

Sept. 20, 1971

J. T. SHORT

3,605,660

YARN FEEDING MECHANISM FOR A PILE LOOP-FORMING MACHINE

Filed May 13, 1969

8 Sheets-Sheet 1

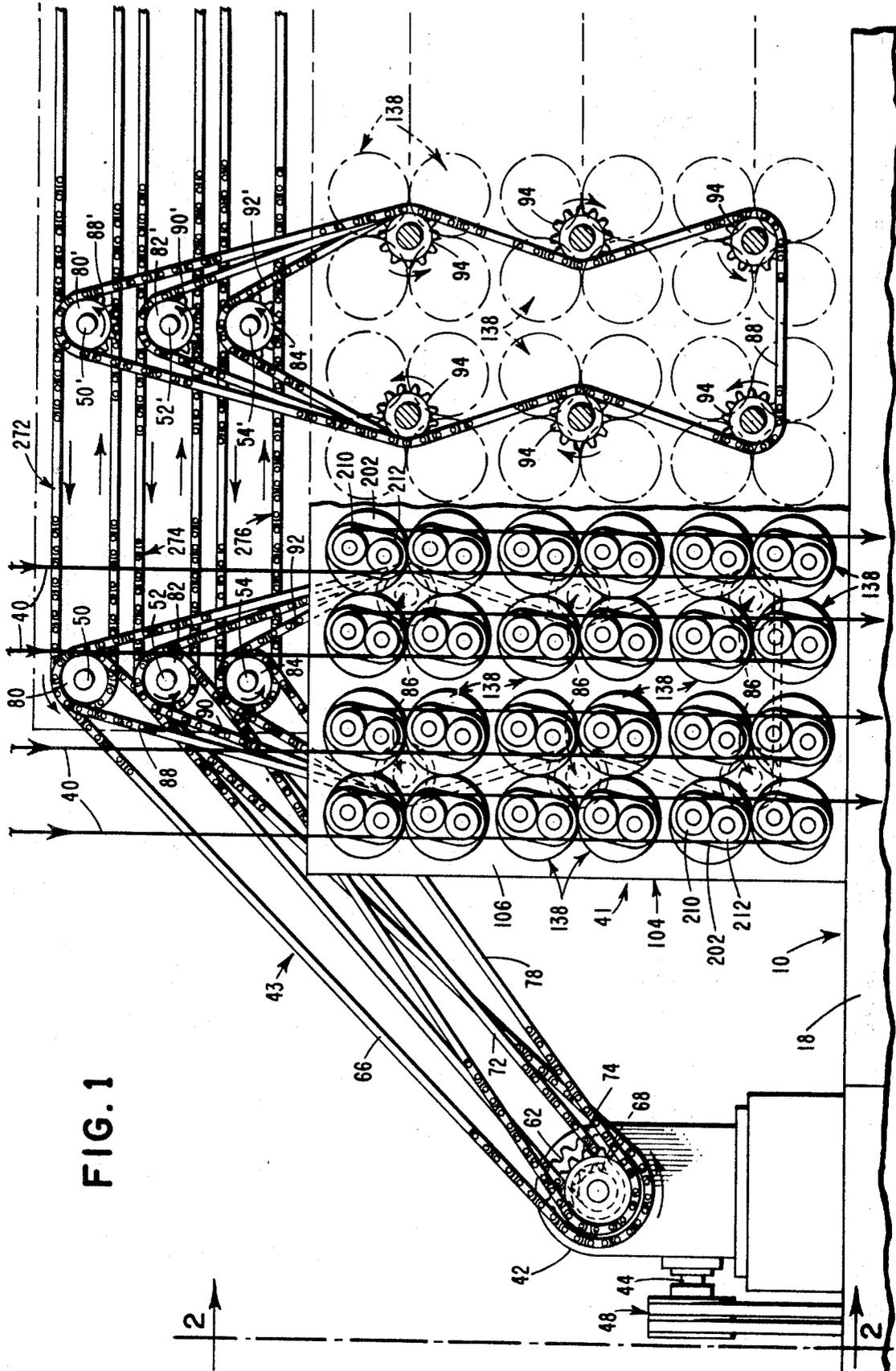


FIG. 1

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8 Sheets-Sheet 2

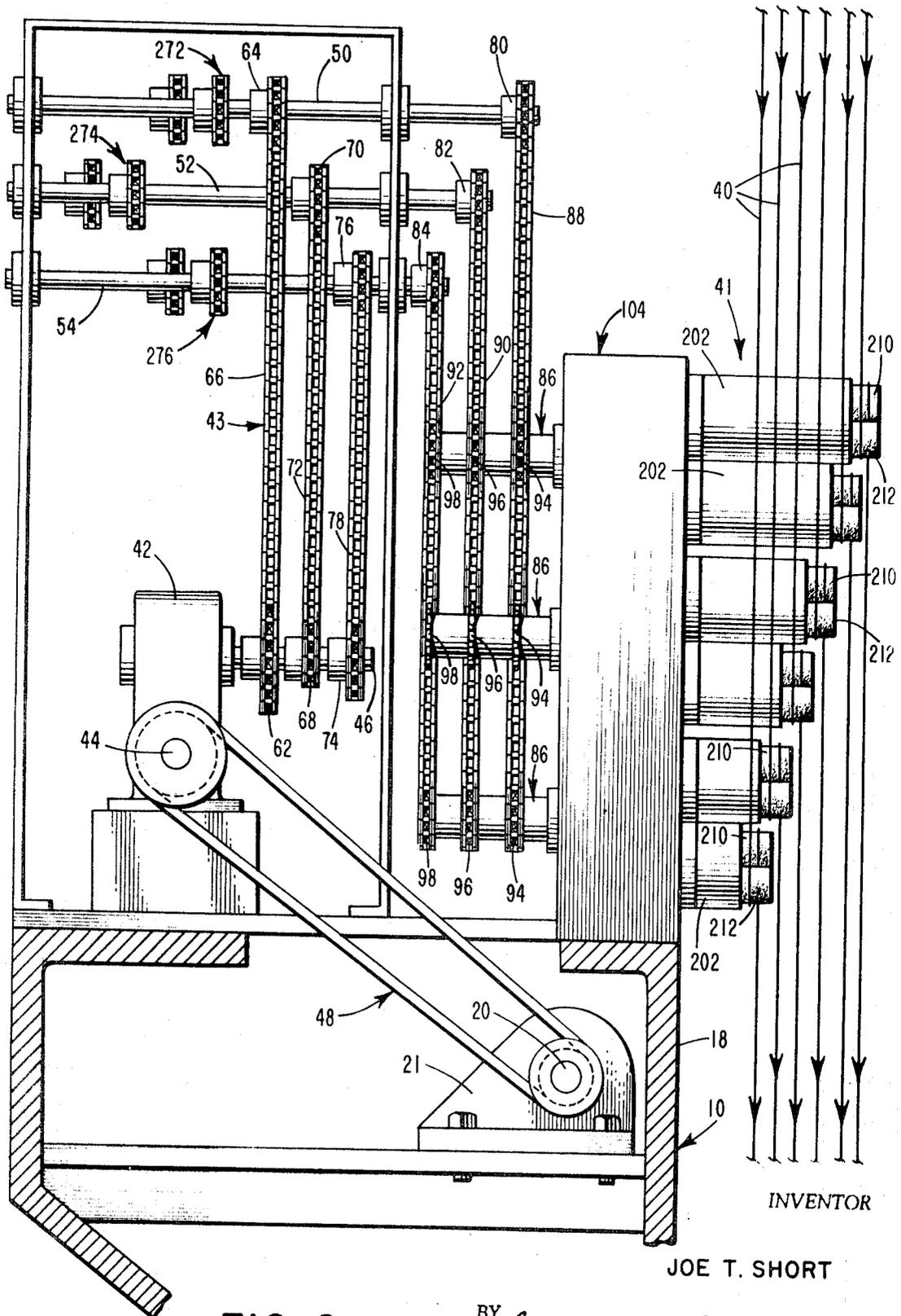


FIG. 2

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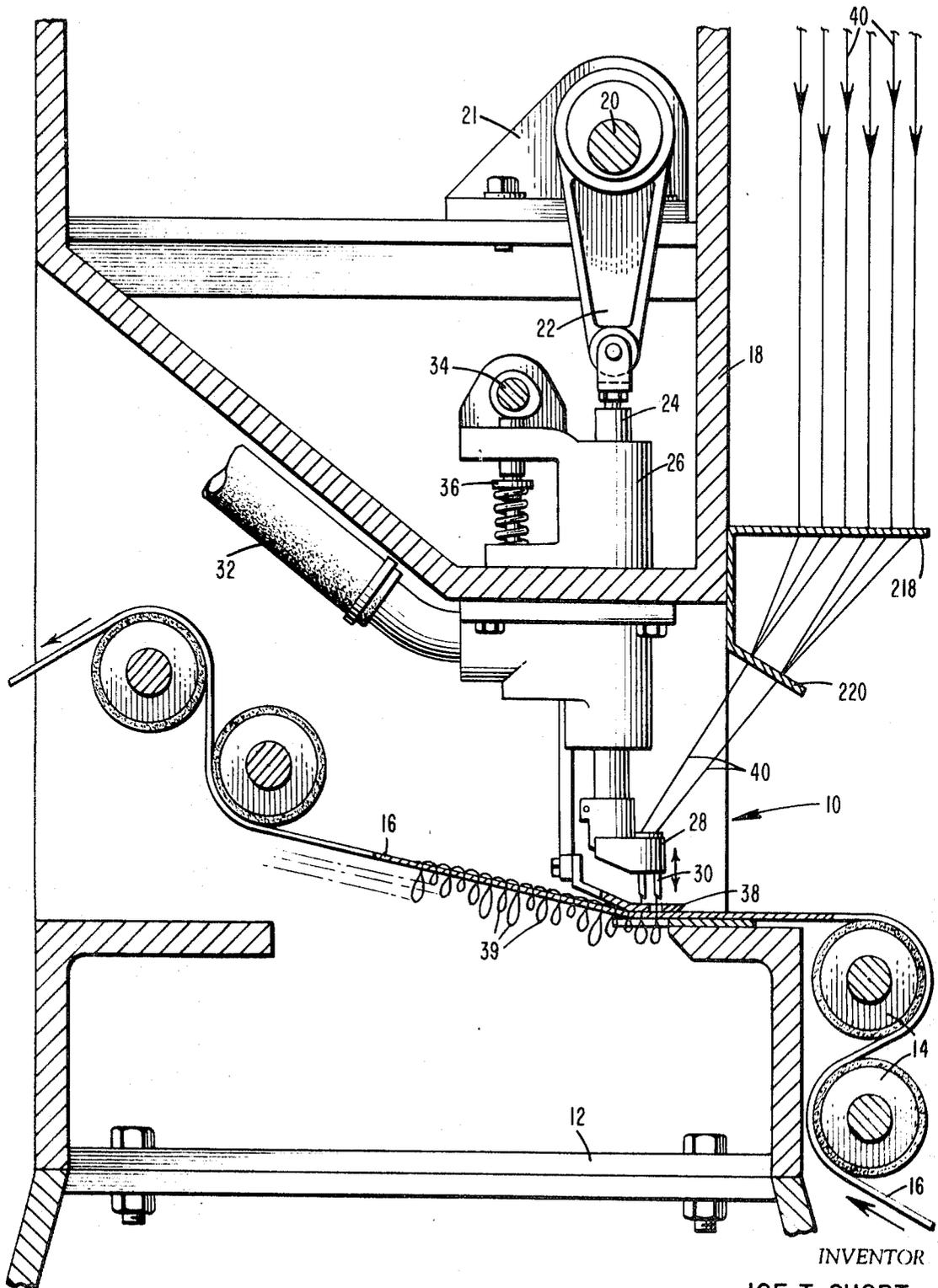
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YARN FEEDING MECHANISM FOR A PILE LOOP-FORMING MACHINE

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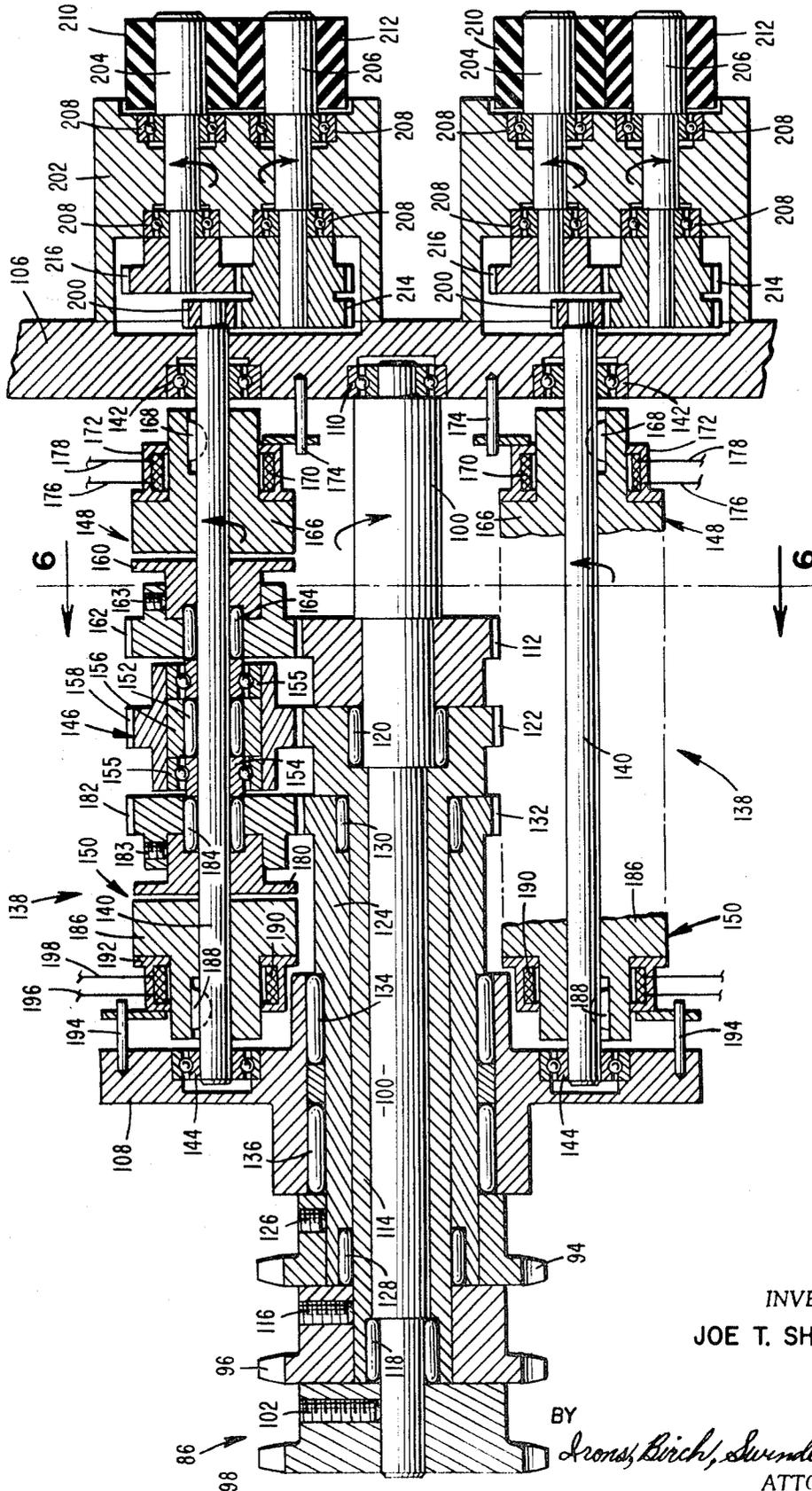
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YARN FEEDING MECHANISM FOR A PILE LOOP-FORMING MACHINE

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FIG. 5



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8 Sheets-Sheet 6

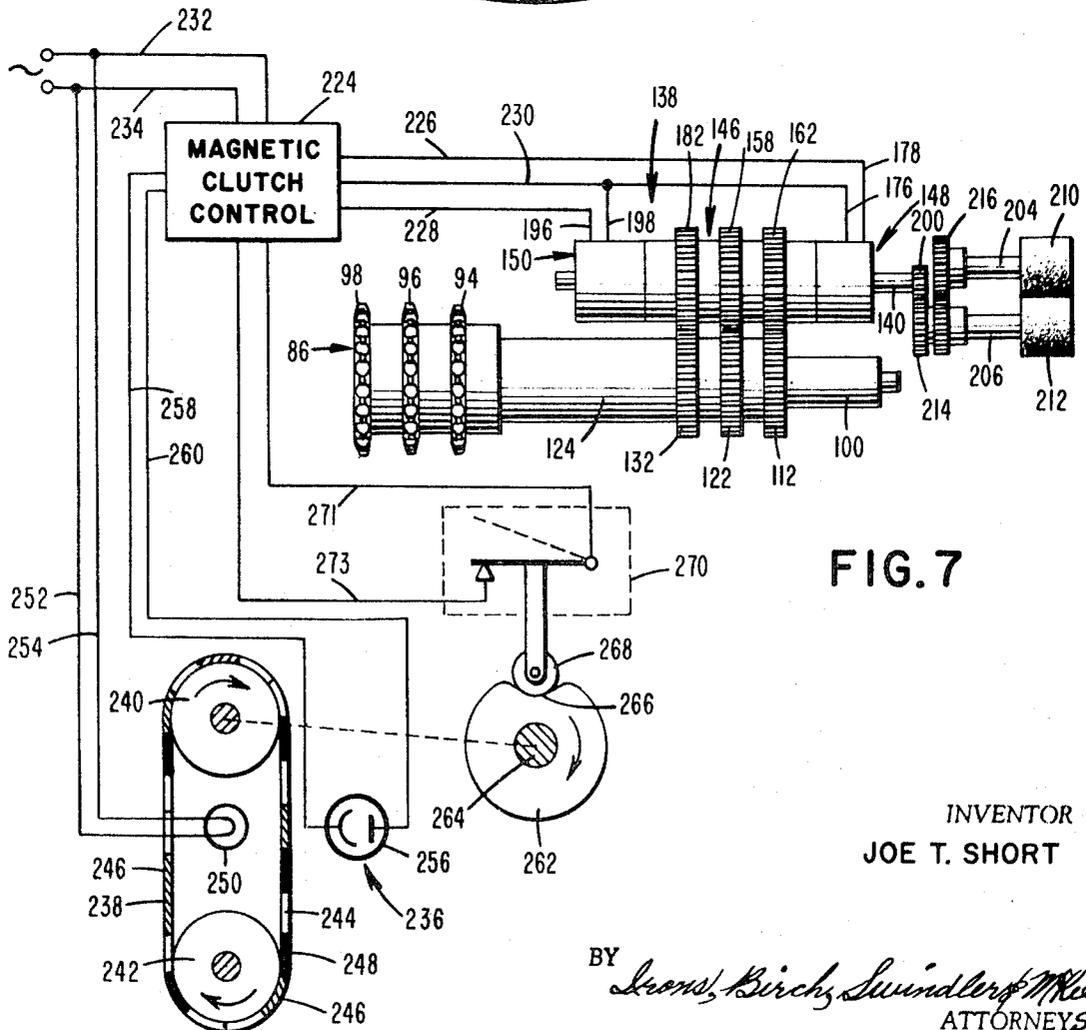
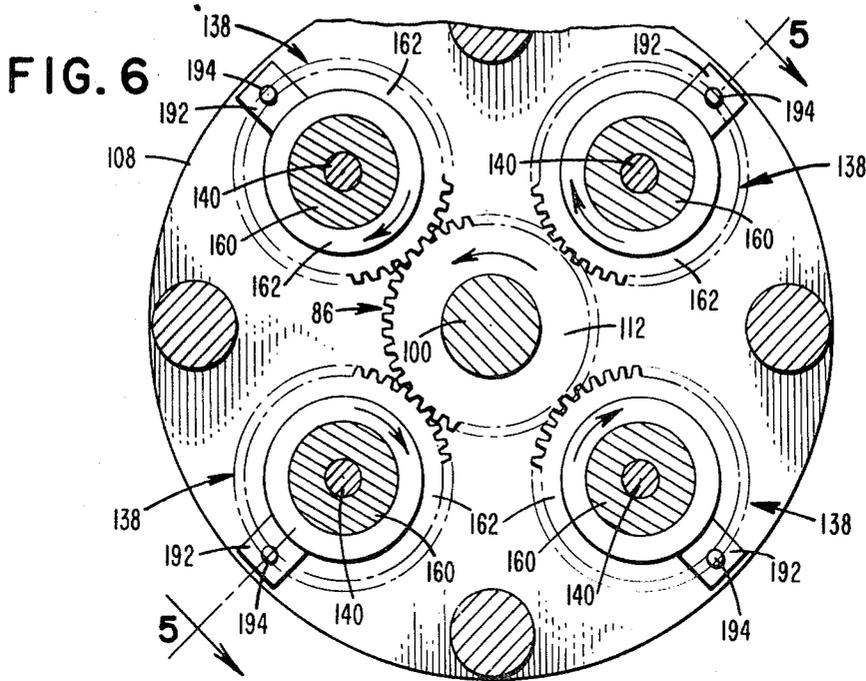


FIG. 7

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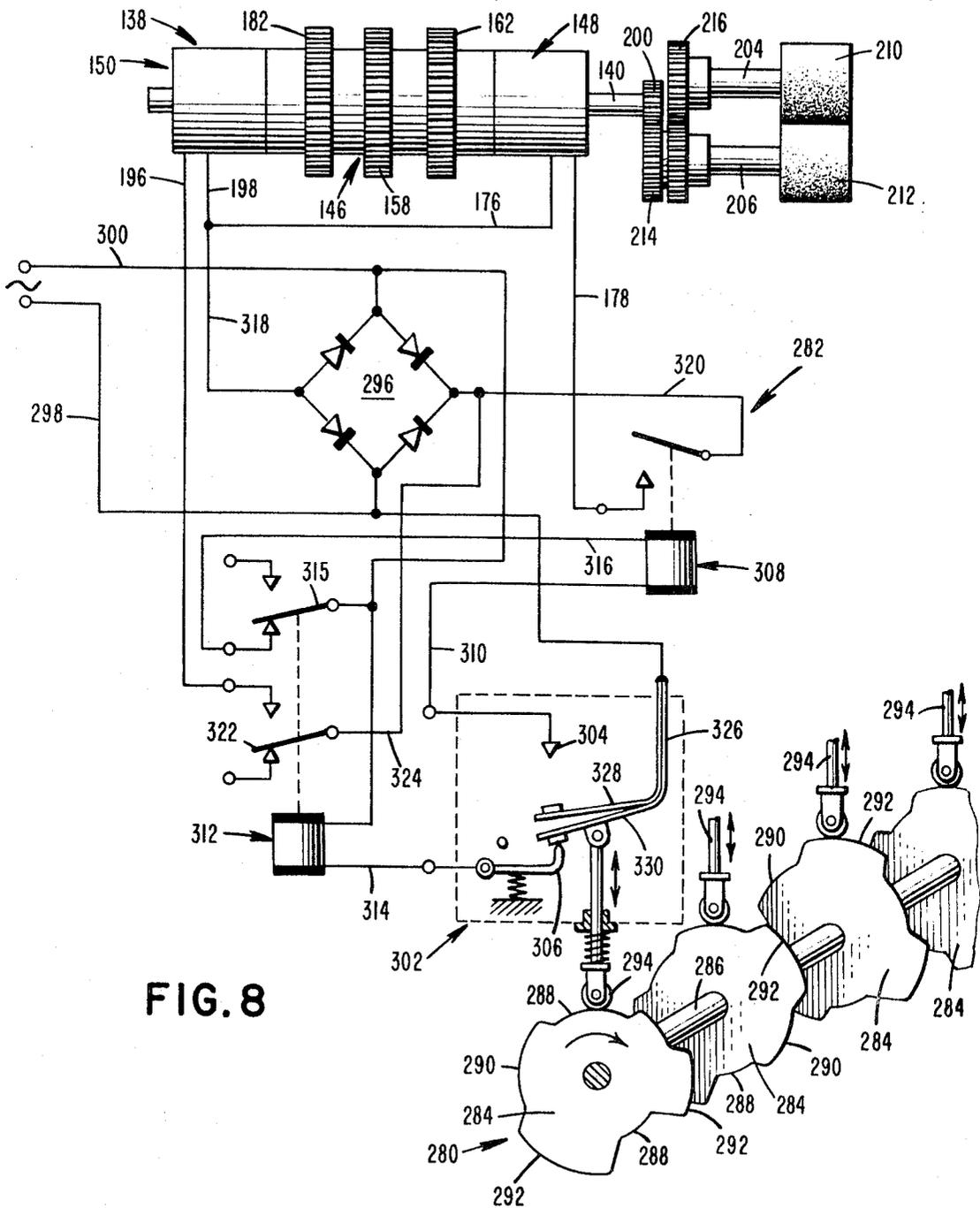


FIG. 8

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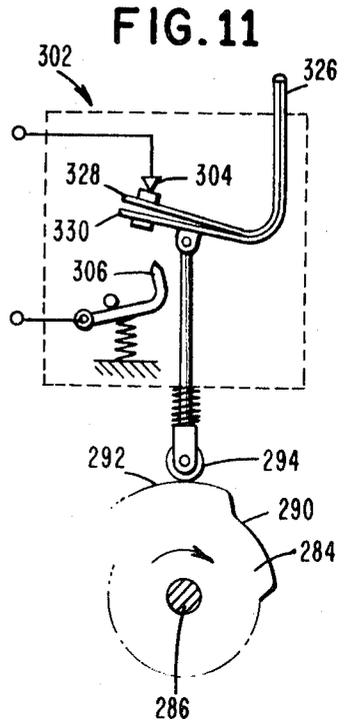
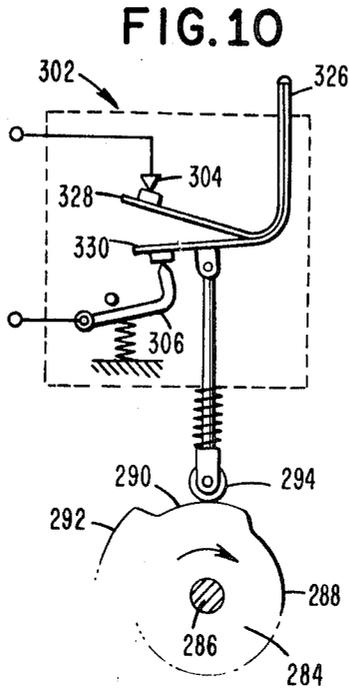
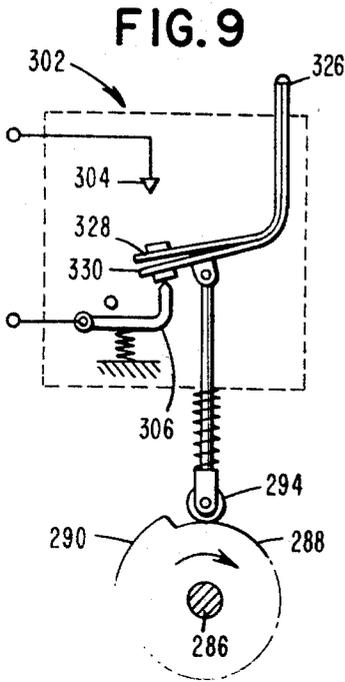
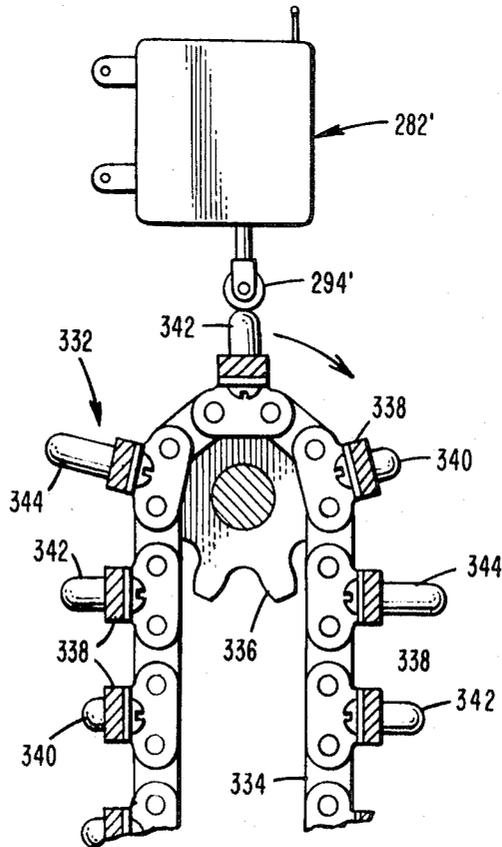


FIG. 12



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YARN FEEDING MECHANISM FOR A PILE LOOP-FORMING MACHINE

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24 Claims

ABSTRACT OF THE DISCLOSURE

A yarn feeding mechanism for a pile loop-forming machine comprising a central drive unit and a plurality of yarn feed modules positioned about the drive unit, each of the modules including a yarn feed drive shaft, a plurality of selectively engageable clutches mounted on the drive shaft and drivably connected to the drive unit for selectively rotating the shaft at different rotational velocities, and yarn feed means drivably connected to the drive shaft and operable to feed different lengths of yarn depending upon which of the clutches rotates the drive shaft.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to yarn feeding mechanisms for pile loop-forming machines, and more specifically to a mechanism for feeding variable lengths of yarn to the pile loop formers of such a machine.

Description of the prior art

Many mechanisms are known for feeding variable lengths of yarn to the pile loop formers of a pile loop-forming machine, such as a tufting or knitting machine. Representative of such mechanisms are those disclosed in Elvin et al. Pat. 2,304,902; Card Pat. 2,862,465; Nix Pat. 2,875,714; MacCaffray Pat. 2,932,181; Card Pat. 2,966,866; MacCaffray Pat. 3,001,388; Wilcox Pat. 3,067,701; Card Pat. 3,075,482; Broadrick Pat. 3,100,465; Hammel Pat. 3,103,187; Beasley Pat. 3,134,529; and Erwin et al. Pat. 3,272,163. Generally, these mechanisms include a plurality of yarn feed means, such as a plurality of pairs of yarn feed rolls. Each of the feed means feeds a plurality of yarn ends to a corresponding plurality of pile loop formers, such as a plurality of tufting or knitting needles. The maximum width of the pile loop patterns that may be produced by a machine using a yarn feeding mechanism of this type is limited by the number of yarn feed means, because all of the yarn ends fed by a particular feed means must necessarily be fed in equal lengths. Obviously this limits the number and types of patterns that may be produced by the machine.

Also, because each yarn feed means feeds a plurality of yarn ends to a corresponding plurality of pile loop formers, the lengths of yarn extending between each feed means and the associated pile loop formers vary widely. For example, one of the pile loop formers associated with a particular feed means may be positioned relatively close thereto, i.e. directly under the feed means, whereas another pile loop former associated with the same feed means may be positioned relatively distant therefrom, i.e. across substantially the entire width of the machine from the feed means. This variation in yarn lengths results in differences in the amount of yarn stretching that occur between each of the feed means and the associated pile loop formers, and consequently in differences in the lengths of yarn received by such pile loop formers. These differences in the lengths of yarn received by the pile loop formers associated with each feed means result in variations in the heights of the pile loops formed by such

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pile loop formers, and consequently in poor pattern definition.

One solution to the foregoing problems would be to use a yarn feeding mechanism having a separate yarn feed means for each pile loop former. The use of such a mechanism has been precluded principally because the driving means for the yarn feed means of the prior art yarn feeding mechanisms comprise relatively bulky, space-consuming mechanical systems. Due to the bulkiness and size of such systems, if a yarn feeding mechanism were to employ such a system for driving a separate yarn feed means for each pile loop former, such a mechanism would be operatively impractical. Moreover, such a mechanism would not solve the problem of differences in the amount of yarn stretching, because, due to the size of the mechanism, the distance between each yarn feed means and the associated pile loop former would vary widely.

SUMMARY OF THE INVENTION

The foregoing problems are obviated by the yarn feeding mechanism of the invention which includes an extremely compact driving means for the yarn feed means of the mechanism.

Generally described, the mechanism of the invention comprises a central drive unit including a plurality of independently rotatable concentric shafts; a plurality of yarn feed modules positioned about the drive unit, each of the modules comprising, a rotatable yarn feed drive shaft, a plurality of selectively engageable clutches mounted on the drive shaft, means drivably connecting the concentric shafts to the clutches for rotating the clutches, yarn feed means, and means drivably connecting the drive shaft to the feed means for operating the feed means; power transmission means connected to the drive unit for driving the concentric shafts to rotate the clutches at different rotational velocities, the clutches being operable to selectively rotate the drive shaft at said different velocities, and the feed means being operable to feed different lengths of yarn when the drive shaft is selectively rotated by different ones of the clutches; and means for selectively engaging the clutches.

Each of the yarn feed modules preferably includes: an overrunning clutch mounted on the yarn feed drive shaft, means drivably connecting one of the concentric shafts to the overrunning clutch for rotating the overrunning clutch at a first rotational velocity, the overrunning clutch being operable to rotate the drive shaft at said first velocity and being overrun by the drive shaft when the drive shaft is rotated at a rotational velocity greater than said first velocity, at least one selectively engageable magnetic clutch mounted on the drive shaft, and means drivably connecting another of the concentric shafts to the magnetic clutch for rotating the magnetic clutch at a second rotational velocity greater than said first velocity, the magnetic clutch being operable when engaged to rotate the drive shaft at said second velocity so that the drive shaft overruns the overrunning clutch.

Preferably, at least four yarn feed modules are positioned about each central drive unit, resulting in an extremely compact structure so that a separate yarn feed means may be provided for each of the pile loop formers of a pile loop-forming machine. Moreover, each of the modules may include two or more magnetic clutches so that a wide range of pile loop heights may be obtained.

The yarn feed means preferably comprises a pair of rotatable yarn feed rolls. Moreover, due to the compact structure of the mechanism each feed roll pair may be positioned at approximately the same distance from the associated pile loop former.

The means for selectively engaging the clutches preferably comprises, switching means operatively connected

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to the magnetic clutch for changing the energization state thereof and control means operatively connected to the switching means for controlling the state of the switching means and thereby controlling the energization state of the magnetic clutch.

With the foregoing in mind, it is an object of the invention to provide an improved yarn feeding mechanism for a pile loop-forming machine.

It is also an object of the invention to provide a yarn feeding mechanism for a pile loop-forming machine, which mechanism embodies an extremely compact structure.

It is a further object of the invention to provide a yarn feeding mechanism for a pile loop-forming machine, which mechanism includes a separate yarn feed means for each of the pile loop formers of the machine.

It is an additional object of the invention to provide a yarn feeding mechanism as described in the preceding object, which mechanism further includes means for feeding different lengths of yarn to each of the pile loop formers of the machine.

These and other objects of the invention will become apparent upon a consideration of the detailed description of the preferred embodiments thereof given in connection with the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view, partially broken away, of a portion of a tufting machine incorporating the yarn feeding mechanism of the invention;

FIG. 2 is an end view of the tufting machine portion shown in FIG. 1;

FIG. 3 is a front view of another portion of the tufting machine shown in FIG. 1;

FIG. 4 is an end view of the tufting machine portion shown in FIG. 3;

FIG. 5 is a sectional view of the central drive unit and associated yarn feed modules of the mechanism of the invention, taken on line 5—5 of FIG. 6;

FIG. 6 is a sectional view taken on line 6—6 of FIG. 5;

FIG. 7 is a diagrammatic view of a first embodiment of the control means and the switching means of the mechanism of the invention;

FIG. 8 is a diagrammatic view of a second embodiment of the control means and the switching means of the mechanism of the invention;

FIGS. 9, 10 and 11 are diagrammatic views showing the various states of a make-before-break switch employed in the switching means shown in FIG. 8; and

FIG. 12 is a diagrammatic view of a third embodiment of the control means and the switching means of the mechanism of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The yarn feeding mechanism of the invention is shown in the drawings as installed in a tufting machine 10. However, the mechanism is equally well adapted for installation in a knitting machine or any other type of pile loop-forming machine.

Tufting machine 10 (FIGS. 3 and 4) is of the type disclosed in Short Pat. 3,089,442 and includes a base 12 on which are journaled a plurality of rolls 14 for guiding and supporting a sheet of backing fabric 16. Also supported on frame 12 is a crankcase 18. A crankshaft 20 is mounted within crankcase 18 and is journaled in bearing mounts 21. A suitable motive means, such as an electric motor (not shown) is drivingly connected to crankshaft 20. A plurality of connecting rods 22 are eccentrically journaled at one end on crankshaft 20 and are pivotally connected at the other end to a plurality of push rods 24. Each push rod 24 extends downwardly from the associated connecting rod 22 through an associated housing 26 affixed to and extending through the bottom of

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crankcase 18, to a needle bar 28. A plurality of hollow tufting needles 30 are affixed to and carried by needle bar 28. Housings 26 enclose valving means for cyclically admitting compressed fluid to needles 30. The compressed fluid is admitted to housings 26 through conduits 32. The valving means within the housings are operated by a cam shaft 34 and cooperating tappets 36 mounted within crankcase 18. Affixed to the lower portion of housings 26 and extending under needle bar 28 is a presser foot 38 which ensures that backing fabric 16 is properly positioned for receiving needles 30 therethrough.

Needle bar 28 and needles 30 carried thereby are cyclically reciprocated by connecting rods 22 and push rods 24 upon rotation of crankshaft 20, so that the needles are cyclically inserted through and retracted from backing material 16 as the material moves under presser foot 38. Upon each insertion of each needle 30 through backing material 16, a length of yarn from a yarn end 40 is forced through the needle by the compressed fluid to form a pile loop 39. The length of yarn fed to a particular needle during a particular needle cycle determines the height of the pile loop formed by that needle during that cycle. Therefore, in order to obtain a pattern of different height pile loops, different lengths of yarn must be fed to the needles during successive cycles. The yarn feeding mechanism of the invention is designed to accomplish this function in an efficient and improved manner.

The mechanism is designated generally by reference numeral 41 (FIGS. 1 and 2) and includes a yarn feed drive means. The yarn feed drive means comprises a power transmission means 43 and a plurality of central drive units 86 drivably connected to the transmission means. Transmission means 43 includes a transmission 42 having an input shaft 44 and an output shaft 46. Input shaft 44 is connected to crankshaft 20 by any suitable power transmission means, such as belt and pulley drive 48. Output shaft 46 has three sprockets 62, 68 and 74 affixed thereto. Sprocket 62 is drivingly connected to a sprocket 64 by a chain 66, and sprocket 64 is affixed to a countershaft 50 journaled in the frame of the machine. Similarly, sprocket 68 is drivingly connected to a sprocket 70 by a chain 72, and sprocket 70 is affixed to a countershaft 52 journaled in the frame of the machine. Also, sprocket 74 is drivingly connected to a sprocket 76 by a chain 78, and sprocket 76 is affixed to a countershaft 54 journaled in the frame of the machine. Sprockets 64, 70 and 76 are of substantially equal diameter, while sprocket 62 is of a greater diameter than sprocket 74 and the latter is of a greater diameter than sprocket 68. Thus, countershaft 50 is rotated at a greater rotational velocity than countershaft 54, and the latter is rotated at a greater rotational velocity than countershaft 52.

Also affixed to countershafts 50, 52 and 54 are sprockets 80, 82 and 84, respectively. These latter sprockets are in turn drivingly connected to central drive units 86 by chains 88, 90 and 92, respectively.

Each central drive unit 86 (FIG. 5) includes three sprockets 94, 96 and 98 about which chains 88, 90 and 92 are trained, respectively. Sprocket 98 is affixed to a shaft 100 by a set screw 102. Shaft 100 extends into an equipment enclosure 104 mounted on frame 12 and having a front wall 106 and a rear wall 108. Shaft 100 is journaled for rotation in front wall 106 by a bearing 110 and in rear wall 108 by a bearing arrangement described below, and has a gear 112 affixed thereto within enclosure 104.

Sprocket 96 is affixed to a hollow shaft 114 by a set screw 116. Shaft 114 is concentrically mounted on shaft 100, being journaled thereon by bearings 118 and 120, and has a gear 122 affixed thereto within enclosure 104.

Sprocket 94 is affixed to a shaft 124 by a set screw 126. Shaft 124 is concentrically mounted on shaft 114, being journaled thereon by bearings 128 and 130, and has a gear 132 affixed thereto within enclosure 104. Shaft

124 is also journalled in rear wall 108 by a pair of bearings 134 and 136. Bearings 134 and 136 and bearing 110 thus rotatably support central drive unit 86 in enclosure 104.

Sprockets 80, 82 and 84 are of substantially equal diameter as are sprockets 94, 96 and 98. Therefore, the differences in rotational velocity imparted to counter-shafts 50, 52 and 54 by sprockets 62, 68 and 74 are maintained by shafts 100, 114 and 124.

A plurality of yarn feed modules 138 are circumferentially spaced about each central drive unit 86 in contiguous relationship thereto. Each module 138 includes a yarn feed drive shaft 140 journalled for rotation in walls 106 and 108 by bearings 142 and 144, respectively. Mounted on shaft 140 are an overrunning clutch 146 and two magnetic clutches 148 and 150.

Overrunning clutch 146 is of conventional construction including a driven component comprising a plurality of rollers 152 carried in radially tapered housings 154, the axial walls of which are defined by the inner races of bearings 155. A cylindrical driving component 156 is affixed between the outer races of bearings 155 and defines the outer tapered walls of housings 154.

Driving component 156 is engageable with rollers 152 for locking the rollers to shaft 140 so that the shaft will be rotated by the driving component. As long as the rotational velocity of shaft 140 does not exceed the rotational velocity of driving component 156, the driving component will remain engaged with rollers 152 and the rollers will remain locked to the shaft. When the rotational velocity of shaft 140 exceeds the rotational velocity of driving component 156, rollers 152 will become unlocked from the shaft and will disengage the driving component, whereupon rollers 152 and shaft 140 will rotate relative to and overrun the driving component.

A gear 158 is affixed to driving component 156 and is drivably meshed with gear 122. Gears 122 and 158 thus comprise a means for drivably connecting shaft 114 to overrunning clutch 146.

Gear 158, and therefore driving component 156, are rotated continuously by a first drive system formed by the yarn feed drive means comprising gear 122, shaft 114, sprocket 96, chain 90, sprocket 82, countershaft 52, sprocket 70, chain 72 and sprocket 68.

Magnetic clutch 148 includes a driving component constituted by an armature 160 to which a gear 162 is secured by a set screw 163. Armature 160 and gear 162 are journalled for rotation on shaft 140 by a bearing 164 and are movable axially of the shaft. Clutch 148 also includes a driven component constituted by a rotor 166 which is affixed to shaft 140 by a Woodruff key 168. A coil 170 is positioned concentrically about rotor 166 and is mounted in a stationary housing 172 within which rotor 166 rotates. Housing 172 is affixed to front wall 106 by a pin 174. A pair of leads 176 and 178 connect coil 170 to a source of electrical current as described below. When electrical current is passed through coil 170, the coil becomes energized, whereupon armature 160 is attracted to and frictionally engages rotor 166, thereby causing shaft 140 to be rotated at the same rotational velocity as armature 160.

Gear 162 is drivably meshed with gear 112. Gears 112 and 162 thus comprise a means for drivably connecting shaft 100 to clutch 148.

Gear 162, and therefore armature 160, are rotated continuously by a second drive system formed by the yarn feed drive means comprising gear 112, shaft 100, sprocket 98, chain 92, sprocket 84, countershaft 54, sprocket 76, chain 78 and sprocket 74.

Magnetic clutch 150 is similar to clutch 148 and includes a driving component constituted by an armature 180 to which a gear 182 is secured by a set screw 183. Armature 180 and gear 182 are journalled for rotation on shaft 140 by a bearing 184 and are movable axially of the shaft. Magnetic clutch 150 also includes a driven compo-

nent constituted by a rotor 186 which is affixed to shaft 140 by a Woodruff key 188. A coil 190 is positioned concentrically about rotor 186 and is mounted in a stationary housing 192 within which rotor 186 rotates. Housing 192 is affixed to rear wall 108 by a pin 194. A pair of leads 196 and 198 connect coil 190 to a source of electrical current as described below. When electrical current is passed through coil 190, the coil becomes energized, whereupon armature 180 is attracted to and frictionally engages rotor 186, thereby causing shaft 140 to be rotated at the same rotational velocity as armature 180.

Gear 132 is drivably meshed with gear 182. Gears 132 and 182 thus comprise a means for drivably connecting shaft 124 to clutch 150.

Gear 182, and therefore armature 180, are rotated continuously by a third drive system formed by the yarn feed drive means comprising gear 132, shaft 124, sprocket 94, chain 88, sprocket 80, countershaft 50, sprocket 64, chain 66 and sprocket 62.

Gears 112, 122 and 132 are of substantially equal diameter as are gears 158, 162 and 182. Therefore, the differences in rotational velocity imparted to shaft 100, 114 and 124 by power transmission means 43 are maintained by gears 158, 162 and 182 associated with clutches 146, 148 and 150, respectively. Therefore, shaft 140 will be rotated at a relatively low rotational velocity by clutch 146 as long as magnetic clutches 148 and 150 are disengaged. Upon engagement of either of clutches 148 or 150, shaft 140 will be rotated at either an intermediate or relatively high rotational velocity, respectively, overrunning clutch 146.

Shaft 140 is drivably connected to a yarn feed means comprising a pair of rotatable yarn feed rolls 210 and 212. For this purpose, shaft 140 extends through an opening in front wall 106 and has a gear 200 affixed to the forward end thereof. A housing 202 is attached to front wall 106 about gear 200. A pair of yarn feed roll shafts 204 and 206 are journalled within housing 202 by bearings 208. Shafts 204 and 206 extend beyond the forward end of housing 202 and have feed rolls 210 and 212 affixed to the forward ends thereof, respectively. The peripheral surfaces of rolls 210 and 212 are resilient and contact each other forming a nip through which one of yarn ends 40 is inserted to be fed to one of needles 30. Affixed to the rear end of shaft 206 is a first feed roll gear 214 having a double set of gear teeth, and affixed to the rear end of shaft 204 is a second feed roll gear 216 having a diameter substantially equal to the diameter of gear 214. Gear 200 is drivably meshed with one of the sets of teeth of gear 214, and the other set of teeth of gear 214 is drivably meshed with gear 216, so that upon rotation of shaft 140, feed rolls 210 and 212 are rotated in opposite directions at substantially the same rotational velocity.

As mentioned above, a plurality of yarn feed modules 138 are positioned about each central drive unit 86 (FIGS. 1, 5 and 6). In the embodiment shown in the drawings four yarn feed modules are positioned about and driven by each central drive unit. This arrangement is made possible by the compact structure of the drive units and feed modules, and permits a single pair of feed rolls to be employed for each needle 30.

Also, in the embodiment shown in the drawings, central drive units 86 are arranged in vertical groups of three drive units each, and the drive unit groups are disposed in side-by-side relationship across the width of tufting machine 10 (FIG. 1). Thus, each group of drive units is capable of driving two vertical groups of six yarn feed modules each. Each vertical group of drive units may include more or less than three such units, depending upon the number of yarn feed modules required.

To prevent the yarn ends 40 which are fed by a single vertical group of modules from becoming tangled with each other and the associated feed rolls 210 and 212, the forward ends of housing 202 and feed roll shafts 204 and

206 are progressively horizontally offset in each group of modules (FIG. 2). Each yarn end 40 is passed around one of the feed rolls 212, through the nip between that roll and the associated roll 210, and around the latter roll (FIGS. 1 and 2), so that the feed rolls will positively grip and feed the desired lengths of yarn to the associated needle 30.

Yarn ends 40 extend downwardly from the feed rolls through perforated yarn guides 218 and 220 (FIGS. 3 and 4), which direct the yarn ends to needles 30.

The vertical groups of central drive units 86 are driven in pairs by chains 88, 90 and 92 (FIG. 1). The chains are trained outboard around the upper drive units of each pair of groups, inboard around the intermediate drive units of each pair of groups, and outboard around and below the lower drive units of each pair of groups. This arrangement causes concentric shafts 100, 114 and 124 of the intermediate pair of drive units to be rotated in the opposite direction from the direction of rotation of the corresponding shafts of the upper and lower pairs of drive units. To compensate for this difference, feed roll gear 214 of each module 138 associated with the intermediate pair of drive units is affixed to feed roll shaft 204 instead of shaft 206, and feed roll gear 216 is affixed to feed roll shaft 206 instead of shaft 204, with drive shaft gear 200 drivingly engaging gear 214 as described above. This arrangement results in all of the feed rolls 210 being rotated in one direction and all of the feed rolls 212 being rotated in the opposite direction.

The vertical groups of drive units more distant from transmission 42 than the pair of groups nearest thereto are drivably connected to the transmission by chain and sprocket drives associated with countershafts 50, 52 and 54 (FIGS. 1 and 2). Thus, countershaft 50 is drivingly connected to a countershaft 50' journalled in the frame of the machine and transversely spaced from countershaft 50, by a chain and sprocket drive 272. Similarly, countershaft 52 is drivingly connected to a countershaft 52' journalled in the frame of the machine and transversely spaced from countershaft 52, by a chain and sprocket drive 274. Also, countershaft 54 is drivingly connected to a countershaft 54' journalled in the frame of the machine and transversely spaced from countershaft 54, by a chain and sprocket drive 276. Chain and sprocket drives 272, 274 and 276 rotate countershafts 50', 52' and 54' at the same rotational velocities as countershafts 50, 52 and 54, respectively.

Affixed to countershafts 50', 52' and 54' are sprockets 80', 82' and 84', respectively, which are connected to the drive units 86 of the second pair of drive unit groups, i.e. the third and fourth vertical groups of drive units from transmission 42, by chains 88', 90' and 92', respectively. Concentric shafts 100, 114 and 124 of the drive units of the second pair of drive unit groups are thus rotated at the same rotational velocities as the corresponding shafts of the drive units of the first pair of drive unit groups, i.e. the first and second vertical groups of drive units from transmission 42. The clutch driving components of the yarn feed modules associated with the drive units of the second pair of drive unit groups are thus also rotated at the same rotational velocities as the corresponding clutch driving components of the yarn feed modules associated with the drive units of the first pair of drive unit groups.

This arrangement is repeated across the width of tufting machine 10, with the countershafts associated with each pair of drive unit groups being drivably connected to the countershafts associated with the preceding pair of drive unit groups by chain and sprocket drives similar to chain and sprocket drives 272, 274 and 276.

As mentioned above, due to the compact structure of central drive units 86 and yarn feed modules 138, a separate pair of feed rolls 210 and 212 may be provided for each needle 30. Thus, the lengths of yarn fed to each needle are independent of the lengths of yarn fed to every

other needle; permitting machine 10 to form pile loop patterns as wide as backing fabric 16.

Also, the only differences in the lengths of yarn extending between the various feed roll pairs 210 and 212 and the associated needles 30 are the relatively slight vertical distances by which the feed roll pairs are separated (FIG. 2). Since these differences are relatively slight, only minimal variations in yarn stretching will occur between the feed roll pairs and the needles. Thus, the lengths of yarn received by the needles for the formation of pile loops of various heights will be relatively constant for all pile loops of a particular height, i.e. the lengths of yarn received by the needles for the formation of all low pile loops, for example, will be relatively constant, resulting in excellent pattern definition.

Mechanism 41 also includes means for selectively engaging magnetic clutches 148 and 150. Such means include a switching means which is operatively connected to the magnetic clutches for selectively changing the energization state thereof. Also, such means include a control means which is operatively connected to the switching means for controlling the state of the switching means and thereby controlling the energization state of the magnetic clutches. A separate switching means and associated control means are provided for each yarn feed module 138 or for each group of modules, all of which feed equal lengths of yarn for a particular pile loop pattern.

A first embodiment of the switching means and the control means is shown in FIG. 7, including a switching means 224 which may comprise a conventional arrangement of electro-mechanical or electronic switching devices, such as relays or solid state devices as disclosed in Short Pat. 3,435,787. Each switching means 224 is connected to leads 176, 178, 196 and 198 of the associated yarn feed module 138 by three leads 226, 228 and 230; lead 178 being connected to lead 226, lead 196 being connected to lead 228, and leads 176 and 198 being both connected to lead 230.

Each switching means 224 is also connected to a source of alternating current by leads 232 and 234 and includes a rectifier for supplying direct current at leads 226, 228 and 230 for selectively energizing coil 170 of the associated clutch 148 or coil 190 of the associated clutch 150. Thus, when the appropriate switching devices of switching means 224 are closed, either clutch 148 or clutch 150 of the associated yarn feed module 138 will be engaged.

Operatively connected to each switching means 224 is a control means 236. Each of the control means embodiments includes a movable element having pattern-defining means thereon and means for sensing such pattern-defining means.

The movable element of control means 236 comprises an endless member, such as a belt 238, which is mounted on rotatable rolls 240 and 242. Belt 238 is comprised of a plurality of longitudinally extending tracks of a plurality of areas of different relative transparency, such as fully transparent areas 244, translucent areas 246, and opaque areas 248. Areas 244, 246 and 248 thus comprise pattern-defining means on belt 238. A separate track of pattern areas 244, 246 and 248 is provided for each switching means 224 and associated yarn feed module 138.

The sensing means of control means 236 includes a light source such as an electric lamp 250, which is disposed on one side of belt 238 and is connected to the source of alternating current by leads 252 and 254. The sensing means also includes a light-sensitive cell, such as a photocell 256, which is disposed on the other side of belt 238 in opposing relationship to lamp 250. One lamp 250 and an associated photocell 256 are provided for each track of pattern areas on belt 238. Alternatively, one lamp of sufficient size, i.e. an elongated fluorescent lamp extending the width of belt 238, may be provided for all of the photocells.

Each photocell 256 senses the amount of light transmitted through belt 238 as the associated track of pattern

areas 244, 246 and 248 passes between the light source and the photocell. Each photocell 256 is connected to the associated switching means 224 by leads 258 and 260 for controlling the state of the switching devices comprising the switching means in response to the amount of light transmitted through belt 238. For example, the switching means may be wired so that when a transparent pattern area 244 is interposed between lamp 250 and photocell 256, the appropriate switching devices of the switching means for engaging clutch 150 will be closed. However, the correspondence between pattern areas 244, 246 and 248 and clutches 146, 148 and 150 is immaterial as long as magnetic clutch 148 is engaged in response to the sensing of one type of pattern area, magnetic clutch 150 is engaged in response to the sensing of another type of pattern area, and both magnetic clutches are disengaged in response to the sensing of the third type of pattern area.

Rolls 242 and 244 are rotated by any conventional driving means in synchronization with the pile loop-forming cycles of needles 30, and each pattern area on belt 238 corresponds to one such cycle.

As described in the aforementioned Short Pat. 3,435,787, the control means also desirably includes a disabling means for preventing the state of the switching devices comprising each switching means 224, and therefore the energization state of the associated magnetic clutches 148 and 150, from being changed except within a specified period during each pile loop-forming cycle of needles 30. The preferable period within each cycle for changing the energization state of the clutches is immediately after needles 30 have reached the maximum upper position of each retraction stroke. By changing the energization state of the clutches within this period, and only within this period, the yarn feed rate for each pair of feed rolls will be constant throughout the ensuing portion of the pile loop-forming cycle, thus ensuring that the lengths of yarn fed to the needles for the formation of pile loops of various heights will be constant for all pile loops of a particular height.

Suitable disabling means for accomplishing this function are described in detail in the aforementioned Short Pat. 3,435,787, and basically include a cam 262 which is mounted on a rotatable shaft 264. Shaft 264 is rotated by suitable driving means in synchronism with the pile loop-forming cycles of needles 30 so that each revolution of cam 262 corresponds to one such cycle. Cam 262 has a peripheral recess 266 which defines the period during each needle cycle within which the energization state of clutches 148 and 150 may be changed by photocells 256, as described above. A cam follower 268 contacts the periphery of cam 262 and is connected to a switch 270. Switch 270 is connected to each switching means 224 by leads 271 and 273. Switch 270 is normally held open by follower 268. While switch 270 is in an open state, each switching means 224 is disabled from changing the energization state of the associated clutches 148 and 150 even though an energization state change may be signalled by the associated photocell 256. When cam 262 rotates to the position shown in FIG. 7, follower 268 moves into peripheral recess 266 and switch 270 is closed. Within the period that switch 270 is closed, and only within that period, each switching means 224 is enabled to perform a change in the energization state of the associated clutches 148 and 150. Cam 262 is positioned on shaft 264 so that cam follower 268 will move into recess 266 when needles 30 have reached the upper position of each retraction stroke. After the energization state of the clutches 148 and 150 of a particular yarn feed module 138 has been set by the associated switching means 224 in response to the signals generated by the associated photocell 256 at the beginning of a particular cycle, the energization state of the clutches, and therefore the yarn feed rate of the module, cannot thereafter be changed during that cycle.

A second embodiment of the control means and the

switching means is shown in FIG. 8, including a control means 280 and a switching means 282. Control means 280 comprises a plurality of cams 284 affixed to a cam shaft 286. A separate cam 284 is provided for each switching means 282 and associated yarn feed module 138. Cams 284 have a plurality of peripheral pattern projections thereon, including low projections 288, intermediate projections 290 and high projections 292. The different heights of the pattern projections correspond to the different yarn lengths which may be fed by the yarn feed modules. Each cam 284 thus comprises the movable element of control means 280 and projections 288, 290 and 292 comprise the pattern-defining means thereon.

Cam shaft 286 is rotated by a cyclical stepping mechanism (not shown) which rotates the cams the width of one pattern projection just prior to the completion of each pile loop-forming cycle of the needles, i.e. just before the needles reach the maximum upper position of each retraction stroke.

The sensing means of control means 280 comprises a cam follower 294 for each of cams 284. Each cam follower 294 is biased toward the associated cam 284 so that the follower contacts pattern projections 288, 290 and 292. As the cams are cyclically rotated, followers 294 are raised and lowered in correspondence with the heights of the pattern projections contacted thereby.

One of the switching means 282 is operatively connected to each cam follower 294 for changing the energization state of the magnetic clutches 148 and 150 of the associated yarn feed module 138 in response to the heights of the pattern projections sensed by the follower. Each switching means 282 includes a rectifier 296 which is connected to a source of alternating current by leads 298 and 300. Lead 298 is also connected to a double leaf switching element 326 of a make-before-break switch 302. Switch 302 has two switch contacts 304 and 306. Contact 304 is connected to the coil of a single pole, single throw relay 308 by a lead 310; and contact 306 is connected to the coil of a double throw, double pole relay 312 by a lead 314. Lead 300 is also connected to the coil relay 312 and to one of the switching elements 314 thereof. The coil of relay 308 is additionally connected to the relay-energized contact of element 314 by a lead 316.

One of the direct current terminals of rectifier 296 is connected to leads 176 and 198 of coils 170 and 190 of the associated clutches 148 and 150, respectively, by a lead 318. The other direct current terminal of rectifier 296 is connected to the switching element of relay 308 by a lead 320. The same terminal of rectifier 296 is connected to the second switching element 322 of relay 312 by a lead 324.

Lead 178 of coil 170 of the associated clutch 148 is connected to the single contact of relay 308, and lead 196 of coil 190 of the associated clutch 150 is connected to the relay-deenergized contact of element 322. The relay-deenergized contact of element 314 and the relay-energized contact of element 322 are insulated from the switching means circuit.

Double leaf switching element 326 of switch 302 comprises an upper leaf 328 and a lower leaf 330. Leaves 328 and 330 comprise superposed substantially L-shaped members, the upstanding legs of which are affixed to each other and the lower legs of which are independently movable. The lower leg of leaf 330 is pivotally connected to the associated cam follower 294, so that the lower legs of leaves 328 and 330 may be raised and lowered in response to the movement of the follower.

When cam follower 294 is in contact with a low pattern projection 288, lower leaf 330 engages contact 306 and upper leaf 328 disengages contact 304 (FIG. 9). When switch 302 is in this state, relay 312 is energized and relay 308 is deenergized so that no current is provided at leads 178 and 196 for energizing coils 170 and 190 of clutches 148 and 150. Thus, when follower 294 is in

contact with a low pattern projection 288, shaft 140 of the associated yarn feed module 138 is driven by over-running clutch 146 at a relatively low rotational velocity, and the associated feed rolls 210 and 212 feed a relatively short length of yarn to the associated needle 30, so that a low pile loop is formed during the ensuing pile loop-forming cycle of the needle.

When cam follower 294 is in contact with an intermediate pattern projection 290, upper leaf 328 is raised sufficiently to spring upwardly into engagement with contact 304, however, the upward movement of the leaves is insufficient to disengage lower leaf 330 from contact 306 (FIG. 10). When switch 302 is in this state, both relays 308 and 312 are energized so that direct current is provided at leads 176 and 178 of coil 170 of clutch 148 resulting in the engagement of this clutch, while clutch 150 remains disengaged. Thus, when follower 294 is in contact with an intermediate pattern projection 290, shaft 140 of the associated yarn feed module 138 is driven by magnetic clutch 148 at an intermediate rotational velocity overrunning clutch 146, and the associated feed rolls 210 and 212 feed an intermediate length of yarn to the associated needle 30, so that a minimum pile loop is formed during the ensuing pile loop-forming cycle of the needle.

When cam follower 294 is in contact with a high pattern projection 292, lower leaf 330 is raised sufficiently to disengage contact 306, however, upper leaf 328 remains engaged with contact 304 (FIG. 11). When switch 302 is in this state, both of relays 308 and 312 are deenergized so that direct current is provided at leads 196 and 198 of coil 190 of clutch 150 resulting in the engagement of this clutch, while clutch 148 remains disengaged. Thus, when follower 294 is in contact with a high pattern projection 292, shaft 140 of the associated yarn feed module 138 is driven by magnetic clutch 150 at a relatively high rotational velocity overrunning clutch 146, and the associated feed rolls 210 and 212 feed a relatively long length of yarn to the associated needle 30, so that a high pile loop is formed during the ensuing pile loop-forming cycle of the needle.

Since cam shaft 286 is rotated by a cyclical stepping mechanism just prior to the completion of each needle cycle, there is no need to employ a disabling means, such as cam 262, in the second embodiment of the control means to ensure that the yarn feed rate may be changed only within a particular period during each cycle.

A third embodiment of the control means and the switching means is shown in FIG. 12, including a switching means 282', which is identical to switching means 282, and a control means 332. Control means 332 includes two or more pattern chains 334 which are trained about rotatable sprockets 336, only one of the chains and an associated sprocket being shown in the drawings. Chains 334 are disposed in parallel relationship and have a plurality of relatively long bars 338 affixed to the lugs thereof. Mounted on bars 338 are a plurality of tracks of a plurality of upstanding pattern lugs 340, 342 and 344; lugs 342 extending outwardly from the bars further than lugs 340, and lugs 344 extending outwardly from the bars further than lugs 342. Each chain 334 thus comprises the movable element of control means 332 and lugs 40, 342 and 344 comprise the pattern-defining means thereof.

A separate track of pattern lugs is provided for each switching means 282' and associated yarn feed module 138. Also, each lug corresponds to one pile loop-forming cycle of needles 30.

The pattern lugs 340, 342 and 344 of each track are contacted by a plunger 294' which functions similarly to cam follower 294 of control means 280 and which comprises the sensing means of control means 332. Sprockets 336 are rotated just prior to the completion of each needle stroke by a cyclical stepping mechanism (not shown) similar to the mechanism employed for rotating cam shaft 286 of control means 280 so that each plunger 294' cy-

clically contacts the pattern lugs of the associated track. Also similarly to control means 280, the stepping mechanism obviates the need for control means 332 to include a switching means disabling means.

As will be apparent from this description, when plunger 294' is in contact with a low pattern lug 340, the associated yarn feed module 138 feeds a relatively short length of yarn to the associated needle 30, so that a low pile loop is formed by the needle during the ensuing cycle; when plunger 294' is in contact with an intermediate pattern lug 342, the associated yarn feed module 138 feeds an intermediate length of yarn to the associated needle 30, so that a medium pile loop is formed by the needle during the ensuing cycle; and when plunger 294' is in contact with a high pattern lug 344, the associated yarn feed module 138 feeds a relatively long length of yarn to the associated needle 30, so that a high pile loop is formed by the needle during the ensuing cycle.

The various control means and switching means embodiments particularly described above are representative of the many such devices that may be employed in the yarn feeding mechanism of the invention. For example, the control means may comprise magnetic or perforated tape, or punchcard reading devices.

Also, the yarn feed modules, instead of employing two magnetic clutches, may employ one or three or more such clutches, depending upon the variations in pile loop height desired. Should the yarn feed modules employ more or less than two magnetic clutches, it will be appreciated that the central drive units employed in conjunction therewith would include either two or more than three concentric shafts for rotating the driving components of over-running clutch 146 and the desired number of magnetic clutches.

In addition, it will be appreciated that the yarn feeding mechanism of the invention is operationally flexible and may be employed advantageously in the production of single height pile loop fabrics as well as multiple height pile loop fabrics.

While the foregoing constitutes a detailed description of the preferred embodiments of the invention, it is appreciated that various modifications thereof will occur to those skilled in the art. Therefore, the scope of the invention is to be limited solely by the scope of the appended claims.

I claim:

1. A yarn feeding mechanism for a pile loop-forming machine, said mechanism comprising:

a central drive unit including a plurality of independently rotatable concentric shafts;

a plurality of yarn feed modules circumferentially spaced about said drive unit in contiguous relationship thereto, each said module comprising, a rotatable yarn feed drive shaft, a plurality of selectively engageable clutches mounted on said drive shaft, means drivingly connecting said concentric shafts to said clutches for rotating the clutches, yarn feed means, and means drivingly connecting said drive shaft to said feed means for operating the feed means;

power transmission means connected to said drive unit for driving said concentric shafts to rotate said clutches at different rotational velocities, said clutches being operable to selectively rotate said drive shaft at said different velocities, and said feed means being operable to feed different lengths of yarn when said drive shaft is selectively rotated by different ones of said clutches; and

means for selectively engaging said clutches.

2. A yarn feeding mechanism for a pile loop-forming machine, said mechanism comprising:

yarn feed drive means;

a plurality of yarn feed modules each comprising, a rotatable yarn feed drive shaft, an overrunning clutch mounted on said drive shaft, means driving-

ly connecting said drive means to said overrunning clutch for rotating the overrunning clutch at a first rotational velocity, said overrunning clutch being operable to rotate said drive shaft at said first velocity and being overrun by said drive shaft when the drive shaft is rotated at a rotational velocity greater than said first velocity, at least one selectively engageable magnetic clutch mounted on said drive shaft, means drivingly connecting said drive means to said magnetic clutch for rotating the magnetic clutch at a second rotational velocity greater than said first velocity, said magnetic clutch being operable when engaged to rotate said drive shaft at said second velocity so that the drive shaft overruns said overrunning clutch, yarn feed means, and means drivingly connecting said drive shaft to said feed means for operating the feed means, said feed means being operable to feed a first length of yarn when said drive shaft is rotated by said overrunning clutch and a second length of yarn longer than said first length when said drive shaft is rotated by said magnetic clutch; and

means for selectively engaging said magnetic clutch.

3. A mechanism as recited in claim 2; wherein said yarn feed drive means comprises, a central drive unit including a plurality of independently rotatable concentric shafts and power transmission means connected to said drive unit for rotating said concentric shafts; and wherein said yarn feed modules are positioned about said drive unit; and wherein said means drivingly connecting said drive means to said overrunning clutch comprises means drivingly connecting one of said concentric shafts to the overrunning clutch and said means drivingly connecting said drive means to said magnetic clutch comprises means drivingly connecting another of said concentric shafts to the magnetic clutch.

4. A mechanism as recited in claim 2, wherein said means for selectively engaging said magnetic clutch comprises, switching means operatively connected to the magnetic clutch for changing the energization state thereof, and control means operatively connected to said switching means for controlling the state of the switching means and thereby controlling the energization state of the magnetic clutch.

5. A mechanism as recited in claim 4, wherein said control means comprises, a movable element having pattern-defining means thereon and means for sensing said pattern-defining means said sensing means being operatively connected to said switching means for controlling the state of the switching means and thereby controlling the energization state of said magnetic clutch in response to said pattern-defining means.

6. A mechanism as recited in claim 5, wherein said element is an endless member, said pattern-defining means are areas of different relative transparency on said member, and said sensing means comprises a light source disposed on one side of said member and a light-sensitive cell disposed on the other side of said member in opposing relationship to said source, said cell being operatively connected to said switching means for controlling the energization state of said magnetic clutch in response to the amount of light transmitted through said member.

7. A mechanism as recited in claim 6, wherein said machine operates cyclically; and wherein said control means further includes disabling means for preventing the control means from changing the state of said switching means except within a selected period during each cycle of operation of said machine so that the energization state of said magnetic clutch may be changed only within said period.

8. A mechanism as recited in claim 5, wherein said element is a cam, said pattern-defining means are peripheral projections on said cam, and said sensing means is a cam follower contacting said projections and opera-

tively connected to said switching means for controlling the energization state of said magnetic clutch in response to movement of said follower.

9. A mechanism as recited in claim 5, wherein said element is a chain, said pattern-defining means are upstanding lugs connected to said chain, and said sensing means is a plunger contacting said lugs and operatively connected to said switching means for controlling the energization state of said magnetic clutch in response to movement of said plunger.

10. A mechanism as recited in claim 3, wherein said overrunning clutch comprises, a driven component disposed about said drive shaft and lockable thereto, and a driving component disposed concentrically about said driven component, said driving component being engageable with said driven component for locking the driven component to said drive shaft for rotating the drive shaft at said first velocity and rotatable relative to said driven component when the drive shaft is rotated at a rotational velocity greater than said first velocity; and wherein said means drivingly connecting said one concentric shaft to said overrunning clutch comprises a gear affixed to said one concentric shaft and a gear affixed to said driving component, said concentric shaft gear being drivingly meshed with said driving component gear.

11. A mechanism as recited in claim 3, wherein said magnetic clutch comprises a driven component affixed to said drive shaft and a driving component journaled on said drive shaft, said driving component being engageable with said driven component for rotating said drive shaft at said second velocity; and wherein said means drivingly connecting said other concentric shaft to said magnetic clutch comprises a gear affixed to said other concentric shaft and a gear affixed to said driving component, said concentric shaft gear being drivingly meshed with said driving component gear.

12. A mechanism as recited in claim 3; wherein said means drivingly connecting said one concentric shaft to said overrunning clutch comprises a first gear affixed to said one concentric shaft and a second gear affixed to said overrunning clutch, said first gear being drivingly meshed with said second gear; and wherein said means drivingly connecting said other concentric shaft to said magnetic clutch comprises a third gear affixed to said other concentric shaft and a fourth gear affixed to said magnetic clutch, said third gear being drivingly meshed with said fourth gear.

13. A mechanism as recited in claim 3, wherein said yarn feed means comprises a pair of rotatable yarn feed rolls.

14. A mechanism as recited in claim 13, wherein said means drivingly connecting said drive shaft to said yarn feed means comprises a gear affixed to said drive shaft, a first rotatable feed roll shaft having one of said feed rolls and a first feed roll gear affixed thereto, and a second rotatable feed roll shaft having the other of said feed rolls and a second feed roll gear affixed thereto, said drive shaft gear being drivingly meshed with said first feed roll gear and said first feed roll gear being drivingly meshed with said second feed roll gear so that the feed rolls are rotated in opposite directions.

15. A mechanism as recited in claim 14, wherein said first and second feed roll gears are of equal diameter so that said feed rolls are rotated at the same rotational velocity.

16. A mechanism as recited in claim 3, wherein four of said yarn feed modules are positioned about said central drive unit.

17. A mechanism as recited in claim 2, wherein said drive module includes a plurality of said selectively engageable magnetic clutches, and means drivingly connecting said drive means to said magnetic clutches for rotating the magnetic clutches at different rotational velocities greater than said first velocity, said magnetic

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clutches being operable to selectively rotate said drive shaft at said different velocities.

18. A yarn feeding mechanism as recited in claim 1, wherein said means drivingly connecting said concentric shafts to said clutches comprises first gears affixed respectively to each of said concentric shafts and second gears affixed respectively to each of said clutches, said first gears being drivingly meshed with said second gears.

19. A yarn feeding mechanism as defined in claim 1 and a plurality of cyclically operable pile loop formers operatively associated therewith for receiving yarn therefrom.

20. A yarn feeding mechanism as defined in claim 2 and a plurality of cyclically operable pile loop formers operatively associated therewith for receiving yarn therefrom.

21. A yarn feeding mechanism as defined in claim 3 and a plurality of cyclically operable pile loop formers operatively associated therewith for receiving yarn therefrom.

22. Apparatus as defined in claim 21 wherein only one cyclically operable pile loop former is operatively con-

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nected to receive yarn from a yarn feed module of said yarn feeding mechanism.

23. Apparatus as defined in claim 21 wherein each of said pile loop formers is a needle.

24. Apparatus as defined in claim 23 wherein said apparatus is a tufting machine.

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