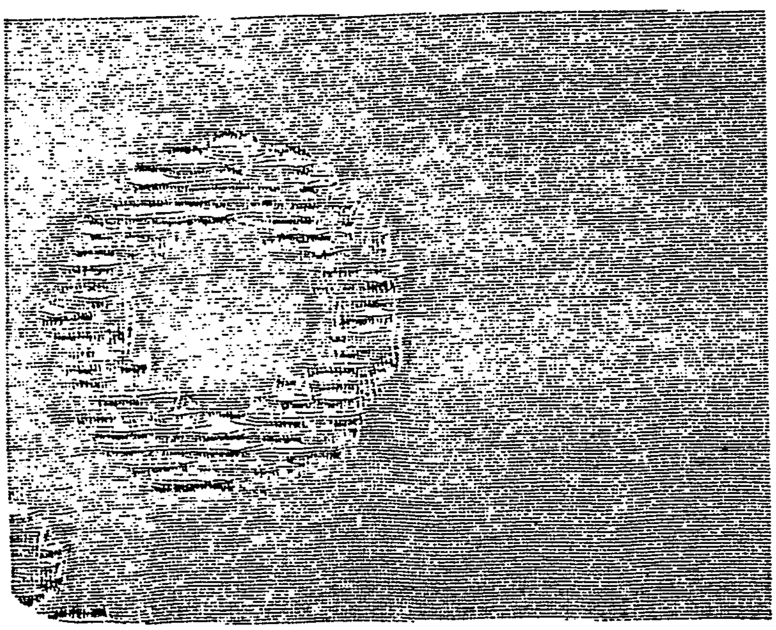

FIG. -34-

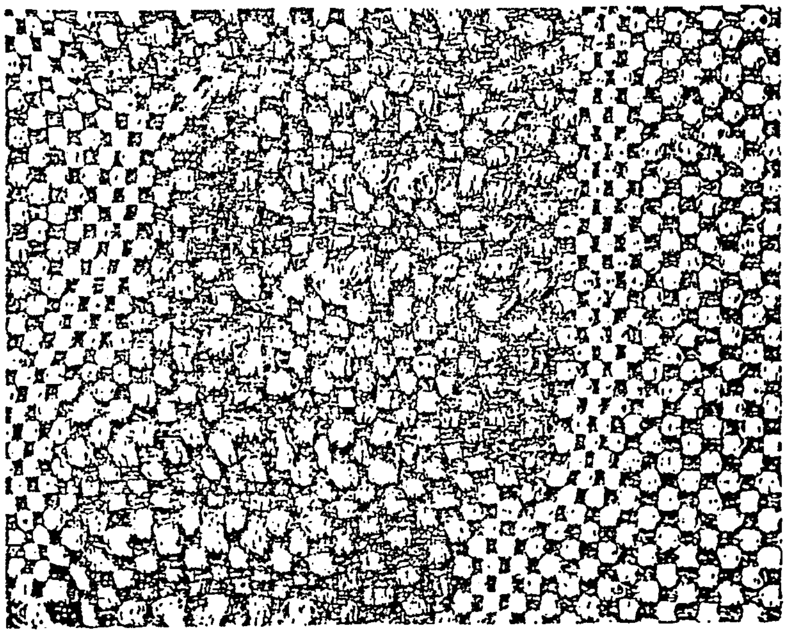

FIG. - 35 -

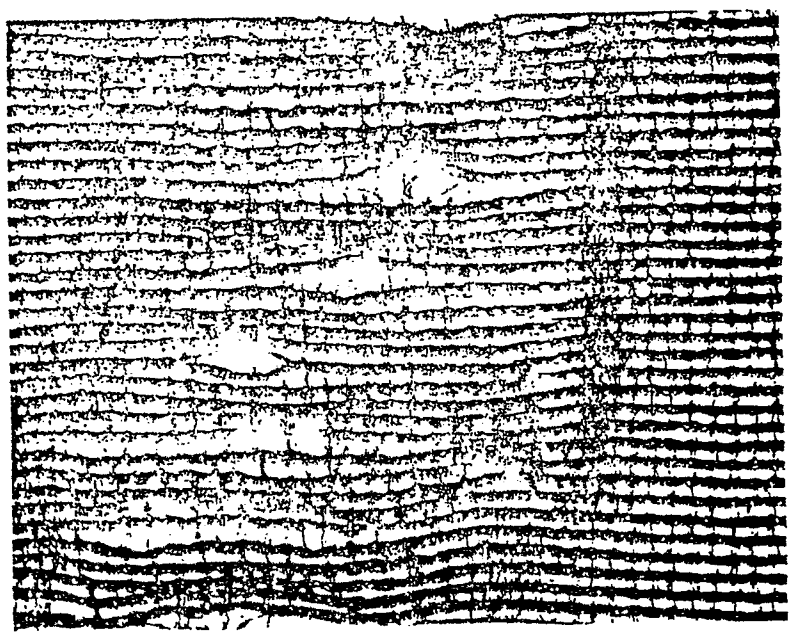

FIG. - 36 -

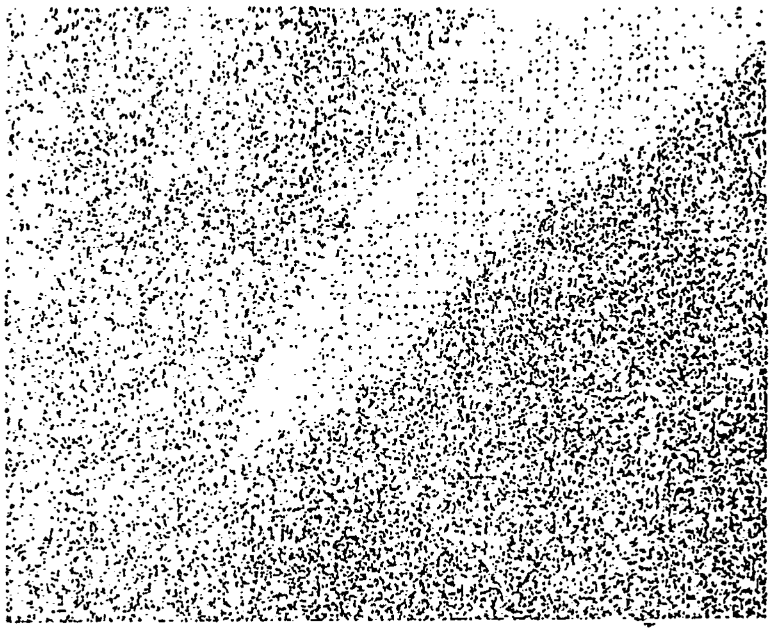

FIG. -37-

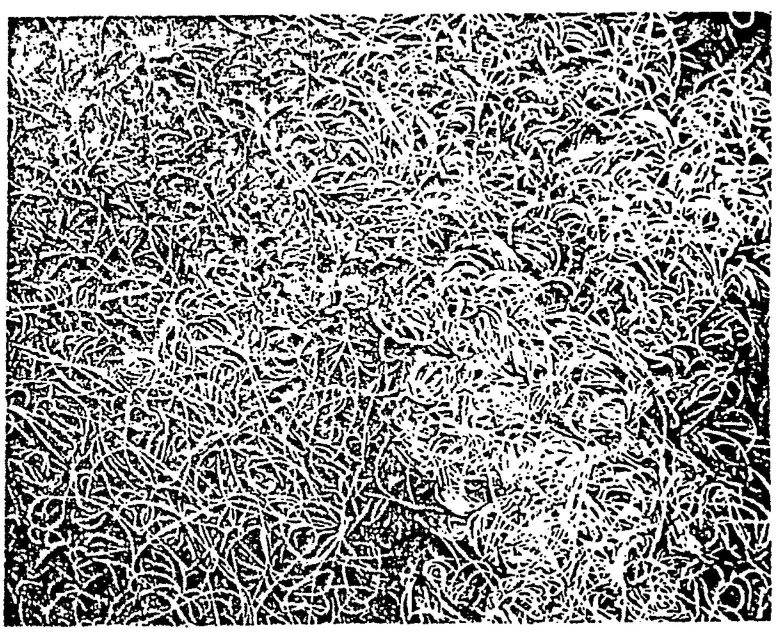

FIG. -38-

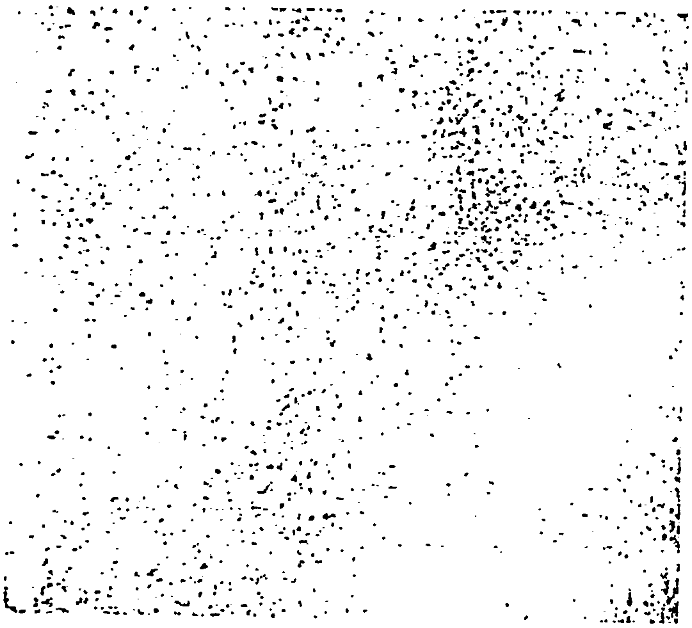

FIG.-39-

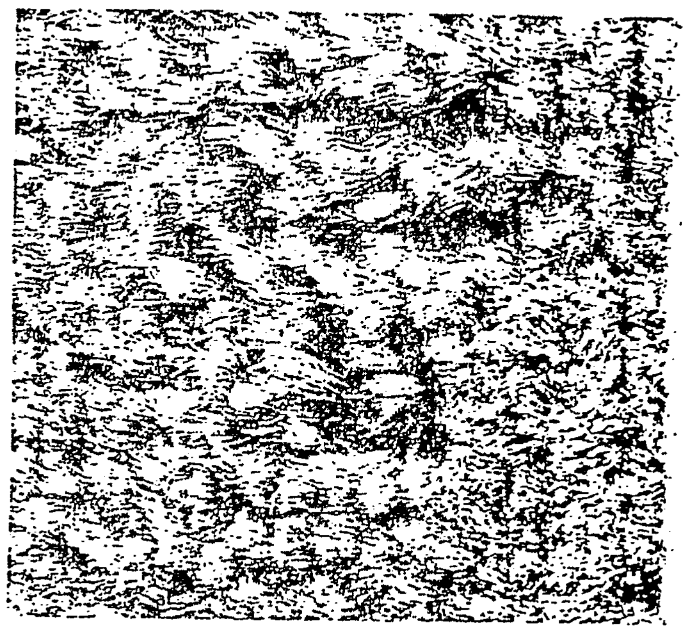

FIG.-40-

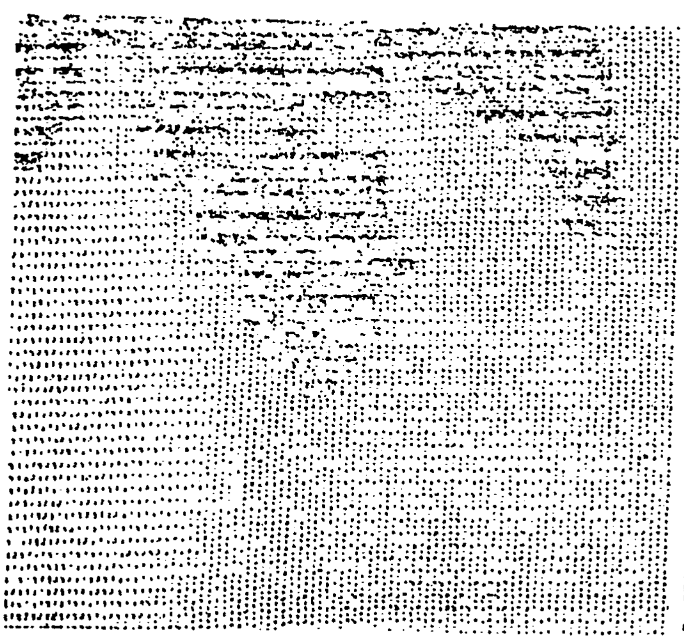

FIG.-41-

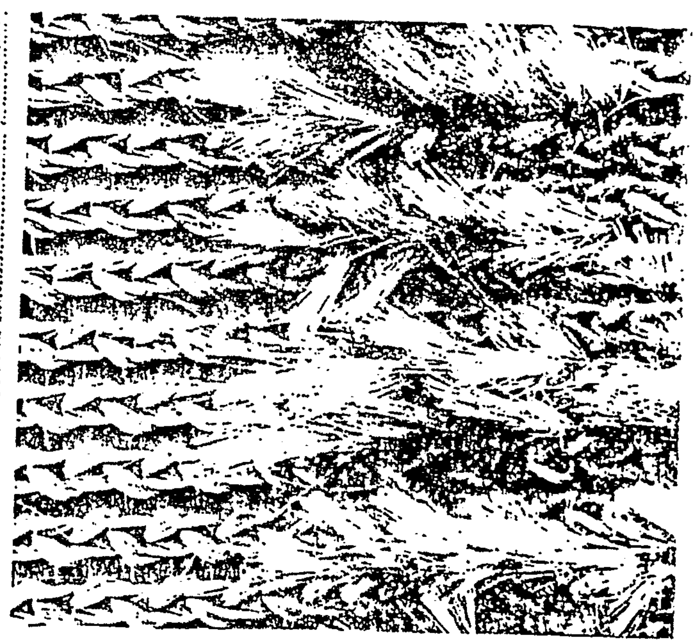

FIG.-42-

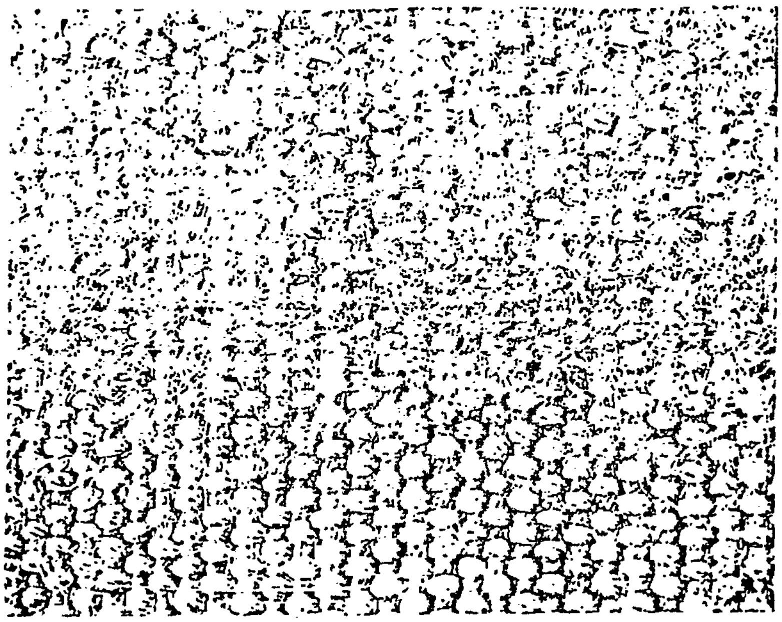

FIG. - 43 -

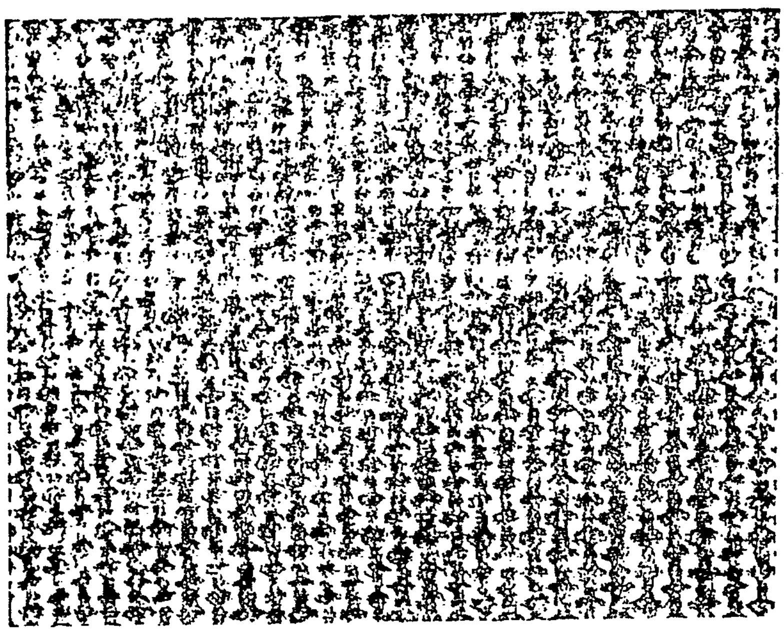

FIG. - 44 -

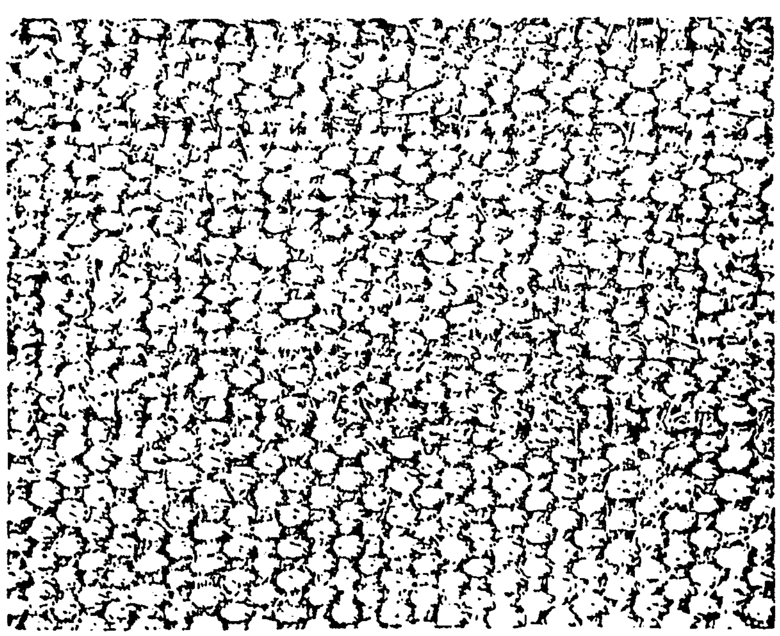

FIG. - 45 -

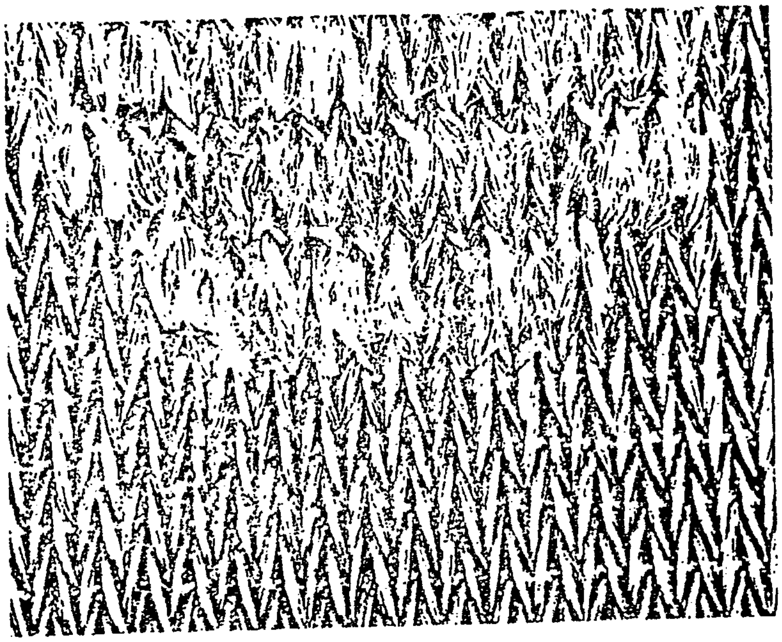

FIG. - 46 -

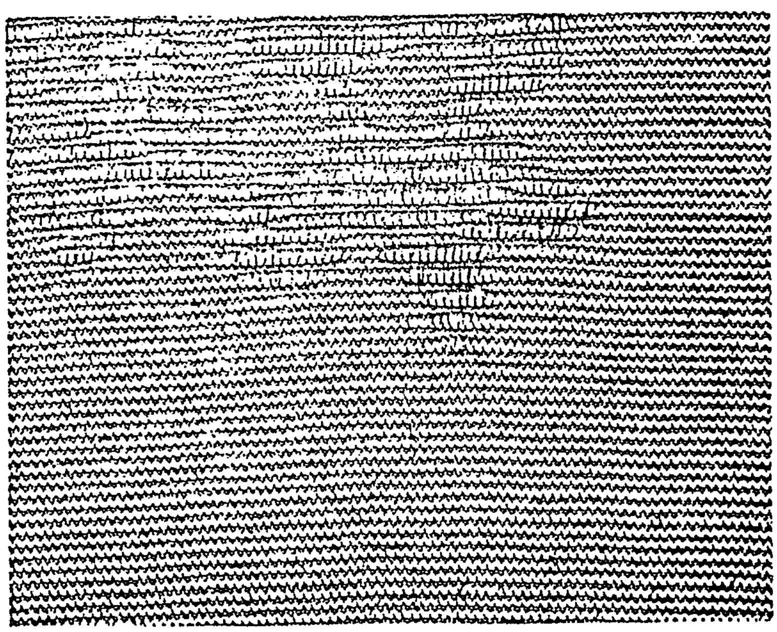

FIG. - 47 -

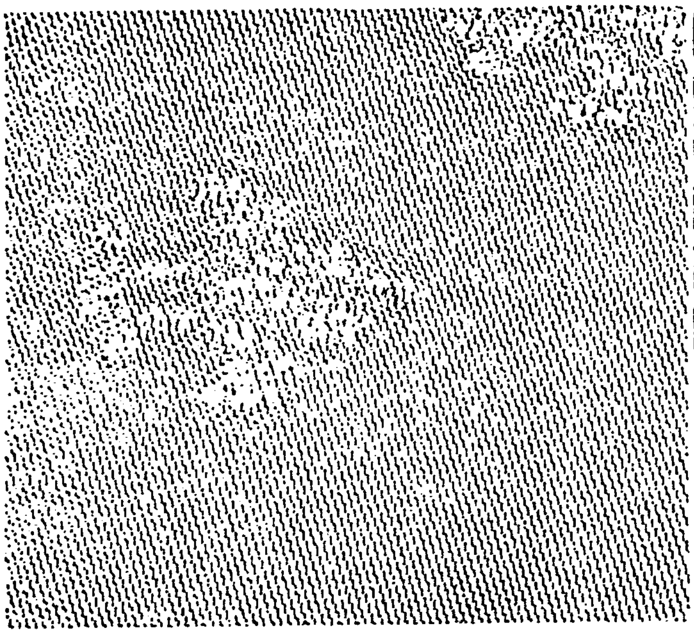

FIG. - 48 -

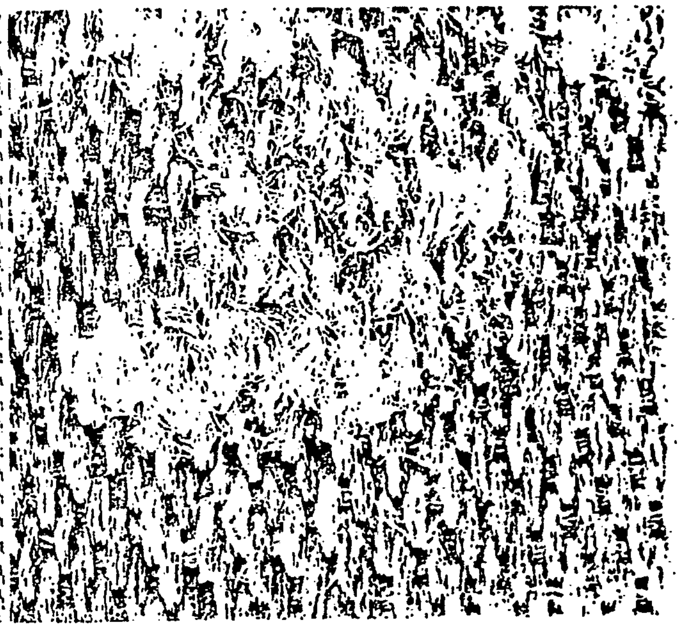

FIG. - 49 -

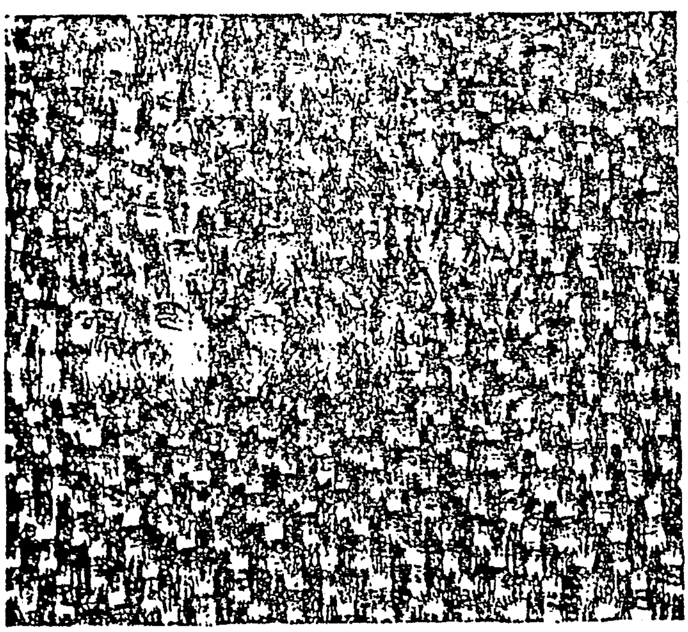

FIG. - 50 -

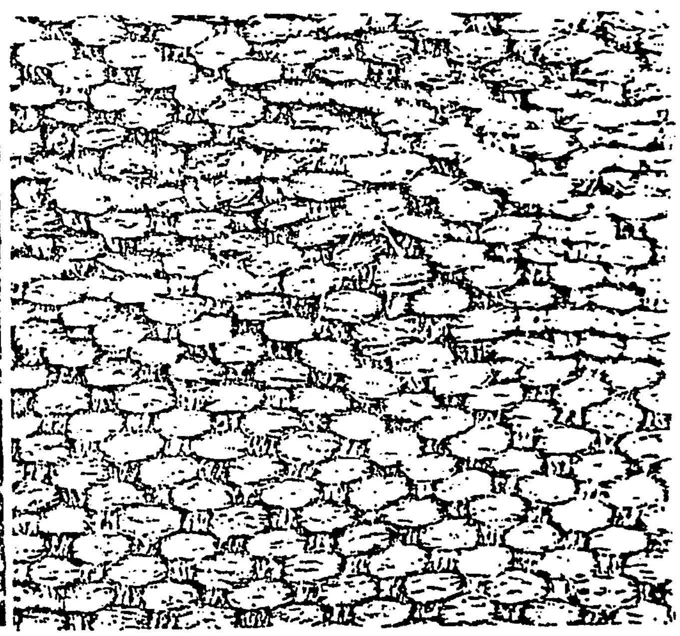

FIG. - 51 -

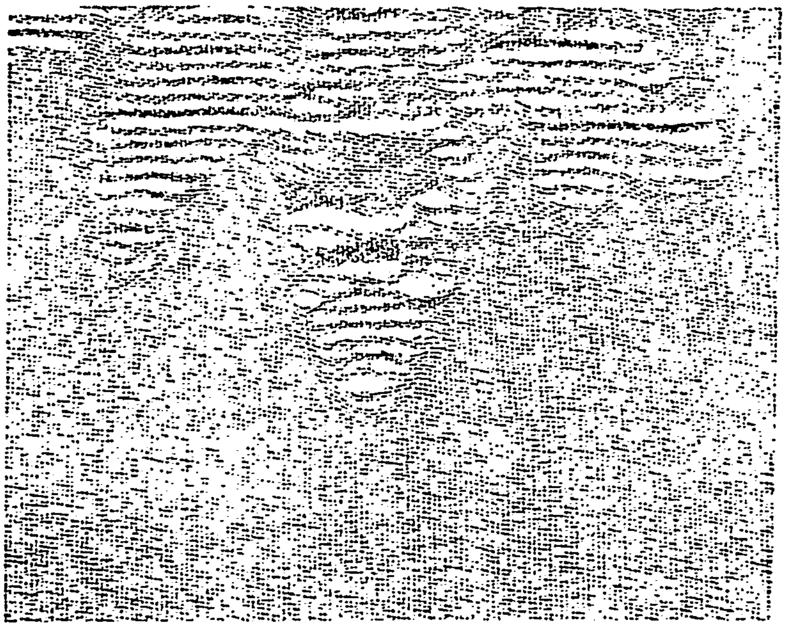

FIG. - 52 -

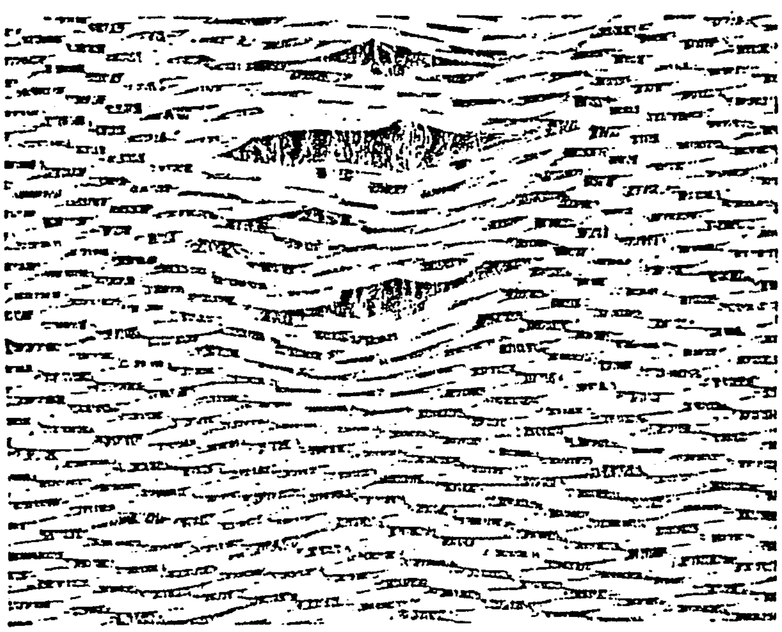

FIG. - 53 -

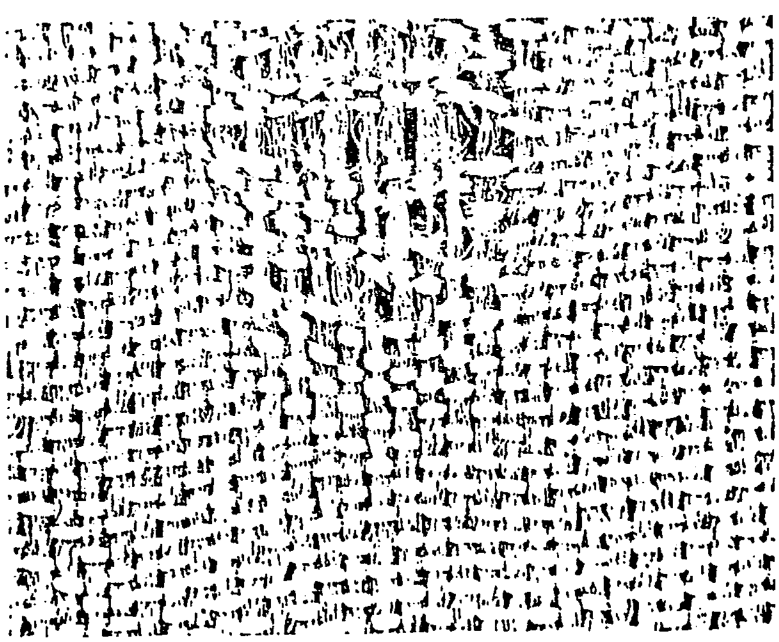

FIG. - 54 -

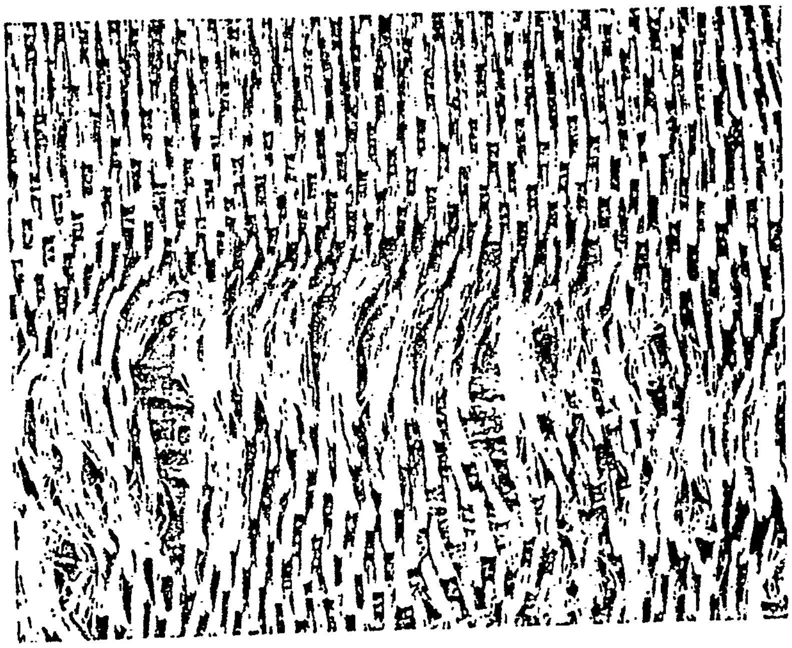

FIG. - 55 -

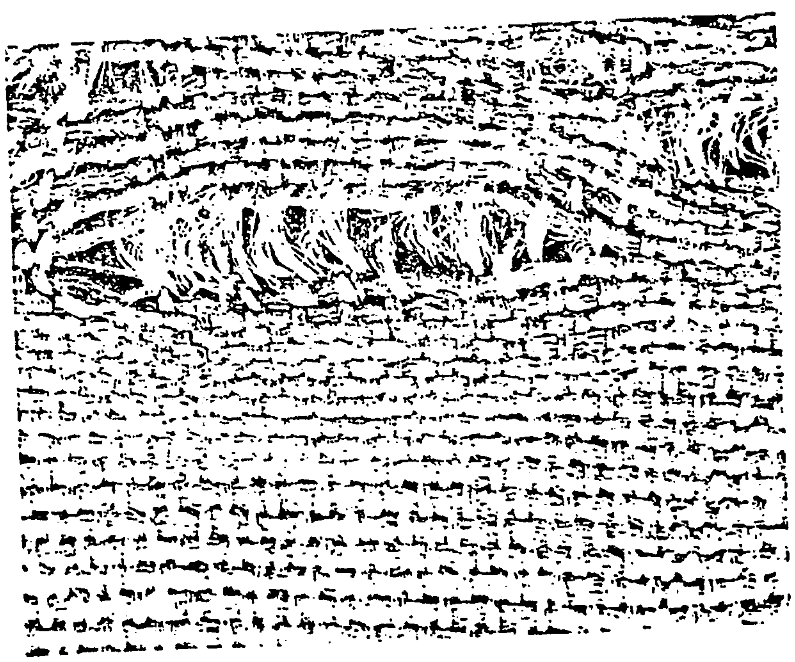

FIG. - 56 -

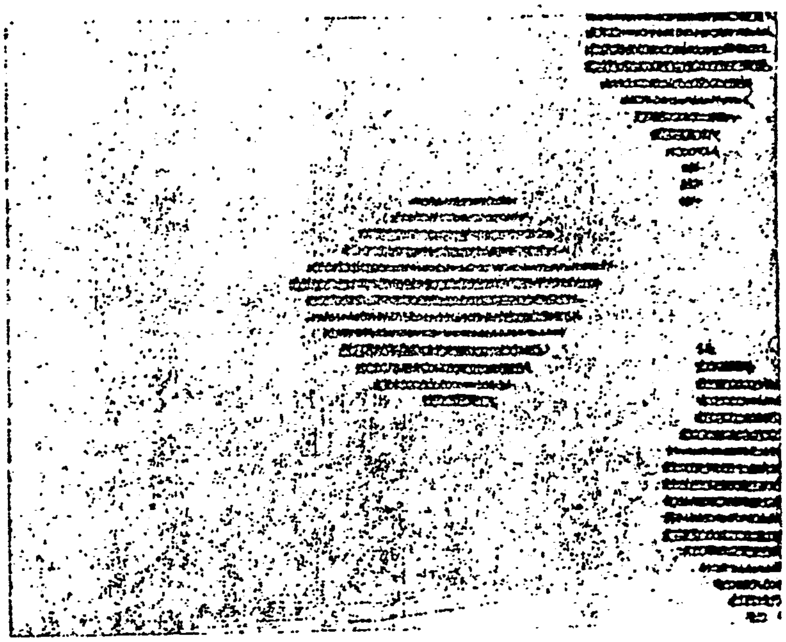

FIG. - 57 -

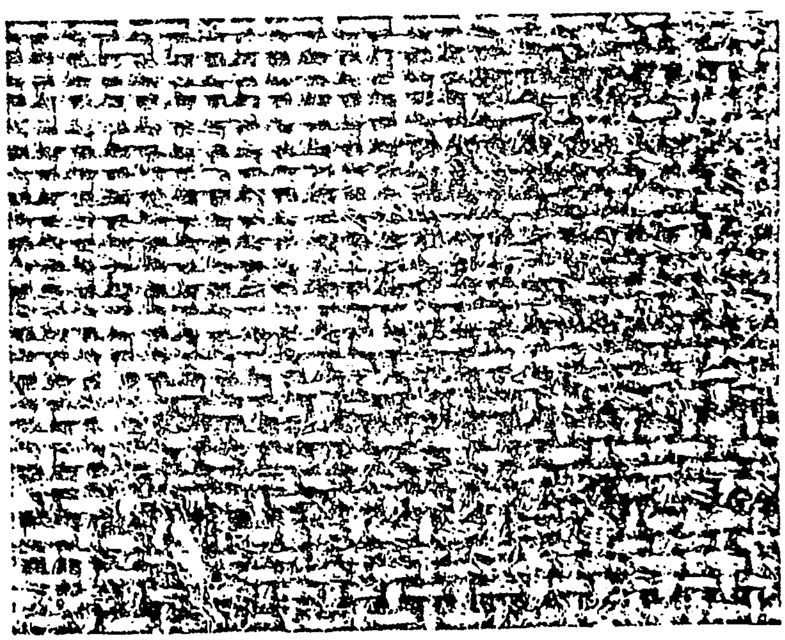

FIG. - 58 -

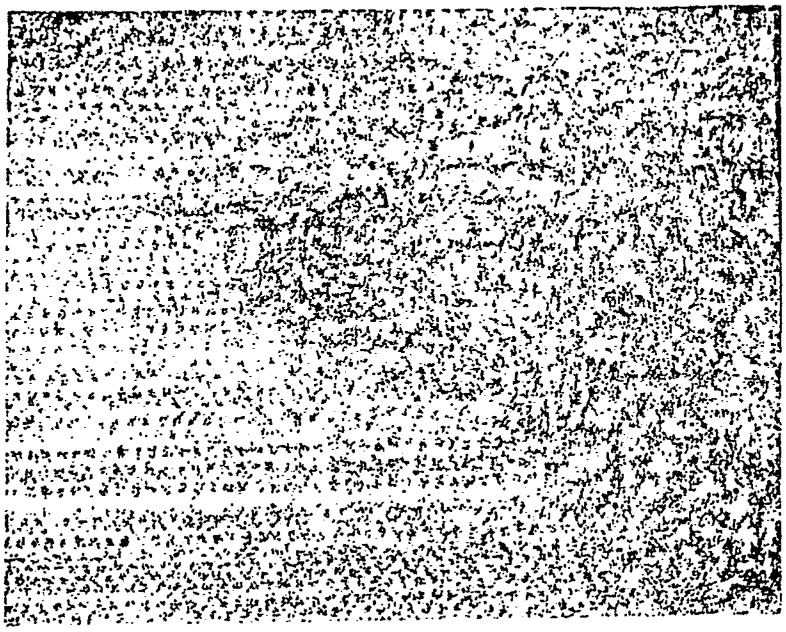

FIG. - 59 -

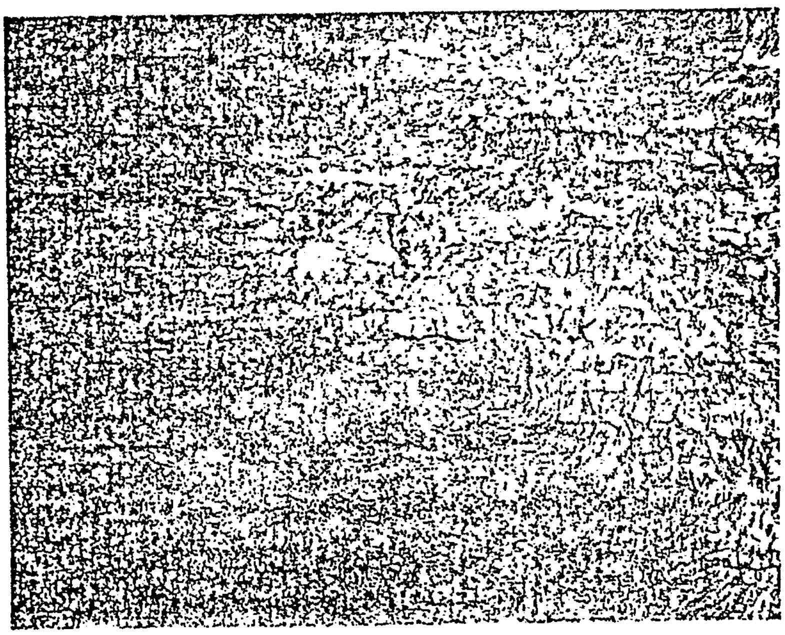

FIG. - 60 -

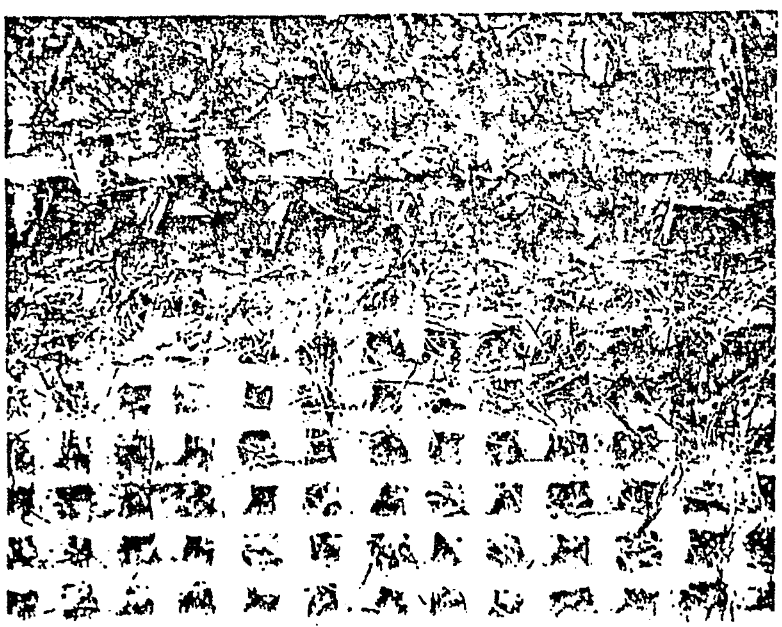

FIG. - 61 -

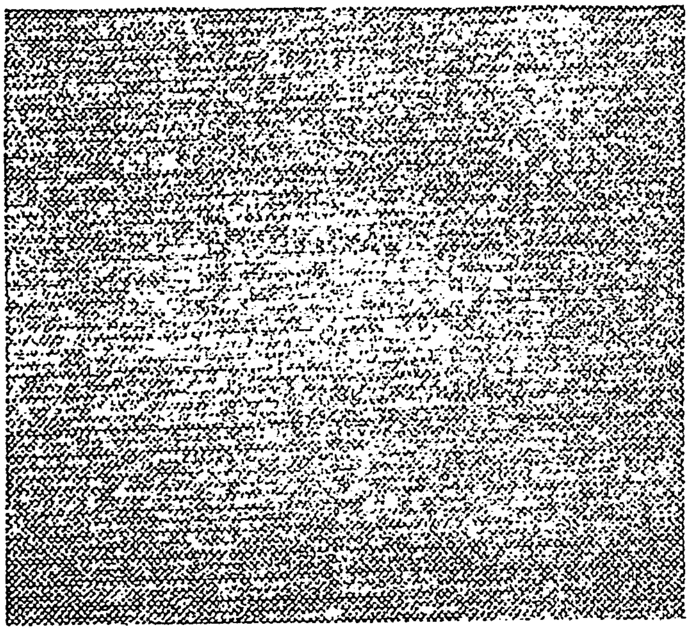

FIG. - 62 -

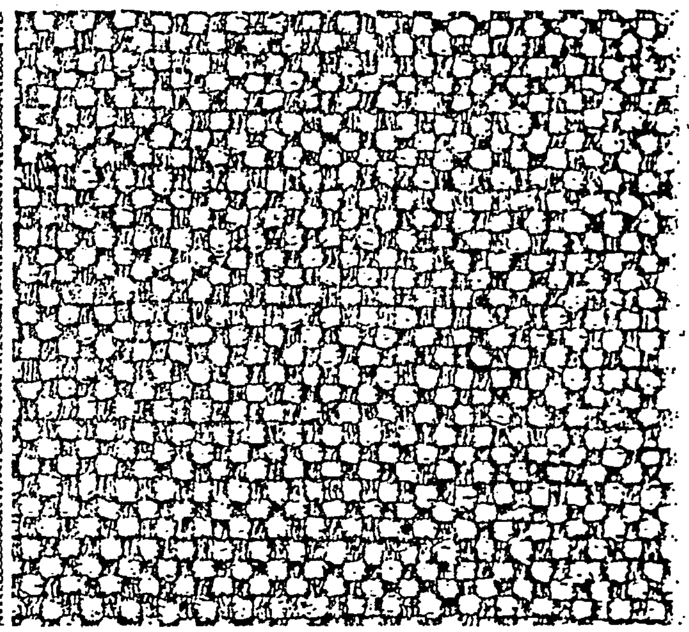

FIG - 63

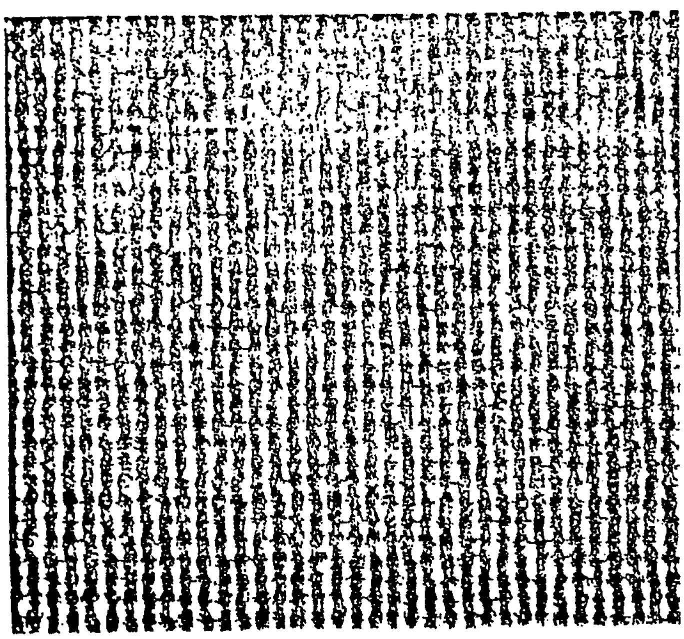

FIG. - 64 -

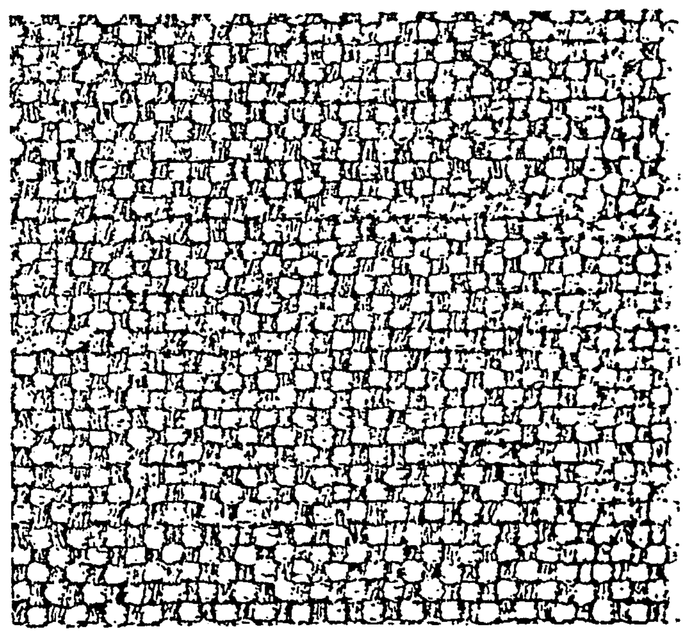

FIG. - 65 -

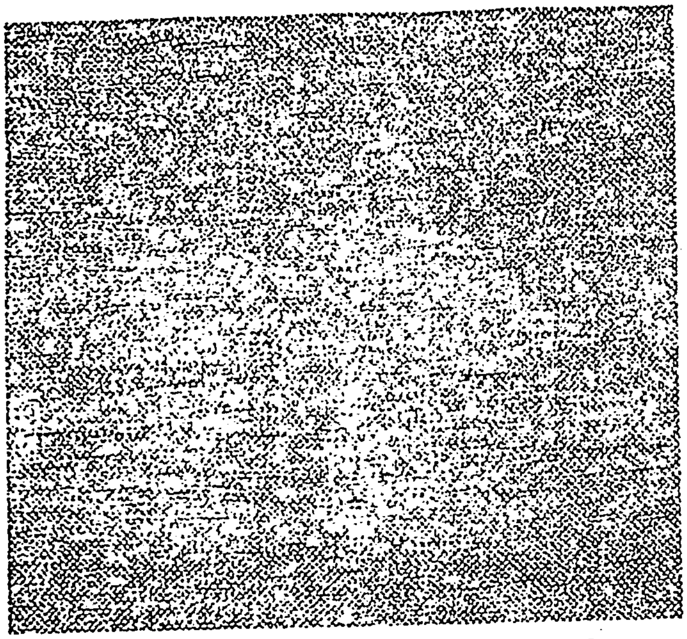

FIG.-66-

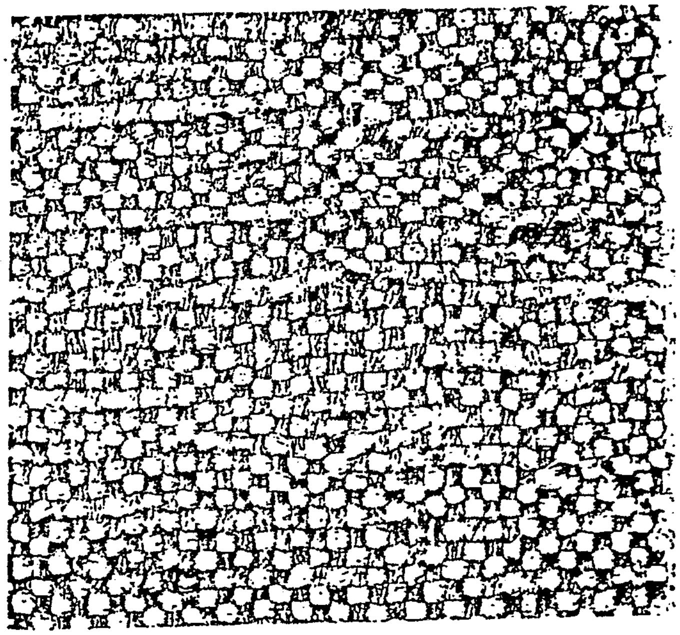

FIG.-67-

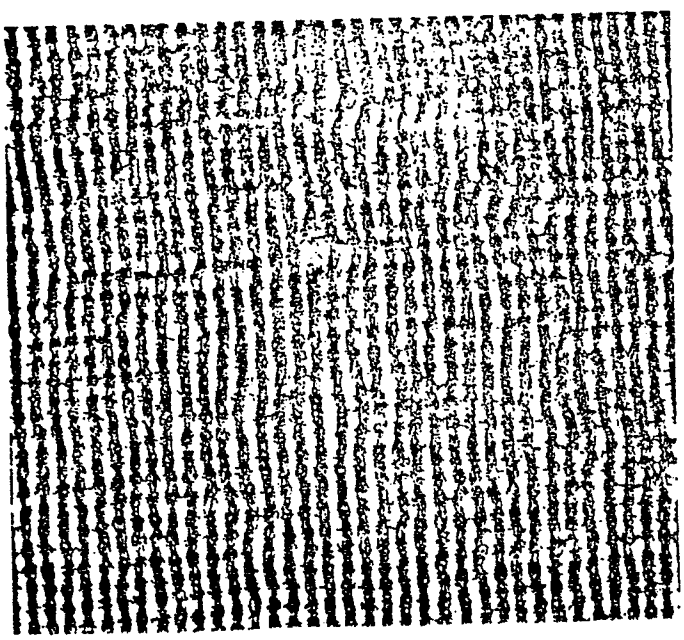

FIG.-68-

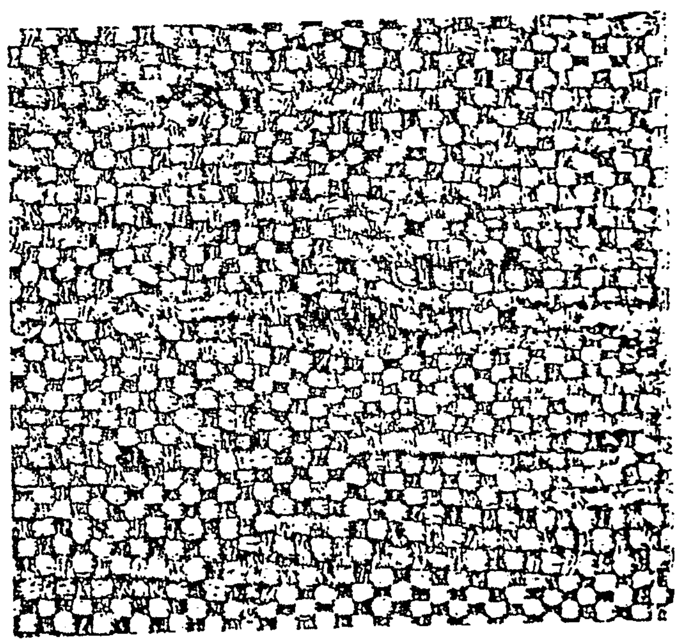

FIG.-69-

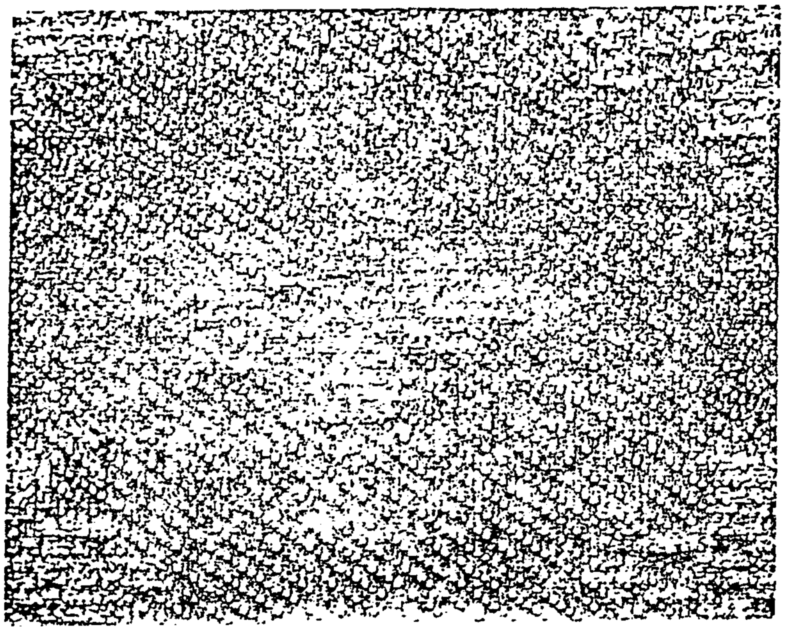

FIG. -70-

FIG. -71-

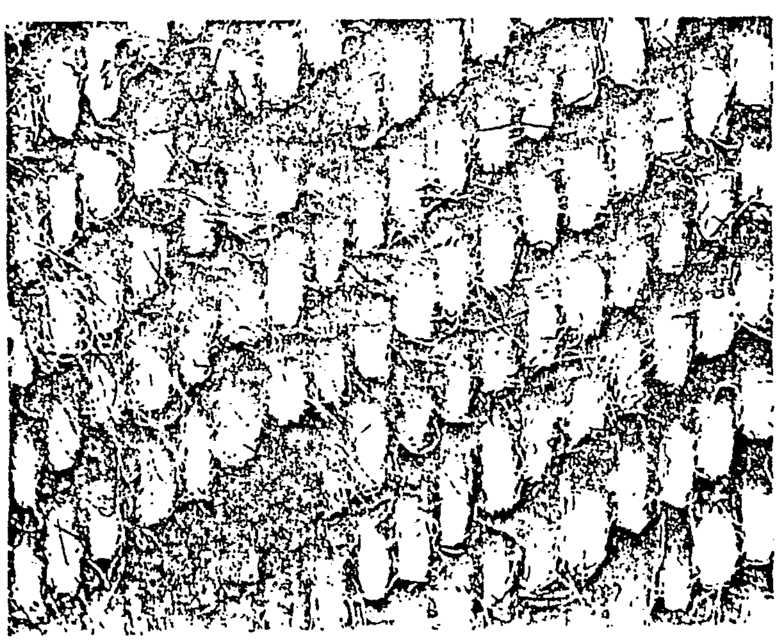

FIG. -72-

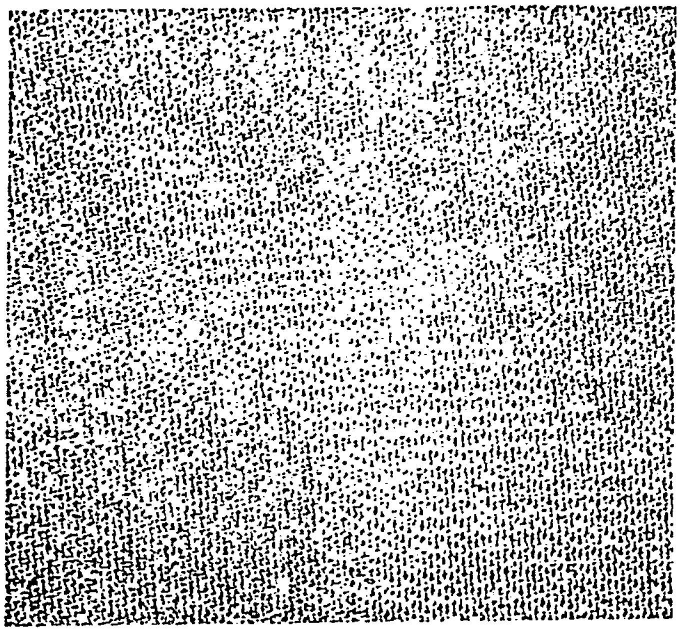

FIG. -73-

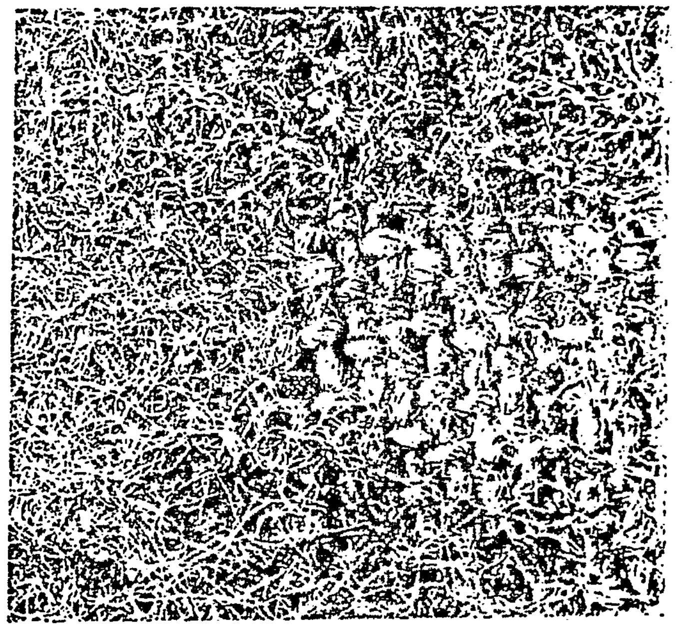

FIG. -74-

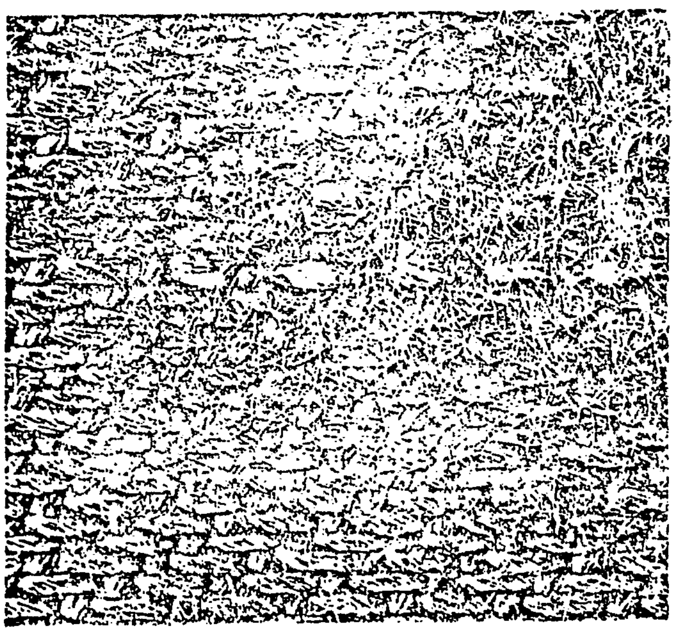

FIG. -75-

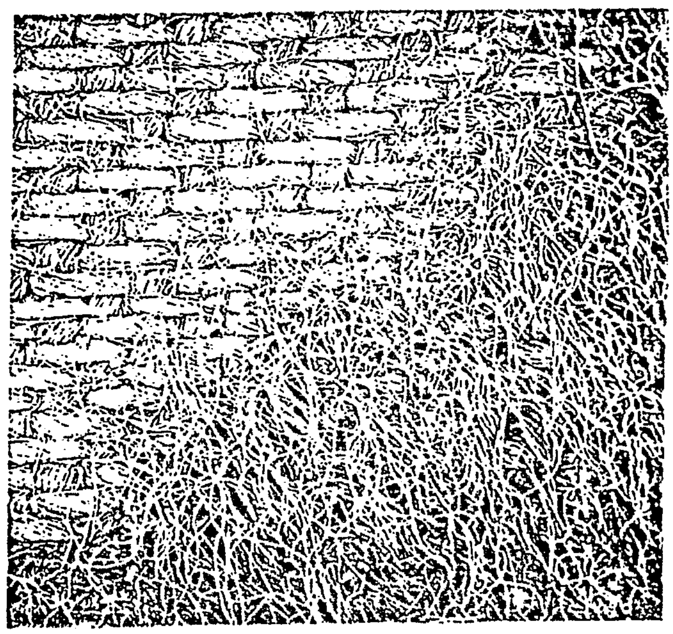

FIG. -76-

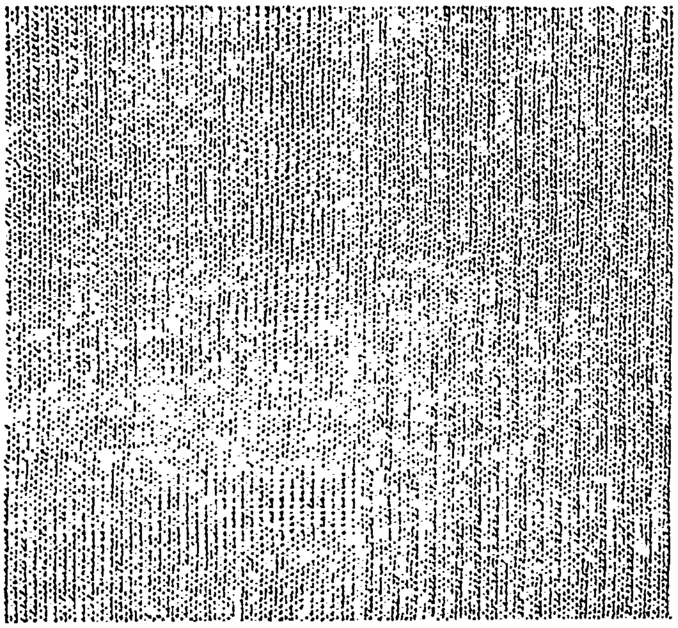

FIG. - 77 -

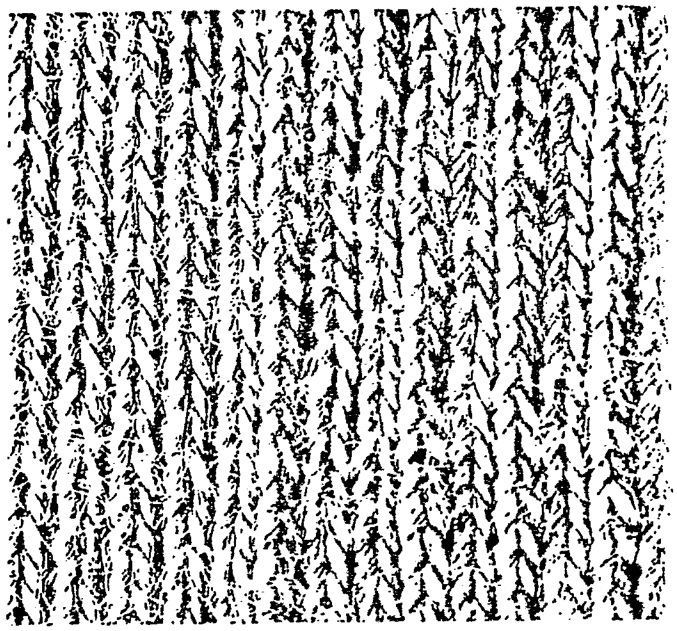

FIG. - 78 -

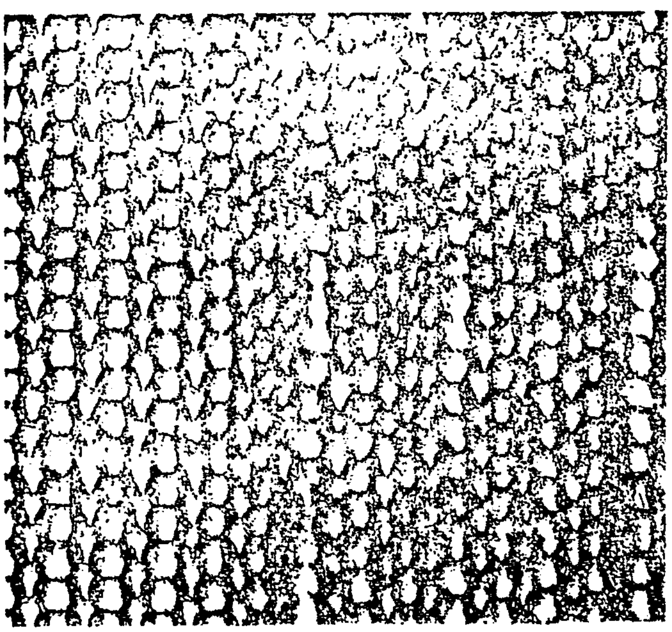

FIG. - 79 -

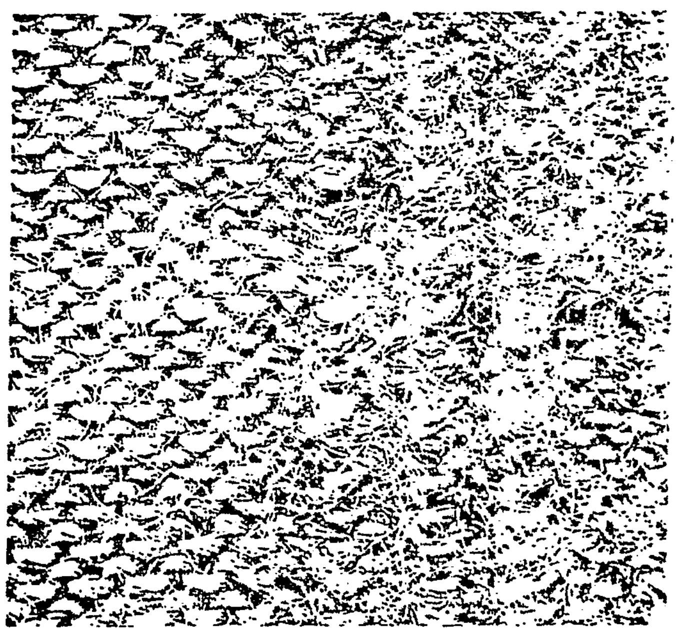

FIG. - 80 -

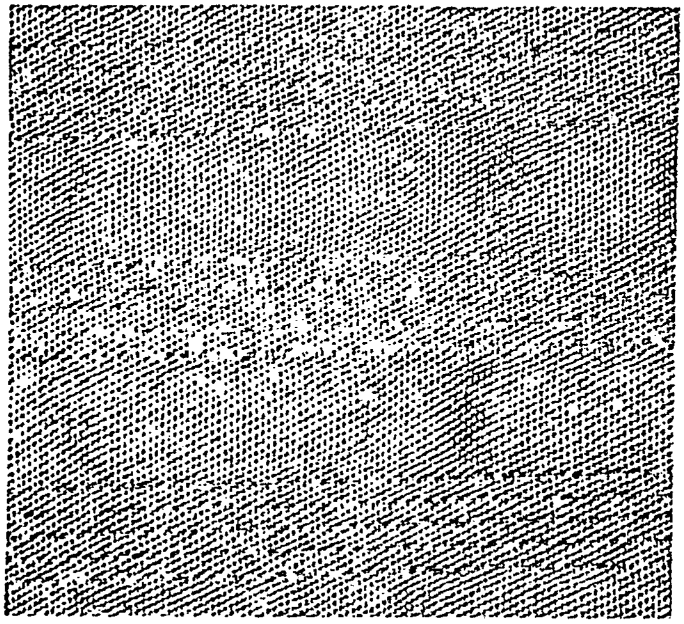

FIG. - 81 -

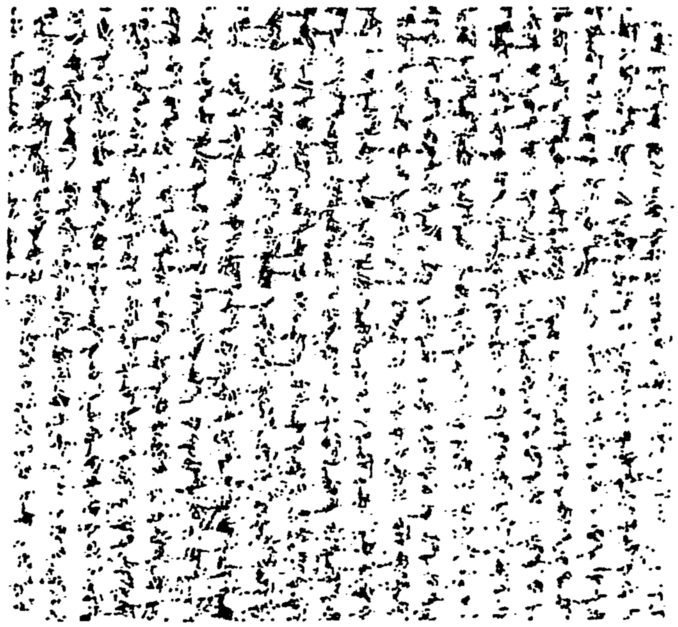

FIG. - 82 -

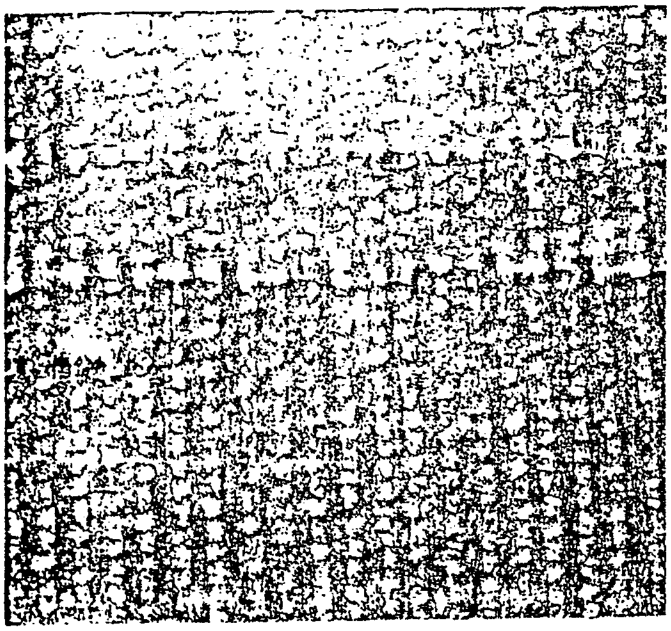

FIG. - 83 -

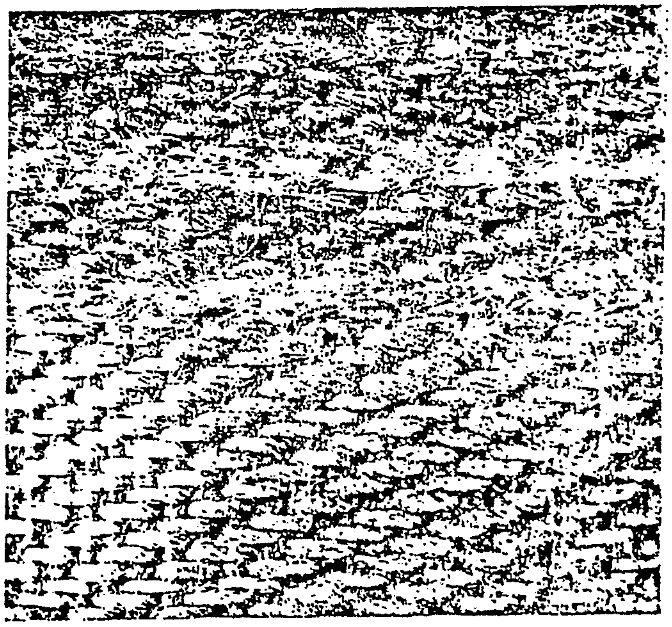

FIG. - 84 -

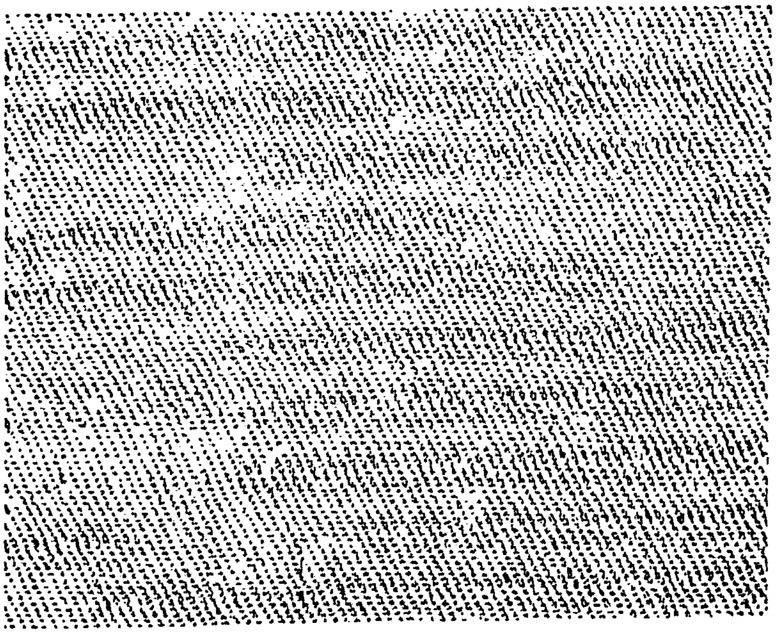

FIG. - 85 -

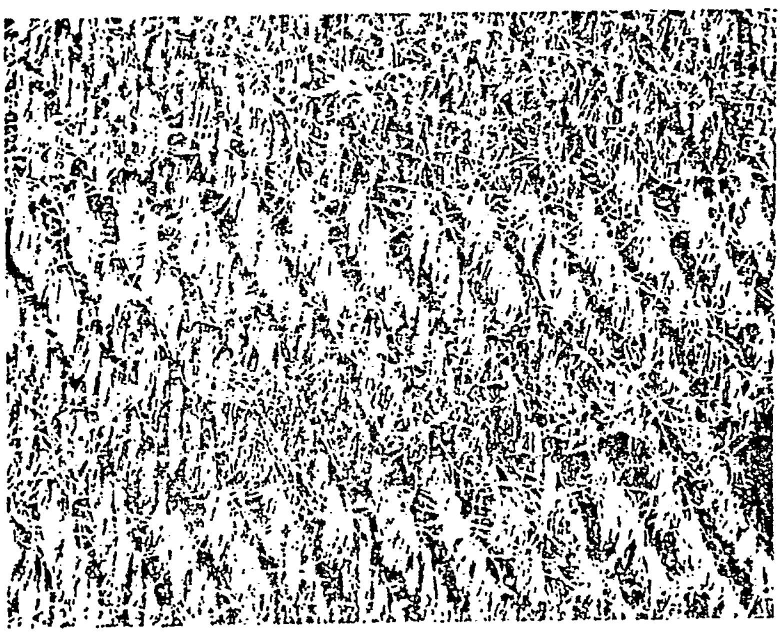

FIG. - 86 -

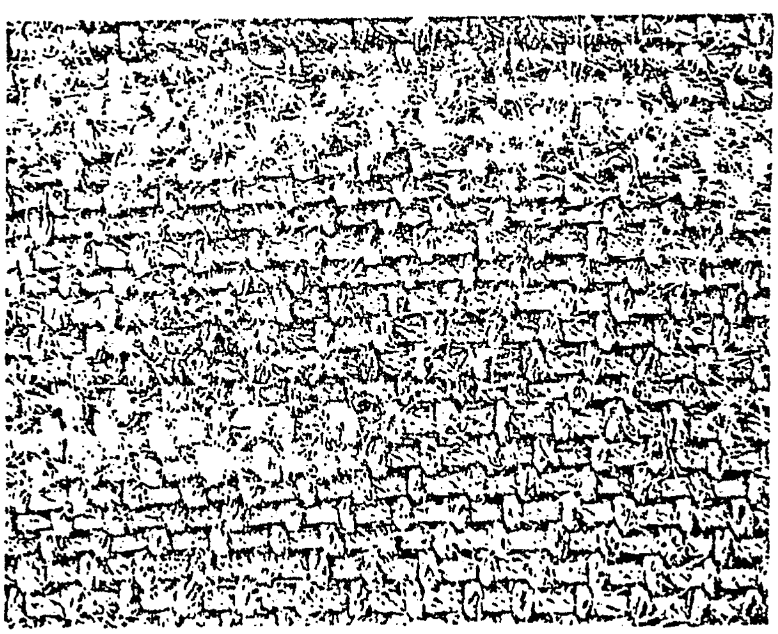

FIG. - 87 -

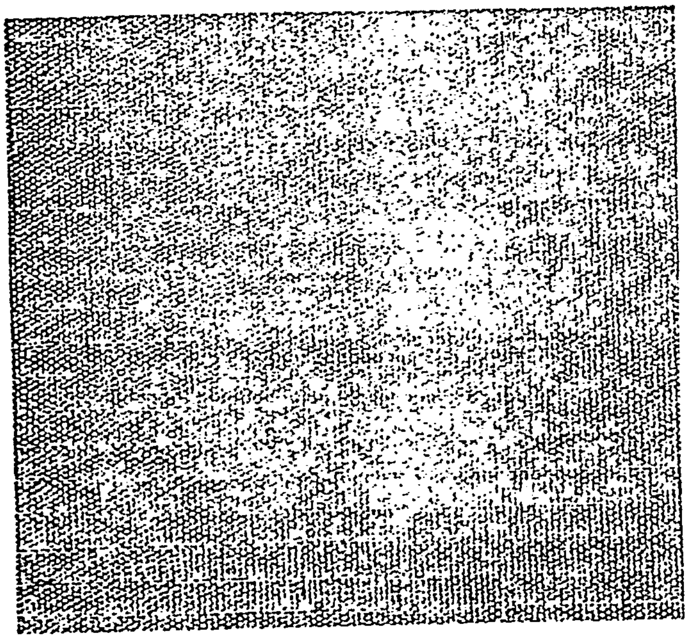

FIG. - 88 -

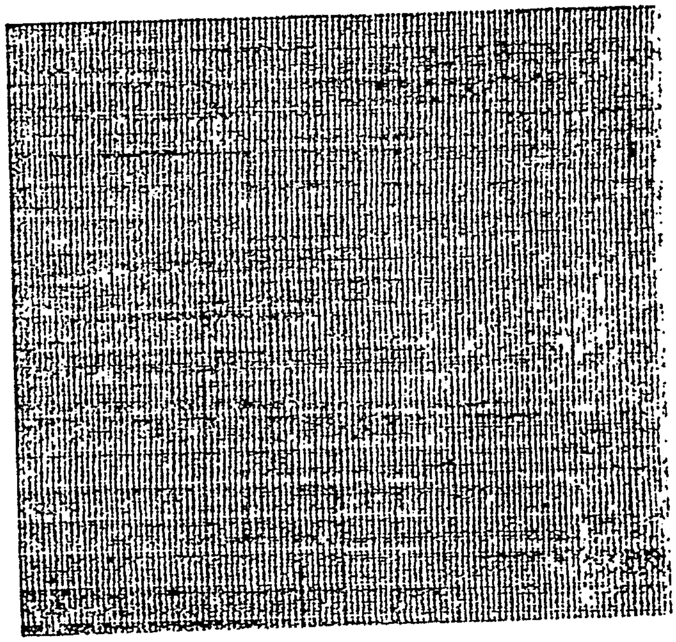

FIG. - 89 -

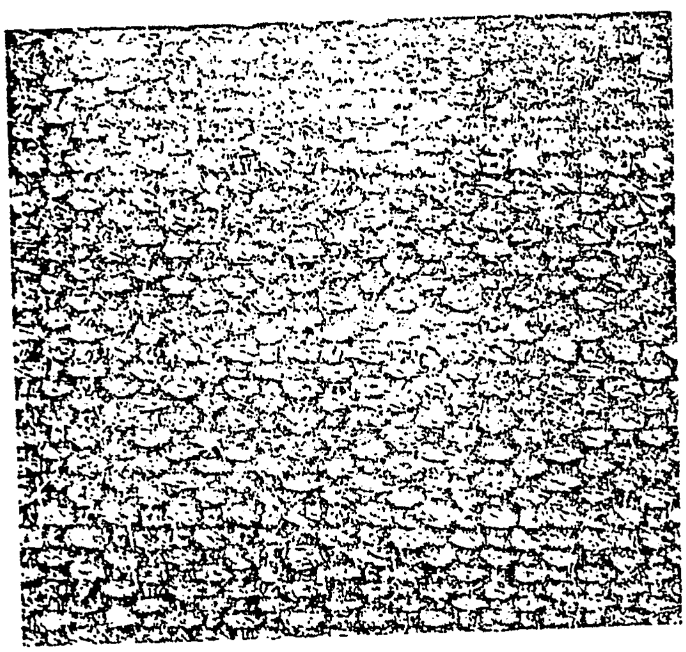

FIG. - 90 -

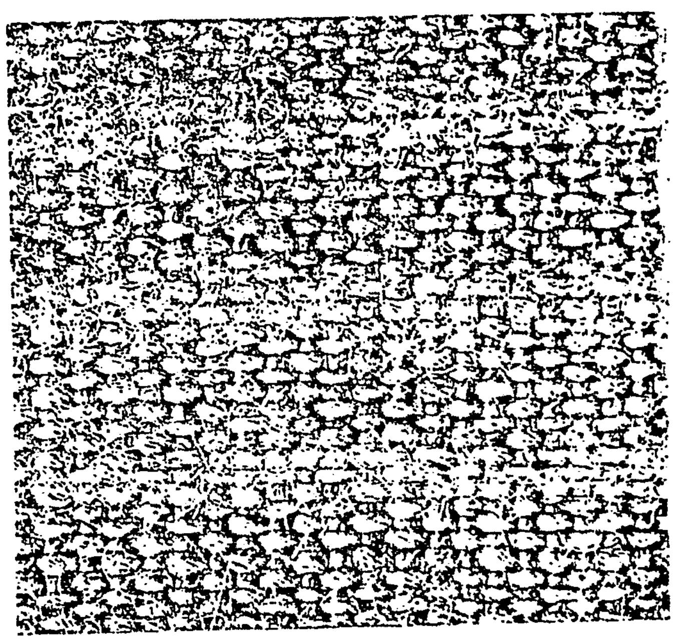

FIG. - 91 -

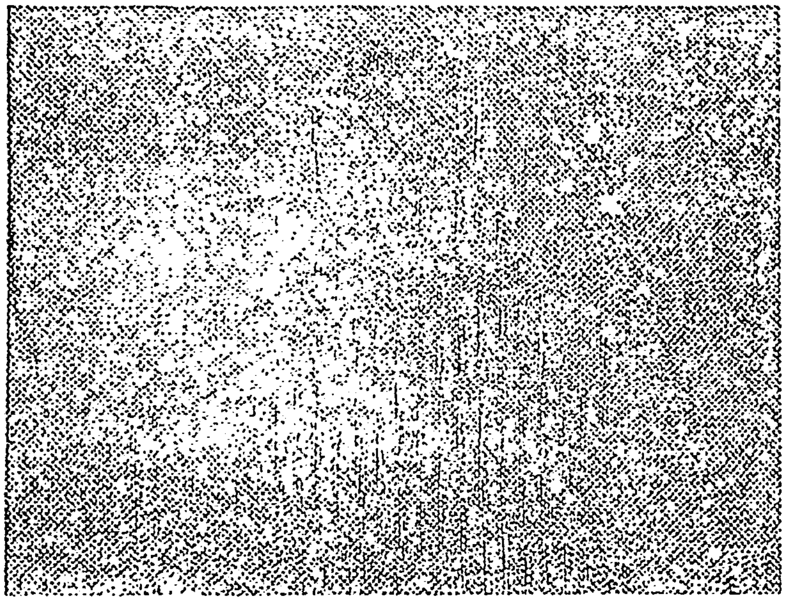

FIG. - 92 -

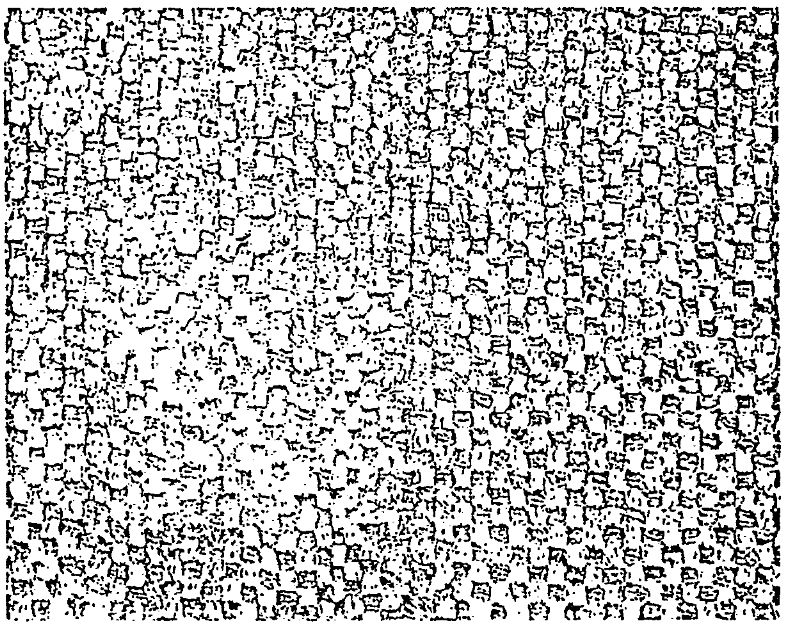

FIG. - 93 -

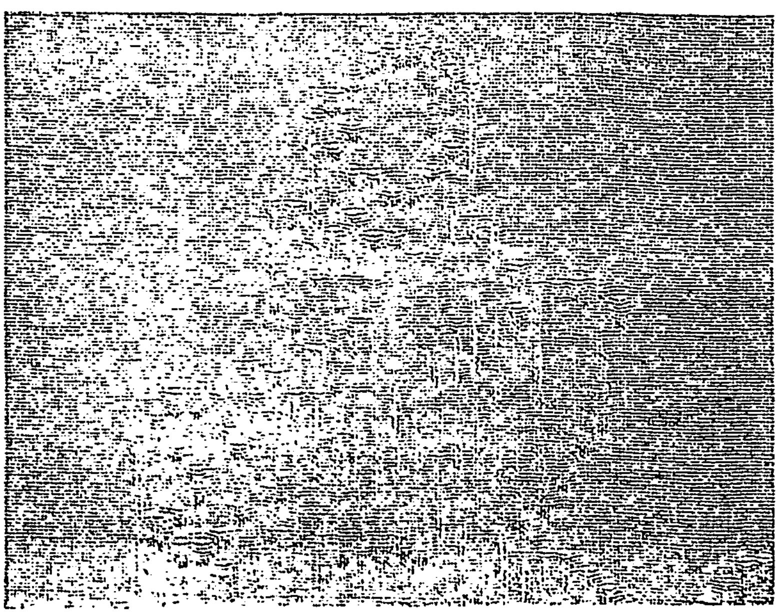

FIG. - 94 -

European Patent Office

EUROPEAN SEARCH REPORT

0177277 Application number

EP 85 30 6852

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 4)
A	EP-A-0 099 639 (MILLIKEN) ---		D 06 C 23/04
A	US-A-3 635 625 (PHILIPS PETROLEUM) ---		
A	US-A-4 471 514 (MILLIKEN) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			D 06 C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	08-01-1986	PETIT J.P.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO Form 1503 03 82