United States Patent

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[54] **METHOD AND APPARATUS FOR INTRODUCING A WEFT THREAD INTO A SHEET OF WARP THREADS**
11 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **139/11,** 139/28, 139/127
[51] **Int. Cl.** **D03d 41/00,** D03d 47/00
[50] **Field of Search** 139/11, 12, 13, 28, 29, 123, 122, 127, 291; 28/1

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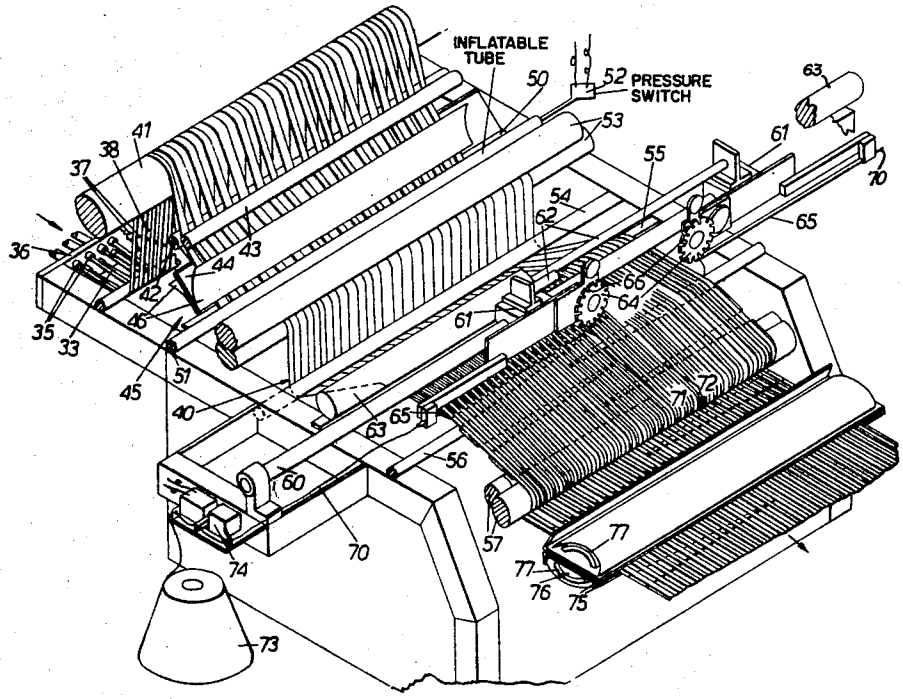
ABSTRACT: This invention concerns a method of introducing at least one weft thread into a sheet of warp threads so as to assist in holding the sheet together, the said method comprising employing at least one toothed wheel which is rolled transversely across the sheet periodically to raise and lower predetermined warp threads in a sequence which permits the passage of the weft thread transversely of at least a part of the sheet, and introducing the said weft thread over and under the said predetermined warp threads.



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SHEET 1 OF 3

FIG. 1.

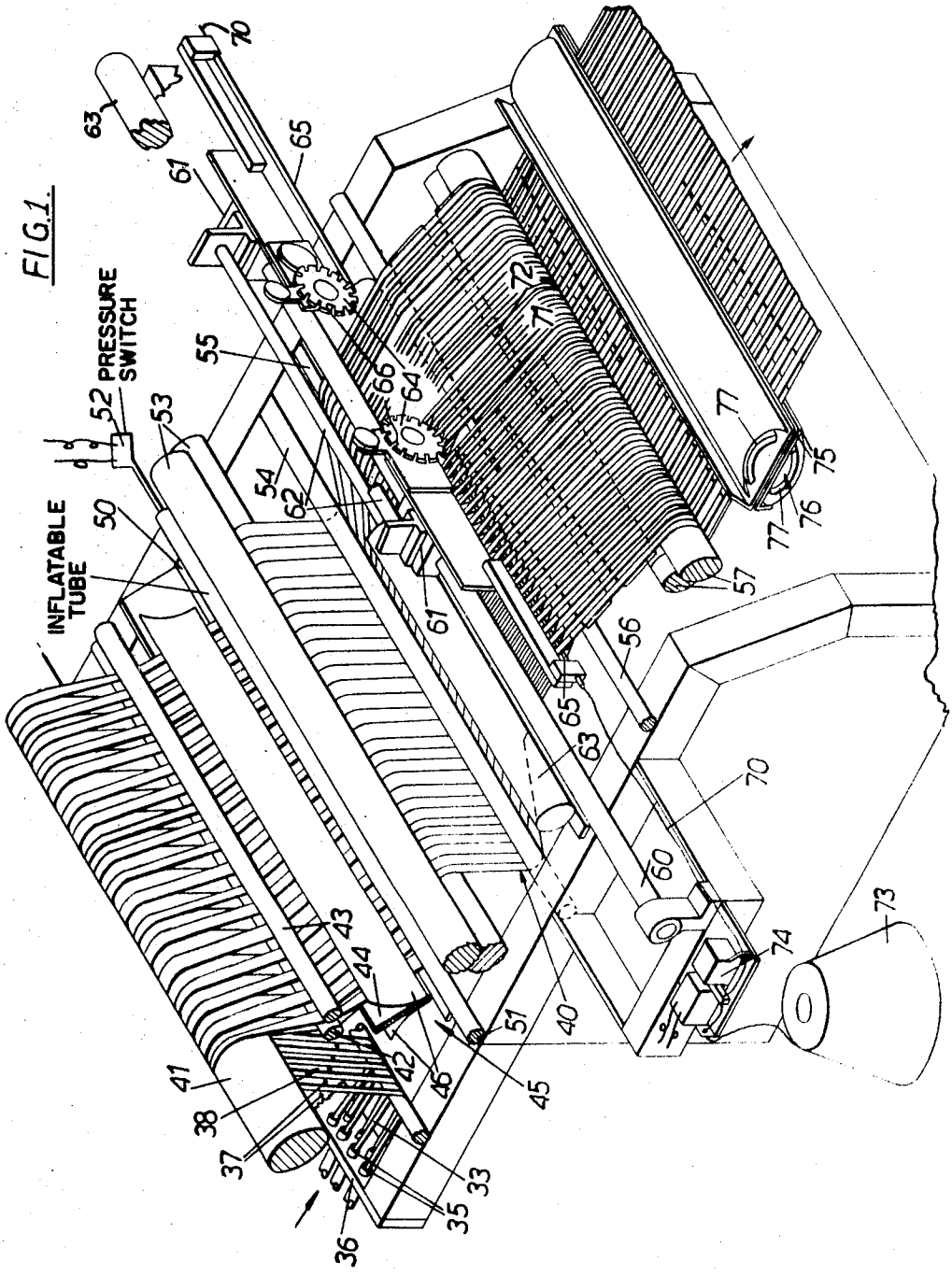

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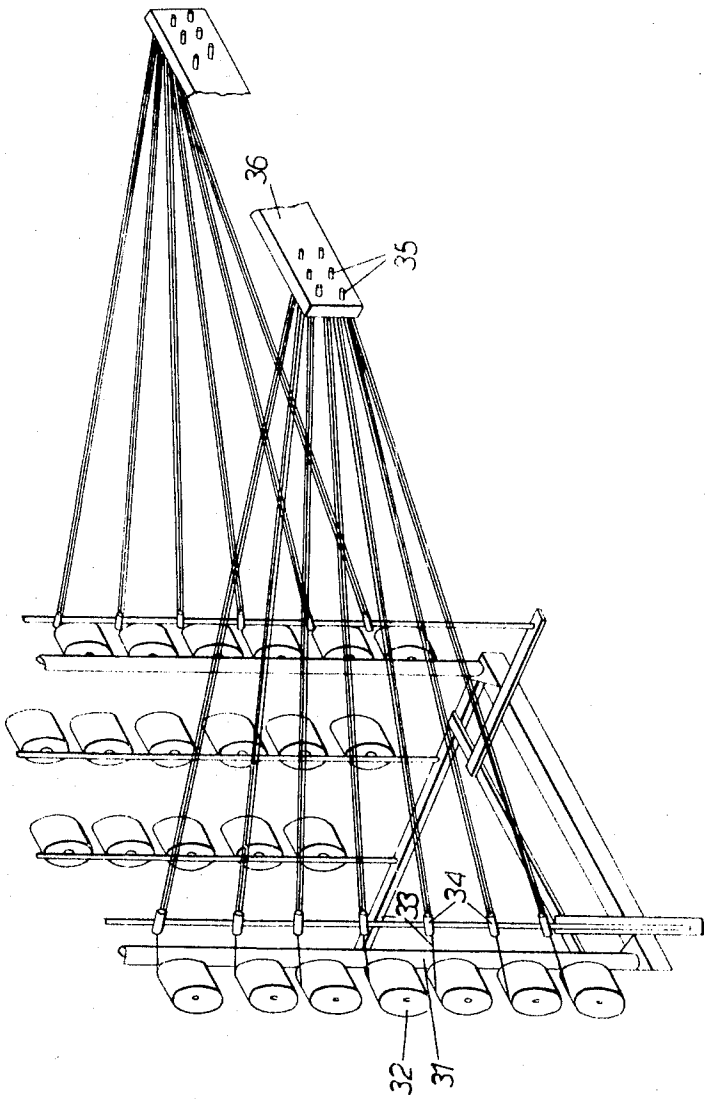
FIG. 2.



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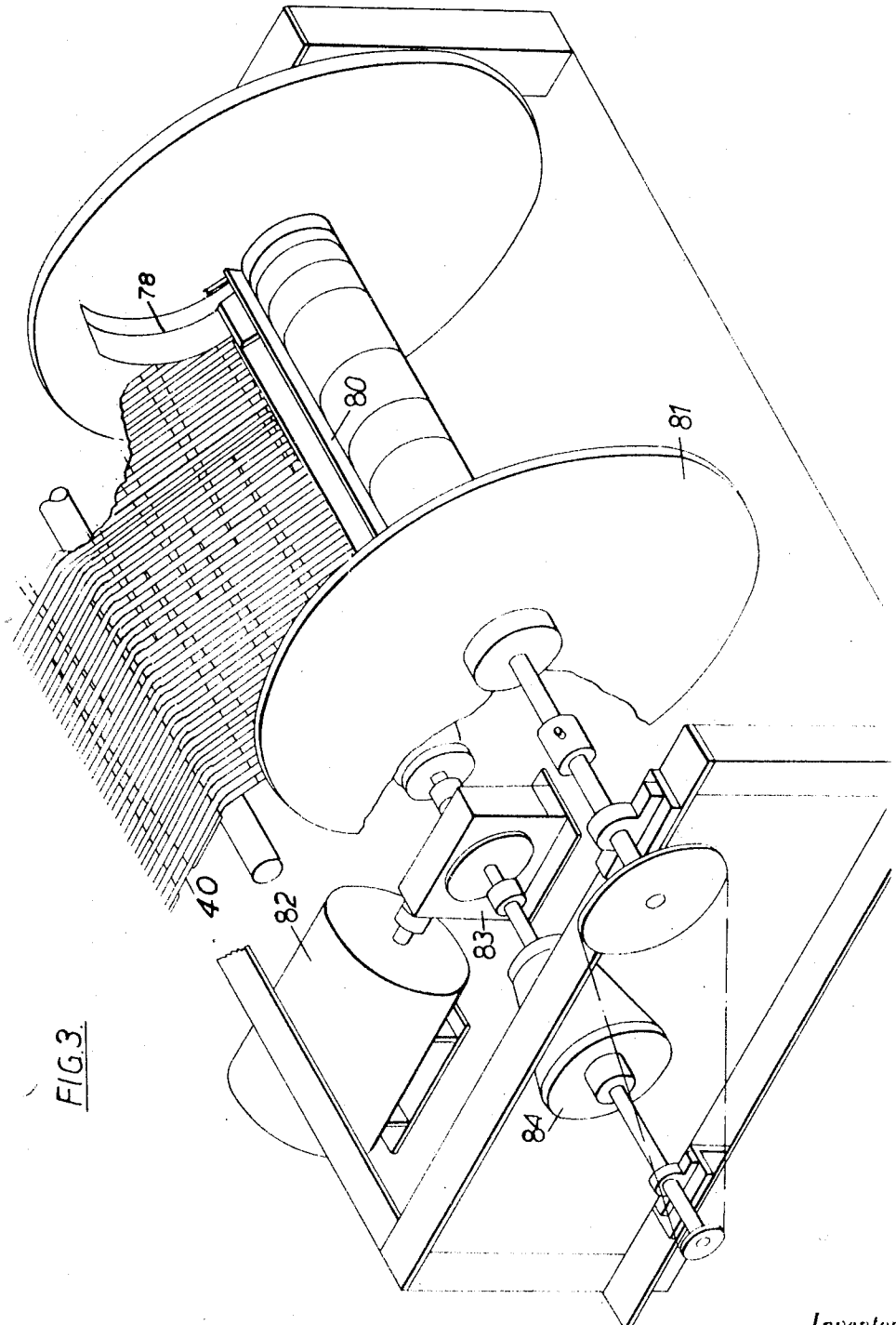

FIG. 3.

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METHOD AND APPARATUS FOR INTRODUCING A WEFT THREAD INTO A SHEET OF WARP THREADS

This invention concerns a method and apparatus for introducing a weft thread into a sheet of warp threads so as to assist in holding the sheet together. This may, for example, be desirable if the sheet is to be passed to a subsequent treatment, such as a heat treatment.

According to the present invention, there is provided a method of introducing at least one weft thread into a sheet of warp threads so as to assist in holding the sheet together, the said method comprising employing at least one toothed wheel which is rolled transversely across the sheet periodically to raise and lower predetermined warp threads in a sequence which permits the passage of the weft thread transversely of at least a part of the sheet, and introducing the said weft thread over and under the said predetermined warp threads.

Preferably the weft thread is introduced during longitudinal movement of the sheet.

The weft thread is preferably carried by a carrier member which is reciprocated transversely of at least part of the sheet.

The sheet of warp threads may be made up of a plurality of tows of warp threads.

Moreover both the warp and weft threads may be made up of continuous filaments.

A plurality of weft threads, or a plurality of different portions of the same weft thread, may be introduced into the said sheet, the various weft threads or said portions being longitudinally spaced apart and introduced over and under different warp threads.

The invention also comprises an apparatus for carrying out the said method comprising means for supporting a sheet of warp threads, at least one toothed wheel for periodically raising and lowering predetermined warp threads of said sheet, means for rolling the toothed wheel transversely across the sheet so that the predetermined warp threads are raised and lowered in a sequence which permits the passage of a weft thread transversely of at least a part of the sheet, and means for introducing the said weft thread over and under the said predetermined warp threads.

The means for supporting the sheet may comprise means for moving the warp threads longitudinally during the introduction of weft thread.

The means for introducing the weft thread may comprise at least one carrier member, and means for reciprocating the or each carrier member transversely of at least part of the sheet.

The or each carrier member is preferably a hollow needle through which the weft thread may pass.

Means may be provided for adjusting the width of the said sheet. Thus the last-mentioned means may comprise a comb having teeth whose distances apart may be varied and between which the warp threads may extend.

Means may moreover be provided for improving the uniformity of the sheet in the transverse direction.

There may be means for detecting excess tension in the sheet and/or breakage of a weft thread, and for stopping the machine when such excess tension or breakage is detected.

Means may be provided for heating the sheet after the weft thread or threads has been introduced thereinto.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:

FIGS. **1** to **3** are diagrammatic perspective views of different parts of an apparatus in accordance with the present invention.

Referring to the drawings, a creel **31** carries a number of bobbins **32** each of which supports a cheese of polyacrylonitrile or other continuous carboniferous filament. A tow **33** of the filaments is withdrawn from each of these cheeses and passes through a respective nylon tube **34** and thence to a respective nylon tube **35** in an assembly plate **36**. The tubes **34**, **35** serve to separate the various tows **33** from each other to prevent the filaments thereof from becoming entangled and damaged, and also to limit external damage to these filaments.

As will be seen from FIG. **1**, the tows **33** which have passed through the nylon tubes **35** of the assembly plate **36** pass between teeth **37** of a comb **38**. The comb **38** functions as a spacing means and is constituted by a "lazy tongs" member (not shown) which carries the said teeth **37** and which may be adjusted (by means not shown) so as to alter the distances of the teeth **37** from each other. Thus by adjusting the spacing of the teeth **37** a variation may be made to the width and density of the sheet **40** into which the tows **33** are ultimately formed.

Alternatively, the width and density of the sheet **40** may be adjusted by arranging that the nylon tubes **35** can be moved towards and away from each other.

The tows **33** which emerge from the nylon tubes **35** and which pass through the comb **38** are in the form of strands of continuous filament of roughly elliptical cross section. In order, however, to improve the uniformity of the resultant sheet **40** in the transverse direction it is necessary to spread the tows **33** out to form a homogeneous sheet having a thickness of, say 0.005 inch. The tows **33** are therefore passed over a horizontal roller **41** and alternate tows **33** are then passed respectively above and below a horizontal bar **42**, the upper tows passing beneath a horizontal bar **43** which is disposed adjacent to the bar **42**. The tows which has thus passed to opposite sides of the bar **42** then pass to opposite sides of a stainless steel plate **44** forming part of a spreader unit **45**. Laminar phosphor-bronze springs **46**, which are disposed on opposite sides of the plate **44**, are forced against the latter so as to effect spreading of the respective tows. The arrangement of the two sets of tows is such that the spaces between the tows in the bottom set coincide with the centerlines of the tows in the top set.

All the tows then pass over a plate **50** and beneath an inflated rubber tube **51**, the pressure in which is detected by a pressure switch **52** (of known construction) the rubber tube **51** being sandwiched between the plate **50** and a further metal plate (not shown). Thus any excess tension in the sheet **40** (which may be caused, for example, by an entangled tow on a cheese, or by a large knot which causes lodgement of the tow in one of the nylon tubes) will cause the pressure in the rubber tube **51** to rise. When the excess pressure exceeds a predetermined level, a circuit (not shown) in which the pressure switch **52** is arranged will stop the whole apparatus.

The tension generated in the tows **33** by pulling them off their cheeses and passing them through the spreader unit **45** is not sufficiently high and is not sufficiently uniform transversely of the sheet **40** to enable the sheet to be held together by subsequently introduced weft threads. The sheet **40** is therefore passed between a pair of intake drafting rollers **53**, under a horizontal bar **54**, over horizontal bars **55**, **56** and between a pair of outlet drafting rollers **57**. The rollers **53**, **57** rotate at the same angular velocity. However, the rollers **57** are of somewhat larger diameter than the rollers **53** and there is therefore a small circumferential speed differential between the rollers **53**, **57** such that the sheet **40** will be drafted by approximately 5 percent.

This amount of draft may be modified, if desired, by making one of the pair of rollers **53** a worm roller having a square worm thread thereon. Thus by altering the width of the square worm thread thereon, it may be arranged that from 50 to 75 percent of the filaments in the sheet **40** will be gripped between the rollers **53**, the remaining 50 to 25 percent thereof being permitted to slip progressively between the rollers **53**.

The rollers **53**, **57** may be driven at a speed such as to move the sheet **40** continuously at a speed of about 1 to 2 yards per minute.

A bar **60** extends transversely across the sheet **40** and above the latter, and supports two carriages **61** which are slidable thereover. Each of the carriages **61** is connected to a rod **62** of a pneumatic or hydraulic double acting ram **63** which may thus be used to effect reciprocation of the respective carriage **61** transversely of the sheet **40**. (In order to simplify FIG. **1**, only one of the rams **63** and rods **62** is shown in its entirety).

Instead of providing rams **63** other prime movers such as lever and cam systems and linear induction motors may be used.

Each of the carriages **61** supports a freely rotatable toothed wheel **64** and a hollow needle **65**, which extends to a position adjacent the bottom of the toothed wheel **64**. The needles **65** may be made of stainless steel thick wall tubing and may be gradually tapered along their lengths. The teeth of the toothed wheels **64** are formed by providing a plurality of angularly spaced-apart slots **66** which extend to the periphery of the wheel and throughout the axial length thereof. The width of each of these slots is such as to permit the entry thereinto of a portion of a tow.

The slots **66** in the toothed wheels **64** may be relatively narrow compared with the width of the unslotted parts around the circumference of the toothed wheels **64** which alternate with between them.

A weft thread **70** is introduced through each of the needles **65** so as to emerge adjacent to the bottom of the respective toothed wheel **64**.

Thus as each carriage **61** is reciprocated across the respective part of the sheet **40**, the wheel **64** engages the warp threads of the sheet **40** so as to be rotated thereby and serves periodically to lower predetermined warp threads in a sequence which permits the passage of the weft thread **70** so that the latter passes over the said predetermined warp threads and under all remaining warp threads.

As will be seen from FIG. **1**, the arrangement is such that each of the toothed wheels **64** is moved between a position in which it is disposed beyond the sheet **40** to a position in which it has moved past the centerline of the sheet. Thus, when the parts are in the position shown in FIG. **1**, the portion of the weft thread **70** which has been introduced by the right-hand needle **65** will be trapped between the various tensioned warp threads of the sheet and, due to the longitudinal movement of the latter, will have been carried away from the respective toothed wheel **64**. At the same time, the left-hand needle **65** will have been introduced to its maximum extent into the sheet **40** and, as it is withdrawn, it will leave the weft thread behind it embedded in the sheet **40**. Thus in the construction shown in the drawings, two weft threads are employed, each of which extends from its respective side of the sheet **40** to a position beyond the longitudinal centerline of the sheet. There thus may be an overlap of, say 3 inches between these two weft threads at the center of the sheet **40**.

When spun yarn is used for the weft thread **70**, it is not necessary to have any mechanism to retain the weft thread **70** in the sheet. However, for continuous filament yarn, a hook system (not shown) can be used to prevent the weft thread from being pulled out of the sheet during the withdrawal of the needles.

Since the wheels **64** will be frictionally rotated by engagement with the sheet **40**, they will continue to rotate even when moved to a position free of the latter. Indeed, means may be provided deliberately to rotate them. As a consequence, the angular positions of the slots **66** in a wheel **64**, will, with respect to the sheet **40**, vary every time the respective carriage **61** is reciprocated. As a consequence, and as shown in FIG. **1**, different portions **71**, **72** of the same weft thread **70** which are longitudinally spaced apart will be introduced over and under different warp threads so as to produce a substantially random weave.

To prevent unnecessary rubbing, means (not shown) may be provided so as to lift each of the wheels **64** out of contact with the sheet **40** whenever the respective needle **65** is withdrawn therefrom. Thus a pneumatic ram may be used for this purpose.

Each of the weft threads **70** is withdrawn from a cheese **73** and, on its way to its respective needle **65**, passes a weft break detector **74**. The detectors **74** may be photoelectric, capacitive, electromechanical, or incorporating fluid logic devices, and are such that in the event of weft breakage, a signal is provided which stops the apparatus.

After the sheet **40**, which has had the weft threads **70** so introduced, has passed between the rollers **57**, it passes between two plates **75** of a heating unit **76**. The heating unit **76** and means for moving it may be of known constructions, as shown for example in U.S. Pat. No. 2,769,222. Each of the plates **75** may, for example, be constituted by a steel plate coated with polytetrafluorethylene. Each of the plates **75** carries an infrared heater **77**, the temperature of which is maintained reasonably constant by a thermostat (not shown). The sheet **40** is thus heated while under tension, so that its material will stretch, and protruding filaments will be shrunk, and its modulus of elasticity will be increased. Thus a sheet of material will be produced which is more highly orientated so as to facilitate its consequent handling.

Whenever the machine stops, the plates **75** and their heaters **77** are moved away from the sheet **40** (by means not shown), but the heaters **77** are not switched off.

If desired, high frequency dielectric heating can be used instead.

In order to produce a stable beam of the sheet **40** which has been so heated, it is necessary to introduce at intervals, narrow strips of paper **78** called "collars" at the edges of the beams. This operation is usually performed by hand. Semiautomatic means are illustrated at **80** (FIG. **3**) to allow quicker and easier insertion of the collars **78**. The system can, if desired, be fully automated to deal either with the continuous length of collar **78** or to cut and insert short lengths as required.

The sheet **40** is thus wound onto a spool **81** which is rotated by means of an electric motor **82** by way of a reduction gear **83** and hydraulic dashpots **84**. The surface velocity of the spool **81** is considerably higher than the velocity of the sheet **40** which has just been heat treated, and tension is thus generated in the latter due to slip in the hydraulic dashpots **84** that act as couplings. The tension in the sheet can be adjusted by changing the torque settings of the hydraulic dashpots **84** or by changing the speed ratio between the sheet **40** and the circumferential velocity of the spool **81**.

Torque electric motors can be used instead of hydraulic dashpots. In this case, torque values are changed by altering the voltages supplied in the motors.

In either case, a condition of constant tension can be achieved and the level of tension can be preset. The spools **81** may be wound to a diameter of 24 inches, but larger diameters can also be used if desired.

As will be appreciated, although the invention has been discussed above in relation to the production of a sheet of polyacrylonitrile tows, the invention may also be used to provide fabrics of novel construction from, say, natural fibers.

I claim:

1. A method of introducing at least one weft thread into a sheet of warp threads so as to assist in holding the sheet together, said method comprising moving the sheet of warp threads longitudinally in a substantially flat plane, employing at least one freely rotatable toothed wheel which is reciprocated transversely across the sheet and in engagement with the warp threads to effect rotation of the toothed wheel to periodically depress predetermined warp threads out of said flat plane, while leaving remaining warp threads in said flat plane, in a sequence which permits the passage of the weft thread transversely of at least a part of the sheet, and introducing the said weft thread between said predetermined warp threads and said remaining warp threads, and moving the toothed wheel so that, at the end of each complete reciprocation thereof, the toothed wheel is disposed beyond the sheet and out of engagement with the warp threads.

2. A method as claimed in claim **1** in which two weft threads and two toothed wheels are employed, each weft thread and toothed wheel being carried by a carriage which is reciprocated transversely of a part only of the sheet, the carriages being moved to opposite sides of the sheet.

3. A method as claimed in claim **1** in which the sheet of warp threads is made up of a plurality of tows of warp threads.

4. A method as claimed in claim 1 in which the warp and weft threads are made up of continuous filaments.

5. Apparatus for introducing at least one weft thread into a sheet of warp threads so as to assist in holding the sheet together, said apparatus comprising means for moving a sheet of warp threads longitudinally, at least one freely rotatable toothed wheel engageable with the warp threads for periodically depressing predetermined warp threads of said sheet, means for reciprocating the toothed wheel transversely across the sheet and in engagement with the warp threads to effect rotation of the toothed wheel so that the predetermined warp threads are lowered in a sequence which permits the passage of a weft thread transversely of at least a part of the sheet, and means for introducing the said weft thread over the said predetermined warp threads and under the remaining warp threads, the toothed wheel, at the end of each complete reciprocation thereof, being disposed beyond the sheet, and out of engagement with the warp threads.

6. Apparatus as claimed in claim 5 in which two weft threads and two toothed wheels are employed, the means for introducing each weft thread comprising a carriage which carries both a carrier member for the weft thread and a toothed wheel, and means for reciprocating each carriage transversely of a part only of the sheet, said carriages being positioned for movement to opposite sides of the sheet.

7. Apparatus as claimed in claim 6 in which the carrier member is a hollow needle through which the weft thread may pass.

8. Apparatus as claimed in claim 5 in which means are provided for improving the uniformity of the sheet in the transverse direction.

9. Apparatus as claimed in claim 5 in which there are means for detecting excess tension in the sheet and for stopping the apparatus when such excess tension is detected.

10. Apparatus as claimed in claim 5 in which there are means for detecting breakage of a weft thread, and for stopping the apparatus when such breakage is detected.

11. Apparatus as claimed in claim 5 in which means are provided for heating the sheet after the weft thread has been introduced thereinto.