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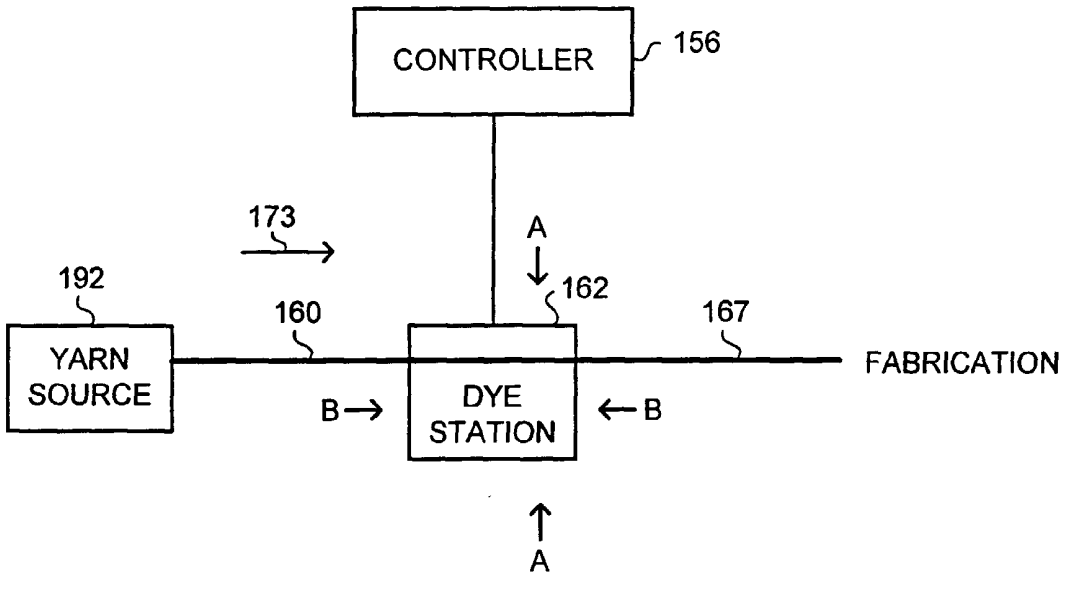
(54) **Title:** METHOD AND APPARATUS FOR DYEING OF YARNS OF CARPETS



(57) **Abstract:** An apparatus for dyeing at least one yarn for fabrication in a carpet, the apparatus including at least one dye station for applying variable amounts of at least one color dye along the yarn.

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METHOD AND APPARATUS FOR DYEING OF YARNS OF CARPETS

FIELD OF THE INVENTION

The present invention relates to fabrication of carpets, rugs, upholstery, mats, and any such products made of yarns, in general, and to dyeing of individual yarns, prior to integration of the yarns in the product, in particular.

BACKGROUND OF THE INVENTION

Carpets, rugs, upholstery, mats, and any such products made of integrated yarns, in general, are fabricated by a variety of methods. For the sake of convenience, the term "carpet" herein below, refers to all such products mentioned above. These methods include tufting, for pile carpets, and weaving, sewing, adhesive bonding and further methods, in the case of other types of carpets. All such methods employ the combining of yarns or a series of yarns into the final product.

General review of prior art is now made with reference to Figure 1. Figure 1 is a schematic illustration of a system, generally referenced 100, for fabricating carpets (not shown), as known in the art. System 100 includes a yarn or a plurality of yarns 102, a plurality of N dye stations 104, a fixation station 110, and a feeding mechanism 112. For simplicity, only the first dye station #1 and the last dye station #N are shown. Dye stations 104 are located along the path of each of the yarns 102 advancing through system 100 along a direction designated by an arrow 106. Each dye station applies a different dye to distinct sections of yarn(s) 102. Feeding mechanism 112, feeds yarn(s) 102 to a fabrication machinery (not shown).

US Patent 1,990,907 issued to Kellogg, entitled "Method and Apparatus for Producing Pile Fabrics", and US Patent 4,106,416 issued to Blackstone et al., entitled "Control Apparatus for Textile Dyeing and

Tufting Machinery", teach such methods, as described above with reference to Figure 1.

Kellogg employs a dye station consisting of a pair of pads, a fixed one containing a dye, and a movable one, above it. The moving yarn travels between the two pads, and the dye is applied to the yarn, whenever the upper pad moves down, and presses the yarn against the fixed pad. The movement of the upper pad is controlled by a jacquard mechanism. The jacquard mechanism imparts movement to the pads according to a set of punched cards, which correspond to the final pattern of the carpet. Blackstone et al. employ a dye station in the form of a pick-up roll partly submerged in a dye bath, and rotating continuously, whereupon an air cylinder is situated. The moving yarn passes between the pick-up roll and the air cylinder, and whenever the cylinder rod extends, it presses the yarn against the pick-up roll, and the dye is applied to the yarn. In both methods the dye station operates in synchrony with movement of the yarn through the system. It will be observed that in both methods the number of different hues available for dyeing the yarn(s), is confined to the number of dye stations employed in the system.

SUMMARY OF THE INVENTION

There is thus provided according to the present invention, an apparatus for dyeing at least one yarn for fabricating a carpet, where the apparatus includes at least one dye station for applying variable amounts of at least one color die along the yarns. Preferably, each amount of the variable amounts of color dye imparts a specific hue of each color on a section along each yarn. Further preferably, the section along each yarn is selected according to a predetermined location on the carpet, onto which the section is designated to fabricate.

There is also provided a method for dyeing at least one yarn for fabrication of a carpet. The method includes the step of applying variable amounts of at least one color dye along the yarn. The method preferably further includes the steps of imparting a specific hue of the color dye on a section along the yarn by applying variable amounts, and selecting the section according to a predetermined location on the carpet to which the section is designated.

The apparatus or the method may further include a controller for controlling the application of variable amounts of color die, in registration with the section of the yarn, by controlling the amount of dye which a dye station dispenses on a unit of length along the section. The controller may also control the feeding of the section of the yarn in registration with the predetermined location of the section, on the carpet.

The carpet can be fabricated by a variety of methods such as tufting, weaving, knitting, braiding, lacing, sewing, adhesive bonding, and the like. The color dye preferably includes more than one color, the variable amounts of which intermix on the section of the yarn, to impart the resultant hue thereon. Optionally, the color dye is a single color selected from a list consisting of black, white, gray, yellow, green, red, blue, orange, and green.

The color dye preferably includes a plurality of color dyes, the combination of which forms a color palette. The color palette may be selected from a list consisting of cyan, magenta, yellow, and black ("CMYK"); cyan, magenta, yellow, black, orange, and green ("Hexachrome"); and red, green, and blue (RGB). The type of the dye station can be continuous ink jet, piezoelectric ink jet, thermal ink jet, drop-on-demand, valve application, solenoid valve application, air brush, and the like.

Optionally, the dye station ejects the color dye, through at least one nozzle located in the periphery of the yarn, and directed to emit dye thereon. In a preferable embodiment, the cross section of the outlet of the nozzle through which the dye ejects, is variable.

The nozzle may preferably include a plurality of sub-nozzles. Each sub-nozzle may be connected to a dye source, where each dye source contains the same color dye, but in a distinct concentration. Ejection of the dye from different combinations of the sub-nozzles, and intermixing of the dye on the predetermined section of the yarn, provides ejection of different amounts of the dye, from the nozzle.

Optionally, each sub-nozzle has a different cross section, the sub-nozzles being connected to a dye source, whereby ejection of dye from different combinations of the sub-nozzles, and intermixing of the dye on the predetermined section of the yarn, provides ejection of different amounts of dye from the nozzle. The nozzle may further include a series of nozzles located sequentially, each of the series of nozzles dyeing the same section of the yarn, wherein a relative motion of the section of the yarn is provided with respect to each of the series of nozzles.

Further optionally, the nozzle includes a series of nozzles located sequentially, wherein each of the series of nozzles dyes the same section of the yarn, and the amount of the color dyes which is ejected from each of the series of nozzles per unit time, is constant. Furthermore, the speed of

travel of the predetermined section of the yarn relative to each of the series of nozzles, determines the amount of the color dye which is applied to the section. The relative motion may be a reciprocating motion.

In a preferable embodiment, the dye station includes a plurality of dye stations arranged in a matrix, a plurality of yarns travel under a row of the matrix, and each dye station ejects the dye in at least one hue. Optionally, a plurality of dye stations are arranged in a column, and a plurality of yarns are arranged in a column. Each yarn moves in registration, through each dye station, each dye station dyes a corresponding yarn from the plurality of yarns with one dye, wherein the dyes are selected from a color palette.

Further features of a preferable embodiment may include a controller, at least one fixation station for providing color fixation to the dye, at least one fabrication machine for fabricating the carpet with the yarns, at least one feeding mechanism for feeding the yarns to the fabrication machine, at least one marker for marking the dyed yarns with mark(s), informing the location of the section or a consecutive sequence of the sections, and at least one sensor for sensing the mark(s). The sensor senses the mark(s), and notifies the controller of the mark. The controller controls the dye imparted by the dye station, as well as the marks imparted by the marker. The controller further controls the feeding of the feeding mechanism, and the action of the fabrication machine, thereby fabricating the carpet according to a selected color pattern.

The fabrication machine may incorporate the feeding mechanism. Preferably, the fixation station fixes the dye immediately following ejection of the dye by the dye station. The apparatus or the method may further include at least one pre-fixation station for prefixing the dyed yarn immediately after its dyeing by the dying station. The apparatus or the method may further include at least one inventory of dyed and prefixed or fixed yarns, and at least one fabrication machine, wherein the inventory includes stacks of dyed and prefixed yarns, or fixed yarns being fed to the

fabrication machine upon exhaustion of a dyed and prefixed yarns, or fixed yarns of a previous stack of the inventory.

According to a preferable embodiment, the apparatus or the method further includes a fabrication machine for fabricating the carpet with the yarn. The fabrication machine includes at least one yarn application unit and a backing sheet. The yarn application unit combines the yarn with the backing sheet, and the fabrication machine provides a relative motion between the yarn application unit and the backing sheet.

The apparatus or the method may further include a back coating applicator for applying a coating to the underside of the carpet, an application unit mover for providing the relative motion, or a take-up mechanism for moving the backing sheet with respect to the application unit. The backing sheet may be provided on a frame. The fabrication machine may employ a fabrication method such as combining at least one row of the yarn with the backing sheet, combining at least a portion of a row of the yarn with the backing sheet, combining at least one column of the yarn with the backing sheet and combining at least one matrix of the yarn with the backing sheet.

A take-up mechanism for unwinding the backing sheet from a backing drum, and winding the carpet on a carpet take-up drum may be provided, whereby the backing drum and the carpet take-up drum may be supported by a framework. The backing sheet may be stretched between a first take-up mechanism, and a second take-up mechanism. The yarn may be dyed and prefixed. The fabrication machine further includes a final fixation station providing final fixation of the dye of the dyed and prefixed yarn. Preferably, the final fixation station provides the final fixation to the fabricated carpet. In accordance with a preferable embodiment, the backing sheet includes a weft or a weft and a warp.

BRIEF DESCRIPTION OF THE INVENTION

The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with drawings in which:

Figure 1 is a schematic illustration of a system for dyeing of carpet yarns, as known in the art;

Figure 2 is a schematic illustration of a system for dyeing of carpet yarns, in accordance with a preferred embodiment of the present invention;

Figure 3 is a schematic illustration of cross section of a pile carpet, manufactured in accordance with another preferred embodiment of the present invention;

Figure 4 is a schematic illustration of cross section of another pile carpet, manufactured in accordance with a further preferred embodiment of the present invention;

Figure 5 is a schematic illustration of a system for dyeing of carpet yarn(s), constructed and operative in accordance with another preferred embodiment of the present invention;

Figure 6 is a schematic illustration of the dyed yarn of Figure 2, in accordance with a further preferred embodiment of the present invention;;

Figure 7 is a schematic illustration of a system for dyeing of yarns of carpet, constructed and operative in accordance with another preferred embodiment of the present invention;

Figure 8 is a schematic illustration of a system for dyeing of carpet yarns, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 9 is a schematic illustration of a system for fabrication of carpet, constructed and operative in accordance with another preferred embodiment of the present invention;

Figure 10 is a schematic illustration of a system for dyeing of carpet yarns, and manufacture of carpet, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 11 is a schematic illustration of a fabrication machine, constructed and operative in accordance with another preferred embodiment of the present invention;

Figure 12 is a schematic illustration of a fabrication machine, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 13 is a schematic illustration of the fabrication and fixation machine of Figure 10, constructed and operative in accordance with another preferred embodiment of the present invention;;

Figure 14, is a perspective illustration of a carpet fabrication system, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 15, is a perspective illustration of another variation of the carpet fabrication system of Figure 14, constructed and operative in accordance with another preferred embodiment of the present invention;

Figure 16 is a perspective illustration of a further variation of the carpet fabrication system of Figures 14 and 15, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 17 is a schematic illustration of side view of a nozzle, of dye station of Figure 2, constructed and operative in accordance with another preferred embodiment of the present invention;

Figure 18 is a schematic illustration of cross sectional bottom view of the nozzle of Figure 17, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 19 is a schematic sectional view of a dye station, constructed and operative in accordance with another preferred embodiment of the present invention;

Figure 20 is a schematic illustration of a nozzle, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 21 is a schematic illustration of a dye supply assembly of each sub-nozzle of the nozzle of Figure 20, constructed and operative in accordance with another preferred embodiment of the present invention;

Figure 22 is a schematic illustration of a nozzle, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 23 is a schematic illustration of a dye supply assembly of each sub-nozzle of the nozzle of Figure 22, constructed and operative in accordance with another preferred embodiment of the present invention;

Figure 24 is a side view of one possible embodiment of the dye station of Figure 2, taken along intersection A-A in Figure 2, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 25 is a schematic illustration of the nozzles of Figure 24, constructed and operative in accordance with another preferred embodiment of the present invention;

Figure 26 is a schematic illustration of a side view of the dye station of Figure 2, constructed and operative in accordance with a further preferred embodiment of the present invention;

Figure 27 is a schematic illustration of a side view of the dye station of Figure 2, constructed and operative in accordance with another preferred embodiment of the present invention;

Figure 28 is a schematic illustration of the bottom view of the dye station of Figure 2, taken along intersection B-B, constructed and

operative in accordance with a further preferred embodiment of the present invention;

Figure 29 is a schematic illustration of the dye station of Figure 2, constructed and operative in accordance with another preferred embodiment of the present invention; and

Figure 30 is a schematic illustration of a side view of the dye station of Figure 2, taken along intersection A-A in Figure 5, constructed and operative in accordance with a further preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The detailed description of the invention is generally applicable to fabrication of carpets. In particular, the description is concerned with "in-line" or "in-situ" dyeing of the yarns of a carpet, in a practically unlimited number of hues.

The present invention overcomes the disadvantages of the prior art by employing a dye station which can impart almost any hue in the visible range, to the yarn, by employing dye application techniques known in the printing art. A dye station in the printing art generally consists of a palette of colors, for instance Cyan (C), Magenta (M), Yellow (Y), and blacK (K), known in the art as the CMYK color palette. Other color palettes may be employed, such as Cyan, Magenta, Yellow, Black, Orange, and Green ("Hexachrome"), or Red, Green, and Blue ("RGB"). These color palettes are not exhaustive, and other color palettes may also be employed. As is well known, it is theoretically possible to create unlimited number of hues in the visible range, by using only the four pigments in the CMYK color palette. Creation of a certain hue is provided by mixing together the color pigments (or the basic pigments of other color palettes), each in a certain ratio. It is noted that the present invention provides creation of a practically almost unlimited number of colors from a certain color palette, but not in a theoretically unlimited range.

Reference is now made to Figure 2, which is a schematic illustration of a carpet fabrication apparatus and system, generally referenced 145, constructed and operative in accordance with a preferred embodiment of the present invention. System 145 operates on at least one yarn 160, from at least one yarn source 192. Yarn 160 travels through the system 145, in a direction 173, and yarn 160 is dyed by at least one dye station 162. System 145 optionally, includes a controller 156. The dyed yarn(s) is referenced by numeral 167. Dye station 162 is a device which applies different pigments from a color palette, in proper ratios, to

be mixed on yarn(s) 160. Alternatively, dye station 162, may apply only one dye to yarn(s) 160, in various amounts, whereby yarn(s) 160 lengthwise through station 162, is dyed in a uniform hue. Thus, application of a dye to yarn(s) 160, in amounts varying along the length of yarn(s) 160, may impart various shades of the dye along yarn(s) 160. For example, if various amounts of a black dye are applied along the length of a white yarn(s) 160, then various sections of yarn(s) 160, are dyed in various shades of gray, respectively. The term "palette" herein shall therefore include also a single color "palette".

Dye station 162 dyes yarn(s) 160, while yarn(s) 160, continuously or intermittently, travel through system 145 in the direction depicted by arrow 173. Dyed yarn(s) 167 are then fabricated into a carpet (not shown). Dye station 162 preferably operates according to one of the dye application methods as described below, or other methods such as continuous ink jet, piezoelectric ink jet, thermal ink jet, drop-on-demand, valve application, solenoid valve application, air brush, and the like. Controller 156, controls the amount of dye which the dye station 162, dispenses on a unit of length of yarn 160.

Yarn 160 may include a plurality of yarns which, when placed side by side, and processed into the carpet, by conventional fabrication methods, such as tufting, weaving, knitting, braiding, lacing, sewing, adhesive bonding, and the like, make up the final thickness of the carpet. Yarn source 192 may include a cylindrical or a conical object about which yarn 160 is wound, or alternatively, any yarn storage, supply, inventory or manufacturing source. A plurality of yarns 160 may also be supplied from a plurality of yarn sources 192.

Reference is now made to Figure 3, which is a schematic illustration of a cross-section of a pile carpet, generally referenced 130, manufactured in accordance with another preferred embodiment of the present invention. The pile carpet includes dyed yarn 167, combined with

a backing sheet 136, and a back coating 138. The back coating 138, may be any material which is conventionally employed in the art, to cover the loops of the dyed yarn 167, protruding from or disposed underneath backing sheet 136. The visibly apparent sections of dyed yarn 167, correspond to sections 132, protruding from and above backing sheet 136. Sections 134, intermediate between sections 132, are concealed within or beneath backing sheet 136. Hence, the dye of sections 132 is visible, while sections 134 need not be dyed due to their concealment.

Reference is further made to Figure 4, which is a schematic illustration of cross section of another pile carpet, manufactured in accordance with a further preferred embodiment of the present invention. Like sections 134 described in connection with Figure 3, sections 139 need not be dyed, due to their removal. The arrangement shown in Figures 3, or 4, may be obtained, by timing the operation of each dye station 162, with movement of the yarn(s) 160 through the system 145, so that sections 132 are dyed, while sections 134 (and 139 - if extant as in Fig. 4) are not necessarily dyed.

Reference is now made to Figure 5, which is a schematic illustration of a system for dyeing of carpet yarn(s), generally referenced 150, constructed and operative in accordance with another preferred embodiment of the present invention. System 150, includes the controller 156, at least one yarn source 158, at least one yarn 160, and at least one dye station 162. Yarn source 158 may comprise an inventory of yarn or any other supply of gathered yarn, or in-line yarn manufacturing means. System 150 further includes at least one fixation station 164, at least one feeding mechanism 166, a fabrication machine 168, a sensor 170, and a marker 172. Controller 156 includes data related to the pattern opted to appear on the carpet (not shown). The data may include information such as hue, the location of each hue along the length of each of the yarns 160 which make up the carpet, and the like. The data in controller 156, may

be furnished by an external source (not shown), interface means (not shown), generated by an external scanner (not shown) for scanning an existing image, or provided by any other suitable means. Controller 156 preferably controls the operation sequence of further devices of system 150.

Fixation station 164 may include curing or heat emitting sources, such as electric heating elements, RF heating elements, infrared lamps, ultraviolet lamps, hot air sources, and the like. Fixation station 164, may further include a radiation source, which induces chemical reactions between the dye molecules and the yarn molecules, thereby causing atomic bonds there between. Fixation station 164 may also provide for evaporation of solvent or other chemicals contained in the dye, and thereby result in the adhesion of pigment to yarn 160. Other curing methods employed in fixation station 164, may provide for emission of materials that reach the dyed yarn 160, and react therewith to bond the dye to yarn 160. Fixation station 164, may also comprise a chamber whereby air flow is maintained, and the dye dries in ambient air.

Feeding mechanism 166 feeds yarn 160 in system 150 by employing feeding implements known in the art, such as counter-rotating rollers, frictional pulleys, and the like. Fabrication machine 168 is a machine that performs one of the yarn application operations known in the art, such as tufting, weaving, knitting, braiding, lacing, sewing, adhesive bonding, and the like. Marker 172 marks yarn 160, preferably after dye application or after fixation, but can also be arranged to provide the mark before fixation or before dye application. Marker 172 may be of the types known in the art to apply a mark to a yarn or similar substrate, such as a magnetic mark, an optic mark - in the visible or invisible range, a radioactive mark, a physical (mechanical) mark, and the like, each type adapted to be detected by a corresponding type of sensor 170. Sensor 170 senses the longitudinal position of yarn 160 in, or before entering

fabrication machine 168. Sensor 170 may be of the types known in the art, such as magnetic, optic, radioactive, mechanical, and the like. Thence, sensor 170 can detect the position of yarn 160 in fabrication machine 168, by sensing the mark applied by marker 172 to yarn 160. Marker 172, may provide marking of the yarn at predetermined locations along the yarn 160, such as every unit length, every row of the finished carpet, start or end of each pattern, at the start or end of each new color, and the like.

Yarn source(s) 158 are positioned upstream of dye station 162, respective of the direction 173 of the advancement of yarn(s) 160 through system 150. Fixation station 164 is positioned downstream of dye station 162, and the feeding mechanism 166, is located downstream of the fixation station 164. Feeding mechanism 166 and/or auxiliary feeding mechanisms (not shown) may be located anywhere along yarn(s) 160, as desired. Fabrication machine 168 is positioned downstream of feeding mechanism 166, which may be integrated therewith. Dyed yarn 167 is fed to the fabrication machine 168, while passing through the fixation station 164, and the feeding mechanism 166. Controller 156 is preferably connected to all or part of the following components: dye station 162, fixation station 164, marker 172, feeding mechanism 166, sensor 170, and fabrication machine 168.

Reference is now made to Figure 6, which is a schematic illustration of the dyed yarn of Figure 2, in accordance with a further preferred embodiment of the present invention. Sections 132 of dyed yarn 167 are visibly apparent and dyed. Sections 134 are concealed beneath the backing sheet 136 (or sections 139 - if extant are cut out, and are not dyed). The start and end point of each dyed section 132 are designated by references 133, and 135, respectively.

Controller 156 (Figure 5), controls the operation of dye station 162, and the feeding mechanism 166, in order to dye specific sections 132

of yarn(s) 160, to specific hues. Controller 156, sends a signal to dye station 162. Dye station 162, in response to the signal, applies a dye to yarn 160, in a hue according to the signal. The hue is created by dispensing the dyes from the color palette in proper ratios or amounts, according to the type of dye station being employed, as described above in connection with Figure 2.

Fixation station 164 (Figure 5), applies heat or curing to the dye, thereby evaporating the solvent of the dye, or inducing other bonding reactions, as described above, and causing the dye to adhere to yarn 160. Activation of the fixation function may be provided automatically for the adequate time interval, by mere passing of yarn 160 there through. It is noted that fixation of the dye also depends on the speed of travel of yarn 160 in system 150. For example, if a heat emitting fixation station is employed, the faster the dyed yarn 167 advances through system 150, the greater must be the power output of the heating elements (not shown). If excessive fixation is to be avoided, the activation and deactivation of the fixation may be synchronized in agreement with a signal received from controller 156. Such synchronization may be provided according to the speed of travel of dyed yarn 167, or the start or end points 133, and 135, of the dyed sections 132, with or without the control of controller 156. The operation of fabrication machine 168, is synchronized with operation of dye station 162, so that a specific section 132 of dyed yarn 167, is applied at a specific position on the backing sheet 136. For reliability, the synchronization preferably relies upon the readings of sensor 170, based on the markings of marker 172. Marker 172, and sensor 170 might be entirely eliminated from the system 150, if controller 156 provides the appropriate synchronization between dye station 162, and fabrication machine 168.

Marker 172, marks the start 133 (or, alternatively - the ending 135) of section 132, according to a signal received from processor 156.

Sensor 170, senses the start 133 (or ending 135) of section 132, and informs controller 156 of this information, by sending a signal to controller 156. Controller 156 receives the signal from sensor 170 and controls the operation of fabrication machine 168, by sending a signal to fabrication machine 168, so that fabrication machine 168 applies section 132 to the specific position on the backing sheet 136. Feeding mechanism 166, feeds dyed yarn 167 to fabrication machine 168, according to a signal received from controller 156.

Reference is now made to Figure 7, which is a schematic illustration of a system for dyeing of yarns of carpet, generally referenced 155, constructed and operative in accordance with another preferred embodiment of the present invention. System 155 is an alternate embodiment of system 145 (Figure 2), whereby a fixation station is located downstream of each dye station. For example, fixation station 164 is located downstream of dye station 162, and a fixation station 165 is located downstream a dye station 163. It is noted that a plurality of dye stations and fixation stations might be employed.

Reference is now made to Figure 8, which is a schematic illustration of a system for dyeing of carpet yarns, generally referenced 190, constructed and operative in accordance with a further preferred embodiment of the present invention. A plurality of yarn stacks #1, #2, until #N, respectively designated 192, 194, and 196, are positioned in series, so that after yarn 160 is entirely depleted or unwound from yarn stack 192, a yarn stack 194 is brought into position. Thereafter, a yarn 198 is unwound from yarn stack 194, and fed to system 190, and so on until yarn stack 196. Thence, system 190 is able to operate continuously, whereby a supply of yarn is available as long as a series of yarn stacks #1, #2, until #N, respectively designated 192, 194, until 196, or a series of any number of yarn stacks, or at least one stack, are available.

Dyed yarn 167 may pass through a pre-fixation station 200, after being dyed by dye station 162. It is noted that the pre-fixation period is substantially shorter than the fixation period, because the pre-fixation station 200, partially evaporates the solvent contained in the dye or partially applies bonding reactions or environment thereto. Thereby, yarn 160 can travel at a high speed through system 190. A single or a plurality of dyed and pre-fixed yarn(s) 204, are then accumulated in an inventory of dyed and pre-fixed yarns.

Reference is further made to Figure 9, which is a schematic illustration of a system for fabrication of carpet, generally referenced 195, constructed and operative in accordance with another preferred embodiment of the present invention. Controller 156, controls the retrieval sequence of yarns 206 from dyed and pre-fixed stacks 208 to 210. Controller 156, further controls the marking of yarns 206 by marker 172, and also the operation of fabrication and fixation machine 202.

An inventory of dyed and pre-fixed yarns 209, includes a plurality of dyed and pre-fixed stacks #1 through #M, designated by references 208, and 210. It is noted that the dyed and pre-fixed yarn(s) 204 of system 190 of Figure 8, may be fed to the inventory of dyed and pre-fixed yarn(s) of system 195 of Figure 9. Thereby, accumulation of a supply of dyed and pre-fixed yarn(s) 206 is ready to be fed to the fabrication and fixation machine 202. The fabrication and fixation machine 202, fabricates the carpet from the dyed and pre-fixed yarn(s) 206, which are identified by the sensor 170, according to the pattern stored in controller 156. The fabrication and fixation machine 202, further applies a final fixation to the yarns of the finished carpet, independent of the pace of operation of dye station 162 (Figure 8), and pre-fixation station 200. The isolation of the process of the dye and pre-fixation from the process of feeding, final fixation and fabrication is provided by the inventory of dyed and pre-fixed

yarns 209. Thence, system 195 can fabricate a carpet in a shorter time, once dyed stacks 208 to 210 are accumulated.

Reference is further made to Figure 10, which is a schematic illustration of a system for dyeing of carpet yarns and manufacture of carpet, generally referenced 220, constructed and operative in accordance with a further preferred embodiment of the present invention. Systems 190, and 195, as described above in connection with Figures 8, and 9, are combined here, in an integrated system designated by reference 220.

Reference is now made to Figures 5 and 11. Figure 11 is a schematic illustration of a fabrication machine, generally referenced 300, constructed and operative in accordance with another preferred embodiment of the present invention. System 300 includes a backing drum 304, a carpet take-up drum 306, a take-up mechanism 308, a stretch mechanism 313, a back coating applicator 318, and a yarn application unit 310. A backing sheet 302 is rolled about and spread between backing drum 304, and carpet take-up drum 306. Backing sheet 302 is used for backing carpet 314 produced thereupon. Backing sheet 302, is a continuous sheet together on which yarn 167 (such as in Figure 2) is combined. System 300 is shown with the backing sheet 302, in a horizontal orientation, although a vertical orientation may also be employed. Back coating applicator 318, applies a coating to the underside of the carpet 314, as described above in connection with Figure 3.

Take-up mechanism 308, pulls and unwinds backing sheet 302 from backing drum 304, advances the carpet 314, towards drum 306, whereby carpet 314 winds on carpet take-up drum 306. Stretch mechanism 313, may be optionally incorporated with system 300. Stretch mechanism 313 is generally employed to counteract take-up mechanism 308, thereby maintaining the portion of the backing sheet 302, between backing drum 304, and carpet take-up drum 306, in a substantially stretched state. Stretch mechanism 313 may include a pair of pressing

rolls, and the like, effective to eliminate or attenuate wrinkles, waves and folds along or across backing sheet 302. Stretch mechanism 313 may operate according to a signal received from controller 156. Stretch mechanism 313 may alternatively be a substantially passive device, with or without constant application of a pulling force toward backing drum 304, whereby it maintains the backing sheet in a substantially stretched state, without receiving any signal from controller 156.

Carpet take up drum 306 may include a rolling mechanism for furthering the winding of carpet 314 there upon. Take-up mechanism 308 operates according to a signal, received from controller 156, and in synchrony with fabrication of carpet 314, by the yarn application unit 310.

The continuous backing sheet 302, is unwound from backing drum 304 and advances in a direction designated by an arrow 312. Carpet 314, which is formed together with backing sheet 302, is wound on the carpet take-up drum 306. Yarn application unit 310 is a device which receives the dyed yarn 167 from dye station 162 (as in Figure 2), and combines at least one dyed yarn 167, with the backing sheet 302, by methods known in the art, such as mentioned above.

Yarn application unit 310 is controlled by controller 156, and therefore it combines a plurality of dyed yarns 167, (or short sections of dyed yarns 167), dyed in the required hue, to the backing sheet 302. A relative motion between the yarn application unit 310, and the backing sheet 302 is provided, in a horizontal direction normal to the drawing sheet. Such a motion of yarn application unit 310 may be imparted by an application unit mover 311 in accordance with a signal fed by controller 156. Alternatively, such a motion of backing drum 304 and carpet take-up drum 306, may be imparted by a framework 315, in accordance with a signal fed by controller 156.

Yarn application unit 310, may include a feeding mechanism, whereby yarn(s) 167 are fed through system 300 (or yarn(s) 160 through

system 145 in Figure 2). Yarn application unit 310 combines at least one yarn 167 with a section of backing sheet 302. The length and width of such a section corresponds to the number of dyed yarns 167, being simultaneously applied by yarn application unit 310. Thereafter, yarn application unit 310 moves with the aid of application unit mover 311, a horizontal step normal to the drawing sheet, and combines further portions of dyed yarn 167, or of another plurality of dyed yarns 167, with another section of backing sheet 302. Likewise, yarn application unit 310, fabricates one (or several) row(s) of yarn on backing sheet 302. Thereafter, backing sheet 302, moves in direction 312, by the synchronized action of take-up mechanism 308, and thence yarn application unit 310 fabricates further row(s) of carpet 314. Carpet 314 is then taken up by the carpet take-up drum 306.

Reference is now made to Figure 12, which is a schematic illustration of a fabrication machine, generally referenced 301, constructed and operative in accordance with a further preferred embodiment of the present invention. A backing sheet 303, is provided on a frame 305 on which a carpet 319 is fabricated. Instead of a backing sheet 303, frame 305 may include weft, or warp and weft 303, on which the carpet 319 is fabricated by conventional methods, such as tufting, weaving, knitting, braiding, lacing, sewing, adhesive bonding, and the like. It may be noted that by employing a frame type backing sheet 303, the backing drum 304 (Figure 11), and carpet take-up drum 306, are eliminated.

Backing sheet 303 which is stretched on a frame 305, may be provided with horizontal and/or vertical motion relative to the yarn application unit 310, in synchronization with advancement of the carpet manufacture. Such a motion may be imparted by a frame mover 307 in accordance with a signal fed by controller 156.

Reference is now made to Figures 10 and 13. Figure 13 is a schematic illustration of the fabrication and fixation machine of Figure 10,

constructed and operative in accordance with another preferred embodiment of the present invention. Fabrication machine 202, may include a pre-fixation station 200, in which case such station 200 is eliminated in Figure 10. Fabrication machine 202 includes a final fixation station 316. It will be appreciated that pre-fixation of a dyed yarn is a relatively short treatment, aimed at avoiding removal of the dye from the yarn, and unfixed dye contamination of other portions of the yarn or the machinery, only until the final fixation; while final fixation is a relatively through treatment aimed at avoiding removal of dye for the entire "life-span" of the carpet. The short treatment is better suited for a rapid in-line process, while the final fixation - if applied to a portion of backing sheet 302, enables to provide the more thorough fixation treatment to a large amount of dyed yarn at once, and so save on precious in-line manufacturing time. Accordingly, dyed yarn 167 is pre-fixed in the pre-fixation station 200, and fed to the yarn application unit 310. Yarn application unit 310 applies pre-fixed yarn 204 to backing sheet 302, and fabricates carpet 314. Back coating applicator 318, applies a back coating to carpet 314, as described above in connection with Figure 11. Carpet 314 passes through final fixation station 316, whereby the dyes are adhered to the yarns integrated in carpet 314. Thereafter, carpet 314 is rolled on the carpet take-up drum 306. The embodiment shown in Figure 13 is a variation of those shown in Figures 10, 11, and 12, and accordingly all the other elements are not shown. It will be noted that final fixation station 316, which is located on carpet 314, provides at once, fixation to a large number of dyed sections of a yarn integrated in carpet 314- a simpler and faster process in comparison with the in-line full fixation of the yarn, prior to its integration in the carpet.

Reference is now made to Figure 14, which is a perspective illustration of a carpet fabrication system, generally referenced 600, constructed and operative in accordance with a further preferred

embodiment of the present invention. Fabrication system 600 includes a backing sheet 602, and a set of dyed yarns 167.

Backing sheet 602 may be employed in any of the arrangements described with reference to either of Figures 11, 12, or 13. The set of dyed yarns 167, may be either pre-fixed or fixed, as described with reference to either of Figures 11, 12, or 13. A plurality of yarn application units 310 (Figures 11, 12, or 13) may be located along a row Q, across backing sheet 602, and substantially perpendicular to a direction designated by an arrow referenced 608. Each yarn application unit 310 combines each dyed yarn 167, with backing sheet 602. The set of dyed yarns 167 are simultaneously combined with backing sheet 602, thus fabricating a row Q of a carpet 604 at once. Thereafter, backing sheet 602 moves in direction 608, and an adjacent row V is fabricated. Thus, the carpet may be fabricated by fabricating each row in sequence.

Alternatively, in each step of fabrication, only a part of the row Q may be fabricated, wherein additional movements in directions designated by reference arrows 606 and 610, are imparted to backing sheet 602.

It is noted that directions 606, 608, and 610, are relative to the yarn application units 310, and either the yarn application units 310, or the backing sheet 602, may move relative to one another, in either of the relative directions 606, 608, 610 or *vice versa*.

Reference is now made to Figure 15, which is a perspective illustration of another variation of the carpet fabrication system of Figure 14, generally referenced 630, constructed and operative in accordance with another preferred embodiment of the present invention. Yarn application units 310 (Figure 11, 12, or 13) simultaneously combine a set of dyed yarns 167, with a backing sheet 632, thus fabricating a column W of the carpet (Figure 15). Thereafter, yarn application units 310 cease operation, and backing sheet 632 moves in a direction designated by an arrow referenced 634, such that a column Y, adjacent to column W, is

fabricated. Further fabrication cycles, accompanied by step-wise movements of backing sheet 632, in direction 634 are performed, such that further columns of the carpet up to and including column Z, are fabricated. In this manner, a length of carpet designated by reference 640, is fabricated. Thereafter, backing sheet 632, moves in directions designated by references 636, and 638, and a further length of the carpet is analogously fabricated. It is noted that length 640 of the columns W through Z, may be equal to the length of the entire carpet to be manufactured, whereby backing sheet 632, moves only in direction 634 (and 638 only after the carpet is finished) relative to yarn application units 310, movements in direction 636 does not take place, and the carpet fabrication is performed in a single sequence.

It is noted that directions 634, 636, and 638, are relative to the yarn application units 310, and either the yarn application units 310, or the backing sheet 632, may move relative to one another, in either of the relative directions 634, 636, 638 or *vice versa*.

Reference is now made to Figure 16, which is a perspective illustration of a further variation of the carpet fabrication system of Figures 14 and 15, constructed and operative in accordance with a further preferred embodiment of the present invention. Yarn application units 310 (Figure 11, 12, or 13), may be located in a matrix P, whose first term is designated by reference $660_{1,1}$, and whose last term is designated by reference $660_{K,L}$. Indices K, and L, designate the number of 'K' rows and 'L' columns of matrix P, respectively. Yarn application units 310, simultaneously combine a set of dyed yarns $167_{1,1}$ through $167_{K,L}$, with a backing sheet 652, thereby fabricating a section of the carpet manufactured on backing sheet 652, whereby the size of such a section is substantially equal to the area encompassed by matrix P. Thereafter, backing sheet 652, moves in a direction designated by reference 654, and a further section of the carpet is similarly fabricated. Further such sections

are fabricated, until a length of the carpet, designated by reference 662, is fabricated across the entire width of backing sheet 652. Thereafter, backing sheet 652, moves in directions designated by references 656, and 658, and further sections of the carpet are similarly fabricated.

It is noted that directions 654, 656, and 658, are relative to the yarn application units 310, and either the yarn application units 310, or the backing sheet 652, may move relative to one another, in either of the relative directions 654, 656, 658, or *vice versa*.

It will be noted that the number of columns L of matrix P, may be such that a section of the carpet, having a width 664, equal to width 666 of the entire carpet, is simultaneously fabricated. Furthermore, the number of rows K of matrix P, may be such that a section of the carpet having a length 662 equal to entire length of the carpet, is simultaneously fabricated. Alternatively, any combinations of the above carpet lengths and widths may be employed. Furthermore, the number of rows K or columns L, of different matrices P, employed in fabricating different sections of the carpet, may vary. Therefore, it is possible to simultaneously combine a set of dyed yarns $167_{1,1}$ through $167_{K,L}$ with backing sheet 652, thereby fabricating the carpet in its entirety, in a single step, whereby no relative movement between backing sheet 652, and yarn application units 310, is required.

Reference is now made to Figure 17, which is a schematic illustration of side view of a nozzle, generally referenced 322, of dye station of Figure 2, constructed and operative in accordance with another preferred embodiment of the present invention. It is noted that dye station 162, may include as many nozzles 322, as there are dyes in the color palette being employed in system 145 (Figure 2). For example, if the CMYK color palette is employed, dye station 162 may include four nozzles referenced 322, one nozzle for each color.

Reference is further made to Figure 18, which is a schematic illustration of cross sectional bottom view of nozzle 322 of Figure 17, constructed and operative in accordance with a further preferred embodiment of the present invention.

The side wall of nozzle 322, is designated by reference 324, and an opening of the nozzle, through which the dye exits, is designated by reference 326. For the sake of convenience, the cross section of opening 326, is shown as a circle in Figure 18, but the cross section may be of any geometry, such as square, rectangle, and the like. Furthermore, opening 326, is of a variable cross section, thereby allowing control of the flow rate of the dye, when a constant fluid pressure of the dye is provided within nozzle 322. The cross section of opening 326, may be varied by using any mechanism known in the art, for varying a cross section. Such mechanisms may include flaps 327 resembling those used in cameras, as shown in Figure 18, a door (not shown) which reciprocates in a direction normal to axis of the opening 326, thus, allowing full closure, full opening, or partial openings in between, and the like.

The cross section of opening 326, is controlled by a signal sent to dye station 162, by the controller 156 (Figure 2). It is noted that by varying the cross section of opening 326 of each nozzle 322 in a dye station 162, it is possible to vary the relative amounts of each of the dyes in the color palette applied to a portion of yarn 160, thereby creating a desired hue on the yarn 160.

Reference is now made to Figure 19, which is a schematic sectional view of a dye station, generally referenced 330, constructed and operative in accordance with another preferred embodiment of the present invention. System 330 includes a yarn 160, moving in a direction designated by arrow 332, while nozzles 328, and 334, dispense a stream of dye, on yarn 160. It is noted that the term "stream" herein below, may refer to a substantially intermittent or continuous flow of dye, or

alternatively drops of dye. Only two of the nozzles 328, and 334 of dye station 162, are shown in Figure 19, where as discussed in connection with Figure 17, as many nozzles 328 or 334, as the number of dyes in the color palette, may be employed. It is noted that each nozzle 328 or 334, dispenses a different dye 344 or 346, respectively.

If the application of dye stream (or drops) 344 or 346 is provided at a constant rate, the amount of dye dispensed on yarn 160 per unit time, by nozzle 328 or 334, depends on the speed of travel of yarn 160, and therefore, such speed is variable. Thus, if yarn 160 travels faster, yarn 160 absorbs less dye, and if yarn 160 travels at a slower rate, yarn 160 absorbs a greater amount of dye. In the present embodiment, nozzle 328, dispenses a stream of dye 344, while yarn 160 travels at a speed V_1 in direction of arrow 332, and thus nozzle 328, dyes a section 336, starting at a point 338 on yarn 160, and ending at a point 340.

The flow of dye 344, from nozzle 328 stops, and while yarn 160 travels at a different speed V_2 in direction of arrow 332, nozzle 334 starts dispensing a stream of dye 346, on yarn 160. Nozzle 334 dispenses a stream of dye 346, on section 336 which was dyed by the stream of dye 344, starting from point 338, and ending at point 340. It is noted that the streams of dye 344, and 346, intermix on yarn 160. Due to the fact that speeds V_1 and V_2 are different, dyes 344, and 346, are dispensed on yarn 160, in different relative amounts, and therefore it is possible to create a specific hue on yarn 160.

Reference is now made to Figures 20, and 21. Figure 20, is a schematic illustration of a nozzle, generally referenced 348, constructed and operative in accordance with a further preferred embodiment of the present invention. Figure 21, is a schematic illustration of a dye supply assembly of each sub-nozzle of the nozzle of Figure 20, constructed and operative in accordance with another preferred embodiment of the present invention.

Nozzle 348 includes a plurality of sub-nozzles 350A, 350B, 350C, 350D and 350E. Each of the sub-nozzles 350A, 350B, 350C, 350D and 350E is of the type described herein above in connection with Figure 18. Sub-nozzle 350A is in fluid connection with a color supply represented by a container 352A, the connection being designated by a conduit 354A. A stream of dye 356A ejects from sub-nozzle 350A by a flow controller 358A. Each of the sub-nozzles 350B, 350C, 350D and 350E is similarly connected to a respective container (not shown), by a respective conduit (not shown), and a stream of dye dispenses from each of the sub-nozzles 350B, 350C, 350D and 350E, from a respective flow controller (not shown). Each of the containers (such as container 352A) contains dye 356A, of the same hue, but in a predetermined concentration in a solvent, differing from the concentration in the other containers.

For example, if nozzle 348 is allocated to dispense a yellow dye, each of the sub-nozzles 350A, 350B, 350C, 350D and 350E, dispenses a yellow dye in a different concentration, and thus, each sub-nozzle 350A, 350B, 350C, 350D and 350E dispenses a different amount of yellow dye. Thus, nozzle 348 dispenses a selected shade of yellow dye. For instance, sub-nozzle 350A may dispense a yellow dye with 50% concentration (1/2), sub-nozzle 350B - a yellow dye with 25% (1/4) concentration, sub-nozzle 350C - a yellow dye with 12.5% (1/8) concentration, sub-nozzle 350D - a yellow dye with 6.25% (1/16) concentration, and sub-nozzle 350E - a yellow dye with 3.125% (1/32) concentration.

Each flow controller (such as flow controller 358A) operates by a signal, received from controller 156 (Figure 2) to dispense a dye (such as dye 356A), from a respective container (such as container 352A). Any combination of flow controllers (such as flow controller 358A) may operate simultaneously, or - if so desired - repeatedly. For example, the combination of 50%, 12.5% and 3.125% sub-nozzles will provide for a hue corresponding to a concentration of 65.625% (=21/32) concentration.

Therefore, depending on the combination of sub-nozzles 350A, 350B, 350C, 350D and 350E dispensing dye simultaneously (or repeatedly), nozzle 348 is able to dispense a required amount of dye per unit length of the yarn 160. Thus, if for example, the CMYK color palette is employed, the relative amounts of the four primary dyes (i.e., cyan, magenta, yellow, and black) dispensed on yarn 160, by each of the four nozzles 348, of dye station 162, may be controlled, and it is possible to dye the yarn 160, in practically an immensely large number of hues.

Reference is now made to Figures 22, and 23. Figure 22, is a schematic illustration of a nozzle, generally referenced 360, constructed and operative in accordance with a further preferred embodiment of the present invention. Figure 23, is a schematic illustration of a dye supply assembly of each sub-nozzle of the nozzle of Figure 22, constructed and operative in accordance with another preferred embodiment of the present invention.

Nozzle 360 includes a plurality of sub-nozzles, such as sub-nozzles 362, 364, and 366. The openings of sub-nozzles 362, 364, and 366, are of different cross sections. Furthermore, sub-nozzles 362, 364, and 366, are together connected to a color supply or a container 368, by conduits 362A, 364A, and 366A, respectively, whereby container 368 contains a dye. Dye streams 362B, 364B, and 366B, are ejected by flow controllers 370, through sub-nozzles 362, 364, and 366, respectively. each of the flow controllers 370, operates according to a signal, received from controller 156 (Figure 2).

The openings of sub-nozzles 362, 364, and 366 are of different cross sections, and flow controllers 370 are substantially similar. Thus, the rate of flow of each of the streams 362B, 364B, and 366B, and the amount of dye ejected from each of the sub-nozzles 362, 364, and 366, respectively, varies in correlation with the cross sectional area of each of the sub-nozzles 362, 364, and 366, respectively. Furthermore, any

combination of flow controllers 370, may operate simultaneously. Therefore, depending on combination of sub-nozzles 362, 364, and 366, dispensing dye simultaneously, nozzle 360 is able to dispense a required amount of dye, per unit length of the yarn 160.

Thus, if for example, the CMYK color palette is employed, the relative amounts of the four primary dyes (i.e., cyan, magenta, yellow, and black) dispensed on yarn 160, by each of the four nozzles 360, of dye station 162, may be controlled. Accordingly, it is possible to dye the yarn 160, in practically an immensely large number of hues, the creation of which hues is analogous to the example described in reference with Figures 20 and 21.

In an alternative embodiment, sub-nozzles 362, 364, and 366, may be of equal cross sections, whereby flow controller 370, controls the rate of flow of stream of dye, dispensed from the respective sub-nozzle.

Reference is now made to Figure 24. Figure 24 is a side view of one possible embodiment of dye station 162 of Figure 2, taken along intersection A-A in Figure 2, constructed and operative in accordance with a further preferred embodiment of the present invention. The dyeing system of the dye station is generally referenced 400, and includes dye nozzles 402, 404, 406, and 408. Yarn 160 passes thereby, and dye droplets or streams of dye, designated 410, eject from nozzles 402, 404, 406, and 408 toward yarn 160. Dye nozzles 402, 404, 406, and 408 are of similar structure, and comprise nozzles of dye applicators such as continuous ink jet, piezoelectric ink jet, thermal ink jet, drop-on-demand, valve application, solenoid valve application, air brush, and the like.

The following description of some of the printing methods constitutes an example of the implementation of such methods in the context of the present invention.

The drop-on-demand ink jet dye applicator is of the types such as solenoid, thermal, and piezoelectric.

In the solenoid type, an electric solenoid (not shown) ejects a stream of dye, or a number of drops of dye, dependent on the period of time in which the solenoid is in the activated state. The dye is pressurized by a pump (not shown) upstream of the solenoid. The solenoid is activated by receiving a signal from controller 156 (Figure 2).

The thermal type dye applicator incorporates a heating element (not shown) disposed upstream of the nozzle. Applying heat to the dye increases the volume of the dye present in a confined space upstream of the nozzle, thereby pressurizing the dye toward the nozzle. The pressure-rise causes a stream of dye, or drops of dye to be ejected from the nozzle. The amount of dye dispensed, or the number of drops ejected, depends on the period of time in which the heating element is activated, in response to a signal from controller 156 (Figure 2).

The piezoelectric type dye applicator likewise causes a stream or drops of dye to be ejected, by pressurizing the dye. The pressurization is provided by decreasing a confined volume of dye. The decrease in volume is provided by movement of a piezoelectric crystal. Applying an electric pulse to the crystal, in response to a signal from controller 156 (Figure 2), causes a mechanical strain of the crystal and its movement.

The continuous ink jet dye applicator, is likewise of the types known in the printing art or other suitable types. A fixed amount of electrically charged stream or drops of dye are continuously ejected from a nozzle. Prior to ejection from the nozzle, a potential is applied to the dye, whereby part of the dye is pumped back (by its electromagnetic attraction to the applied potential), and thereby less dye is ejected from the nozzle. The amount of dye, or the number of drops of dye ejected from the nozzle, is dictated by the degree of the potential difference. The potential difference is increased or decreased in response to a signal from controller 156 (Figure 2).

An air brush dye applicator is of the type known in the art. A Venturi section (not shown) of a tube, is connected to a reservoir containing dye. Flowing air in the tube, causes a pressure drop in the Venturi section, thereby sucking the dye from the reservoir. Thereafter, the dye is forced in the direction of air-flow, and ejected from the nozzle, in the form of droplets. The number of droplets ejected, varies according to variations in the rate of flow of air in the tube. The rate of air-flow is controlled by an adequate flow generator (not shown), in response to a signal from controller 156 (Figure 2).

It is noted that all types of dye applicators employed in this invention, provide adjustment of relative ratios of the dyes (for example: four in CMYK color palette) applied to yarn 160. Thence, it is possible to dye the yarn 160, in a practically immense number of hues.

The number of the dye nozzles installed in a dye station 162, depends on the type of color palette used for creating the hues. For example, if the CMYK system is employed, then four of the dye nozzles 402, 404, 406, and 408, are installed in each dye station 162. The four dye nozzles, are located in the periphery of yarn 160, where each nozzle axis passes through the center of cross section of yarn 160, as is demonstrated for instance in Figures 24, 25 and 26, and where each nozzle axis is substantially perpendicular to the axis of travel of yarn 160 in system 145 (Figure 2).

Depending on the type of color palette employed, a different dye is used in each of the dye nozzles. For example, if the CMYK palette is used, the first dye applicator dispenses cyan dye, the second dispenses magenta dye, the third dispenses yellow dye, and the fourth dispenses black dye. Signals are sent to dye nozzles 402, 404, 406, and 408 from controller 156. Each signal activates a dye nozzle, whereby streams or droplets 410 impinge upon yarn 160. The signal controls the amount of dye, or the number of droplets 410 ejected from a dye nozzle. Therefore,

the relative ratios of the four dyes are controlled, and thus a practically immense number of hues may be created. Streams of dye, or droplets 410 are absorbed by yarn 160, by flowing through the pores and fibers of the yarn 160, thereby mixing together and creating the required hue of the yarn 160. Thereafter, the dyed yarn 160 passes through some fixation station, such as fixation station 164 of Figure 5, wherein the solvent of the dye is evaporated, or the dye is otherwise cured, and a bond is created between the pigment of the dye and yarn 160.

Reference is further made to Figure 25, which is a schematic illustration of the nozzles of Figure 24, constructed and operative in accordance with another preferred embodiment of the present invention. Nozzles 402, 404, 406 and 408 of Figure 25 are mutually perpendicular. Reference is now made to Figure 26, which is a schematic illustration of a side view of dye station 162 of Figure 2, constructed and operative in accordance with a further preferred embodiment of the present invention. The dyeing system of the dye station is generally referenced 460, and includes dye nozzles 462, 464, 466, and 468. These nozzles are positioned side by side, above yarn 160, in a row whose axis is substantially parallel to path of travel of yarn 160 in system 145 (Figure 2), and in the plane of this path. These dye nozzles are fixed to a support 470. Provision is made for relative motion between the dyeing system 460, and yarn 160, during each dyeing cycle, in directions 474, and 476.

Reference is also made to Figures 3, 4, and 6, with respect to which the operation of dye station 460 is described. For example, if dye system 460 is stationary, the section 132 of yarn 160 is dyed in the following cycle. At the start, point 133 on yarn 160 is located directly below dye nozzle 462. Dye nozzle 462 dispenses dye on yarn 160, and yarn 160 simultaneously moves in direction 474, a distance equal to the length of section 132, until point 135 is located below nozzle 462. At the end of travel, dye nozzle 462 is deactivated, and yarn 160 moves in

direction 476, whereby point 133 on yarn 160, is placed directly below nozzle 464. The dye nozzles 464, 466, and 468, analogously dye the yarn 160 in the same process as of dye nozzle 462. It will be appreciated that the particular cycles described above were brought as an example to the many possible variations of such cycles. It is noted that movements in directions 474, and 476, are relative between dye system 460, and yarn 160. Therefore, either yarn 160, or dye system 460, may remain stationary, while the other moves.

One such variation will now be described with reference to Figure 27, which is a schematic illustration of a side view of dye station 162 of Figure 2, constructed and operative in accordance with another preferred embodiment of the present invention. The dyeing system of the dye station is generally referenced 480, and includes dye nozzles 483, 484, 485, and 486. The embodiment shown in Figure 27, is similar to the one described in connection with Figure 26, except that relative motion between the dyeing system 480, and yarn 160, during each dyeing cycle, is allowed only in one direction along the axis of travel of yarn 160, such as a direction designated by arrow 482.

A dyeing cycle may proceed for example as follows. While the dyeing system 480, is stationary, and yarn 160 travels in direction 482, nozzle 483 dyes section 132, starting at point 135, and ending at point 133. Nozzle 483 is deactivated, and while yarn 160 continues to advance in direction 482, nozzle 484 dyes the dyed section 132, starting at point 135, and ending at point 133. The same cycle is likewise repeated by nozzles 485, and 486. Alternatively, yarn 160 may remain stationary, while dyeing system 480 performs the dyeing cycle in a direction designated by an arrow 487.

Reference is now made to Figure 28, which is a schematic illustration of the bottom view of dye station 162 of Figure 2, taken along intersection B-B, constructed and operative in accordance with a further

preferred embodiment of the present invention. The dyeing system of the dye station generally referenced 500, is stationary and includes a plurality of dye heads $504_{i,j}$ arranged in a matrix-like arrangement, from $504_{1,1}$ to $504_{R,S}$, respectively. The index "i" designates the yarn number ranging from 1 to R, and the index "j" designates the dye number ranging from 1 to S. Each item $504_{i,j}$ represents a dye head constructed according to any of the embodiments described above, such as with reference to Figures 18-27.

Each dye head $504_{i,,j}$ applies a dye only in one hue (i), which may include any hue in the visible range, by methods such as continuous ink jet, piezoelectric ink jet, thermal ink jet, drop-on-demand, valve application, solenoid valve application, air brush, and the like, mentioned above. Furthermore, each dye head $504_{i,,j}$ controls the amount of dye applied to yarns 160_i (i = 1, 2, ...R), per unit length of the yarn, by receiving a signal from controller 156 (Figure 2). A plurality of yarns 160_i travel under the dye system 500 in a direction 506. The amount of dye dispensed on the yarns 160_i may be varied also by varying the speed of travel of yarns 160_i through system 145 (Figure 2).

Each of the dye heads $504_{i,,j}$ applies dye to the yarns 160_i as the yarns travel beneath the dye heads $504_{i,,j}$. Thus, a plurality of R yarns can be simultaneously dyed. The different dyes sequentially applied to a yarn, such as yarn 160_1, each in a controlled amount, from a row of dye heads $504_{1,j}$, (ranging from $504_{1,1}$ to $504_{1,S}$), intermix and therefore it is possible to dye a yarn such as yarn 160_1, in practically an immense number of hues.

Reference is now made to Figure 29, which is a schematic illustration of dye station 162 of Figure 2, constructed and operative in accordance with another preferred embodiment of the present invention. The dyeing system of dye station 162, is generally referenced 540, and it includes a plurality of dye applicators 542. As many dye applicators 542,

as the number of the dyes in the color palette may be employed. For example, if the three-color system is employed, then a dye station 162 includes three dye applicators 542. Each dye applicator is in fluid connection with a dye supply such as container 544, by a conduit 546, and a flow controller 548. Each dye container 544 contains a different dye. For example, if the CMYK color palette is employed, then the first dye container 544, contains a cyan dye, the second, a magenta dye, the third, a yellow dye, and the fourth, a black dye.

The flow controller 548 allows a controlled amount of the dye to flow out of dye container 544 to dye applicator 542. Flow controller 548 operates according to a signal received from controller 156 (Figure 2). While a plurality of yarns 160_i (i = 1, 2, ...R), travel through the openings in dye applicator 542, the dye applicator 542 simultaneously applies a controlled amount of the dye per unit length of yarn, to the yarns 160_i. Furthermore, without special implementations, dye applicator 542 applies an equal amount of dye to each of the yarns 160_i. However it will be appreciated that such implementations may be added with analogy to the different nozzles and arrangements described herein above.

Dye applicator 550 then simultaneously dyes the dyed yarns 160_i with another dye, also in a controlled amount. The dye applied to the yarns 160_i by dye applicators 549 through 550 (all intermediate applicators are cut away for simplicity), mixes with the dye previously applied by dye applicator 542. Therefore, yarns 160_i are dyed in a specific hue, depending on the relative ratio of the dyes dispensed by dye applicators 542 through 550. Due to the fact that each of the flow controllers 548, controls the amount of dye applied to yarns 160_i, it is possible to create a practically immense number of hues, by applying the dyes from a color palette, in different ratios.

Reference is now made to Figure 30, which is a schematic illustration of a side view of dye station 162 of Figure 2, taken along

intersection A-A in Figure 5, constructed and operative in accordance with a further preferred embodiment of the present invention. The dyeing system of the dye station is generally referenced 440, and is constructed of dye nozzles 442, 444, 446, and 448, positioned side by side, with nozzle 442 above yarn 160_1, the cross section of which yarn is shown. Each of the dye nozzles 442, 444, 446, and 448, dispenses a dye in a different hue. These nozzles are arranged in a row whose axis is substantially parallel and perpendicular to path of travel of yarn 160_1 in system 145 (Figure 2). The dye nozzles are fixed to a support 450. Provision is made for system 440 to reciprocate in directions 452, and 454. Such motion allows the dye nozzles 442 through 448 to dispense dye, sequentially, on yarn 160_1, the dyes intermixing, and creating the required hue.

Reference is also made to Figures 3, 4, and 6, with respect to which the operation of dye station 440 will be now described. Section 132 of yarn 160_1, is dyed in the following exemplary cycle. When dye station 440 is in a position in which the dye nozzle 442, is directly above yarn 160_1, dye nozzle 442 is activated and it dispenses dye on yarn 160_1. Simultaneously, a relative motion between dye station 440, and yarn 160_1, in direction of travel of yarn 160_1 through system 145 (Figure 2), or opposite thereto, is provided, in a distance substantially equal to section 132 (Figures 3, 4 and 6). Then, dye nozzle 442 is deactivated, and yarn 160_1 either remains stationary, or is moved back in its travel path, a distance equal to section 132, depending on the distance required for dyeing section 132 in a single phase of its dying, by a single nozzle. Then dye station 440 advances one stage in direction 452, so that the dye nozzle 444 is positioned directly above yarn 160_1. At this instance dye nozzle 444 is activated, it analogously dispenses dye on yarn 160_1 along section 132, and is then deactivated. Yarn 160_1 simultaneously reciprocates (if necessary) a distance equal to section 132 in its travel

path, as described in relation with dye nozzle 442. This process is likewise repeated for dye nozzles 446, and 448. Following deactivation of dye nozzle 448, dye system 440 moves back to its starting position in direction 454, wherein dye nozzle 442 is again directly above the yarn 160_1, while yarn 160_1 advances an appropriate distance, for the next section 132 of yarn 160_1 to be dyed.

It is noted that a plurality of yarns 160_1 through 160_R may be simultaneously dyed, by each nozzle 442, 444, 446, and 448. In this arrangement, for example - dye nozzle 442, dispenses dye on yarns 160_1 through 160_R, while the yarns remain stationary, and dye system 440 moves in direction 452, or 454. Alternatively, when dye nozzle 442 dispenses dye on yarn 160_1, a relative motion between the nozzles 442, 444, 446, and 448 and yarns 160_1 to 160_R, in perpendicular to the drawing sheet, will provide for the dying of an entire section of yarn 160_1 such as section 132 in Figure 6. Thereafter, yarns 160_1 through 160_R, advance through the system 145 (Figure 2), and a further section of the yarns are dyed by dye nozzle 442. The yarns may advance, and dyed any number of times, by dye nozzle 442, as necessary in order to dye the section 132, of yarns 160_1 through 160_R. The yarns then recede simultaneously, to the position where dye nozzle 442 first started to dispense dye, and the dyeing cycle is likewise repeated for each of dye nozzles 444, 446, and 448.

Nozzles 442, 444, 446, and 448 may simultaneously dye neighboring yarns 160_1 through 160_R in one session. For example, when nozzle 442 is placed directly above yarn 160_2 and dispenses dye thereto, nozzle 444 is placed directly above yarn 160_1 and dispenses dye thereto. Alternatively, the steps of advancement and recession of the yarns may be interchanged.

While the invention has been described with respect to specific embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made.

With the foregoing description, it is believed apparent that the present invention enables the attainment of the objects initially set forth herein.

It should be understood, however, that the invention is not intended to be limited to the specifics of the illustrated or described embodiments or methods, but rather is defined by the accompanying claims.

CLAIMS

1. An apparatus for dyeing at least one yarn for fabrication in a carpet, comprising at least one dye station for applying variable amounts of at least one color dye along said at least one yarn.
2. The apparatus as in claim 1, wherein each amount of said variable amounts imparts a specific hue of said at least one color on a section along said at least one yarn.
3. The apparatus as in claim 1, wherein a section along said at least one yarn is selected according to a predetermined location on the carpet onto which said section is designated to fabricate.
4. The apparatus as in claim 1, further comprising a controller for controlling the application of said variable amounts in registration to a section along said at least one yarn, by controlling the amount of dye which said at least one dye station dispenses on a unit of length along said section.
5. The apparatus as in claim 4, wherein said controller controls the feeding of said section in registration with a predetermined location on said carpet.
6. The apparatus as in claim 1, wherein said fabrication includes any one of the methods selected from a list consisting of: tufting, weaving, knitting, braiding, lacing, sewing and adhesive bonding.
7. The apparatus as in claim 1, wherein said at least one color dye includes more than one color, the variable amounts of which intermix on a section along said at least one yarn, to impart the resultant hue on said at least one yarn.
8. The apparatus as in claim 1, wherein said at least one color dye is a single color selected from a list consisting of black, white, gray, yellow, green, red, blue, orange, and green.

9. The apparatus as in claim 1, wherein said at least one color dye comprises a plurality of color dyes, the combination of which dyes comprises a color palette.

10. The apparatus as in claim 9, wherein said color palette is selected from a list consisting of:

cyan, magenta, yellow, and black ("CMYK");

cyan, magenta, yellow, black, orange, and green ("Hexachrome"); and

red, green, and blue (RGB).

11. The apparatus as in claim 1, wherein said at least one dye station is selected from a list consisting of:

continuous ink jet;

piezoelectric ink jet;

thermal ink jet;

drop-on-demand;

valve application;

solenoid valve application; and

air brush.

12. An apparatus as in claim 1, wherein said at least one dye station ejects said at least one color dye, through at least one nozzle located in a periphery of said at least one yarn and directed to emit dye on said at least one yarn.

13. The apparatus as in claim 12, wherein cross section of the outlet of said at least one nozzle through which said at least one color dye ejects, is variable.

14. The apparatus as in claim 12, wherein said at least one nozzle comprises a plurality of sub-nozzles.

15. The apparatus as in claim 14, wherein each one of said sub-nozzles is connected to a different dye source, each said different dye source contains the same said at least one color dye, but in a different

concentration, whereby ejection of said at least one color dye from different combinations of said sub-nozzles, and intermixing of said at least one color dye on a predetermined section of said at least one yarn, provides ejection of a different amount of said at least one color dye, from said at least one nozzle.

16. The apparatus as in claim 14, wherein each one of said sub-nozzles is of a different cross section, said sub-nozzles being connected to a dye source, whereby ejection of dye from different combinations of said sub-nozzles, and intermixing of said dye on a predetermined section of said at least one yarn, provides ejection of different amounts of said dye from said at least one nozzle.

17. The apparatus as in claim 14, wherein said at least one nozzle comprises a series of nozzles located sequentially, each of said series of nozzles dyeing the same section of said at least one yarn, and wherein a relative motion of said section of said at least one yarn is provided with respect to each of said series of nozzles.

18. The apparatus as in claim 14, wherein said at least one nozzle comprises a series of nozzles located sequentially, each of said series of nozzles dyeing the same section of said at least one yarn, the amounts per time unit of said at least one color dye ejected from each of said series of nozzles being constant, and wherein the speed of relative travel of a predetermined section of said at least one yarn with respect to each of said series of nozzles, determines the amount of said at least one color dye applied to said section.

19. The apparatus as in claim 17, wherein said relative motion is a reciprocating motion.

20. The apparatus as in claim 1, wherein said at least one dye station comprises a plurality of secondary dye stations arranged in a matrix, said at least one yarn travel under a row of said matrix, each said

secondary dye stations ejecting said at least one color dye in at least one hue.

21. The apparatus as in claim 1, wherein said at least one dye station comprises a plurality of secondary dye stations arranged in a column, said at least one yarn are arranged in a column, each of said at least one yarn moves, in registration, through one of said secondary dye stations, each of secondary dye stations dyeing a corresponding said at least one yarn with said at least one color dye, the collection of said at least one color dyes comprising a color palette.

22. The apparatus as in claim 1, further comprising:

a controller;

at least one fixation station for providing color fixation to said at least one color dye;

at least one fabrication machine for fabricating said carpet with said at least one yarn;

at least one feeding mechanism for feeding said at least one yarn to said fabrication machine;

at least one marker for marking at least one dyed yarn with at least one mark, informing the location of a section or a consecutive sequence of said sections; and

at least one sensor for sensing said at least one mark,

wherein said at least one sensor senses said at least one mark, said at least one sensor notifies said controller of said at least one mark, said controller controls the amount of said at least one color dye imparted by said at least one dye station, as well as said at least one mark imparted by said at least one marker, feeding of said at least one feeding mechanism, and action of said at least one fabrication machine, thereby fabricating said carpet according to a selected color pattern.

23. The apparatus as in claim 22, wherein said at least one fabrication machine incorporates said at least one feeding mechanism.

24. The apparatus as in claim 22, wherein said at least one fixation station fixes said at least one color dye immediately following ejection of said at least one color dye by said at least one dye station.

25. The apparatus as in claim 1, further comprising at least one pre-fixation station for prefixing at least one dyed yarn immediately after dyeing of said at least one yarn by said at least one dye station.

26. The apparatus as in claim 1, further comprising at least one inventory of dyed and (pre)fixed yarns, and at least one fabrication machine, wherein said at least one inventory comprises a plurality of stacks of dyed and (pre)fixed yarn being fed to said at least one fabrication machine upon exhaustion of a dyed and (pre)fixed yarn of a previous stack of said inventory.

27. The apparatus as in claim 1, further comprising a fabrication machine for fabricating said carpet with said at least one yarn, said fabrication machine further comprising:

at least one yarn application unit; and

a backing sheet,

wherein said at least one yarn application unit combines said at least one yarn, with said backing sheet, and said fabrication machine provides a relative motion between said at least one yarn application unit and said backing sheet.

28. The apparatus as in claim 27, further comprising a back coating applicator for applying a coating to an underside of said carpet.

29. The apparatus as in claim 27, further comprising an application unit mover for providing said relative motion.

30. The apparatus as in claim 27, further comprising a take-up mechanism for moving said backing sheet with respect to said at least one application unit.

31. The apparatus as in claim 27, wherein said backing sheet is provided on a frame.

32. The apparatus as in claim 27, wherein said fabrication machine employs a method selected from a list consisting of:

combining at least one row of said at least one yarn, with said backing sheet;

combining at least a portion of at least one row of said at least one yarn, with said backing sheet;

combining at least one column of said at least one yarn, with said backing sheet; and

combining at least one matrix of said at least one yarn, with said backing sheet.

33. The apparatus as in claim 27, further comprising a take-up mechanism for unwinding said backing sheet from a backing drum, and winding said carpet on a carpet take-up drum, said backing drum and said carpet take-up drum being supported by a framework.

34. The apparatus as in claim 27, wherein said backing sheet, is stretched between a first take-up mechanism, and a second take-up mechanism.

35. The apparatus as in claim 27, wherein said at least one yarn is dyed and prefixed, said fabrication machine further comprises a final fixation station providing final fixation of said at least one color dye of said at least one dyed and prefixed yarn.

36. The apparatus as in claim 35, wherein said final fixation station provides said final fixation to said carpet.

37. The apparatus as in claim 31, wherein said backing sheet comprises a weft.

38. The apparatus as in claim 31, wherein said backing sheet comprises a weft and a warp.

39. A method for dyeing at least one yarn for fabrication in a carpet, the method comprising the step of applying variable amounts of at least one color dye along said at least one yarn.

40. The method as in claim 39, further comprising a step of imparting a specific hue of said at least one color dye on a section along said at least one yarn by applying said variable amounts.

41. The method as in claim 39, further comprising a step of selecting a section according to a predetermined location on said carpet to which said section is designated.

42. The method as in claim 39, further comprising a step of providing a controller for controlling the application of said variable amounts in registration with a section of said at least one yarn, by controlling the amount of said at least one color dye which a dye station dispenses on a unit of length along said section.

43. The method as in claim 42, wherein said controller controls the feeding of said section in registration with a predetermined location on said carpet.

44. The method as in claim 39, wherein the method of fabrication of said carpet includes any one of the methods selected from a list consisting of: tufting, weaving, knitting, braiding, lacing, sewing and adhesive bonding.

45. The method as in claim 39, wherein variable amounts of said at least one color dye intermix on a section of said at least one yarn to impart a resultant hue thereon.

46. The method as in claim 39, wherein said at least one color dye is a single color selected from a list consisting of black, white, gray, yellow, green, red, blue, orange, CMYK and hexachrome.

47. The method as in claim 39, wherein a combination of a plurality of said at least one color dyes comprises a color palette.

48. The method as in claim 47, wherein said color palette is selected from a list consisting of:

cyan, magenta, yellow, and black ("CMYK");

cyan, magenta, yellow, black, orange, and green ("Hexachrome"); and

red, green, and blue (RGB).

49. The method as in claim 39, wherein the type of a dye station is selected from a list consisting of:

continuous ink jet;

piezoelectric ink jet;

thermal ink jet;

drop-on-demand;

valve application;

solenoid valve application; and

air brush.

50. The method as in claim 39, wherein at least one dye station ejects said at least one color dye, through at least one nozzle located in a periphery of said at least one yarn and directed to emit said at least one color dye toward said at least one yarn.

51. The method as in claim 50, wherein cross section of the outlet of said at least one nozzle through which said at least one color dye ejects, is variable.

52. The method as in claim 50, wherein said at least one nozzle comprises a plurality of sub-nozzles.

53. The method as in claim 52, wherein each one of said sub-nozzles is connected to a different dye source, each said different dye source containing the same said at least one color dye, but in a different concentration, whereby ejection of said at least one color dye from different combinations of said sub-nozzles, and intermixing of said at least one color dye on predetermined section of said at least one

yarn, provides ejection of different amounts of said at least one color dye, from said at least one nozzle.

54. The method as in claim 52, wherein each one of said sub-nozzles is of a different cross section, said sub-nozzles being connected to a dye source, whereby ejection of dye from different combinations of said sub-nozzles, and intermixing of said dye on said predetermined section of said yarn, provides ejection of different amounts of said dye from said at least one nozzle.

55. The method as in claim 52, wherein said at least one nozzle comprises a series of nozzles located sequentially, each of said series of nozzles dyeing the same section of said at least one yarn, and wherein a relative motion of said section of said at least one yarn is provided with respect to each of said series of nozzles.

56. The method as in claim 52, wherein said at least one nozzle comprises a series of nozzles located sequentially, each of said series of nozzles dyeing the same section of said at least one yarn, the amounts per time unit of said at least one color dye ejected from each of said series of nozzles being constant, and wherein the speed of relative travel of a predetermined section of said at least one yarn with respect to each of said series of nozzles, determines the amount of said at least one color dye applied to said section.

57. The method as in claim 55, wherein said relative motion is a reciprocating motion.

58. The method as in claim 39, wherein said at least one dye station comprises a plurality of secondary dye stations arranged in a matrix, said at least one yarn travel under a row of said matrix, each said secondary dye stations ejecting said at least one color dye in at least one hue.

59. The method as in claim 39, wherein said at least one dye station comprises a plurality of secondary dye stations arranged in a column,

said at least one yarn are arranged in a column, each of said at least one yarn moves, in registration, through one of said secondary dye stations, each of said secondary dye stations dyeing a corresponding at least one yarn with said at least one color dye, the collection of said at least one color dyes comprising a color palette.

60. The method as in claim 39, further comprising:

a controller;

at least one fixation station for providing color fixation to said at least one color dye;

at least one fabrication machine for fabricating said carpet with said at least one yarn;

at least one feeding mechanism for feeding said at least one yarn to said fabrication machine;

at least one marker for marking at least one dyed yarn with at least one mark informing the location of said section or a consecutive sequence of said sections; and

at least one sensor for sensing said mark(s),

wherein said at least one sensor senses said mark(s), said at least one sensor notifies said controller of said at least one mark, said controller controls the dye imparted by said at least one dye station, as well as the marks imparted by said at least one marker, the feeding of said at least one feeding mechanism, and the action of said at least one fabrication machine, thereby fabricating the carpet according to a selected color pattern.

61. The method as in claim 60, wherein said at least one fabrication machine incorporates said at least one feeding mechanism.

62. The method as in claim 60, wherein said at least one fixation station fixes said at least one color dye immediately following ejection of said at least one color dye by said at least one dye station.

63. The method as in claim 39, further comprising providing at least one pre-fixation station for prefixing said at least one dyed yarn immediately after its dyeing by said at least one dying station.

64. The method as in claim 39, further comprising providing at least one inventory of dyed and prefixed or fixed yarns, and at least one fabrication machine, wherein said inventory includes stacks of dyed and prefixed or fixed yarn being fed to said at least one fabrication machine upon the exhaustion of a dyed and prefixed or fixed yarn of a previous stack of said inventory.

65. The method as in claim 39, further comprising providing a fabrication machine for fabricating the carpet with said at least one yarn, the fabrication machine comprising:

at least one yarn application unit; and

a backing sheet,

wherein said at least one yarn application unit combines said at least one yarn, with said backing sheet, and said fabrication machine provides a relative motion between said at least one yarn application unit and said backing sheet.

66. The method as in claim 65, further comprising providing a back coating applicator for applying a coating to the underside of the carpet.

67. The method as in claim 65, further comprising providing an application unit mover for providing said relative motion.

68. The method as in claim 65, further comprising providing a take-up mechanism for moving said backing sheet with respect to said at least one application unit.

69. The method as in claim 65, wherein said backing sheet is provided on a frame.

70. The method as in claim 65, wherein said fabrication machine employs a method selected from a list consisting of:

combining at least one row of said at least one yarn, with said backing sheet;

combining at least a portion of said at least one row of said at least one yarn, with said backing sheet;

combining at least one column of said at least one yarn, with said backing sheet; and

combining at least one matrix of said at least one yarn, with said backing sheet.

71. The method as in claim 65, further comprising providing a take-up mechanism for unwinding said backing sheet from a backing drum, and winding the carpet on a carpet take-up drum, said backing drum and said carpet take-up drum are supported by a framework.

72. The method as in claim 65, wherein said backing sheet, is stretched between a first take-up mechanism, and a second take-up mechanism.

73. The method as in claim 65, wherein said at least one yarn is dyed and prefixed, said fabrication machine further comprises a final fixation station providing final fixation of said at least one color dye of at least one dyed and prefixed yarn.

74. The method as in claim 73, wherein said final fixation station provides said final fixation to said carpet.

75. The method as in claim 69, wherein said backing sheet comprises a weft.

76. The method as in claim 69, wherein said backing sheet comprises a weft and a warp.

77. An apparatus substantially as hereinbefore claimed and described with reference to the accompanying drawings.

78. A method substantially as hereinbefore claimed and described with reference to the accompanying drawings.

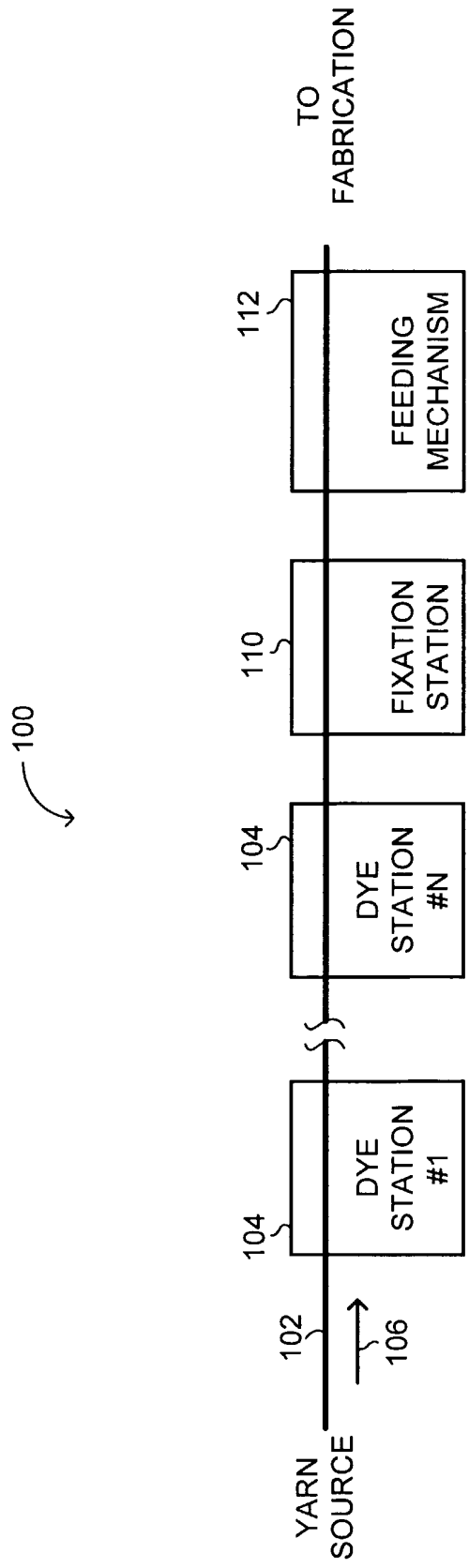


FIG. 1
PRIOR ART

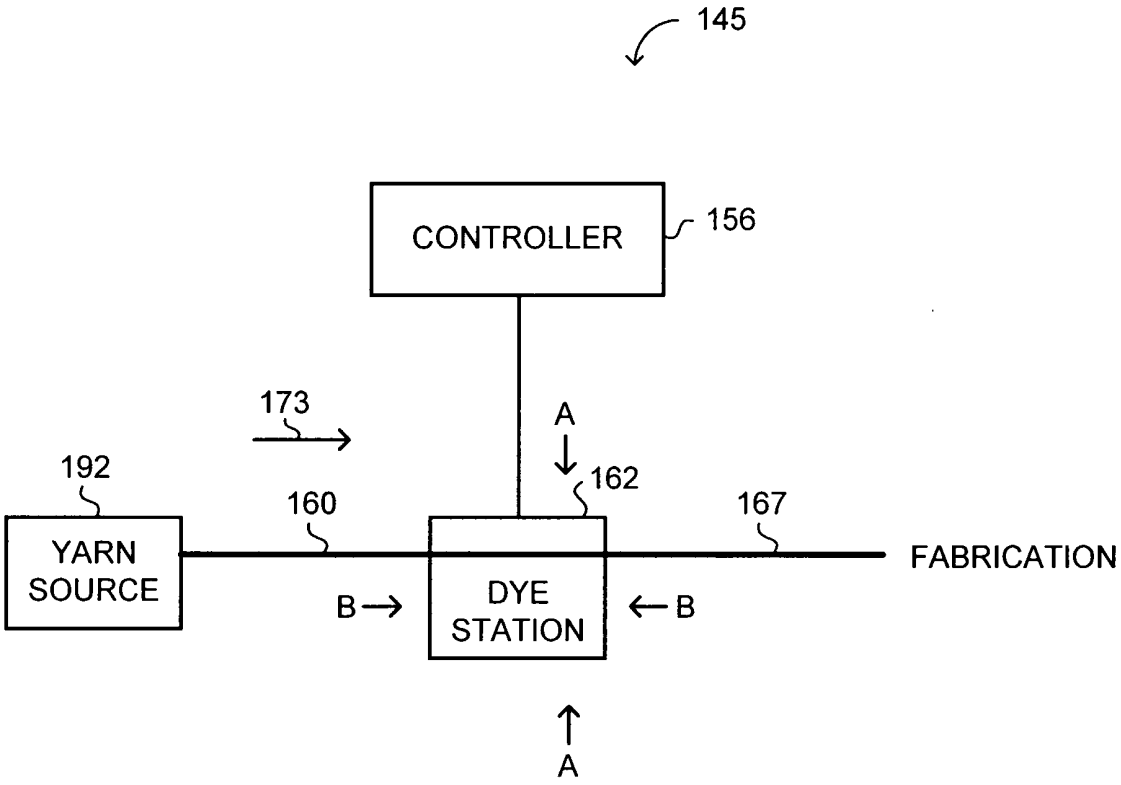

145
CONTROLLER
156
173
A
192
162
160
167
YARN SOURCE
FABRICATION
B
DYE STATION
B
A

FIG. 2

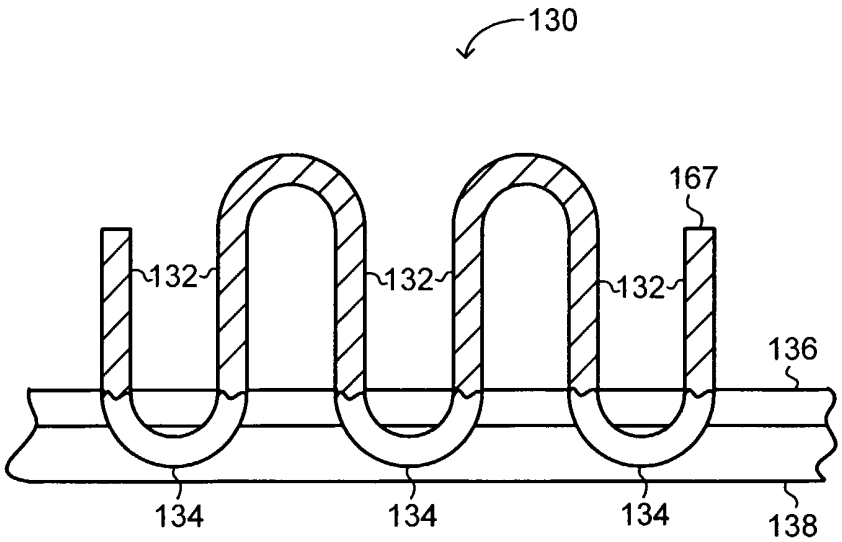


FIG. 3

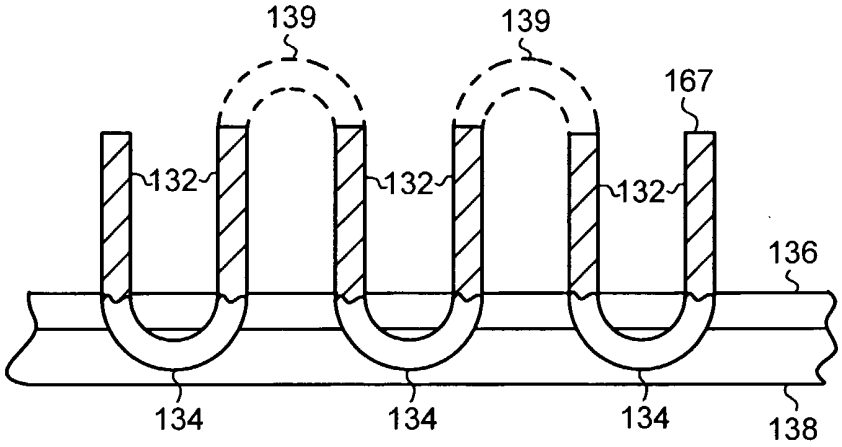


FIG. 4

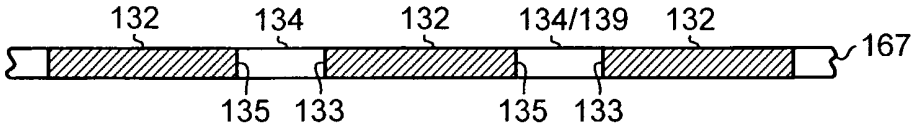


FIG. 6

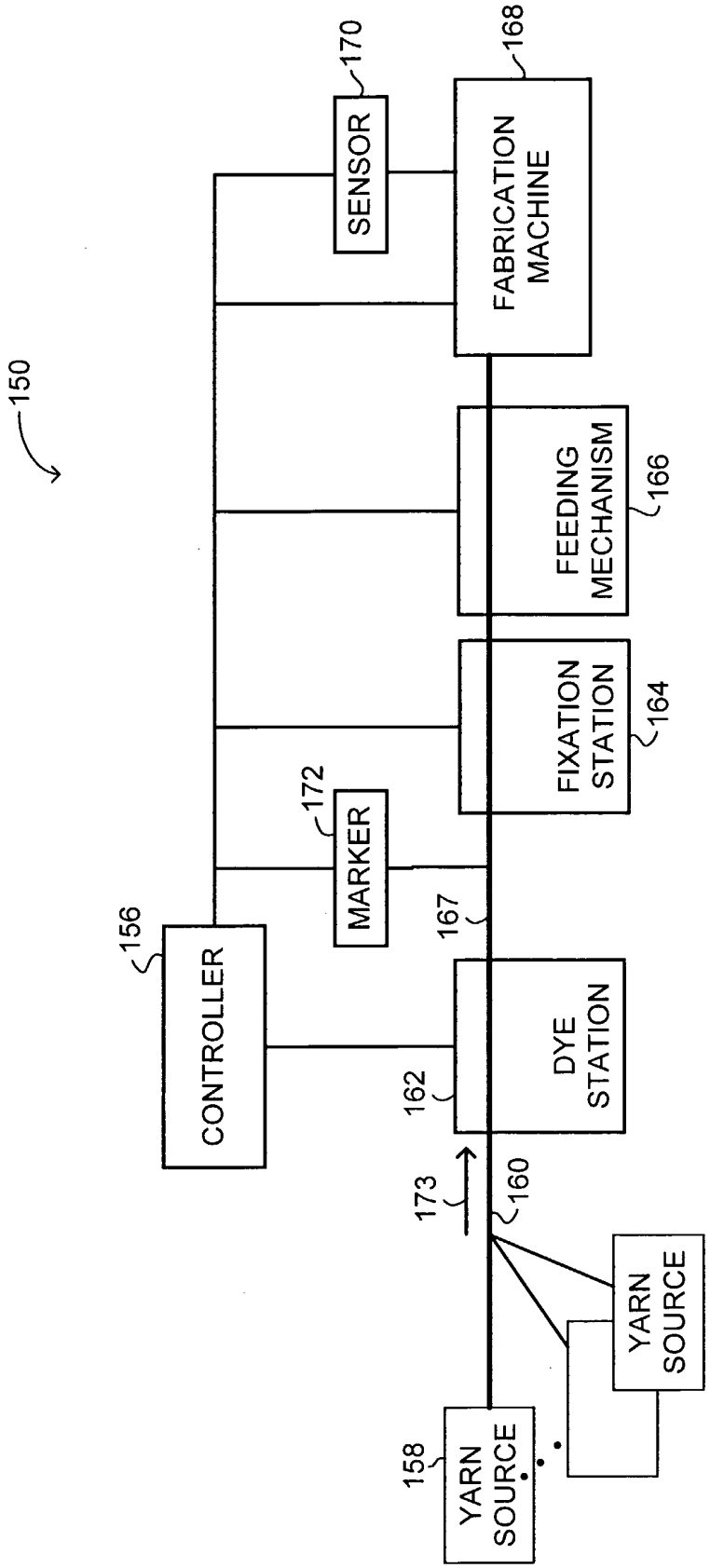
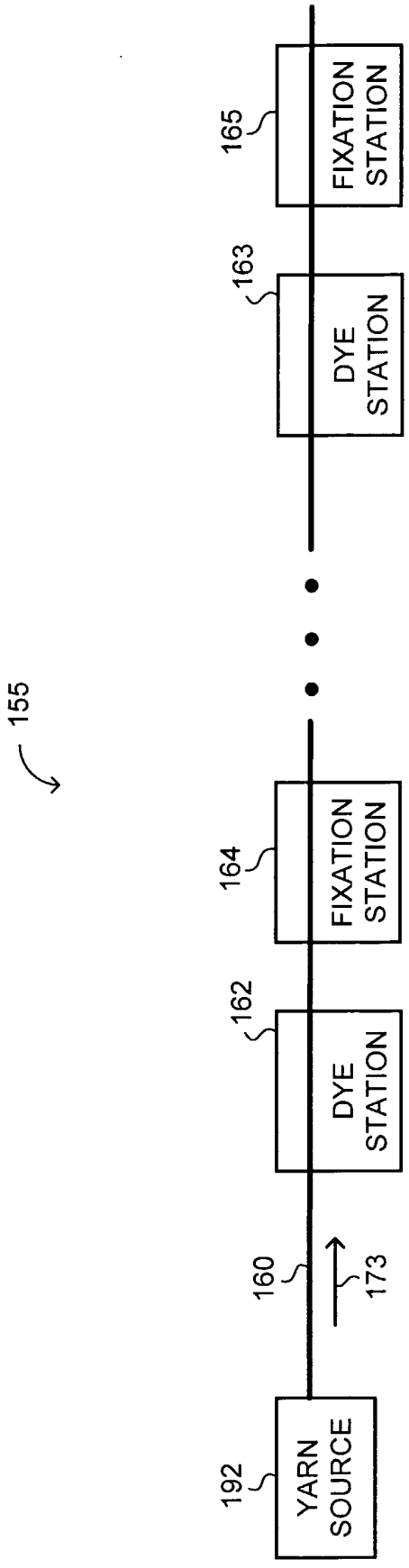

150
SENSOR
170
FABRICATION MACHINE
168
FEEDING MECHANISM
166
FIXATION STATION
164
MARKER
172
167
CONTROLLER
156
DYE STATION
162
173
160
YARN SOURCE
YARN SOURCE
158

FIG. 5


155
192
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160
173
162
DYE STATION
164
FIXATION STATION
163
DYE STATION
165
FIXATION STATION

FIG. 7

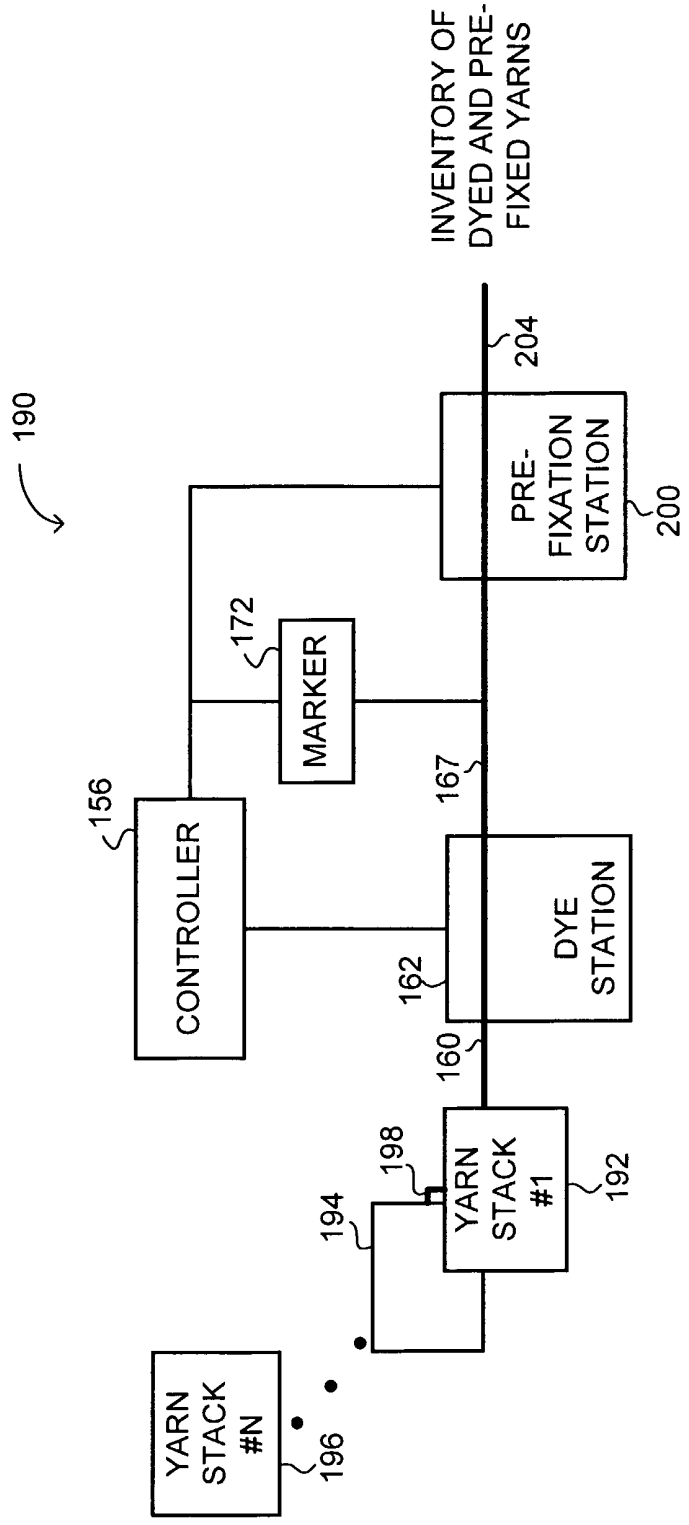
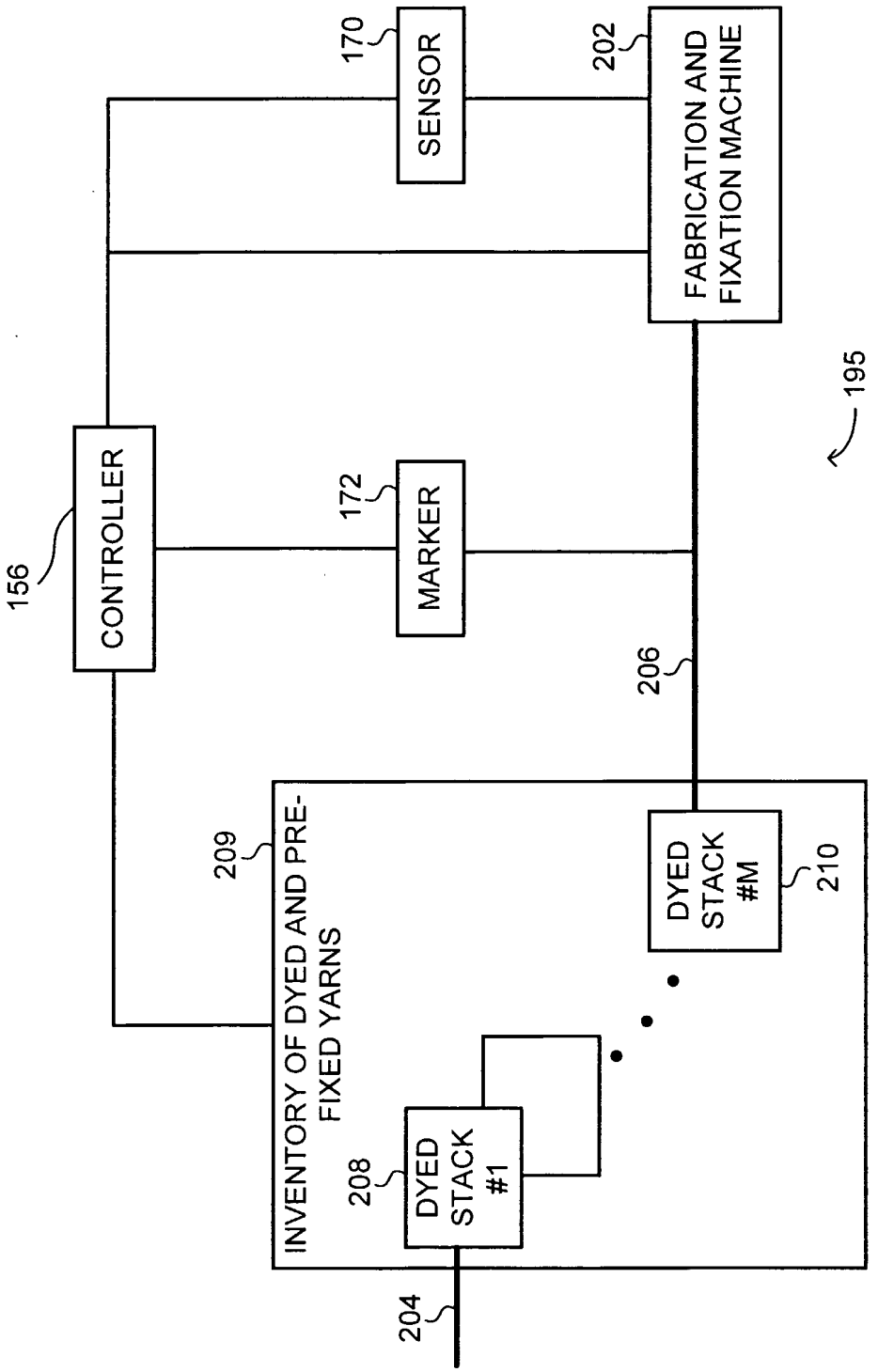

INVENTORY OF DYED AND PRE-FIXED YARNS
204
190
PRE-FIXATION STATION
200
172
MARKER
167
156
CONTROLLER
DYE STATION
162
160
198
YARN STACK #1
192
194
YARN STACK #N
196

FIG. 8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SENSOR
202
FABRICATION AND FIXATION MACHINE
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156
CONTROLLER
172
MARKER
206
209
INVENTORY OF DYED AND PRE-FIXED YARNS
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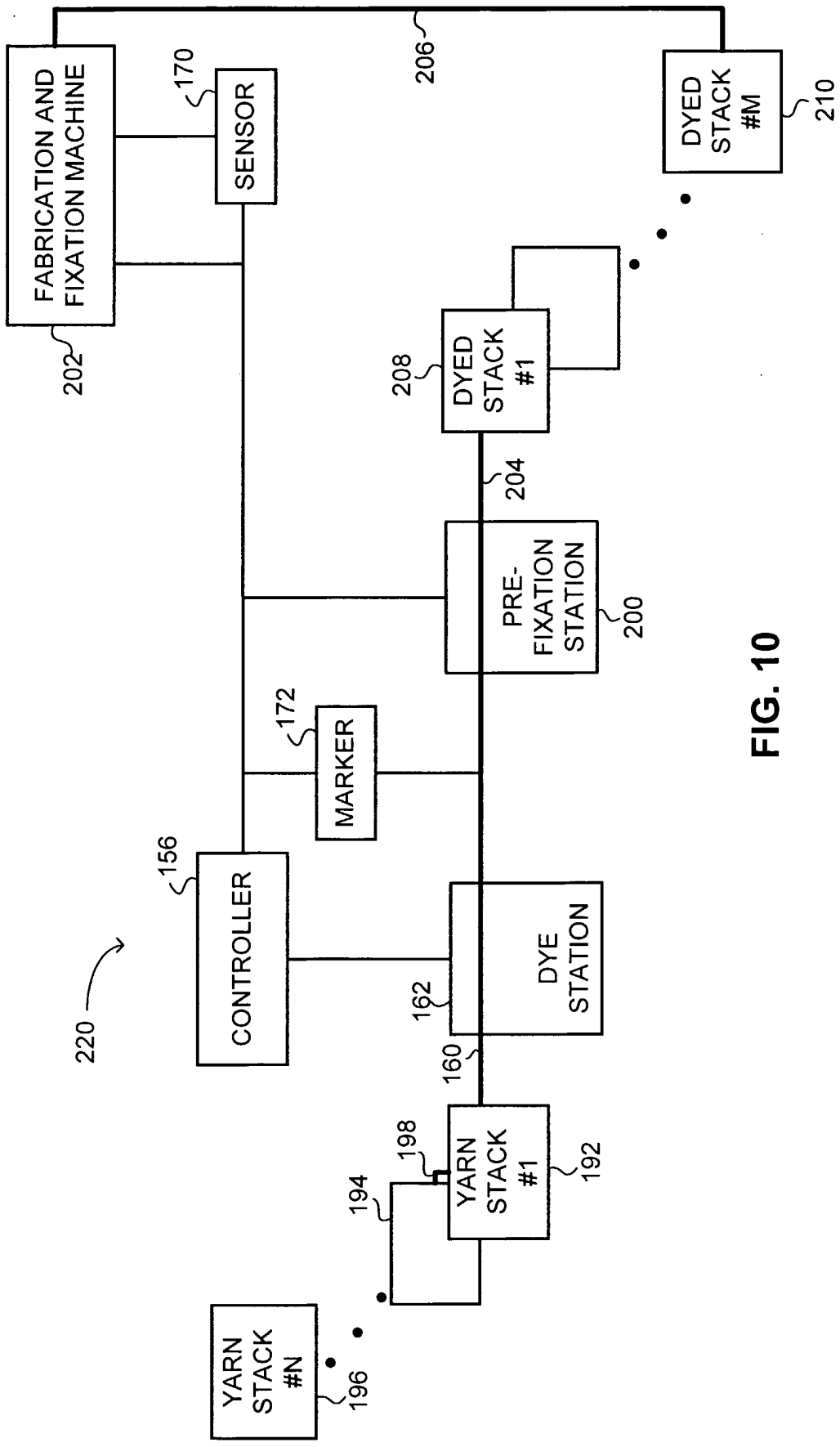
210
208
DYED STACK #1
204

FIG. 9


FABRICATION AND FIXATION MACHINE
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170
SENSOR
206
DYED STACK #M
210
208
DYED STACK #1
204
PRE-FIXATION STATION
200
172
MARKER
156
CONTROLLER
220
DYE STATION
162
160
198
YARN STACK #1
192
194
YARN STACK #N
196

FIG. 10

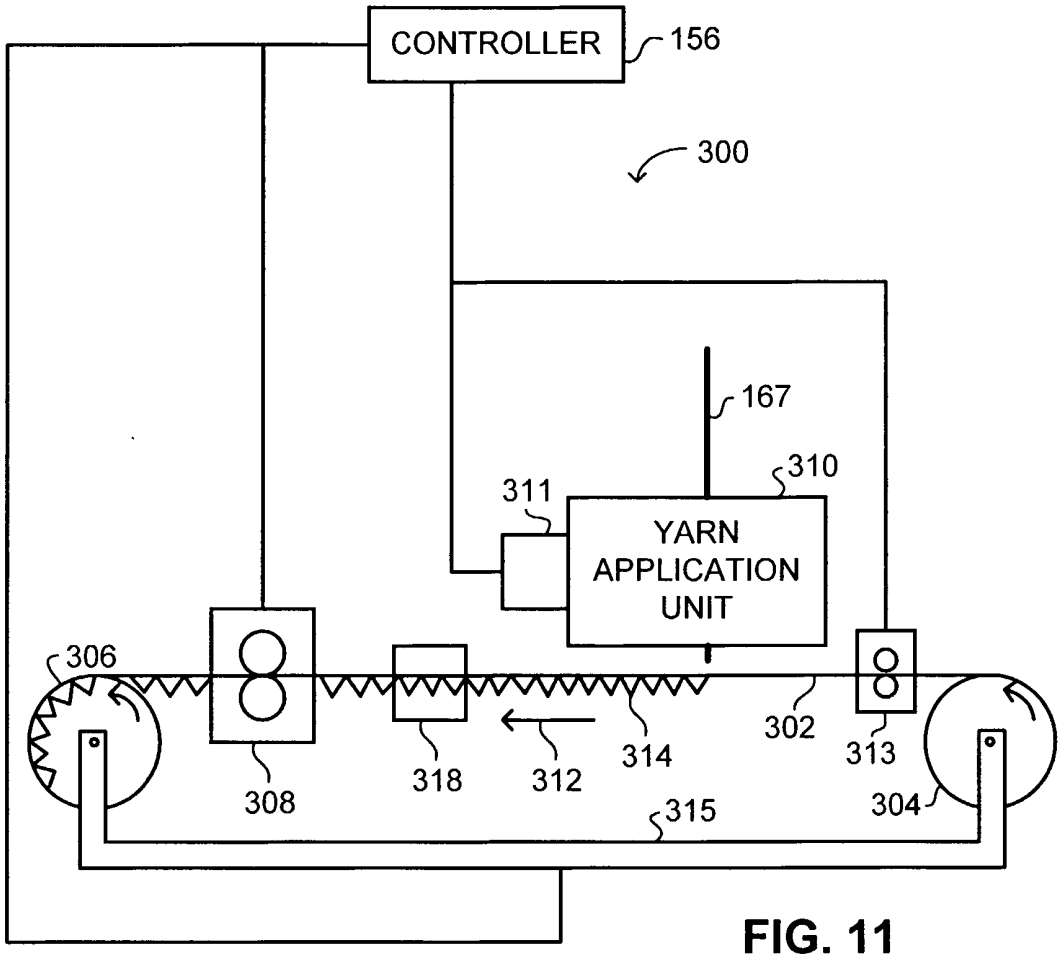

CONTROLLER
156
300
167
310
311
YARN
APPLICATION
UNIT
306
308
318
312
314
302
313
304
315

FIG. 11

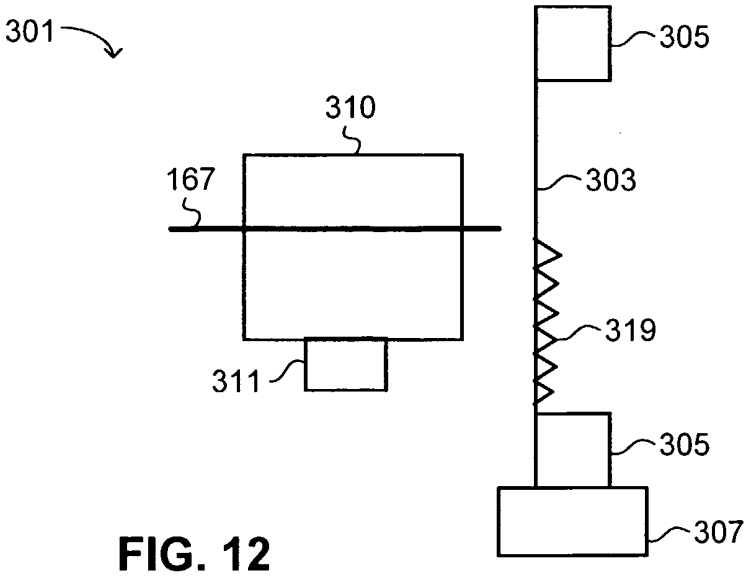

301
305
310
167
303
319
311
305
307

FIG. 12

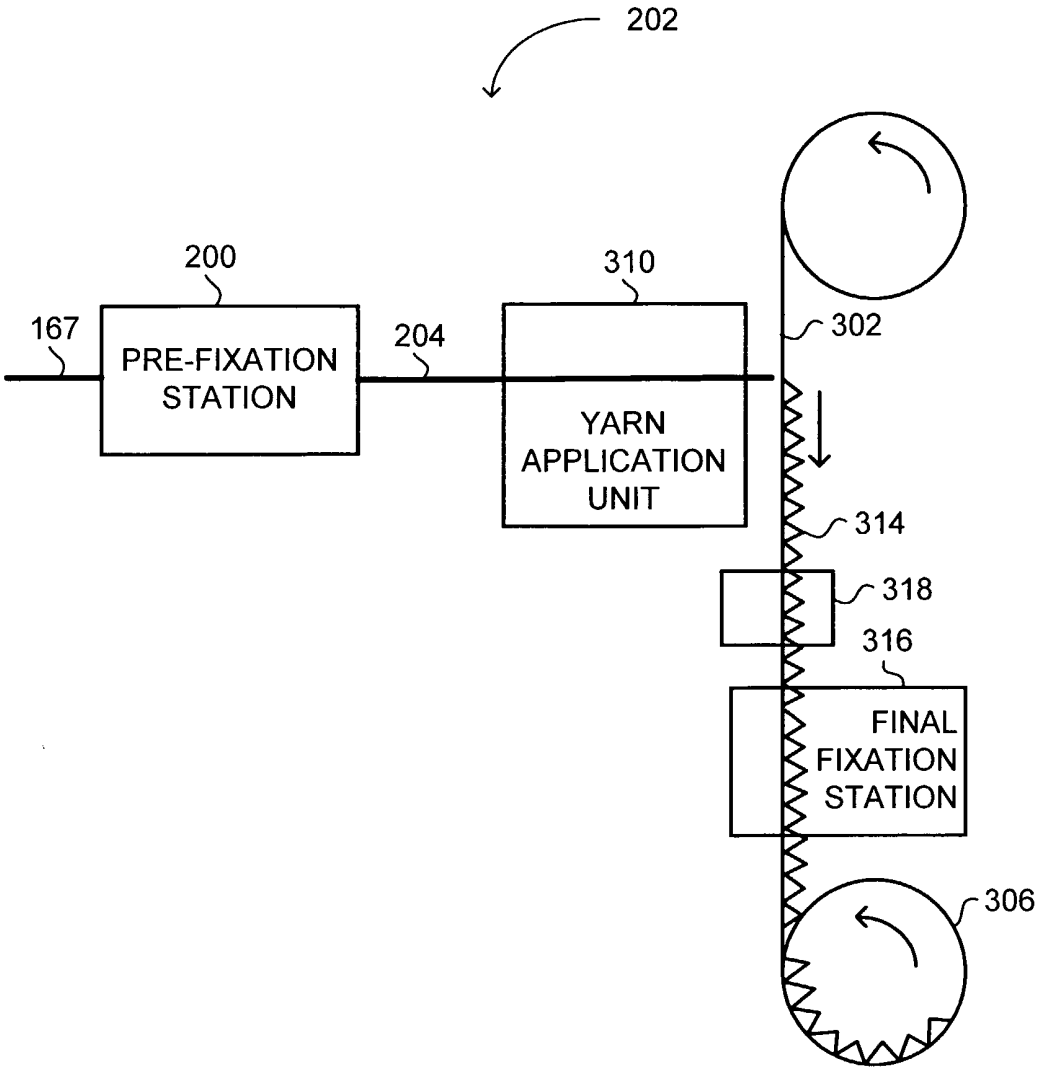

202
200
310
167
PRE-FIXATION STATION
204
YARN APPLICATION UNIT
302
314
318
316
FINAL FIXATION STATION
306

FIG. 13

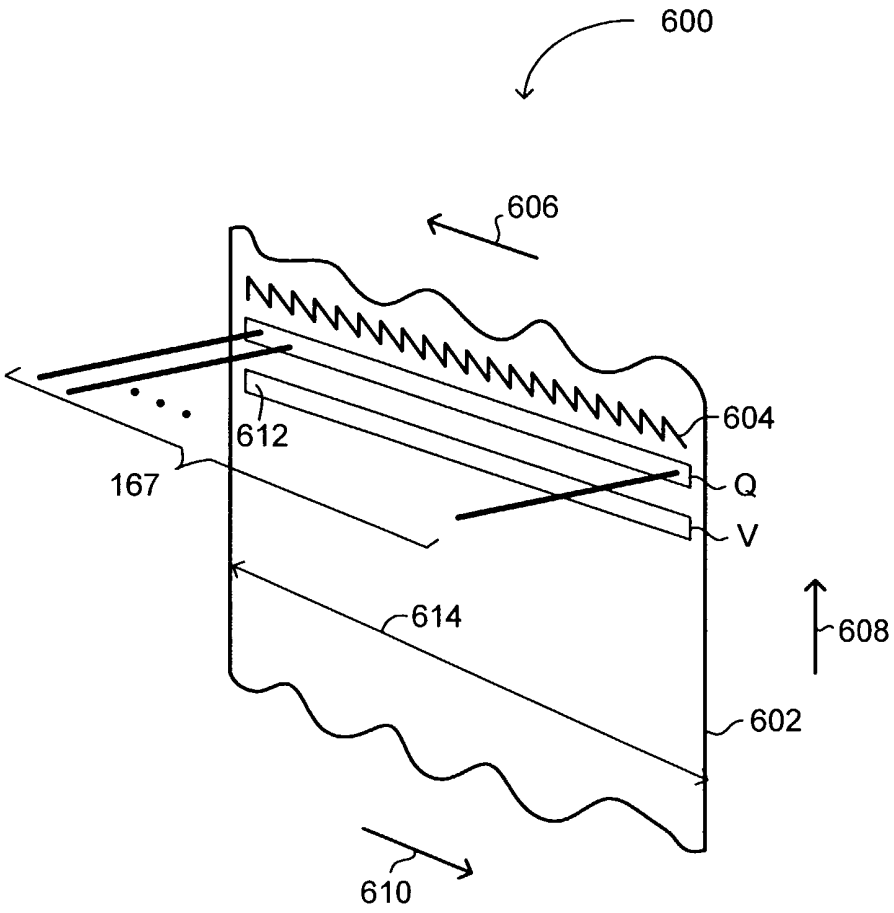


FIG. 14

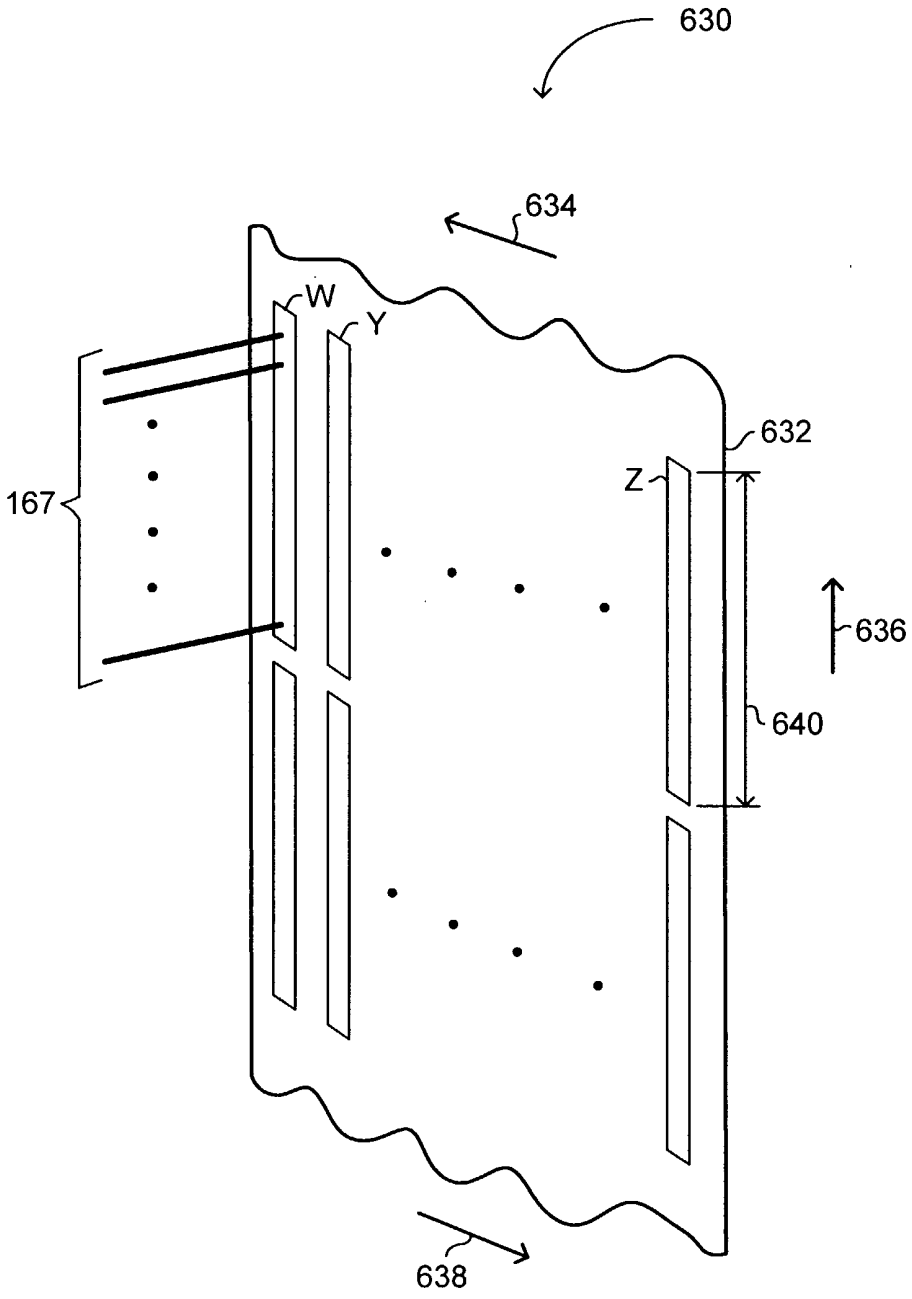


FIG. 15

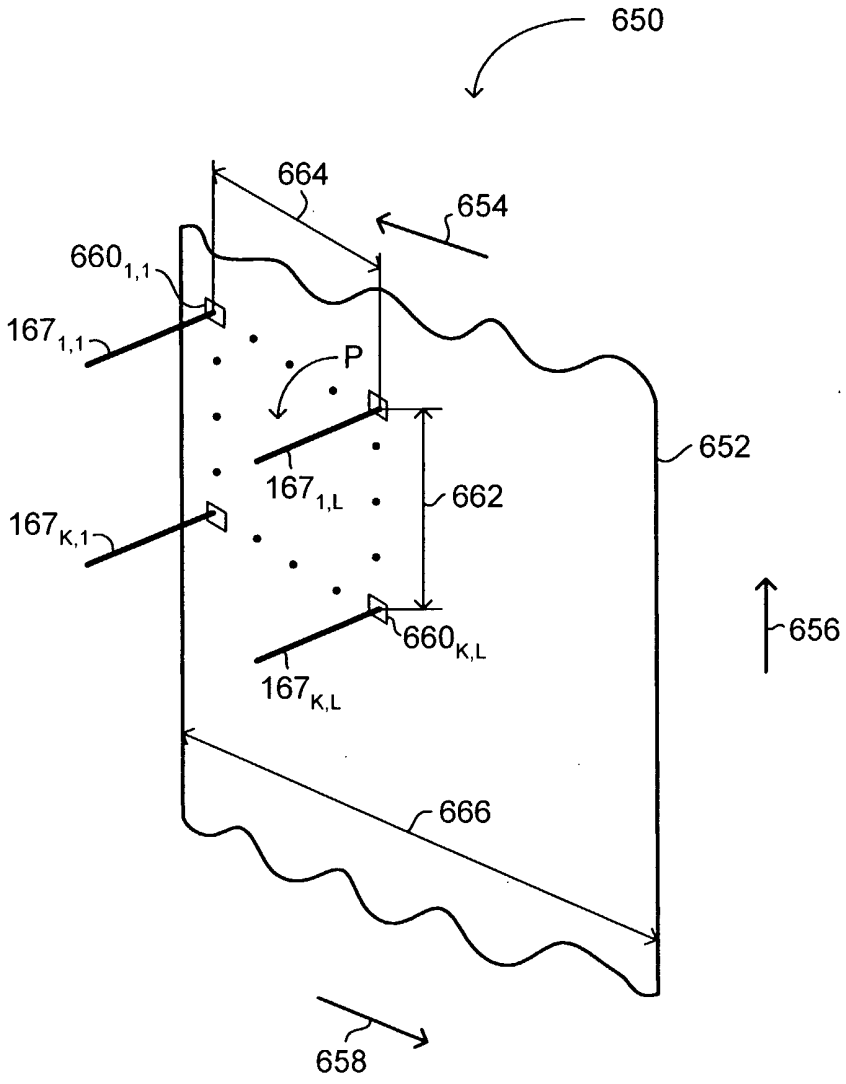
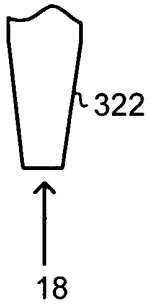

650
664
654
$660_{1,1}$
$167_{1,1}$
P
$167_{1,L}$
662
652
$167_{K,1}$
$660_{K,L}$
$167_{K,L}$
656
666
658

FIG. 16

FIG. 17



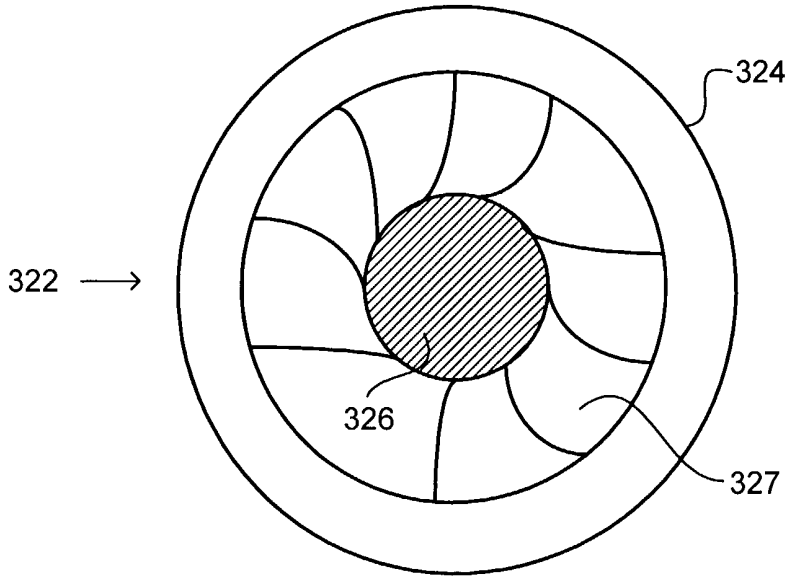


FIG. 18

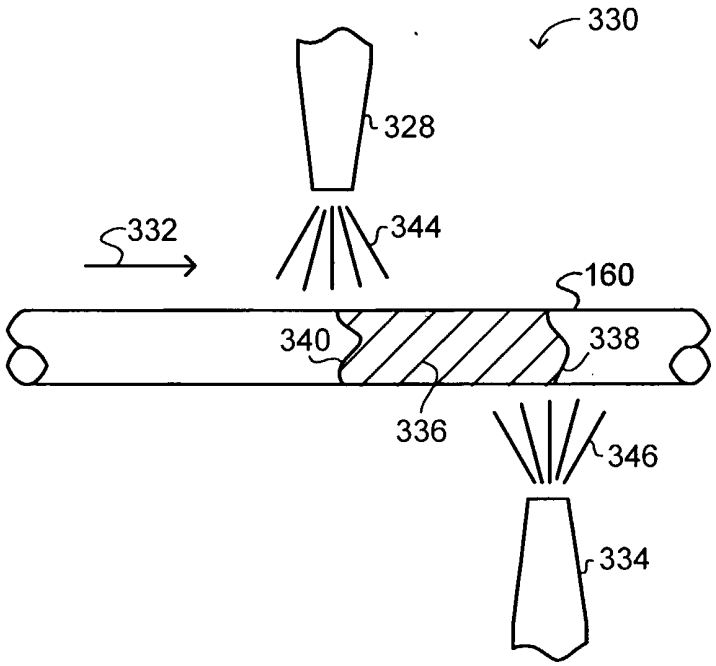


FIG. 19

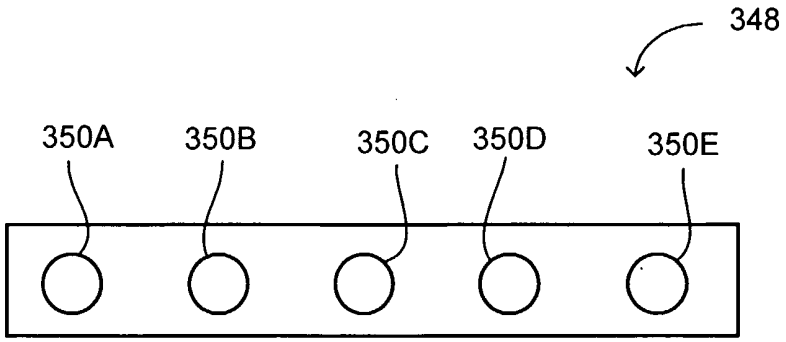


FIG. 20

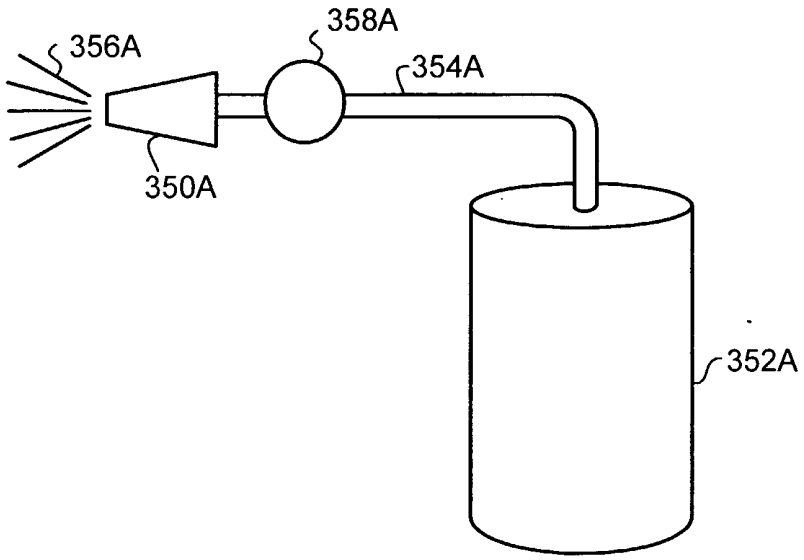


FIG. 21

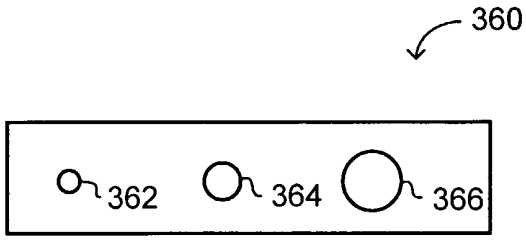

360
362
364
366

FIG. 22

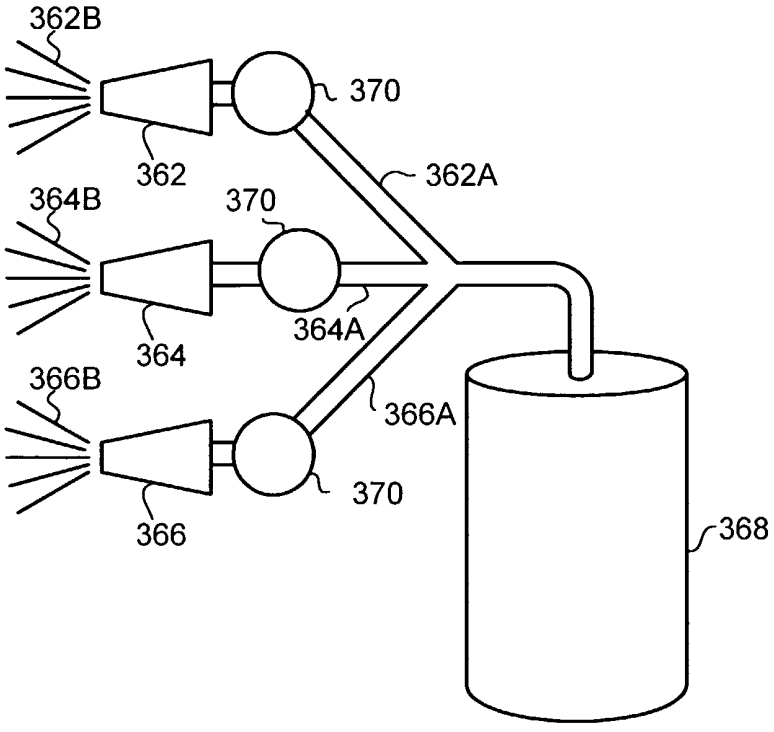

362B
370
362
362A
364B
370
364A
364
366B
366A
370
366
368

FIG. 23

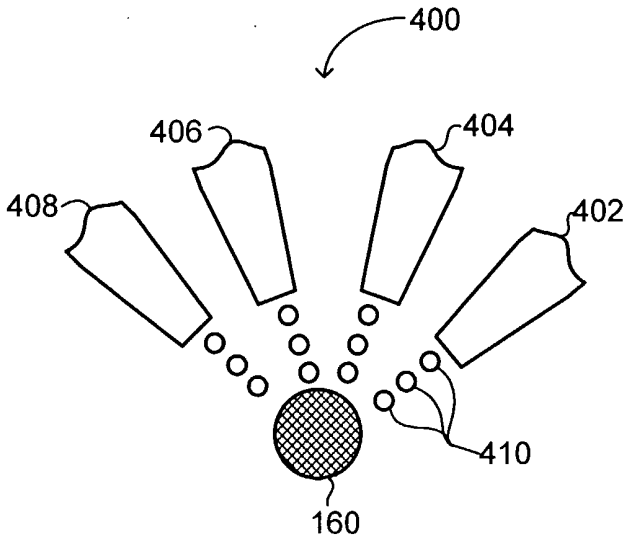


FIG. 24

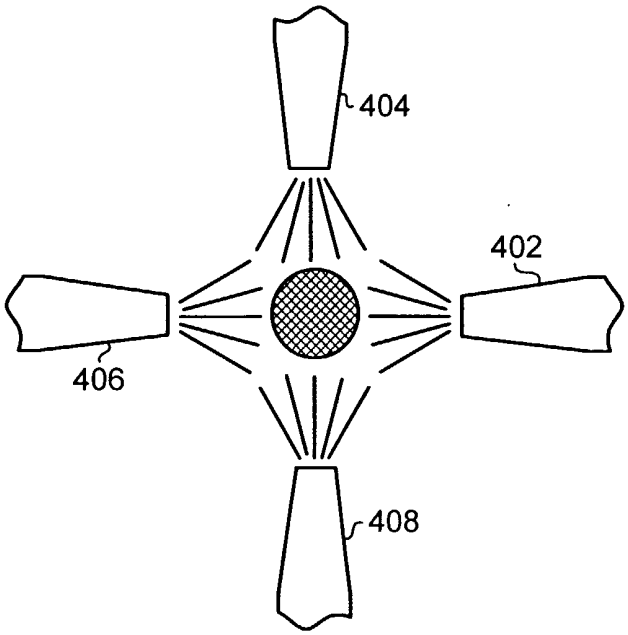


FIG. 25

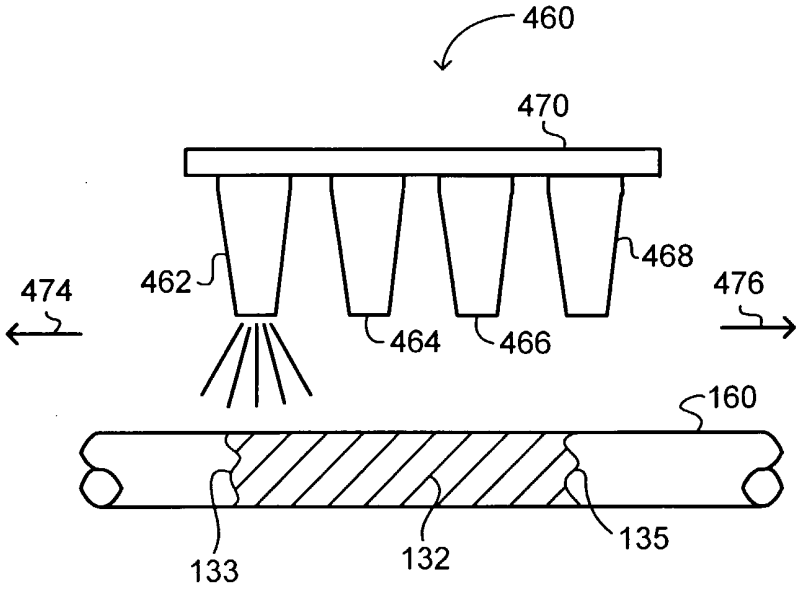


FIG. 26

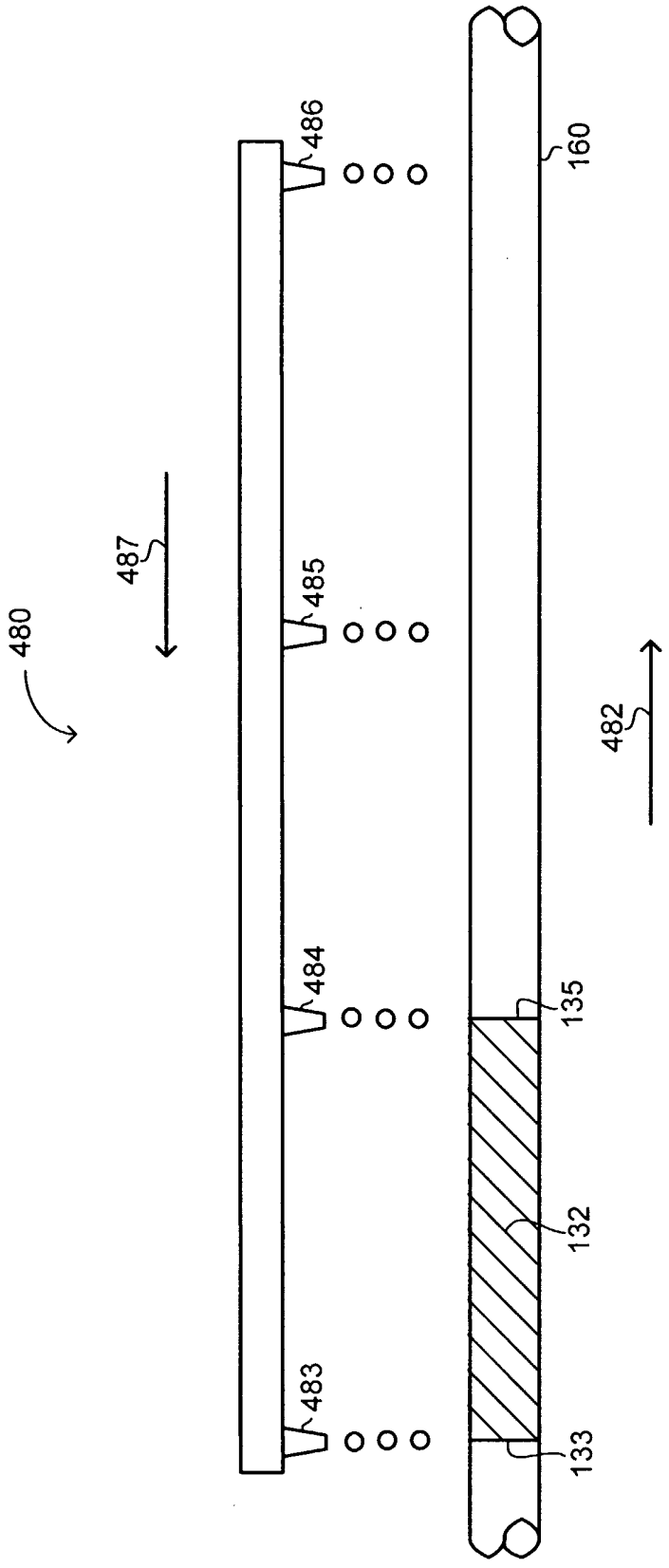


FIG. 27

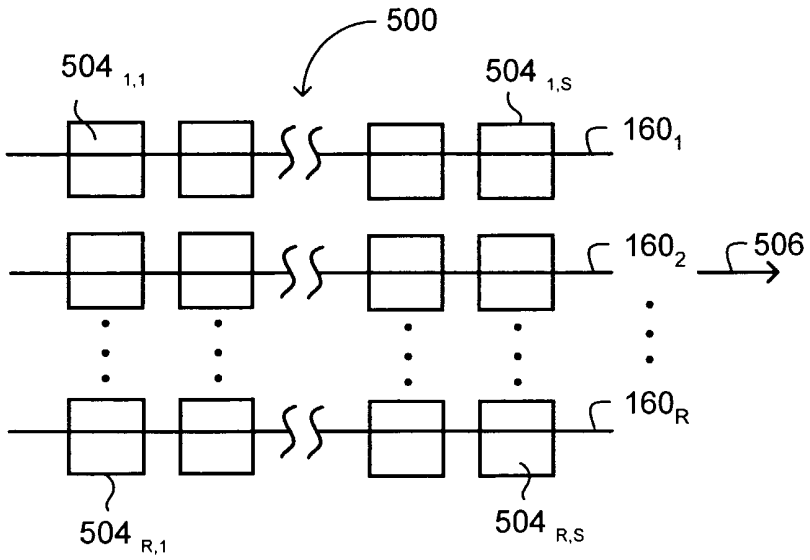

500
504 1,1
504 1,S
160 1
160 2
506
160 R
504 R,1
504 R,S

FIG. 28

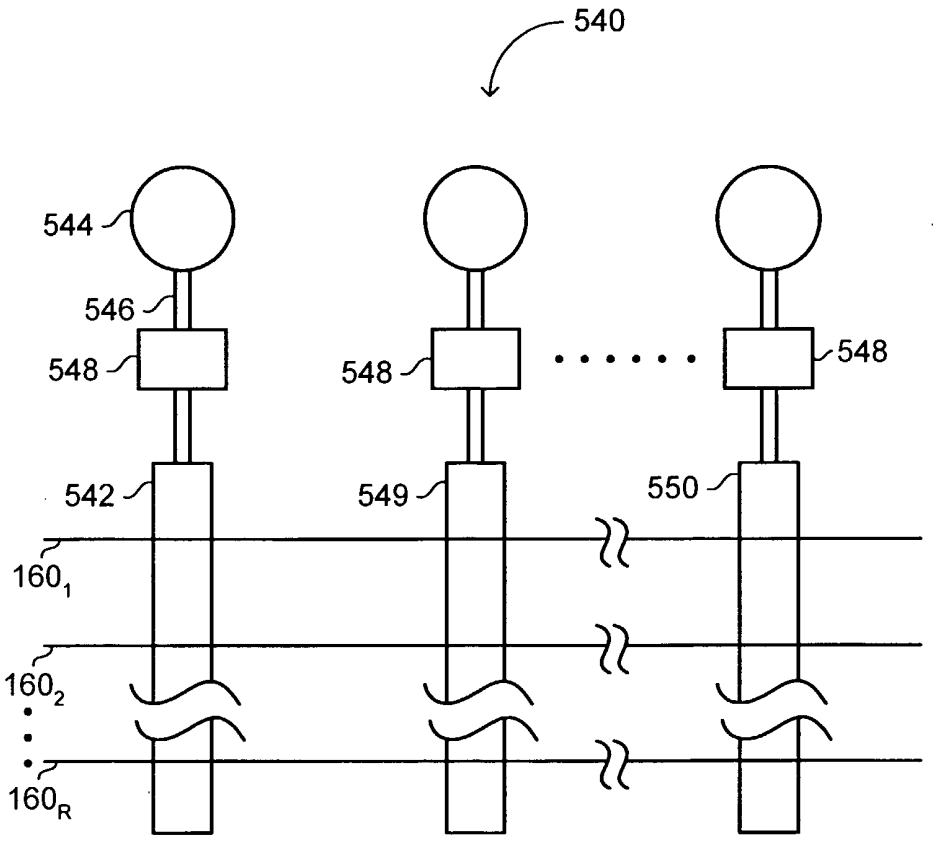

540
544
546
548
548
548
542
549
550
160 1
160 2
160 R

FIG. 29

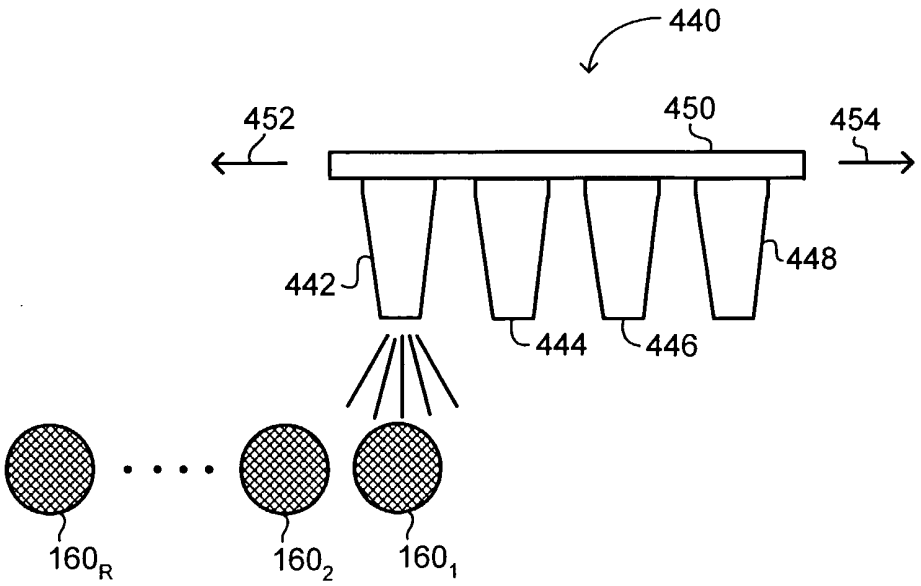


FIG. 30