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Davidson

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[54] **ELECTRO-MECHANICAL ACTUATOR**

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[52] **U.S. Cl.** ..... **112/158 E;** 112/221; 318/467; 318/567

[51] **Int. Cl.** **D05b 3/02**

[58] **Field of Search** ..... 112/158 E, 158 R, 65, 220, 112/221; 318/467, 468, 567, 600, 267

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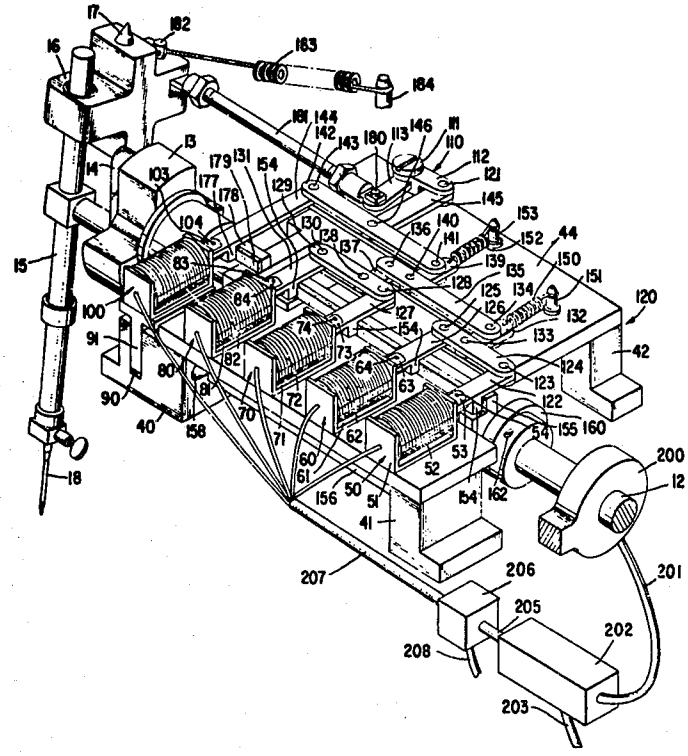
Attorney, Agent, or Firm—Robert E. Smith; Edward L. Bell

[57] **ABSTRACT**

A device responsive to electrical control signals for influencing the operation of sewing machine stitch forming instrumentalities to produce predetermined stitch patterns. The device includes a whippletree adder mechanism of which the input arms are selectively influenced by solenoids responsive to the electrical control signals. A mechanical drive is provided from the sewing machine actuating mechanism effective during each stitch for shifting each input arm of the whippletree adder into fully actuated position, in which position the solenoids are selectively energized.

5 Claims, 4 Drawing Figures



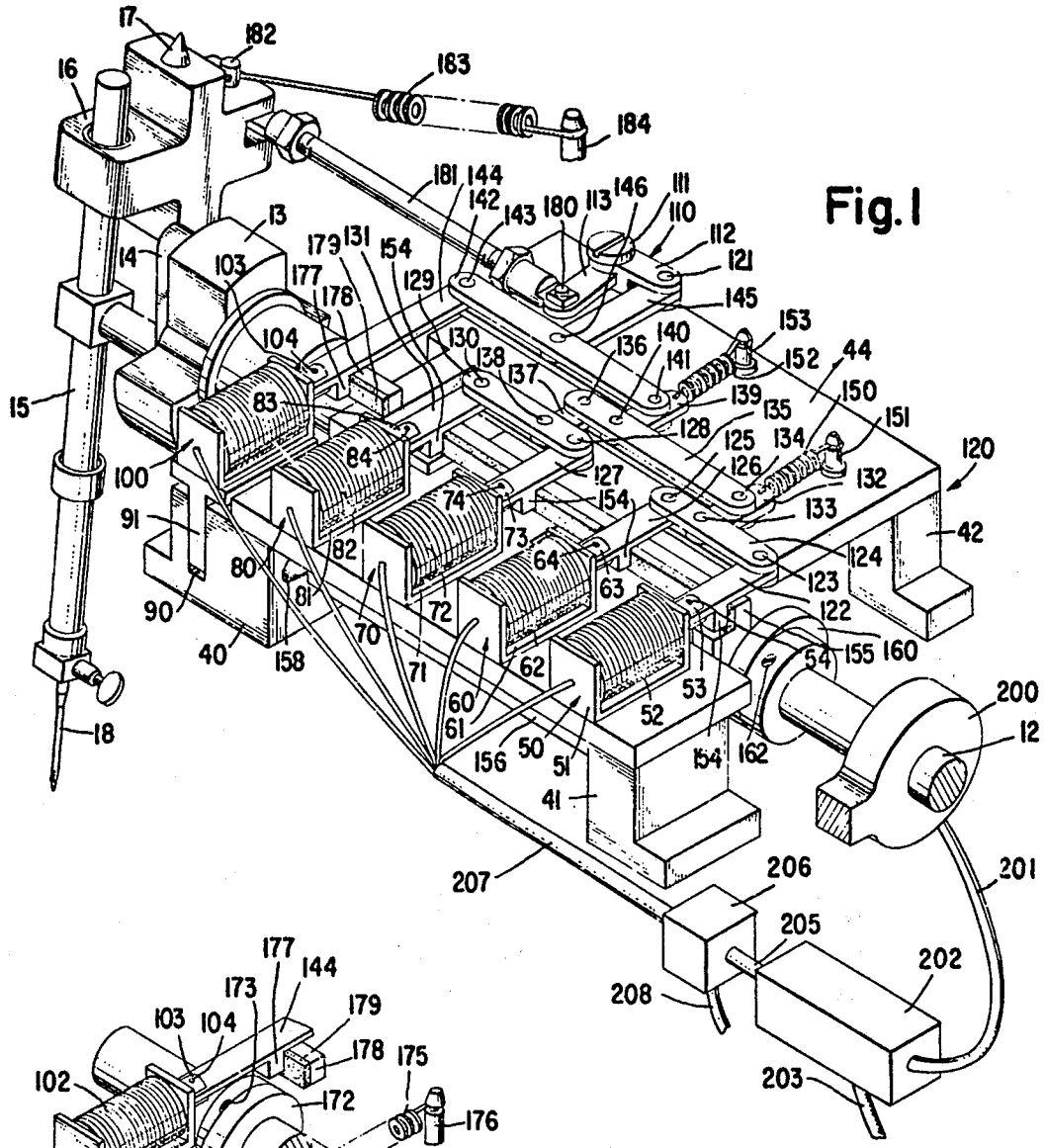

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Fig.1

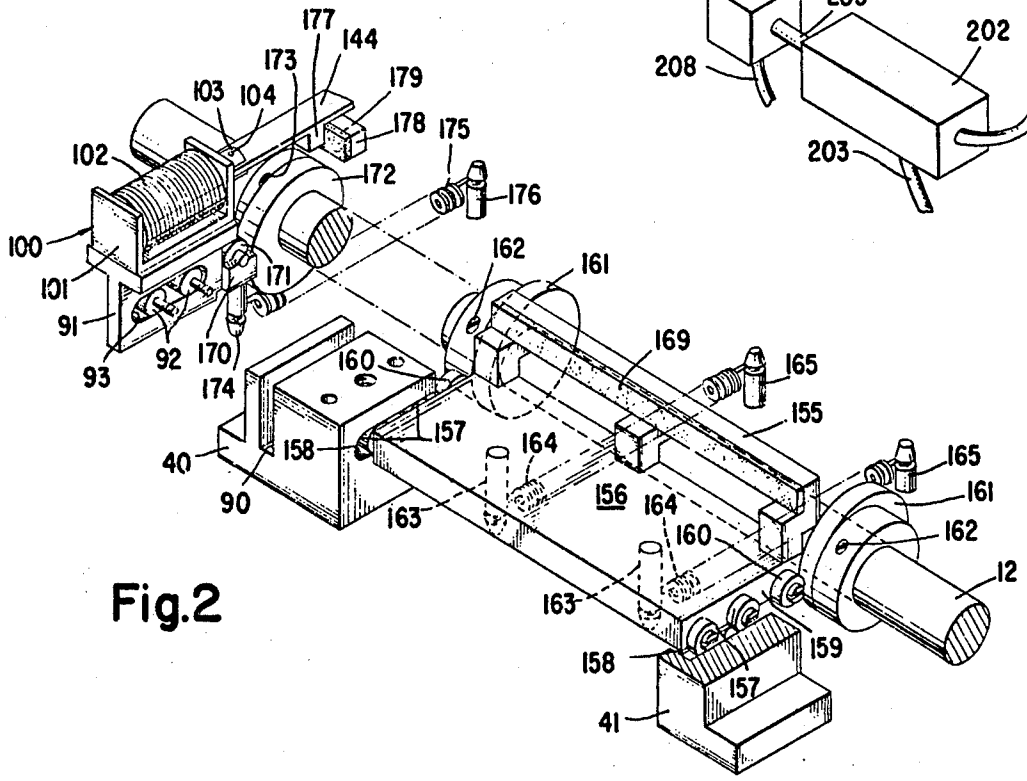
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Fig.2

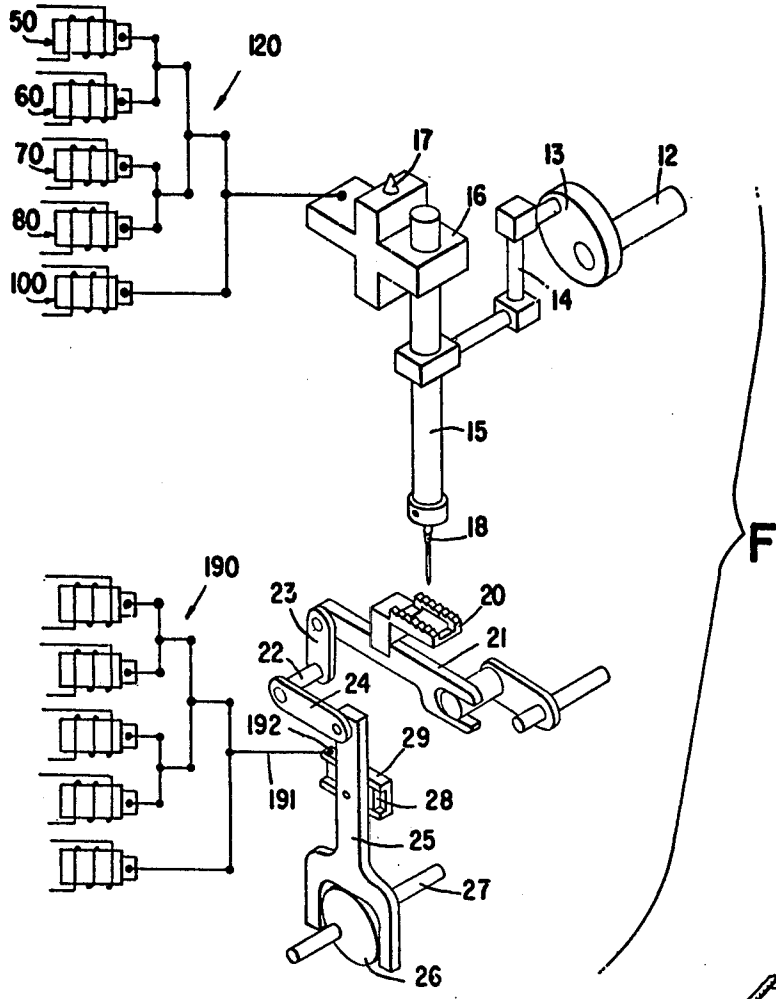
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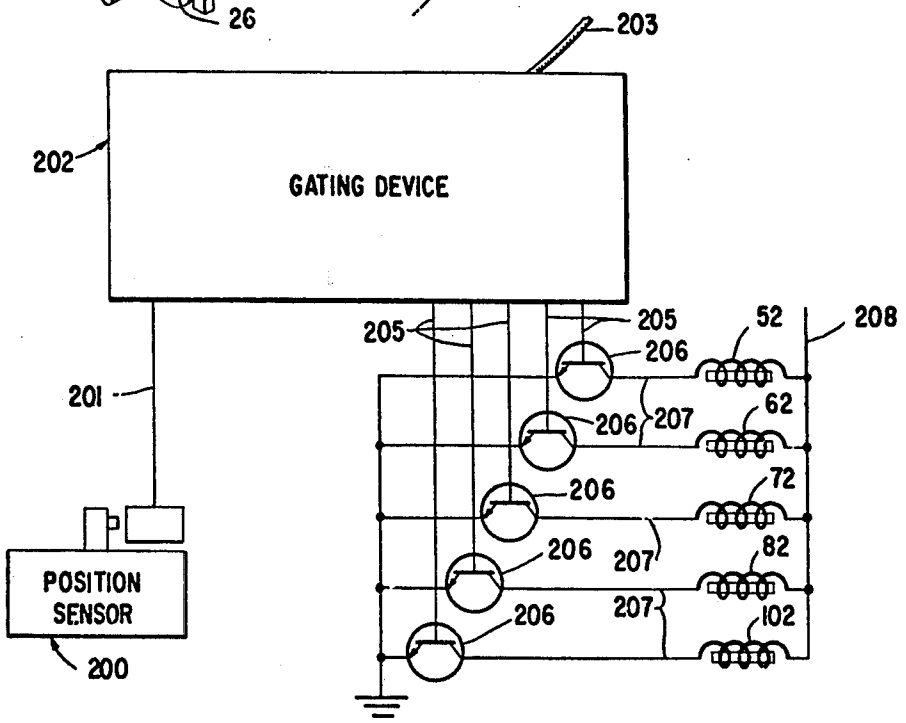
Fig. 3


203
202
GATING DEVICE
201
POSITION SENSOR
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205
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52
62
72
82
102
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Fig. 4

ELECTRO-MECHANICAL ACTUATOR

BACKGROUND OF THE INVENTION

In a prior whippletree adder mechanisms for controlling formation of patterns of stitches by a sewing machine, the solenoids for influencing the input arms of the whippletree adder are required to drive the input arms from a retracted to a fully actuated position. As a result very large solenoids were required, power consumption was high, and the noise and vibrations incident to said powerful solenoid operation was excessive.

In addition the prior whippletree adder arrangement provided incremental control in only one direction and between stitches returned the related stitch forming instrumentality to an extreme position in the opposite direction. As a result, appreciable motion of the regulated stitch forming instrumentality was occasioned which not only slowed the response time of the mechanism but consumed excessive power.

BRIEF SUMMARY OF THE INVENTION

It is an object of the present invention to provide a whippletree adder mechanism for producing pattern stitching in a sewing machine utilizing solenoids of minimum size and power for influencing whippletree adder input arms. This object of the invention is attained by the provision of a mechanical drive operated by the sewing machine mechanism during each stitch for shifting the whippletree input arms into fully actuated position and then selectively actuating the solenoids so that they need only retain the input arm in fully actuated position. As a result, solenoids with less power and size may be used and noise and vibration are minimized.

Another object of this invention is to minimize the movement of the whippletree adder mechanism incident to its return to relaxed position of the whippletree input arms between each successive control selection. This object of the invention is obtained by an arrangement of lever arms in the whippletree adder mechanism such that all but one input arm contributes to incremental movement in one direction from a central position and only one input arm determines in which direction from the central position the other input arms will operate.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a portion of a sewing machine showing a whippletree adder mechanism of this invention applied thereto to influence the position of lateral needle vibration in the production of zigzag stitches.

FIG. **2**, is a perspective view of a fragment of a whippletree adder mechanism of FIG. **1** with portions cut away to illustrate the cooperation of parts,

FIG. **3**, is a diagramatic representation of the whippletree lever arm arrangement as applied to both the needle jogging and work feeding mechanism of a sewing machine, and

FIG. **4** is a block diagram of the control circuit means for supplying electrical control signals to the solenoids influencing the input arms of the whippletree adder of this invention.

As illustrated in FIGS. **1** and **2**, **12** is a rotary drive shaft which forms a part of the sewing machine actuating mechanism. A crank **13**, is driven by the drive shaft **12** and acts by way of a drive link **14** to impart endwise reciprocation to a needle carrying bar **15** which is endwise moveable in a gate **16** pivoted at **17** in the sewing machine frame. The needle bar **15** carries a needle **18** which partakes of the endwise movement of the needle bar for work penetration and partakes of the jogging movement of the gate **16** for lateral shifting movements to produce zigzag stitches.

The parts described above are also indicated diagrammatically in FIG. **3**.

Not included in FIGS. **1** and **2** but shown diagrammatically in FIG. **3** is a typical work feeding mechanism for a sewing machine comprising a feed dog **20** carried beneath the work by a feed bar **21** and adapted alternately to rise into engagement with and transport the work and between each work transport stroke to drop beneath the work and partake of a return movment. A feed rock shaft **22** connected by a rock arm **23** to the feed bar serves for imparting work transporting movement thereto and is connected by a rock arm **24** to a pitman **25** bifurcated to embrace a constant breadth cam **26** fast on a feed drive shaft **27**. A slide block **28** pivotably secured on the pitman **25** is constrained in a slotted guide block **29** of which the angular position determines the direction and magnitude of transport of the work feed dog, in a manner well known in the art.

It will be appreciated that the angular position which the needle bar gate **16** occupies during work penetration by the needle will determine the lateral placement of each stitch, and therefore, the pattern in which zigzag stitches are formed. Likewise, the angular position of feed regulating guide block **29** during each feed transport stroke of the feed dog will determine the direction and magnitude of work feed between successive needle penetrations.

In the present invention separate whippletree adder mechanisms are employed one for influencing the zigzag pattern and the other for the work feed. The whippletree adder mechanism for zigzag patterning is illustrated in detail in FIGS. **1** and **2**, and it will be understood that the adder mechanism for the feed may follow the same construction, or if desired the arrangement may be modified better to tailor the output to the specific needs of the feed regulating system.

Carried on support blocks **40, 41, 42,** and secured in the machine frame is a flat horizontal platform **44** on which four linear solenoids **50, 60, 70,** and **80** are fastened. Each of these solenoids are alike and may be of conventional construction including a support frame **51, 61, 71** and **81,** respectively, in which a cylindrical field coil **52, 62, 72,** and **82** is carried and through which an armature rod **53, 63, 73,** and **83** is axially shiftable. The operation of each of the solenoids is such that when the field coil is not electrically actuated, the armature rod is free to move axially relative thereto, but when the field coil is excited, the armature arm will be urged magnetically toward a particular position which may be called a fully seated position relatively to the field coil and the support frame.

The frame support block **40** is formed with an upwardly open guide slot **90** in which a T-shaped slider **91** is constrained. For anti-friction considerations a pair of rollers **92** may be journaled in this block **40** and located in the guide slot **90** and within an elongate aperture **93** in the T-shaped slider **91**. A solenoid **100** is secured atop the T-shaped slider any may be construed in exactly the same fashion as the solenoids **50, 60, 70** and

80; that is, it includes a support frame 101, a cylindrical field coil 102, and armature rod 103.

At the opposite side of the platform 44 from the solenoids 50, 60, 70 and 80 a bell crank lever 110 is pivotably supported on a shouldered fulcrum screw 111. The bell crank lever 110 is formed with diverging arms 112 and 113. A whippletree linkage indicated generally at 120 is supported by a pivotal connection 121 with one arm 112 of the bell crank 110 and is also supported by pivotal connections 54, 64, 74, 84 and 104 with the armature rods 53, 63, 73, 83 and 103, respectively.

In general, the whippletree linkage 120 is arranged such that the solenoids 50, 60, 70 and 80 have a total possible accumulated affect which is substantially equal to the effect which can be exerted by the solenoid 100. The whippletree linkage is arranged, therefor, so that the solenoids 50, 60, 70 and 80 determine the magnitude of shift from a central position and the solenoid 100 determines the direction from the central position toward which the shift influenced by the other solenoids will occur.

Specifically, the whippletree linkage 120 comprises a link 122 connected by the pivot 54 to the armature rod 53 which is connected by a pivot pin 123 to one end of a set of integrating levers 124. The integrating levers 124 are connected by a pivot pin 125 to a link 126 connected by a pivot 64 to the armature 63. Similarly a link 127 which is connected by the pivot 74 to the armature rod 73 is connected by a pivot pin 128 to one end of a set of integrating levers 129 which are connected by a pivot pin 130 with a link 131 connected by a pivot pin 84 to the armature rod 83.

A connecting link 132 which is secured by a pivot pin 133 to the integrating levers 124, is connected by a pivot pin 134 to one end of a set of integrating levers 135. At the other end the integrating levers 135 are connected by a pivot pin 136 to a connecting link 137 which is secured by a pivot pin 138 to the integrating lever 129.

A connecting link 139 which is secured by a pivot pin 140 to the integrating levers 135 is connected by a pivot pin 141 to one end of a set of integrating levers 142. The other end of the integrating levers 142 is connected by a pivot pin 143 to a link 144 which is connected by the pivot 104 to the armature rod 103 of the solenoid 100.

A final connecting link 145 is secured at one end by a pivot pin 146 to the integrating levers 142 and at the other end is secured to the ball crank lever arm 112 by the pivotal connection 121.

As shown in FIG. 1, a tension spring 150 extends between the connecting link 132 and an anchor pin 151 secured in the platform 44. Similarly a tension spring 152 extends between the connecting link 139 and an anchor pin 153 secured in the platform 44. These springs 150 and 152 bias each of the armature rods 53, 63, 73, and 83 to the right as viewed in FIG. 1 out of fully seated position relatively to the solenoids 50, 60, 70 and 80 respectively.

Also as shown in FIG. 1, each of the links 122, 126, 127 and 131 connected respectively to the armature rods 53, 63, 73 and 83 is formed with a depending abutment lug 154. Each of the abutment lugs 154 is adapted to engage an abutment bar 155 which extends upwardly from a plate 156 that is slidably constrained to move horizontal beneath the platform 44. Preferably the plate 156 carries at each side a pair of rollers 157 which ride in guide channels 158 formed in the support blocks 40 and 41. The plate 156 is also formed at each side with an extension 159 carrying a follower roller 160. Each of the follower rollers 160 is adapted to track a cam 161 which is made fast, as by a set screw 162, to the drive shaft 12. Retaining pins 163 depending from the plate 156 accommodate tension springs 164 which are supported on anchor pins 165 in the machine frame and serve to bias the plate 156 toward the drive shaft 12 to maintain the follower rollers 160 in engagement with the cams 161.

The cams 161 are each formed with a rise of approximately 73° timed on the shaft 12 to shift the abutment bar 155 to the left, as viewed in FIG. 1, carrying each of the solenoid armature rods 53, 63, 73 and 83 into fully seated position during each needle up stroke out of work penetrating position. Since the sewing machine actuating mechanism drives each of the solenoids 50, 60, 70, and 80 into fully seated or interlocked relative position automatically prior to the selection of needle jogged position preceeding each stitch, solenoids 50, 60, 70 and 80 when actuated need only hold the armature in this fully seated position, that is, the solenoids 50, 60, 70 and 80 are never called upon to draw their respective armature rods from relaxed position into fully seated position. The solenoids 50, 60, 70 and 80, therefore, may be greatly reduced in size and power from that value which would be required if the solenoids were expected to perform the total work of whippletree adder input arm positioning. It has also been found to be expedient to attach a cushioning pad 169 to the abutment bar 155 further to reduce noise incident to the operation of this mechanism.

The cams 161 are formed with a small dwe;ll of approximately 14° at the top of the rise and it is while this small dwell is effective on the follower rollers 160 that the solenoids 50, 60, 70 and 80 may be selectively energized and deenergized without influencing appreciable movement of the respective armatures. The cams 161 are then each formed with a descending segment of approximately 73° and with a dwell of approximately 200° extending to the base of the rise.

The solenoid 100 is treated in a different fashion than the treatment accorded to the solenoids 50, 60, 70 and 80. The T-shaped slider 91 to which the solenoid 100 is secured is formed with an extension 170 which carries a follower roller 171 that tracks a cam 172 which may be formed in the same manner as cam 161 and is secured, as by a set screw 173, on the drive shaft 12 of the sewing machine. The extension 170 also carries a pin 174 engaging a tension spring 175 which is secured to an anchor pin 176 carried by the machine frame 11. The tension spring 175 maintains the follower rollers 171 in contact with the cam 172 which thus serves to carry the solenoid supporting frame 101 and the field coil 102 thereon relatively to the armature rod 103 so that it is by movement of the field coil that the fully seated position of the armature rod 103 is accomplished in the case of the solenoid 100 rather than by movement of the armature rod as in the case with respect to the solenoids 50, 60, 70 and 80. This treatment of the solenoid 100 also has the effect that the link 144 is not physically shifted to a retracted position between successive stitches but remains stationary except in the case in which the field coil 102 of the solenoid 100 is energized after the cam 172 shifts the coil so that the armature rod occupies fully seated position.

In this case, the cam **172** will mechanically drive the locked solenoid **100** into a position shifted to the left, as viewed in FIG. **1**, away from the drive shaft **12**. An abutment lug **177** is formed on the link **144** for engagement with a stop **178** on the machine frame to limit the movement of the link **144** to the right as viewed in FIG. **2**, and a cushioning pad **179** may be attached to the stop **178** to reduce noise.

With respect to solenoid **100**, therefore, it is the cam **172** on the drive shaft **12** which mechanically drives the whippletree link **144** and not the operation of the solenoid **100**. The solenoid **100** in the construction described above simply is required to lock the armature rod **103** in the fully seated or interlocked relative position in which the armature rod is shifted by the eccentric **172**.

The lever arm **113** of the bell crank **110** is connected by a pivot pin **180** to a connecting rod **181** which is pivotably connected in turn as at **182** to the needle bar gate **16** so as to transmit the accumulated pattern information derived from the whippletree linkage **120** to the needle bar gate for use in patterning the zigzag stitch operation of the sewing machine. A return spring **183** extending between the pivot **182** on the needle bar gate and an anchor pin **184** on the machine frame biases the needle bar gate in opposition to the movements imparted by the whippletree linkage.

Referring to FIG. **3** it will be noted that a whippletree linkage **190** for the feed regulation is indicated which is arranged in a fashion very similar to that previously described for the zigzag pattern control, although as mentioned above, the whippletree linkage **190** may be modified better to suit the requirements of the feed regulating system. The final connecting link **191** of the whippletree linkage for the control of the work feed operation may be connected directly by the pivotal connection **192** to the feed regulation guide block **29**, or if required any suitable linkage may be interposed therebetween in order to obtain the required motion relationship between the whippletree linkage and the regulator block.

The timing of the cams **161** and **172** on the drive shaft **12** with respect to the needle reciprocation is important in the operation of this whippletree adder mechanism. The cams **161** must be positioned on the drive shaft **12** in timed relation with the needle reciprocating crank **13** such that the plate **156** and the abutment bar **155** associated therewith will be shifted to the left as viewed in FIGS. **1** and **2** by the cams **161** during that increment of movement of the drive shaft **12** in which the needle is reciprocated endwise upwardly out of the work and into its uppermost position of reciprocation. The timing of the cam **172** on the drive shaft **12** must be such that the T-shaped slider **91** and the solenoid support frame **101** and field coil **102** are shifted into the right hand position as viewed in FIGS. **1** and **2** during the increment of turning movement of shaft **12** in which the needle is raised from the work into its uppermost position. In this position in which the needle is in its uppermost position and the mechanism of the sewing machine has mechanically shifted the solenoid coils and armature rods into fully seated position that the solenoids must be selectively actuated. Thereafter as the cams **161** and **172** continue to turn the mechanism for mechanically shifting the solenoids into fully seated position is retracted and those of the solenoids which have been energized will retain their armature rods in fully seated position while those of the solenoids which have not had their field coils excited will have no influence and their respective armature rods will be free to shift axially relatively to their field coils and exert no influence on the accumulated output of the whippletree linkage.

In the case of the whippletree linkage **190** for the work feed regulation, the cams corresponding to the cam **161** and **172** of the zigzag controlling actuator must be timed substantially 180° out of phase relatively to the cams **161** and **172** since the active work feed stroke takes place while the needle is elevated out of the work.

For supplying control signals to the solenoids **50, 60,** 70, 80 and **100** to operate the whippletree adder mechanism for providing a preselected pattern, any arrangement may be utilized which is capable of impressing selective electrical actuation for the various solenoids during successive needle reciprocations.

The block diagram of FIG. **4** illustrates the components of a simple form of system for selectively energizing the actuators of this invention.

Indicated at **200** is a sewing machine drive shaft position sensor which is effective to provide a signal pulse in the conductor **201** during each increment of turning, for instance, of the drive shaft **12** at a time when selective actuation or deactuation of the solenoids **50, 60,** 70, 80 and **100** is appropriate.

The conductor **201** delivers such synchronizing pulses to a gating device **202** into which electrical signals for regulating the pattern of stitching are delivered as through a wiring harness **203** from any suitable source of pattern information such as punched or magnetic cards, tape, or the like. Preferably the electrical signals gated by the device **202** flow in selected ones of the conductors **205** leading to current amplifiers, such as transistors **206**, located each in a circuit **207** connecting one of the field coils **52, 62, 72, 82,** and **102** across an appropriate source **208** of electrical energy.

Having set forth the nature of this invention, what is claimed herein is:

1. In a sewing machine having a frame, stitch-forming instrumentalities in said frame, and actuating mechanism for imparting stitch-forming movement of said stitch-forming instrumentalities, control linkage in said sewing machine frame operatively associated with said stitch-forming instrumentalities for selectively influencing the production of a variety of patterns of stitches, an electromagnetic locking device comprising a field coil element and an armature element, said elements being free to shift relatively to each other in one predetermined direction when said field coil element is not electrically actuated, and said elements being urged magnetically toward an interlocked relative position when said field coil element is electrically actuated, means for interconnecting said control linkage to one of said electromagnetic locking device elements, means for supporting the other of said electromagnetic locking device elements relatively to said sewing machine frame, mechanism driven in timed relation with said sewing machine actuating mechanism for vibrating one of said electromagnetic device elements in said predetermined direction into and out of said interlocked relative position, and means for selectively energizing said field coil element electrically during each vibration of said electromagnetic device elements into said interlocked relative position.

2. A sewing machine having a frame, stitch-forming instrumentalities in said frame, actuating mechanism in said frame for said stitch-forming instrumentalities, and a control device for defining a predetermined pattern in the relative position of successive stitches formed by said stitch-forming instrumentalities, said control device comprising a series of electromagnets, means for selectively transmitting electricity of said electromagnets, a whippletree linkage having an output arm operatively associated with said stitch-forming instrumentalities and including a series of input arms, each input arm arranged to assume alternatively one of two extreme positions, relatively to one of said electromagnets, one of said extreme positions being a fully seated position toward which said input arm will be urged when said electromagnet is energized, and mechanical drive means operated in timed relationship with said sewing machine actuating mechanism for alternately shifting said associated electromagnets and input arms relatively to each other into and out of said fully seated position, and means for selectively transmitting electricity to said electromagnets after shift of said associated electromagnets and input arms into said fully seated position by said mechanical drive means.

3. In a sewing machine having a frame, stitch-forming instrumentalities in said frame, and actuating mechanism for imparting stitch-forming movements to said stitch-forming instrumentalies, an electromagnetic locking device including a solenoid element and an armature element telescopically arranged within said solenoid element, said elements being interrelated so as to be urged telescopically toward predetermined relative position upon application of electrical acutation to said solenoid element, control linkage in said sewing machine frame operatively associated with said stitch-forming instrumentalities, means for interconnecting said control linkage to one of said electromagnetic locking device elements, means for supporting the other of said electromagnetic locking device elements relatively to said sewing machine frame, mechanism driven by said sewing machine actuating mechanism for mechanically vibrating said electro-mechanical locking device elements telescopically into and out of said predetermined relative position, and means for selectively applying electrical actuation to said solenoid element when said elements are mechanically vibrated into said predetermined position.

4. In a sewing machine as set forth in claim 3 in which said means for interconnecting said control linkage to one of said electromagnetic locking device elements comprises a pivotal connection of said control linkage to said armature element, in which said solenoid element is fixed relatively to said sewing machine frame, and in which said means for selectively applying electrical actuation of said solenoid element is effective when said armature element is vibrated mechanically by said driven mechanism into a telescoped locked position with respect to said solenoid element.

5. In a sewing machine as set forth in claim 3 in which said means for interconnecting said control linkage to one of said electromagnetic locking device elements comprises a pivot pin interconnecting said control element with said armature element, in which said mechanism driven by said sewing machine actuating mechanism for mechanically vibrating said electromagnetic locking device element telescopically into and out of said predetermined relative position comprises mechanism for shifting said solenoid element relatively to said sewing machine frame and relatively to said armature element.

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