April 9, 1968 R. E. SCHROTER 3,377,438

PIVOTALLY MOUNTED CAPSTANS

Filed May 1, 1963 7 Sheets-Sheet 1

Fig. 1

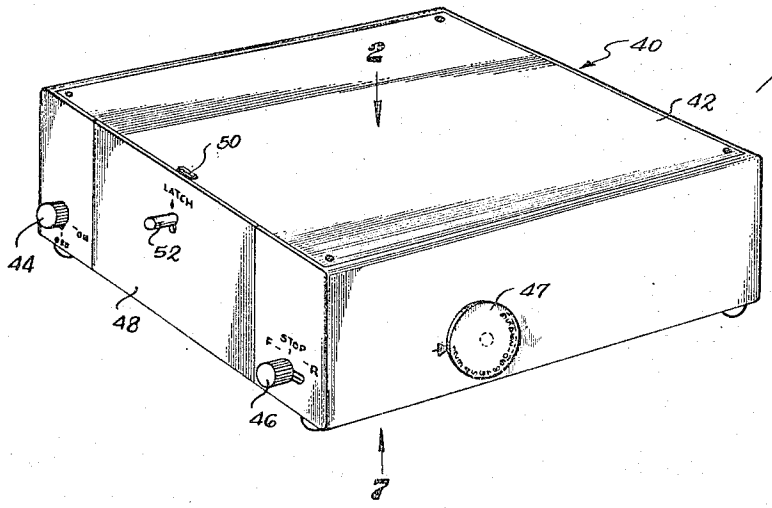
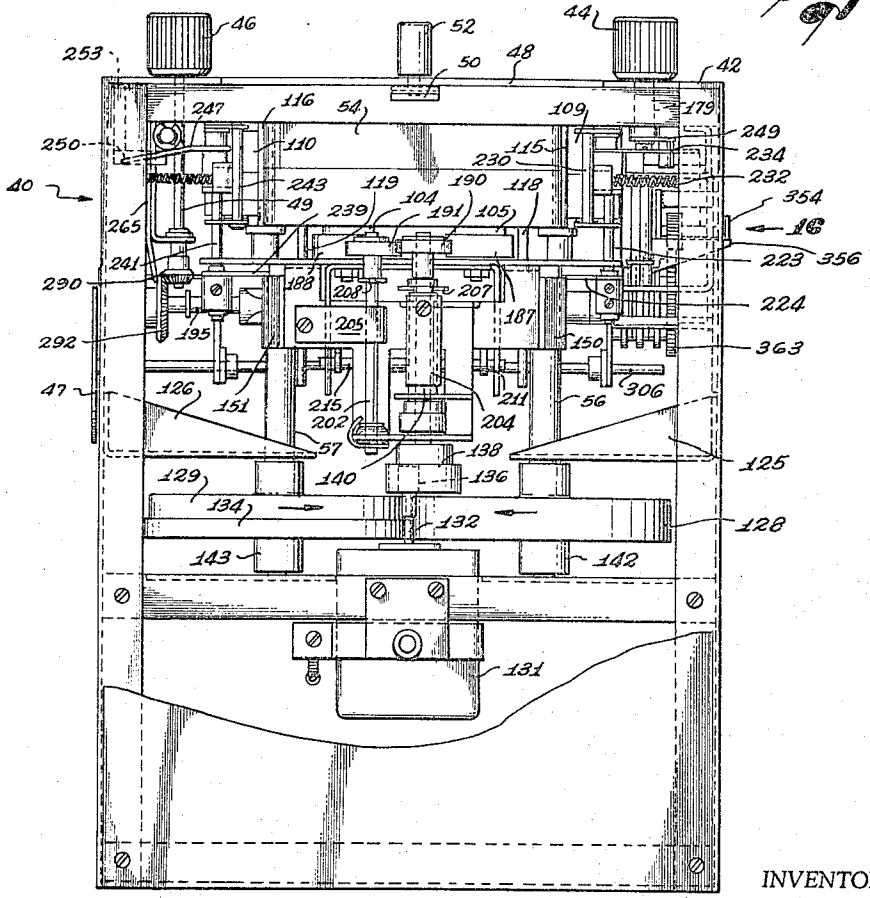



Fig. 2

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April 9, 1968 R. E. SCHROTER 3,377,438

PIVOTALLY MOUNTED CAPSTANS

Filed May 1, 1963 7 Sheets-Sheet 2

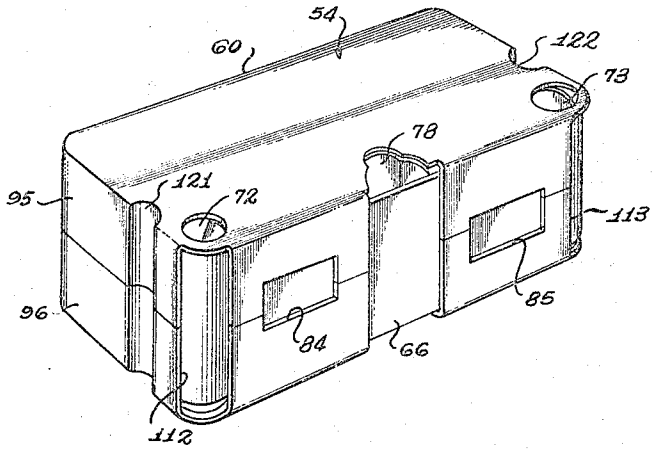


Fig. 3

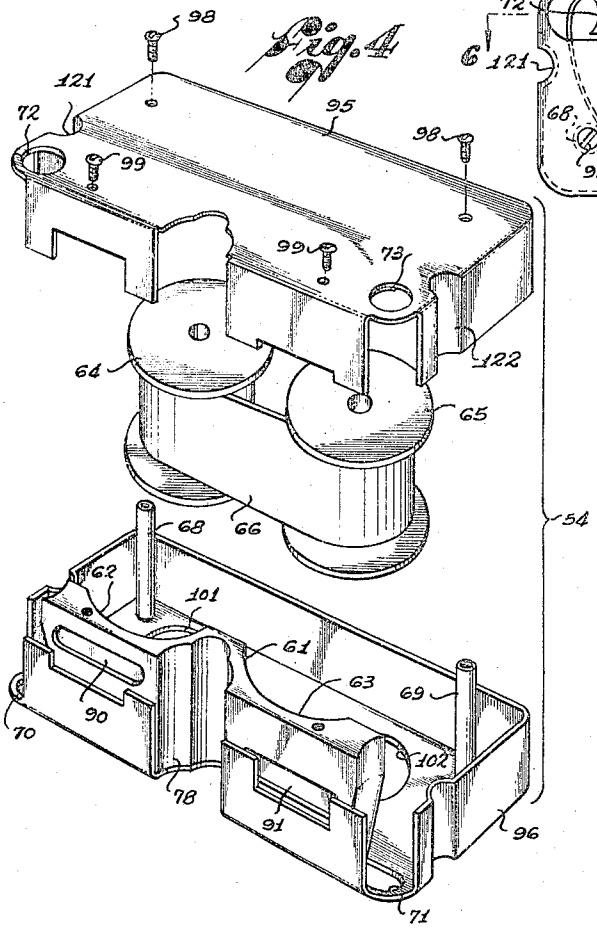


Fig. 4

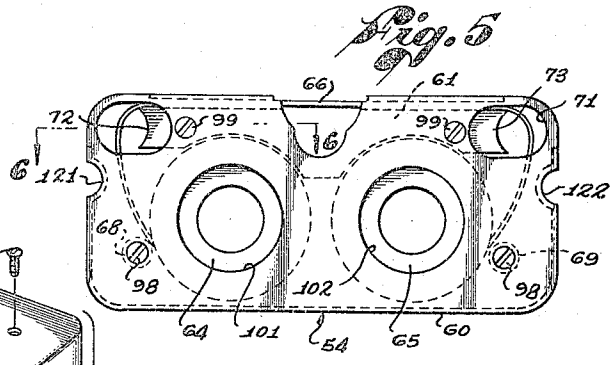


Fig. 5

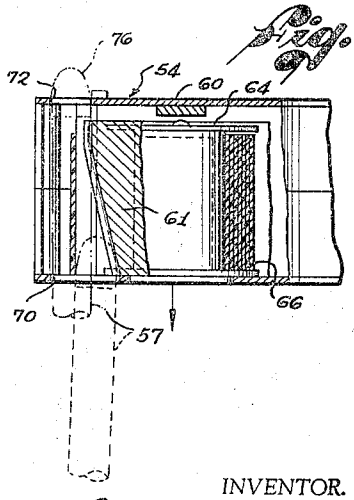


Fig. 6

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April 9, 1968 R. E. SCHROTER 3,377,438

PIVOTALLY MOUNTED CAPSTANS

Filed May 1, 1963 7 Sheets-Sheet 3

Fig. 7

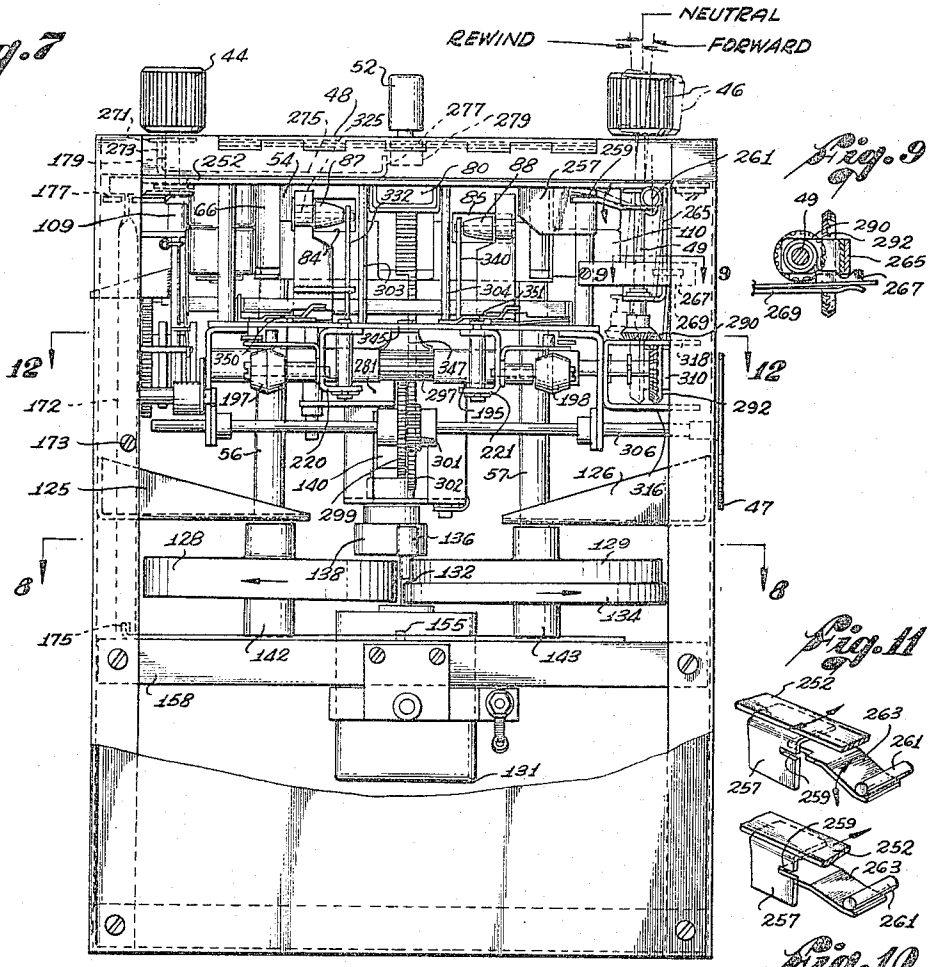



Fig. 9

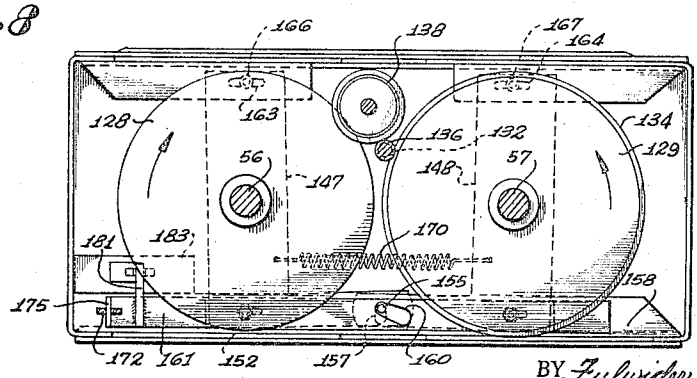



Fig. 11




Fig. 10

Fig. 8

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April 9, 1968 R. E. SCHROTER 3,377,438

PIVOTALLY MOUNTED CAPSTANS

Filed May 1, 1963 7 Sheets-Sheet 4

Fig. 12

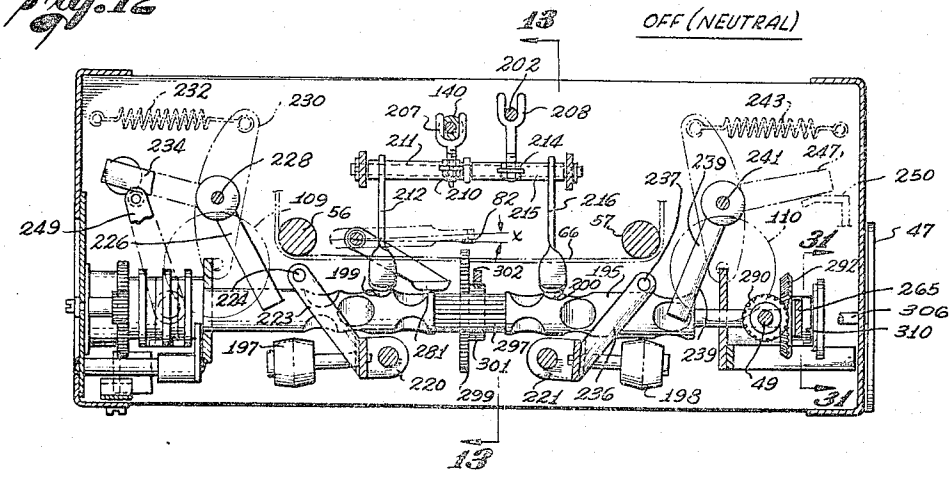



Fig. 16

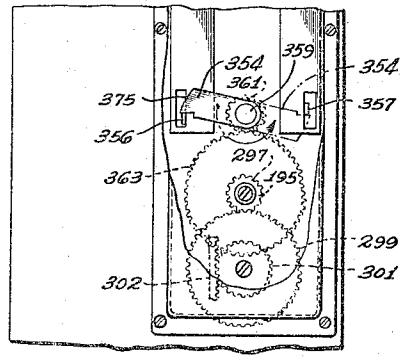



Fig. 13

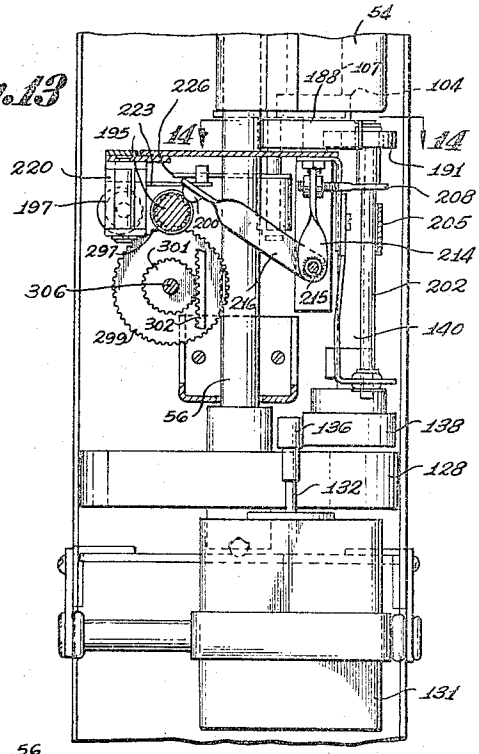



Fig. 14

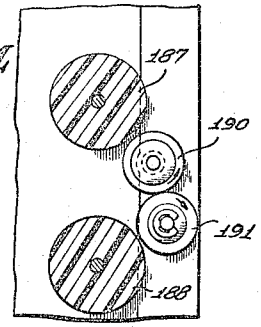
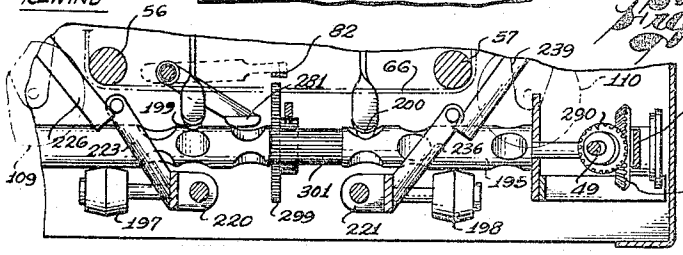



Fig. 15

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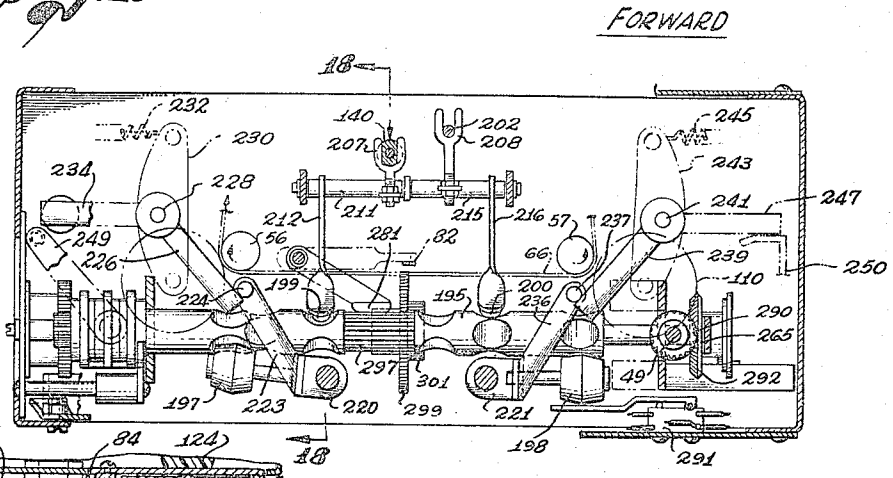
April 9, 1968 R. E. SCHROTER 3,377,438

PIVOTALLY MOUNTED CAPSTANS

Filed May 1, 1963 7 Sheets-Sheet 5

Fig. 17



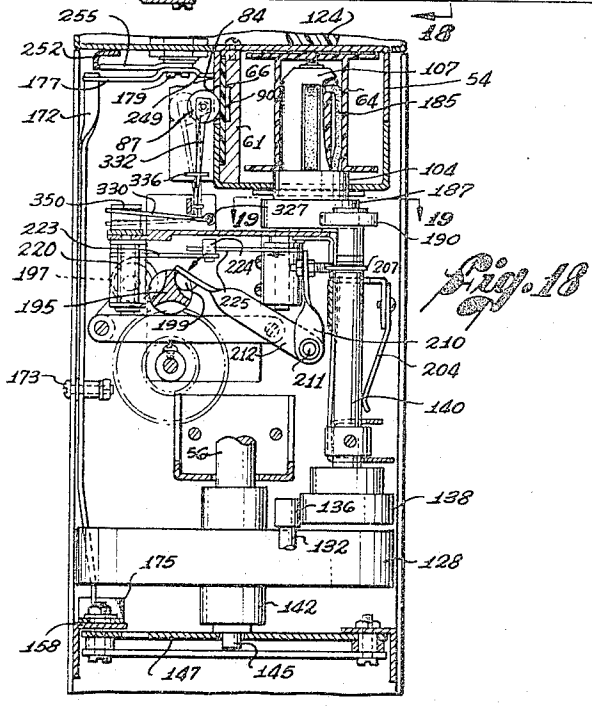




Fig. 18

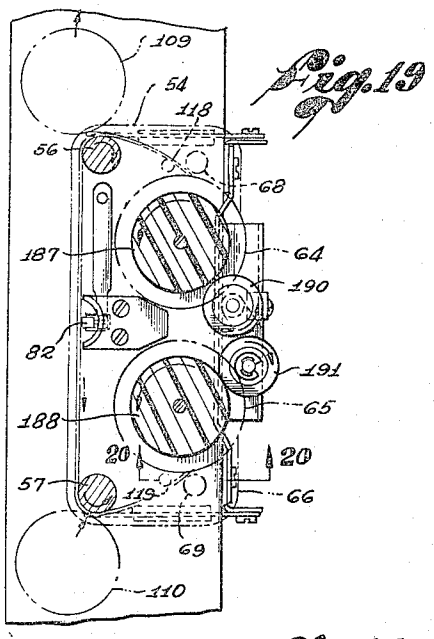



Fig. 19

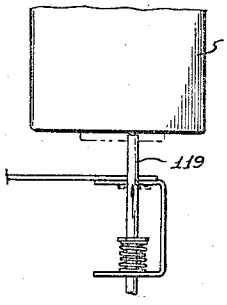



Fig. 20

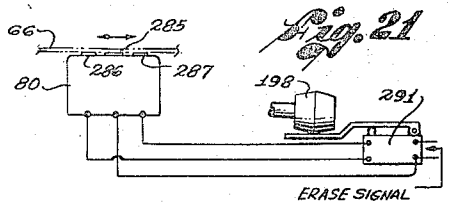



Fig. 21

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April 9, 1968 R. E. SCHROTER 3,377,438

PIVOTALLY MOUNTED CAPSTANS

Filed May 1, 1963 7 Sheets-Sheet 6

Fig. 23

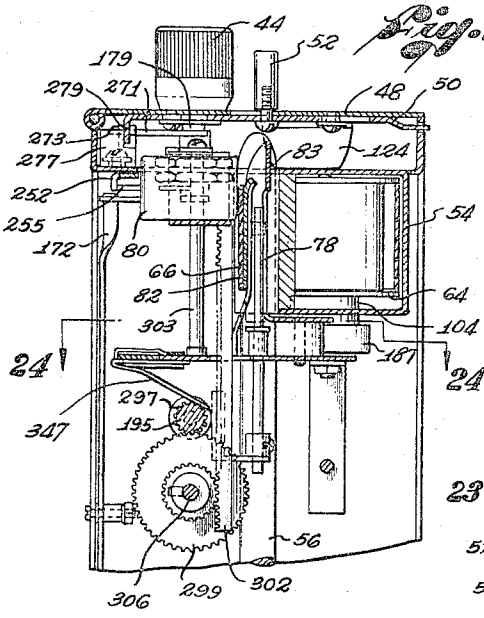



Fig. 22

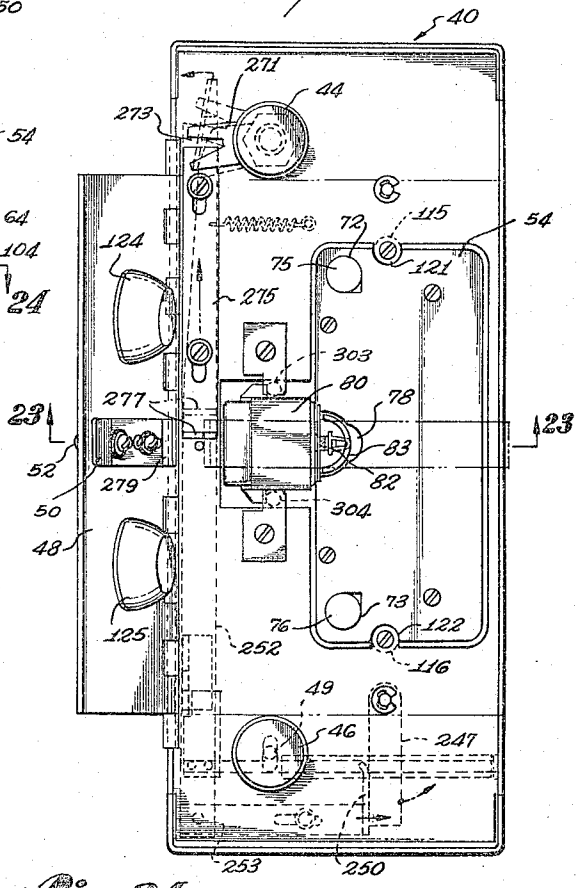



Fig. 24

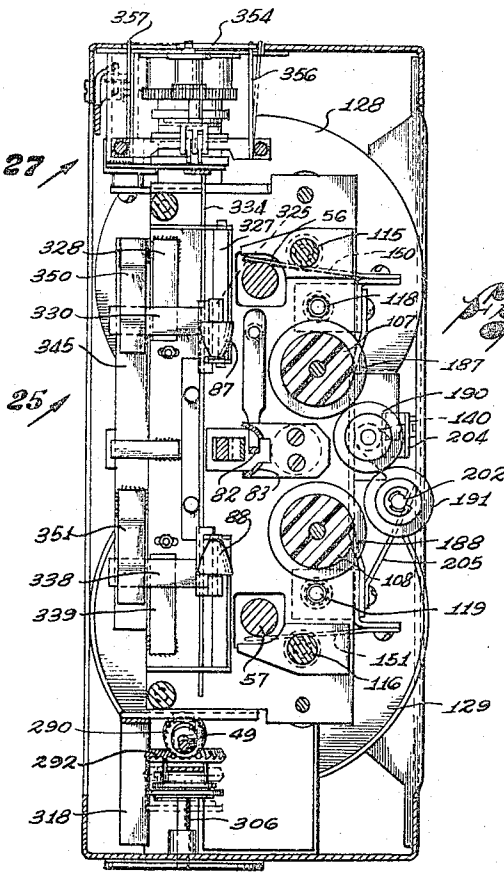



Fig. 25

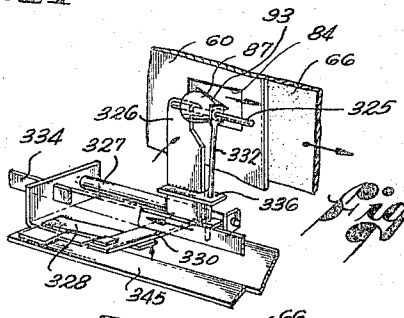
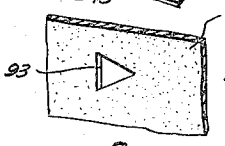



Fig. 26

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April 9, 1968 R. E. SCHROTER 3,377,438

PIVOTALLY MOUNTED CAPSTANS

Filed May 1, 1963 7 Sheets-Sheet 7

Fig. 27

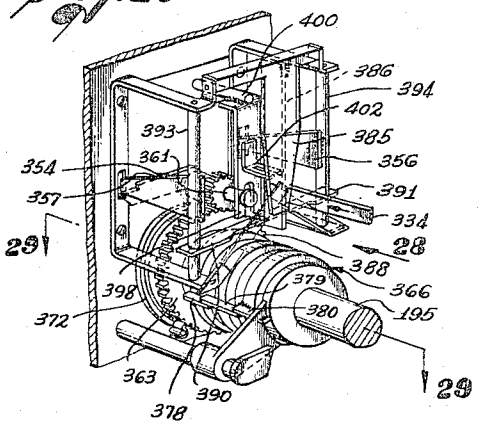



Fig. 28

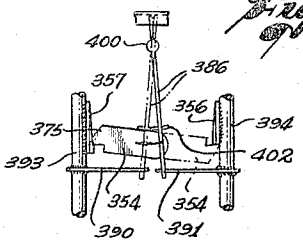



Fig. 30

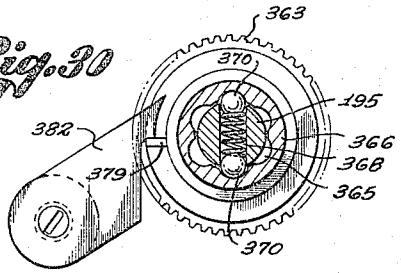



Fig. 31

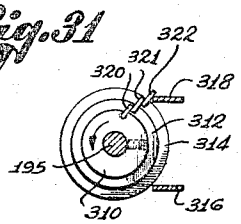
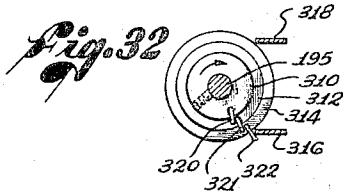



Fig. 32



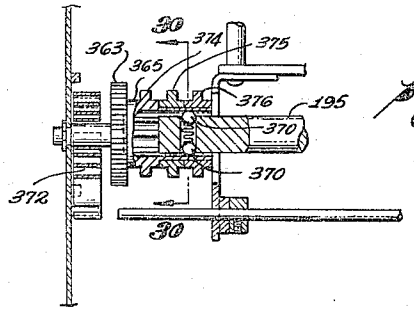




Fig. 29

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United States Patent Office

3,377,438

Patented Apr. 9, 1968



3,377,438

# PIVOTALLY MOUNTED CAPSTANS

Richard E. Schroter, Hollywood, Calif., assignor to Ralph J. Samuels, Los Angeles, Calif.

Filed May 1, 1963, Ser. No. 277,384
22 Claims. (Cl. 179—100.2)

This invention relates generally to sound recorders and reproducers, and more particularly to improvements in tape driving and head shifting means for magnetic tape recorders and reproducers of the type which use removable tape cartridges.

More specifically, this invention relates to improvements in miniature tape recorders and reproducers of the type described and claimed in my copending application Ser. No. 261,953, filed Feb. 27, 1963, for Tape Recorder and Reproducer, and assigned to Ralph J. Samuels.

In the aforementioned application Ser. No. 261,953, there are disclosed tape recorders and reproducers that overcome a major stumbling block that had previously existed in connection with miniature tape recorders, namely, that such recorders of the prior art were incapable of both high quality reproduction and the long playing times of the "suitcase size" tape recorders that utilize large reels of tape.

In my co-pending application, a small, removable tape cartridge is disclosed wherein a relatively wide strip of tape adapted for multi-lane recording is wound on a pair of spools, and the tape between the spools is in constant idling contact with a pair of capstans which are continuously rotated in opposite directions. A pair of pressure rollers is also provided to selectively bring about driving engagement between the tape and one or the other of the capstans, and thus control movement of the tape in either of two directions. The present invention is directed primarily to improvements in tape recorders and reproducers using such removable cartridges and continuously rotating, dual capstan drive systems.

Accordingly, a major object of the present invention is the provision of a new and improved tape recorder and reproducer of the type utilizing a wide strip of tape and a multi-position recording and reproducing transducer device.

Another object is to provide a new and improved tape recorder and reproducer which utilizes removable cartridges of magnetic tape, and wherein the tape never has to be handled in any manner.

A further object of the invention is the provision of a new and improved tape driving means for selectively controlling the direction of movement of magnetic tape in a removable cartridge.

Still another object of the present invention is to provide a tape driving means capable of more rapidly reversing the direction of tape movement.

Yet another object of the present invention is the provision of a constantly rotating, dual capstan, tape driving system capable of reversing the direction of tape movement with minimum time lag.

A still further object is to provide a new and improved tape rewind mechanism which is rapid and of simple design.

Still another object of this invention is to provide new and improved means for incrementally shifting a recording and playback head transversely along a magnetic tape to record and reproduce sounds along multiple lanes of the tape.

Yet another object is to provide, for a magnetic tape recorder and reproducer utilizing a removable cartridge containing a multi-lane tape, new and improved mechanical means for simultaneously controlling the position of a shiftable recording and playback head on the tape and controlling the direction of the movement of the tape.



The above and other objects and advantages of this invention will be better understood by reference to the following detailed description, when considered in connection with the accompanying drawings of an illustrative embodiment thereof, and wherein:

FIGURE 1 is a perspective view of a tape recorder and reproducer, in accordance with the invention, and illustrating the external case and controls;

FIGURE 2 is a top plan view of the recorder of FIGURE 1, a portion of the top plate being broken away to illustrate internal structure;

FIGURE 3 is a perspective view of a removable tape cartridge for use with the recorder of FIGURES 1 and 2, and shows a pair of guide openings in the cartridge housing for receiving externally operated capstans;

FIGURE 4 is an exploded view of the parts of the tape cartridge of FIGURE 3;

FIGURE 5 is a bottom plan view of the tape cartridge of FIGURE 3, and illustrates the cam surface portions for guiding the capstans into proper alignment;

FIGURE 6 is a fragmentary sectional view taken along the line **6—6** of FIGURE 5, and further illustrates the manner in which each capstan is guided by a cam surface into proper alignment for driving the tape within the cartridge;

FIGURE 7 is a bottom plan view of the tape recorder and reproducer of FIGURE 1, a portion of the bottom plate being broken away, and shows the tape driving mechanism in the "off" position;

FIGURE 8 is a sectional view, taken along the line **8—8** of FIGURE 7, and illustrates the means for shifting the flywheels of a pair of capstans into driving engagement with one another;

FIGURE 9 is a fragmentary sectional view, taken along the line **9—9** in FIGURE 7, and illustrates the detent mechanism for locating the "neutral" position of the line selector and tape direction control;

FIGURES 10 and 11 are perspective views of the interlock means for preventing the tape recorder and reproducer from being turned "off" except when the tape driving means is in the "neutral" state;

FIGURE 12 is a sectional view, taken substantially along the line **12—12** in FIGURE 7, and illustrates the camming means for controlling the line change and tape driving mechanisms of the tape recorder and reproducer;

FIGURE 13 is a fragmentary sectional view, taken along the line **13—13** in FIGURE 12, and shows further details of the line change and tape driving mechanisms of the recorder;

FIGURE 14 is a fragmentary sectional view, taken along the line **14—14** in FIGURE 13, and shows the relative positions of the tape spool drive posts and their respective drive rollers when the drive system is in "neutral";

FIGURE 15 is a fragmentary sectional view, similar to that of FIGURE 12, but with the camshaft and cam followers in their proper positions for the "rewind" state of the drive system;

FIGURE 16 is a fragmentary, side elevational view, taken in the direction of the arrow **16** in FIGURE 2, portions being broken away to illustrate the over-all gearing relationship between the manual line change mechanism, the camshaft and the automatic line change mechanism;

FIGURE 17 is a sectional view, similar to that of FIGURE 12, but with the camshaft and cams in their positions for placing the tape driving system in the "forward" state;

FIGURE 18 is a sectional view, taken along the line **18—18** in FIGURE 17, and illustrating the tape spool drive means and the automatic line change triggering mechanism;

FIGURE 19 is a fragmentary sectional view, taken along the line 19—19 in FIGURE 18, and shows the relative positions of the tape and tape spool drive elements immediately after a line change and reversal of the direction of tape movement;

FIGURE 20 is a fragmentary sectional view, taken along the line 20—20 in FIGURE 19, and illustrates one of a pair of spring-loaded plungers adapted for tape cartridge ejection;

FIGURE 21 is a fragmentary, partially schematic view illustrating the cooperation between one of the cam followers and an electrical switch for controlling the erase signal input to a tape head assembly;

FIGURE 22 is a front elevational view of the recorder of FIGURE 1, with the cartridge compartment cover in the open position;

FIGURE 23 is a fragmentary sectional view, taken along the line 23—23 in FIGURE 22, illustrating the gear arrangement for shifting the recording and playback head, and the camming arrangement for controlling the position of the tape pressure pad;

FIGURE 24 is a sectional view, taken along the line 24—24 in FIGURE 23, and illustrating further details of the tape drive and automatic line changing mechanisms;

FIGURE 25 is a fragmentary perspective view, taken in the direction of the arrow 25 in FIGURE 24, and illustrates the trigger mechanism for the automatic line changer;

FIGURE 26 is a fragmentary perspective view illustrating a hole at one end of a length of tape, such hole being used to trip the trigger mechanism shown in FIGURE 25;

FIGURE 27 is a fragmentary perspective view, taken in the direction of the arrow 27 in FIGURE 24, illustrating the automatic line change mechanism at one end of the camshaft;

FIGURE 28 is a fragmentary view, taken in the direction of the arrow 28 in FIGURE 27, and illustrates portions of the trigger mechanism for the automatic line change ratchet;

FIGURE 29 is a fragmentary sectional view, taken along the line 29—29 in FIGURE 27, and illustrating the spring drive for the automatic line change ratchet mechanism, as well as the controlled slippage system for coupling the camshaft to the line change mechanism;

FIGURE 30 is a sectional view taken along the line 30—30 in FIGURE 29; and

FIGURES 31 and 32 are sectional views, taken along the line 31—31 in FIGURE 12, and illustrating the stop mechanism for limiting rotation of the camshaft and transverse shifting of the recording and playback head.

Referring now to the drawings, and particularly to FIGURES 1, 2 and 7 thereof, there is shown a tape recorder and reproducer 40 having an external casing or housing 42. A machine "on"-"off" control knob 44 and tape direction and line selector control knob 46 project through the front face of the housing 42 at opposite ends thereof. The control knob 46 is affixed to one end of a pivotal shaft 49, the pivotal position of the shaft determining whether the tape drive system is in the "forward," "neutral," or "rewind" state. Rotation of the knob 46 and shaft 49 causes incremental shifting of a head assembly to different transverse positions relative to a tape, the position of the head assembly being indicated upon a numbered disc 47 at one side of the housing 42.

The front face of the housing 42 is also provided with a hinged cover plate 48 for selectively shielding and exposing a tape cartridge compartment within the recorder. The cover plate 48 can be locked in the closed position by an appropriate sliding latch 50 controlled by a latch handle 52 extending from the forward face of the cover plate 48.

As shown in FIGURES 2, 7, 13 and 19, the removable tape cartridge 54, once inserted into the recorder 40, automatically engages a pair of tape driving capstans 56, 57. The construction of the removable tape cartridge 54, and its cooperation with the driving capstans 56, 57, are best observed in FIGURES 3–6.



The cartridge 54 includes a housing 60 having a thick internal section 61. The inner surface of the section 61 is formed with a pair of curved portions 62, 63, each portion having a radius of curvature to match that of the flanges of a pair of spools 64, 65 by which a length of magnetic tape 66 is carried.

The section 61 may be a molded insert, e.g., of plastic or the like. The front surface of the section 61 is spaced sufficiently behind the front of the housing 60 to provide a space or channel for the tape 66. When the spools 64, 65 are located within the housing 60, the tape 66 thereon is passed between the spools and a pair of rods 68, 69 which extend through the housing outboard of and parallel to the spools, and the tape passes through the space between the section 61 and the front of the housing. The rods 68, 69 also aid in locating the spools 64, 65.

The end surfaces of the section 61 are spaced from the ends of the housing 60, to facilitate looping of the tape 66 over the section 61 during assembly of the cartridge 54. Furthermore, the ends of the section 61 are tapered, so that the section is generally trapezoidal in shape. Preferably, these end surfaces of the section 61 are also concave.

At opposite ends of the housing 60, slotted openings 70, 71 are provided which have their outermost ends aligned with respective openings 72, 73, and the innermost ends of the slotted openings 70, 71 are aligned with the innermost portions of the tapered end surfaces of the section 61.

Referring to FIGURE 5, it will be observed that, by virtue of the shapes of the section 61 and openings 70–73, when the tape 66 is passed over the front surface of the section 61, there is a substantial clearance between the tape and the ends of the shorter side of the section 61. The significance of this arrangement will be apparent in FIGURE 6, which shows the manner in which the driving capstans 57, 59 are automatically properly aligned for driving the tape 66 upon insertion of the cartridge 54 into the recorder 40. Although FIGURE 6 illustrates alignment only of the single capstan 57, both of the capstans 56, 57 are identical, and it is to be understood that alignment of the capstan 56 by insertion of the cartridge 54 is accomplished in exactly the same manner as shown for the capstan 57.

For purposes of discussion, it will be assumed that both capstans 56, 57 are pivotally mounted and have their outer ends normally biased towards each other. The specific manner in which the capstans 56, 57 are supported will be subsequently pointed out in connection with the detailed description of the drive system.

In the innermost positions of the capstans 56, 57, their outer ends are in position to be engaged by the inner portions of the end surfaces of the section 61, when the cartridge 54 is positioned so as to move it into place in the cartridge compartment below the hinged cover plate 48 (see FIGURES 2, 7, 22 and 23). To aid in this regard, the outer ends of the capstans are tapered to insure their entering the space between the tape 66 and the end surfaces of the section 61.

As indicated by the dotted and phantom positions of the capstan 57 in FIGURE 6, one of the end surfaces of the section 61 effectively cams the capstan outwardly. While thus being cammed, the capstan 57 inherently moves the tape 66 outwardly with it. When the cartridge 54 is locked in place within the recorder 40, both of the capstans 56, 57 have been brought into proper alignment adjacent the tape 66 (see FIGURE 19).

The shapes of the section 61 and the openings 70, 71 are chosen to insure that the capstans are properly cammed outwardly to their proper positions adjacent the tape 66. If desired, the section 61 may be rectangular in shape rather than trapezoidal, in which case the open-

ings **70**, **71** are appropriately shaped, e.g., pear-shaped, to effect the desired camming action upon the capstans.

With the cartridge **54** inserted into the recorder **40**, the outer end of each of the capstans **56**, **57** extends through the openings **72**, **73** respectively, and the top face of the cartridge **54** (see FIGURES 6 and 22). The outer ends of the capstans **56**, **57** are bearing caps **75**, **76**, respectively, which are rotatably mounted on the ends of the capstans. These bearings caps **75**, **76** are frictionally held in the circular openings **72**, **73**. Hence, lateral play of the capstans **56**, **57** is substantially eliminated, because each capstan rotates within its fixed bearing cap. The bearing caps **75**, **76** also prevents rotational contact of the capstans with portions of the cartridge **54** other than the tape **66**. Otherwise, portions of the cartridge in contact with the rotating capstans, as well as the capstans themselves, would wear rapidly.

Referring now again to FIGURES 3–5, the section **61** is provided with a central depression or recess **78** in its front surface. This arrangement permits the tape **66** to slide between a magnetic head assembly **80** and a pressure pad **82** when the cartridge **54** is inserted into the recorder **40** (see FIGURES 22 and 23). In this connection, a guide **83** is mounted within the cartridge compartment of the recorder to seat within the recess **78** when the cartridge is inserted.

As will be noted in FIGURE 3, the front of the housing **60** is provided with openings **84**, **85**, to permit entrance of a pair of line change triggers **87**, **88** (see FIGURES 7, 18, 24 and 25). In this connection, it should also be noted that the section **61** also has spaced shelf-like surface portions with recesses **90**, **91** aligned with the openings **84**, **85**, respectively, to provide clearance space into which the line change triggers may move when openings in the tape **66**, such as the trigger opening **93** shown in FIGURE 26, pass behind the triggers.

To facilitate assembly of the tape-filled cartridge **54**, the housing **60** may be formed in two parts **95**, **96**. The rods **68**, **69** are integral with one part **96**, and both parts **95**, **96** have slots in their front surfaces so as to form the openings **84**, **85** when the two parts are secured together.

The section **61** is positioned in one part **96** of the housing **60**. The spools **64**, **65** with the tape **66** thereon are positioned to fit in the curved wall portions **62**, **63**. Then the tape **66** is looped over the section **61**. The other part **95** of the housing **60** is then secured in place. In this connection, the two parts **95**, **96** of the housing **60** may be secured together by screws **98** for securing the part **95** to the outer ends of the rods **68**, **69**, and by screws **99** for securing the part **95** to the section **61**.

The housing **60** also has a pair of openings **101**, **102** in its underside (see FIGURES 4 and 5). When the cartridge **54** is moved into place within the recorder **40**, the openings **101**, **102** receive suitable support elements in the form of flanges **104**, **105**, respectively, carried at the lower ends of a pair of spool drive posts **107**, **108** (see FIGURES 2, 18, 19, 23 and 24).

As best observed in FIGURES 2, 7, 12, 17 and 19, movement of the tape **66** is aided by two banks of pressure rollers **109**, **110** which straddle the cartridge **54**. In this connection, the corners of the cartridge housing **60** are cut away to provide access openings **112**, **113**, and thereby permit the rollers **109**, **110** to selectively engage the tape **66** and press it against one of the capstans **56**, **57**, respectively.

As will be apparent in FIGURES 2, 8, 17 and 19, the tape driving capstans **56**, **57** are adapted for continuous rotation in opposite directions. Hence, to move the tape from right to left in FIGURE 17, the pressure rollers **109** are moved into engagement with the tape **66**, so that the capstan **56** controls the movement of the tape. Similarly, to move the tape **66** from left to right, the rollers **109** are moved out of engagement with the tape and the rollers **110** are brought into engagement with the tape, so that the capstan **57** controls the movement of the tape



(see FIGURE 19). When the tape drive system is in neutral as shown in FIGURE 12, neither of the pressure rollers **109**, **110** is in engagement with the tape **66**. In this case, neither capstan **56**, **57** imparts any movement to the tape **66**, and the tape remains stationary. The reason for this is that, although both capstans are at all times in contact with the tape **66**, until the pressure rollers **109** or **110** are brought into engagement with the tape **66** to press it against one or the other capstans **56**, **57**, there is insufficient frictional force between either capstan and the tape to drive the tape. Therefore, the capstans merely idle adjacent the tape, with total slippage between the surface of the tape and each capstan surface, until one of the pressure rollers **109**, **110** is brought into contact with the tape to press it against one of the capstans.

Referring to FIGURES 2 and 24, it will be observed that a pair of posts **115**, **116**, at opposite ends of the cartridge compartment in the recorder aid in guiding the cartridge **54** during its insertion into the recorder. These posts **115**, **116** minimize lateral play of the cartridge while it is being inserted. It will also be noted in FIGURES, 2, 19, 20 and 24, that a pair of spring-biased rods **118**, **119** are disposed below the cartridge **54** at opposite ends thereof, and are adapted to bias the cartridge upwardly as seen in FIGURE 2. Hence, when the cover plate **48** is unlatched and opened the cartridge **54** rises for ease of accessibility during removal.

The housing **60** of the cartridge **54** is provided with recesses **121**, **122** at both sides (see FIGURES 3–5) which are adapted to receive the guideposts **115**, **116** in the cartridge compartment of the recorder (see FIGURE 22). When the cartridge **54** has been completely inserted, the cover plate **48** is closed and latched, and the cartridge is held in position by a pair of resilient bumper elements **124**, **125** secured to the inside face of the cover plate (see FIGURES 18, 22 and 23).

Referring now to FIGURES 2, 7 and 8, the capstans **56**, **57** each pass through slightly oversized openings in a pair of mounting brackets **125**, **126**, respectively, and have their lower ends secured to a pair of flywheels **128**, **129**, respectively. An electric motor **131** is mounted within the recorder **40** below the flywheels **128**, **129** (see FIGURES 2, 7, 8 and 13) to present its output shaft **132** in driving engagement with a resilient peripheral rim **134** of the flywheel **129**. The output shaft **132** is provided with a portion **136** of enlarged diameter at its upper end, and this enlarged diameter portion is in driving engagement with a resilient roller **138** affixed to a shaft **140** which supplies motive power to the system for selectively imparting rotary motion to the spool drive posts **107**, **108** (see FIGURES 2, 7, 8, 13 and 18).

As shown in FIGURES 7 and 8, the flywheels **128**, **129** are normally held apart when the control knob **44** is in the "off" position, and the flywheels are brought into driving engagement with one another when the recorder **40** is turned "on" as shown in FIGURE 2. This is accomplished by mounting lower flywheel hub projections **142**, **143** so that they rest, via reduced diameter portions **145** passing through slightly oversized holes, in a pair of L-shaped support plates **147**, **148** (see FIGURES 8 and 18). The reason for the slightly oversized holes is to permit sufficient play so that the capstans **56**, **57** can be pivoted towards each other for proper insertion of the cartridge **54** into the recorder. The capstans **56**, **57** are normally biased towards one another by the leaf spring elements **150**, **151** shown in FIGURES 2 and 24.

Referring now more particularly to FIGURE 8, the L-shaped plates **148**, **149** are each pivoted about pins **152**, **153**, respectively, at the plate. A single pin **155** passes through overlapping portions of the shorter legs of both plates **147**, **148**. The pin **155** also passes through a clearance slot **157** in a horizontal support member **158** and through a cam slot **160** in a slide bar **161** adapted to move along the upper face of the support member **158**. The free ends of the longer legs of the L-shaped plates **147**,

148 are each provided with transverse clearance slots 163, 164 through which pins 166, 167, respectively, pass. The longer legs of the plates 147, 148 are coupled together by means of a coil spring 170, so that the longer legs, and hence the flywheels 128, 129, are biased towards each other.

When the slide bar 161 is in the extreme right position in FIGURE 8, the pin 155 is cammed to a position which causes the plates 147, 148 to overcome the biasing force of the spring 170 and pivot about their pins 152, 153, respectively. This causes the flywheels 128, 129 to move out of engagement and away from each other. However, if the slide bar 161 is moved to the left, the pin 155 is no longer cammed to a position which forces the flywheels to move away from each other, and the spring 170 will cause the plates 147, 148 to pivot so that the flywheels are again brought into engagement.

The position of the slide bar 161 is controlled by a pivotal arm 172 (see FIGURES 7, 8 and 18). The arm 172 extends along one side of the recorder housing and is pivoted at 173. The lower end of the arm 172 is pivotally coupled to one end of the slide bar 161 at 175, whereas the upper end of the arm is pivotally coupled to a rotatable plate 177 (see FIGURES 7 and 18). The plate 177 is, in turn, affixed to the lower end of the shaft 179 upon which the on-off control knob 44 is mounted. Hence, operation of the control knob 44 causes the slide bar 161 to move one way or the other and thus shift the flywheels 128, 129 into or out of driving engagement with each other.

When the control knob 44 is in the "off" position, the flywheels 128, 129 are out of engagement as shown in FIGURES 7 and 8. When the control knob 44 is in the "on" position, the flywheel 128 and peripheral rim 134 of the flywheel 129 are brought into driving engagement. Since the rim 134 of flywheel 129 is driven by the output shaft 132 of the motor 131, contact of the flywheel 128 with the rim 134 causes the flywheel 128 to also be driven, but in the opposite direction of rotation than the flywheel 129. Hence, both capstans 56, 57 rotate in opposite directions, as indicated in the previous general discussion, when the control knob 44 is moved to the "on" position. In this connection, it will be observed in FIGURE 8 that the slide bar 161 also carries a transverse finger 181 adapted to trip a two-position electrical switch 183 through which electrical power is supplied to the recorder 40. Thus, operation of the control knob 44 also operates the switch 183, through the elements 179, 177, 172 and 161, to turn on the supply of electrical power to the recorder.

As previously mentioned, selective engagement of either bank of pressure rollers 109, 110 with the tape 66 causes the respective capstan 56, 57 to drive the tape in one direction or the other (see FIGURES 17 and 19). Cooperating with this latter arrangement, means are provided for selectively rotating the spool drive posts 107, 108 on the same side of the cartridge 54 as the capstan which is driving the tape. As best observed in FIGURE 18, each spool drive post is provided with a plurality of vertical recesses, each recess receiving an outwardly bowed resilient member 185 covered with felt or the like. Hence, these members provide limited frictional contact between each spool drive post 107, 108 and the corresponding tape spool 64, 65 when the cartridge is inserted into the recorder.

In operation, the spool drive posts 107, 108 are always driven more rapidly than their corresponding capstans 56, 57. Hence, the corresponding spool 64 or 65, on the same side of the cartridge 54 as the capstan controlling movement of the tape 66, effectively takes up all of the tape driven by that capstan. However, the higher speed of the take-up spool than the capstan cannot alter the tape speed established by the capstan because of the limited frictional contact between the spool drive post and the spool. If the spool attempts to wind the tape 66 faster than the tape is moved by the driving capstan, the drag of the slower moving capstan causes slippage between the spool drive post and the spool, rather than causing a change in tape speed.

Referring to FIGURES 2, 13, 14, 18, 19 and 24, the spool drive posts are rotated by integral turntables 187, 188 at the base of each post 107, 108, respectively, and each turntable is selectively driven by one of a pair of drive rollers 190, 191, respectively. When the pressure rollers 109, 110 are both disengaged from the tape 66 in the "neutral" position of the tape direction control 46, both drive rollers 190, 191 are also disengaged from their respective turntables 187, 188 (see FIGURE 14). On the other hand, when the direction control 46 is in the "forward" position to bring one of the banks of pressure rollers 109, 110 into contact with the tape 66, the corresponding drive roller 190 or 191 is brought into engagement with the appropriate turntable 187, 188 (see FIGURES 19 and 24).

When the control 46 is placed in the "rewind" position, neither of the banks of pressure rollers 109, 110 engages the tape 66. However, in contrast to the "neutral" position, one of the drive rollers 190, 191 does contact its corresponding turntable 187, 188. The result is a rapid and extremely effective rewinding of the tape 66 from one spool to the other, with virtually no tendency for the tape to break or tear free from the spool being unwound when the end of the tape is reached.

The aforedescribed rapid rewinding of the tape 66 is accomplished because neither of the capstans 56, 57 imposes any drag on the tape to cause the spool drive posts 107, 108 to slip with respect to their spools. In the absence of such slippage between the spool drive posts and the spools, the tape 66 is wound at essentially the full speed at which the appropriate drive post turntable 187 or 188 is driven. However, when the end of the tape 66 is reached, the connection between the tape end and one of the spools 64, 65 applies sufficient drag to again cause slippage between the spool post being driven and its associated spool. In other words, the resistance of the wide tape 66 against tearing free from a spool exceeds the frictional forces between the spool drive posts and the spools, so that no tape breakage can occur at the end of a rapid rewind cycle.

Positioning of the banks of pressure rollers 109, 110 and turntable drive rollers 190, 191 for the "neutral," "forward" and "rewind" states, is accomplished by a rotatable and longitudinally shiftable camshaft 195 in cooperation with a pair of cam followers 197, 198 for controlling the position of the pressure rollers, and a pair of cam followers 199, 200 for controlling the positions of the turntable drive rollers (see FIGURES 12 15 and 17).

The drive roller 190 is mounted at the upper end of the driven shaft 140 for direct rotation with that shaft (see FIGURES 2, 18 and 24). The drive roller 191, on the other hand, is rotatably mounted at the upper end of a rotationally fixed shaft 202 (see FIGURES 2, 13 and 24). Although the shaft 202 is not a driven shaft, it will be noted in FIGURES 14, 19 and 24 that the drive rollers 190 and 191 are always in engagement with each other, so that the roller 190 always drives the roller 191 when the roller 190 is itself driven by the shaft 140.

A pair of leaf spring elements 204 and 205 (see FIGURES 2, 13, 18 and 24) bias the shafts 140 and 202 so that their respective drive rollers 190, 191 have a normal tendency to engage corresponding turntables 187, 188. However, each of the shafts 140, 202 is engaged by a fork 207, 208, respectively, for controlling the positions of the shafts in accordance with the positioning of the cam followers 199, 200 by the camshaft 195 (see FIGURES 12, 13, 17 and 18). The fork 207 is coupled by an arm 210 to a pivotal shaft 211, the shaft 211 being coupled by an arm 212 to the cam folllower 199. Similarly, the fork 208 is connected to an arm 214 which is affixed to a pivotal shaft 215, the shaft 215 being con-

nected by an arm **216** to the cam follower **200** (see FIGURES 10, 12, 13, 17 and 18). Hence, depending upon the camming effect of the camshaft **195** upon the cam followers **199, 200**, the positions of the forks **207, 208** are varied to bring their respective drive rollers **190, 191** into engagement with the corresponding spool post turntables **187, 188**.

Each of the cam followers **197, 198** is connected to rocker arms **220, 221**, respectively. The rocker arm **220** carries an arm **223** with a projection **224** (see FIGURES 17, 18) adapted to selectively engage and control the position of an arm **226** extending from a shaft **228**. Also mounted on the shaft **228** is a rocker arm **230** which carries and controls the position of the bank of pressure rollers **109**. Similarly, rocker arm **221** is provided with an arm and projection **236, 237** for engaging an arm **239**, the arm **239** being in turn connected to the same shaft **241** as the rocker arm **243** which carries the bank of pressure rollers **110**.

As best observed in FIGURES 2 and 17, the rocker arms **230** and **243** for the pressure rollers are both biased by coil springs **232, 245**, respectively, so that their respective pressure rollers have a normal tendency to engage the tape **66**. However, depending upon whether or not the cam followers **197, 198** are on high or low face surfaces of the camshaft **195**, the pressure rollers are either forced away from the tape **66** or allowed to engage the tape. Referring particularly to FIGURE 17, it will be noted that the cam follower **197** is resting on a low surface of the camshaft **195** and, therefore, its rocker arm **220** and associated arm **223** pivot to a non-restraining position relative to the arm **226**, so that the pressure roller rocker arm **230** is free to pivot the bank of pressure rollers **109** into engagement with the tape **166**. However, the cam follower **198** is shown to be resting on a high surface of the camshaft **195**. Hence, the rocker arm **221** and arm **236** are pivoted to a position whereby the arm **239** and pressure roller arm **243** are caused to pivot the bank of pressure rollers **110** out of engagement with the tape **66**.

Referring to FIGURES 12, 15 and 17, the camshaft **195** is provided with six sets of peripheral cam surfaces along its length, three sets on each side of center. The inner two sets of cam surfaces are for the cam followers **199, 200** which control the positioning of the rollers **190, 191** for the turntables **187, 188** (see FIGURE 14). The outer set of cam surfaces on each side of the camshaft are used to position the cam followers **197, 198** which control the positions of the banks of pressure rollers **109, 110**. By shifting the camshaft **195** along its longitudinal axis, the set of cam surfaces adjacent each of the cam followers is varied to place the drive system in either the "neutral," "forward" or "rewind" states of FIGURES 12, 17 and 15, respectively.

It will be observed in FIGURE 12 that, with the drive system in "neutral," all of the cam followers **197–200** rest on high surfaces of the camshaft **195**. Hence, neither of the pressure rollers **109, 110** engages the tape **66**, nor are either of the drive rollers **190, 191** in contact with any of the spool drive post turntables. Under these conditions, the tape **66** remains stationary.

As shown in FIGURE 15, when the camshaft **195** is shifted to the extreme right, to place the drive system in the "rewind" state, both of the cam followers **197, 198** abut high surfaces of the camshaft and, therefore, neither of the pressure rollers **109, 110** are brought into engagement with the tape **66**. However, each of the cam followers **199, 200** rests against a set of cam surfaces. Hence, one or the other of the drive rollers **190, 191** is brought into driving engagement with its respective turntable to rapidly wind the tape **66** onto the spool driven by the post of that turntable.

As best observed in FIGURE 17, when the camshaft **195** is longitudinally shifted to the extreme left, all four cam followers **197–200** abut a different set of cam surfaces. Hence, a bank of pressure rollers and a turntable drive roller will always be engaged on one side or the other of the tape cartridge depending upon the direction of movement of the tape. It will also be noted in FIGURE 17 that the camshaft **195** can be rotated about its longitudinal axis to change the positions of the cam followers **197–200**, and hence alter the direction of movement of the tape **66**. This is exactly what occurs during a line change, when the recording head **80** is incrementally shifted to a new line simultaneously with rotation of the camshaft **195** to alter the drive system so that the direction of movement of tape is reversed from one line to the next.

As will be apparent in FIGURES 7, 12, 15, 17 and 23, a cam follower **281** abuts the camshaft **195**, and is adapted to selectively apply or release the spring-biased pressure pad **82** against the tape **66**. A comparison of FIGURES 12, 15 and 17 shows that the pressure pad **82** can engage the tape **66** only when the drive system is in the "forward" state of FIGURE 17. When the drive system is in either the "neutral" or "rewind" states of FIGURES 12 and 15, respectively, the cam follower **281** rests upon a higher surface of the camshaft **195** and thus causes the linkage arrangement coupling the cam follower to the pressure pad to pivot the pressure pad away from the tape.

In order to provide proper clearance for insertion of the cartridge **54** into the cartridge compartment, it is necessary to move the two banks of pressure rollers **109, 110** further away from the capstans **56, 57** than can be accomplished by the normal action of the cam followers **197, 198** riding on the camshaft **195** in its "neutral" position (see FIGURE 12). Therefore, additional means are provided for camming the pressure rollers further away from the tape driving capstans when the direction control **46** is in "neutral" and the control **44** is in the "off" position (see FIGURE 12). In this connection, each of the rocker arm pivot shafts **228, 241** are provided with an additional arm **234, 247**, respectively, adapted to be selectively cammed by elements **249, 250** which are coupled to the on-off control **44** (see FIGURES 2, 12 and 22).

The camming element **249** is carried directly at the lower end of the shaft **179** of control **44** (see FIGURE 2). As best observed in FIGURES 22 and 23, portions also being shown in FIGURES 2, 7 and 18, the camming element **250** is coupled by a pivotal arm **252** and slide bar **253** to the control **44**. The control **44** is provided with an arm **255** so that, when the control **44** is in the "off" position, the arm **255** cams the pivotal arm **252** to bring the element **250** into engagement with the arm **247**. This shifts the bank of pressure rollers **110** further away from the capstan **57** (see FIGURE 12). Hence, with the control **44** in the "off" position, both banks of pressure rollers **109, 110** are shifted sufficiently to provide adequate clearance for insertion of the cartridge **54**.

When the switch **44** is moved to the "on" position, the only change that occurs in the structural arrangement shown in FIGURE 12 is that the camming elements **249, 250** are retracted, so that the arms **226, 239** can swing into abutment with the projections **224, 237**, respectively. Hence, although the pressure rollers **109, 110** move closer to the capstans **56, 57**, they are still spaced away from the tape **66** because both cam followers **197, 198** still abut high surfaces of the camshaft **195**.

The on-off control **44** also controls a number of interlocks to prevent cartridge removal when the recorder is "on," and also to prevent movement of the control **46** away from the "neutral" position when the recorder is "off." In this connection, the pivotal shaft **252** is provided with a depending tab **257** having a horizontal slot **259** at the end of the tab nearer the control **46** (see FIGURES 7, 10 and 11). The shaft **49** of the control **46** pivots about a shaft **261** which has a cantilevered lock tab **263**. The lock tab **263** is substantially horizontal when the control **46** is in the "neutral" position and, in this neutral position, the unsupported end of the lock tab **263** is in horizontal alignment with the slot **259** in the tab **257**. When the control **44** is in the "off" position, the pivotal arm **252** moves

the tab **257** so that the lock tab **263** is within the slot **259**. With the tabs **257** and **263** interlocked in this fashion, the control **46** cannot pivot about the shaft **261** and, hence, the control **46** is locked in the "neutral" position.

When the control **44** is moved to the "on" position, the pivotal arm **252** is actuated to move the tab **257** away from the lock tab **263**. Hence, the tab **263** moves out of the slot **259**, and the control **46** is free to pivot about the shaft **261** and place the tape drive system in the "forward" or "rewind" states.

Referring to FIGURE 7, it will also be apparent that the control **44** cannot be moved from the "on" position to the "off" position when the control **46** is in any position other than "neutral." Movement of the control **46** from the "neutral" position to either the "forward" or "rewind" positions causes the lock tab **263** to pivot out of horizontal alignment with the slot **259** and, therefore, blocks movement of the tab **257** extending from the pivot arm **252**. Hence, the control **44** cannot be returned to the "off" position unless the control **46** is in "neutral." For this reason, a detent mechanism is used to provide positive feel when the control **46** is engaged in the "neutral" position. Referring to FIGURES 7 and 9, it will be observed that the detent mechanism comprises a bar **265** coupled to the shaft **49** of the control **46** and riding against a notched tab **267** carried at the free end of a cantilevered leaf spring element **269**.

Referring more particularly to FIGURES 7, 22 and 23, it will be observed that the on-off control **44** also operates means for selectively locking the cover plate **48**, once the cover has been closed and latched and the recorder has been turned "on." In this regard, a slotted plate **271** is secured to the shaft **179** of the control **44** for rotation therewith. The plate **271** engages a vertical leg **273** of a slide bar **275**. The opposite end of the slide bar **275** is provided with a second vertically extending leg **277**. When the cartridge **54** has been inserted into the recorder **40**, and the cover plate **48** has been closed, the handle **52** is used to operate the sliding latch **50**. When this has been done, and the control **44** is turned "on," the leg **277** moves behind a downwardly extending leg **279** of the latch **50**. This, in turn, prevents the latch **50** from sliding to the left in FIGURE 23, and thus prevents the cover **48** from being opened until the control **44** is returned to the "off" position to shift the leg **277** out of the path of the sliding latch **50**.

Referring now to FIGURE 21, the head assembly **80** includes a pair of erase heads **286, 287** with a recording and playback head **285** spaced centrally between the pair of erase heads. When the head assembly **80** is used for recording on the tape **66** rather than for playback purposes, an erase head must always lead the recording head in the recording path. Since the tape **66** moves first in one direction to record one line, and then in the opposite direction to record the next line, the erase signal must be switched from one erase head to the other at each line change. This is accomplished by means of a single pole, double throw microswitch **291** which selectively switches the erase signal input to one or the other of the erase heads **286, 287** depending upon the position of the cam follower **198** (see FIGURES 17 and 21). Since the position of the cam follower **198** controls the direction of movement of the tape **66**, selective operation of the switch **291** in accordance with the position of the cam follower **198** likewise vary in accordance with the direction of tape movement.

As will be apparent in FIGURES 2, 7 and 17, the pivotal shaft **49** of the control **46** carries a small bevel gear **290** at its lower end. The gear **290** is in mesh with a larger bevel gear **292** carried at one end of the camshaft **195**. The lower end of the bar **265** coupled to the shaft **49** contacts the opposite side of the gear **292** in contact with the gear **290**. With this arrangement, pivoting of the shaft **49** by the control **46** causes the camshaft **195** to shift longitudinally as shown in FIGURES 12, 15 and 17.

Referring to FIGURES 7, 12 and 23, when the shaft **49** is rotated by the control knob **46**, the gear **290** drives gear **292** to rotate the camshaft **195**. This rotation of the camshaft causes the cam followers **197–200** to shift their position and thereby alter the drive system to move the tape in the proper direction for the particular line selected by rotation of the control **46**. The center of the camshaft **195** is processed to provide a gear **297** of slightly reduced diameter than the maximum diameter of the camshaft. The gear **297** is in mesh with a large spur gear **299** which is affixed to a shaft **306** passing through its axis of rotation, the shaft **306** being also coupled to the line indicating disc **47**. Hence, line selection by rotation of the control **46** automatically brings about an indication of the selected line via the disc **47**.

Mounted on the same shaft **306** as the gear **299**, is a small pinion gear **301** which drives a rack **302**. The head assembly **80** is affixed, between a pair of guide posts **303, 304**, to the upper end of the rack **302** for movement with the rack. Hence, rotation of the control **46** to change lines automatically shifts the head assembly **80** to the selected line, automatically rotates the camshaft **195** to cam the drive system into the proper state for driving the tape in the appropriate direction for the selected line, and automatically indicates the selected line by the disc **47**.

To prevent damage to the head assembly **80** by moving the rack **302** too far in either direction, an automatic stop arrangement is used to limit rotation of the camshaft **195** by the control **46** to a specified number of complete revolutions which will not drive the rack beyond safe limits for the head assembly. This stop means is best observed in FIGURES 7, 12, 31 and 32 and comprises a collar **310** secured to the camshaft **195**, together with a pair of discs **312, 314** which are both mounted on the shaft **195** adjacent the collar **310**, but both discs **312, 314** are rotatable with respect to the camshaft and each other. The diameters of the discs and collar in the stop assembly also vary, the collar **310** having the smallest diameter and the outer disc **314** having the largest diameter.

As best observed in FIGURES 7, 31 and 32, a pair of spaced apart, fixed flanges **316, 318** are provided adjacent the stop assembly. The collar **310** and each of the discs **312, 314** are each provided with peripheral tabs **320–322**, respectively. The peripheral tab **320** overlaps the tab **321** but not the tab **322**. The peripheral tab **321**, in turn, radially overlaps the tab **322**. The flanges **316, 318** are positioned so that the tab **322** cannot clear either flange during rotation of the disc **314**, but either of the tabs **320, 321** will clear the flanges during rotation of the collar **310** and disc **312**, respectively.

The arrangement illustrated in FIGURES 31 and 32 limits rotation of the shaft **195** to three revolutions from the upper stop position of FIGURE 31 to the lower stop position of FIGURE 32 and vice versa. In moving from the upper stop position to the lower stop position, the shaft **195** is rotated counterclockwise in FIGURE 31. During the first revolution, the collar **310** rotates with the shaft **195** and the tab **320** clears the lower flange **316** to contact the underside of the tab **321** upon the disc **312**. During the second revolution, both the collar **310** and disc **312** rotate with the shaft **195** and clear the flange **316** to bring the tab **321** into abutment with the underside of the tab **322**. During the third revolution, the collar and both discs rotate with the shaft **195**, and the tab **322** is stopped by the lower flange **316** to prevent further rotation of the camshaft **195**. The sequence is exactly the same is moving from the lower flange **316** to the upper flange **318**. The number of revolutions to which the shaft **195** is limited may be varied in accordance with the number of discs used in the stop assembly, i.e., one additional permissible revolution for each additional disc.

The structure of the automatic line change mechanism is best observed in FIGURES 7, 18 and 23–30. At each end of the tape **66**, the tape is provided with a triggering hole **93**, preferably triangular in shape and in alignment with one of the openings **84**, **85** in the cartridge **54**. The triggers **87**, **88**, preferably conical in shape, extend through the openings **84**, **85** in the cartridge and rest against the tape **66** as the tape moves. When an end of the tape is reached, the triggering hole **93** at that end of the tape comes into registry with the cartridge opening **84** or **85** at that end, and the respective trigger **87**, **88** will slip into the hole **93** and be carried along with the tape to trip the automatic line change mechanism and reverse the direction of movement of the tape.

Each of the triggers **87**, **88** is a unidirectional triggering device, in that the opening **93** in the tape will catch and drive the trigger in one direction but will release the trigger in the other direction. In this connection, the wide base of the conical trigger element **87**, **88** should face in the direction opposite to that in which the tape moves to bring about triggering, and the apex of the conical trigger should face in the same direction as the desired triggering movement of the tape.

The trigger mechanisms for both ends of the tape are similarly mounted, but face in opposite directions. The trigger **87** is mounted for sliding movement along a horizontal shaft **325** which extends from a pivotal plate **326**. The plate **326** is secured to a pivot shaft **327**, and is biased towards the cartridge housing **60** by a leaf spring element **328** in abutment with an arm **330** extending from the lower end of the plate **326**. By biasing the plate **326** towards the cartridge housing **60** in this manner, the trigger **87** is thus biased against the tape **66**.

A trip rod **332** has one end slidably mounted upon the shaft **325** adjacent the apex of the trigger **87**. The opposite end of the trip rod **332** is connected to a trigger push rod **334**, the trip rod **332** being pivoted above the push rod at **336**. Hence, when the trigger **87** engages the hole **93** and is carried by the tape **66**, the upper end of the trip rod **332** is carried with the trigger along the shaft **325**. This causes the trip rod to pivot at **336** and move the push rod **334** to the left in FIGURES 7, 25 and 27. The mounting and biasing arrangement for the trigger **88** is essentially a mirror image arrangement of that for the trigger **87**, except that the trip rod **340** is pivoted below the push rod **334** so that movement of the trigger **88** also causes the push rod **334** to move to the left.

A slide bar **345** is supported just above the cam follower rocker arms **220**, **221** (see FIGURE 7). This slide bar **345** has a depending tab **347** (see FIGURES 7 and 23) which abuts the gear **297** of the cam shaft **195**. Since the gear **297** has a maximum outer diameter which is less than the maximum diameter of the camshaft **195**, a pair of shoulders are provided by the camshaft on each side of the gear **297** to carry the tab **347** with the camshaft whenever the shaft is shifted longitudinally. Hence, whenever the camshaft **195** is shifted by the control **46**, for placing the drive system in the "neutral," "forward" or "rewind" states, the tab **347** and slide bar **345** are also shifted with the camshaft.

As best observed in FIGURES 7, 18, 23 and 24, the slide bar **345** has a pair of cantilevered members **350**, **351**, which overlie each of the pivot arms **330**, **338** of the triggers **87**, **88**, respectively. The members **350**, **351** are each shaped to define two zones of differing spacing between the members and the slide bar **345**, the smaller spacing zone being further to the left, and the zone of greater spacing being further to the right adjacent the free end of each member.

When the control **46** is pivoted to the right in FIGURE 7, to place the drive system in the "forward" state, the camshaft **195** and slide bar **345** are moved to their extreme left positions. This permits the arms **330** and **338** of the triggers **87**, **88**, respectively, to pivot upwardly under the influence of their respective leaf spring



elements **328**, **339**, so that the triggers are biased against the tape **66**. However, when the control **46** is pivoted to the left to place the drive system in either the "neutral" or "rewind" states, the camhsaft **195** and slide bar **345** are moved to their extreme right positions in FIGURE 7. When this occurs, the pivot arms **330** and **338** of the line change triggers are placed within the zones of narrow spacing between the members **350**, **351** and the slide bar **345**. Under these conditions, the biasing forces of the leaf spring elements **328**, **339** are overridden by the members **350**, **351**, and the triggers **87**, **88** are pivoted out of engagement with the tape **66** (see FIGURE 18). This pivoting of the line change triggers **87**, **88** out of engagement with the tape **66** is of particular significance when the drive system is in the "rewind" state, since it is desired that the tape is rewound without the hole **93** at the end of the tape causing any triggering of the automatic line change mechanism.

The push rod **334** releases a spring-wound ratchet mechanism each time it is moved to the left, and this ratchet system rotates the camshaft **195** each time it is released, to cause a single line change. As observed in FIGURE 16, the ratchet **354** is successively spring biased against one or the other of a pair of pawls **356**, **357**. Each time the push rod **334** is moved to the left (see FIGURE 25) one of the pawls **356**, **357** is momentarily shifted out of the path of the ratchet **354**, so that the ratchet moves through 180° to abut the other pawl.

The ratchet **354** is mounted on a shaft **359** carrying a small spur gear **361**. The gear **361** is in mesh with a larger spur gear **363** adapted to drive the camshaft **195**. When the camshaft **195** is rotated, the camshaft gear **297** rotates the gear **299** which, in turn, rotates the pinion **301** to drive the rack **302** and thereby shift the head assembly **80** to a new line on the tape.

The means for selectively releasing the ratchet **354** one step at a time, by actuation of the push rod **334**, are best observed in FIGURES 27–30. The camshaft **195** is adapted to have one end slidably received within an internal keyway **365** of a drum **366**. The end of the camshaft inserted into the keyway is provided with a transverse bore **368** in which are placed a pair of oppositely disposed spring-loaded balls **370**.

A torsion spring **372** (see FIGURE 29) biases the gear **363** and drum **366**. The drum **366** would ordinarily rotate under the influence of the spring **372** except for the restraining action of the ratchet **354** and pawls **356**, **357**. However, the ratchet and pawl arrangement have no restraining effect upon manual line changing by rotation of the camshaft **195**. The reason for this is that the spring-loaded balls allow the camshaft **195** to slip with respect to the drum **366** when any attempt is made to rotate the camshaft while the drum is being held stationary by the ratchet and pawl mechanism. However, when one of the pawls **356**, **357** is momentarily shifted to release the ratchet **354**, the spring **372** momentarily encounters little resistance and, therefore, drives both the drum **366** and camshaft **195** through an automatic single line change.

It will be noted in FIGURES 16 and 28 that the shape of the outer end of the ratchet **354** is such that rotation of the ratchet is restrained by the pawls **356**, **357** only in a single direction. If the ratchet **354** is rotated in the opposite direction, the canted or curved end face **375** of the ratchet automatically cams the pawls **356**, **357** out of the path of the ratchet. Hence, the automatic line change mechanism only is effective to make line changes in ascending order, e.g., lines 1 to 2, 2 to 3, 3 to 4, etc.

Return to the first line on the tape must be accomplished manually by rotation of the line selector control **46**. When the camshaft **195** is rotated manually in this manner, to return to earlier lines on the tape, both the drum **366** and ratchet **354** rotate without restraint with the camshaft. However, manual rotation of the camshaft **195** to move the direction of ascending order of lines upon the tape, always encounters resistance due to the ratchet and pawl

arrangement, and thus causes the camshaft to slip with respect to the drum **366**.

Whenever the camshaft **195** is manually rotated to return to earlier recording lines on the tape, rotation of the drum **366** with the camshaft also rewinds the torsion spring **372**, so that the spring can bias the system through automatic line changes over the entire usable width of the tape. However, since the camshaft **195** slips with respect to the drum **366** when the camshaft is rotated in the opposite direction, the spring **372** is never unwound by manual rotation of the camshaft via the control **46**.

To prevent overwinding of the spring **372**, a stop arrangement, in the form of three drum segments **374**, **375**, **376** having overlapping peripheral tabs **378–380**, respectively, cooperate with a fixed member **382** in the same manner as the stop system for the camshaft **195** illustrated in FIGURES 31 and 32. Hence, the spring **372** is protected by limiting the number of revolutions of the drum **366** which wind the spring.

The push rod **334** has its leading end in abutment with a slightly flexible plate **385** having a mutually perpendicular and also slightly flexible strip **386** positioned behind the plate. A leaf spring **388** biases the plate **385** and push rod **334** to the right, so that the plate **385** does not contact the strip **386** until the tape triggers drive the push rod **334** to the left to override the spring **388**. When the latter occurs, the strip **386** contacts and rotates one or the other of a pair of pivot arms **390**, **391** secured to the pawl pivot shafts **393**, **394**, respectively. Rotation of either of the arms **390**, **391** causes the corresponding pawl **357**, **356** to shift out of engagement with the ratchet **354** so that the latter may rotate through 180°.

When the ratchet **354** rotates, the spur gear **361** rotates with it and drives a coaxial eccentric **396** through 180°. Rotation of the eccentric **396** causes a forked member **398** to pivot slightly about a shaft **400**. Carried on the face of the member **398** is another forked element **402** engaging the trigger strip **386** and moving the latter each time member **398** is pivoted.

The operation of the system is as follows: Movement of the push rod **334** to the left causes the trigger strip **386** to pivot one of the arms, e.g., **390**, to shift the pawl **357** and release a ratchet **354** through 180°. When the ratchet rotates, the gear **361** rotates with it to drive the large gear **363** which, in turn, drives the drum **366** and camshaft **195** through a single line change in ascending numerical order. Rotation of the ratchet **354** also rotates the eccentric **396** which, through members **398** and **402**, shifts the slightly flexible trigger strip **386** to a position adjacent the pivot arm **391**. With the trigger strip **386** thus positioned, upon the next stroke of the push rod **334**, the next pawl **356** will be shifted to again release the ratchet **354** through another 180° and return it to its original position adjacent the pawl **357**. This sequence of events is repeated each time the push rod **334** is driven to the left in FIGURE 27 by one of the tape triggers **87**, **88**, each pawl **356** or **357** being shifted on alternate strokes.

It will be apparent from the foregoing that, while a particular form of my invention has been illustrated and described, various modifications can be made without departing from the spirit and scope of my invention. Accordingly, I do not intend that my invention be limited, except as by the appended claims.

I claim:

**1.** In a tape recorder, the combination comprising:
- a cartridge containing a length of magnetic tape;
- a pair of pivotally mounted tape driving capstans;
- means for biasing the outer ends of said capstans towards each other;
- means within said cartridge for camming the outer ends of said capstans away from each other and bringing said capstans into contact with said tape when said cartridge is inserted onto said capstans;
- means for rotating each of said capstans continuously in opposite directions after insertion of said cartridge;
- and pressure roller means for selectively pressing said tape against one or the other of said capstans to drive said length of tape in either of two directions.

**2.** Magnetic tape recording apparatus, comprising:
- a cartridge;
- a length of magnetic tape supported within said cartridge;
- a pair of pivotally mounted tape driving capstans having their outer ends normally biased towards each other;
- a bearing cap mounted at the outer end of each of said capstans, each bearing cap being rotatable with respect to its capstan;
- means within said cartridge for camming said capstans away from each other and into positions adjacent said tape when said cartridge is moved over said capstans;
- means for continuously rotating said capstans in opposite directions;
- and a pair of pressure roller means for selectively pressing said tape against one of the rotating capstans to drive said length of tape in a first direction, and for selectively pressing said tape against the other of said rotating capstans to drive said length of tape in the opposite direction.

**3.** In a tape recording system having a pair of spools supporting a length of tape, the combination comprising:
- a pair of parallel, tape driving capstans in contact with said tape;
- a pair of spool drive posts in driving engagement with said spools;
- a respective drive roller rotatable to drive one of said spool drive posts in the same direction as the capstan nearer the post to be rotated;
- means for continuously rotating each of said capstans in opposite directions and for continuously rotating each of said drive rollers in opposite directions;
- restraining means for each of said drive rollers to maintain the drive rollers out of driving engagement with said spool drive posts;
- a pair of pressure roller means, each closely adjacent to but spaced from one of said tape driving capstans;
- camming means for selectively actuating one of said pressure roller means to press said tape against the adjacent capstan for driving said length of tape, said camming means also selectively disabling one of said restraining means to bring one of said drive rollers into driving engagement with the spool drive post nearer the capstan driving said tape;
- means for varying said camming means to alter the positions of said pressure roller means and said drive rollers so that the other capstan and spool drive post post nearer the capstan driving said tape;
- and means for further varying said camming means to maintain both of said pressure roller means out of engagement with said tape and selectively bring one or the other of said drive rollers into engagement with one of said spool drive posts.

**4.** Apparatus as set forth in claim **3**, wherein said camming means includes a multi-position camshaft and a plurality of cam followers for controlling the positions of said pressure roller means and said drive rollers.

**5.** Apparatus as set forth in claim **3**, including:
- a surface irregularity at each end of said length of tape;
- and trigger means responsive to the surface irregularity at each end of said length of tape for conditioning said camming means to reverse the direction in which said length of tape is driven.

**6.** Apparatus as set forth in claim **5**, including means for disabling said trigger means whenever said camming means has been varied to bring one of said drive rollers

into driving engagement with one of said spool drive posts while both of said pressure roller means are out of engagement with said tape.

7. In combination with a length of tape having its ends secured to a pair of spools, a tape driving system, comprising:

a pair of parallel, tape driving capstans adjacent said tape;

means for rotating each of said capstans continuously in opposite directions;

a pair of spool drive posts in driving engagement with said spools;

a pair of pressure rollers, each pressure roller being adjacent one of said capstans and selectively movable to press said tape against a capstan;

a pair of drive rollers, each roller being adapted to selectively drive one of said spool drive posts;

means for continuously rotating each of said drive rollers in opposite directions;

a camshaft having a plurality of cam surfaces about its periphery and along its length;

a plurality of cam followers abutting said camshaft for controlling the positions of said pressure rollers and said drive rollers relative to said tape and said spool drive posts, respectively;

first means for selectively rotating and longitudinally shifting said camshaft along its longitudinal axis to adjust said cam followers to a first state wherein one or the other of said pressure rollers is in engagement with said tape and one or the other of said drive rollers is in driving engagement with one of said spool drive posts, to a second state wherein neither of said pressure rollers engages said tape and neither of said drive rollers engages any of said spool drive posts, and to a third state wherein neither of said pressure rollers engages said tape and one of said drive rollers is in driving engagement with one of said spool drive posts;

and normally inactive second means for rotating said camshaft to adjust said cam followers only with respect to said first state.

8. Apparatus as set forth in claim 7, including additional camming means for selectively increasing the spacing between said tape and both of said pressure rollers when said cam followers are in the second state and neither of said capstans or said drive rollers is rotating.

9. Apparatus as set forth in claim 7, including trigger means responsive to a surface irregularity at either end of said length of tape to activate said second means and thereby reverse the direction of movement of said tape.

10. In combination with a length of tape having a surface irregularity at each end of said length of tape:

tape driving means;

control means for said tape driving means for reversing the direction of movement of the tape;

a pair of slidable triggers to engage the tape, each trigger being movable by and with said tape when the trigger encounters a surface irregularity at the end of said tape, movement of one trigger by the surface irregularity at one end of said tape being in the opposite direction to movement of the other trigger by the surface irregularity at the other end of said tape;

an elongated push rod;

and a pair of pivotal trip rods, each trip rod having one end coupled for movement with one of said triggers and each at its other end engaging and longitudinally moving said push rod when the trip rod is pivoted by its respective trigger.

11. A combination as set forth in claim 10, wherein pivotal movement of either of said trip rods always drives said push rod in the same direction.

12. In combination with a length of tape having a surface irregularity at each end of said length of tape:

tape driving means;

control means for said tape driving means for reversing the direction of movement of the tape;

a pair of slidable triggers to rest on the tape, each trigger being movable by and with said tape when the trigger encounters a surface irregularity at the end of said tape, movement of one trigger by the surface irregularity at one end of said tape being in the opposite direction to movement of the other trigger by the surface irregularity at the other end of said tape;

an elongated push rod;

a pair of pivotal trip rods, each rod having one end coupled for movement with one of said triggers and each at its other end engaging and longitudinally moving said push rod in a single, common direction when the trip rod is pivoted by its respective trigger;

means for biasing said triggers into contact with said tape when said tape driving means is in the "forward" drive state;

and disabling means for lifting said triggers out of contact with said tape when said tape driving means is not in the "forward" drive state.

13. In a tape recorder, the combination comprising:

a cartridge containing a length of magnetic tape;

a pair of capstans supported at one end for rotation, said capstans being normally non-parallel but being relatively movable so as to be parallel,

said cartridge having openings to receive the other ends of said non-parallel capstans;

capstan moving means operable upon forcing said cartridge onto said capstans to bring said capstans into parallel relation;

means for rotating said capstans in opposite directions;

and pressure roller means adjacent each capstan for selectively pressing said tape against one or the other of said capstans.

14. For use in tape recorder apparatus having spaced, normally non-parallel capstans capable of relative movement so as to be parallel, and a magnetic transducer intermediate the capstans, the combination of:

a pair of reels supporting a length of magnetic tape;

a housing having front, back and top walls, said housing having compartments in which said reels are located between said front and back walls on parallel axes;

means in said housing supporting the portion of the tape intermediate said reels for movement adjacent said top wall, said top wall having an opening intermediate its ends through which part of the intermediate tape portion is exposed to the exterior of said housing

said front wall having openings to receive the ends of the non-parallel capstans, said front wall openings being positioned so that the ends of the capstans can enter the housing between the respective reels and the parts of the intermediate tape portion adjacent to such reels;

and cam means in said housing and operable, when the housing is forced onto the ends of the capstans, to effect relative movement of the capstans and bring them into parallel relation, the exposed portion of the tape being engageable by the transducer when said housing is on the ends of the capstans.

15. The combination of claim 14, wherein said support means for the intermediate tape portion constitutes a pair of elements in said housing adjacent said front wall openings, said elements having top surfaces adjacent said top wall and over which said intermediate tape portion passes,

and wherein said cam means includes edge surface portions of said elements adapted to be engaged by the ends of the capstans entering said front wall openings, said edge surface portions extending inwardly of said housing at an angle so as to cause the ends

of both capstans to move to the positions in which, when the housing has been forced onto the capstans, the capstans are parallel.

16. The combination of claim 15, wherein said top wall has openings adjacent its ends to expose the portions of the tape engaged by the capstans through which to selectively press said tape against one or the other of the capstans.

17. For use in a tape recorder apparatus having spaced, normally non-parallel capstans capable of relative movement so as to be parallel, and a magnetic transducer intermediate the capstans, a cartridge comprising:

a pair of reels;

a length of tape having its ends attached to said reels, said tape having openings therein adjacent its ends;

a housing having front, back and top walls;

a shelf member in said housing having a pair of spaced surface portions adjacent to said top wall, said surface portions having openings therein,

said top wall having openings therein aligned with said openings in said surface portions,

said housing having compartments below said shelf member, said reels being located in said compartments on parallel axes between said front and back walls,

the portion of said tape intermediate said reels extending over and along said surface portions of said shelf member,

said housing having openings intermediate said first-mentioned openings therein and through which said intermediate tape portion passes and is exposed to the exterior of said housing,

said front wall having respective openings adjacent the ends of said shelf member to receive the ends of the non-parallel capstans, said front wall openings being positioned so that the ends of the capstans can enter the housing between the respective reels and the parts of the intermediate tape portion adjacent to such reels; and

cam means in said housing and operable, when the housing is forced onto the ends of the captans, to effect relative movement of the capstans and bring them into parallel relation, the exposed portion of the tape being engageable by the transducer when said housing is on the ends of the capstans.

18. The assembly of claim 17, wherein said top wall has openings adjacent the ends thereof through which are exposed the portions of the tape adjacent the ends of said shelf member.

19. The assembly of claim 17, wherein the ends of said shelf member having concave edges, the portions of said concave edges adjacent said back wall being parallel, the remaining portions of said concave edges extending forwardly from said parallel portions to said front wall openings,

said front wall openings extending longitudinally in said front wall, the adjacent ends of said front wall openings and the concave edges of said shelf member being similarly curved,

and said back wall having openings adjacent its ends, said back wall openings and the remote ends of said oblong openings being similarly curved.

20. The assembly of claim 17, wherein said front wall openings extend longitudinally in said front wall, the remote ends of said front wall openings being larger than their adjacent ends, and said back wall having openings therein aligned with the enlarged portions of said front wall openings.

21. In a tape recorder, the combination comprising:

a cartridge containing a length of magnetic tape;

a pair of pivotally mounted tape driving capstans;

means for biasing the outer ends of said capstans towards each other; and

means within said cartridge for camming the outer ends of said capstans away from each other and bringing said capstans into contact with said tape when said cartridge is inserted onto said capstans.

22. For use in a tape recorder having spaced, normally non-parallel capstans capable of relative movement so as to be parallel, a cartridge comprising:

a cartridge housing;

means for supporting a length of magnetic tape within said housing; and

capstan moving means operable upon forcing said cartridge onto said capstans to bring said capstans into parallel relation adjacent said tape.

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