

[54] APPARATUS FOR SEAMING PIECES OF TEXTILE FABRIC OR THE LIKE

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[22] Filed: Aug. 3, 1973

[21] Appl. No.: 385,349

[52] U.S. Cl. 112/121.11, 112/212, 226/32, 226/115, 250/548

[51] Int. Cl. D05b 19/00

[58] Field of Search . 112/212, 213, 121.11, 121.12, 112/208, 209, 121.27, 132, 134, 118, 86, 90, 102; 226/32, 115; 250/548

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[57] ABSTRACT

An improvement in apparatus for joining together two pieces of material such as textile fabric. The apparatus comprises means for seaming the two pieces together and means for feeding the two pieces through the seaming means comprising a first feed device for one of said pieces and a second feed device for the other. The improvement comprises means for sensing an out-of-registration condition of trailing ends of the two pieces fed through the seaming means; means for varying the relative speed of the two feed devices; and means responsive to the sensing means for controlling the speed-varying means to bring the trailing ends of the pieces substantially into registration.

27 Claims, 10 Drawing Figures

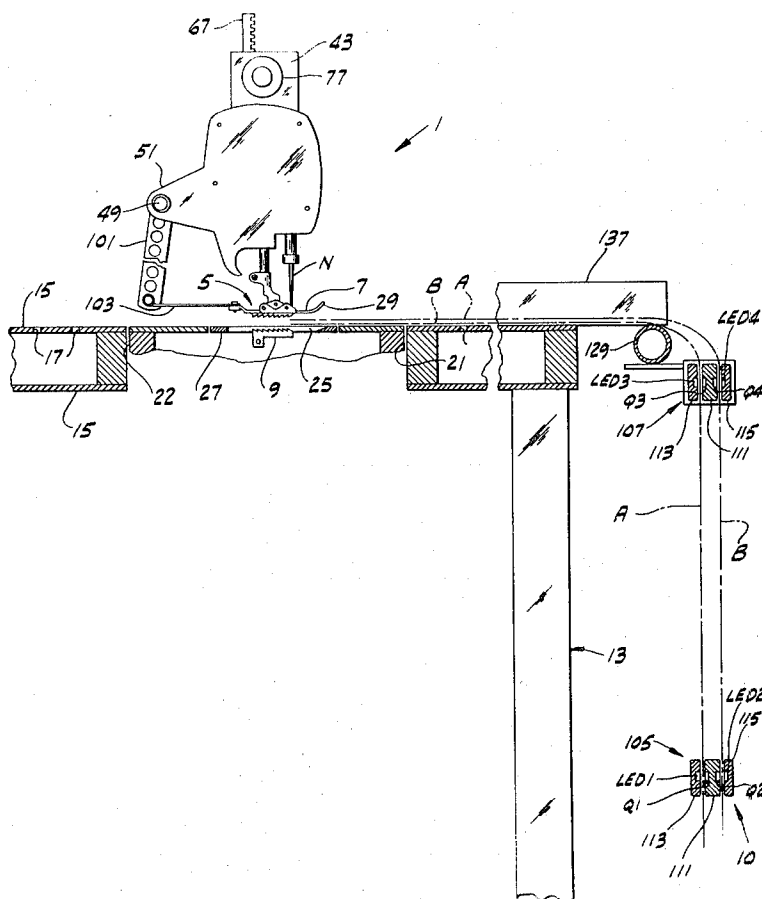


FIG. 1

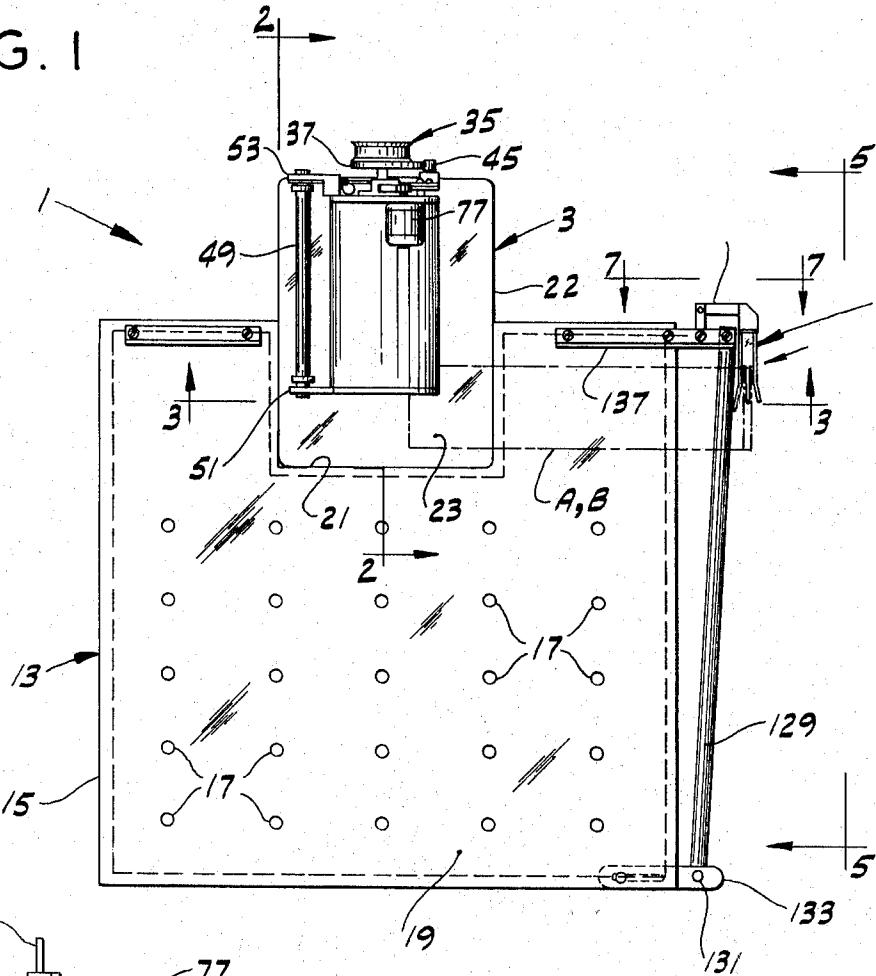


FIG. 2

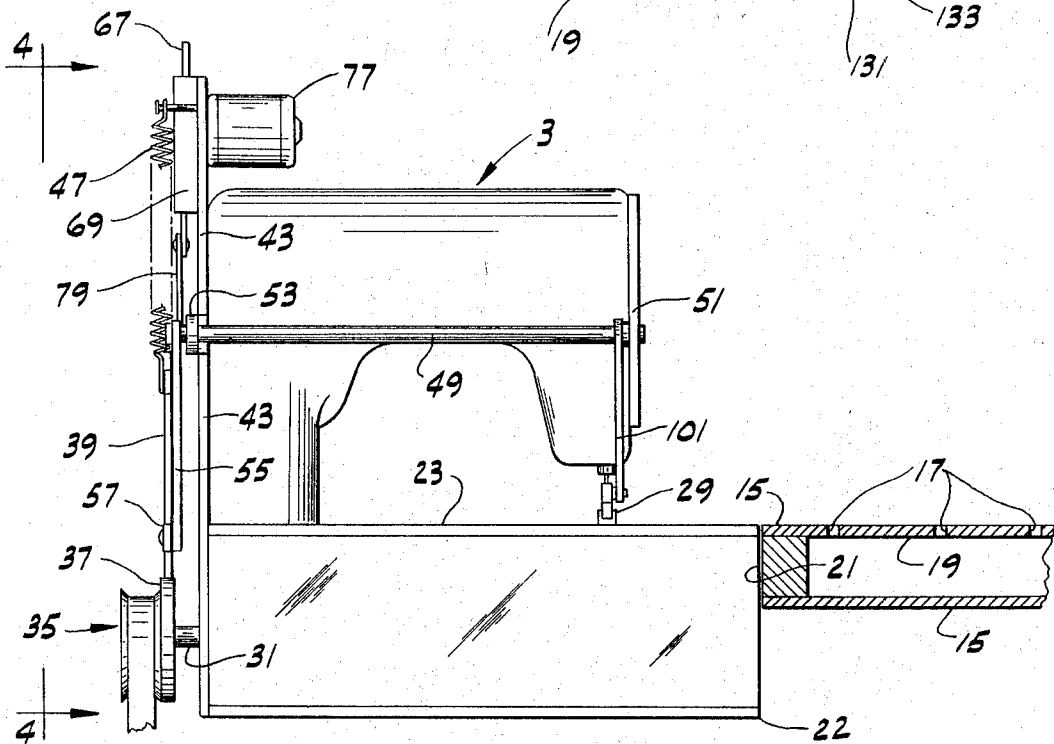


FIG. 5

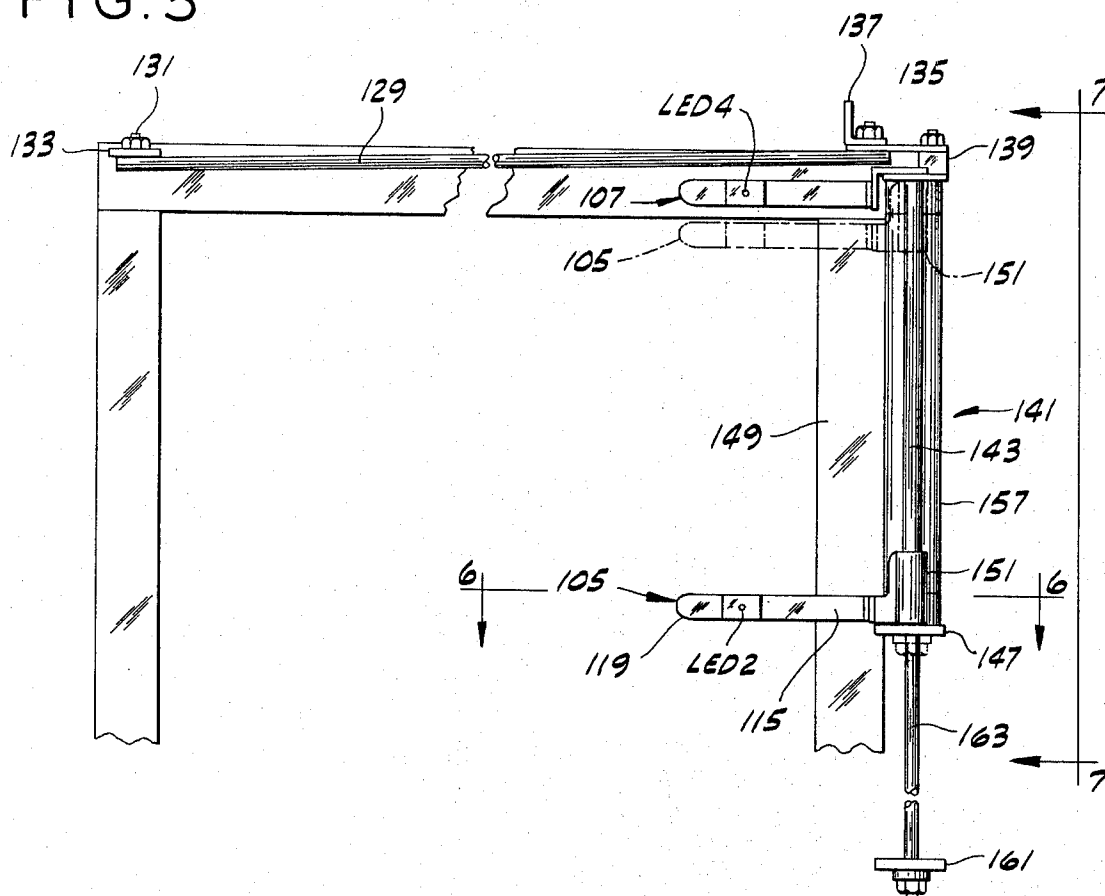


FIG. 6

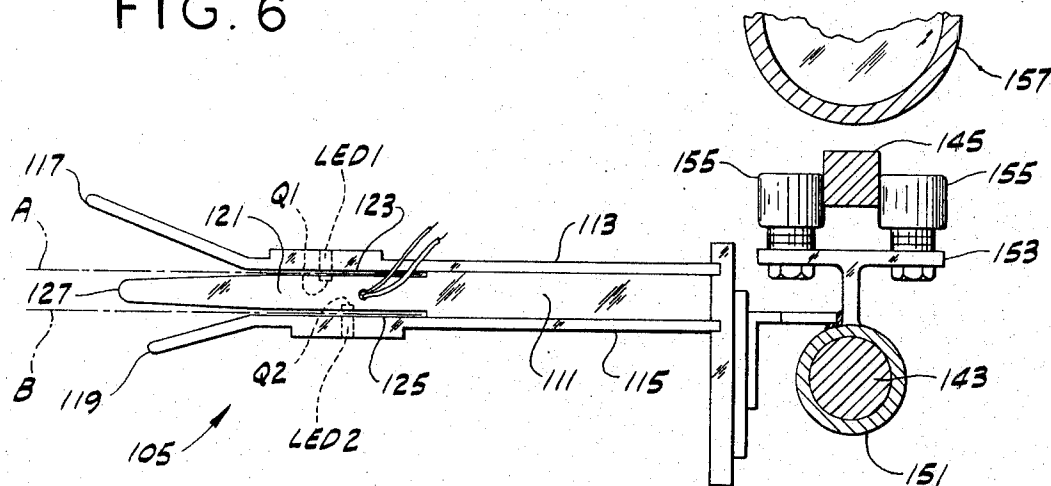


FIG. 7

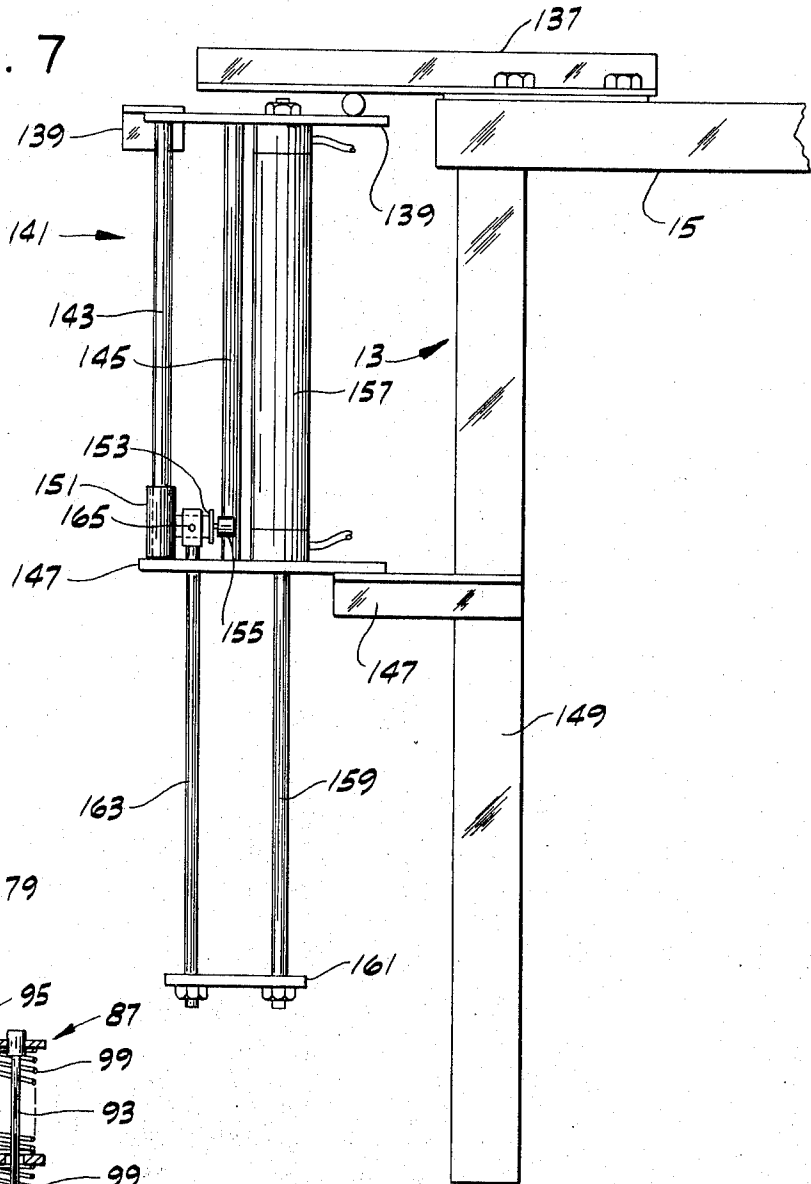
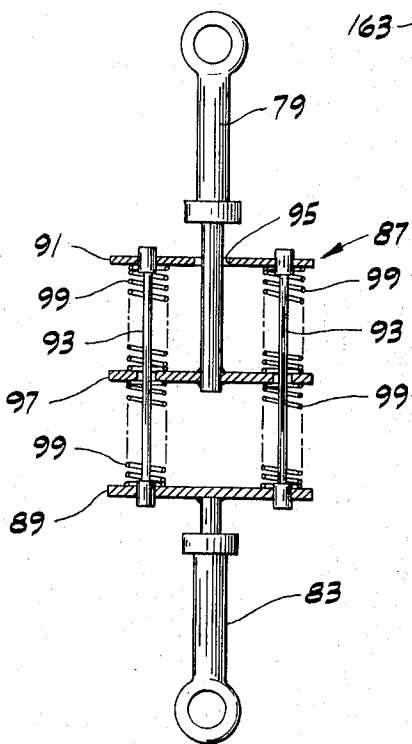


FIG. 8



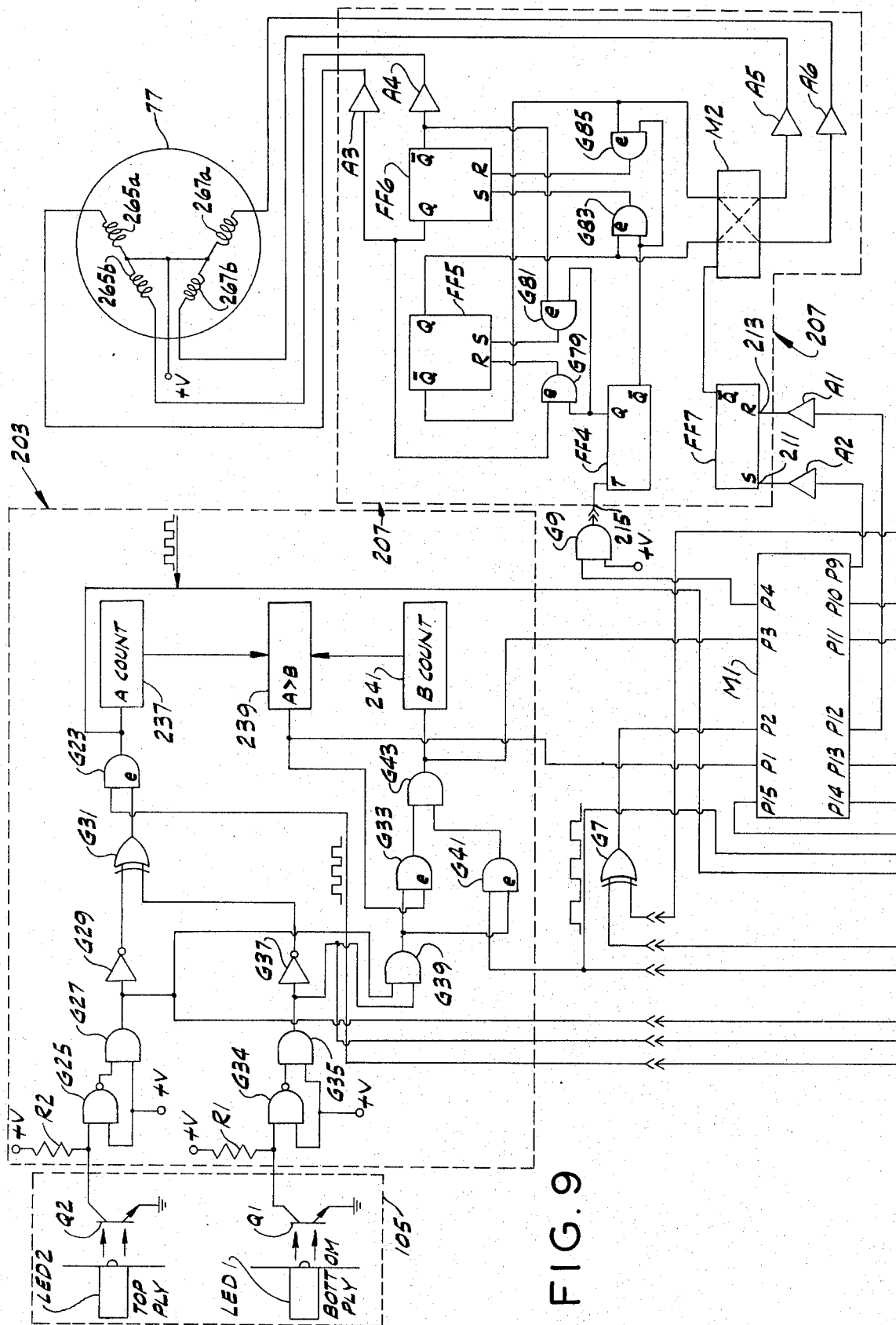
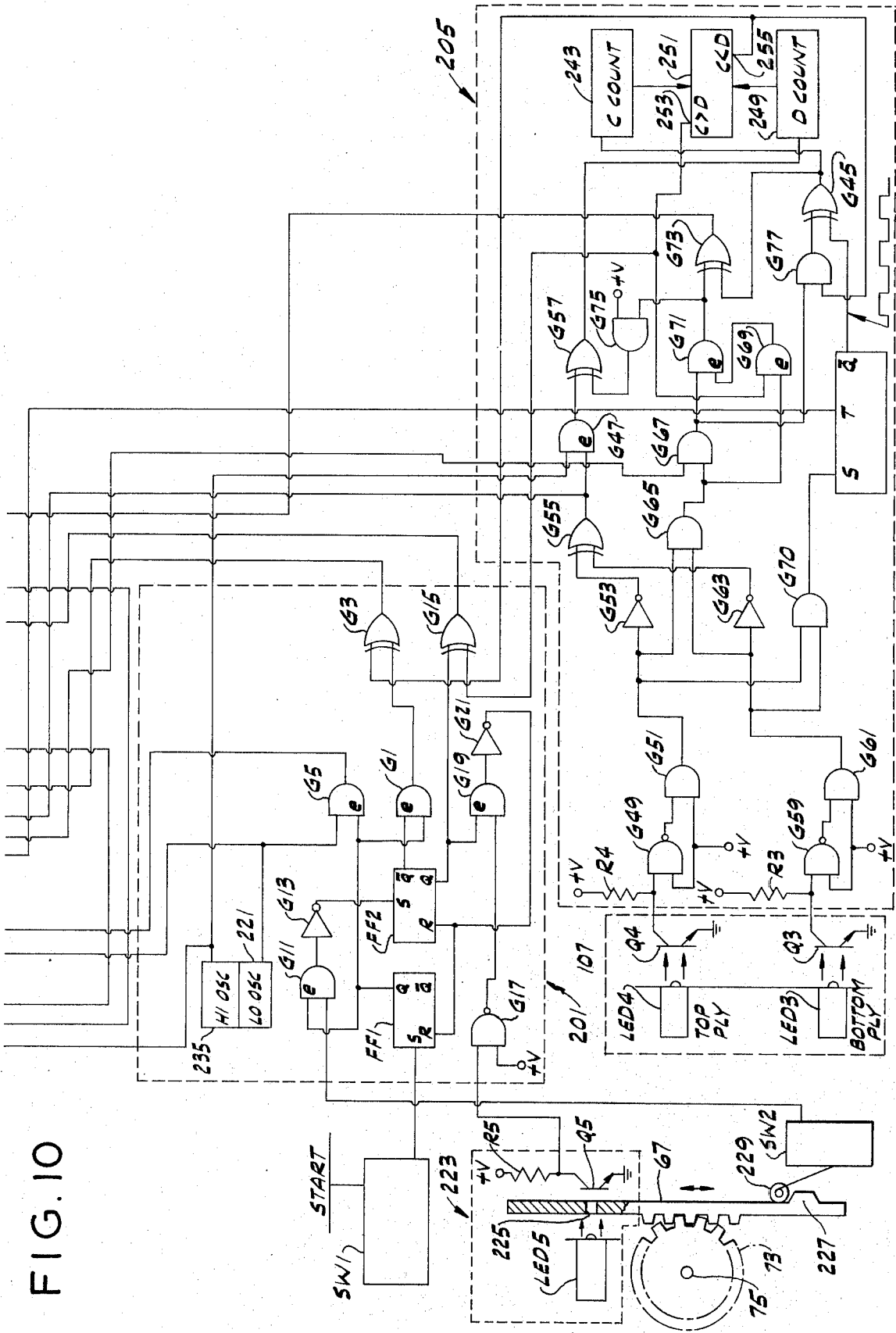


FIG. 9

FIG. 10



APPARATUS FOR SEWING PIECES OF TEXTILE FABRIC OR THE LIKE

BACKGROUND OF THE INVENTION

This invention relates to apparatus for seaming pieces of textile fabric or the like, and more particularly to apparatus for automatically sewing such work-pieces together with their ends matching.

In many sewing operations in which two pieces of material are stitched together, it is necessary to make the start and finish ends of the two pieces sew out even and match, even though the pieces may be of unequal length as received from the cutting department, and even though there may be a tendency, in normal sewing operations in which the material is fed through the sewing machine by a feed dog from underneath, for the bottom piece of material to overfeed in relation to the top piece. In manual operations, the operator may effect the requisite seam end equalization by starting the sewing operation with the starting ends of the two pieces matched, sewing a short distance, stopping, matching the finished ends of the two pieces and holding them between her fingers with some tension while she guides and finishes sewing the seam. What this amounts to is that the operator is compelling the two pieces to feed at the same rate or with a shorter piece stretched slightly to match the longer piece. In automated sewing operations, however, there has been a problem of providing for seam end equalization.

SUMMARY OF THE INVENTION

Among the several objects of this invention may be noted the provision of automatic seam end equalizing means for apparatus for joining together two pieces of material; the provision of such means for automatic sewing apparatus, the provision of such means which is accurate and reliable in operation; and the provision of such means which does not complicate the introduction of the pieces of material to the sewing machine of the apparatus.

In general, apparatus of this invention involves means for joining together two pieces of material such as textile fabric, the apparatus comprising means for seaming the two pieces together and means for feeding the two pieces through the seaming means comprising a first feed device for one of said pieces and a second feed device for the other, with means for sensing an out-of-registration condition of the trailing ends of the two pieces fed through the seaming means, means for varying the relative speed of the two feed devices, and means responsive to the sensing means for controlling the speed-varying means to bring the trailing ends of the pieces substantially into registration.

Other objects and features will be in part apparent and in part pointed out hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan of apparatus embodying this invention;

FIG. 2 is an enlarged vertical section taken generally on line 2—2 of FIG. 1;

FIG. 3 is an enlarged vertical section taken generally on line 3—3 of FIG. 1;

FIG. 4 is a view in elevation on line 4—4 of FIG. 2;

FIG. 5 is a view in elevation on line 5—5 of FIG. 1 on a larger scale than FIG. 1;

FIG. 6 is an enlarged horizontal section taken generally on line 6—6 of FIG. 5;

FIG. 7 is a partial side elevation taken on line 7—7 of FIGS. 1 and 5;

FIG. 8 is an enlarged fragment of FIG. 4 showing details of a resilient coupling; and

FIGS. 9 and 10 together constitute a schematic circuit diagram of the present invention.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, first more particularly to FIGS. 1 and 3, there is generally indicated at 1 apparatus of this invention for joining together two pieces of material A and B such as textile fabric. The apparatus generally comprises means indicated at 3 for seaming the two pieces together, more particularly a sewing machine, having means indicated generally at 5 for feeding the two pieces or "plies" of material A and B there-through. The feeding means comprises a first feed device 7 for one of the pieces (the bottom piece A, as illustrated) and a second feed device 9 for the other (the top piece B, as illustrated). The apparatus further comprises means indicated generally at 10 for sensing an out-of-registration condition of the two pieces A and B, e.g., an out-of-registration condition or "mismatch" of the trailing end of one of said pieces relative to the trailing end of the other piece, as they are fed through the seaming means (the sewing machine), and means indicated generally at 11 controlled by the sensing means for varying the relative speed of the two feed devices 7 and 9 to correct the out-of-registration condition.

More particularly, the apparatus 1 comprises a sewing table 13 over the top of 15 of which plies A and B are fed through the sewing machine. The table top 15 is of the air flotation type, having perforations 17 in its top plate 19 through which air blows out upwardly for "floating" the work (i.e., plies A and B). The table has a cutout 21 in one side and the bed 22 of sewing machine 3 extends into this cutout with the bed plate 23 of the machine flush with the top of the table. The sewing machine is of a commercially available type, such as a Union Special Machine Company Style 56300AK, having the two feed devices 7 and 9 incorporated therein, as to which the first (or lower) feed device 7 (for the bottom piece A) is in the bed of the machine, comprising a so-called feed dog working in slots such as indicated at 25 in FIG. 3 in the so-called throat plate 27 of the machine, and the second (or upper) feed device 9 (for the top piece B) comprises a feed dog working in the presser foot 29 of the machine. As will be understood by those skilled in the art, the lower feed dog 7 is movable forwardly in a raised position through a feed stroke for feeding the lower piece A forward, then rearwardly in a lowered position through a return stroke without feeding the lower piece A rearwardly, by mechanism in the bed of the machine. The upper feed dog 9 (or presser foot feed dog as it may sometimes be called) is similarly movable forwardly in a lowered position through a feed stroke for feeding the upper piece B forward, then rearwardly in a raised position through a return stroke without feeding the upper piece rearwardly, by the variable-speed drive indicated

in its entirety by the reference numeral 11 (see FIG. 4). The needle of the sewing machine is indicated at N. The apparatus may be provided with an edge contour guidance system for the plies A and B of the type shown in the coassigned Conner U.S. Pat. No. 3,636,898. The variable speed drive 11 has as its input the main shaft 31 of the sewing machine which, as illustrated, is driven by an electric motor 33 via a belt and pulley drive 35 (see FIG. 4). A cam 37 constituted by a circular disk is eccentrically mounted on the shaft 31 at the back end of the sewing machine 3 (the end away from the needle). At 39 is indicated a cam follower lever pivoted at 41 on a plate 43 at the back end of the sewing machine 3. The lever 39 has a cam follower roller 45 at its lower end biased into engagement with the cam 37 by a spring 47, the arrangement being such that the lever 39 is swung about its pivot 41 back and forth through a stroke (the arcuate extent of which is determined by the eccentricity of the cam 37) on each revolution of the shaft 31, which means that it is swung through a stroke for each stitch taken by the needle N. A rock shaft 49 is journaled for oscillation on a horizontal axis extending endwise of the sewing machine at one side of the sewing machine in front and rear bearings 51 and 53. A crank 55 secured to this shaft adjacent its back end has its lower end linked to the lever 39 by an adjustable link 57, with a pin and slot connection between the link 57 and the lever 39 comprising a slot 59 in lever 39 and a pin 61 on the link 37 movable up and down in the slot. At its end opposite the pin 61, the link has a pivot pin connection 63 with the lower end of the crank.

The means 11 controlled by the sensing means 10 comprises means generally designated 65 for swinging the link 57 up and down to vary the position of pin 61 in slot 59, thereby to vary the throw of the crank 55 and hence the degree of the oscillation of the rock shaft 49. In this regard, it will be observed that as the pin 61 is moved closer to the pivot 41, the stroke of the pin and hence the throw of the crank 55 is reduced, and as the pin 61 is moved farther from the pivot 41, the stroke of the pin and hence the throw of the crank 55 is increased. Means 65 for varying the position of the link comprises a rack 67 vertically slidable in a guide 69 on the back of plate 43, with a resilient coupling 71 between the lower end of the rack and the link 57. The rack is movable up and down by a pinion 73 in mesh with the rack, the pinion being mounted on the output shaft 75 of a stepping motor 77 mounted on the front of plate 53 with shaft 75 extending through a hole in the plate.

The resilient coupling 71 (see FIG. 8) comprises an upper link 79 pinned at its upper end as indicated at 81 to the lower end of the rack and a lower link 83 pinned at its lower end as indicated at 85 to the link 57. The lower link has a cage 87 secured to its upper end, this cage comprising a lower plate 89 secured to the upper end of the link 85, and an upper plate 91 secured on the upper ends of bars 93 extending up from the lower plate 89. The upper link 79 extends down through a hole 95 in the upper plate, and has a plate 97 on its lower end slidable on the bars 93. Coil compression springs 99 are interposed between plate 97 and 91 and between plates 89 and 97 providing for resilient interconnection between the upper and lower links, functioning to isolate the stepping motor 77 from shock

such as may be transmitted to the lower link 83 by link 57.

An arm 101 extends down from shaft 49 adjacent the front end of the sewing machine, and has its lower end connected to the upper feed dog 9 by a link 103 constituted by a length of relatively thin, flexible steel strip. The arrangement is such that, with motor 33 in operation driving the shaft 31 of the sewing machine 3, lever 39 is oscillated by the cam 37, its throw being determined by the eccentricity of the cam. As the lever 39 oscillates, it oscillates crank 55 and shaft 49 via the link 57, with the degree of oscillation of the crank 55 and shaft 49 dependent upon the angle of the link 57 (or upon the position of pin 61 in slot 59). The angle of the link (or the position of pin 61 in slot 59) is determined by the position of the rack 67, which is moved up or down by the stepping motor 77 to decrease or increase the degree of oscillation of the shaft 49. The arm 101 on shaft 49 acts to reciprocate the upper feed dog 9, with the stroke of the feed dog 9 dependent upon the degree of oscillation of the shaft 49, i.e., the greater the degree of oscillation of shaft 49, the greater the stroke (for each revolution of shaft 31) of the dog 9, and vice versa. Thus, stepping motor 77, when energized to rotate the pinion 73 in the direction to drive the rack 67 up, acts to decrease the stroke (or speed) of the upper feed dog 9, and when energized to rotate the pinion 73 in the direction to drive the rack down, acts to increase the stroke (or speed) of the upper feed dog.

The means 10 for sensing an out-of-registration condition of plies A and B, and more particularly a mismatch of their trailing ends, comprises two sensor units 105 and 107. The first sensor unit 105 has an operative position at a first sensing station spaced upstream from the needle N of the sewing machine a distance measured along the path of travel of plies A and B corresponding generally to the length of the plies, and more particularly slightly greater than the length of the plies. Unit 105 is shown in its said operative position at said sensing station in solid lines in FIG. 3 and in phantom in FIG. 5. The second sensor unit 107 is fixed in position at a second sensing station spaced upstream from the sewing machine generally half said distance. The two sensing units are generally identical, each comprising a three-tined fork designated in its entirety by the reference numeral 109, and made up of a center bar 111 flanked by outside bars 113 and 115 which have outer ends 117 and 119 flaring away from the outer end portion of the center bars. The latter is reduced in thickness as indicated at 121 to provide slots 123 and 125 for receiving the margins of plies A and B and tapered as indicated at 127. Sensor unit 105 has means for sensing the passage of the trailing end of ply A through slot 123 and means for sensing the passage of the trailing end of ply B through slot 125. The first of these means comprises a light emitting diode LED1 mounted in an opening in bar 113 and a phototransistor Q1 mounted in a recess in center bar 111 opposite diode LED1. The second means similarly comprises a light emitting diode LED2 mounted in an opening in bar 115 and a phototransistor Q2 mounted in a recess in center bar 111 opposite diode LED2. Sensor unit 107 similarly has means comprising a light emitting diode LED3 and a phototransistor Q3 for sensing the passage of the trailing end of ply A through its slot 123 and means comprising a light emitting diode LED4 and

a phototransistor Q4 for sensing the passage of the trailing end of ply B through its slot 125.

At the rear end of the top 15 of table 13 (rear meaning upstream in relation to the direction of travel of the plies A and B toward the sewing machine) is a guide 129 for guiding plies A and B traveling upwardly at the rear of the table around onto the top of the table. This guide comprises a length of tubing pinned at one end as indicated at 131 to an adjustable bracket 133 extending rearwardly at the left rear corner of the table top (left as viewed in the direction of travel of the plies toward the sewing machine) and secured at its other end as indicated at 135 to an angle iron 137 (see FIGS. 1, 3, 5 and 7) extending rearwardly from the table top at its right rear corner. Guide 129 may be angled as shown in FIG. 1 relative to the rear edge of the table top. A bracket 139 secured to the angle iron carries the sensor unit 107 in fixed position at the aforesaid second sensing station located slightly to the rear of and below the guide 129 at the right rear corner of the table top with the unit 107 extending generally horizontally from the bracket generally parallel to the rearward edge of the table top, and with its slotted end toward the left (as viewed in FIG. 5).

The sensor unit 105 is mounted for vertical movement between its operative position at the stated first sensing station (in which it is shown in solid lines in FIG. 3 and in phantom in FIG. 5) and a raised position directly below and adjacent unit 107 by means generally designated 141 in FIGS. 5-7 for facilitating entry of plies A and B in the two sensor units as will appear. Means 141 comprises two rods 143 and 145 extending vertically between a lower bracket 147 extending rearwardly from the right rear table leg 149 and the bracket 139. The sensor unit 105 is carried by a tubular slide 151 slidable up and down on rod 143 extending generally horizontally parallel to sensor 107 below and in line with the latter. Unit 105 is maintained in line with unit 107 via a tee 153 on slide 151 carrying a pair of rollers 155 which ride on opposite sides of bar 145. An air cylinder 157 is provided for moving the sensor unit 105 up and down between its lowered sensing position and its raised ply-inserting position. This cylinder extends vertically between brackets 147 and 139 and has its piston rod 159 extending downwardly from its piston (not shown) through a hole in bracket 147 with a yoke 161 at the lower end of the piston rod and rod 163 extending up from the yoke through a hole in bracket 147 to a connection at 165 with the tee 153. The arrangement is such that on extending the piston rod 159 the unit 105 is moved down to its operative position, and on retracting the piston rod the unit 105 is raised to its ply-inserting position.

Unit 105, when raised, is directly below and adjacent unit 107 for simultaneous insertion of ply A in slots 123 and ply B in slots 125 of the two units. After insertion of the plies, unit 105 is lowered to its operative position of FIG. 3, wherein it functions to sense any mismatch of the trailing ends of plies A and B at the start of a sewing operation as they pass upwardly through unit 105. Thus, if the trailing end of ply A leads the trailing end of ply B, phototransistor Q1 is activated before phototransistor Q2, and vice versa. Sensor 107 functions to sense any mismatch of the trailing ends of plies A and B halfway through a sewing operation as the plies pass through unit 107. Thus, if the trailing end of ply A leads the trailing end of ply B at unit 107 (i.e., at the second

sensing station), phototransistor Q3 is activated before phototransistor Q4, and vice versa.

A schematic diagram of the circuitry employed in the present invention is shown in FIGS. 9 and 10. Most of the circuitry in FIGS. 9 and 10 may be conveniently divided into a rack centering section 201, a first measurement and adjustment section 203, a second measurement and adjustment section 205, a motor control section 207, and the d.c. stepping motor 77. The motor control section and the stepping motor comprise means for actuating variable-speed drive 11.

A motor control section has three inputs 211, 213 and 215. A "high" signal at input 211 will cause the motor control section to set the motor to rotate in a "forward" direction and a high signal at input 213 will cause the motor control section to set the motor to rotate in a "reverse" direction. Motor 77 does not begin to step until a proper time-varying voltage is supplied to input 215, at which time the motor will move one step in the predetermined direction for each cycle of the time-varying voltage.

To permit ease in understanding the remaining circuitry, the operation of motor control section 207 and d.c. stepping motor 77 will be explained at this point.

Stepping motor 77 is of the commercially available type having a plurality of windings (such as two windings), the rotor shaft of the motor being adapted to rotate with stepwise movements when the windings are energized with successive sequential changes in polarity, i.e., and as will be understood by those skilled in the art, a stepwise movement of the motor's shaft occurs when the polarity of a first one of the windings is reversed while maintaining the same polarization of the second winding. Then another stepwise movement in the same direction occurs by reversing the polarity of the second winding while maintaining the same polarization of the first winding, and so on. To change the direction of shaft rotation, the windings are energized with a reversed sequence of successive alternate changes in polarity, i.e., one of the two windings has its polarity reversed twice in succession without an intervening reversal of the polarity of the other winding.

Preferably, stepping motor 77 is of a so-called bifilar type having two windings each of two halves. That is, each winding has two sections or coils wound in opposite directions. Stepping motor 77 has a first winding with two coils or sections 265a, 265b and a second winding with sections 267a, 267b. Each half or section of a winding is adapted, when energized, to polarize the respective winding in one direction. The halves of each winding are alternately energized for alternately polarizing the winding.

Referring to motor control section 207, input 215 is connected to the toggle (or clock) input of a flip-flop FF4. The conventional power supply connections for this flip-flop, and for certain other portions of the circuitry, are not shown in order to simplify the drawings.

As is known to those in the electronics art, a flip-flop constitutes a bistable device having a pair of stable states. Such a device is adapted to be switched alternately from one state to the other. Flip-flop FF4 is known as a toggle-type flip-flop, i.e., when toggled, the flip-flop switches from a state in which one of its outputs Q or Q is high and the other "low" to a state in which the former is low and the latter is high. Another type of flip-flop (discussed below) is known as an S-R flip-flop. This type of flip-flop has S and R inputs and

Q and Q outputs. When a signal is present at the R input, the Q output is high and the Q output low. When a signal is applied to the S input, the flipflop changes its state so that the Q output is low and the Q output is high.

Further circuitry of motor control section 207 may logically be divided into a portion for causing motor 77 to step and a portion for setting the motor to rotate in either a forward or a reverse direction.

The portion of the circuitry for effecting stepping of the motor 77 includes the flip-flop FF4 which is toggled by each cycle of the time-varying voltage supplied through input 215. Interconnected with the outputs of flip-flop FF4 is a plurality of AND gates G79, G81, G83 and G85, each of which has a pair of inputs and a single output. The Q output of flip-flop FF4 is commonly connected to an input of G79 and an input of G81, while the Q output of FF4 is commonly connected to respective inputs of gates G83 and G85. The remaining inputs of G79, G81, G83 and G85, i.e., those not connected to the outputs of FF4, will be referred to as "enable" inputs and are indicated by *e*.

Interconnected with gates G79, G81, G83 and G85 are a pair of S-R type flip-flops FF5 and FF6 (note the discussion above of the R-S type of flip-flop). The respective outputs of AND gates G79 and G81 are connected to the R and S inputs of FF5, while the respective outputs of AND gates G83 and G85 are connected to the S and R inputs of FF6. The respective Q and Q outputs of flip-flops FF5 and FF6 are connected to the enable inputs of AND gates G83, G85, G79 and G81, respectively. Therefore, gates G79, G81, G83 and G85 are adapted to sense and be responsive to the state of energization of the respective output terminals of flip-flops FF5 and FF6.

The respective Q and Q outputs of flipflops FF5 and FF6 are also connected to a plurality of switching-type amplifiers (A5, A6, A3 and A4, respectively) to control switching of energization of respective winding sections (267b, 267a, 265a, 265b) of stepping motor 77.

When winding sections 265a and 267b are energized, then only AND gates G79 and G83 have their enable inputs *e* energized. Upon flip-flop FF4 being toggled to change state, its Q output goes high and its Q output goes low. AND gate G79 will then provide a high output to the R input of flip-flop FF5, causing it to switch states thereby energizing winding section 267a and enabling AND gate G85 while deenergizing winding section 267b and disabling AND gate G83. When flip-flop FF4 is next toggled, its Q output will be switched low and its Q output high. The output of AND gate G85 will provide a high output to the R input of flip-flop FF6, causing it to switch state thereby energizing winding section 265b and enabling AND gate G81 while deenergizing winding section 265a and AND gate G79.

The portion of the circuit for setting the motor to rotate shaft 75 in either a forward or a reverse direction includes a further S-R type flip-flop FF7 which has its S input connected to input 211, its R input connected to input 213, and its Q output connected to switching circuit MZ. Switching circuit MZ interconnects the outputs of flip-flops FF5 with motor winding sections 267a and 267b and is connected to the Q output of flip-flop FF7.

Switching circuit MZ is preferably a multiplexer of the integrated circuit type and effects internal switching each time flip-flop FF7 changes state so that the

connection of a respective input to a respective output is reversed. This section of the circuit, therefore, effects reversal of the polarity of one of the windings twice in succession without an intervening reversal of the polarity of the other winding thereby changing the direction of rotation of motor 77 in response to FF7 changing state.

The output shaft 75 of motor 77 rotates pinion 73 which drives rack 67. Rack 67 controls the stroke of the top feed dog 9 so that when shaft 75 is rotated in the "forward" direction the rack is driven down to increase the stroke of the top feed dog so the top ply B is driven at a faster rate. On the other hand, if shaft 75 is rotated in the "reverse" direction, the rack is driven up and decreases the stroke of the top feed dog so that the top ply is driven at a slower rate.

The circuitry functions first to bring the rack controlling the stroke of the top feed dog to a starting or null position so that both feed dogs will start feeding the plies at the same rate. It next functions to measure the difference in length of the two plies as they pass the first sensor unit 105 and to adjust the position of the rack to change the stroke of the top feed dog to compensate for the difference in length of the plies by the time the plies progress from the first sensor unit to the sewing machine 3. Finally the circuitry functions to measure the difference in length of the two plies as they pass the second sensor unit 107 located halfway between the first sensor unit and the sewing machine, to compare the distance measured at the second sensor unit with one-half the distance measured at the first sensor unit, and to readjust the position of the rack if required. The adjustment made in response to the measurement at the first sensor unit may be considered a relatively coarse adjustment while the adjustment associated with the second sensor unit may be considered a vernier adjustment.

In the operation of the apparatus, the operator positions plies A and B on the top 15 of the sewing table 3 with the leading ends of the plies generally matched (i.e., in registration) and located at the sewing machine and with the plies hanging down at the rear of the table around the guide 129. With the first sensor unit 105 in its raised position as indicated in phantom in FIG. 5, the operator inserts ply A in slot 123 of the second sensor unit 107 and in slot 123 of the raised first sensor unit 105, and inserts ply B in slot 125 of unit 107 and in slot 125 of unit 105. The positioning of sensor unit 105 in raised position directly underneath unit 107 facilitates the entry of the margins of the plies in the slots of the sensor units. The unit 105 is then lowered to its operative position (shown in solid lines in FIGS. 3 and 5) in which the trailing ends of the plies are somewhat upstream from (downwardly of) the sensor unit 105. This allows the centering section 201 to return the rack 67 to its starting position before a measurement of the difference in length of the two plies is made at the first sensor station.

Operation of the seam end equalizer then proceeds by actuation of a switch SW1 which energizes or applies a signal to the S input of a flip-flop FF1. The Q output of flip-flop FF1 is connected to input 213 of the motor control section through an AND gate G1, an EXCLUSIVE OR gate G3, a switching circuit M1, and an amplifier A1.

Switching circuit M1 is a monolithic digital multiplexer comprising four multiplexing circuits with com-

mon select (pin P1) and enable (pin P15) logic. The multiplexer is the logical implementation of a four-pole, two-position switch, with the position of the switch being set by the logic level supplied to the select input (P1). The respective inputs for the three multiplexing circuits used are P2 and P3, P10 and P11, and P13 and P14 while the respective outputs are P4, P9 and P12. With a low logic level signal at pin P1, pins P2 and P4, P11 and P9, and P14 and P12 are respectively interconnected. However, if a high signal is supplied at pin P1, the multiplexing circuits switch interconnecting pins P3 and P4, P10 and P9, and P13 and P12, respectively. A high signal at the enable pin P15 disables all outputs. The multiplexing circuit including pins P2, P3 and P4 is employed in providing a time-varying voltage required in driving motor 77 while two other multiplexing circuits, including pins P12, P13, P14 and P9, P10, P11, respectively, are used in setting motor control section 207 to drive the rack either up or down.

Upon actuation, switch SW1 provides a signal to the S input of flip-flop FF1, causing the Q output of FF1 to go high. This high signal is supplied to input 213 of the motor control section, causing motor 77 to be set to drive the rack up.

The high signal at the Q output of FF1 also enables an AND gate G5 to pass oscillations from a low-frequency oscillator 221 to input 215 of the motor control section through an EXCLUSIVE OR gate G7, multiplexer M1, and an AND gate G9. For each oscillation from oscillator 221, motor 77 will rotate one step in the reverse direction, driving rack 67 up.

Motor 77 will continue to drive the rack 67 up in a stepwise manner until either a sensor 223 detects passage of an aperture 225 in rack 67 or a cam surface 227 on the rack 67 strikes an actuating arm 229 of a switch SW2. Sensor 223 comprises a light emitting diode LED 5, a phototransistor Q5 and a resistor R5. The collector of transistor Q5 is connected to a positive voltage supply +V through resistor R1 while its emitter is grounded. The rack being detected blocks the light of LED 5 from impinging on transistor Q5, rendering Q5 nonconductive. When sensor 223 detects aperture 225, transistor Q5 becomes conductive, causing sensor 223 to provide a "low" output signal.

Assuming that the original position of the aperture 225 is above LED 5, the rack will continue moving up until cam surface 227 strikes actuating arm 229, indicating that the maximum upward travel of the rack has been reached. Upon actuation, SW2 provides a signal to the S input of a flip-flop FF2 through an AND gate G11 and a NOT gate G13, causing FF2 to change state so that its Q output provides a low signal which disables gate G1 and thereby causes the high signal from the Q output of FF1 to be removed from the input 213 of the motor control section. The Q output of flip-flop FF2 supplies a high signal to input 211 of the motor control section 207 through an EXCLUSIVE OR gate G15, multiplexer M1, and an amplifier A2 thereby causing motor 77 to reverse its direction of rotation. The Q output of flip-flop FF2 also enables an AND gate G19.

The rack will be driven down until aperture 225 falls into registration with sensor 223. When the rack is centered, sensor 223, connected to the R inputs of flip-flops FF1 and FF2 through a NAND gate G17, AND gate G19, and a NOT gate G21, provides a signal causing both flip-flops to change state thereby stopping

motor 77 and returning the centering section circuitry to a quiescent state.

As previously indicated, first sensor unit 105 includes a sensor comprising light emitting diode LED 1 and phototransistor Q1 for detecting passage of the trailing edge of the bottom ply A and a sensor comprising LED 2 and Q2 for detecting passage of the trailing edge of the top ply B. The emitters of Q1 and Q2 are grounded while their collectors are connected to +V through a resistor R1 and a resistor R2, respectively.

Assuming the top ply B to be the shorter, when it passes phototransistor Q2, the collector of which is connected to an AND gate G23 through a NAND gate G25, an AND gate G27, a NOT gate G29, and an EXCLUSIVE OR gate G31, Q2 provides an output signal enabling gate G23. Oscillations from a high-frequency oscillator 235 pass through enabled gate G23 to a counter 237 and a toggle-type flip-flop FF3. For simplicity, the count accumulated by counter 237 will be referred to as the "A count". The function of flip-flop FF3 will be discussed below.

A comparator 239 is used to compare the A count with a "B count" accumulated by a counter 241. The output of comparator 239 provides a high output when the A count is greater than the B count. The output of comparator 239 is commonly connected to enable an AND gate G33 and to input P1 of multiplexer M1 to cause switching of the multiplexer circuits so that the respective outputs are connected to P3, P10 and P13, respectively. The output of phototransistor Q2, connected to input 213 of the motor control section 207 through gates G25 and G27, multiplexer M1 and amplifier A1, sets motor 77 to drive the rack up.

When the bottom ply passes unit 105, gate G23, connected to the collector of Q1 through a NAND gate G34, an AND gate G35, a NOT gate G37, and gate G31, becomes disabled, stopping the counting of counter 237. The count stored in counter 237 represents both a measurement of the time period between passage of the trailing ends of the two plies by sensor unit 105 and the correction (in steps of motor 77) needed to slow the feed rate of the top feed dog 9 so that the trailing ends of the two plies will come out in registration at the needle.

Since both plies have passed first sensor unit 105, an AND gate G39, which has its input terminals connected to the outputs of both phototransistors (Q1 and Q2), provides an output enabling an AND gate G41 and an AND gate G43. This allows lowfrequency oscillator 221 to supply a time-varying voltage to input 215 of the motor control section 207, causing motor 77 to drive rack 67 upwardly, shortening the stroke of the top feed dog. Counter 241, connected to oscillator 221 through gates G41 and G43, accumulates a count of the number of steps the motor has driven.

When comparator 239 determines that the feed rate of the top ply has been sufficiently slowed (i.e., the A count equals the B count), the output of comparator 239 supplies a low signal which disables gate G43 thereby stopping motor 77. The low output of comparator 239 also causes multiplexer M1 to switch so that its respective outputs are interconnected to inputs P2, P11 and P14, respectively.

Each high-frequency oscillation registered by counter 237 caused toggling of flip-flop FF3. A counter 243 connected to the Q output of FF3 through an EXCLUSIVE OR gate G45 therefore accumulated a count

equal to one-half the A count. The count accumulated in counter 243 will be referred to as the "C count".

The second sensor unit 107 includes a sensor comprising light emitting diode LED 3 and phototransistor Q3 for detecting passage of the trailing edge of the bottom ply A and a sensor comprising LED 4 and Q4 for detecting passage of the trailing edge of the top ply B. The emitters of Q3 and Q4 are grounded while their collectors are connected to positive voltage through a resistor R3 and a resistor R4, respectively.

As the top ply B progresses toward the sewing machine, it passes the second sensor unit 107. The output of Q4 enables an AND gate G47 which is connected to the collector of Q4 through a NAND gate G49, an AND gate G51, a NOT gate G53, and an EXCLUSIVE OR gate G55. The output of Q4 also causes a high signal to be supplied to the enable input P15 of multiplexer M1 thereby disabling all outputs of the multiplexer.

Oscillations from high-frequency oscillator 235 are supplied to a further counter 249 through enabled AND gate G47 and an EXCLUSIVE OR gate G57. The count accumulated by counter 249 will be referred to as the "D count".

When the bottom ply passes the second sensor unit, gate G47, which is connected to the collector of Q3 through a NAND gate G59, an AND gate G61, a NOT gate G63 and gate G55, becomes disabled, stopping counter 249. The count stored in counter 249 is then analogous to the time period between the passage of the trailing ends of the two plies by second sensor unit 107. The high signal at the enable input P15 of multiplexer M1 is removed, enabling the various outputs of M1. Since both plies have passed the second sensor unit, an AND gate G65, having its inputs connected to the outputs of both Q3 and Q4, provides a "high" output enabling an AND gate G67 and an AND gate G69. Also, an AND gate G70 (connected to both Q3 and Q4) provides an output to the S input of flip-flop FF3, causing the output of FF3 to provide a low signal.

A comparator 251 compares the C count and the D count. If C equals D, no further adjustment in the stroke of the top feed dog 9 is required because one-half the difference in length of the two plies has been corrected in one-half the distance to the sewing machine. If C is less than D, an undercorrected condition exists so that the stroke of the top feed dog must be shortened to further slow the feed rate of the top ply B. Finally, if C is greater than D, an overcorrected condition exists so that the stroke of the top feed dog must be lengthened to feed the top ply at a faster rate although still slower than the feed rate of the bottom ply.

Comparator 251 has an output 253 which will provide a high output if C is greater than D and an output 255 which will provide a high output if C is less than D.

If C is greater than D, a high signal will be supplied from output 253 to motor control section input 211 through gate G15, multiplexer M1, and amplifier A2 thereby setting motor 77 to drive rack 67 down. The high signal at output 253 also enables an AND gate G71 connected to output 253 through gate G69. This allows oscillations from low-frequency oscillator 221 to be supplied to input 215 of the motor control section through enabled AND gate G67, enabled AND gate G71, an EXCLUSIVE OR gate G73, EXCLUSIVE OR gate G7, multiplexer M1 and AND gate G9, causing the motor to drive rack 67 down thereby increasing the

feed rate of the top ply. Counter 249, being connected to gate G71 through an AND gate G75 and EXCLUSIVE OR gate G57, increases the D count with every step of the motor until C equals D, at which time output 253 provides a low signal, disabling gate G71 and stopping the motor.

On the other hand, if the C count had been less than the D count, a high signal would have been supplied from output 255 of comparator 251 to input 213 of motor control section 207 through EXCLUSIVE OR gate G3, multiplexer M1, and amplifier A1 so as to set the motor to drive rack 67 up. The high signal at output 255 also would have enabled an AND gate G77, allowing oscillations from lowfrequency oscillator 221 to have been supplied to motor control section input 215 through gate G67, gate G77, gate G45, gate G73, gate G7, multiplexer M1, and gate G9, causing the motor to drive rack 67 up thereby further slowing the feed rate of the top ply. Counter 243, being connected to gate G45, would increase the C count with every step of motor 77 until C equals D, at which time output 253 would have provided a low output, disabling gate G77 and stopping the motor.

The operation of the apparatus has been described above for a condition wherein the top ply B is shorter than the bottom ply A. The operation for the condition wherein the top ply B is longer than the bottom ply A is similar to the above and is not believed to require detailed description.

It will be understood that the apparatus may include an edge contour guidance control for plies A and B of the type illustrated in U.S. Pat. No. 3,636,898, issued Jan. 25, 1972.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In apparatus for joining two pieces of material such as textile fabric, said apparatus comprising means for seaming the two pieces together and means for feeding the two pieces through the seaming means comprising a first feed device for one of said pieces and a second feed device for the other, the improvement comprising the provision of:

means for sensing an out-of-registration condition of the trailing end of one of said pieces relative to the trailing end of the other piece as said pieces are fed through the seaming means;

means for varying the relative speed of the two feed devices; and

means responsive to the sensing means for controlling the speed-varying means to bring the trailing ends of the pieces substantially into registration one with the other.

2. In apparatus as set forth in claim 1, the speed-varying means comprising a variable speed drive for one of said feed devices, and the control means comprising means for controlling said variable speed drive to vary the speed of said one feed device.

3. In apparatus as set forth in claim 2, the sensing means comprising a plurality of sensor units each for

sensing out-of-registration conditions of the trailing end of one of said pieces relative to the trailing end of the other piece at a corresponding plurality of stations in the path of travel of the pieces.

4. In apparatus as set forth in claim 3, said sensing means comprising two sensor units, a first of which has an operative position spaced upstream from said seaming means a distance measured along the path of travel of said pieces corresponding generally to the length of said pieces, and the second of which is spaced generally half said distance upstream from said seaming means.

5. In apparatus as set forth in claim 4, each of said sensor units comprising a first sensor for sensing passage of the trailing end of one piece and a second sensor for sensing passage of the trailing end of the other piece.

6. In apparatus as set forth in claim 1, the sensing means comprising a sensor unit including a first sensor for sensing the passage of the trailing end of one piece and a second sensor for sensing the passage of the trailing end of the other, each sensor comprising a pair of elements adapted to be positioned along the path of travel of a respective piece and adjacent thereto, said elements adapted to actuate an electrical circuit to provide a signal upon the passage thereby of the trailing end of said respective piece.

7. In apparatus as set forth in claim 6, one of said sensor elements comprising a light source and the other comprising a light sensitive device.

8. In apparatus as set forth in claim 7, said light source comprising a light emitting diode, and said light sensitive device comprising a phototransistor.

9. In apparatus as set forth in claim 2, said control means further comprising means for measuring the magnitude of the out-of-registration condition of the trailing end of one of said pieces relative to the trailing end of the other piece, said means for controlling the variable speed drive being responsive to said measurement means.

10. In apparatus as set forth in claim 9, the measurement means comprising counter means for registering the magnitude of the out-of-registration condition as the pieces pass said sensing means and means for correcting the speed of the variable speed drive to effect a change in speed of said one feed device so as to bring the trailing ends substantially into registration one with the other when they reach said seaming means.

11. In apparatus as set forth in claim 9, the measurement means comprising counter means for registering the magnitude of the out-of-registration condition as the pieces pass said sensing means and for registering the magnitude of correction made by said variable speed drive and comparison means for determining when said variable speed drive has changed the speed of said one feed device so as to bring the trailing ends substantially into registration when they reach said seaming means.

12. In apparatus as set forth in claim 1, the speed-varying means comprising a variable speed drive for one of said feed devices, the control means including a stepping motor for controlling the variable speed drive and further comprising a counter adapted to accumulate a count analogous to the time period between the passage of the two trailing ends of the pieces by the sensing means and equal to the number of steps of said motor required to vary the speed of one feed device to bring the trailing ends of the pieces substantially into

registration in a preselected length of travel of the trailing ends of said pieces.

13. In apparatus as set forth in claim 12, said control means further comprising means adapted to initiate stepping of said motor after the trailing end of the longer piece passes said sensing means.

14. In apparatus as set forth in claim 13, said control means further comprising a second counter adapted to accumulate a count equal to the number of steps taken by said motor and a comparator adapted to stop said stepping motor from further adjusting said variable speed drive when the count accumulated by said second counter equals the count accumulated by the first counter.

15. In apparatus as set forth in claim 4, said control means further comprising first means responsive to said first sensor unit for measuring the magnitude of the out-of-registration condition of the trailing ends of the two pieces at a distance measured along the path of travel of said pieces corresponding generally to the length of said pieces and a second means responsive to said second sensor unit for measuring the magnitude of the out-of-registration condition of the trailing ends of the two pieces at a distance measured along the path of travel of said pieces corresponding generally to half the length of said pieces, said means for controlling the variable speed drive being sequentially responsive to both of the measurement means.

16. In apparatus as set forth in claim 15, each of the measurement means comprising counter means for registering the magnitude of respective out-of-registration conditions as the pieces pass the respective sensor units and means responsive to said counter means for correcting the speed of the variable speed drive to effect a change in speed of said one feed device so as to bring the trailing ends substantially into registration when they reach said seaming means.

17. In apparatus as set forth in claim 15, each of the measurement means comprising counter means for registering the magnitude of respective out-of-registration conditions as the pieces pass the respective sensor units and for registering the magnitude of correction made by said variable speed drive and comparison means for determining when said variable speed drive has changed the speed of said one feed device to bring the trailing ends of the pieces substantially into registration at said seaming means.

18. In apparatus as set forth in claim 4, said means for actuating the variable speed drive comprising a stepping motor, said control means further comprising a counter adapted to accumulate a count analogous to the time period between the passage of the two trailing ends of the pieces by the first sensor unit and equal to the number of steps of said motor required to vary the speed of the one feed device to bring the trailing end of the pieces substantially into registration in a length of travel of the trailing ends of said pieces generally corresponding to the length of said pieces.

19. In apparatus as set forth in claim 18, said control means further comprising means adapted to initiate stepping of said motor after the trailing end of the longer piece passes said first sensor unit.

20. In apparatus as set forth in claim 19, said control means further comprising a second counter adapted to accumulate a count equal to the number of steps made by said motor and a comparator adapted to stop said stepping motor from further adjusting said variable

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speed drive until said trailing ends have both passed said second sensor unit when the count accumulated by said first counter equals the count accumulated by the second counter.

21. In apparatus as set forth in claim 20, said control means further comprising a third counter adapted to accumulate a count equal to one-half the count accumulated by the first counter; a fourth counter adapted to accumulate a count analogous to the time period between the passage of the two trailing ends by said second sensor unit; and a second comparator adapted to cause said stepping motor to drive a number of steps equal to the difference in the count accumulated by said third counter and the count accumulated by said fourth counter, said second comparator causing said stepping motor to vary the speed of said one feed device to bring the trailing ends of the pieces substantially into registration in a length of travel of the trailing ends of said pieces generally corresponding to half the length of said pieces.

22. In apparatus as set forth in claim 1, means for causing both feed devices to feed at substantially the same rate before said sensing means has sensed an out-of-registration condition of the trailing end of one of said pieces relative to the trailing end of the other.

23. In apparatus as set forth in claim 2, said control means further comprising means for causing the one feed device to feed at substantially the same rate as the other feed device before the sensing means has sensed an out-of-registration condition of the trailing ends of the two pieces, said means for controlling the variable speed drive being responsive to the means for causing both feed devices to feed at substantially the same rate.

24. In apparatus as set forth in claim 23, said means for causing both feed devices to feed at substantially

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the same rate comprising a sensor adapted to provide a signal when both feed devices are feeding at substantially the same rate, the control means being responsive to said signal to cease further adjustment of the variable speed drive until the trailing ends of the two pieces have passed the sensing means.

25. In apparatus as set forth in claim 1, the speed-varying means comprising means for varying the speed of one feed device, the other feed device operating at a substantially constant rate.

26. In apparatus as set forth in claim 4, means mounting said first sensor unit for movement between its operative position and a position adjacent said second sensor unit for facilitating entry of the pieces into the two sensor units.

27. Apparatus for joining two pieces of material such as textile fabric comprising:

means for seaming the two pieces of material together;

means for feeding the two pieces through the seaming means comprising a first feed means for one of said pieces and a second feed means for the other with one of the latter a variable speed feed means; means for sensing any out-of-registration condition of the trailing end of one of said pieces relative to the trailing end of the other piece as they are fed through the seaming means by the feed means; and means controlled by said sensing means for varying the speed of the variable speed feed means to vary the speed of feed of the piece of material being fed thereby through the seaming means to bring the trailing ends of the pieces substantially into registration one with the other.

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