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(54) Apparatus and method of binding a book.

(57) Apparatus and method for binding a plurality of sheets arranged in a stack (36) utilizing a binding tape (32) is disclosed. Control means is provided for controlling the relative positions of the stack support means (44,46,104,76,84) and the platen means (112,114) to that the spine and cover seals can be formed. The control means includes measuring means (58,60) for measuring the thickness of the stack (36) to be bound and means for adjusting the spacing between the two support means (108,110,111,113;152) of the tape positioner means when the tape positioner means is in a tape load mode based upon the measured thickness. The tape positioner means accommodates one of the predetermined tape widths and fully supports the tape (32) during the tape load mode.

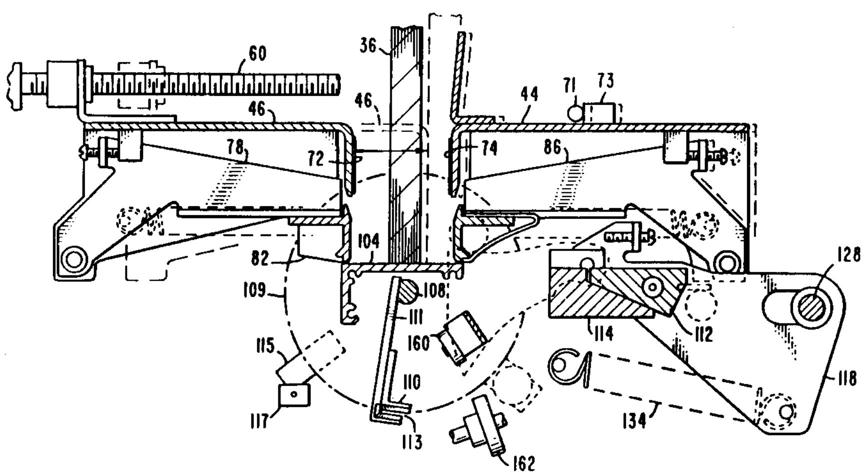

FIG. 11

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1. Field of the Invention

The present invention relates generally to the field of apparatus and method for binding a book and more particulary, to automatic bookbinding apparatus which utilize a binding tape comprised of a substrate which carries an adhesive.

2. Description of Related Art

Apparatus for binding books utilizing a binding tape carrying heat and/or pressure actuated adhesives are well known. For example, US-A-3,928,119 and US-A-3,911,517 disclose a bookbinding machine for binding a stack of sheets. The stack of sheets to be bound is first positioned on a movable plate and clamped between a pair of guides. A binding tape is positioned under the movable plate, below the spine of the book. The binding tape is supported intermediate two moveable heated platens and above a fixed heated platen.

Once the book is positioned, the moveable plate is moved away from the book and the book is translated downward, towards the binding strip. The spine of the book engages the binding strip and forces the strip down between the two moveable heated platen until the center of the strip contacts the fixed heated platen. The moveable heated platens are positioned apart a distance slightly greater than the width of the book so that the periphery of the binding tape will fold over the front and rear book covers.

The moveable platens are then forced together so as to seal the periphery of the binding strip to the front and back cover sheets using heat and pressure. The fixed heated platen functions to melt the central binding tape adhesive so as to wet the spine of the book (the edges of the sheet) with adhesive. The moveable platens are then retracted and the bound book is removed and permitted to cool.

A further bookbinding apparatus is disclosed in US-A-3,531,358. The stack of sheets to be bound is gripped between a pair of opposing clamps. A binding tape having heat and pressure sensitive adhesive is positioned on top of a pair of heated moveable platens. The stack is then lowered on the binding tape so that molten adhesive contacts the edges of the sheets.

The pair of opposing platens then separate a distance slightly wider than the stack and the stack is forced down between the opposing platens thereby causing the peripheries of the binding tape to fold up against the front and back covers of the stack. The opposing platens are then forced against the stack so as to seal the tape to the covers. The platens are then opened so that the bound book may be removed.

In the abovementioned US-A-3 911 517 there is described a binding apparatus according to the preamble of claim 1. A method of binding a plurality of sheets arranged in a stack according to the preamble of claim 16 is also known from US-A-3 911 517. Specifically, US-A-3 911 517 discloses an apparatus for feeding the binding tape into the binding apparatus and for accepting binding tapes of varying thickness. The thickness of the stack is measured by manual rotation of a calipering knob which causes a pair of tape guides to move with respect to one another so that the guides will accept a tape of appropriate width for the stack to be bound. Since the tape is always located at the center of the stack to be bound it is not necessary to justify the tape so that the center of the tape is always located at the center of the edge of the stack.

A principal shortcoming of the previously-described prior art tape handling mechanism is that it is required, at least every time a stack which differs in thickness from the previous stack bound, to manually adjust the machine. This presents a serious disadvantage when it is necessary to bind a large number of stacks of varying thickness.

Therefore, it is a primary object of the present invention to overcome the above-noted inadequacies and shortcoming of the prior art proposals of bookbinding apparatus.

To achieve this, the apparatus of the invention is characterized by the features claimed in the characterizing part of claim 1 and the invention provides a method according to the characterizing part of claim 16.

Basically, in the apparatus according to the invention, the thickness of the stack to be bound is automatically measured and the spacing between the two support means of the tape positioner is automatically adjusted to accommodate one of the predetermined tape widths and to support the tape based upon the measured thickness.

The present invention overcomes the disadvantages of the prior art tape binding mechanisms in that, at the beginning of each tape binding operation, the stack is placed in the machine and the thickness of the stack is automatically measured and a tape guide is automatically adjusted. No intervention by the operator is required.

Preferably, the tape positioner is also movable from the tape load mode to the binding mode where the control means functions to position the first tape support means, depending upon the measured thickness, so that an edge of the tape is positioned relative to the stack based upon the thickness of the stack to be bound. In this manner, the tape will be appropriately positioned so that the first cover seal may then be formed by the platen means by forcing the tape edge and first cover sheet together.

SUMMARY OF THE INVENTION

Apparatus and method for binding a plurality of sheets arranged in a stack is disclosed. A binding tape which includes a flexible substrate having an adhesive is utilized. The adhesive is preferably heat activated, although pressure sensitive adhesives can be also be used. The binding tape is provided in a plurality of predetermined tape widths to accommodate stacks having varying thicknesses.

The apparatus includes stack support means for supporting the stack of sheets to be bound and tape positioner means for receiving the tape into the apparatus and for positioning the tape relative to the stack to be bound. The apparatus further includes first and second tape support means for supporting first and second respective edges of the tape. Platen means is further included for forming the spine of the book and for applying the tape against the front and back cover sheets of the stack so as to form the front and back cover seals of the book. Control means is provided for controlling the relative positions of the stack support means and the platen means to that the spine and cover seals can be formed.

The control means includes measuring means for automatically measuring the thickness of the stack to be bound and means associated with the tape positioner means for automatically adjusting the distance between the two tape support means of the tape positioner means when the tape positioner means is in a tape load mode based upon the measured thickness. Thus, the tape positioner means is able to accommodate one of the predetermined tape widths and fully support the tape during the tape load mode based upon the thickness of the stack to be bound.

In one embodiment of the invention, apparatus is also provided for justifying the tape relative to the stack so that the tape will be centered on the spine of the bound book for all stack thicknesses. These and other advantages of the present invention will become apparent to those skilled in the art upon reading the following Detailed Description of the Preferred Embodiment together with the drawings.

Brief Description of the Drawings

Figure 1 is a perspective view of the subject binding apparatus showing the housing and a thick binding tape to be used for binding a thick book.

Figure 2 is a perspective view of a narrow binding tape of the type to be used in the subject binding apparatus.

Figure 3 is an elevated cross-sectional view of a relatively thick bound book using the wide binding tape of Figure 1.

Figure 4 is an elevated cross-sectional view of a relatively thin bound book using a binding tape depicted in Figure 2.

Figure 5 is on elevated cross-sectional view of the subject binding apparatus showing key elements including the front clamp, rear clamp, tape positioner, cool platen and rotating platen.

Figure 6 is an elevational perspective view of the underside of the carriage assembly of the subject binding apparatus showing key elements, including the front and rear clamps, the front and rear backup bars and the lead screw for driving the clamps.

Figure 7 is an elevated cross-sectional view of the subject binding strip showing key elements, including the tape positioner gear (in phantom), the cool platen, binding tape feed bar and the rotating platen.

Figure 8 is an elevated cross-sectional view showing the carriage assembly of the subject binding apparatus rotated upwards to an open position.

Figure 9A is a front cross-sectional view of the movable platen assembly in the operating position with the assembly held down by the stop brackets.

Figure 9B is a side view of the movable platen assembly in the operating position and in the open position (in phantom).

Figure 10 is a cutaway view of the binding tape feed mechanism of subject binding apparatus.

Figure 11 is an elevational cross-sectional view showing the front and rear clamps gripping a book during the preliminary stage of the binding sequence.

Figure 12 is a simplified schematic representation of the various electro-mechanical drive elements of the subject binding apparatus.

Figure 13 shows the tape guide pivot arm of the Figure 10 tape feed mechanism in a closed position so as to prevent manual feeding of an additional binding tape.

Figure 14 shows the tape feed mechanism of Figure 10 with a relatively narrow binding tape in the process of being fed into the subject apparatus.

Figure 15 shows the tape feed mechanism of Figure 10 with a relatively wide binding tape in the process of being fed into the subject apparatus.

Figure 16 shows the tape positioner during the initial stages of the binding process wherein the tape positioner is pivoted upwards to ensure that the binding tape is properly loaded in the tape feed bar.

Figure 17 shows the stage of the binding sequence wherein the seal of the binding tape to the back cover of the book is being formed.

Figure 18 shows the stage of the binding sequence immediately following the formation of the first seal, with the book being backed away from the heated platen.

Figure 19A shows the stage of the binding sequence just after the rotating platen has been rotated to a horizontal position and the book has been translated towards the heated platen to the over platen position which causes the binding tape to fold under the book.

Figure 19B shows the stage of the binding sequence where the book has been translated from the over platen position (Figure 19A) to the fold position.

Figure 19C shows the melt to fold stage of the binding sequence for very thin books, which is intermediate the over platen position (Figure 19A) and the over platen position (Figure 19B).

Figure 20 shows the stage of the binding sequence just after the rotating platen has been rotated to a vertical position so as to fold the binding tape and to effect the seal between the binding tape and the front cover of the book.

Figure 21 shows the final stage of the binding sequence wherein the rotating platen is rotated to the horizontal position and the bound book is transferred from the heated platen to the cool platen (in phantom).

Figure 22 is a schematic diagram of the tape feed mechanism showing the inner and outer tape position sensors and the tape width sensor.

Figure 23 is a simplified block diagram of the control circuitry of the subject binding apparatus, including the programmed Central Processing Unit, the three drive motors and other primary components.

Figures 24A - 24E show the various positions of the front and rear clamps of the carriage assembly during the initial stages of a typical binding sequence.

Figures 25A and 25B are a timing diagram which show the position of the various binding apparatus mechanical components during a typical binding sequence.

Figures 26A - 26D is a simplified flow chart of the primary software program for controlling the Central Processing Unit.

Figures 27A - 27B is a simplified flow chart of the Initialize subroutine used in the primary software program of Figures 26A - 26D.

Figure 28 is a simplified flow chart of the Eject Tape subroutine used in the primary software program of Figures 26A - 26D and in other subroutines.

Figure 29 is a simplified flow chart of the Edit Cycle subroutine used in the primary software program of Figure 26A - 26D.

Figure 30 is a simplified flow chart of the Start Tape subroutine used in the primary software program of Figures 26A - 26D.

Figure 31 is a simplified flow chart of the First Feed subroutine used in the Start Tape subroutine of Figure 30.

Figure 32 is a simplified flow chart of the Final Feed subroutine used in the primary software program of Figures 26A - 26D.

Detailed Description of the Preferred Embodiment

Referring now to the drawings, Figure 1 shows the subject binding apparatus enclosed in a housing 30. Housing 30 includes a control panel having a display 32 and control buttons 34 to be used by the operator.

Housing 30 is provided with a large opening on the top panel for receiving a book 36 to be bound or edited. The term book as used here is intended to mean a collection or stack of sheets, either bound or unbound. The subject apparatus includes a book guide 38 for supporting the book during the binding or editing sequence.

An opening 40 is formed in housing 30 for receiving a binding tape, generally designated by the numeral 32. Details regarding to construction of the binding tape 32 are disclosed in U.S.P. No.4,496,617, the contents of which are hereby incorporated by reference. The operator preferably stands in front of the machine, with tape opening 40 located to the right. For purposes of the present description of the invention, motion towards the operator is forward motion and motion away from the operator is rearward motion.

Binding tape 32, also depicted in Figure 2, includes a flexible substrate 32a having a length which is equal to the length of the book to be bound and a width which is substantially greater than the thickness of the book to be bound. A pair of narrow outer adhesive strips 32b are formed along the periphery of substrate 32c, for making contact with the front and back sheets of the book which will form the front and back book covers. A wide central adhesive strip 32c is formed intermediate the peripheral strips 32b for contacting the edges of the book sheets so as to form the spine of the book.

Peripheral adhesive strips 32b are preferably a high tack, heat activated adhesive having high viscosity. Central adhesive strip 32c is preferably a low tack heat activated adhesive. The central adhesive should be of low viscosity to ensure that the edges of the pages to be bound are thoroughly wetted by the adhesive.

Figure 3 shows a section of a book bound utilizing the wide width binding tape 32 of Figure 1. The substrate 32a extends around the edge of the bound pages, with the peripheral high tack adhesive strips 32b securing the substrate to the front and back sheets 36a and 36b, respectively, which form the front and back covers. The central, low viscosity adhesive 32c wets the edges of the remaining sheets thereby securing the sheets to the substrate so as to form an integral bound book.

Figure 4 shows a bound book which is substantially thinner than the book of Figure 3. A narrow width binding tape is used as shown in Figure 2. Intermediate or medium width binding tape is preferably used for books of medium width.

As will be described later in greater detail, the subject binding apparatus binds a book by first gripping the book to be bound. A seal is formed between the unfolded binding tape by applying one of the peripheral adhesive strips 32b to sheet 36b which will be the back cover of the book. Both pressure and heat are used to effect the seal. The position of the seal on the back cover will depend on the thickness of the book with respect to the width of the tape. The thicker the book the lower the first seal on the back cover 36b.

Once the first seal is formed, the substrate is folded at a right angle so that the central adhesive strip 32c will contact the edges of the sheets which form the book. Heat and pressure are applied for several seconds so as to melt the central adhesive and thoroughly wet the edges of the sheets. Next, the substrate is folded a second time so that the remaining peripheral adhesive strip 32b will come into contact with sheet 32a which will form the front cover of the book. Heat and pressure are applied to form the second seal, thereby completing the binding sequence.

Figure 8 shows some of the details of the construction of the subject binding apparatus. Housing 30 is removed to disclose a lower base assembly, generally designated by the numeral 42, and an upper carriage assembly, generally designated by the numeral 45. The carriage assembly 45, which includes a carriage frame 50, is pivotally mounted on the base assembly 42 and is shown pivoted up in an open position to facilitate servicing.

Further details of the carriage assembly 45 are shown in Figure 6. The carriage assembly includes a front clamp 46 and a rear clamp 44, both of which are mounted for movement on the carriage frame 50 (Figure 8). Front and rear clamps 46 and 44 are independently guided on guide shaft 52 which is mounted on carriage frame 50. Guide shaft 52 extends through openings in mounting block 54 secured to front clamp 46 and in mounting block 56 secured to rear clamp 44. The bearing for supporting guide blocks 54 and 56 are not depicted.

The carriage assembly includes a carriage drive motor 58 (Figure 8) mounted on frame 50 for driving the front and rear clamps. Motor 58 is a conventional stepping motor. Motor 58 drives a lead screw 60 by way of pulleys 62 and 64 and drive belt 66. Pulley 64 (Figure 6) is mounted on lead screw 66, with lead screw 60 engaging a drive nut 68 secured to mounting block 54 of the front clamp. Thus, front clamp 46 may be driven directly in either a forward or reverse direction by motor 58.

The rear clamp 44 is coupled to the front clamp 46 by way of a pair of clamp springs 70. Springs 70 tend to force the two clamps together so as to grip a book positioned intermediate the clamps. As will be described in greater detail, the front and rear clamps function generally to grip the book and translate the book horizontally during the binding sequence.

A boss 71 is mounted on carriage frame 50 to limit movement of rear clamp 44 in the forward direction (towards the operator). Rear clamp 44 carries a stop member 73 which limits movement in the forward direction when the member engages boss 71. Boss 71 and stop member 73 cause the rear clamp 44 to separate from the front clamp 46 so that a book may be inserted between the two clamps.

Front clamp 46 and rear clamp 44 include vertical grip members 72 and 74, respectively, for gripping the book to be bound. The surface of the grip members is preferably covered with a textured coating to prevent the book from slipping during the binding sequence.

A front backup bar 76 is mounted on front clamp 46 by way of support arms 78. Support arms 78 are pivotally mounted on the underside of the front clamp by way of pivot pins and bearings 80. A front cam shoe 82 is secured to the front backup bar 76. Front cam shoe 82 engages a rotating platen, to be described later, which causes the front back up bar to pivot between an engaged position wherein the bar is contacting the book to be bound and a non-engaged position where the bar is displaced from the book. Sets screws 83 are provided for adjusting the position of the front backup bar when in the engaged position.

A rear back up bar 84 is mounted on rear clamp 44 by way of support arms 86. Support arms 86 are pivotally mounted on the underside of rear clamp 44 by way of pivot pins and bearings 88. A pair of rear cam shoes 91 is secured to the rear backup bar 84. Cam shoes 90 engage a rotating platen, as will be described, which causes the bar to pivot from an engaged position contacting the book to be bound to a non-engaged position displaced from the book. Set screws 90 are provided for adjusting the position of the rear backup bar when in the engaged position.

The carriage assembly 45 includes three optical sensors, including a book sensor 92 mounted on the right extreme edge of front grip member 72. Sensor 92 is preferably a reflective optical sensor wherein a light emitting diode is positioned adjacent a photo-transistor. The sensor is actuated when a reflective surface such as a book, reflects light from the diode back to the photo-transistor Book sensor 92 will be actuated when the user has properly placed a book between the front and rear grip members 72 and 74, as will be described.

A carriage home sensor 94 is mounted on carriage frame 50 for sensing when front clamp 46 is in the home position. Sensor 94 is a slot type optical sensor having light emitting diode spaced apart from and facing a photo-transistor. The photo-transistor will be normally illuminated by the diode until an element such as a flag is positioned in the sensor slot so as to block light to the transistor. Front clamp 46 carries a flag 96 which will actuate sensor 94 when the front clamp is in the home position, as will be described later.

The carriage assembly 45 further includes a clamp sensor 98 which is actuated when the front and rear clamps have clamped a book. Clamp sensor 98 is mounted on frame 50 and is a slot type sensor actuated by a flag 100 carried on back clamp 44.

Referring back to Figure 8, the base assembly 42 includes a tape feed mechanism for receiving the binding tape and various platens for forming the book seals. The base assembly includes a base frame 102 for mounting the various components which comprise the base assembly.

The base assembly 42 includes a cool platen 104 which is rigidly secured to base frame 102. Cool platen 104 supports the book during the initial and final stages of the binding sequence. A movable platen assembly, generally designated by the numeral 106, is positioned on frame 102 adjacent fixed cool platen 104.

Further details of cool platen 104 and moveable platen assembly 106 may be seen in Figures 5 and 7. Cool platen 104 includes a horizontal surface for receiving the book.

A tape positioner shaft 108 is located immediately below cool platen 104. The positioner shaft is rotatably mounted on frame 102 and is driven in either direction by a tape positioner gear 109 (Figure 7). The positioner shaft 108 carries a tape feed bar 110 by way of a support arm 111 which supports the binding tape during the initial stage of the binding sequence. Tape feed bar 110 is provided with a slot or groove 113 which receives tape, as will be described.

Moveable platen assembly 106 includes a heated platen 112 and a rotating platen 114. In operation, heated platen is heated to approximately 420°F by a conventional heating element 116 mounted inside the heated platen. Heated platen 112 is supported at either end by direct connection to end brackets 118. The heated platen includes a top surface 112a which engages the binding tape during the binding sequence.

Rotating platen 114, preferably made of solid aluminum, is positioned adjacent heated platen 112 and is also supported by end brackets 118. A pair of pivot 114 plates 120 are secured to the ends of rotating platen for rotatably mounting the platen on brackets 118.

Rotating platen 114 has a first surface 114a which is used to form the first seal to the book cover. A second surface 114b is used to form the second seal to the remaining book cover. Rotating platen 114 is shown in Figure 7 in a horizontal position where surface 114c of the platen is in intimate contact with surface 112b of the heated platen. Thus, when rotating platen 114 is in the horizontal position, heat is transferred from the heated platen to the rotating platen by conduction.

One of the pivot plates 120 which supports the rotating platen carries a pivot pin 122 and the other carries a pivot shaft 124. Pivot pin 122 and coaxial pivot shaft 124 are arranged such that rotating platen 114 rotates about an axis located at the junction of platen surfaces 112a and 114b. A spring 126 is disposed around pivot shaft 124 to bias the rotating platen to the horizontal position so that rotating platen 114 will normally be heated by the heated platen 112. Rotating platen 114 has sufficient heat retention properties to provide the desired heating when the two seals are formed, at which times the platen is rotated to the vertical position.

The movable platen assembly 106 is mounted on base frame 102 so that the assembly may be slightly translated in either the vertical or horizontal direction. A pivot shaft 128, mounted on the base frame, extended through elongated openings 130 in end brackets 118. Pivot bearings 132 secure the end brackets in place, limiting lateral movement of the assembly. A pair of platen springs 134 are provided, each having one end secured to the base frame and the remaining end secured to the end bracket 118 below shaft 128.

Moveable platen assembly 106 may be manually pivoted about shaft 128 from an operating position to an open position to facilitate servicing of the machine. As can be seen in Figure 9A, a front view of the platen assembly, a pair of stop bearings 119 are rotatably mounted at opposite ends of the platen assembly. Platen springs 134 (Figure 7) have a tendency to pivot the forward portion of the platen assembly upwards about pivot shaft 128. A pair of stop brackets 121, secured to bass frame

102, normally engage stop bearings 119 thereby limiting upward movement so that the assembly will remain in the operating position.

In the event the platen assembly is to be placed in an open position for servicing and the like, a rearward force is manually applied to the assembly. If the platen assembly is heated, protective gloves or the like should be used. Rearward movement of the assembly causes the platen springs 134 to stretch slightly and the forward portion of elongated openings 130 to contact pivot bearings 132 (Figure 7). At this point, stop bearings 119 are no longer disposed below stop brackets 121. As can be seen in Figure 9B, the platen assembly 106 can then be manually lifted, using gloves if necessary, to the open position. This permits cleaning of the platen assembly, removal of jammed binding tape from the tape feed bar 110 and other servicing of the machine.

Rotating platen 114 is rotated by a lever arm 136 secured to pivot shaft 124 (Figure 7). Lever arm 136 has a lower bearing surface 136a which engages an outer cam bearing 138 (shown in phantom). Outer cam bearing is secured to the tape positioner gear 109 by way of an arm support 140. Thus, cam bearing 138 rotates with the positioner gear 109 in an arc coaxial with the gear. The tape positioner shaft 108 is also driven by the gear.

Lever arm 136 further has an upper cam bearing surface 136b which engages an inner cam bearing 142 also mounted on positioner gear 109. Cam bearing 142 is positioned closer to the axis of rotation of gear 109 than outer cam bearing 138, with the radius of curvature of the inner cam bearing arc being less than that of the outer cam bearing.

Positioner gear 109 may be driven in either direction, as represented by arrow 144. Gear 109 is driven by a smaller drive gear 146, which is, in turn, driven by a tape positioner motor (not depicted in Figure 7). In the event positioner gear 109 is driven in direction A, indicated by arrow 144, outer cam bearing 138 will engage lower surface 136a of lever arm 136 causing the rotating platen 114 to pivot from a horizontal position to a vertical position.

In the event the positioner gear 109 is driven in direction B, indicated by arrow 144, inner cam bearing 142 will engage upper surface 136b of lever arm 136. This action will force the platen assembly 106 down, causing platen springs 134 to expand slightly.

Positioner gear 109 also carries a positioner flag 115 which operates in conjunction with a positioner home sensor 117. Sensor 117 is a slot type optical sensor mounted on the base frame 102. The sensor 117 is activated when flag 115 enters the sensor slot. As will be subsequently described, sensor 117 provides a reference point for controlling the position of tape positioner gear 109.

The base assembly 102 further includes a tape feed mechanism for properly positioning the binding tape. As can be seen in Figure 8, the base frame 102 includes an opening 150 for receiving the tape. The end of the tape is manually inserted in the opening with the adhesive strips facing upwards. Once the presence of the tape is detected by the tape feed mechanism, the mechanism automatically draws the tape into the apparatus and positions the tape for binding.

Details of the construction of the tape feed mechanism are shown in Figures 10 and 13-15. The feed mechanism includes a tape guide assembly, generally designated by the numeral 152. A principal function of the tape guide assembly is to align the end of the binding tape 32 with the slot 113 in the tape feed bar 110. Tape feed bar 110 has a fluted section (not designated) at the end of the bar to guide the tape into slot 113. The assembly includes a tape guide pivot arm 154 which is pivotally mounted on shaft 156 which is secured to the base assembly frame.

One end of pivot arm 154 carries a tape guide 158 which is generally perpendicular with respect to the pivot arm. Tape guide 158 includes an inner pair of tabs 158a which define a slot therebetween generally coplanar with groove 113 of the tape feed bar 113. The guide further includes an outer pair of tabs 158b, which define a slot therebetween which is coplanar with the slot defined by inner tabs 158a and groove 113 and spaced apart from the inner tab. An idler roller 160 is rotatably mounted on guide 158, with the periphery of the roller being aligned slightly past the slots defined by tabs 158a and 158b. Coplanar groove 113 and the slots defined by tabs 158a and 158b define a tape feed path. When a binding tape 32 is inserted in the tape feed path, the tape will contact the idler roller 160.

Tape guide 158 also includes a blocking tab 158c which extends from outer tab 158a and which is generally parallel with respect to pivot arm 154. Blocking tab 158c functions to block the opening 40 in the housing (Figure 1) to enable a binding tape to be inserted only when needed.

The tape feed mechanism further includes a feed roller 162 mounted on one end of a drive shaft 164. The drive shaft 164 is rotatably mounted on the base assembly frame by way of ball bearings (not shown). A pulley 166 is mounted on the other end of the drive shaft 164. Pulley 166 carries a drive belt 168 which is driven by a tape feed motor 210 (not shown in Figure 10) mounted on the base frame.

Tape guide assembly 152 is pivoted about shaft 156, between a tape drive position and a disengage position, by a solenoid 170. The assembly is normally held in the no feed position by a guide assembly spring (not depicted). Solenoid 170 is mounted on the base assembly frame 102 by way of a mounting bracket 172. The solenoid actuator 174 is coupled to the free end of pivot arm 154 by way of a spring 176.

When the tape guide assembly is in the disengaged position, solenoid 170 is off. As can be seen in Figure 13, the guide assembly spring (not depicted) retains the assembly in the disengaged position, with the idler roller 160 displaced from the feed roller 162. Blocking tab 158c is positioned to prevent a binding tape from being inserted in the tape feed mechanism.

During the initial stages of the binding sequence, solenoid 170 is turned on causing actuator 174 to retract thereby pulling the lower portion of pivot arm 154 towards the solenoid by way of spring 176. The force applied by solenoid 170 causes the tape guide assembly to pivot to the tape drive position, as depicted in Figure 14. Blocking tab 158c is depressed below the opening 150 to permit a binding tape 32 to be manually inserted in the tape feed mechanism.

As will be subsequently described, the tape feed bar 110 will be rotated by tape positioner shaft 108 so that the feed bar will be positioned opposite the tape guide 158. The position of the feed bar 110 with respect to the tape guide is a function of the width of the binding tape to be used which, in turn, is a function of the thickness of the book 36 to be bound.

A thin book, typically less than 1/2 inch thick will be bound with a narrow binding tape having a width of approximately 1 3/16 inches. A medium width book having a thickness ranging from approximately 1/2 inch to 1 inch will be bound with a medium width tape of 1 11/16 inches. A relatively thick book having a thickness ranging from 1 inch to 1 1/2 inches will be bound with a wide tape of approximately 2 3/16 inches.

The position of feed bar 110 in Figure 14 corresponds to a book having a thickness which utilize a binding tape of medium width. Upon prompting by display 33 (Figure 1), the user inserts a medium width binding tape 32, positioning the tape, with the adhesive strips up, on tape guide 158. As will be subsequently described, a sensor will detect the presence of the tape and will cause the tape feed motor to turn on thereby causing the feed roller 162 to rotate. Rotation of the feed roller 162 will cause the binding tape to be gripped between the feed roller and idle roller 160 thereby causing the binding tape to be drawn along grove 113 of tape feed bar 110. The feed roller will rotate until the tape is fully inserted in the feed bar.

In the event the book 30 is relatively thick, the display 32 will indicate to the operator that a wide binding tape is to be inserted. As depicted in Figure 15, tape feed bar 110 will be positioned relative tape guide 158 to accommodate the width of a wide tape. The feed bar will be positioned relatively close to tape guide 158 in the event the book to be bound is thin. In that event, the display will prompt the operator to insert a narrow binding tape.

Figure 22 shows the three sensors associated with the tape feed mechanism together with the book position sensor 92. A binding tape is fully fed into the binding apparatus when the end of the tape coincides with the end-of-book line 178. Line 178 represents the position of the right end of the book when the book is properly positioned between the front and rear clamps 46 and 44. As previously noted, book sensor 92, mounted on the front clamp, will not be actuated unless the book is properly positioned between the clamps. The book must be in a right-justified position so that the end of the book will coincide with line 178.

An outer tape sensor 184 is positioned on tape feed bar 110 to detect the presence of a tape between opening 150 in housing 102 and feed roller 162. An inner tape sensor 182 is positioned on tape guide 158 to the left of the feed roller 162. Thus, sensor 182 will detect the presence of the tape when it has been fed past feed roller 162. Sensor 182 is a reflective type sensor and sensor 184 is preferably a slot type optical sensor which is more accurate than a reflective sensor.

Alternatively, the inner tape sensor 182 and tape width sensor 180 can be mounted on the base assembly frame immediately below the tape guide 158. Sensor 182 detects the presence of tape by way of an opening in the lower outer tab 158b. A corresponding opening is located in the upper tab 158b so that light will not be reflected unless tape is present. Sensor 182 detects the presence of tape at the periphery of inner tab 158a. The advantage of this alternative configuration is that sensors 180 and 182 remain fixed and do not move with the tape guide assembly.

The tape feed mechanism includes a third sensor, a tape width sensor 180 mounted on tape guide 158. The function of sensor 180, a reflective type sensor, is to verify that a tape 32 has been inserted of the proper width. It is not possible to insert a tape of greater width than prescribed since the tape feed bar 110 will be positioned too close to the tape guide 158 to permit the tape to be inserted. It is, however, possible to insert a tape which is narrower than prescribed. For example, if the apparatus has measured a book and determined that a wide tape should be used, it is possible for the user to incorrectly insert either a medium or narrow width tape. In that event, either sensor 180 or 184 will not detect the presence of the tape since the tape will not be sufficiently wide to simultaneously actuate both sensors. The display will issue an error message if an attempt is made to use a tape narrower than prescribed.

Figure 12 is a simplified schematic diagram of the principal drive components of the subject binding apparatus. The components for controlling the operation of the apparatus are collectively represented by element 185. Tape position motor 204 drives the tape positioner gear 109 and the carriage drive motor 58 drives lead screw 60. Tape feed motor 210 drives tape feed roller 162 and solenoid 170 actuates pivot arm 154 of the tape feed mechanism.

Figure 23 is a simplified block diagram of the control circuitry of the subject binding apparatus. The circuitry includes a central processing unit or CPU 186. An 8 bit CPU sold by Intel under the designation 80C451 has been found suitable for this application. Various memory devices, represented by memory 188, are used in conjunction with CPU 186 for storing, among other things, the program for controlling the subject binding apparatus. Some of the memory devices which comprise memory 188 include an electrically programmable read only memory (EPROM) which will retain data in the absence of memory power.

CPU 186 has several internal input/output devices so that the CPU can be directly interfaced with the various sensors drivers and the like which comprise the subject binding apparatus. The various CPU input/output lines are represented by elements 190, 192 and 194.

At power up, CPU 186 will monitor the hot platen heating element 116 to verify that the platen has reached operating temperature. A thermostat 196 mounted on the hot platen is used for controlling the platen temperature. The heater is preferably isolated from the CPU by an optical coupler (not depicted).

CPU also controls the front panel display 32 and is responsive to inputs provided by the operator by way of control buttons 34. As will be subsequently described, button 34a, labeled "BIND" is used when a book is to be bound. Button 34b, labeled "EDIT", is used when it is desired to add sheets or delete sheets from a previously bound book. Finally, button 34c labeled "OPEN", is used to open front and rear clamps 46 and 48 to a maximum position.

Block 198 includes the various components, associated with carriage assembly 45. Carriage drive motor 58 is a conventional stepping motor which provides drive in both directions. Motor 58 is controlled by a bipolar motor control 200. Motor control 200 is preferably comprised of commercially available integrated circuit devices. A dual full-bridge driver circuit sold by SGS under the designation L998N can be directly coupled to the stepper motor and has been found suitable for the present application. The driver circuit is used in conjunction with a current controller also sold by SGS under the designation L6506. The driver circuit together with the current controller form a constant current drive for stepping motor 58 and interface directly with CPU 186, as represented by element 194.

The carriage assembly sensors include clamp sensor 98, home sensor 94 and, as previously noted, book sensor 92. The outputs of these sensors are coupled to CPU 186, as represented by element 194.

The tape positioner components are depicted in block 202. The tape positioner motor 204 is a conventional stepping motor which functions to drive positioner gear 109 in either direction in response to commands from CPU 186. Motor control 206 is a bipolar control for tape positioner motor 204 and is similar in construction to control 200. The tape positioner home sensor 117 output is coupled to CPU 186, as represented by element 192.

The components associated with the tape feed mechanism are depicted in block 208. Tape feed motor 210, which drives tape feed roller 162, is a conventional stepping motor. A motor control 212, similar in construction to controls 200 and 206, provides bipolar control for motor 210 in response to commands from CPU 186.

The outputs of inner tape sensor 182, outer tape sensor 184 and tape sensor 180 are coupled to CPU 186, as represented by element 192. Solenoid 170 which actuates tape guide pivot arm 154, is driven by a conventional discrete transistor circuit, represented by element 214. Solenoid 170 is actuated in response to commands from CPU 186, as represented by element 194.

Having described the construction of the subject binding apparatus, operation of the apparatus will now be described. As previously noted, the program for controlling the operation of the subject binding apparatus is stored in memory 188 (Figure 23). The detailed source code for such a program would vary depending upon, for example, the exact physical dimensions of the binding apparatus, including gear ratios, pulley ratios and the like. It is believed that a description of the operation of the subject binding apparatus utilizing flow charts, timing diagrams and drawings is preferable to disclosure of a particular source code for the purpose of enabling one of ordinary skill to practice the subject invention.

Figures 24A-24E depict the preliminary sequence for binding a book. Figure 24A is a schematic representation of the front and rear clamps 46 and 44 of the carriage assembly. The clamps are shown clamped together in an uncalibrated position, with carriage drive motor 58 positioning the clamps towards the rear of the apparatus. In this position, neither the carriage home sensor 94 nor the carriage clamped sensor 98 are actuated.

Motor 58 is first caused to drive lead screw 60 in a forward direction, as shown in Figure 24B, which pulls the front clamp 46 forward. Rear clamp 44 is pulled with the front clamp by carriage springs 70. Rear clamp 44 will continue to follow the front clamp until stop member 73 on the rear clamp contacts boss 71. At this time, flag 100 will actuate clamp sensor 98.

Motor 58 will continue to drive the front clamp 46 in a forward direction as shown in Figure 24C. The rear clamp 44 will not move forward because member 73 is contacting boss 71. Front clamp 46 will continue to move forward expanding springs 70 until the carriage home sensor 94 is actuated by flag 96 carried on the front clamp. Front and roar clamps 46 and 44 are now in the carriage home position.

Motor 58 will continue to drive front clamp 46 a predetermined number of steps from the carriage home position until the front and rear clamp are separated a maximum amount as shown in Figure 24D. The carriage assembly is then in the open wide position and ready to accept a book of maximum thickness. Flag 96 is of sufficient width that the carriage home sensor 94 will remain actuated when the front clamp travels from the carriage home position of Figure 24C to the open wide position.

When the carriage is in the open wide position, a book 36 to be bound or edited is positioned between the two clamps, resting on cool platen 104 (Figure 5). The book is right justified so that book sensor 92 (Figure 23) will be actuated.

The drive motor 58 will then reverse direction thereby causing the front clamp 46 to be driven rearward towards the book 36. When the front clamp contacts the book 36, the rear clamp 44 will be forced rearward. As shown in Figure 24E, flag 100 on the rear clamp will clear clamp sensor 98 thereby indicating that the book is clamped. The number of steps required by motor 58 to advance the front clamp from the open wide position to the clamped position is indicative of the thickness of the book to be bound. This information is stored and used to determine whether a narrow, medium or wide tape is to be inserted. In addition, the information is used for controlling the tape positioner, as will be described.

The remaining description of the operation the subject binding apparatus will be made with reference to the flow chart, timing diagrams and other figures of the drawings, Figures 25A and 25B are a timing diagram depicting the position of the various mechanical components throughout an exemplary binding sequence for a book approximately one half inch thick. The sequence takes something less than approximately 20 seconds.

The top waveform 216 (Figure 25A) represents the position of front clamp 46 throughout the binding sequence. The second from top waveform 218 represents the position or rear clamp 44 during the bind sequence. The next waveform down, waveform 220, represents the state of carriage drive motor 58. The condition of tape feed solenoid 170 is indicated by waveform 222 and the state of tape feed motor 210 is represented by waveform 224.

The position of tape positioner gear 109 is represented by the angle of rotation of the gear from the home position, as determined by sensor 117. This angle is represented by waveform 226. The state of rotating platen 114, either horizontal or vertical, is represented by waveform 228. Finally, the positions of rear cam shoe 91 and front cam shoe 82 are represented by waveforms 230 and 232, respectively.

The timing diagram of Figures 25A and 25B will be periodically referred to in the following description of the operation of the subject binding apparatus. A flow chart of the primary program stored in memory 188, is depicted in Figures 26A - 26D. The beginning of the binding sequence is represented by element 234 of Figure 26A. An initialization subroutine is first entered, as shown by block 236.

The initialization subroutine is depicted in the flow diagram of Figures 27A and 27B. Block 340 represents power on. As indicated by block 342, a self-test sequence is carried out to confirm operation of the binding apparatus electronics. Next, the various stepping motors are initialized or placed in a proper state. Since the heated platen 112 will not yet have reached operating temperature, the message "HEATING" will be shown on front panel display 33 as indicated by block 346.

The state of the three control buttons 34a, 34b and 34c are then examined, as represented by element 348. If all three buttons are simultaneously depressed, the system enters a diagnostic mode, as indicated by block 350. The diagnostic mode forms no part of the subject invention and will not described.

Assuming that a self test is not requested, the program enters an eject tape subroutine as shown by element 352. This subroutine, which will be described later, is precautionary and functions to remove any binding tape which may be present in tape feed bar 110 from a previous binding sequence.

Solenoid 170 is then turned off thereby causing the tape guide assembly 152 to pivot away from feed roller 162, as shown by block 354 into the disengaged position. This enables blocking tab 158C (Fig. 13) to prevent premature tape feeding. Next, tape positioner gear 109 is set to the home position utilizing sensor 117, as shown by block 356. In this position, tape feed bar 110 is displaced from the heated platen (Figure 5) so that the feed bar will remain cool and not tend to melt the tape adhesive during tape feeding.

Referring to Figure 27B, a determination is made as to whether the heated platen 112 has reached operating temperature. As shown by element 362, the sequence will enter an idle mode until the platen is at temperature. Next, as shown by block 364, the carriage assembly is placed in the home position as depicted in Figure 24C. The carriage assembly is then driven to the open wide position as shown in Figure 24D, according to block 366. A determination is then made, as indicated by element 368, as to whether clamp sensor 98 is in the active state, with flag 100 disposed in the sensor slot. Since the rear clamp should be abutting boss 71 in the open wide state, the sensor should be active and an error message will issue in the event it is not active, as indicated by block 372. The initialize subroutine is then completed, and the sequence will return to the main program at element 238 in Figure 26A.

The display will then show a "READY" message as indicated by block 240. The states of "EDIT" button 34b, "BIND" button 34a and "OPEN" button 34c will then be periodically examined to determine whether an operator has depressed any of the buttons, as indicated by elements 242, 244 and 246, respectively.

Assuming that the operator wishes to bind a book, the operator would first position the book 36 to be bound between the front and rear clamps, making sure that the book is in a right-justified position. This stage is the binding sequence is represented by time = 0 seconds in the Figure 25A timing diagrams.

As can be seen in Figure 11, the book 36 initially rests on cool platen 104. The operator then actuates the "BIND" button 34a, which will be detected as indicated by element 244 of the Figure 26A flow chart. The book is then clamped as represented by block 250 of the flow chart.

Clamping is accomplished by causing the carriage drive motor 58 to be driven in the reverse direction as represented by waveform 220 of the Figure 25A timing diagram. For a book with a thickness of approximately one half inch, waveform 216 of the timing diagram indicates that the front clamp will be driven from the open position in a rearward direction for approximately one and one half inches until the front clamp engages the book. As indicated by waveform 218, the rear clamp will move away slightly from the home position thereby causing the clamp sensor 98 to change state, as depicted in Figure 24E and as shown in phantom in Figure 11. Drive motor 58 will then be turned off as indicated by waveform 220.

As previously noted, the distance required by the front clamp to travel from the reference position (in this case from the open wide position) to the clamped position is indicative of the thickness of the book 36. A value representing the book thickness is computed and stored, as represented by block 252 of the Figure 26A flow chart.

It should be noted that the reference position is determined by the thickness of the book last bound. For example, if the previous book called for a narrow tape, the reference position for the next bind would be the open narrow position. Similarly, is the previous book called for a medium tape, the reference position would be the open medium position.

As represented by element 254, the book sensor 92 is then examined to determine whether a book has been inserted, and, if so, inserted properly. Assuming that the book sensor does not sense a book, block 268 indicates that the carriage assembly will be opened. A "JUSTIFY" message will then be displayed for about 2 or 3 seconds as shown by blocks 270 and 272. The sequence will then cause a "READY" message to be displayed, as indicated by elements 238 and 240.

Assuming that the book was properly positioned (element 254), element 280 of the Figure 26B flow chart indicates that a start tape subroutine is entered into. The subroutine accomplishes loading of the binding tape 32.

The start tape subroutine is illustrated in Figure 30 flow chart. First, a determination is made as to whether there is presently a tape in the tape feed bar 111 by examining the inner and outer tape sensors 182, 184 and the tape width sensor 180. It is possible that a tape was inserted during a previous binding sequence, as will be described later.

If any of the three sensors detect the presence of a tape, a determination is made as to whether the tape was properly started. In the event the inner sensor 182 detects the presence of tape and the outer sensor 184 does not, an anomaly has occurred. As represented by element 450, a determination is made if such an anomaly has occurred, and if so, attempt is made to eject the tape by entering an eject tape routine represented by block 445, which will subsequently be described.

Assuming that the anomaly did not occur, a determination is made (element 452), whether the loaded tape is the correct width for the book to be bound. This is done by comparing the tape width just determined with a tape width value which was stored during the previous binding sequence. In the event the tape width is not correct, the eject tape subroutine will be executed.

Assuming that the tape width is correct, a determination is made as to whether the inner and outer tape sensors both detect the precence of the tape, as indicated by element 454. If both sensors do detect the tape, the tape is presently properly loaded. Accordingly, tape feeding is not required and the sequence returns to the main program as shown by element 456. If both sensors do not sense the presence of tape (element 454), an attempt will be made to load the tape properly and, if that is not possible, to eject the tape, as will be described.

Assuming that none of the three sensors detect the presence of tape, the display will show an "INSERT (X) TAPE" message with X being either "N" (narrow), "M" (medium) or "W" (wide) depending on the measured width of the book. In the present case, the one half inch thick book would dictate a narrow tape.

Once the message is displayed, tape positioner gear 109 will rotate to a position which corresponds to the width of the tape to be fed. The tape feed bar 111 will be positioned next to and spaced apart from tape guide 158 a distance which corresponds to the width of the tape to be fed into the machine as depicted in Figure 14 for a narrow tape and Figure 15 for a wide tape.

The timing diagram of Figure 25A shows the rotation of positioner gear 109 in waveform 226 at point 226(a) to the narrow tape position. The tape positioner gear 109 drives the tape feed bar 110 by way of shaft 108, as previously described. Note that the narrow tape requires a rotation from the home position of approximately 20 degrees, whereas the wide tape requires no rotation.

At the same time that the tape positioner gear is rotated (if required), the tape feed solenoid 170 is actuated as represented by block 434. Actuation of solenoid 170 causes the pivot arm 154 to pivot down to the tape drive position, as shown in Figure 14. Thus, the idler roller 160 will engage feed roller 162. Curve 222 of the Figure 25A timing diagram, at point 222(a) illustrates actuation of the solenoid.

The operator then proceeds to insert a binding tape 32 into the tape feed mechanism, with the adhesive strips up. At this time, the tape feed motor 210 is not running. A determination is then made, as represented by element 436 (Figure 30), whether outer tape sensor 184 (Figure 22) and tape width sensor 180 detect the inserted tape. Assuming that a tape of the correct width is properly inserted, sensors 180 and 184 will both detect the tape and the tape feed sequence will proceed. However, if a tape is not sensed, it is possible that either no tape has been inserted, or a tape of incorrect width has been inserted.

If tape is not detected, it is possible that the operator elected to terminate the binding sequence by depressing the "OPEN" button 34C. If the button was not depressed, the sensors are again examined, as shown by elements 444 and 436. If the user did actuate the "OPEN" button, the carriage assembly will open to accept the book, as indicated by block 446. The sequence will then return to the main program (Figure 26A) where the control button will be monitored for further input from the user.

If a tape of the correct width has been inserted, a timer is turned on which will limit the maximum time that the tape feed motor 210 will be permitted to run, as represented by block 438. The program will then proceed to execute a first feed subroutine, as indicated by blocks 440.

The first feed subroutine flow chart is depicted in Figure 31. As indicated by elements 458 and 460, a "PUSH IN TAPE" message is displayed to prompt the operator to push the tape into the machine so that it will be gripped between idler roller 160 and feed roller 162.

A determination is then made as to whether outer tape sensor 184 continues to sense the presence of the tape. If tape is no longer detected, the operator has withdrawn the tape. As represented by elements 462, 472 and 474, if the tape is not longer sensed, the display will be blanked and the sequence will return to the main program.

Assuming that the tape is still present, the timer associated with the tape feed motor is examined to determine whether it has timed out. If the timer has timed out, thereby indicating that a user has only partially inserted a tape for more than a predetermined amount of time, the sequence defaults to the main program, as indicated by elements 464, 472 and 474.

If the tape has been inserted properly, tape feed motor 210 will advance a single step, as indicated by block 466. The motor is driven in this manner so as to slowly grip the tape and withdraw the tape from the operator's hand. This step in the binding sequence is depicted by the tape motor feed waveform 224 in the Figure 25A timing diagram at point 224(a).

Each time the tape feed motor 210 has completed a step, the inner tape sensor 182 and outer tape sensor 184 are examined to determined whether the tape has been fed into the machine a sufficient distance so as to be detected by the inner tape sensor 182. As indicated by element 468, the tape feed motor will continue to single step until both sensors 182 and 184 detect tape.

Once both sensors 182 and 184 detect tape, the tape feed motor will advance twenty steps, as indicated by block 470, thereby insuring that the tape has been inserted sufficiently to actuate inner tape sensor 182. The sequence then returns to the start tape subroutine of Figure 30.

Returning to Figure 30, block 442 indicates that the timer which limits the amount of time the tape feed motor will run (block 438) is stopped. A determination is then made as to whether the inner tape sensor 182 has detected the presence of tape as represented by element 443. If the first feed subroutine was successful, all three tape sensors will detect the presence of tape.

Unless an anomaly has occurred, the inner sensor will be actuated. If it is not actuated, the eject tape subroutine will be entered, as shown by block 445.

Assuming that no anomaly has occurred, the sequence will return to element 428. The sensors will not all be clear of tape, therefore the sequence will proceed to element 450. At this point the inner sensor 182 will be detecting tape, as will the outer sensor 184. Accordingly, a determination is then made as to whether a tape of the correct width has been loaded, as shown by element 452. If the width is proper, both outer sensor 184 and tape width sensor 180 will detect the tape.

A determination will then be made as to the whether the inner and outer tape sensors detect tape, as indicated by element 454. If both detect tape, the tape is in the proper position for this stage of tape loading and the start tape subroutine is completed. The sequence will then return to the main program, as represented by element 450. If both sensors do not detect tape, an anomaly has occurred and the first feed routine (block 440) will be repeated.

Referring back to the main program at Figure 26B, as represented by block 282, a "BINDING" message will be displayed indicating that the binding sequence has commenced. A final feed subroutine is then entered as indicated by block 284. The final feed subroutine, which is depicted in Figure 32, completes the tape feeding sequence.

As indicated by elements 476 and 478 of the final feed subroutine, the tape feed motor 210 is then speeded up so that the remainder of the tape will be quickly fed into the binding apparatus. The change in tape feed speed is illustrated in the Figure 25A waveform 224 at point 224(b). The speed is increased by stepping the motor of a faster rate.

As represented by block 480, a tape feed counter is set to zero. For each motor step, the tape feed counter is incremented, as represented by block 484. The purpose of the counter is to limit the amount of time that the tape feed motor will be permitted to run as high speed. This feature would, for example, cause the motor to eventually drop back to the low speed in the event a partially inserted tape has become lodged in the machine. At low speeds, the motor has a large amount of torque and is less susceptible to being forced out of control by external forces such as a lodged tape. The increased torque also enables the motor to more easily free lodged tapes.

A determination is then made as to whether the end of the tape 32 has been fed past outer tape sensor 184. Assuming that the tape has not yet been fed to this point, outer sensor 184 will continue to sense tape. As represented by elements 486 and 492, the tape feed counter will then be examined to determine whether the maximum count has been reached.

Assuming that the maximum count has not been reached, the sequence returns to block 482 and the motor will advance another step at the fast speed. This sequence will continue until the end of the tape passes sensor 184 and sensor 184 no longer detects tape. At this point, the end of the tape will be located at a fixed position (Figure 22), just to the left of sensor 184. It is necessary to advance the tape further until the end of the tape coincides with end of book line 178.

As indicated by block 488, the tape is driven a fixed distance, approximately 1 inch and the motor decelerated until the end of the tape comes to rest at line 178. Waveform 224 of Figure 25, at point 224(c) shows the tape feed motor turning off after the tape has been fully fed. The sequence will then return to the main program.

Assuming that, for some reason, the tape feed counter had timed out (element 492), the sequence would have proceeded to element 494. This is an anomalous condition. A determination is made as to whether the tape speed is high. If so, the tape speed is set to slow, as indicated by block 496, and an attempt is made to feed the tape at the slower speed by returning to block 480 of the sequence. If the tape is not successfully fed at the slow speed, elements 498 and 500 indicate that an "ERROR FEEDING" message will be displayed and the binding sequence terminated.

If the tape is properly fed, block 285 of Figure 26B of the main program indicates that tape feed solenoid 170 will be turned off. This action is depicted by waveform 222 of Figure 25 at point 222(b) and causes the blocking tab 158C to prevent feeding of an additional tape during the remainder of the sequence.

Since the tape is fed into slot 113 of the relatively long tape feed bar, it is possible that the tape will not be seated evenly against the bottom of the slot of the feed bar. In order to ensure that the tape is seated evenly, the tape positioner gear 109 is rotated until the outer edge of the tape contacts the rear cam shoes 91 as shown in Figure

16. This action tends to force tape 32 completely into slot 113 of the tape feed bar 110 if the tape is not seated correctly.

As indicated by block 286 (Figure 26B), the positioner gear is rotated so as to seat the tape. The amount of positioner gear rotation required to cause the edge of tape 32 to contact the cam shoes 91 is a function of the width of the tape. Greater rotation is required, for example, in the event a narrow tape is being used in comparison to a wide tape. Waveform 226 of Figure 25A at point 226(b) shows the positioner gear 109 rotated approximately 100 degrees for a narrow tape.

When the positioner gear 109 is rotated, the outer cam bearing 138 (Figure 16) will engage lower surface 136a of lever arm 136. This causes rotating platen 114 to rotate from the horizontal position to a vertical position. This rotation of the platen is depicted in waveform 228 of the Figure 25A timing diagram at point 228(a).

The tape positioner gear 109 is then rotated to the position for forming the first seal between the tape and the book, as indicated by block 288. The first seal is made to the back cover 36b of the book (Figure 16). The exact position of the gear is a function of the measured width of the book and the thickness of the tape being used. A straightforward computation is made based upon the two values so that the tape will be sealed to the back cover 36b at the proper distance from the lower edge of the book. The objective is to have equal amounts of tape covering the front and back covers once the binding sequence has been completed.

Figure 16 shows the tape feed bar 110, in phantom, at the position for accomplishing the first seal. Waveform 226 at point 226(c) shows the rotation of tape positioner gear 109 required to position the tape feed bar at the first seal position.

Next, the carriage assembly is brought to the first seal position as represented by block 290 (Figure 26B). This is accomplished by driving both the front and rear clamps 46 and 44 rearward as represented by the carriage motor drive waveform 220 at point 220(a), the front clamp waveform 216 and the rear clamp waveform 218. The book is driven off the cool platen 104 towards the rotating platen 114, which is still in the vertical position.

The front and rear backup bars 76 and 84 will move with the front and rear clamps. The rear cam shoe 91 of the rear backup bar will eventually contact the vertical rotating platen 114 and ride up over the platen as shown in Figure 17. Thus, the rear cam shoes 91 and backup bar 84 will pivot upwards on rear support arm 86 as indicated by waveform 230 at point 230(a). At this stage, the edge of tape 32 will be positioned intermediate book 36 and vertical rotating platen 114. The height of the tape relative the to book will be such that equal amounts of tape will extend over the front and back covers of the book once the binding sequence is completed.

The front and rear clamps 46 and 44 continue to drive the book rearward towards rotating platen 114 until the platen is engaged and pressure applied to the platen. As shown in Figure 7, the moveable platen assembly 106 will be deflected rearward when pressure is applied causing platen springs 134 to expand slightly. This rearward movement is depicted in phantom in Figure 17. The carriage assembly then stops with both pressure and heat from rotating platen being applied to tape 32. The lower portion of book 36 will deflect slightly towards front backup bar 76. Bar 76 will prevent further movement of the book and will provide support for the book during the first seal.

Just as the first seal begins, the positioner gear 109 is rotated as represented by block 292. This rotation causes the tape feed bar to pivot away from the hot rotating platen 114 so that the bar will not become heated so as to interfere with tape loading during subsequent binding sequences. The rotation of the positioner gear 109, which is depicted at location 226(d) of Figure 25A. The positioner is rotated such that the rotating platen will remain in the vertical position when the book is subsequently backed off.

As indicated by block 294, the first seal is formed in about 1 second. During this time, the applied heat and pressure is sufficient to cause the high tack, heat-activated adhesive strip 32b disposed between the back cover 36b and the tape substrate 32a to form a bond.

As indicated by block 296, once the first seal has been formed, the carriage assembly is pulled forward as shown in Figure 18. This is accomplished by momentarily driving the carriage drive motor in the forward direction, as indicated by waveform 220 in Figure 25A at point 220(b). The binding tape 32 is exclusively supported by book 36 at this stage.

In the next stage of the sequence, the binding tape will be folded under book 36 by rotating platen 114 so that the low viscosity central adhesive strip 32c will contact the lower edge 36c of the book which will form the spine. In order to permit the rotating platen 114 to pass under the book, it is necessary to first pull the platen down slightly to accommodate the thickness of the binding tape 32.

As represented by block 298, the tape positioner gear 109 goes to a pull down position. The gear is rotated back to the home position and slightly past the home position so that inner cam bearing 142 (Figure 7) will engage the upper surface 136b of lever arm 136, thereby forcing platen assembly 106 down slightly. At this point the rotating platen will be pivoted to the horizontal position, as indicated in the waveform 228 at point 228(b). The location of positioner gear 109 in the pull down position is shown at point 226(e) of waveform 226 in Figure 25A.

For books that are relatively thin, less than about 1/16 inch thick, it is preferable that a few preliminary steps be carried out to facilitate the remainder of the binding sequence. Accordingly, as represented by element 300, a determination is made as to whether the book is thin. Assuming that the book is not thin, the carriage assembly is driven rearward to an over platen position, as represented by block 310.

Figure 19A shows the position of book 36 relative to platens 114 and 112 when the carriage is in the over platen position. The book 36 is carried rearward over platen 114, with the force the platen causing binding tape 32 to fold under spine 36c of the book so that the central adhesive 32c of the tape will contact spine 36c of the book is in the over platen position when the rear cover 36b of the book is positioned in the center of surface 114b of platen 114. As indicated by block 312, the tape positioner gear

109 is then rotated from the pull down position (block 298) to the home position, as represented by waveform 226 at point 226(f). The carriage drive motor 58 will pause briefly when the tape positioner gear is driven, since the motor controller or CPU 186 is capable of controlling only one motor at a time. This action causes the platen 114 to apply a slight upward force to book 36. The book is then driven further back towards the fold position, as will be described. At this time, a tension will be exerted on binding tape 32, causing the tape to be pulled tightly around the edge of the book.

The carriage assembly will continue to drive book 36 rearward until the book reaches the fold position, as shown by block 314. As can be seen in Figure 19B, when the book is in the fold position, front cover 36a is positioned slightly to the right of front surface 112c of platen 112. Thus, the front cover will be slightly to the right of the pivot axis of rotating platen 114. The action required to place the carriage assembly is the fold position is illustrated by the carriage drive motor waveform 220 at point 220(c).

The tape positioner gear 109 is then driven from the home position to a rotate platen position, as represented by block 316. This is shown by waveform 226 at point 226(g) of Figure 25A. This action causes rotating platen 114 to pivot from the horizontal position to the vertical position, as shown in Figure 20 about pivot pin 122. Also at this time, heat from heated platen 112 will commence melting the central adhesive strip 32C of the binding tape. As indicated by block 318, heat is applied for approximately 7 seconds. The two platens will also apply upward pressure against the book so that both pressure and heat are applied.

When platen 114 rotates during the initial phase of the central adhesive melting period, the platen strikes front cam shoe 82 on front support am 78. This causes the front backup bar 76 on support arms 78 to pivot upwards away from the path of the platen. Waveforms 228 and 232 illustrate the movement of platen 114 and front cam shoe 82 at points 228(c) and 232(a), respectively. Rotation of platen 114 causes the binding tape to fold a second time so that the front cover adhesive strip 32b will contact the front cover 36a of the book.

When the 7 second initial central adhesive melting period is over, block 320 indicates that the carriage assembly is driven slightly in the forward direction as shown in phantom in Figure 20. This can be seen by waveform 220 at point 220(d) of Figure 25A. The movement forces the book against surface 114a of platen 114. Front clamp 46 of the carriage assembly continues to be driven in the forward direction, but rear clamp 44 is restrained from further movement by book 30. The continued movement of forward clamp 46 causes the carriage springs 70 (Figure 6) to expand slightly, so that platen 114 will apply heat and pressure to the edges of the binding tape.

Rear backup bar 84 provides support for the book when the second seal is formed. In this position, front clamp 46 is no longer engaging the book and the book is free to be forced upward by the platen assembly a distance which corresponds to the thickness of the tape. Thus, the book will be at the proper vertical position for transfer back to cool platen 104, as will be described.

As shown, block 322 of Figure 26D, heat and pressure are applied for approximately 1 second so as to completely form the second seal. The carriage assembly is then placed in a back from seal position as indicated by block 323 and waveform 220 at point 220(e). This is accomplished by driving the assembly a short distance in the rear direction, allowing the front and rear clamps 40 and 44 to again grip book 36, as shown in Figure 21. The tape positioner gear 109 is then driven hack to the home position, as shown by block 324, and waveform 226 at point 226(h). This causes rotating platen 114 to pivot to the horizontal position and be reheated by heated platen 112. When platen 114 rotates, front backup bar 76 is free to drop down by the force of gravity. During the process, the central adhesive 32c continues to be heated by platen 112. Block 325 indicates that heating of the central adhesive continues for an additional 5 seconds.

At this point in the binding sequence, it is possible to commence loading of a binding tape to be used in the subsequent binding sequence. As indicated by block 326, solenoid 326 is actuated thereby causing the tape guide 158 (Figure 14) to pivot to the engaged position for tape feeding.

The display 33 will then depict an "Insert Tape For Next Bind" message, prompting the user to insert a tape, as indicated by block 327. The tape positioner will then go to a narrow, medium or wide position, depending upon the width of the tape being presently used, as shown by block 328. As previously described, the tape feed bar 110 and the tape guide 158 then define a tape feed path which corresponds to the width of the tape to be fed.

As shown by element 329, a determination is made as to whether the timer has timed out. If the user elects not to feed a tape for the subsequent bind, the present binding sequence continues. If a tape has been manually inserted before the time out, a determination is made as to whether either the outer tape sensor 184 or the tape width sensor 180 sense the presence of tape. If tape is sensed, the first feed (Figure 31) subroutine is entered, as indicated by block 331. The tape will become completely fed during the subsequent binding sequence. Assuming that no tape has been inserted or assuming that the first feed subroutine has been completed, the sequence advances to block 332. The remainder of the sequence will be described later.

Returning to element 300, of Figure 26C, if it is determined that the book is thin, a few preliminary Steps will be carried out prior to driving the carriage to the over platen position (block 310). It has been found that there is a tendency for very thin books to be vertically deflected by the upward force exerted on the books when the second seal is formed. This tendency is eliminated if the relatively thick central adhesive strip 32a is melted prior to the formation of the second seal. Thicker books have sufficient rigidity to resist the upward force, and therefore, the extra steps are not required.

Assuming that the book is thin, the carriage assembly is driven to a melt to fold position as represented by block 302. (This portion of the sequence is not depicted in the waveforms of Figures 25A and 25B.) The tape positioner gear 109 will be in the pull down position, and the carriage assembly will be driven forward thereby causing the rotating platen to engage the binding tape 32 as depicted in Figure 19C. In this position, rear cover 36b is approximately aligned with surface 114c of the rotating platen.

As shown by blocks 304 and 306, the tape position is brought from the pull down position to the home position so that platen 114 will rise slightly so as to apply force to the binding tape 32. Heat and pressure are then applied for about 2 seconds so that the central adhesive 32c is melted in the region where the first fold is to be made. The tape positioner is then returned to the pull down position, as represented by block 308, thereby removing the applied force. The sequence then returns to block 310 where the remaining binding steps are carried out in the same manner as for a thicker book.

Returning to Figure 26D, once the second seal has been formed, the carriage assembly is returned to the home position, as indicated by block 332 and point 220(f) of waveform 220. Prior to this point, platen 112 continues to apply heat to the central adhesive 32c to ensure that the molten adhesive has thoroughly wetted the edges of the sheets which form the book. As shown in phantom in Figure 21, when in the home position the book is shifted horizontally in the forward direction by front and rear clamps 46 and 44 until the finished book is positioned over cool platen 104. When the carriage assembly is driven to the home position the front and rear clamps 46 and 44 release the book.

The carriage clamps are then opened to either a narrow, medium or wide position, depending upon the thickness of the book which was just bound, as shown by block 333. In the event a thin book is to be bound, the front and rear clamps 44 and 46 provide more support for the book in the open narrow position. This feature also speeds up the binding process for a large number of books of the same thickness since a significant amount of time is required for the clamps to travel from the open wide position to a clamped position for a narrow book.

In the event the next book to be bound is wider than the book just bound, the operator can depress the OPEN button 34c. As can be seen by blocks 246 and 248 of the main program flow chart of Figure 26A, this will cause the carriage assembly to go to the open wide position (Figure 24D). Finally, as represented by blocks 334, 335 and 336, a "FINISHED" message will be displayed for 2 seconds. This completes the binding sequence. The program then returns to the "Ready" state of the sequence (block 240) of Figure 20A.

It is possible to edit a book which was previously bound by either adding or deleting sheets. There is, of course, a limit to the number of sheets which can be added to a previously bound book. Referring to the flow chart of Figure 26A, the control buttons are sequentially scanned as represented by blocks 242, 244 and 246 in the main program flow chart, as shown in Figure 26A.

In the event a previously bound book is to be edited, the book is placed between the front and rear clamps, and justified to the right. If the clamps are not opened sufficiently wide to accept the book, the operator can depress the OPEN button and the carriage assembly will go to the open wide position, as shown by block 248.

Once the book to be edited has been placed between the clamps, the operator actuates the EDIT button 34b. The book is clamped and the thickness of the book is measured (blocks 256 and 260), in the same manner as in an ordinary bind (Figures 24A-E). If the book sensor 92 does not sense a book (block 260), the carriage is driven to the open wide position, a "JUSTIFY" message is displayed for about 2-3 seconds, as indicated by blocks 268, 270 and 272.

Assuming that the book has been properly positioned, the eject tape routine is entered for the purpose of removing a tape which may be present in the tape feed bar. The subroutine, which will be described later is represented by block 262.

Assuming further that no tape is present in the machine, solenoid 170 of the tape feed mechanism is turned off (block 264) so that the blocking tab 158c is positioned to prevent feeding of tape (Figure 11). An edit cycle subroutine is then entered, as shown by block 266.

A flow chart for the edit cycle subroutine is depicted in Figure 29. As represented by elements 402 and 404, and "EDIT PREP" message is first displayed. This indicates that the preliminary editing steps are to commence. As indicated by block 406, the tape positioner gear 109 is driven to the pull down position whereby the platen assembly 106 is lowered to a position slightly below cool platen 104 on which the bound book is resting. The rotating platen 114 is in the horizontal position. Next, the carriage is brought to the fold position, such as depicted in Figure 19B, as indicated by block 408. The front and rear clamps 46 and 44 move rearward, transferring the bound book from cool platen 104 to the heating platen 112.

The tape positioner gear 109 is then driven to the home position, as represented by block 410, so that platen 112 will apply an upward force to the book. There is then a 7 second pause (block 412) to permit the central adhesive strip 32c to remelt. The carriage assembly is then returned to the home position (block 414) so that the book will return to the cool platen 104.

The carriage is then opened to the narrow, medium or wide position depending on the thickness of the book to be edited as indicated by block 418. An "EDIT NOW" message is then displayed as shown by block 420. The message is displayed for about 2 seconds and the sequence returns to the main program as indicated by block 422 and element 424. (Why two display blocks?) At this time, the central adhesive 32C will be melted. The front and rear cover seals will not be effected. The user can then remove one or more sheets from the book by gripping the sheets and pulling the sheets from the book. One or more sheets can be added by placing the sheets at the desired locations and forcing the edges of the sheets into the molten central adhesive. As described below, any added sheets will have to be bound.

At the main program (Figure 26A), the state of the control buttons is again monitored. If one or more sheets had been added during the edit cycle, the edit cycle is repeated to bind the added pages. This is accomplished by repositioning the book in the carriage and depressing the EDIT button a second time.

The eject tape subroutine, used in the primary program (block 262, Figure 26A), the start tape subroutine (block 445, Figure 30) and the initialize subroutine (block 352, Figure 27A), functions to remove tape that may be present in the binding apparatus. The eject tape subroutine flow chart is shown in Figure 28. As indicated by elements 376 and 378, a determination is first made as to whether either outer tape sensor 184 (Figure 22) or tape width sensor 180 detects the presence of tape in feed bar 110. If neither sensor is actuated, a determination is made as to whether the inner tape sensor 182 senses tape (element 394). If no tape is sensed here, there is no tape present, and the sequence returns to the program which called for the subroutine, as indicated by element 400.

Assuming that either or both of sensors 180 and 184 sense tape, the tape feed mechanism solenoid 170 (Figure 10) is turned on (block 380). When in the tape drive mode, idler roller 160 will engage feed roller 162. The tape feed motor 210 is turned on so as to drive the feed roller 162 in the reverse direction. If a tape has been pinched between rollers 160 and 162, the tape will be driven for approximately 3 inches in the reverse direction. As set forth below, this may cause the end of the tape to protrude out of the apparatus through opening 150 so that the tape can then be manually removed.

A determination is then made as to whether inner sensor 182 senses tape (block 384). If tape is sensed, a determination is made as to whether both the outer tape sensor 184 and tape width sensor 180 fall to detect the presence of tape, as shown by element 38b. If either sensor detects tape, the end of the tape should be protruding from the binding machine so that it can then be manually removed. The tape feed solenoid 170 is turned off so that rollers 160 and 162 release the tape, as indicated by block 388.

As shown by block 390, a "REMOVE TAPE" message is then displayed. Once the tape has been manually removed, none of the tape sensors will detect the presence of tape. As indicated by elements 392 and 400, the sequence will then return to the calling program. The tape can also be manually removed in the event the inner tape sensor does not detect the presence of tape (element 384), while either the outer, tape sensor or the tape width sensor do detect tape (element 378).

In the event the inner sensor 182 detects tape (element 384), but neither outer sensor 184 nor tape width sensor 180 detect tape (element 386), an anomaly has occurred. It is probable that the right end of the tape is so far to the left of sensors 180 and 184 (Figure 22) that any attempt to remove the tape by reversing the tape feed drive will cause a tape jam. In that event, no attempt will be made to automatically eject the tape. As indicated by blocks 396 and 398, an "ERROR EJECTING TAPE" message will be displayed and the sequence will end. It will be necessary to manually remove the tape. This can be easily accomplished since the moveable platen assembly 106 can be pivoted away from the tape feed bar, as depicted in phantom in Figure 9B.

Thus, a preferred embodiment of the book binding apparatus has been disclosed. Although the preferred embodiment has been described in some detail, changes can be made by those skilled in the art without departing from the spirit and scope of the invention, as defined by the appended claims.

Claims

1. Apparatus for binding a plurality of sheets arranged in a stack (36) utilizing a binding tape (32) which includes a flexible tape substrate (32a) which carries an adhesive (32b, 32c), with the tape (32) being bonded to first and second cover sheets (36b, 36a) of the stack (36) and engaging an edge of the stack (36) so as to form a spine, and with the tape having one of a plurality of predetermined tape widths to accommodate stacks (36) of varying thickness, said apparatus comprising:

stack support means (44, 46, 104, 76, 84) for supporting the stack (36) of sheets;

tape positioner means (108, 109, 110, 111, 204) for receiving the tape (32) and positioning the tape (32) with respect to the stack (36), including first tape support means (108, 110, 111, 113) for supporting the tape (32) and having a first tape guide surface (113) which engages a first edge of the tape (32) and second tape support means (152) for supporting the tape (32) and having a second tape guide surface (158) which engages a second edge of the tape (32), opposite the first edge;

platen means (106, 112, 114) for applying the tape (32) to the stack (36) of sheets so as to form the spine, a first cover seal and a second cover seal; and

control means (185, 198, 202) for controlling said stack support means (44, 46, 104, 76, 84), and said platen means (112, 114) so as to form the spine, first cover seal and second cover seal,

characterized in that said control means (185, 198, 202) includes measuring means (58, 60, 185, 198) for automatically measuring the thickness of the stack (36) to be bound when the tape positioner means (108, 109, 110, 111, 204) is in a tape load mode, and

in that the control means (185, 198, 202) further includes means (206) associated with the tape positioner means (108, 109, 110, 111, 204) for automatically adjusting the distance between the tape guide surfaces (113, 158) in response to the measuring means (58, 60, 185, 198) when the tape positioner means (108, 109, 110, 111, 204) is in the tape load mode, so that the first and second tape support means (108, 110, 111, 113 and 152) can support a tape (32) having one of the predetermined widths based upon the thickness of the stack (36) to be bound.

2. The apparatus of claim 1, characterized in that the first tape support means (108, 110, 111, 113) is movable between a tape load position when the tape positioner means (108, 109, 110, 111, 204) is in the tape load mode and a binding position when the tape positioner means (108, 109, 110, 111, 204) is in a binding mode, and when the tape positioner means is in the binding mode the control means (185, 198, 202) functions to position the first tape support means (108, 110, 111, 113) relative to the stack (36) at a location dependent upon the thickness of the stack (36), as determined by the measuring means (58, 60, 185, 198), to permit the second edge of the tape (32) and the first cover sheet (36b) of the stack (36) to be forced together.

3. The apparatus of claim 2, characterized in that the second tape support means (152) is moveable between a tape load position when the tape positioner means (108, 109, 110, 111, 204) is in the tape load mode and a binding position, displaced from the tape load position, when the tape positioner means (108, 109, 110, 111, 204) is in the binding mode, so that the second tape support means (152) is positioned such that the first tape support means (108, 110, 111, 113) is free to move between the tape load position and the binding position.

4. The apparatus of claim 3, characterized in that the first tape support means (108, 110, 111, 113) includes mounting means (108, 111) for causing the first tape guide surface (113) to move in an arc between the tape load and binding positions.

5. The apparatus of claim 4, characterized in that the mounting means (108, 111) includes a rotatable shaft (108) and a support arm (111) connecting the tape guide surface (113) to the shaft (108).

6. The apparatus of claim 5, characterized in further including tape drive means (160, 162, 164, 166) for sensing when the tape positioner means (108, 109, 110, 111, 202) is in the tape load mode and for drawing a tape (32) into the tape positioner means (108, 109, 110 111, 204) at the beginning of a binding operation.

7. The apparatus of claim 6, characterized in that the tape (32) is manually inserted into the tape positioner means (108, 109, 110, 111, 204), and in that the tape drive means (160, 162, 164, 166) initially draws the tape (32) into the tape positioner means (108, 109, 110, 111, 2049 at a first rate of speed and then draws the tape (32) at a second rate of speed greater than the first rate.

8. The apparatus of claim 6, characterized in that the tape drive means (160, 162, 164, 166) includes first and second drive elements (160, 162) which engage the tape (32) on opposite sides thereof when the tape positioner means (108, 109, 110, 111, 204) is in the tape load mode and with the first drive element (160) being supported on the second tape support means (152).

9. The apparatus of claim 8, characterized in that the first and second drive elements (160, 162) are first and second rollers (160, 162), respectively, and in that the first roller (160) is an idle roller (160) and the second roller (162) is a driven roller (162).

10. The apparatus of claim 9, characterized in that the tape (32) is manually inserted into the tape positioner means (108, 109, 110, 111, 204) and the tape positioner means (108, 109, 110, 111, 204) includes blocking means (158c) for preventing insertion of the tape (32) when the tape positioner means (108, 109, 110, 111, 204) is in the binding mode.

11. The apparatus of claim 10, characterized in that the blocking means (158c) includes a tab member (158c) mounted on the second tape support means (152) which obstructs a tape feed path along which the tape (32) is inserted into the tape positioner means (108, 109, 110, 111, 204) when the second tape support means (152) is in the binding position and moves away from the path when the second tape support means (152) is in the tape load position.

12. The apparatus of claim 1, characterized in that said control means (185, 198, 202) includes a single positioner motor (204) which functions to control the position of the platen means (106, 112, 114) relative to the tape (32) during the formation of the spine, first cover seal and second cover seal, and in that said single positioner motor (204) is also part of the tape positioner means (108, 109, 110, 111, 202) and functions to adjust the distance between the first and second tape guide surfaces (113, 158) when the tape positioner means (108, 109, 110, 111, 204) is in the tape load mode.

13. The apparatus of claim 12, characterized in that the platen means (106, 112, 114) includes first and second platens (112, 114), with the second platen (114) being rotatable relative to the first platen (112) between first and second rotated positions during the formation of the first and second cover seals, and in that said single positioner motor (204) also functions to rotate said second platen (114) between said first and second rotated positions.

14. The apparatus of claim 13, characterized in that the first and second platens (112, 114) move together between a first platen position wherein the tape (32) is forced against the edge of the stack (36) so as to form the spine and a second platen position wherein the tape (32) is folded around the end of the stack (36), and in that the single positioner motor (204) further functions to move the first and second platens (112, 114) between the first and second platen positions.

15. The apparatus of claim 14, characterized in that the single positioner motor (204) drives a single rotatable element (109) which functions to control the distance between the first and second tape guide surfaces (113, 158), to control movement between the first and second rotated positions and to control movement between the first and second platen positions.

16. A method of binding a plurality of sheets arranged in a stack (36) utilizing a tape (32) having a flexible substrate (32a) which carries an adhesive (32b, 32c), with the tape (32) having one of a plurality of predetermined tape widths to accommodate stacks (36) of varying thickness, said method comprising the steps of:

supporting the stack (36) of sheets;

supporting a first edge of the tape (32) utilizing a first tape guide surface (113) which engages the first edge of the tape (32) and supporting a second edge of the tape, opposite the first edge, utilizing a second tape guide surface (158);

positioning the tape (32) with respect to the stack (36); and

applying the tape (32) against the stack (36) of sheets thereby forming a spine, a first cover seal and a second cover seal,

characterized by the steps of:

automatically measuring the thickness of the stack (36) to be bound, and

automatically adjusting the spacing between the first and second tape guide surfaces (113, 158), based upon said step of measuring, so that the respective tape guide surfaces (113, 158) are spaced apart from one another a distance which corresponds to one of the predetermined tape widths so as to accommodate the tape (32) having the one predetermined width.

17. The method of claim 16, characterized in that the step of forming the first cover seal includes the step of positioning the tape (32) relative to the first cover (36b) at a location based upon said step of automatically measuring.

18. The method of claim 17, characterized in that the step of positioning the tape (32) relative to the first cover (36b) includes the step of supporting the tape (32) only at one of the opposite tape edges.

19. The method of claim 18, characterized in that the step of supporting the tape (32) only at one of the opposite tape edges is carried out utilizing one of the respective tape guide surfaces (113).

20. The method of claim 19, characterized in that, subsequent to the step of forming the first cover seal, the tape (32) is supported independent of the respective support surfaces (113, 158).

21. The method of claim 16, characterized in that the step of supporting the tape (32) at opposite edges includes the step of forming a tape feed path defined by the respective tape guide surfaces (113, 158), and in including the further steps of disposing an end of one of the tapes (32) into the tape feed path, and drawing the disposed tape (32) along the tape feed path until the tape (32) is at a tape load position with one tape end being positioned in alignment with one end of the stack (36) to be bound and a second tape end, opposite the one tape end, is positioned in alignment with another end of the stack (36) to be bound.

22. The method of claim 21, characterized in that the step of drawing includes the step of driving the tape (32) towards the tape load position at a first rate of speed followed by the step of driving the tape (32) towards the tape load position at a second rate of speed greater than said first rate of speed.

23. The method of claim 22, characterized in including the step of preventing another one of the tapes (32) from being drawn into the tape feed path when the first cover seal is being formed.

24. The method of claim 23, characterized in that the step of preventing includes the step of positioning a blocking element (158c) in the tape (32) feed path.

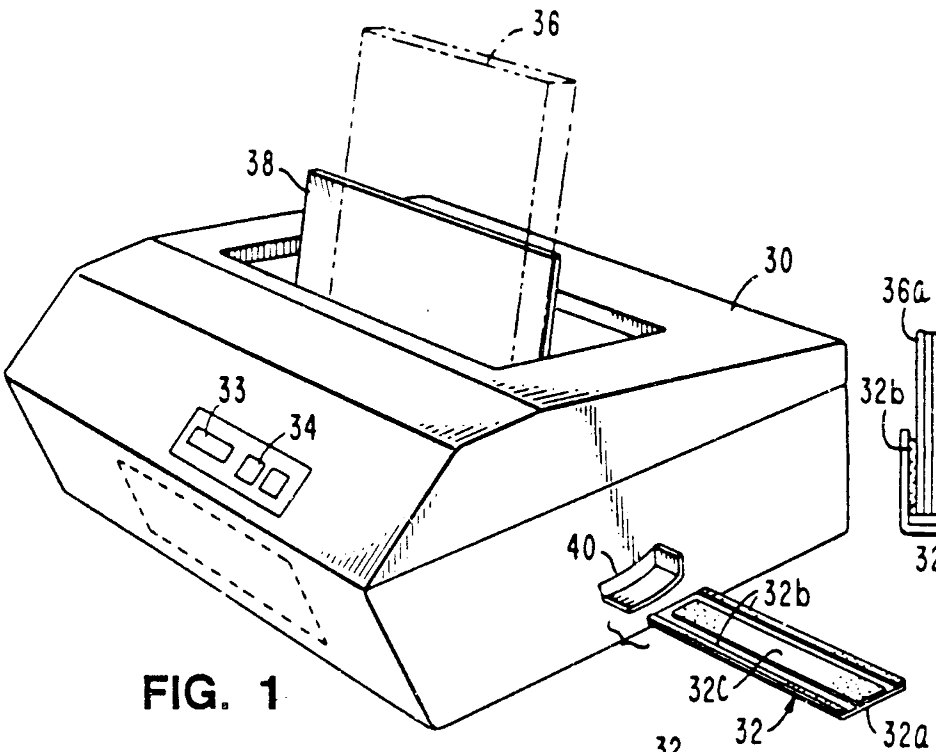


FIG. 1

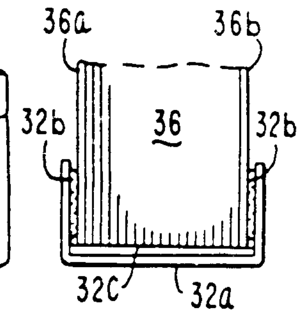


FIG. 3

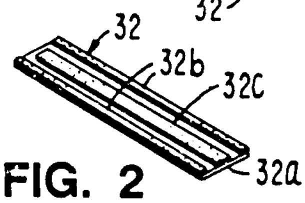


FIG. 2

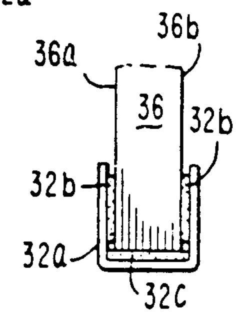


FIG. 4

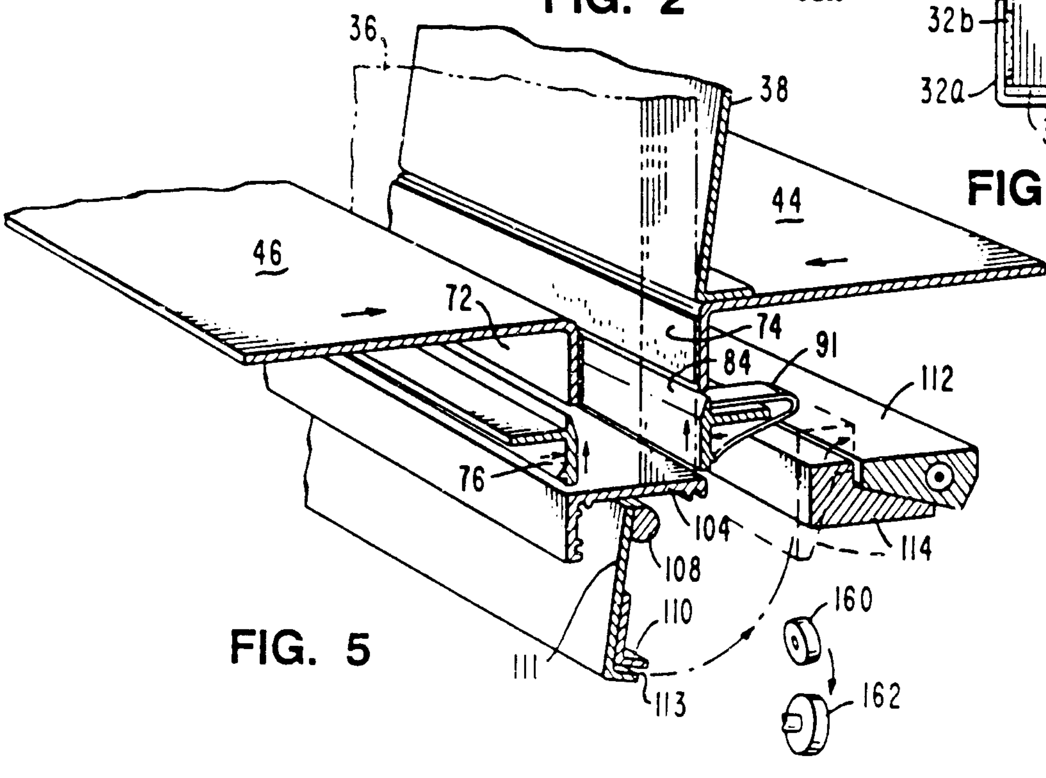
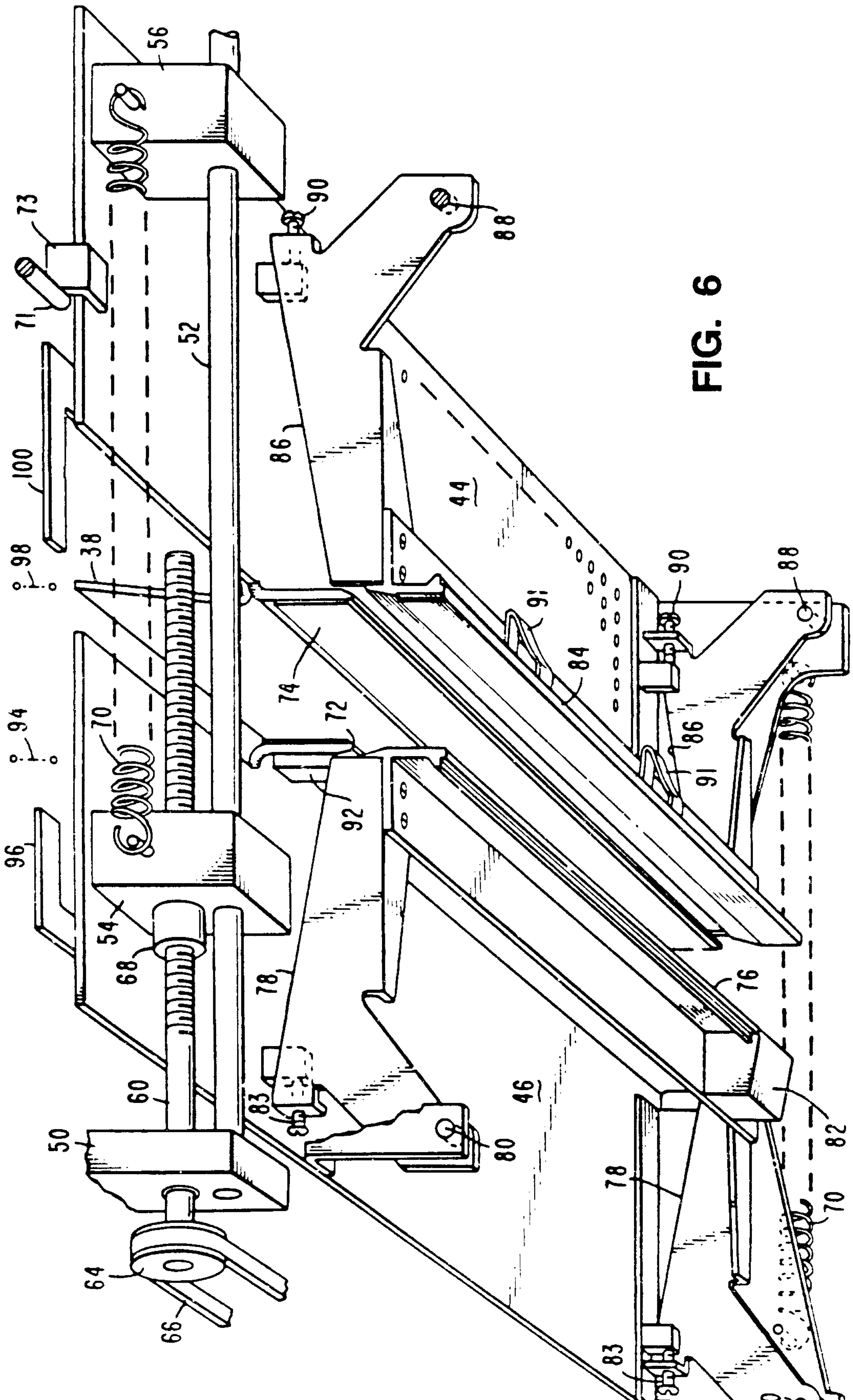


FIG. 5


56
73
71
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90
88
100
98
38
86
44
94
70
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91
84
90
88
96
92
86
91
54
68
78
76
60
83
50
80
46
82
78
70
64
66
83
80

FIG. 6

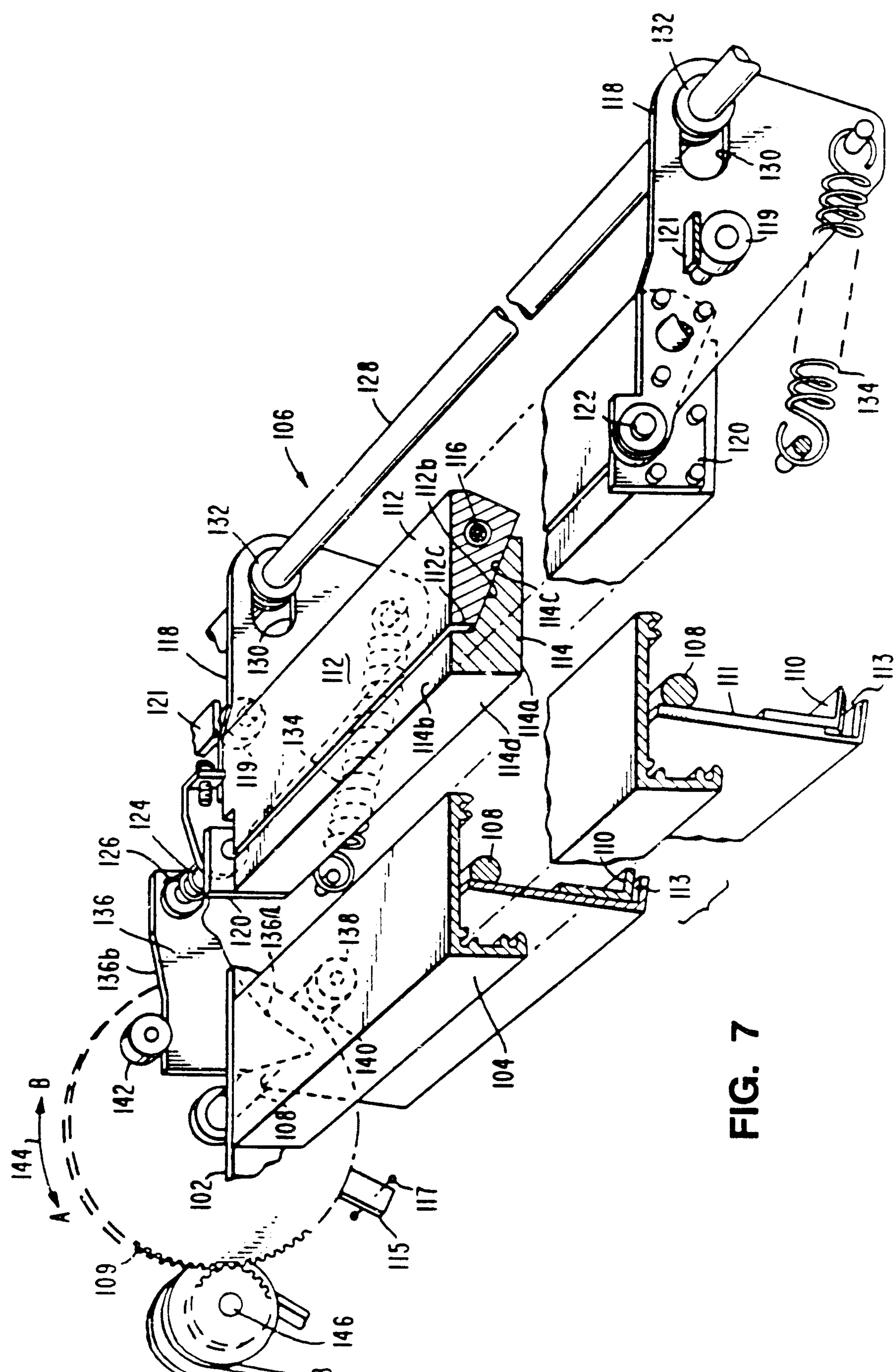

132
118
130
121
119
128
106
134
122
120
116
112b
112
112C
114C
114
114a
114d
114b
108
111
110
113
124
126
136
136b
136a
138
140
104
142
144
B
A
102
117
115
109
146
148

FIG. 7

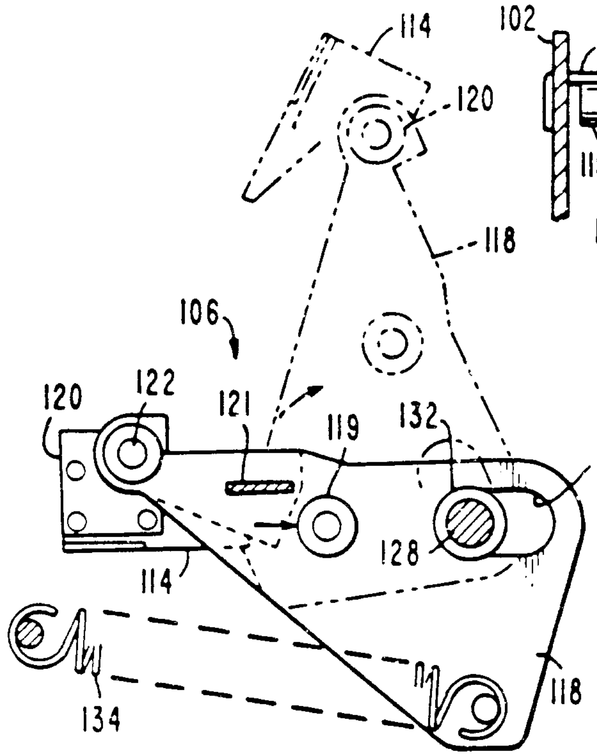


FIG. 9B

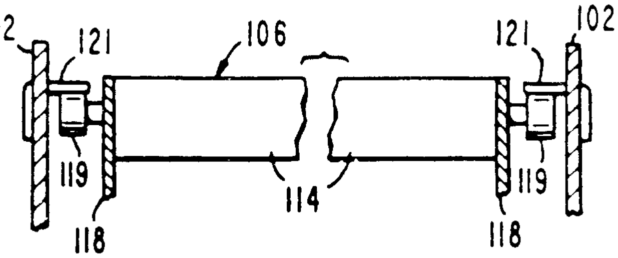


FIG. 9A

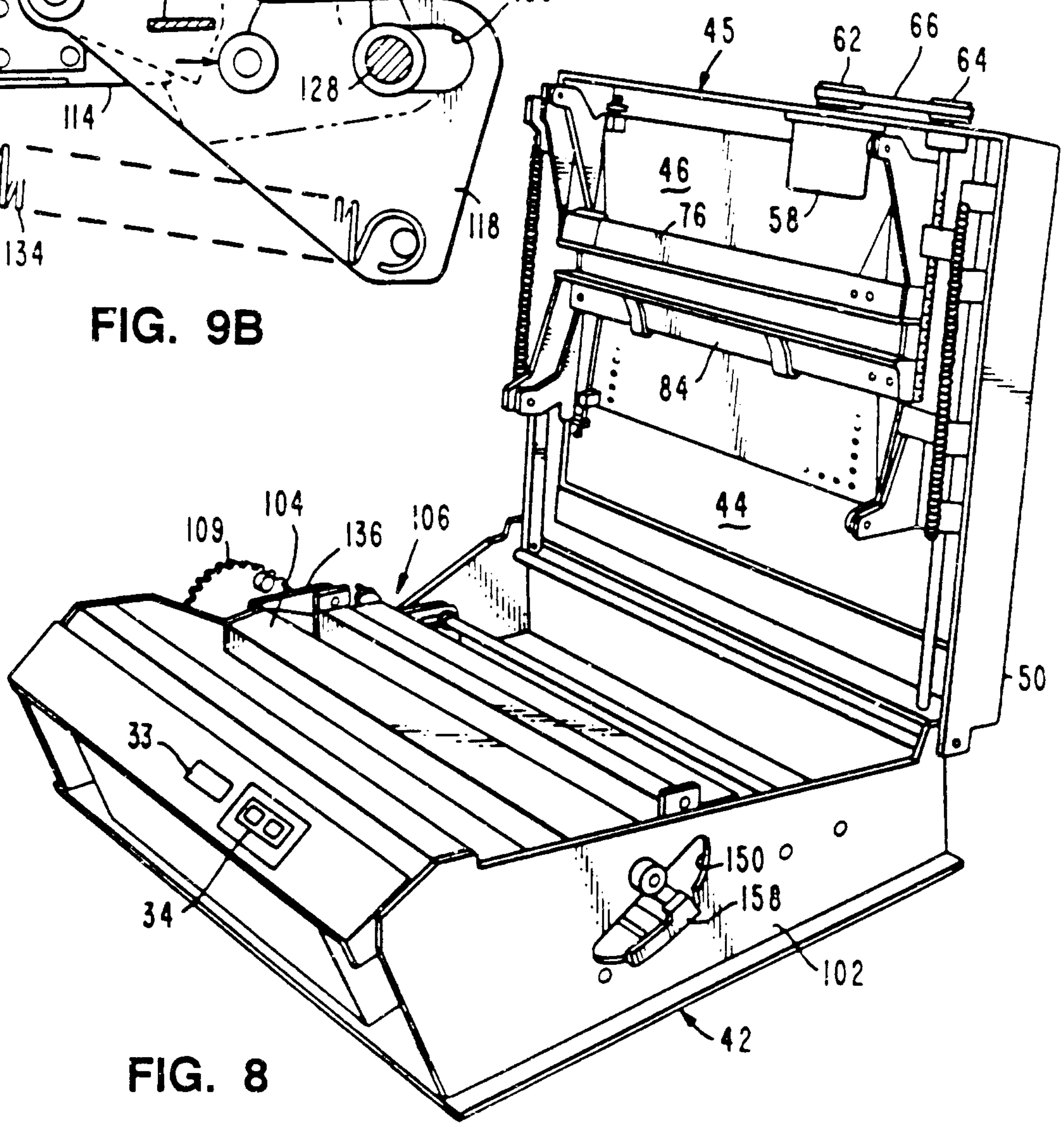


FIG. 8

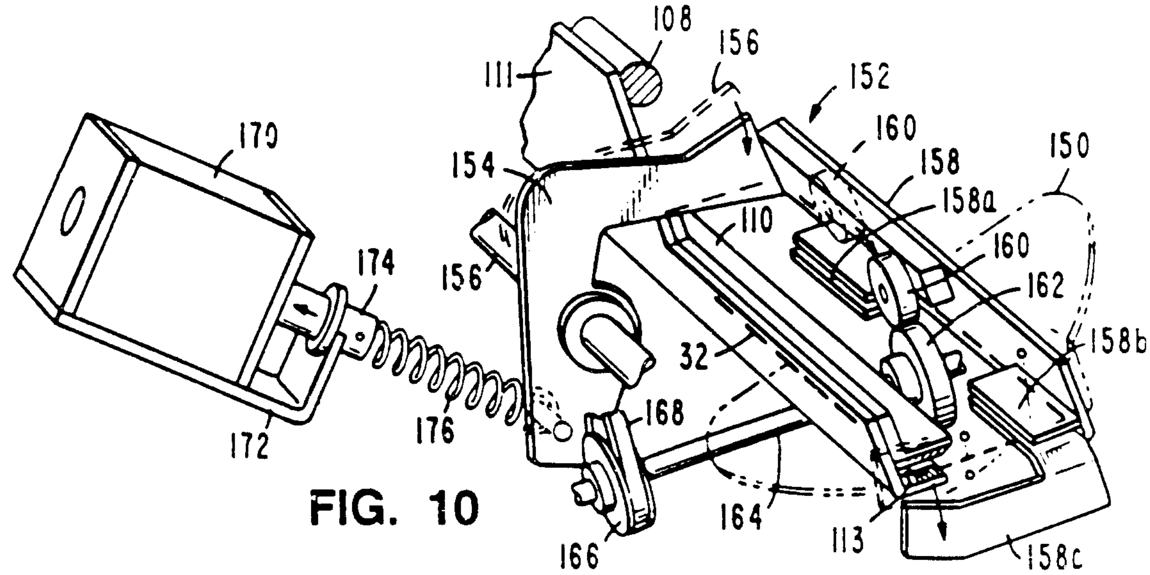


FIG. 10

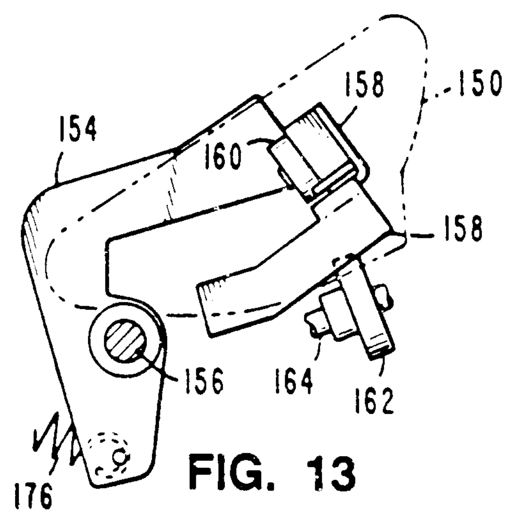


FIG. 13

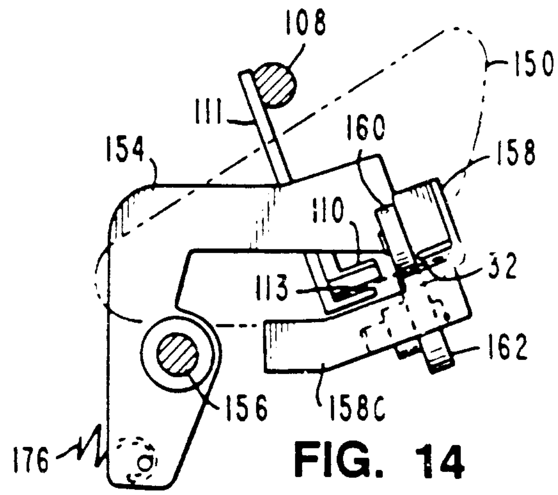


FIG. 14

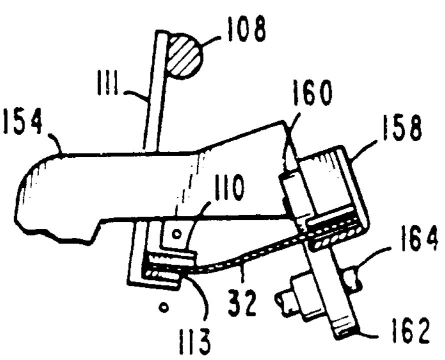


FIG. 15

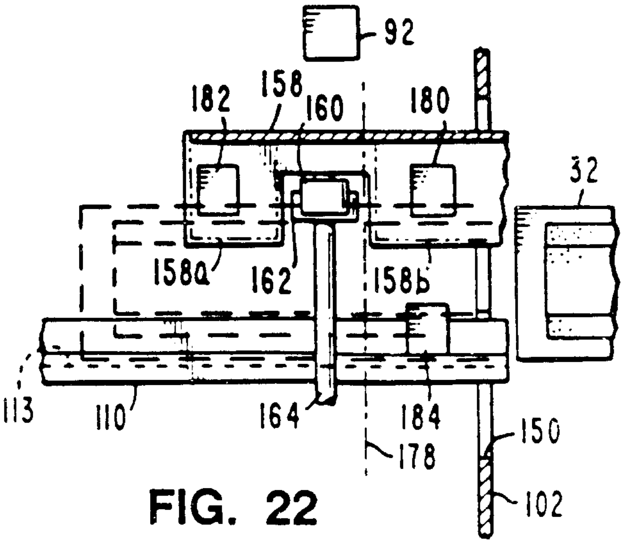


FIG. 22

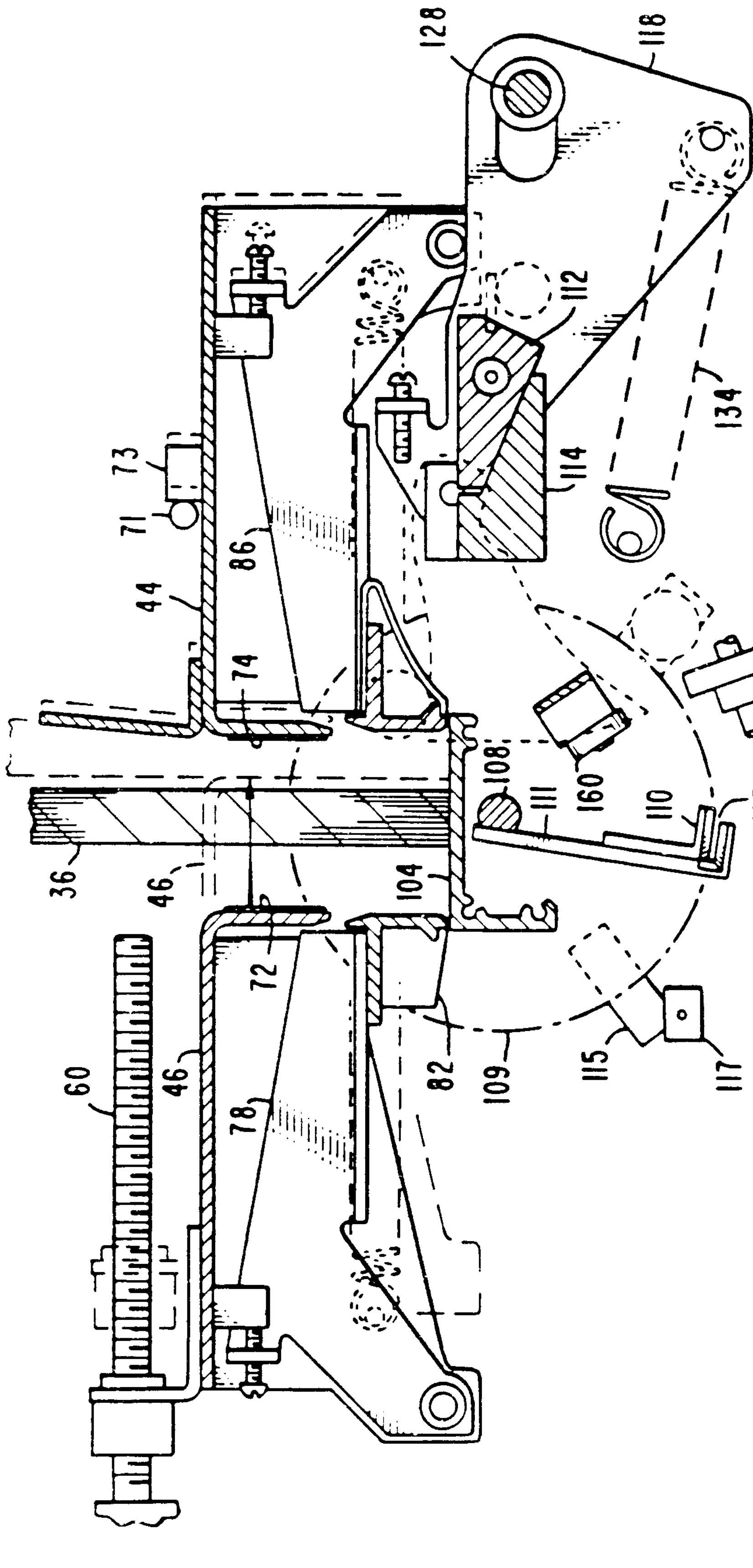

128
116
112
134
114
73
71
44
86
74
162
108
160
111
110
113
36
46
104
72
60
46
82
109
78
115
117

FIG. 11

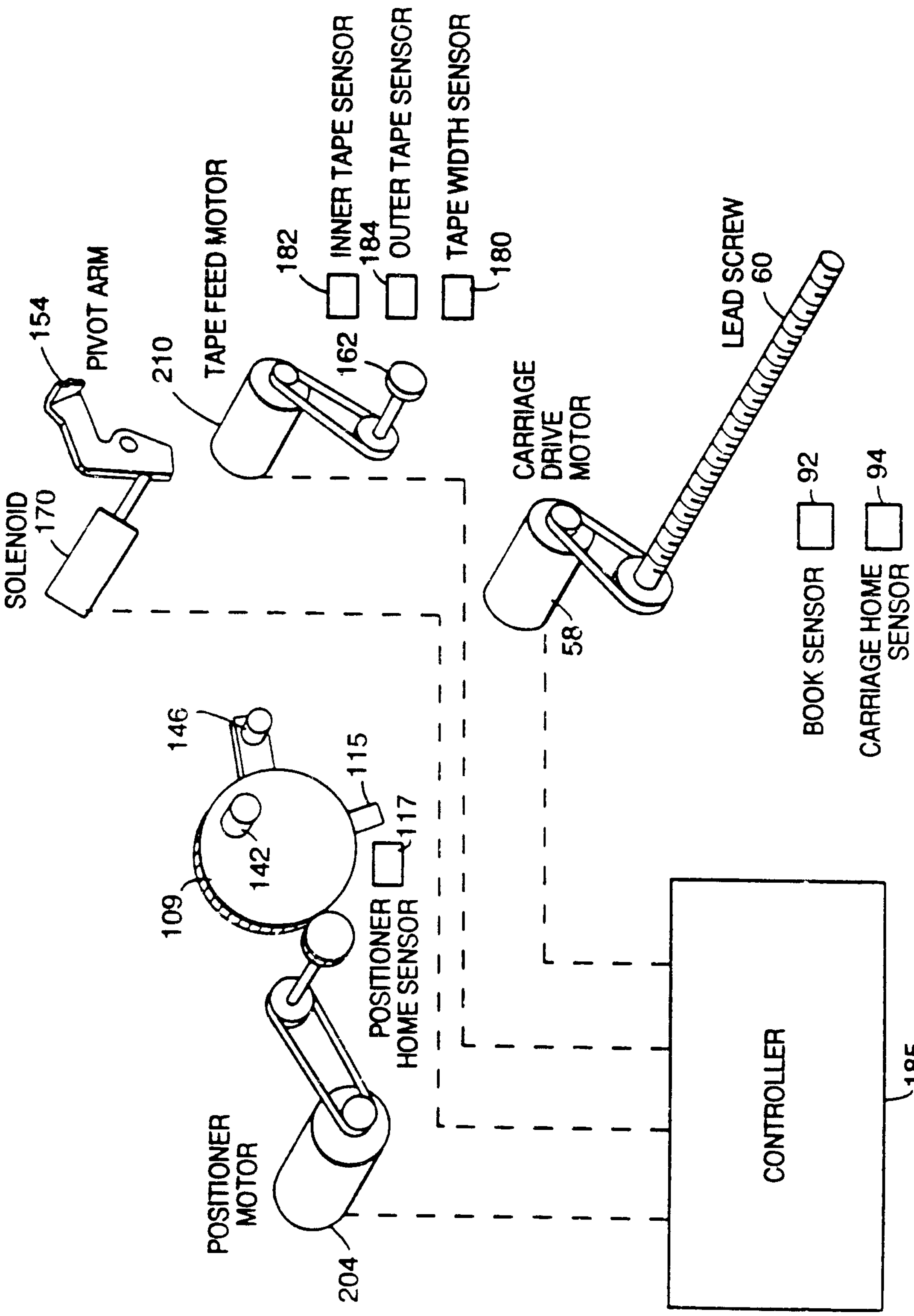
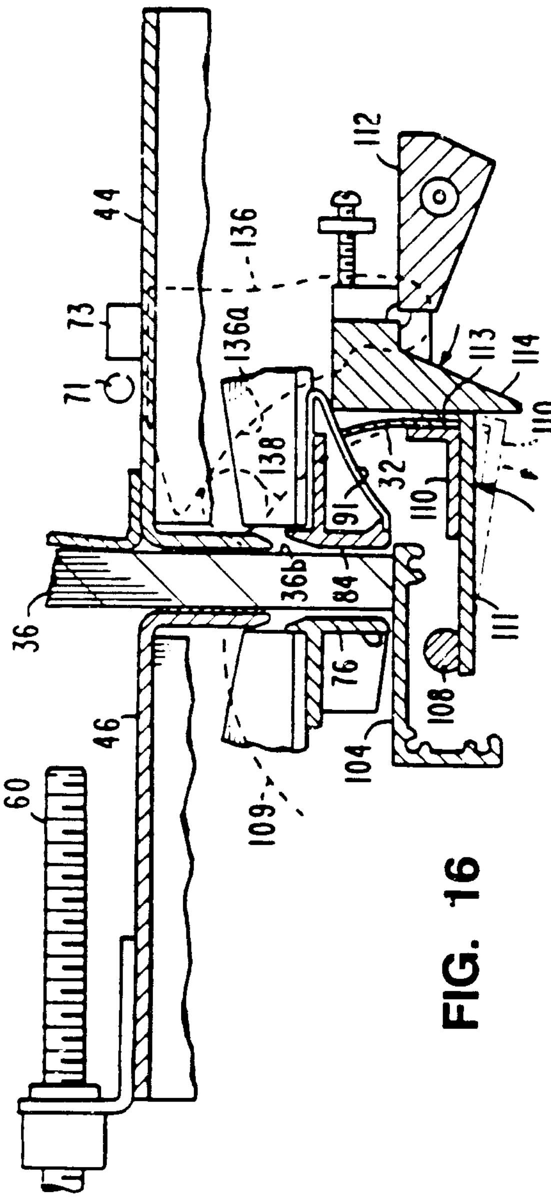
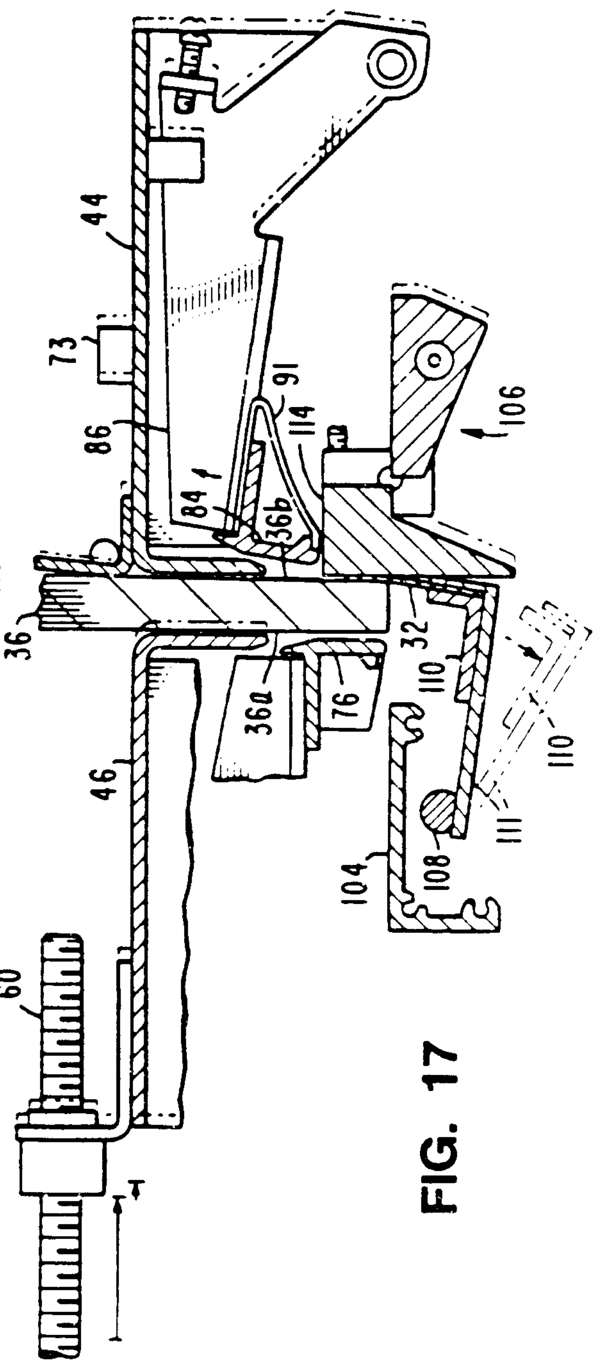

SOLENOID
170
154
PIVOT ARM
210
TAPE FEED MOTOR
162
182
INNER TAPE SENSOR
184
OUTER TAPE SENSOR
TAPE WIDTH SENSOR
180
LEAD SCREW
60
CARRIAGE
DRIVE
MOTOR
58
92
94
98
BOOK SENSOR
CARRIAGE HOME
SENSOR
CLAMP SENSOR
146
115
117
142
109
POSITIONER
HOME SENSOR
POSITIONER
MOTOR
204
CONTROLLER
185

FIG. 12



36
46
60
109
104
108
76
84
36b
111
110
91
32
138
136a
71
73
136
44
112
113
114

FIG. 16



36
46
60
104
108
111
110
76
36a
32
84
36b
86
73
44
91
114
106

FIG. 17

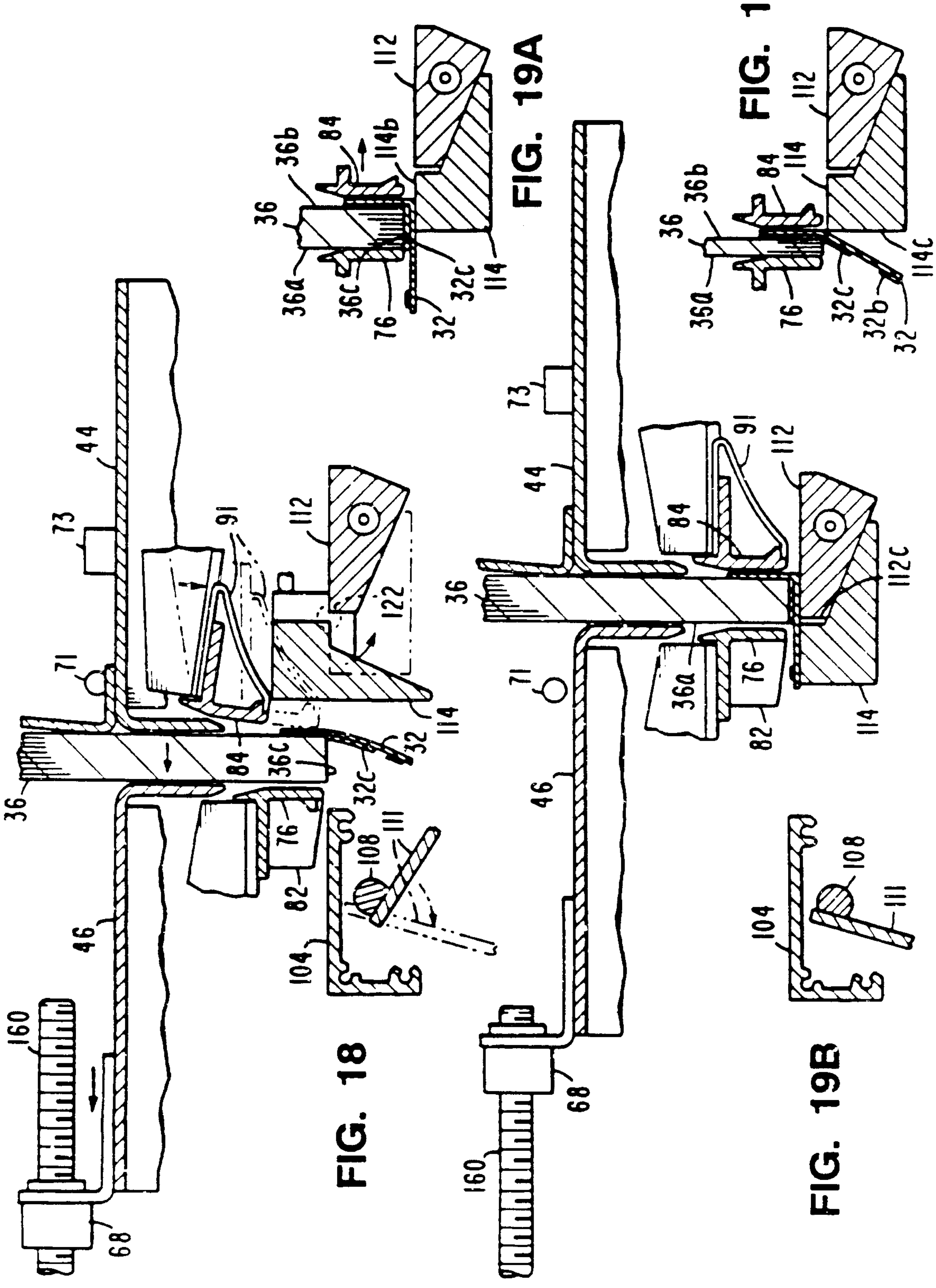


FIG. 18

FIG. 19A

FIG. 19B

FIG. 19C

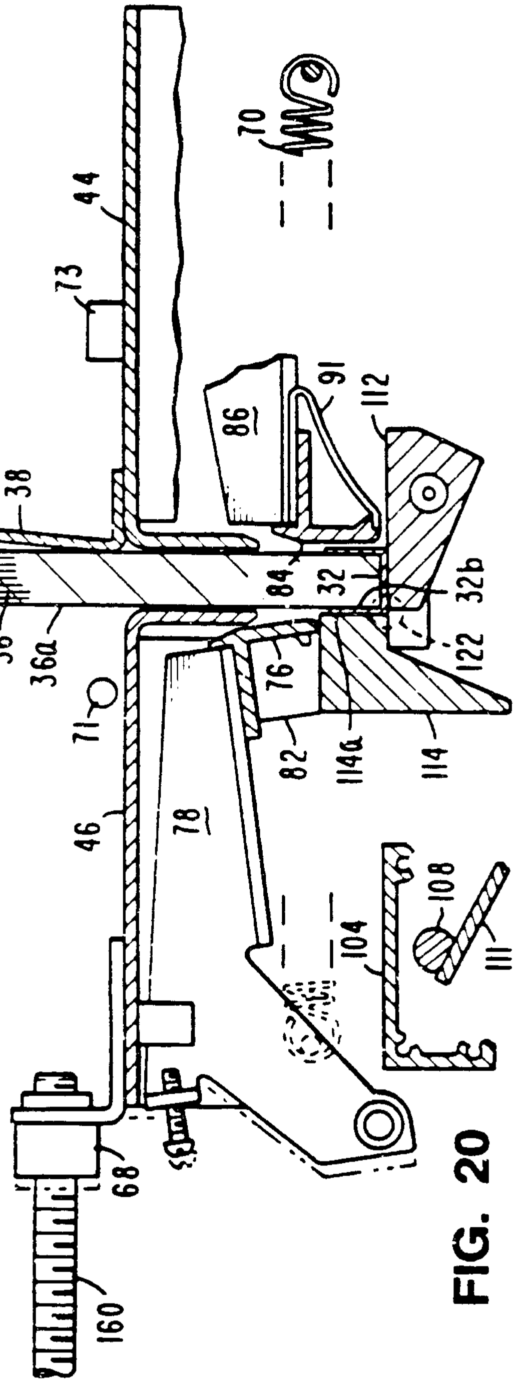

38
73
44
70
86
91
112
84
32
32b
122
36
36a
71
76
82
114a
114
46
78
108
104
111
68
160

FIG. 20

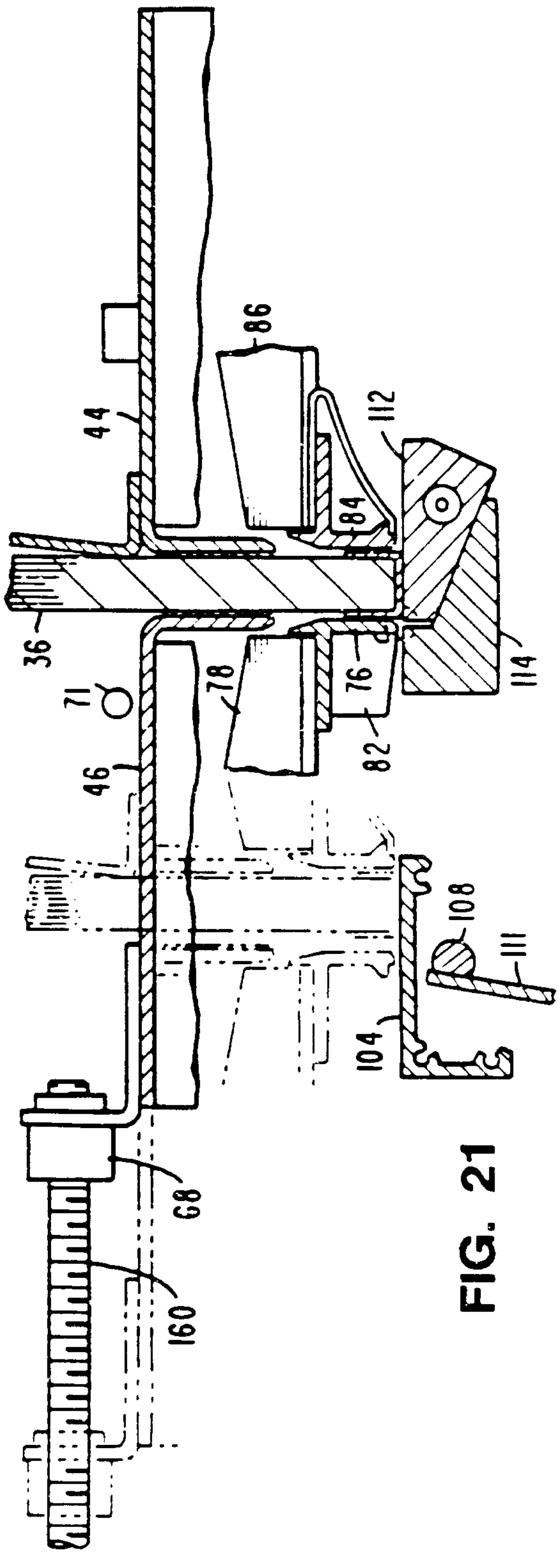
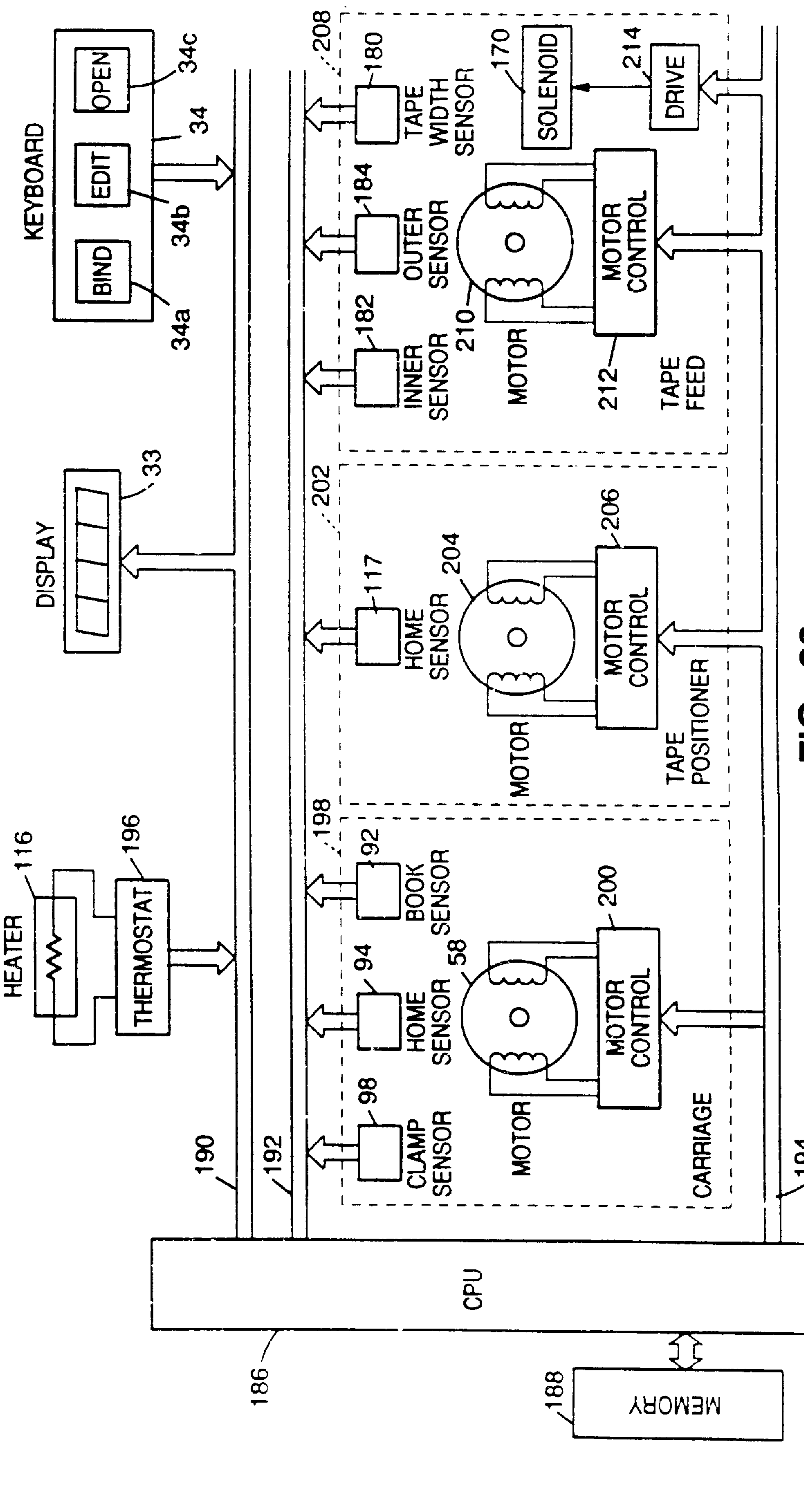

86
44
112
84
36
71
78
76
82
114
46
108
111
104
68
160

FIG. 21



KEYBOARD
BIND
EDIT
OPEN
34a
34b
34c
34
DISPLAY
33
HEATER
116
THERMOSTAT
196
190
192
194
186
CPU
MEMORY
188
198
CLAMP SENSOR
98
HOME SENSOR
94
BOOK SENSOR
92
MOTOR
58
MOTOR CONTROL
200
CARRIAGE
202
HOME SENSOR
117
MOTOR
204
MOTOR CONTROL
206
TAPE POSITIONER
208
INNER SENSOR
182
OUTER SENSOR
184
TAPE WIDTH SENSOR
180
MOTOR
210
MOTOR CONTROL
212
TAPE FEED
SOLENOID
170
DRIVE
214

FIG. 23

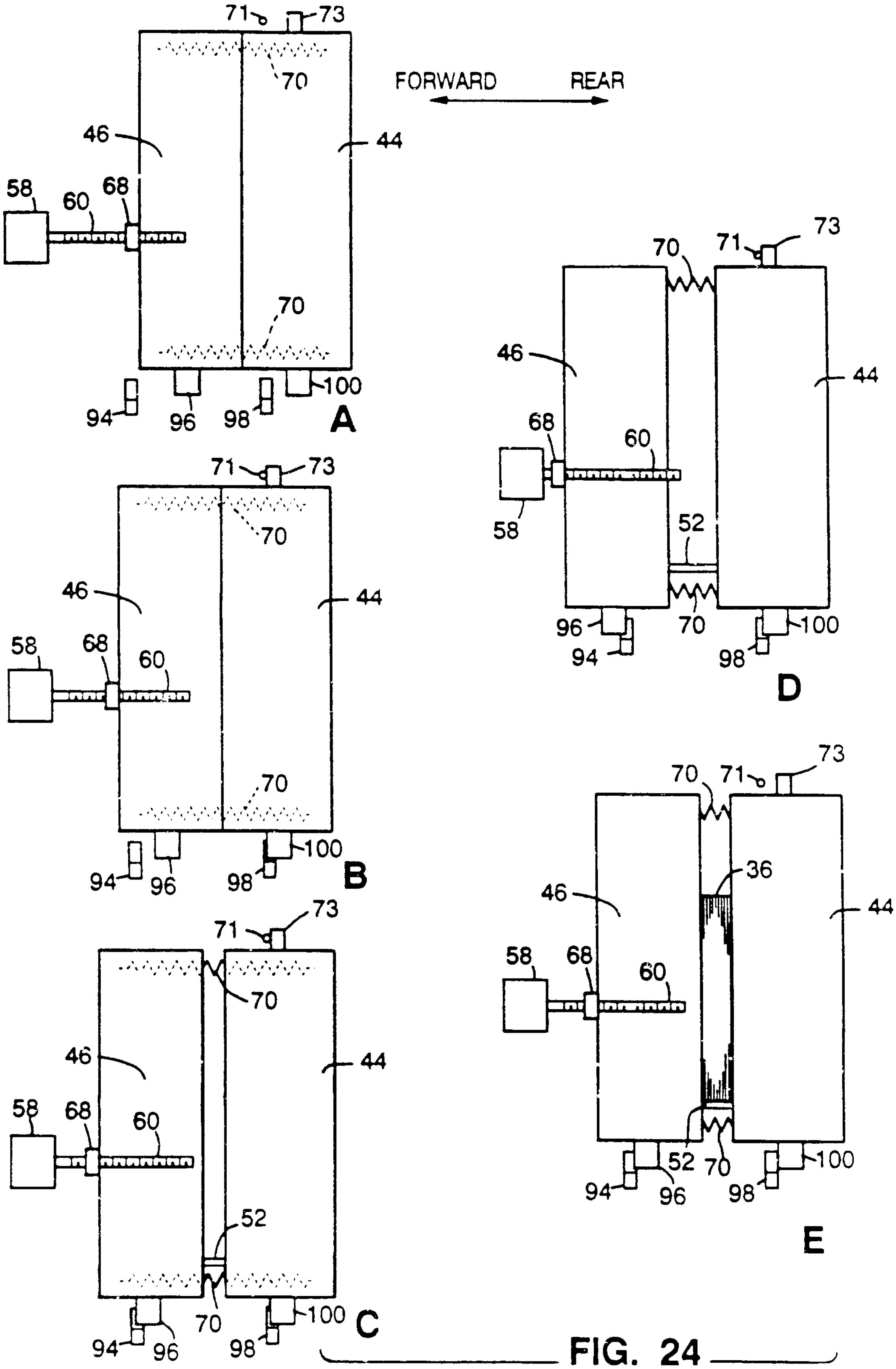

71
73
70
FORWARD
REAR
46
44
58
60
68
70
94
96
98
100
A
71
73
70
46
44
58
68
60
70
94
96
98
100
B
71
73
70
46
44
58
68
60
52
70
94
96
98
100
C
70
71
73
46
44
68
60
58
52
96
94
70
98
100
D
70
71
73
36
46
44
58
68
60
52
70
94
96
98
100
E

FIG. 24

FIG. 25A

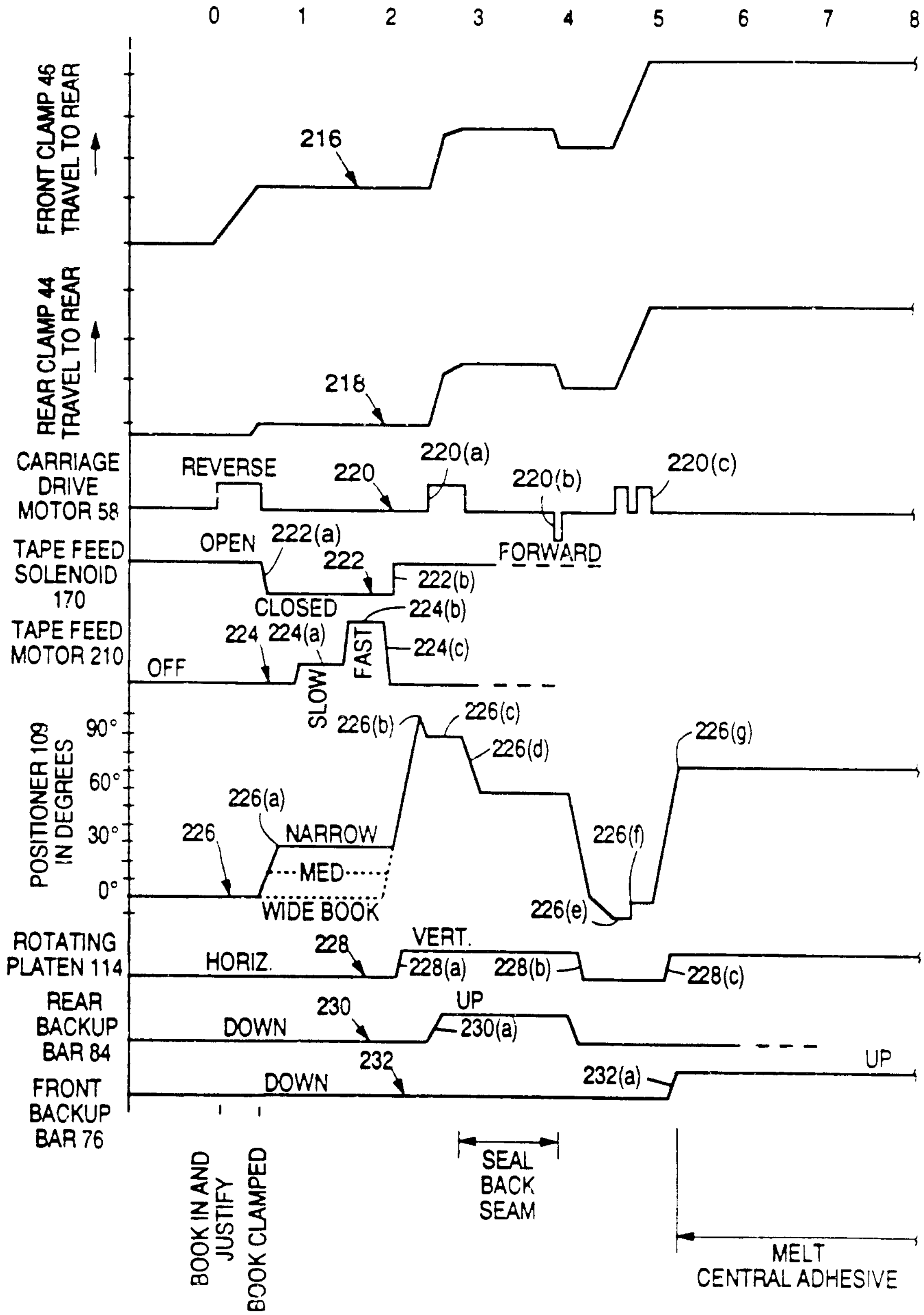
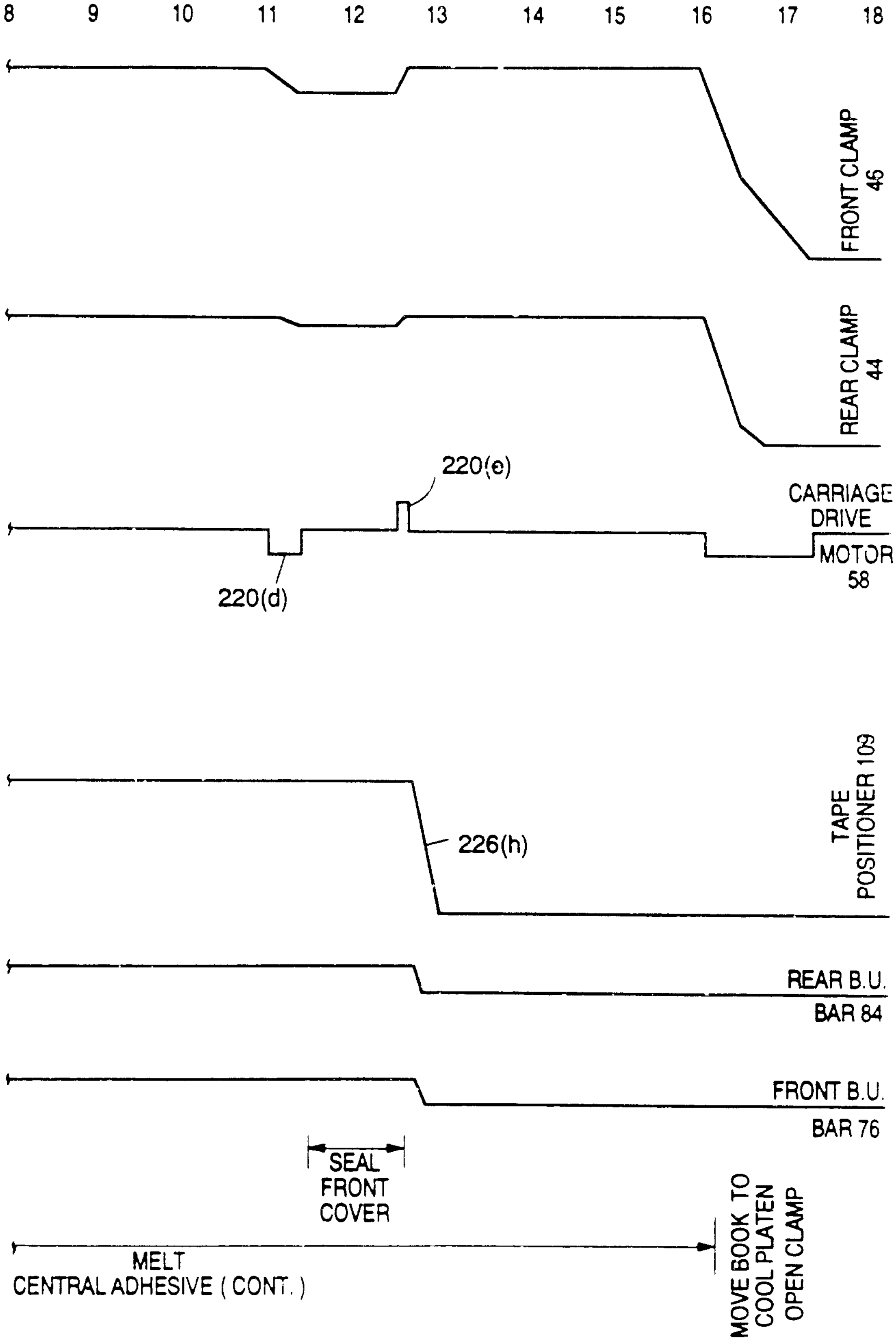
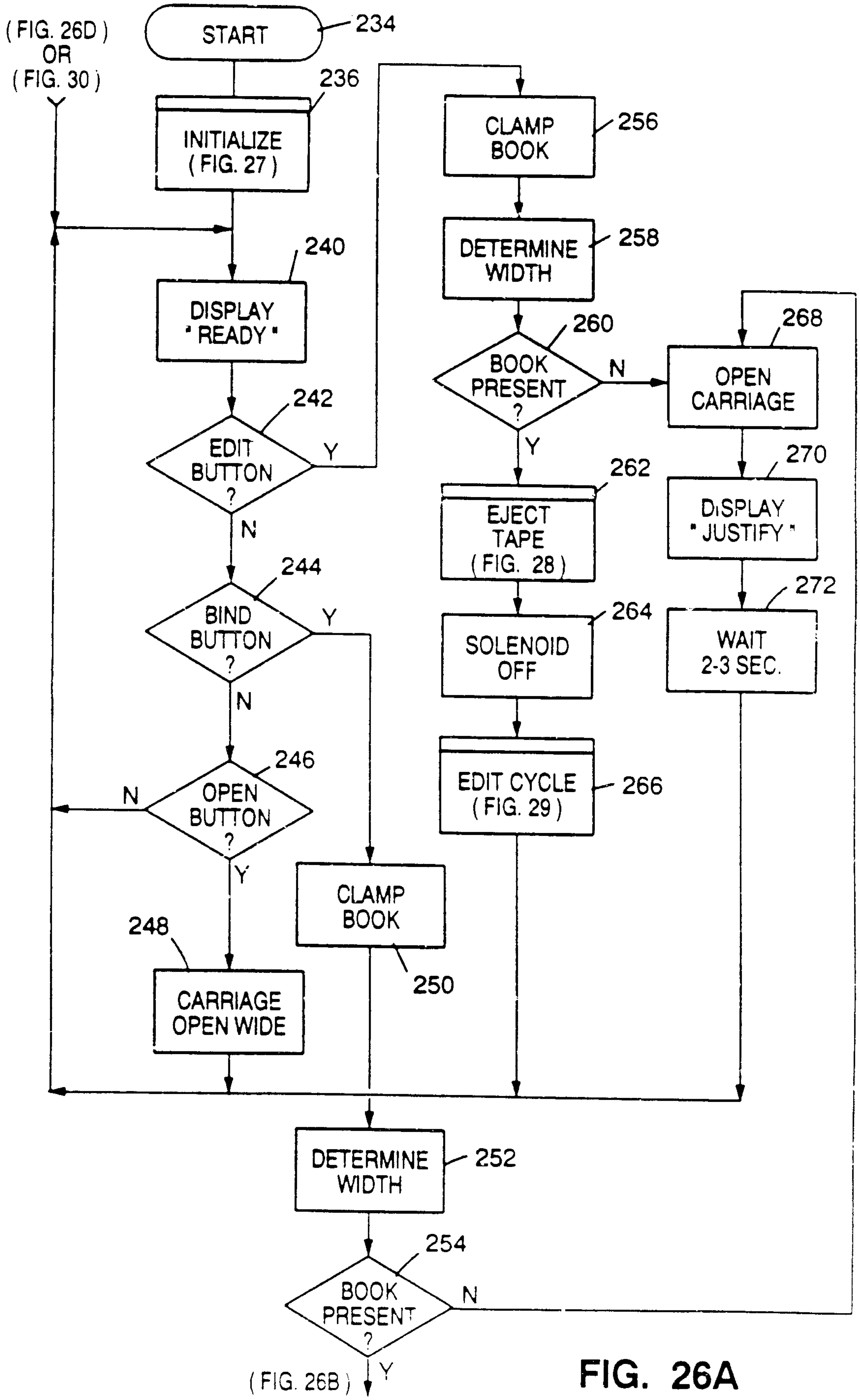

0
1
2
3
4
5
6
7
8
FRONT CLAMP 46 TRAVEL TO REAR
216
REAR CLAMP 44 TRAVEL TO REAR
218
CARRIAGE DRIVE MOTOR 58
REVERSE
220
220(a)
220(b)
220(c)
FORWARD
TAPE FEED SOLENOID 170
OPEN
222(a)
222
222(b)
CLOSED
TAPE FEED MOTOR 210
OFF
224
224(a)
224(b)
224(c)
SLOW
FAST
POSITIONER 109 IN DEGREES
90°
60°
30°
0°
226
226(a)
226(b)
226(c)
226(d)
226(e)
226(f)
226(g)
NARROW
MED
WIDE BOOK
ROTATING PLATEN 114
HORIZ.
VERT.
228
228(a)
228(b)
228(c)
REAR BACKUP BAR 84
DOWN
UP
230
230(a)
FRONT BACKUP BAR 76
DOWN
UP
232
232(a)
BOOK IN AND JUSTIFY
BOOK CLAMPED
SEAL BACK SEAM
MELT CENTRAL ADHESIVE

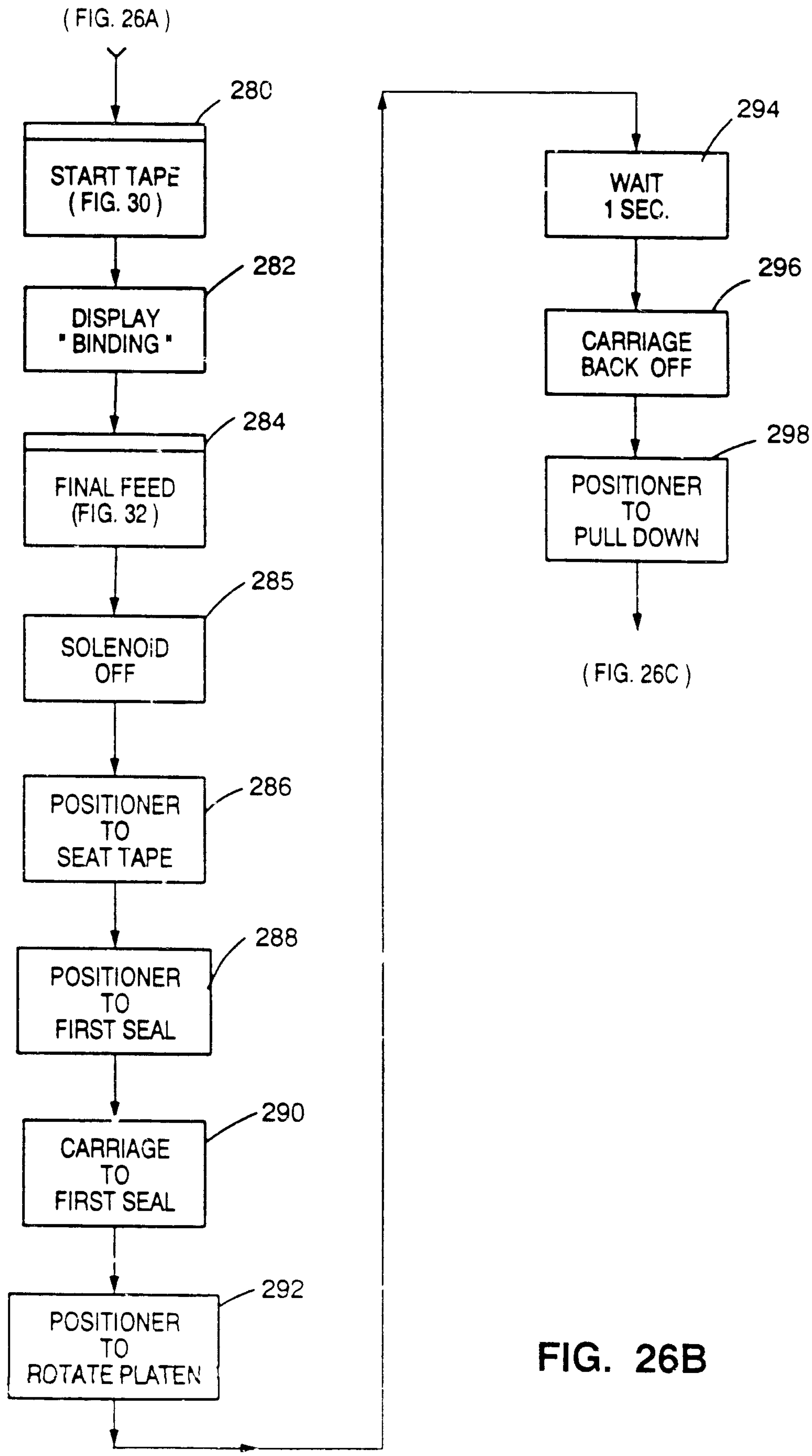
FIG. 25B


8
9
10
11
12
13
14
15
16
17
18
FRONT CLAMP 46
REAR CLAMP 44
220(e)
CARRIAGE DRIVE MOTOR 58
220(d)
TAPE POSITIONER 103
226(h)
REAR B.U. BAR 84
FRONT B.U. BAR 76
SEAL FRONT COVER
MELT CENTRAL ADHESIVE (CONT.)
MOVE BOOK TO COOL PLATEN OPEN CLAMP



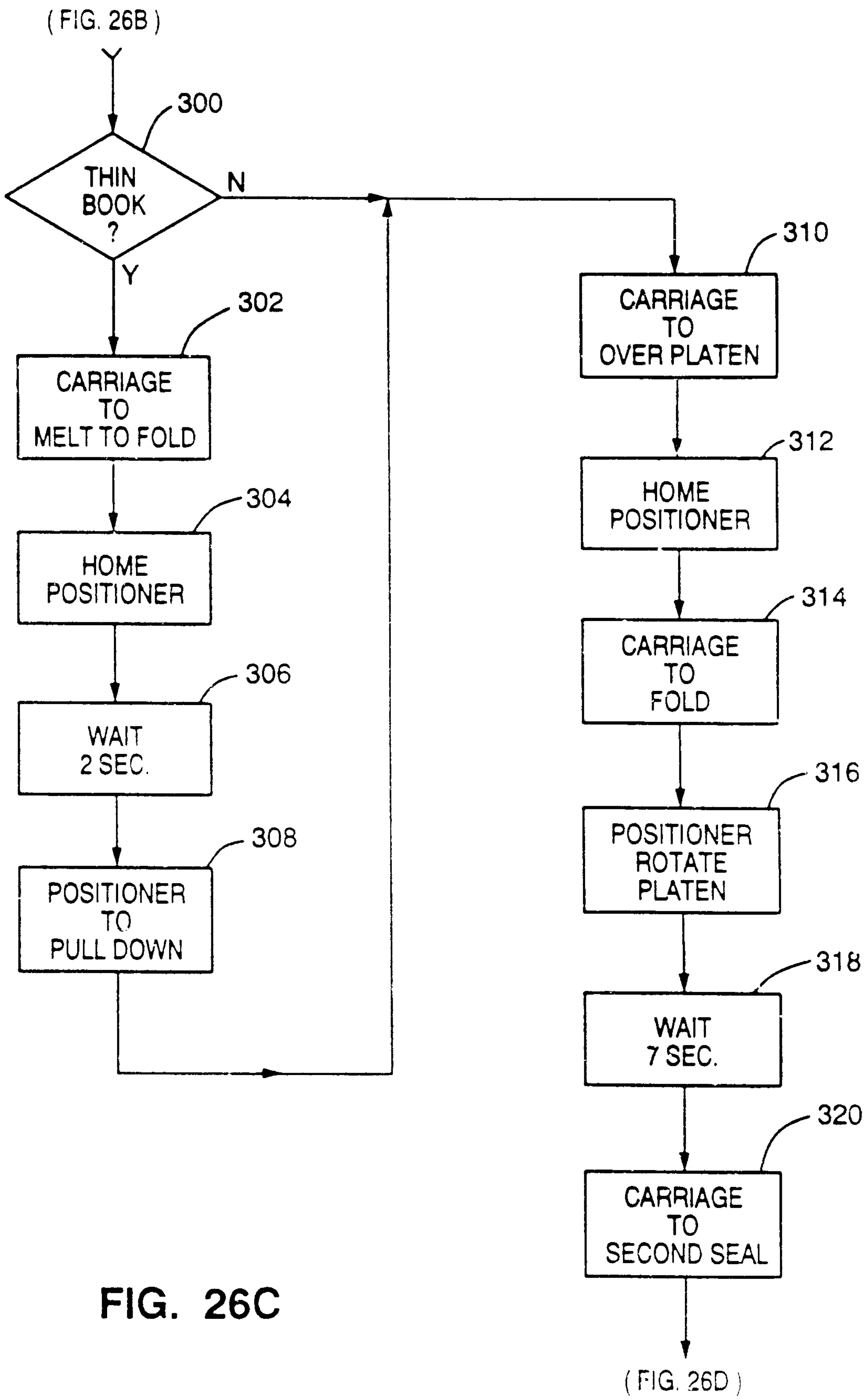
(FIG. 26D) OR (FIG. 30)
START
234
INITIALIZE (FIG. 27)
236
DISPLAY "READY"
240
EDIT BUTTON ?
242
Y
N
BIND BUTTON ?
244
Y
N
OPEN BUTTON ?
246
N
Y
CARRIAGE OPEN WIDE
248
CLAMP BOOK
250
CLAMP BOOK
256
DETERMINE WIDTH
258
BOOK PRESENT ?
260
N
Y
EJECT TAPE (FIG. 28)
262
SOLENOID OFF
264
EDIT CYCLE (FIG. 29)
266
OPEN CARRIAGE
268
DISPLAY "JUSTIFY"
270
WAIT 2-3 SEC.
272
DETERMINE WIDTH
252
BOOK PRESENT ?
254
N
Y
(FIG. 26B)

FIG. 26A



(FIG. 26A)
280
START TAPE
(FIG. 30)
282
DISPLAY
" BINDING "
284
FINAL FEED
(FIG. 32)
285
SOLENOID
OFF
286
POSITIONER
TO
SEAT TAPE
288
POSITIONER
TO
FIRST SEAL
290
CARRIAGE
TO
FIRST SEAL
292
POSITIONER
TO
ROTATE PLATEN
294
WAIT
1 SEC.
296
CARRIAGE
BACK OFF
298
POSITIONER
TO
PULL DOWN
(FIG. 26C)

FIG. 26B



(FIG. 26B)
Y
300
THIN BOOK ?
N
Y
302
CARRIAGE TO MELT TO FOLD
304
HOME POSITIONER
306
WAIT 2 SEC.
308
POSITIONER TO PULL DOWN
310
CARRIAGE TO OVER PLATEN
312
HOME POSITIONER
314
CARRIAGE TO FOLD
316
POSITIONER ROTATE PLATEN
318
WAIT 7 SEC.
320
CARRIAGE TO SECOND SEAL
(FIG. 26D)

FIG. 26C

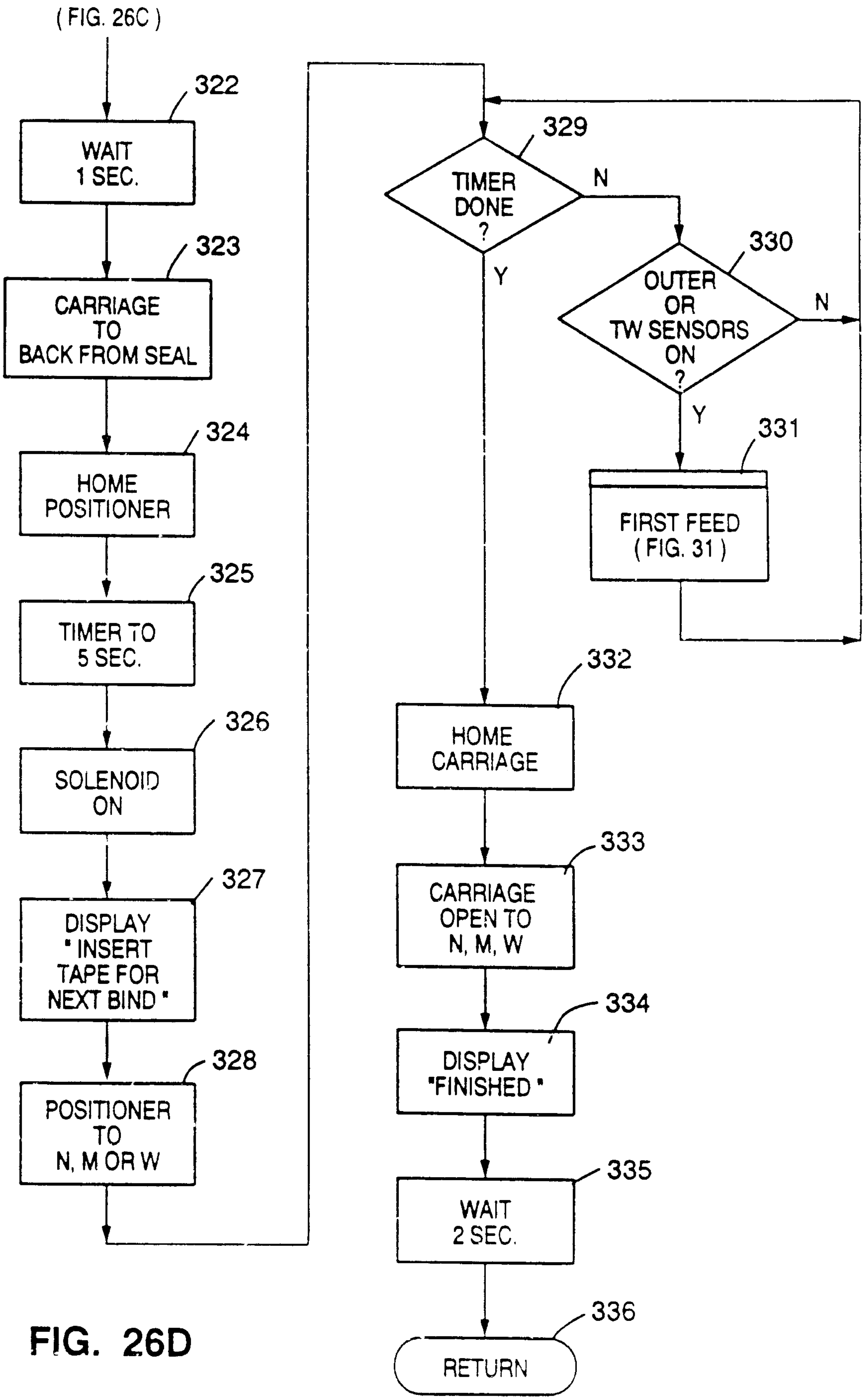

(FIG. 26C)
322
WAIT 1 SEC.
323
CARRIAGE TO BACK FROM SEAL
324
HOME POSITIONER
325
TIMER TO 5 SEC.
326
SOLENOID ON
327
DISPLAY " INSERT TAPE FOR NEXT BIND "
328
POSITIONER TO N, M OR W
329
TIMER DONE ?
N
Y
330
OUTER OR TW SENSORS ON ?
N
Y
331
FIRST FEED (FIG. 31)
332
HOME CARRIAGE
333
CARRIAGE OPEN TO N, M, W
334
DISPLAY "FINISHED"
335
WAIT 2 SEC.
336
RETURN

FIG. 26D

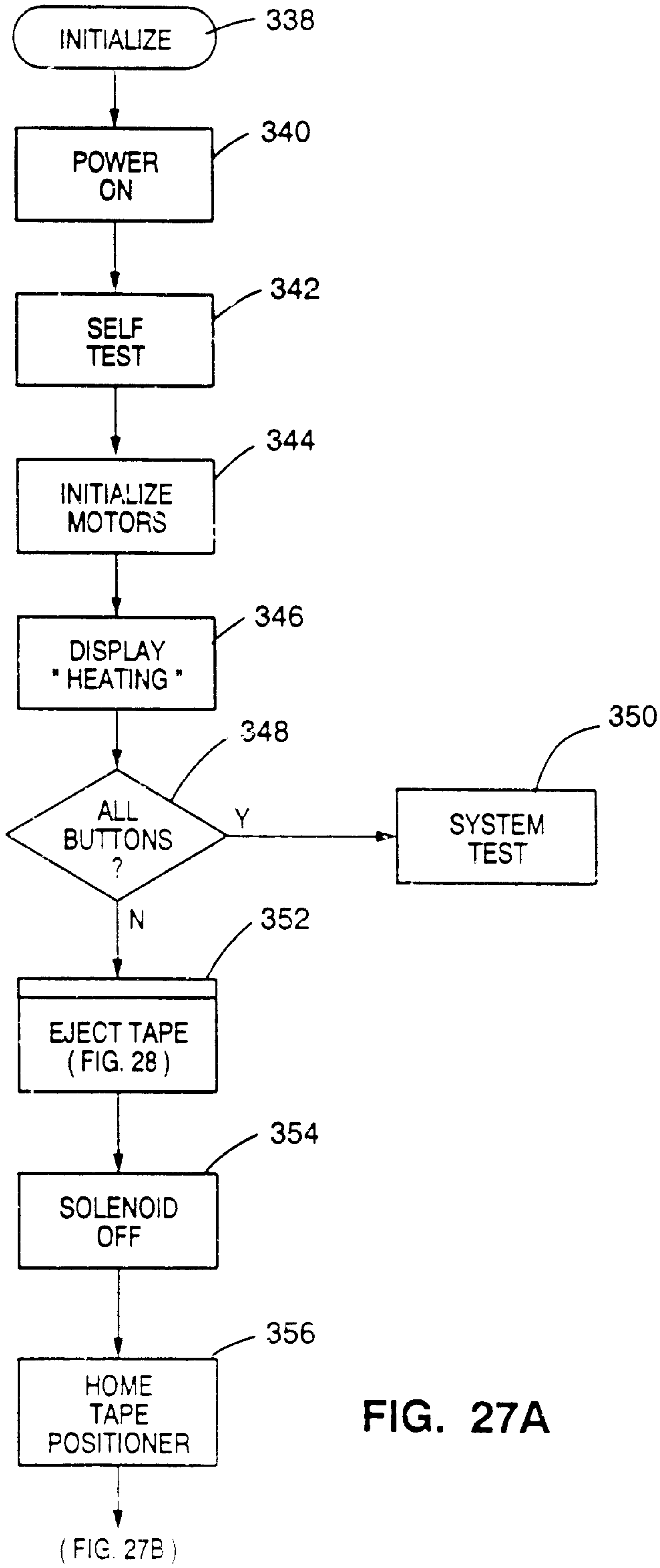

INITIALIZE
338
POWER ON
340
SELF TEST
342
INITIALIZE MOTORS
344
DISPLAY " HEATING "
346
348
ALL BUTTONS ?
Y
N
SYSTEM TEST
350
EJECT TAPE (FIG. 28)
352
SOLENOID OFF
354
HOME TAPE POSITIONER
356
(FIG. 27B)

FIG. 27A

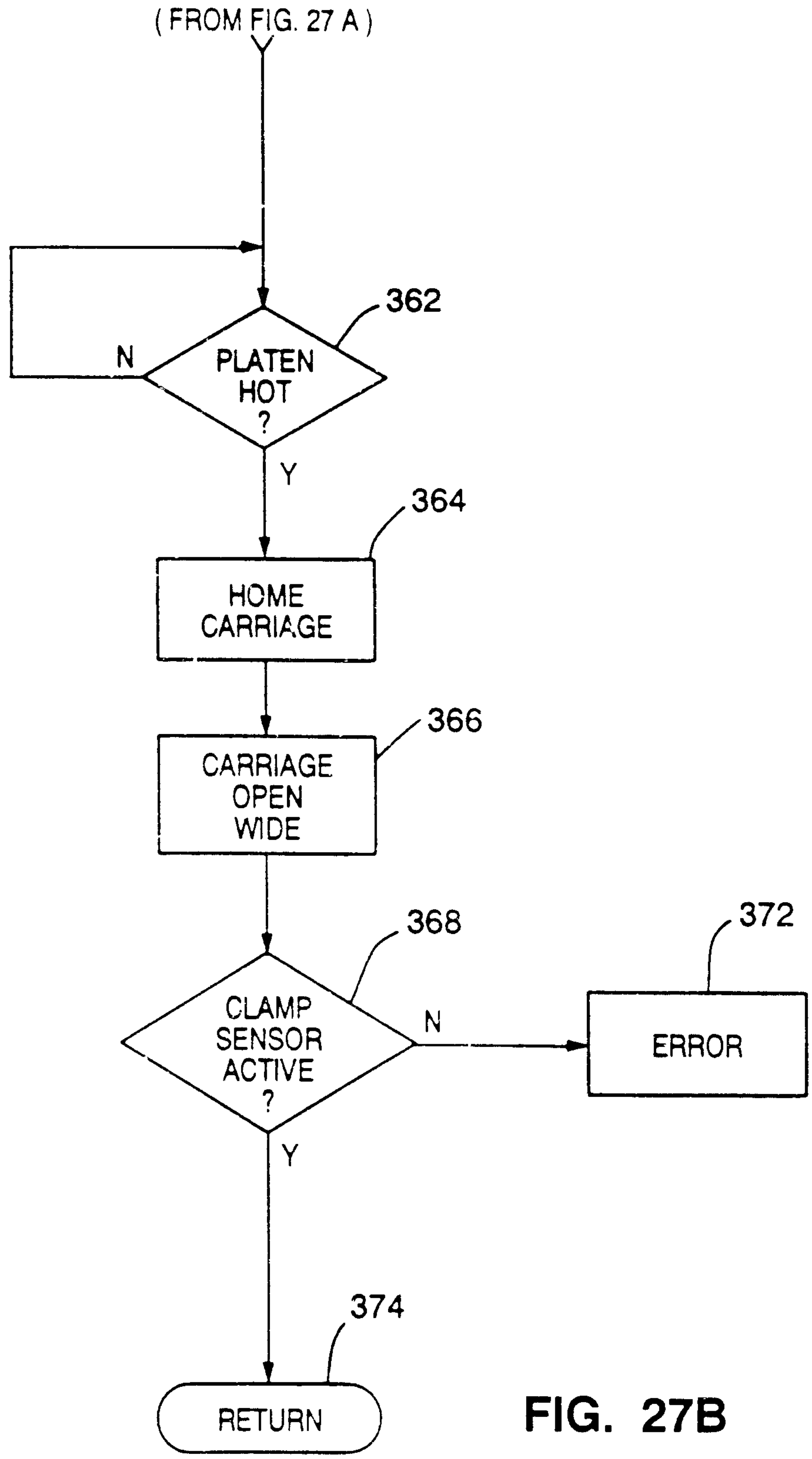
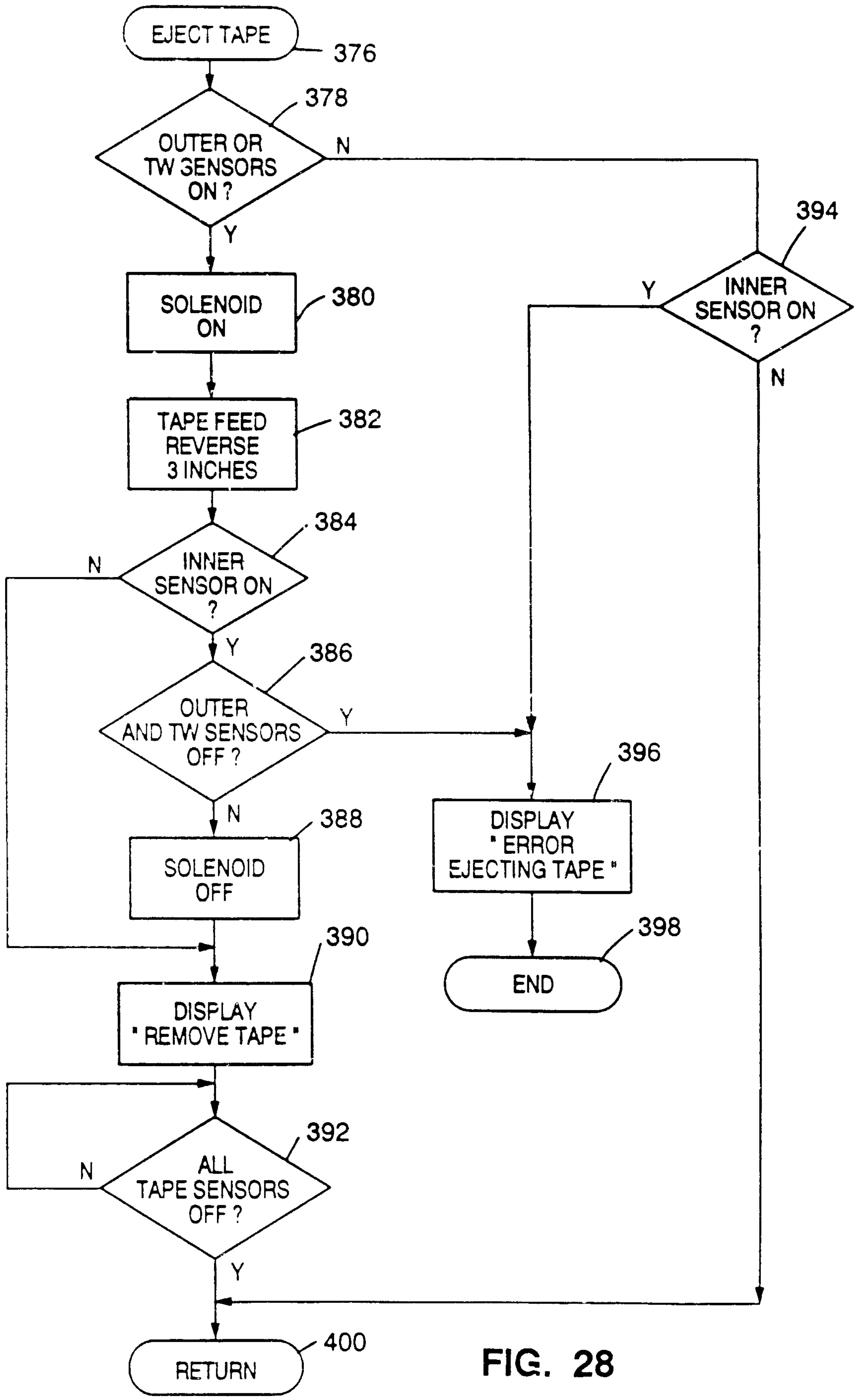

(FROM FIG. 27 A)
362
N
PLATEN HOT ?
Y
364
HOME CARRIAGE
366
CARRIAGE OPEN WIDE
368
CLAMP SENSOR ACTIVE ?
N
372
ERROR
Y
374
RETURN

FIG. 27B



EJECT TAPE
376
378
OUTER OR TW SENSORS ON ?
N
Y
380
SOLENOID ON
382
TAPE FEED REVERSE 3 INCHES
384
INNER SENSOR ON ?
N
Y
386
OUTER AND TW SENSORS OFF ?
Y
N
388
SOLENOID OFF
390
DISPLAY " REMOVE TAPE "
392
ALL TAPE SENSORS OFF ?
N
Y
400
RETURN
394
INNER SENSOR ON ?
Y
N
396
DISPLAY " ERROR EJECTING TAPE "
398
END

FIG. 28

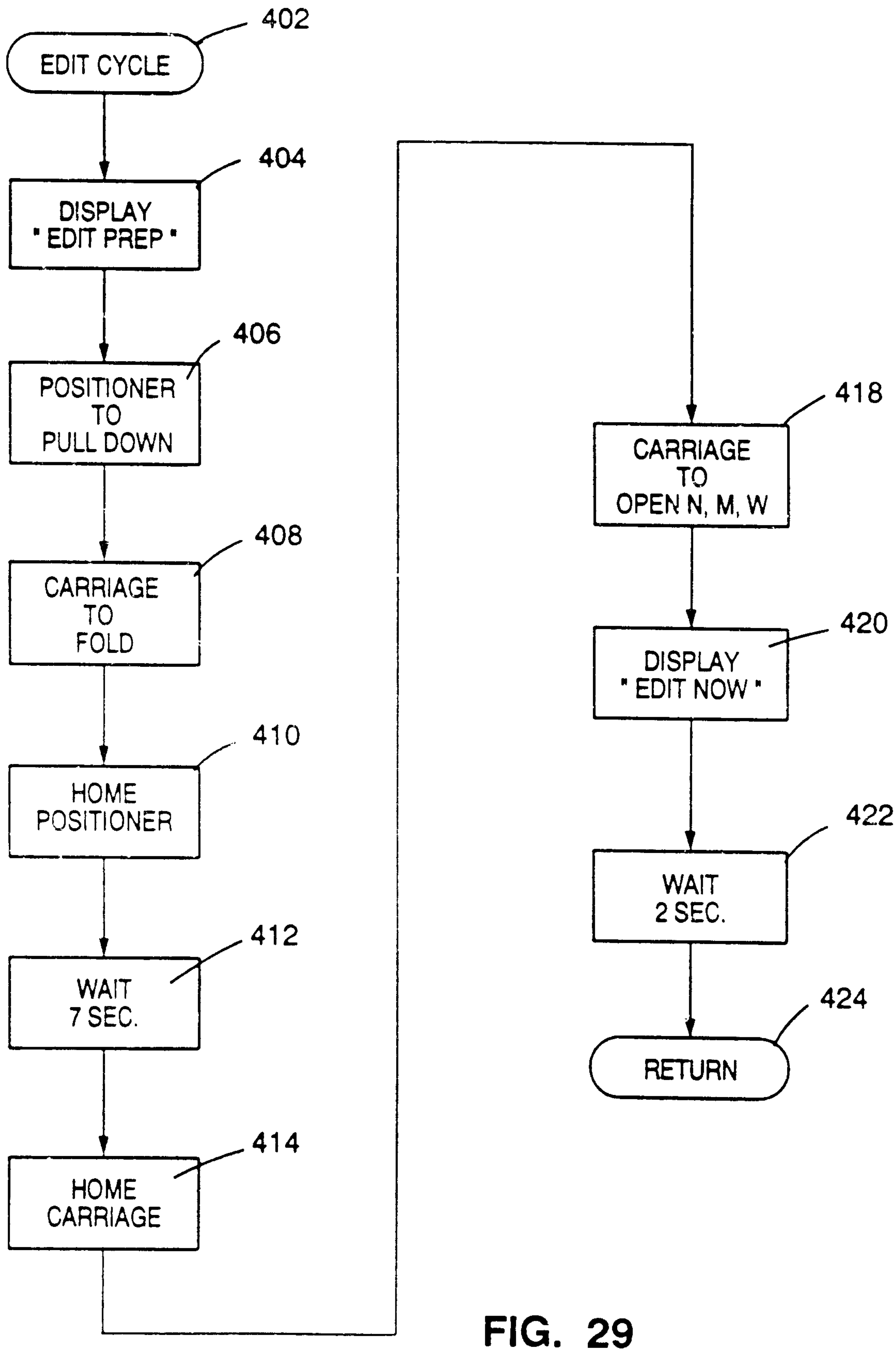

402
EDIT CYCLE
404
DISPLAY
" EDIT PREP "
406
POSITIONER
TO
PULL DOWN
408
CARRIAGE
TO
FOLD
410
HOME
POSITIONER
412
WAIT
7 SEC.
414
HOME
CARRIAGE
418
CARRIAGE
TO
OPEN N, M, W
420
DISPLAY
" EDIT NOW "
422
WAIT
2 SEC.
424
RETURN

FIG. 29

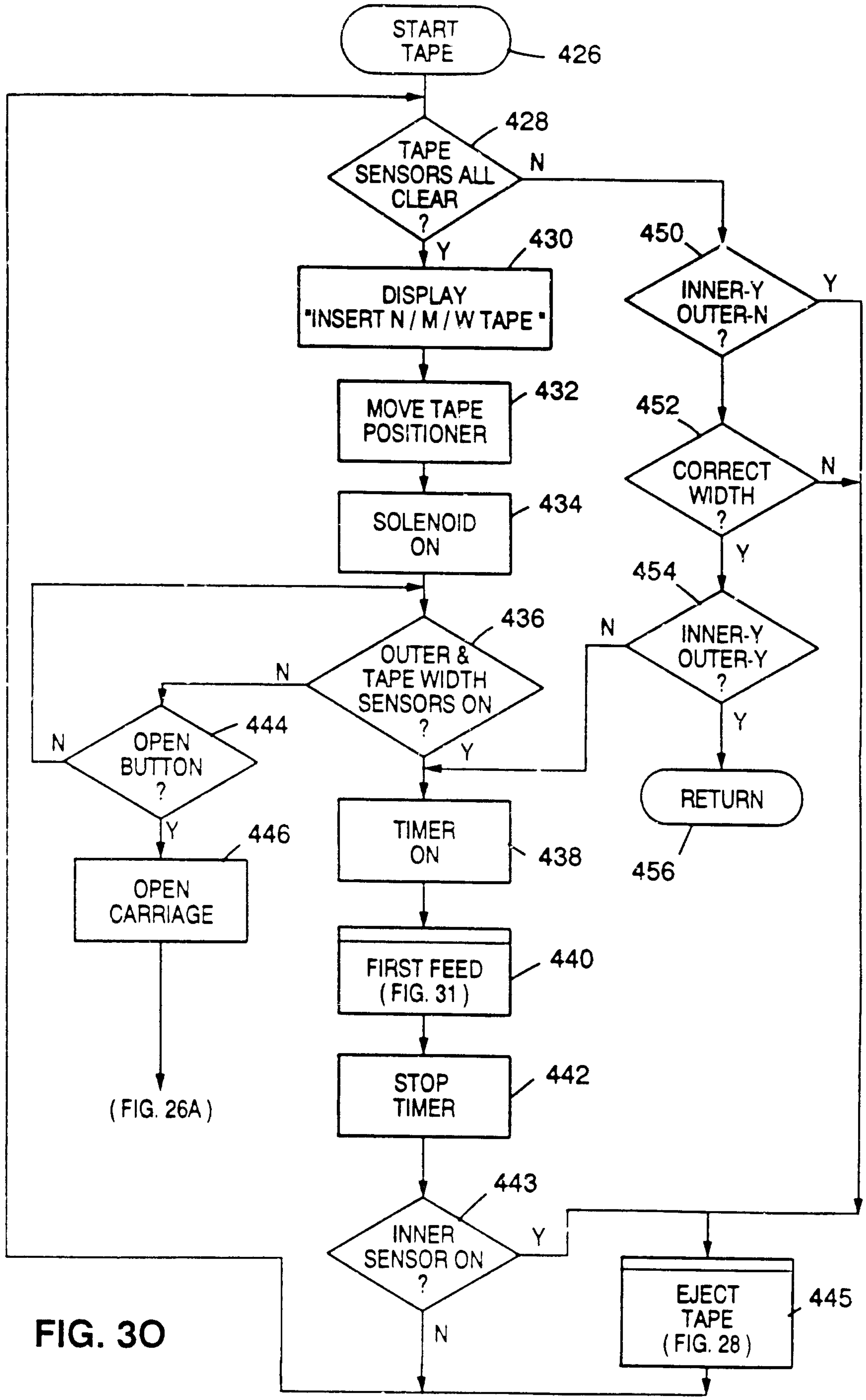

START TAPE
426
428
TAPE SENSORS ALL CLEAR ?
N
Y
430
DISPLAY "INSERT N / M / W TAPE "
432
MOVE TAPE POSITIONER
434
SOLENOID ON
436
OUTER & TAPE WIDTH SENSORS ON ?
N
Y
444
OPEN BUTTON ?
N
Y
446
OPEN CARRIAGE
(FIG. 26A)
TIMER ON
438
FIRST FEED (FIG. 31)
440
STOP TIMER
442
443
INNER SENSOR ON ?
Y
N
EJECT TAPE (FIG. 28)
445
450
INNER-Y OUTER-N ?
Y
452
CORRECT WIDTH ?
N
Y
454
INNER-Y OUTER-Y ?
N
Y
RETURN
456

FIG. 3O

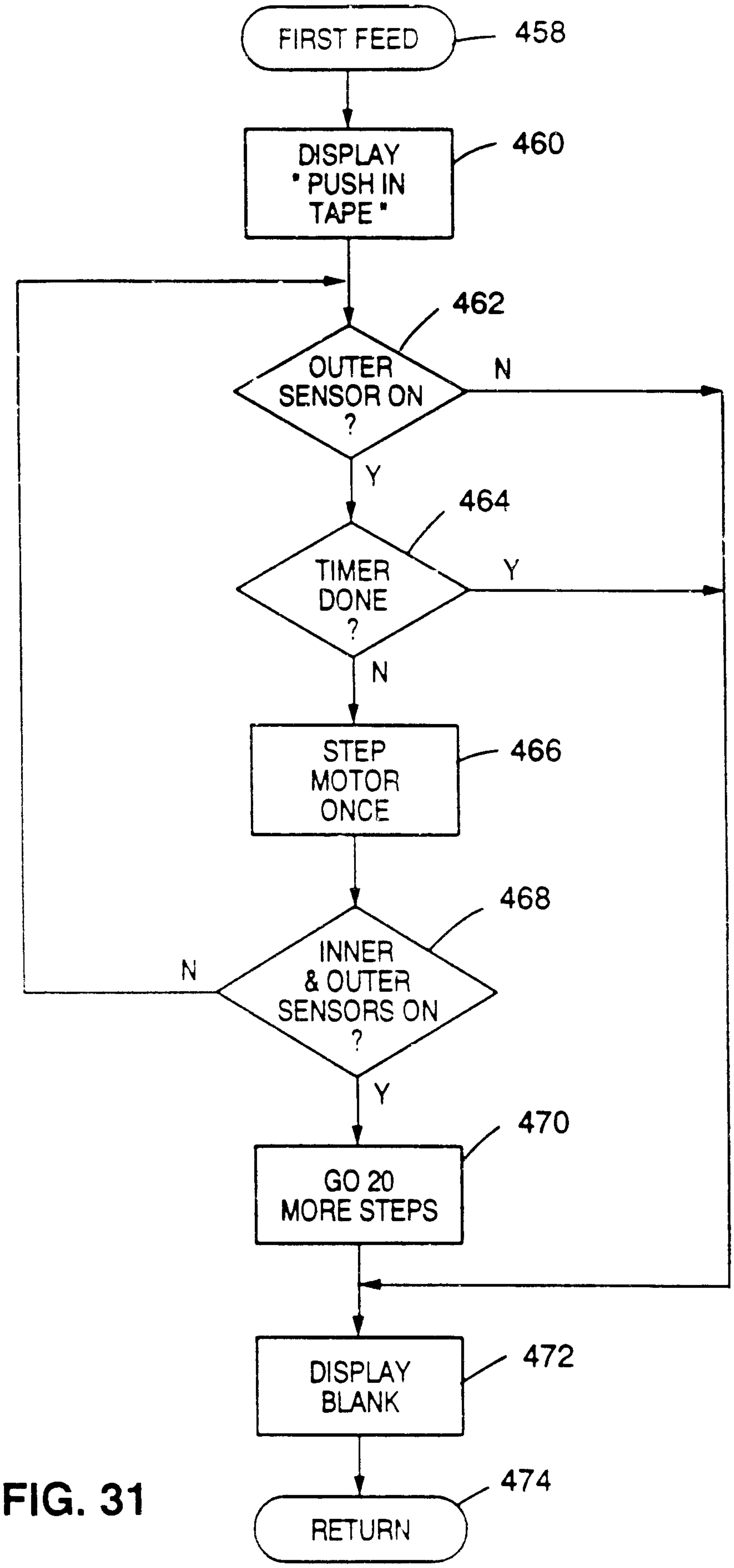

FIRST FEED
458
DISPLAY " PUSH IN TAPE "
460
462
OUTER SENSOR ON ?
N
Y
464
TIMER DONE ?
Y
N
STEP MOTOR ONCE
466
468
INNER & OUTER SENSORS ON ?
N
Y
470
GO 20 MORE STEPS
DISPLAY BLANK
472
474
RETURN

FIG. 31

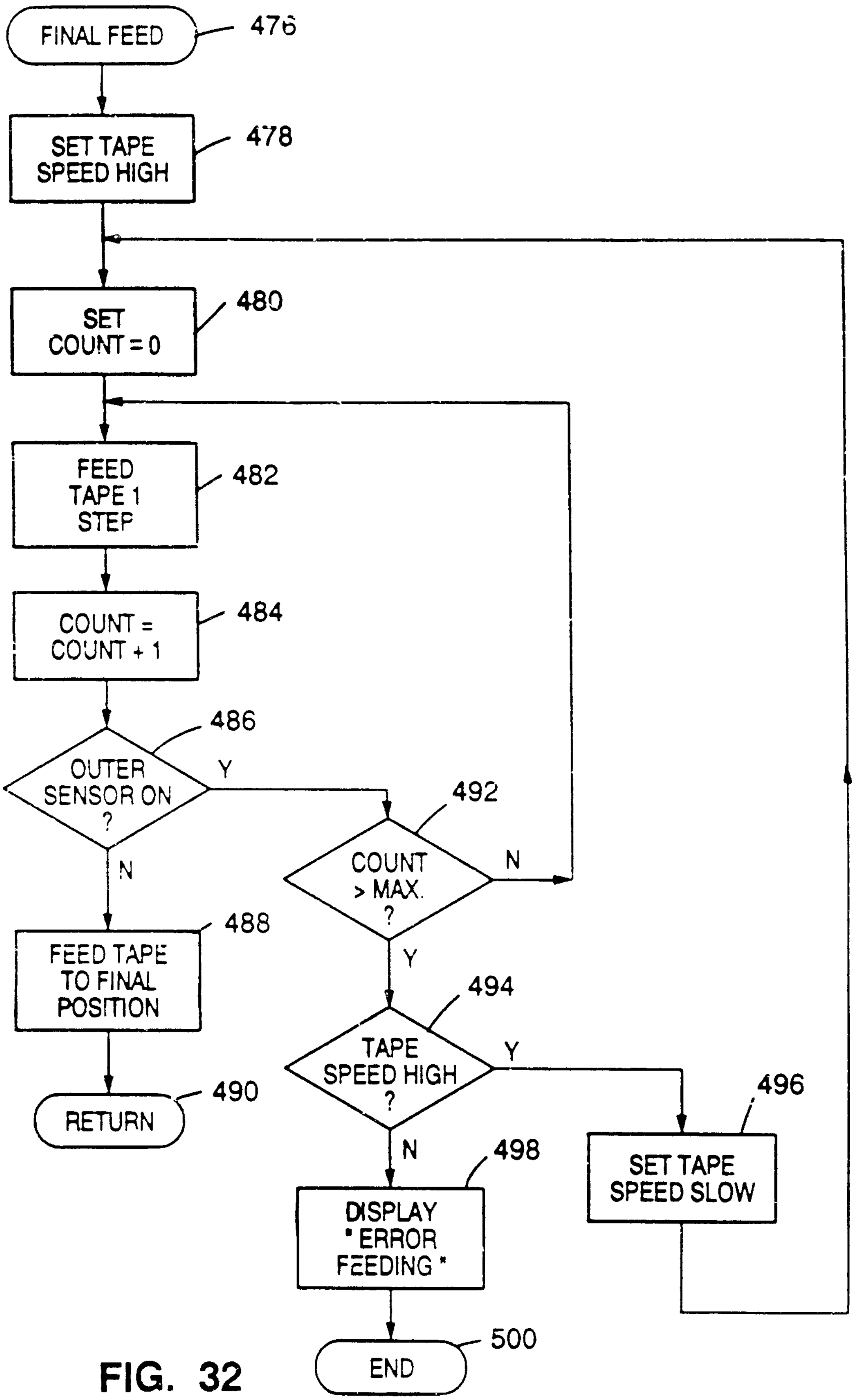

FINAL FEED
476
SET TAPE SPEED HIGH
478
SET COUNT = 0
480
FEED TAPE 1 STEP
482
COUNT = COUNT + 1
484
486
OUTER SENSOR ON ?
Y
N
492
COUNT > MAX. ?
N
Y
FEED TAPE TO FINAL POSITION
488
RETURN
490
494
TAPE SPEED HIGH ?
Y
N
496
SET TAPE SPEED SLOW
498
DISPLAY " ERROR FEEDING "
END
500

FIG. 32