PATENT SPECIFICATION (11) 1 604 784

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(21) Application No. 24579/78 (22) Filed 30 May 1978
(31) Convention Application No. 52/064290 (32) Filed 31 May 1977 in
(33) Japan (JP)
(44) Complete Specification published 16 Dec. 1981
(51) INT. CL.³ B29F 3/12
(52) Index at acceptance
B5A 1G10 1G2 1G7A1 1G7AX 1G7B 1R314C1X 1R457 T17D

(54) METHOD AND APPARATUS FOR PRODUCING A THERMOPLASTICS SHEET WITH COMPLEX FLOWING PATTERN

(71) We, DAICEL LIMITED, a Japanese Company of No. 1 Teppo-cho, Sakai-shi, Osaka, Japan, do hereby declare the invention for which we pray that a Patent may be granted to us and the method by which it is to be performed to be particularly described in and by the following statement:–

This invention relates to a method of and apparatus for producing a thermoplastics sheet having a decorative pattern therein.

Heretofore, various techniques have been proposed for producing flat or three dimensional patterns in plastics sheets. They are generally grouped into two categories:–

1. Introducing differently coloured, pattern-forming polymer streams (simply referred to as "differently coloured streams" hereinafter) from separate extruders under continuous or pulsating pressure into a matrix polymer stream (simply referred to as "matrix stream" hereinafter) as the matrix stream from a main extruder passes through an extrusion die. In this procedure, various attractive patterns, either in two- or three-dimensional configuration, can be obtained by selecting the points of introduction of the differently coloured streams into the matrix stream, the types of colouring agents or pigments, and the number and quantity of the differently coloured stream pulses being introduced.

2. Mixing coloured polymers having different melt indexes in the matrix stream before the matrix stream enters the die, so that the coloured polymers become molten one after another because of the difference in melt index in the matrix polymer, thus forming differently codloured patterns in the polymer mixture as it passes through the die.

Combinations of these two procedures have also been proposed and disclosed, for example, in Japanese Laid Open Specification No. 51-109954. Typical examples of the above procedures are those disclosed in U.S. Patent No. 2 803 041, Japanese Patent Publication Nos. 39-24132, 52-12221, and Japanese Laid Open Specification Nos. 48-49849 and 49-93480.

In the prior techniques disclosed in U.S. Patent No. 2 803 041, Japanese Patent Publication Nos. 39-24132, 52-12221, and Japanese Laid Open Specification No. 48-49849, the patterns produced in the matrix are of a single or multi-layer structure which are generally linear and extend parallel to the surface of the sheet. By contrast, the pattern produced by the method disclosed in Japanese Laid Open Specification No. 49-93480 consists of two differently coloured intersecting bands having spaced arcuate configurations when the sheet is viewed in transverse cross section. Thus this technique provides a three-dimensional, complicated design compared with the plain laminar pattern produced by the previously mentioned techniques.

The present invention provides an improved method for producing thermoplastics sheets having patterns of more complicated, three dimensional, flowing appearance which cannot be produced by any of the above previous techniques and which is particularly adapted for optical frames.

In one aspect, the invention resides in a method of producing an extruded thermoplastics sheet having a decorative pattern encapsulated in a matrix, including the steps of dividing a matrix stream into two branch streams flowing in opposite directions around a hollow die member disposed in a material flow passage of an extrusion die, the branch streams recombining together at the side of the die member remote from the branching point, intermittently, producing each of two or more individual streams of differently coloured polymers in said hollow die member, delivering said differently coloured polymer streams through openings in said hollow die member so that they enter the recombined matrix stream in the direction of extrusion and collecting together the differently coloured polymer streams as or before they encounter the recombined matrix stream.

In a further aspect, the invention resides in a method of producing a thermoplastics sheet having a decorative pattern encapsulated in a matrix, including the steps of

dividing a matrix thermoplastics polymer stream into two branch streams flowing in opposite circumferential directions around a hollow die member disposed in a material flow passage of an extrusion die, introducing two or more differently coloured polymer streams each from a respective perforated cylindrical tube rotating in individual chambers of the said hollow die member into a further die member, said coloured polymer streams being delivered through openings in said hollow die member and collected together in said further die member when the perforations of said rotating tubes are brought into alignment with said openings in said hollow die member, and introducing the collected differently coloured polymer streams from said further die member into said matrix stream at or near a point where said branch matrix streams are re-combined together.

Preferably, the surface of the further die member facing the junction of said branch stream includes projections and/or indentations which cause disturbance of the branch streams as or before they are re-combined together.

According to yet a further aspect, the present invention resides in apparatus for producing an extruded thermoplastics sheet having a decorative pattern encapsulated in a matrix, comprising a main extruder for supplying a matrix polymer stream, auxiliary extruders for extruding individual differently coloured polymer streams, an extrusion die having a matrix flow passage communicating with said main extruder, a hollow die member located in said flow passage to divide said flow passage into two branching passages extending around said hollow die member, said hollow die member including an elongate slot opening to the junction of said branching matrix passages, and two or more individual cylindrical chambers rotatably receiving perforated tubes communicating with said auxiliary extruders, power means for rotating said perforated tubes in said chambers, said hollow die member including openings connecting said chamber with said slot in said hollow die member and communicating intermittently with the perforations of said perforated rotating tubes during said rotation of the tubes, and a further die member disposed in the slot in said hollow die member, said further die member including a cavity for collecting together said coloured polymer streams delivered through said openings, and said cavity communicating with said matrix flow passage so that said differently coloured polymer streams collected in said cavity are conducted into said matrix stream.

Referring to the drawings;

Fig. 1 is a plan view of extrusion apparatus in accordance with one example of the present invention,

Fig. 2 is a longitudinal cross sectional view taken along the path of the matrix polymer stream through the die body of Fig. 1,

Fig. 3 is a plan view showing a hollow die member of Fig. 1,

Fig. 4 illustrates a cross section taken along line A-A of Fig. 3,

Figs. 5, 7, 9, 11 and 13 are plan views of various forms of further die members,

Figs. 6, 8, 10, 12 and 14 are sectional views of the above mentioned further die members,

Fig. 15 is a plan view showing a rotating tube of the apparatus shown in Figure 1,

Fig. 16 illustrates a pattern produced by using the further die member of Figs. 5 and 6,

Fig. 17 illustrates another pattern produced by using the further die member of Fig. 9 and 10.

Fig. 18 illustrates a modified pattern produced with the further die member of Fig. 11 and 12 and,

Fig. 19 illustrates a modified pattern produced with the further die member of Fig. 13 and 14.

Referring to Figures 1 to 4 and Figure 15 the apparatus of said one example comprises a main extruder (1), auxiliary extruders (2), (3), a die body (7), a connecting tube (4) between the main extruder (1) and the die body (7), connecting tubes (5), (6) between the auxiliary extruders (2), (3) respectively and the die body (7), a hollow die member (9) disposed in an ellipsoidal chamber of the die body, (7), cylindrical tubes (13), (16) formed with perforations (15), (18) respectively and rotatably fitted in cylindrical chambers (14), (17) respectively of the hollow die member (9), a further die member (21) fitted in a complimentary elongate slot (27) of the hollow die member (9), and power means (10), (11) for imparting rotation to the tubes (13), (16) in their respective chambers (14), (17).

A stream (8) of a matrix polymer from the main extruder and streams of differently coloured pattern-forming polymers from the separate auxiliary extruders are conducted to the die body (7) through the conduits (4), (5), (6) respectively in a well-known manner. The matrix stream (8) introduced into the ellipsoidal chamber of the die body (7) is divided into two branch streams (8_1), (8_2) by the hollow die member (9) which has an outer surface spacedly conforming to the ellipsoidal chamber walls of the die body, as shown in Fig. 4. The branch streams (8_1), (8_2) are combined again at or near the outlet end of the chamber.

The differently coloured polymer streams conveyed from the auxiliary extruders (2),

(3) through the conduits (5), (6) are introduced into the tubes (13), (16) rotating in the hollow die member (9) and driven by the power means (10), (13). The slot (27) formed in the hollow die member is of a trapezoidal cross section facing the junction of the branch streams (8_1, (8_2), and communicates with the cylindrical chambers (14), (17) of the mandrel through spaced openings (19), (20). The further die member (21) is detachably fitted in the slot (27). The differently coloured streams are intermittently delivered from the rotating tubes into the slot (27) when the perforations (15), (18) are brought into alignment with the openings (19), (20) by the rotation of the tubes (13), (16).

The further die member (21) further includes one or more outlet ports (22) having a circular, ellipsoidal, rectangular or other cross sectional configuration opening into the matrix flow passage, and a part-cylindrical cavity (26) facing the openings (19), (20) for receiving the discontinuous streams of coloured polymers. The coloured polymer streams gathered in the cavity (26) are then delivered into the matrix stream at or near the junction point of the branch streams (8_1), (8_2), to form a complex flowing pattern in the matrix stream. The further die member (21) may be provided in the surface facing the recombined matrix stream (8) with grooves (indicated at 35 in Figures 8 and 7) or projecting lands (indicated at 43 in Figures 13 and 14) whereby a more complex flowing pattern of different colours is obtained.

Figures 5 to 14 illustrate various modified forms of further die member for use in the apparatus of the above example in place of the member (21). Thus in Figures 5 and 6, there is shown a further die member (29) which is formed with a plurality of longitudinally spaced circular cross-section outlet ports (31) communicating with respective cavities (30) which face the openings (19), (20). Each cavity (30) is of generally quadrantal cross section with the centre of the circle lying on the longitudinal axis of the die member (29) and with adjacent cavities (30) extending towards opposite longitudinal edges respectively of the die member. In Figures 7 and 8, there is shown a further die member (33) which is formed with a plurality of spaced, parallel grooves (35) presented to the recombined matrix stream (8) and extending diagonally across the member (33). At its opposite ends, each of the central grooves (35) communicates with respective outlet ports (34), while one end of each end groove (35) communicates with a single outlet port (34). A different further die member 36 is shown in Figures 9 and 10 and includes a single outlet port 37 in the form of an elongate slot extending through the die member. At the surface of the die member (36) facing the openings (19), (20), the port (37) communicates with a plurality of spaced, part spherical cavities arranged alternatively on opposite sides respectively of the port (37).

The further die members (21), (29), (33) and (36) are all of trapezoidal cross section and are accommodated within the complementary slot (27) of the hollow die member (9). However, in Figures 11 and 12 an alternative die member (38) is shown which is provided with a rectangular section projection (38a) which extends into the recombined matrix stream (8). The die member (38) is also formed with a plurality of longitudinally spaced outlet ports (40) which extend through the projection 38(a) and the remainder of the member (38) to communicate with an elongate cavity (39) facing the openings (19), (20). A similar arrangement is shown in Figures 13 and 14 in which a further die member (41) is provided with a plurality of spaced, triangular projections (43) extending into the recombined matrix stream (8). Each projection (43) is arranged so that its apex is aligned with the base of the adjacent projection and formed in each projection (43) is an outlet port 42 which extends through the body of the member (41) to communicate with a part-cylindrical cavity 42(a) facing the openings (19), (20).

Figure 16 illustrates a pattern which is obtained by using the further die member shown in Fig. 5 and which includes oval or ellipsoidal spots (51), (52) of different colours which are spaced along alternate lengthwise-extending paths at different depths in the thickness of the matrix sheet, and flowing materials (510), (520) connecting adjacent spots in each path.

Fig. 17 illustrates a modified pattern produced by using the further die member of Fig. 9, in which the different coloured spots (61), (62) are partially overlapped and are connected by flowing bands (610), (620).

Fig. 18 shows a more complex pattern obtained by using the further die member shown in Fig. 11 and which includes irregularly arranged tear-drop spots (71), (72), and narrow flowing bands (73), (74) of the different colours and combinations thereof disposed between the adjacent tear-drop spots.

Fig. 19 illustrates a further modified design produced by using the further die member shown in Fig. 13 and which comprises non-uniform irregularly connected swirl patterns including spaced wide portions (81), (82) and narrow bands (83) connecting the adjacent wide portions, both in complicated, combined colours.

The patterns of Figs. 16 to 19 are all three-dimensionally disposed across the

thickness of the matrix sheet.

Further variations in pattern can be obtained by increasing or decreasing the number of auxiliary extruders, changing the rotational speed of the rotating tubes, and by varying the shape and arrangement of the perforations in the rotating tubes as well as of the openings of the hollow die member to the die (7) chamber, of the outlet port of the further die member, and of the surface of the further die member facing the recombined matrix stream.

WHAT WE CLAIM IS:-

1. A method of producing an extruded thermoplastics sheet having a decorative pattern encapsulated in a matrix, including the steps of dividing a matrix stream into two branch streams flowing in opposite directions around a hollow die member disposed in a material flow passage of an extrusion die, the branch streams recombining together at the side of the die member remote from the branching point, intermittently producing each of two or more individual streams of differently coloured polymers in said hollow die member, delivering said differently coloured polymer streams through openings in said hollow die member so that they enter the recombined matrix stream in the direction of extrusion and collecting together the differently coloured polymer streams as or before they encounter the recombined matrix stream.

2. A method of producing a thermoplastic sheet having a decorative pattern encapsulated in a matrix, including the steps of dividing a matrix thermoplastics polymer stream into two branch streams flowing in opposite circumferential directions around a hollow die member disposed in a material flow passage of an extrusion die, introducing two or more differently coloured polymer streams each from a respective perforated cylindrical tube rotating in individual chambers of the said hollow die member into a further die member, said coloured polymer streams being delivered through openings in said hollow die member and collected together in said further die member when the perforations of said rotating tubes are brought into alignment with said openings in said hollow die member, and introducing the collected differently coloured polymer streams from said further die member into said matrix stream at or near a point where said branch matrix streams are recombined together.

3. A method as claimed in claim 2 wherein the surface of the further die member facing the junction of said branch streams includes projections and/or indentations which cause disturbance of the branch streams as or before they are recombined together.

4. Apparatus for producing an extruded thermoplastics sheet having a decorative pattern encapsulated in a matrix, comprising a main extruder for supplying a matrix polymer stream, auxiliary extruders for extruding individual differently coloured polymer streams, an extrusion die having a matrix flow passage communicating with said main extruder, a hollow die member located in said flow passage to divide said flow passage into two branching passages extending around said hollow die member, said hollow die member including an elongate slot opening to the junction of said branching matrix passages, and two or more individual cylindrical chambers rotatably receiving perforated tubes communicating with said auxiliary extruders, power means for rotating said perforated tubes in said chambers, said hollow die member including openings connecting said chamber with said slot in said hollow die member and communicating intermittently with the perforations of said perforated rotating tubes during said rotation of the tubes, and a further die member disposed in the slot in said hollow die member, said further die member including a cavity for collecting together said coloured polymer streams delivered through said openings, and said cavity communicating with said matrix flow passage so that said differently coloured polymer streams collected in said cavity are conducted into said matrix stream.

5. Apparatus as claimed in claim 4 for producing an extruded thermoplastics sheet having a decorative pattern encapsulated in a matrix, comprising a combination and arrangement of parts substantially as hereinbefore described with reference to, and as shown in, Figures 1 to 15 of the accompanying drawings.

6. A method as claimed in Claim 1 or Claim 2, of producing an extruded thermoplastics sheet having a decorative pattern encapsulated in a matrix substantially as hereinbefore described.

7. An extruded thermoplastics sheet having a decorative pattern encapsulated in a matrix produced by a method as claimed in any one of Claims 1, 2 and 6.

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Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1981. Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1604784 COMPLETE SPECIFICATION
8 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

FIG. 1

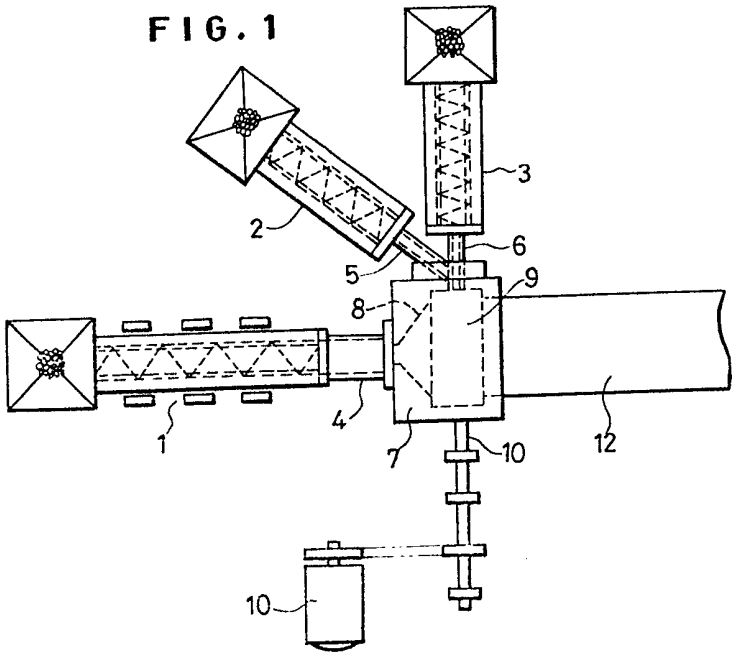
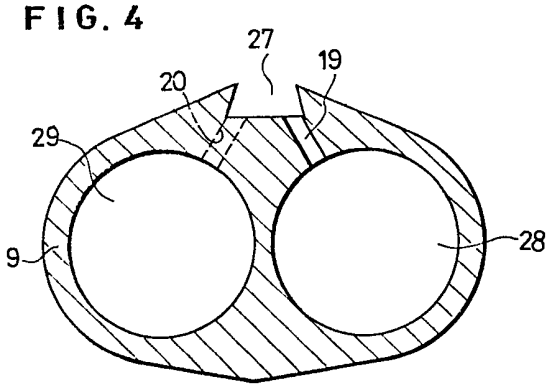


FIG. 4



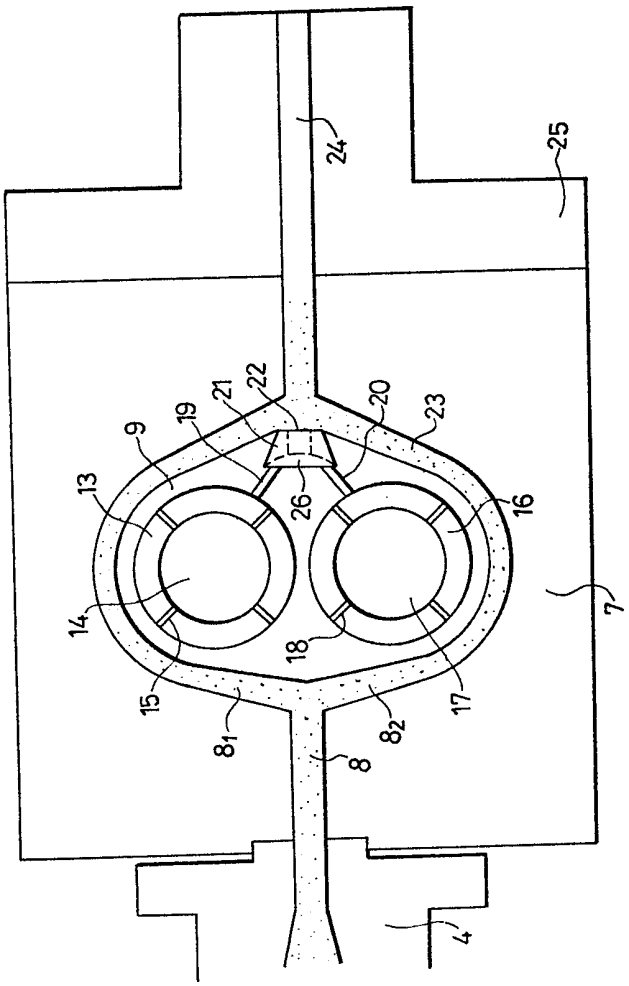


FIG. 2

FIG. 3

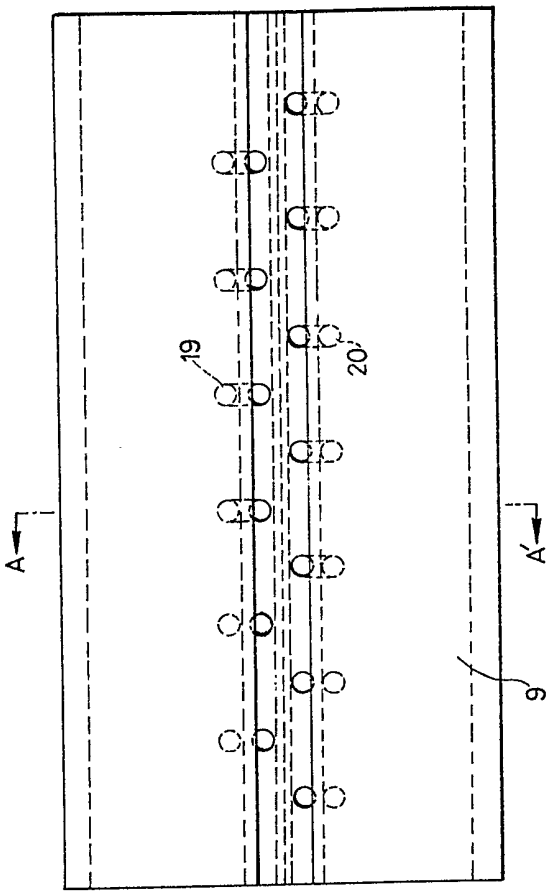


FIG. 5

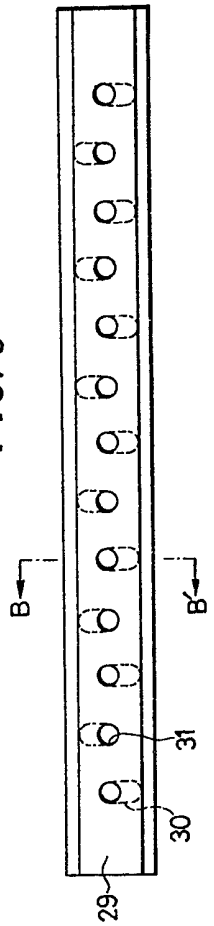


FIG. 7

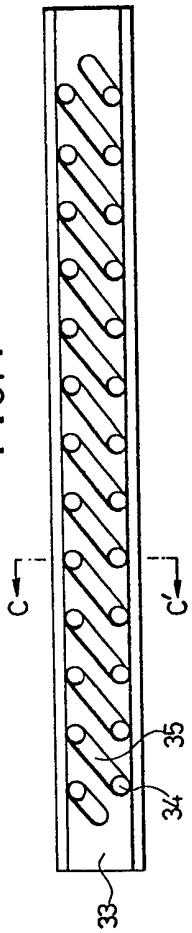


FIG. 8

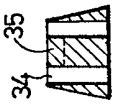


FIG. 6

FIG. 9

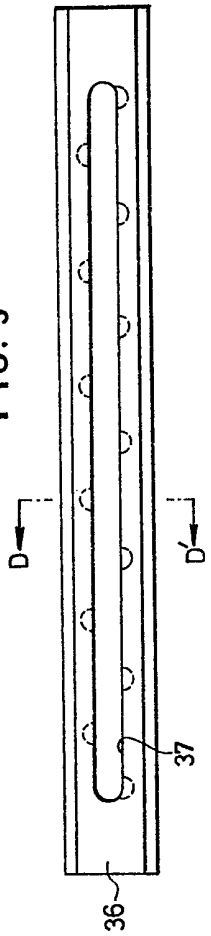


FIG. 11

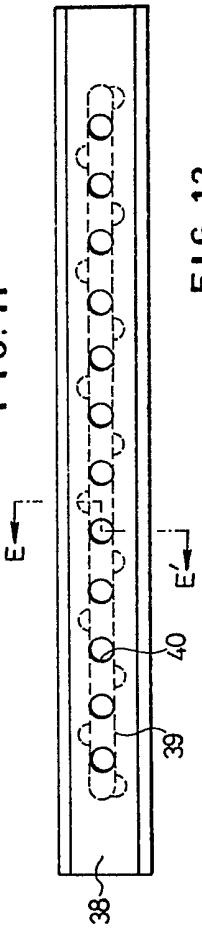


FIG. 12

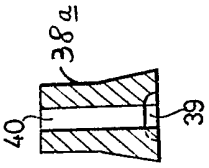


FIG. 10

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Sheet 6

FIG. 13

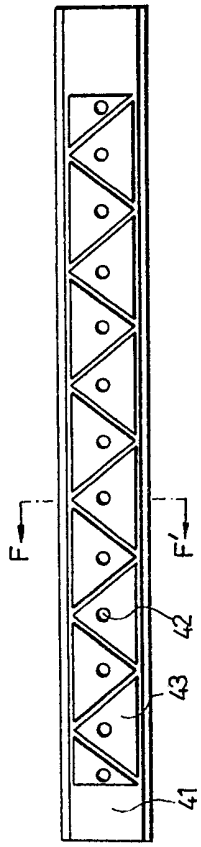

FIG. 14

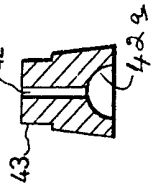

FIG. 15

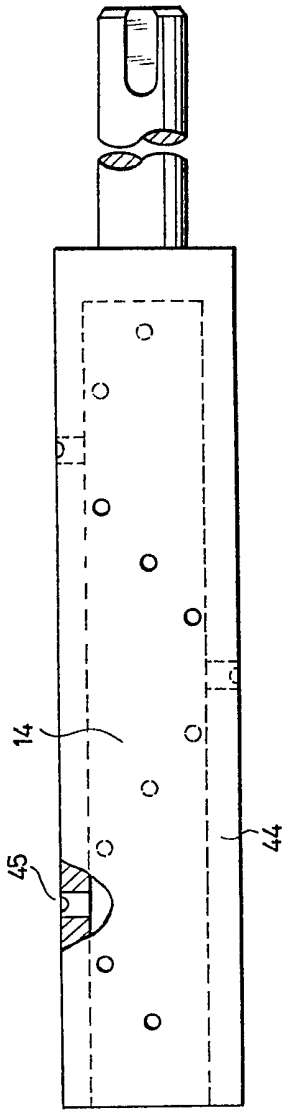

FIG. 16

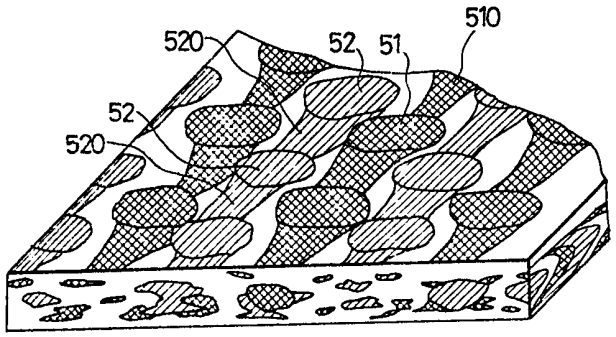

FIG. 17

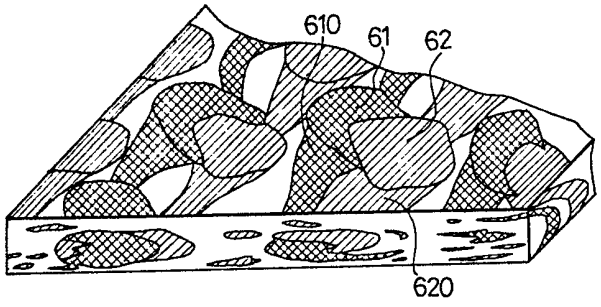

FIG. 18

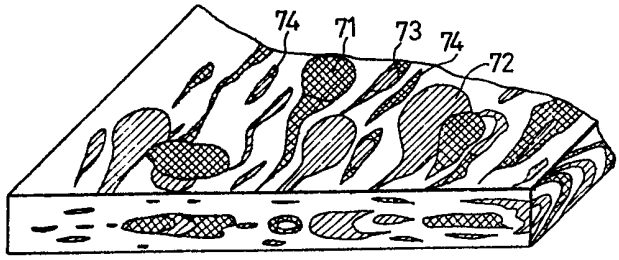

FIG. 19