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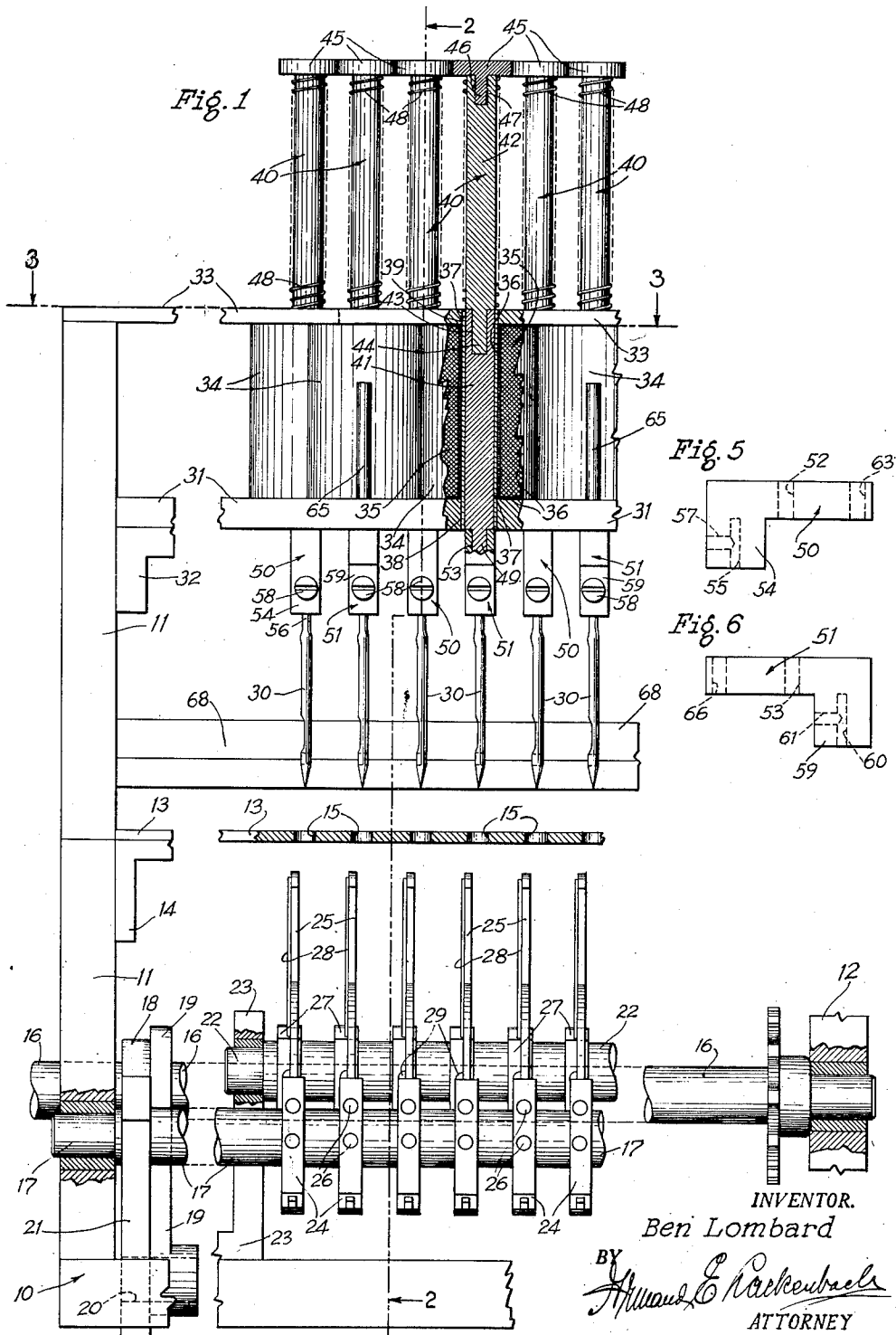
B. LOMBARD

2,768,593

APPARATUS FOR TUFTING

Filed Feb. 16, 1954

4 Sheets-Sheet 1



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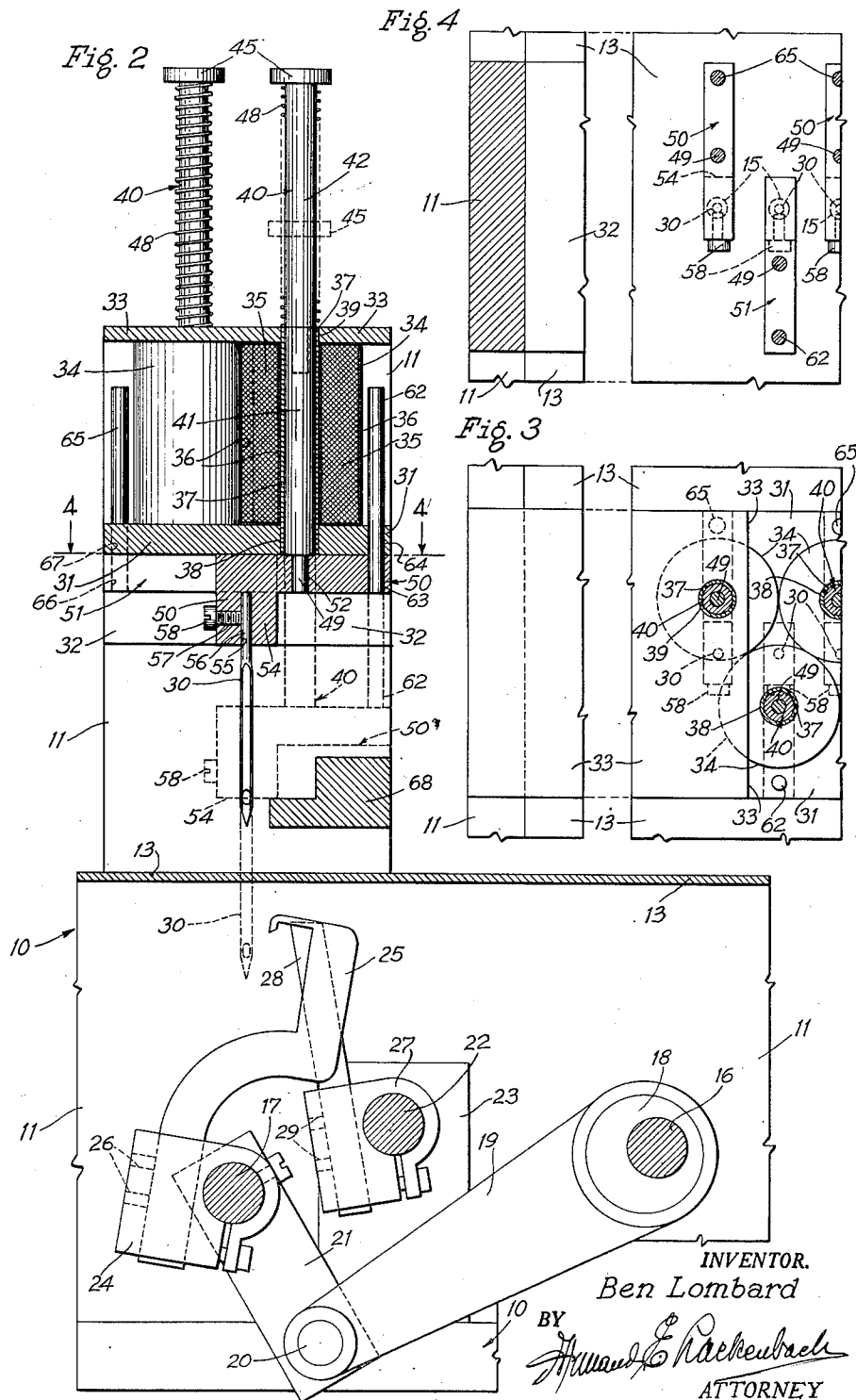
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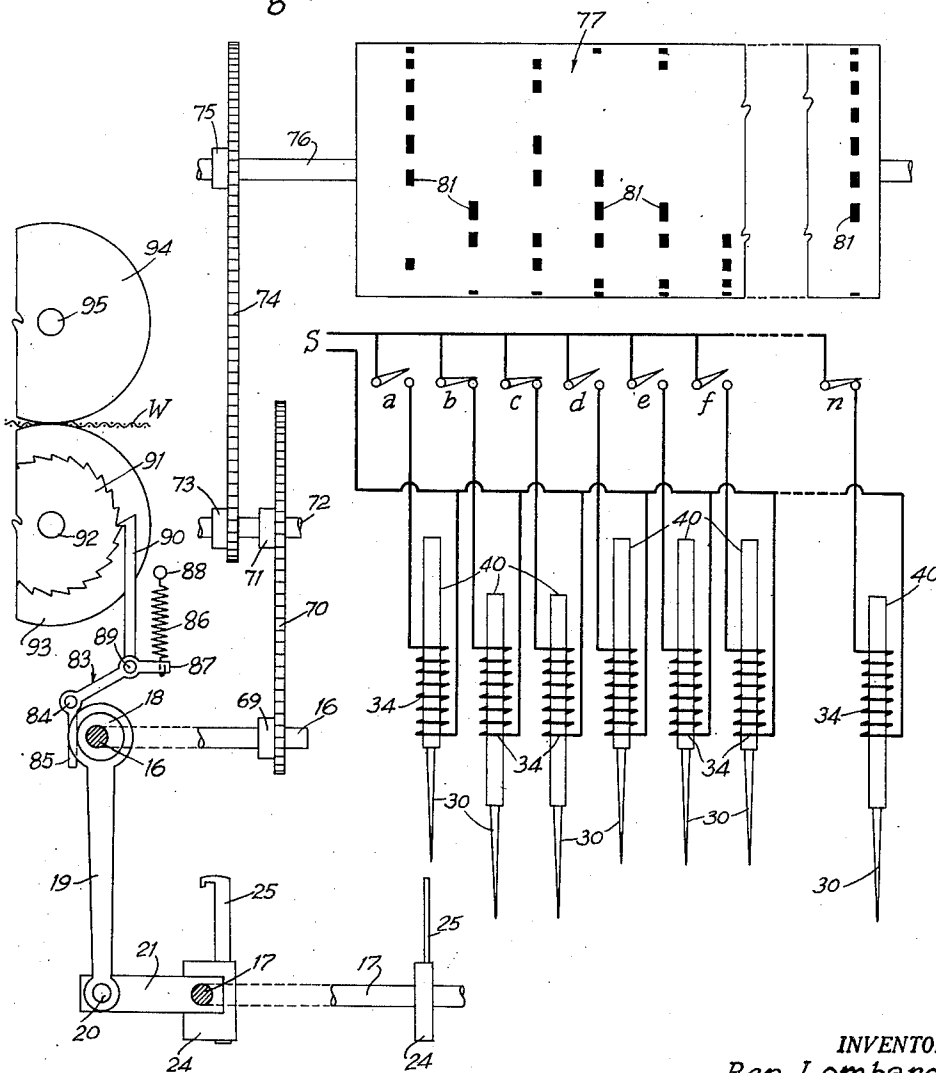
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APPARATUS FOR TUFTING

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Filed Feb. 16, 1954

4 Sheets-Sheet 3

Fig. 7



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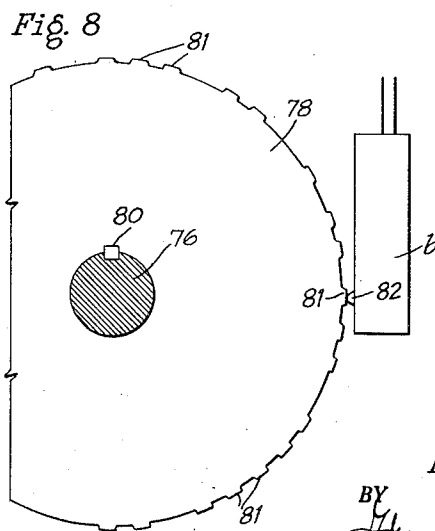
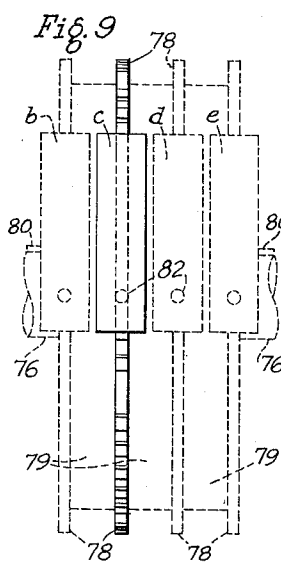
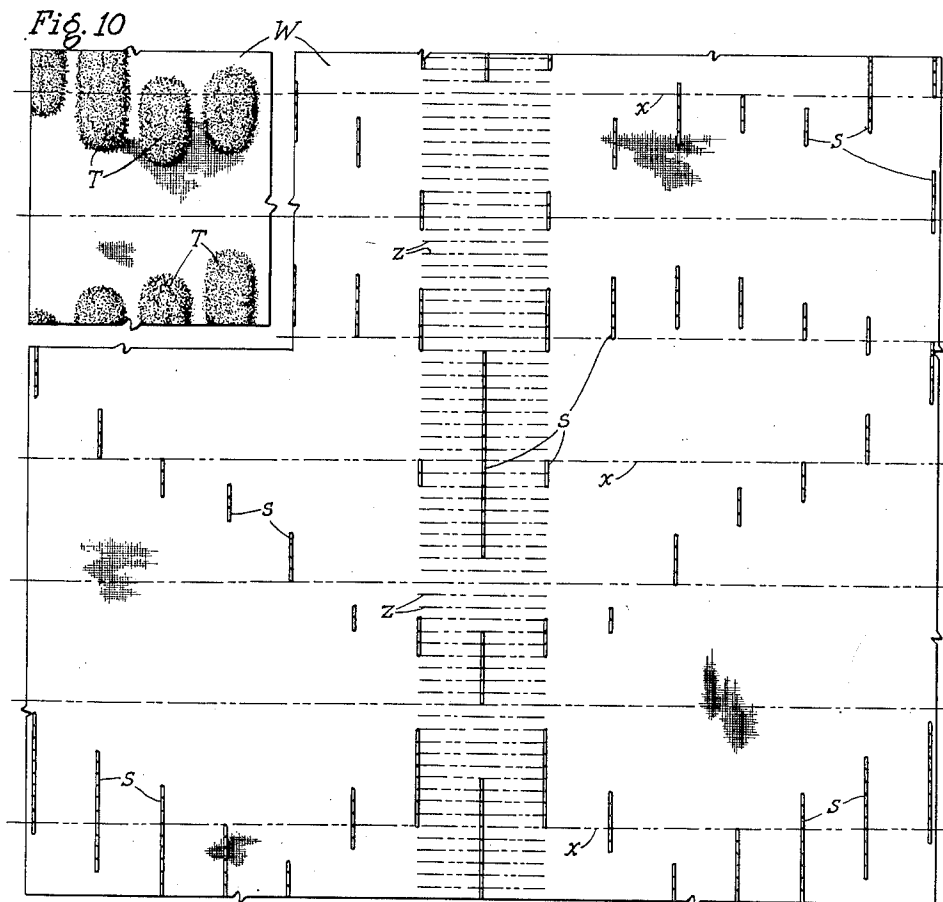
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4 Sheets-Sheet 4



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APPARATUS FOR TUFTING

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Application February 16, 1954, Serial No. 410,629

6 Claims. (Cl. 112—79)

This invention relates to a method and apparatus for producing tufts on a web of material. Particularly the invention is an improvement in means for the yardage production of tufted fabric.

A yardage tufting machine, as generally known in the art, comprises an aligned series of tufting devices, all of which are adapted to operate simultaneously, and each of which includes a needle, a hook, and a knife. The series of tufting devices extends laterally with respect to the machine, with all needles mounted on a common bar which is adapted to reciprocate toward and away from a perforate work surface, or bed, on which a web of base material is fed step by step longitudinally with respect to the machine in timed relationship to the reciprocations of the abovementioned bar. The reciprocating bar, with its needles, is usually referred to as a needle bank. The needles, of course, repeatedly pass through the web and the perforate bed, and carry loops of yarn to cooperating hooks and knives mounted on two rocking shafts journaled beneath the bed; and, as the machine operates, parallel rows of tufting are applied to one side of the web. Ordinarily the rows of tufts are straight and, of course, longitudinally disposed with respect to the web, which is commonly fed through the machine from a roll. Attachments are known for producing wavy rows of tufts; and, on sewing machines having tufting attachments, means are known for producing interrupted rows of tufts. But a yardage tufting machine, as heretofore known, produces, on a web of base material, only continuous parallel rows of tufts, the rows being straight or wavy as the case may be; and the pattern of any relatively narrow transverse strip of the finished product is continuously repeated.

The general object of the present invention is to provide means for the yardage production of tufted fabric having any of a variety of pictorial patterns of tufts thereon. The invention contemplates means for the yardage production of tufted fabric having an ornamental pattern of disconnected candlewick or pompom tufts, of continuous or interrupted rows of tufts, straight or wavy, of Wall of Troy and other geometric effects, of tufted areas of various peripheries in simulation of sculpture, or of combinations of any of the types of tufting set forth above.

Specifically the invention contemplates means for selectively operating any one or more of a plurality of tufting devices of a yardage tufting machine during part of the period having relationship to a particular feed step of the web of base material to be tufted.

Whereas in a yardage tufting machine, as heretofore known, all needles, and, in consequence, each of the series of tufting devices, must operate simultaneously, in the apparatus of the present invention each tufting device of the series incorporated in the machine may operate independently of all others. Therefore, for example, during a single period relating to a particular feed step of the web, all odd-numbered tufting devices of the series

2

may operate while the even-numbered devices produce no tufts; or, any selected devices of the series may produce tufts while the other devices are withheld from operation.

It will be more fully understood from the following disclosure that it is necessary only to control the operation of the various needles of the series of tufting devices in order to produce the result contemplated by the invention. The invention is therefore particularly concerned with the selective control of the needles of the related yardage tufting machine; and the invention may be practised without modification, in principle, of a great number of elements and mechanisms commonly found in yardage tufting machines. Broadly, the invention may be applied to known yardage tufting machines by modification only of the needle actuating mechanism and its control. However, in known yardage tufting machines the design of the entire main frame is influenced by the fact that a common drive shaft is used for operating the needle bank, the hook shaft, the knife shaft, and mechanism for feeding the web through the machine; and it has been found convenient to position the drive shaft in the head of the machine above the bed thereof. Since, in practice, the present invention does not require the known head, nor a positioning of the drive shaft above the machine bed, and, in fact, the known main frame structure is unnecessary and actually extremely inconvenient, a modification of the main frame and of the hook and knife drive mechanism is indicated along with a novel arrangement of the needles and their actuating means.

Herein the phrase "tufted fabric" is used to mean a fabric decorated with fluffy tufts or soft twist, multiple ply cotton yarns. "Web" signifies the base material onto which the tufts are applied; "tuft" is one of the clusters of extra yarn drawn through a web and projecting from one surface thereof, or is an isolated section of yarn drawn through a web and projecting from one surface thereof and which is not part of a cluster. "Tufting" is used to signify one tuft or a cluster or series of tufts, or the entire work applied to the web. With reference to a web or a tufted fabric, "reverse" means that side of the web at which the needles point or that side of the tufted fabric on which only the stitches of the yarn appear; and "obverse" means the opposite side of the web or the fabric. The phrase "step by step" indicates an intermittent motion in one direction; "electromagnet" and "armature" respectively include a solenoid and the movable core of a solenoid; and "excerption" means any selection of one or more units from a series of units.

The objects, features, and advantages of the invention will be more fully understood from the following description.

In the drawing:

Fig. 1 is a fragmentary front elevational view of a yardage tufting machine built according to the present invention, and shows several functionally equivalent and independently operable tufting devices of a series thereof assumed to extend transversely with respect to the machine.

Fig. 2 is the stepped section 2—2 of Fig. 1.

Fig. 3 is the stepped section 3—3 of Fig. 1.

Fig. 4 is the section 4—4 of Fig. 2.

Fig. 5 is a side elevational view of an element included in one of the two types of tufting apparatus comprising the series.

Fig. 6 is a side elevational view of an element included in the other of the two types of tufting apparatus.

The elements of Figs. 5 and 6 are each a part of the needle bar of one of the two types of tufting devices shown in the illustrated embodiment of the invention. If the tufting devices of the transverse series are assumed to be ordinarily numbered beginning at the left in Fig. 1,

3

the element of Fig. 5 relates to an odd-numbered, and the element of Fig. 6 relates to an even-numbered, tufting device.

Fig. 7 is a diagram generally illustrating the principle of the embodiment of the invention pictorially shown elsewhere in the drawing.

Fig. 8 is a fragmentary detail of an exemplary means for controlling operation of a single tufting device needle.

Fig. 9 is a view of the same means rotated 90°.

Fig. 10 is generally a reverse plan view of an area of tufted fabric having a pattern such as may be produced in accordance with the invention. The upper lefthand portion of this figure, which is broken away from the main part of the figure, is an obverse plan view of a small part of the area.

Only one embodiment of the invention is illustrated herein. This embodiment is a yardage tufting machine having a transverse series of spaced tufting devices, each of which is independently operable, and each of which is electrically controlled. It will be subsequently shown that, within the scope of the invention, the several tufting devices of the series may be controlled otherwise.

The drawing is generally limited to the essentials of the invention, and mechanism for the step by step feed of the web of base material through the machine, and certain other well known required parts of a yardage tufting machine are not illustrated. Further, as, for example, in Fig. 1, which is a fragmentary front elevational view of the present apparatus, the machine is condensed by the use of erasures, and only several tufting devices of the transverse series appear.

In Fig. 1 the main frame of the machine is generally designated 10. This frame comprises upright portions 11 and 12, respectively to the left and to the right in this figure. The bed of the machine, over which the web (not shown) is fed step by step is a plate 13, and is supported by brackets 14 (of which only one is shown) attached in suitable manner to the uprights 11 and 12. The bed plate 13 is provided with a series of perforations 15 through which the needles of the various tufting devices may pass. The bed plate 13 is partly in section in Fig. 1 in order clearly to show the perforations 15; see, also, Fig. 4.

The drive shaft of the machine is indexed 16, and is journaled in uprights 11 and 12 beneath the bed plate 13. The shaft 16 not only extends across the main frame of the machine but also extends to the left of upright 11. Beyond upright 11 the shaft 16 is broken away, but it will be understood that here the drive shaft may be coupled to a motor (not shown). Also journaled in uprights 11 and 12, and paralleling the drive shaft, is the hook shaft 17. Shaft 17 is erased to the right in the figure so that the drive shaft may not be obscured at and near upright 12, and, consequently, the righthand journal of shaft 17 is not shown.

Mounted on the drive shaft 16 near the left side of the main frame, as of Fig. 1, is an eccentric 18, which is best seen in Fig. 2, the stepped section 2-2 of Fig. 1.

The eccentric is assumed to be keyed to the drive shaft, or otherwise mounted thereon for rotation therewith. Slidably mounted on the eccentric 18 is one end of a link 19, the other end of which is pivotally connected at 20 to an arm 21 rigidly mounted on the hook shaft 17 and radially extending therefrom. The well known structure described immediately above effects a rocking cycle of the hook shaft during each revolution of the drive shaft.

Also paralleling the drive shaft is the knife shaft 22. This shaft may be journaled in any suitable manner, but its lefthand end, as in Fig. 1, is shown to be journaled in a bracket 23 mounted on the main frame, and its righthand end is assumed to be journaled in upright 12. At a convenient place, as, for example, toward the right side of the machine, according to Fig. 1, the hook shaft 17 and the knife shaft 22 are linked together in

4

usual manner whereby the latter shaft is rocked during part of the rocking cycle of the former shaft. The linkage between the hook shaft and the knife shaft is common to many known tufting machines, and is omitted in the drawing.

Fig. 2 is a clear illustration of the linkage between the drive shaft 16 and the hook shaft 17, and of the relative positions of the drive, hook, and knife shafts, as well as of the needle, hook, and knife of any one of the series of tufting devices incorporated in the machine. It may be pointed out here that, while all tufting devices of the machine are functionally equivalent, and almost exact duplicates of each other, all odd-numbered devices are slightly different from all even-numbered devices—the difference having to do solely with a part of the needle bars of the series of devices, as will be subsequently clarified. Fig. 1 is illustrative of the first six independently operable tufting devices forming part of the series of devices extending across the machine. Of course, in so far as the invention is concerned, the number of tufting devices of the series, and the gage, i. e., the distance between the spaced devices, are immaterial. For convenience herein the leftmost device in Fig. 1 is regarded as the first device. Consequently, the view of Fig. 2 shows parts of the second and third tufting devices.

In Fig. 2 a block 24 is shown clamped to the hook shaft 17. The block is slotted in usual manner to receive the lower extremity of the hook 25, which is rigidly secured to the block by means of set screws 26. For simplicity, in the drawing, the actual hook as well as its supporting arm or shank is shown as a single element. In practice, of course, the actual hook is a relatively small element of hardened steel, since the hook is part of a shear; and the hook is secured, as by screws, to its supporting arm. However, the design of the hook is not part of the present invention, and its conventionalization herein will be understood.

Another block 27 is shown in Fig. 2 to be clamped to the knife shaft 22. This block is also slotted in usual manner to receive the lower extremity of the knife 28, which is rigidly secured to block 27 by means of set screws 29.

Each tufting device comprises a block 24, a hook 25, a block 27, and a knife 28, and the relative positions of these elements pertaining to any device, and viewed at 90° to the angle of Fig. 2, is illustrated in Fig. 1, wherein it is seen that the groups of four elements mentioned above are repeated at regularly spaced intervals across the machine along shafts 17 and 22.

In Fig. 2 the hook is shown withdrawn from the needle path, and the knife is shown in its extreme position following a cutting movement. It will be noted, in this figure, that the top, or cutting, edge of the knife has passed the cutting edge of the hook, this lastmentioned edge being within the bay of the hook. The other positions of the hook and knife are not illustrated, as their paths will be readily understood by those versed in the art.

The needle of any tufting device is designated 30. In the apparatus of the present invention the operation of any needle with relationship to the operations of its associated hook and knife is substantially similar to the cooperative movements of the needle, hook, and knife of any known single tufting device, and the tuft is formed in the same way; but the essential feature of the invention involves the prospect that any particular needle may not operate at all in conjunction with the operations of its associated hook and knife, and that, as a consequence, no tuft is then produced in correspondence with such operations of the hook and knife.

So far in the description little novel matter has been mentioned. The structure of the machine beneath the bed plate is mechanically equivalent to structures to be found in many yardage tufting machines. Here the po-

sition of the drive shaft is somewhat unusual; but its relationship, in mechanics, to the hook and knife shafts is not new.

As the drive shaft 16 is linked to the hook shaft 17, and the latter is linked to the knife shaft 22, the advance and retraction of each hook and of each knife take place once during a revolution of the drive shaft without respect to the operation of the needle relating to the hook and the knife. If a needle should descend through the web and the bed plate 13 in usual manner in relationship to a revolution of the drive shaft, and thereby bring down a loop of yarn, the loop is caught by the hook, subsequently cut by the knife, and a tuft is formed. If the needle of a tufting device does not descend in relationship to a revolution of the drive shaft, of course no loop of yarn is brought down for the hook of that device, and the hook and knife thereof swing through their well known cycles substantially as if yarn were present. Thus, since all hooks and knives move through their cycles in relationship to each revolution of the drive shaft, but only particular needles descend during the revolution of the drive shaft, tufts are produced in a transverse pattern which relates to the tufting devices whose needles are operated. Quite conceivably the desired finished pattern of tufted fabric might require that for one or more revolutions of the drive shaft, and, consequently, for one or more feed steps of the web, no tufting devices operate, so that a lateral strip of the finished fabric would have no tufts at all thereon. It may be pointed out here that, even though the hook and the knife of each tufting device operates to move through their cycles once for each revolution of the drive shaft, the tufting device, as a whole, can be said to operate only if its needle cooperates with the hook and knife.

Above the bed plate 13 a horizontal bar 31 extends across the machine, and is supported by brackets 32 (only one of which is shown) secured to uprights 11 and 12. Bar 31 is shown in section in Fig. 2, and is presumed to be both rigid and of considerable thickness for reasons set forth below. Mounted on the tops of uprights 11 and 12, and also extending across the machine, is another horizontal bar 33. This bar is also shown in section in Fig. 2. It is particularly important that no perceptible catenary form in either bar 31 or bar 33, and suitable reinforcements or intermediate supports are assumed to be provided.

Mounted on bar 31, and positioned between that bar and bar 33, are a plurality of like solenoids 34, there being one solenoid for each tufting device, and two rows—a front and a back row—of solenoids extending across the machine, the solenoids of one row being staggered with relationship to the solenoids of the other row (see Figs. 1, 2, and 3). The arrangement of the solenoids in two rows, with the solenoids of one row staggered with respect to those of the other row, is adopted here as a convenience in view of the fact that the gage of the machine is less than the distance between the axes of two solenoids relating to adjacent tufting devices, and so that the solenoid bank may be on a single level. It will be obvious that other arrangements of the solenoids might be adopted to accommodate the gage of the machine. The arrangement shown, however, is preferred, since the diameter of the solenoids if desired to be as great as practicable. The diameter of the solenoids shown in the drawing is twice the gage of the machine. Therefore all solenoids of each row form a transverse series of elements in contact, and, it will be noted from Fig. 3, the solenoids of the front row contact the solenoids of the rear row. Fig. 3 best indicates that anteroposterior vertical planes including the axes of the solenoids of the front row, and the axes of the needles of the tufting devices relating to these solenoids, pass between the solenoids of the rear row; and, conversely, similar planes including the axes of the solenoids of the rear row, and the axes of the needles of the tufting devices relating to these

solenoids, pass between the solenoids of the front row. Thus, all such anteroposterior planes are spaced according to the gage of the machine. It will be noted in Figs. 2, 3, and 4 that the axes of all solenoids are offset forwardly or rearwardly with respect to the axes of the needles to which they relate—this fact, of course, being caused by the machine gage and the solenoid arrangement adopted to accommodate it.

The solenoids, i. e., specifically, the windings 35 thereof, and the insulating jackets 36 thereof, surrounded sleeves 37, which may be of brass or other suitable non-magnetic material. Each sleeve 37 is preferably force fitted into one of a plurality of circular perforations 38 (see Fig. 3) provided in bar 31 so that the lower end of the sleeve is flush with the lower surface of the bar, as shown in Figs. 1 and 2. The upper extremities of sleeves 37 are received within circular perforations 39 (see Figs. 1 and 2) provided in bar 33. The pattern of the circular perforations in bar 31 is in register with that of the perforations in bar 33 so that the sleeves 37 are maintained truly vertical.

Each solenoid is provided with a rigid plunger designated 40 in its entirety, the plungers being slidably received within sleeves 37, as shown in Figs. 1 and 2. That portion of each plunger which is received within a sleeve 37 is of uniform circular cross section, although this portion is of two parts—a lower part 41 of brass or other non-magnetic material, and an upper part 42 of mild permeable material, such as Swedish steel. The two parts are coaxially joined together in any suitable manner. In Fig. 1, wherein one solenoid and its plunger are shown partly in section, a means of coupling the two parts of the plunger together is illustrated. Here the top end of the nonmagnetic lower part 41 of the plunger 40 is axially bored for a short distance at 43, and the lower end of the permeable upper part 42 is turned down to provide a pin 44 which may be force fitted into the bore at 43.

The top of each plunger 40 is provided with a cap 45, as shown in Figs. 1 and 2. Each cap 45 is of greater diameter than parts 41 and 42 of the plunger, and each cap is actually the head of a screw 46 which is driven into a threaded bore 47 provided in the top end of a part 42 of a plunger 40. See Fig. 1, particularly. Surrounding each plunger between the cap 45 and the upper surface of bar 33 is a compression spring 48. The compression springs 48 tend to maintain the plungers in the relative positions illustrated in Fig. 1.

The lower end of the nonmagnetic lower part 41 of each plunger 40 is turned down to provide a pin 49. By means of this pin the plunger is attached to an element 50 or an element 51, respectively shown in Figs. 5 and 6, depending upon the character of the ordinal number of the tufting device to which the plunger relates. If the ordinal number of the device is odd, the pin 49 is force fitted into a bore 52 provided in an element 50; and if the ordinal number of the device is even, the pin 49 is force fitted into a bore 53 provided in an element 51. Normally, as shown in Fig. 1, the elements 50 and 51, which alternate across the machine, are just beneath the bar 31 and in contact with its lower surface. In fact the elements 50 and 51 are normally maintained in this position by the compression springs 48.

As will be evident from Figs. 1 through 4, the plunger 40 of each solenoid 34 and the element 50 or 51, as the case may be, constitute a needle bar for one tufting device. The elements 50 and 51 are primarily employed as corrective offset means since it is plain, in Figs. 2, 3, and 4, that the axis of each plunger is necessarily offset from the axis of the needle 30 to which it relates. Thus the elements 50 and 51 are used to tie the plunger and needle together. Each of the elements 50 and 51 are L-shaped blocks, preferably of nonmagnetic material so that they cannot tend to operate as armatures for the particular solenoids to which they relate or to adjacent solenoids. Elements 50, all of which relate to odd-numbered

tufting devices, are best understood from the sample shown in side elevation in Fig. 5; and elements 51, all of which relate to even-numbered tufting devices, are best understood from the sample shown in side elevation in Fig. 6. Each element 50 has a dependent lug 54 toward the front, and the lug is provided with a bore 55 from beneath to accommodate the shank 56 of a needle 30. The lug is also cross bored at 57 to intersect the bore 55, and threaded to accommodate a set screw 58 for clamping the needle shank in position. See Fig. 2, particularly. Each element 51 has a dependent lug 59 toward the rear, and this lug is provided with a bore 60 (equivalent to bore 55, mentioned above with respect to element 50) from beneath to accommodate the shank of a needle. This lug is also cross bored at 61 to intersect the bore 60, and threaded to accommodate a set screw 58 for clamping the needle shank. Fig. 4 is the section 4—4 of Fig. 2, and most clearly shows the arrangement, in plan, of elements 50 and 51. The lugs 54 and 59 of elements 50 and 51, respectively, are in register with each other on the machine, and constitute a transverse series of lugs from one side of the machine to the other. The height of elements 50 and 51 is common, as seen best in Figs. 1 and 2. In the machine the bodies of elements 50 extend predominantly to the rear of the vertical transverse plane which includes the axes of all needles, and the bodies of elements 51 extend predominantly to the front of this plane, as clearly shown in Figs. 3 and 4. It is of course necessary to prevent rotation of the needles, and therefore necessary to prevent rotation of the elements 50 and 51. For this reason each element 50 is provided with an upwardly extending pin 62 which is force fitted into a bore 63 at the rear of the body of the element and which pin operates as a key to prevent rotation of the element by passing through a bore 64 provided in bar 31; and each element 51 is provided with a functionally equivalent upwardly extending pin 65 which is force fitted into a bore 66 at the front of the body of the element and which pin passes through a bore 67 provided in bar 31. See Figs. 1, 2, 3, and 4; also Figs. 5 and 6. The free height of each pin 62 or 65 is common and is slightly greater than the range of axial movement of any solenoid plunger, which, of course, is equal to the axial movement of any needle.

Upon energization of any solenoid its plunger 40 is of course drawn downwardly for the reason that the upper part 42 of the plunger is the armature of the particular solenoid. It will be noted in Fig. 1 that, normally, about one sixth of the armature, or upper part 42 of the plunger 40, is within the sleeve 37, so that, upon energization of the solenoid, the greatest attractive force is immediately applied to the armature. Thus the greatest attractive force is available for overcoming the inertia of the plunger, its element 50 or 51, as the case may be, the needle, and yarn threaded through the needle. Yarn is not shown in connection with the needle in the drawing, but it will be understood that the yarn will ordinarily be derived from a cone mounted for rotation on a rack, and is passed through certain guides and tensioning devices, so that the starting of the yarn from standstill requires no negligible force. As any plunger continues to descend during the sucking into the sleeve 37 of the armature of the related solenoid, the descending cap 45 compresses a spring 48. Of course the armature tends to overthrow; but, as the plunger continues to descend, the spring 48 increasingly resists the movement of the plunger, and, also, as the armature, i. e., the permeable upper part 42 of the plunger, approaches a condition of completely occupying that portion of the sleeve 37 actually surrounded by the winding 35 of the solenoid, the magnetomotive force of the solenoid field with relationship to the armature approaches zero; and, in effect, the plunger tends to come to rest at a particular position with respect to its solenoid. However, to insure arrest of the plunger at a desired position (preferably one at which the magnetomotive force of the solenoid field with relationship to the armature tends per-

ceptibly to urge the armature downwardly), a stop 68 is provided. This stop is here shown as a rigid bar disposed transversely with respect to the machine, and is adapted to be engaged by a part of a lug 54 of an element 50 or of a lug 59 of an element 51. See Fig. 2, particularly, wherein, in dotted lines, the plunger, element 50, and the related needle 30 of the third tufting device are shown in downmost position. Here the needle is indicated as having passed through the web (not shown) and the bed plate 13 of the machine, and, assuming the needle to have brought down a loop of yarn (not shown), the hook 25 then proceeds to catch the loop and draw it away from the needle path in usual manner. In Fig. 2 the lug 54 of element 50 is shown in contact with the stop 68, which is in section. As a refinement the stop 68 may be padded; and, of course, the stop should be amply reinforced or intermediately supported in suitable manner to prevent deflection. The stop 68 may be supported by the uprights 11 and 12. See Fig. 1.

It will be understood from the foregoing that any tufting device of the series may be caused to operate to produce a tuft during part of a revolution of the drive shaft if the solenoid of that device is energized for a particular period during such revolution. Accordingly, if the several solenoids related to selected tufting devices are energized simultaneously throughout a particular period during a revolution of the drive shaft, a number of tufts, spaced as desired, may be produced in a transverse row corresponding to a single feed step of the web. The period of energization of one or more solenoids relating to a particular revolution of the drive shaft is obviously but a fraction of the time required for the whole revolution, and is, further, much less than half the time required for the revolution. For example, Fig. 2 may be taken as an illustration of the relative positions of parts of operating tufting devices at the moment of the beginning of a single revolution of the drive shaft. The hook 25 is retracted from the needle path, and the knife is in its furthest cutting position, i. e., the knife is at its extreme position following a cutting movement. As the drive shaft turns through one cycle the linkage between that shaft and the hook shaft causes the latter to rock first in one direction and next in the opposite direction, and each half cycle of the hook shaft, and consequently of the hook itself, begins very slowly from zero speed, accelerates to maximum, and decelerates from maximum, speed—the acceleration portion being a reverse pattern of the deceleration portion—and very slowly attains zero speed. Thus the hook starts away from the position shown in Fig. 2 very slowly, accelerates, decelerates, and comes to rest very slowly adjacent the needle path, and returns to the position shown in Fig. 2 with an identical speed pattern. The needle, of course, must arrive at the position shown in dotted lines in Fig. 2 before the hook arrives at a position adjacent the needle path, for the yarn loop must be present when the hook approaches the needle. The needle may begin its return whenever the hook has caught the yarn loop. During the cycle of operation of the hook the knife is first retracted from the hook so that the loop may be freely caught on the hook and then the knife is advanced toward the hook so as to cut the loop to form the tuft.

Thus the solenoid relating to a tufting device which is to operate during a particular revolution of the drive shaft should be energized at or shortly after the beginning of the revolution, but certainly in ample time to effect arrival of the needle in the dotted line position shown in Fig. 2 before the hook advances into position to receive the yarn loop. Deenergization of the solenoid may take place at or approximately at the end of the first half cycle of the drive shaft revolution, which is, of course, equivalent to the end of the first half cycle of the hook operation. When the solenoid is deenergized the related compression spring 48 returns the needle to normal position, as shown in Fig. 1 and in solid lines in Fig. 2.

Mounted on the drive shaft 16 at the righthand side

9

10

of the machine as shown in Fig. 1 is a sprocket 69. No chain is shown on the sprocket in Fig. 1, but in the diagram of Fig. 7 a chain 70 is shown connecting this sprocket with a larger sprocket 71 mounted on an idler shaft 72; and mounted also on the idler shaft is another small sprocket 73 which is connected by a chain 74 with another larger sprocket 75 on a shaft 76. In Fig. 7 the sprockets are indicated by their hubs since the chains obscure the actual sprockets. The idler shaft 72 and shaft 76 are both parallel to the drive shaft 16, and are suitably journaled and supported; but shafts 72 and 76 need not be dependent upon the main frame of the machine for support, and may be positioned away from the main frame if such practice is desired, as for reasons of simplifying the mechanism to which and through which the web and yarn is fed. The function of the connections between the drive shaft 16 and shaft 76 is to effect a predetermined, and much slower, rate of revolution of shaft 76 than that of the drive shaft. The degree of reduction of speed and the distance between the drive shaft and shaft 76 are both, of course, matters of choice.

Mounted on shaft 76 is a composite switch actuator, generally designated 77. While such actuator may be built in any of several forms, it is suggested in Figs. 8 and 9 that the actuator comprise a sandwich structure made up alternately of disks 78 and spacers 79, the latter of less diameter than the disks, the disks and spacers being mounted on shaft 76 and keyed thereto by means of a common key 80. Each disk of the sandwich structure relates to one tufting device, and the periphery of the disk is provided with a number of switch-actuating teeth 81, adapted to engage and operate the button 82 of a device such as a microswitch. Fig. 8 is a cross sectional view of the composite switch actuator and shows more than half of one disk 78, and a microswitch positioned to be operated by the teeth 81 of the disk as the latter rotates. In Fig. 8 one tooth 81 is shown in contact with button 82 of the microswitch, indicating that such switch is closed, and that the solenoid to which the microswitch relates is energized. Fig. 9 is a fragmentary view of the composite switch actuator taken at 90° to the view of Fig. 8. Fig. 9 indicates the arrangement of a series of microswitches relating to a series of disks 78. Of course, in association with a large yardage tufting machine, the number of disks and microswitches would be considerable, and would occupy a good deal of space. Consequently it might well be necessary to position the switch actuator and switches at some distance from the actual tufting mechanism to avoid interference with the web and the yarn rack.

There is, of course, one disk 78, one microswitch, and suitable wiring, in parallel, for each solenoid of the tufting machine. This is diagrammatically illustrated in Fig. 7. If it be assumed that the conventionalized needle arrangement shown in Fig. 7 corresponds to the arrangement shown in Fig. 1, it is seen that microswitch *a* relates to the solenoid of the first tufting device, and microswitches *b*, *c*, *d*, *e*, and *f* relate, respectively, to the solenoids of the second, third, fourth, fifth, and sixth tufting devices, of Fig. 1. The switches, in Fig. 7, are indicated by symbols. That microswitch, indexed *n*, is assumed to relate to the last solenoid to the right of the complete machine. It will be seen in Fig. 7 that all solenoids of the machine are wired in parallel and are connected to a common source *S*, and that any solenoid or any group of solenoids may be energized at the same time by the closing of the microswitch or microswitches involved. Fig. 9 shows, in outline, microswitches *b*, *c*, *d*, and *e*, while Fig. 8 shows only microswitch *b*, with its leads extending from the top thereof. Any suitable means for supporting the series of microswitches may be adopted.

In Fig. 7 the teeth of various disks 78 are indicated by solidly inked rectangles, and the differences in size of the rectangles is a diagrammatic showing of the rotund character of the actuator 77.

It will be plain from the foregoing that the actuator is timed with respect to the drive shaft 16, and that the angular dimension of each tooth 81, as well as the angular position of the tooth, is determined by the length and point of time during and at which a related microswitch is to be closed.

It will be understood that, while each disk 78 must be specially prepared for the control of the tufting device to which it relates, and that considerable work is involved in preparing a number of such disks to effect the production of a particular pattern of tufting on a web, the machine, once set up for that pattern, may be expected to operate for a great number of yards of material; and, that, quite possibly, a switch actuator structure prepared for a particular pattern may be in use for several months.

It is seen in Fig. 8 that certain pairs of teeth 81 are separated by greater distances than other pairs. Those pairs least separated may be taken to indicate an arrangement for effecting operation of the related tufting device one time during each of two consecutive revolutions of the drive shaft. Of course the dentition of a disk 78 may accord with any of a great variety of specifications for the operations of a particular tufting device.

Fig. 10 is, in large part, a reverse plan view, and in small part (in the upper lefthand corner), an obverse plan view of a sample of tufted fabric which may be produced according to the invention. The web of base material is indexed *W*. *T* indicates tufting, and *s* indicates stitches, respectively on the obverse and reverse sides of the web.

The web, of which a sample is shown in Fig. 10, passes through the machine in the direction which is vertical in the figure. In usual manner every revolution of the drive shaft effects one feed step of the web, and the dot and dashed lines *x* and *z* (horizontal in the figure and corresponding to transverse in the machine) indicate, respectively, the alignment of the series of needles at every tenth feed step, and the alignment at each step between the steps which are multiples of ten. The product shown in Fig. 10 is assumed to have been laundered and the filaments of the yarn on the obverse or tufted side of the fabric are indicated as being variously separated and spread in many directions to form foliate groups. All groups shown in the upper lefthand corner of Fig. 10 are assumed to have been formed of several stitches each, and correspond to the mirror image of the pattern, shown only as stitching, in the upper righthand corner of the figure.

Fig. 7 shows diagrammatically a means for feeding a web step by step through the machine and the plurality of independently operable tufting devices. A bellcrank 83, pivoted at 84 at a convenient place on the main frame or an attachment thereto, has an arm 85 which engages eccentric 18 or an equivalent thereof, and which is urged, like a cam follower, into contact with the eccentric at all times by a spring 86 which is attached to the outer extremity of the other arm 87 of the bellcrank and to any suitable fixed element 88. Obviously the bellcrank oscillates through a complete cycle for each revolution of the drive shaft 16. Pivotaly mounted at 89 on arm 87 of the bellcrank is a pawl 90, which may be assumed to be guided in suitable manner, and which coacts with a ratchet 91 mounted on a shaft 92. Also mounted on shaft 92 is a feed roller 93 which cooperates with another feed roller 94. The web *W* is fed step by step between these rollers. Of course it will be understood that the step by step feed mechanism illustrated in the diagram is not intended to have any particular spatial relationship to the needle bank of the machine; and it will also be understood that the feed mechanism and those parts of the diagram to which it is attached by solid lines are seen at 90° to other parts of the diagram.

I claim:

1. In a yardage tufting machine, a row of needles, each thereof being normally maintained in a common

11

alignment with respect to the longest dimension of the needles; a row of independently operable needle bars holding said needles, there being one bar for each needle; and at least two rows of electromagnets, each electromagnet having an armature for actuating a needle bar, there being one armature for each bar, with the electromagnets of one row being staggered with respect to the electromagnets of another row; and with all rows recited herein being in parallelism.

2. The combination of claim 1 wherein the electromagnets of a row thereof are consecutively contiguous.

3. The combination of claim 1 wherein the electromagnets of a row thereof are consecutively contiguous, and wherein said rows of electromagnets are contiguous.

4. In a yardage tufting machine, a row of needles, each thereof being normally maintained in a common alignment with respect to the longest dimension of the needles; a row of independently operable needle bars holding said needles, there being one bar for each needle; at least two rows of electromagnets, each electromagnet having an armature for actuating a needle bar, there being one armature for each bar, with the electromagnets

12

of one row being staggered with respect to the electromagnets of another row; and with all rows recited herein being transverse with respect to the machine, and means for moving a web of material step by step through the machine near and perpendicularly to the row of needles when the needles are in said common alignment.

5. The combination of claim 4, including other means for synchronizing energization of excerpptions of said electromagnets with intervals between steps of said web.

6. The combination of claim 4, including other means for synchronizing energization of excerpptions of said electromagnets with intervals between steps of said web, and apparatus for predetermining particular excerpptions of said electromagnets to be energized during said intervals.

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