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[54] **CONTROLLABLE TENSIONING DEVICES FOR STRAND MATERIAL**

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[52] **U.S. Cl.** .....**112/255,** 242/155 M

[51] **Int. Cl.** **D05b 47/00**

[58] **Field of Search** ..112/254, 255; 242/155 M, 156; 188/171

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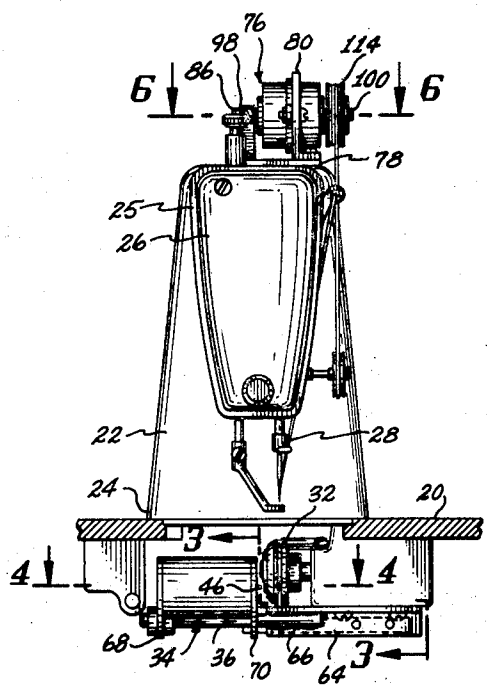
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[57] **ABSTRACT**

Command responsive devices allow tension adjustments to be made to a strand material on a sewing machine during the sewing operation. The devices comprise an upper strand tensioning device and a lower strand tensioning device, both of which are adapted to apply various tension values to the respective strands in accordance with the command signals received.

5 Claims, 6 Drawing Figures



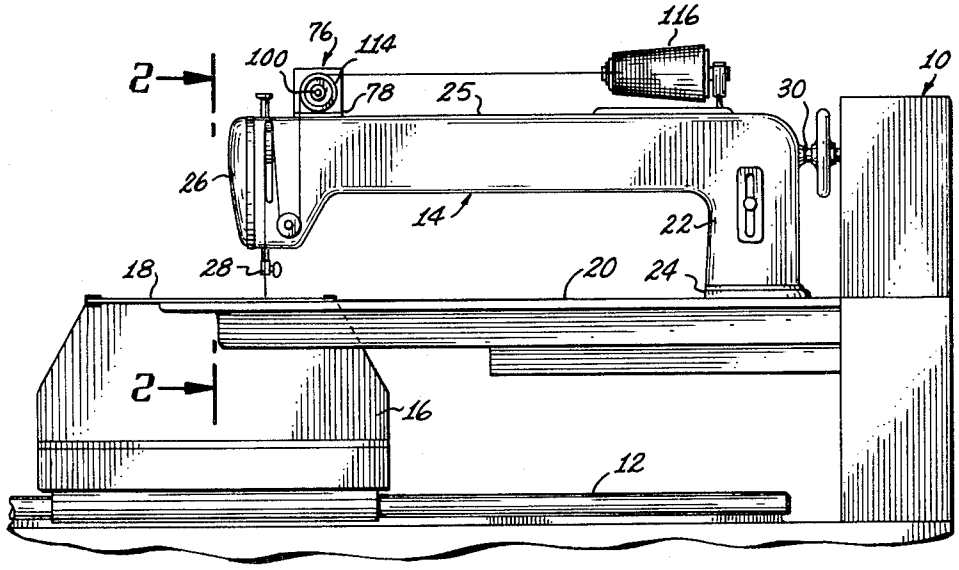


Fig-1

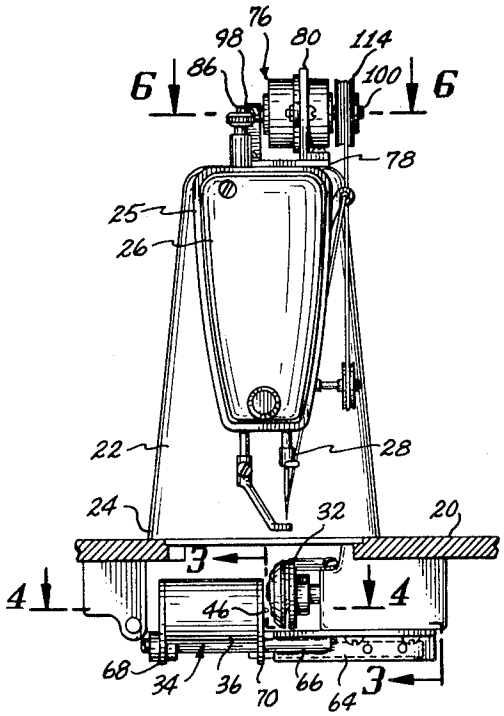


Fig-2

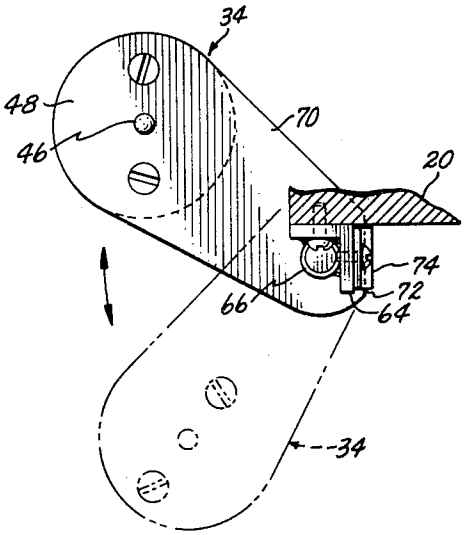


Fig-3

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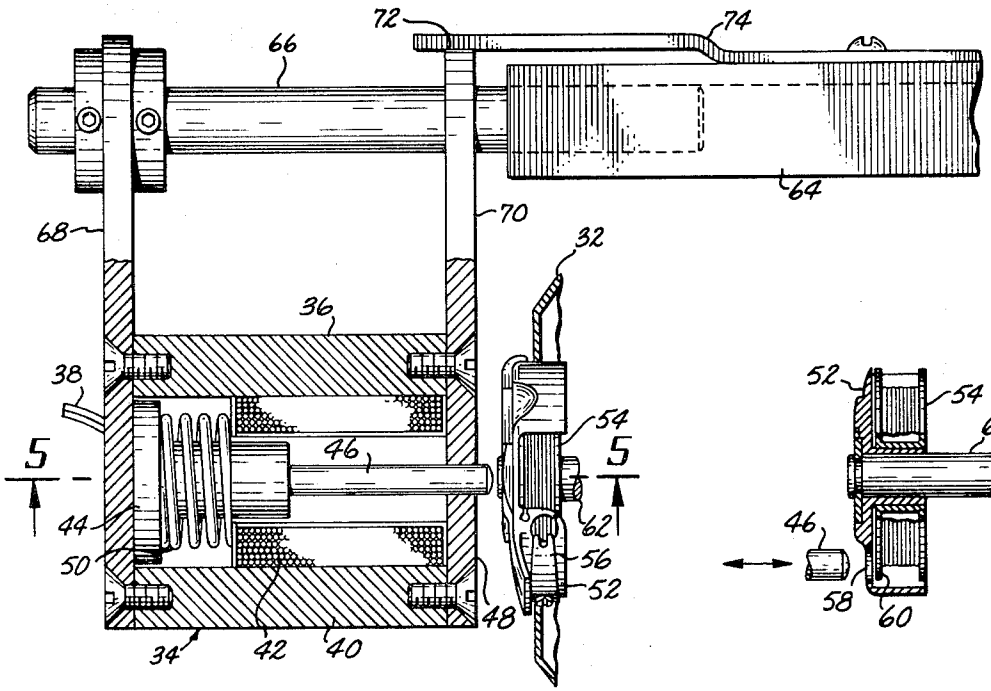


FIG-4

FIG-5

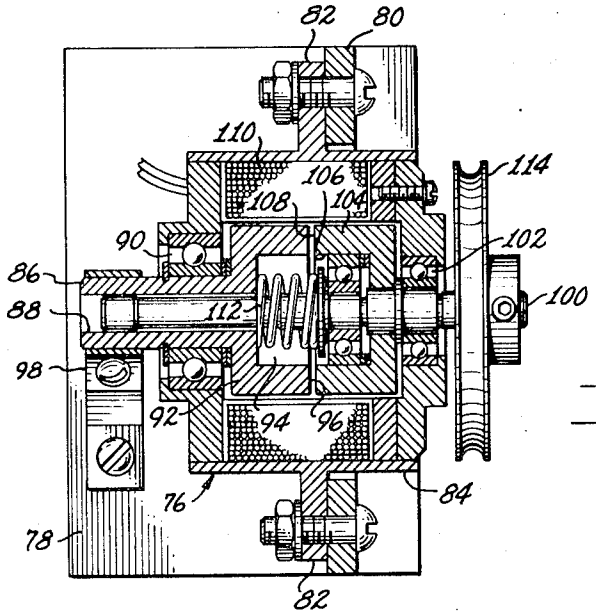


FIG-6

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CONTROLLABLE TENSIONING DEVICES FOR STRAND MATERIAL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to control mechanisms for material of indeterminate length and more particularly to tensioning mechanisms to retard movement of the material.

2. Description of the Prior Art

A particular application for the tensioning devices of the present invention is sewing conductive wire onto circuit boards. A method for conducting electrical signals to selected areas of a circuit board by the sewing of conductive wire therein is fully disclosed in copending U.S. Patent applications, Ser. No. 39,728, Filed May 22, 1970, by the same inventor as the present invention and assigned to the same assignee.

That method, briefly described, comprises the sewing of insulated conductive wire into apertures formed in solder coated conductive areas or pads of the circuit board. The conductor is sequentially sewn into a predetermined series of pads to form a discrete signal path. The conductor is then cut and another signal path may then be sewn. The sewing and cutting continues until all the desired signal paths are installed. Heat is then applied to the pads to melt the insulation from the conductors in the area of the apertured pads. This same heat also reflows the solder thus tacking the conductors in place.

The solder coating is applied to the pads by a plating process which results in a relatively thin deposition. Therefore the apertures remain substantially open after the above described heating step so that the leads of electrical elements such as integrated circuit packages, transistors and the like may be inserted therein. After the elements are inserted, the circuit board is flow soldered in the normal manner to form electrical connections among the leads, conductors, and pads.

The sewing of conductors onto circuit boards is accomplished by a modified sewing machine on which the insulated wire is wound on the bobbin (lower strand), and a nonconductive material such as thread is supplied to the needle from a spool (upper strand). The thread is employed in the initial forming of the stitch, and temporarily holds the conductive wire until it is soldered in place as described.

During implementation and development of the hereinbefore described method of sewing conductive wire into circuit boards, further inventions were developed.

One such invention comprises electrically-isolated apertured areas formed on the circuit board into which the conductors are sewn for controlled routing thereof. This invention is fully disclosed in copending U.S. Patent application, Ser. No. 50,508, filed June 29, 1970, by the same inventor as the present invention and assigned to the same assignee.

The first of the above referenced U.S. patent applications discloses, among other things, the need for melting the insulation on the loops of the stitches so that the conductive wire may be electrically connected to the pads and element leads. The second of the above referenced U.S. patent applications teaches that stitches may also be formed only for routing purposes. Thus it is not always desirable to melt the insulation on the loops of the stitches.

A method of forming a special purpose stitch in which the insulation will not be melted during the flow soldering step is to increase the tension on the bobbin supplied wire or decrease the tension on the spool supplied thread just prior to the wire entering the aperture. Either of these tension changes will result in the wire laying across the aperture rather than entering therein. The wire is held in this position by the thread which passes through the aperture, loops around the wire and re-enters the aperture. The heat which is applied to the pads to melt the insulation and tack the conductors in place is not applied to the pads with the wire laying across and, when the circuit board is flow soldered, the solder wave is allowed to contact only the surface of the board on which the thread is disposed. The solder which enters the apertures by capillary action will not reach any portion of the wire which has not entered the aperture.

A third related invention comprises stitch control mechanisms which, among other things, cut the wire upon completion of a discrete signal path. When the conductive wire is cut, the loose ends of the first and last stitches in each discrete signal path are positioned adjacent to the surface of the circuit board by the stitch control mechanisms. To prevent the first and last stitches from being pulled loose prior to soldering, a restraining loop is formed on each of these stitches. This invention is fully disclosed in copending U.S. Patent application, Ser. No. 103,508, filed Jan. 4, 1971, by the same inventor as the present invention and assigned to the same assignee.

As disclosed in the third referenced U.S. patent application, the bobbin tension must be increased during the forming of the first or initial stitch in a series to halt movement of the wire so that a restraining loop may be formed thereon. Thus a special purpose stitch different from normal stitching is required for the initial stitch. Conventional sewing machines lack the necessary tensioning devices to perform these special functions.

A conventional sewing machine when properly adjusted will form normal stitches, that is, the loop of the stitch will be positioned half way between the external surfaces of the material(s) being sewn. If the upper thread tension is increased or decreased, the stitch loop will be correspondingly positioned higher or lower respectively in the material. The same result except reversed will occur if the bobbin tension is increased or decreased. Once the tensions on a conventional sewing machine have been set to suit such variables as material, thread denier, humidity and the like, the tension will not be adjusted again until one or more of the variables change.

If one or more of the variables change or other than normal stitches are required from the prior art sewing machines, the machine must be stopped and adjustments made to one or both of the tensioning devices. Adjustment of bobbin tension on prior art sewing machines requires that the bobbin and bobbin case be removed from the sewing machine so that a screw mounted leaf spring may be turned until the proper drag on the thread paying out of the bobbin is obtained.

Upper thread tensioning devices on prior art sewing machines generally provide three separate tension values or pressure settings which cooperate to perform the sewing operations. The first pressure setting is obtained by a pair of coaxially mounted discs which are

spring biased toward each other. Adjustments may be made in the spring biasing mechanism to apply more or less pressure on the thread which feeds between the discs. The second pressure setting is accomplished by a check spring which halts thread movement at a specific time during the formation of each stitch to control the amount of thread dispensed. The check spring pulls the stitch taut in the material. The third pressure setting is obtained by a release mechanism which is mechanically coupled to the presser foot of the machine. This device releases the upper thread tension so that the workpiece may be removed from the machine when the sewing operation is complete.

Therefore, it should be apparent that, in prior art sewing machines, the strand tensioning devices were designed for fixed tension settings, that is, once properly set for forming the required stitches, they are intended to retain that setting through many sewing operations. The timed sequence in which the tension settings affect strand movement is also fixed, and cannot be easily adjusted. Hence these prior art devices are either non-adjustable or cannot be adjusted for a particular stitch or series of stitches without stopping the sewing operation and performing time-consuming adjustments.

In view of the foregoing, a need exists for command signal responsive sewing machine strand tensioning devices which permit the tension values to be adjusted during the sewing operation.

SUMMARY OF THE INVENTION

In accordance with the invention claimed, new and useful command responsive upper and lower strand tensioning devices for a sewing machine are disclosed which allow various tension values to be selectively applied to the strands which form the stitches. The tension values may be changed at any time during the sewing process so that the machine can be adjusted to form normal or special purpose stitches. This is accomplished by changing the tension value of one or both of the strands. Changing the tension on either or both of the strands enables the loop of a stitch to be selectively positioned transverse with respect to a workpiece.

The upper strand control device includes a variable drag means for applying a resistance to a strand or filament paying out from a spool. The lower strand control device is selectively adjustable to apply tension to a lower or bobbin supplied strand by controlling the rotation of the bobbin. The upper strand control device includes a capstan or strand engaging mechanism which engages the strand payed out from the spool. The capstan is coupled to a first signal responsive means shown as an electromagnetically operated clutch which produces a variable drag on the capstan in response to the voltage amplitude signal applied.

The lower strand control device comprises a braking means or pin which is reciprocally operable into and out of engagement with the bobbin for controlling rotation thereof. A second signal responsive means in the form of a solenoid controls the movements of the braking means in accordance with the signal applied.

Accordingly, it is an object of the present invention to provide new and useful tensioning devices to control the movement of material of indeterminate length.

Another object of the present invention is to provide new and useful tension control devices for a sewing machine which allow tension adjustments to be made during the sewing operation.

Another object of the present invention is to provide new and useful tension control devices for a sewing machine which allow selective positioning of the loop of a stitch.

Another object of the present invention is to provide a new and useful tensioning device for a sewing machine which adjusts the tension applied to the upper strand in response to command signals applied to the device.

Still another object of the present invention is to provide a new and useful tensioning device for a sewing machine which adjusts the tension applied to the lower strand in response to command signals applied to the device.

A still further object of the present invention is to provide new and useful upper and lower strand tensioning devices for a sewing machine each of the devices adapted to respond to commands applied thereto for applying various tensions to the strands.

The foregoing and other objects of this invention, the various features thereof, as well as the invention itself, may be more fully understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of a sewing machine incorporating the features of the present invention and including a fragmentary portion of an environmental system;

FIG. 2 is an enlarged front view of the sewing machine incorporating the features of the present invention taken on the line 2—2 of FIG. 1;

FIG. 3 is a fragmentary sectional view taken on the line 3—3 of FIG. 2;

FIG. 4 is a fragmentary sectional view taken on the line 4—4 of FIG. 2;

FIG. 5 is a fragmentary sectional view taken on the line 5—5 of FIG. 4;

FIG. 6 is an enlarged sectional view taken on the line 6—6 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more particularly to the drawings, FIG. 1 illustrates a system 10 for sewing electrical conductors into circuit boards. The system 10 is fully described in the hereinbefore referenced patent application, Ser. No. 103,508, filed Jan. 4, 1971, and therefore will only be briefly described herein. It is obvious, however, that the devices of the present invention can be used on any type of machine adapted for paying out any type or density of strand or filament and shall be limited to sewing machines only for purposes of description as a preferred embodiment.

The system 10 includes a conventional X–Y positioning table 12 (partially shown), a sewing machine 14, and a special pedestal 16 on which a circuit board 18 is mounted. The X–Y table 12, under control of a programmed controller (not shown), will accurately position the pedestal 16, and thus the circuit board 18, in a

predetermined series of locations with respect to the sewing machine **14**. The sewing machine, also under control of the controller, will sew the conductive wire into the circuit board in predetermined discrete signal paths.

The sewing machine **14** as seen in FIGS. **1** and **2**, is provided with an enlarged work support bed **20** on which the circuit board **18** will move. The sewing machine **14** is also provided with the normal enclosing frame, which includes a vertical standard **22** having a base portion **24** at its lower end for mounting on the support bed **20**. Extending outwardly from the upper end of the vertical standard **22** is an overhanging arm **25**. Attached to the other end of the overhanging arm **25** is a head **26** inside which is mounted a vertically reciprocatory needle **28**. It will be understood that suitable drive mechanisms (not shown) are provided from a main drive shaft **30** and mounted in the frame of the machine to operate the needle **28** and associated mechanisms such as the usual shuttle mechanism **32** (FIGS. **2** and **4**). The drive mechanism can be of a standard type commonly used in sewing machines.

As shown in FIGS. **2**, **3**, **4** and **5**, a bobbin tensioning device or lower strand tensioning device is provided which is indicated generally by the reference numeral **34**. Referring particularly to FIG. **4**, the bobbin tension device **34** comprises a signal responsive means shown as solenoid **36** which is electrically coupled to the controller of the system **10** by wires **38**. The solenoid **36** is enclosed by a case **40** and includes a conventional coil **42** and a plunger **44**. Plunger **44** has a braking means shown as a brake pin **46** reciprocally extendable through one end **48** of the case **40**. The plunger **44** and the brake pin **46** are biased toward the retracted position by a spring **50**, and will move toward the extended position in response to voltage applied to the coil **42** in accordance with well-known principles.

The solenoid **36** is mounted in close proximity to the shuttle **32**, a bobbin case **52**, and a bobbin **54**, which cooperate to form the lower strand dispensing mechanism. These devices, the shuttle **32**, the bobbin case **52** and the bobbin **54**, are mounted and function in the normal manner, that is, the shuttle **32** catches the upper strand, supplied by the needle **28**, and passes it around the bobbin **54** and bobbin case **52** to form the loop of a stitch. The bobbin case **52** is a stationary container for the free spinning bobbin **54**. As seen in FIG. **4**, the bobbin case **52** may be provided with the usual leaf spring **56** which applies a preset tension to the lower strand dispensed by the bobbin **54**.

The bobbin case **52** is provided with an opening **58** formed therein (see FIG. **5**) which aligns with the brake pin **46** of the solenoid **36**. When the solenoid **36** is moved to the extended position as hereinbefore described, the brake pin **46** will enter the bobbin case **52** through the opening **58** and engage a peripheral edge **60** of the bobbin **54**. The brake pin **46** exerts a force on the bobbin **54** and causes the bobbin **54** to frictionally engage the bobbin enclosure. The force exerted on the bobbin **54** by the brake pin **46** is in proportion to the voltage amplitude signal applied to the solenoid **36**. Therefore, it may readily be seen that by applying appropriate voltages to the solenoid **36** and with the proper timing of the voltage applications, the bobbin supplied or lower strand may be selectively tensioned at any time during the formation of a stitch except at the moment the spool supplied material passes around the bobbin case **52** to form the loop with the bobbin supplied material. At this time the brake pin **46** must provide access for the thread. It should also be noted that the preset tension supplied by the leaf spring **56** may be removed as its function can now be duplicated with the fully adjustable tension force supplied by the solenoid **36**.

Referring to FIG. **3**, the solenoid **36** is adapted to pivot between an operational position shown in solid lines in FIG. **3** and an access position shown in broken lines in the same figure. The pivoting of solenoid **36** provides access to the bobbin **54** and the bobbin case **52**. Access to the bobbin is periodically necessary to replenish the bobbin supplied strand.

Still referring to FIGS. **2**, **3**, **4** and **5** and particularly to FIG. **4**, the pivotable mounting of the solenoid is accomplished by an angle bracket **64** suitably attached to the lower portion of the support bed **20**. The bracket **64** is provided with a shaft or trunion **66** cantilevered therefrom about which a pair of arms **68** and **70** are journaled for pivotal movement. The arms **68** and **70** support the solenoid **36**. To limit pivotal movement and to insure proper operational positioning of the solenoid **36**, the arm **70** has a flat **72** (see FIG. **3**) machined or otherwise formed in its outermost extending portion. The flat **72** engages a detent spring **74**. The detent spring **74** is attached to the angle bracket **64** so that one end of the spring is in constant biasing engagement with the arm **70** and will engage the flat **72** when the solenoid **36** is pivoted to the operational position.

In the preferred embodiment of the invention being described, the spring biased discs, check spring and release mechanism, used as tensioning devices for the upper strand in conventional sewing machines (none shown), have been replaced with a command responsive upper strand tensioning device shown in the preferred embodiment as an electric clutch **76**, see FIG. **1**. The clutch **76** has been modified to suit the particular operational requirements of this invention.

The upper strand tensioning device, the electric clutch **76** as shown in FIGS. **1**, **2** and **6**, is mounted on a platform **78** fastened to the upper surface of the overhanging arm **25**. The platform **78** carries a bracket **80** to which a mounting flange **82** (see FIG. **6**) of the clutch **76** is appropriately secured.

Referring to FIG. **6**, the clutch **76** is provided with a housing **84**. A fixed shaft **86** having an axial bore **88** formed therethrough extends from one end of the housing **84**. The fixed shaft **86** is mounted in a bearing **90**. The driven section of the clutch includes a clutch disc **92** integrally formed on the inwardly disposed end of the fixed shaft **86**. The clutch disc **92** defines a center cavity **94**, and a clutch face **96**, both of which are disposed inwardly with respect to the housing **84** and are formed concentric with the shaft **86**.

If the clutch **76** were operating in a conventional capacity, the fixed shaft **86** and its fixed clutch disc **92** would revolve in response to input torque applied thereto. However, for reasons to be hereinafter described, the fixed shaft **86** and disc **92** are held stationary by a clamp **98** having one end secured to the periphery of the shaft **86** and the other end suitably attached to the platform **78**.

A rotatable shaft 100 extends from the other end of the housing 84. The shaft 100 is rotatably and slidably journaled to the extending end of the housing 84 by a bearing 102. The shaft 100 is supported on its other end in the axial bore 88 by a bushing surface formed around the shaft. The driving section of the clutch 76 includes a clutch disc 104 integrally formed on the shaft 100. The clutch disc 104 defines a center cavity 106 and a clutch face 108 both of which face inwardly in axial alignment with the cavity 94 and face 96 of clutch disc 92.

The signal responsive means for activating the clutch 76 is an electromagnetic coil 110 formed within the housing 84. The coil 110 is disposed radially and concentrically adjacent to clutch discs 92 and 104 so that, when a signal voltage is applied to the coil 110, an electromagnetic attraction is induced which slides the rotatable clutch disc 104 of the driving section of the clutch axially toward the affixed clutch disc 92 of the driven section. The clutch discs 92 and 104 are biased apart by a spring 112 which is disposed within the aligned cavities 94 and 106. The spring 112 is selected such that, when a signal in the form of a voltage amplitude of approximately 3 to 4 volts is applied to the coil 110, the rotatable clutch disc 104 will move axially against the spring bias, thereby placing the clutch faces 96 and 108 in light contiguous engagement with each other. With the fixed shaft 86 and fixed clutch disc 92 held stationary as previously described, the light contiguous engagement of the clutch faces 96 and 108 produces a correspondingly light frictional drag which resists rotational movement of the shaft 100. As increasing voltage values are applied to the coil 110, a proportionally increasing drag on the rotation of the shaft 110 results.

A strand engaging mechanism shown as capstan 114 is fixed on the outermost extending end of the rotatable shaft 100. The upper strand, supplied from a spool 116, is wound around the capstan 114 so that strand movement caused by the sewing machine's stitch forming mechanism will impart a rotary motion to the clutch disc 104 of the tensioning device 76 via the capstan 114 and the shaft 100.

Therefore, it should be apparent that various tensions may be selectively applied to the upper strand by applying various signals in the form of various voltage amplitudes to the coil 110 of the clutch 76. If the spring 112 is selected as previously described, voltages of less than 3 or 4 volts will apply virtually no tension to the upper strand. Voltage applications in the 3 to 4 volt range apply a light tension and voltage values of 7 to 8 volts apply tension just under the breaking point of a normal textile thread. Applications of voltages above the 7 to 8 volt level cause sufficient drag to be placed on the capstan 114 so that attempts to move a textile thread will cause its breakage.

Now that the command responsive upper and lower strand tensioning devices of the present invention have been fully disclosed, it may easily be seen that, by selective applications of voltages to either or both of these devices, many stitch variations are possible. For example, an increase in the tension value applied to either the upper or the lower strand will retard that strand's movement toward the workpiece. Retarding the movement of either strand will disturb the tension balance necessary to position the loop of the stitch intermediate the surfaces of the workpiece. It should be obvious therefore, that increasing the tension applied to the lower strand causes the loop of the stitch to be positioned toward the bobbin side of the workpiece, and that increasing the tension applied to the upper strand will cause the loop to be positioned toward the needle side of the workpiece.

Relatively small changes in the position of the loop of the stitch may be accomplished by increasing the tension applied to either of the strands as previously described. However, when large position changes are required, the chance of strand breakage may be reduced by simultaneously increasing the tension applied to one strand and decreasing the tension applied to the other strand.

The selective voltage applications may be applied under program control as previously described with reference to the system 10, to form special stitches. Also these devices may be employed in more conventional forms of sewing so that an operator may compensate for the variables which effect normal stitches without interrupting the sewing operations.

While the principles of the invention have now been made clear in an illustrative embodiment, there will be immediately obvious to those skilled in the art many modifications of structure, arrangement, proportions, the elements, materials, and components, used in the practice of the invention and otherwise which are particularly adapted for specific environments and operating requirements without departing from those principles.

For instance, the tensioning device of the present invention may be useful on any type of machine including a sewing machine wherein a filament or strand of material is payed from one or two spools. Also the use of an electric clutch as an upper strand control device could be a mechanical clutch operable by a solenoid or a cam arrangement. The lower strand control device could be a mechanically moved magnet, or an electromagnetic arrangement in which a magnetic field is employed to produce the desired drag on the bobbin. Other devices such as an air pressured piston can be used as a signal responsive means instead of the solenoid 36 shown in the preferred embodiment. The pressure applied to the bobbin via the brake pin can be varied by controlling the air pressure applied to the piston and thus a similar result as that of controlling the voltage applied to the solenoid can be obtained. Thus the controlling variable signal for the signal responsive means when a piston is used would be the varying air pressure. The appended claims are therefore intended to cover and embrace any such modifications within the limits only of the true spirit and scope of the invention.

What I claim is:

1. In a sewing machine including a stitching mechanism paying out an upper strand from a supply spool and a lower strand from a bobbin of a lower strand dispensing mechanism, wherein the improvement comprises:

an upper strand tensioning device positioned on the sewing machine for frictional engagement with the upper strand between the supply spool and the stitching mechanism; and

a lower strand tensioning device positioned adjacent to the lower strand dispensing mechanism of the sewing machine, said lower strand tensioning device adapted to receive a variable electrical signal and exert a drag on the lower strand dispensing mechanism to control the dispensing rate thereof, the amount of drag exerted by said lower strand tensioning device varying in accordance with the electrical signal received;

wherein said lower strand tensioning device includes,

a housing,

a plunger reciprocally mounted within said housing,

a brake pin attached to and reciprocally movable with said plunger, said brake pin having one end extending from said housing for contacting the bobbin of the lower strand dispensing mechanism and exerting a frictional drag thereon when said plunger moves said brake pin to an extended position,

biasing means positioned within said housing for biasing said plunger and said brake pin in a retracted position, and

signal responsive means mounted in said housing and responsive to the electrical signal for moving said plunger and said brake pin to the extended position, the extending force exerted by said moving means varying in response to the electrical signal applied thereto.

2. A command responsive tensioning device according to claim 1 wherein said signal responsive means comprises an electromagnet and said plunger forms the core of said electromagnet, and the variable electrical signal is in the form of a variable voltage amplitude, said electromagnet applying a force to said rod proportional to the voltage amplitude applied thereto.

3. Command responsive tensioning devices as claimed in claim 1 further including mounting means connecting said lower strand tensioning device to the sewing machine, the mounting means adapted to permit pivotal movement of said lower strand tensioning device between an operational position and an access position to allow servicing thereof, said mounting means comprising:

a bracket attached to the sewing machine;

a trunion extending from said bracket;

at least one arm extending from said lower strand tensioning device, said arm adapted for pivotable movement about said trunion;

a flat formed on said arm; and

a detent spring attached on one end thereof to said bracket, the other end of said detent spring positioned to engage said flat to accurately position said lower strand tensioning device in the operational position and to yield when said lower strand tensioning device is moved to the access position.

4. In a sewing machine including a stitching mechanism paying out an upper strand from a supply spool and a lower strand from a lower strand dispensing mechanism, wherein the improvement comprises:

a strand engaging mechanism rotatably mounted to the sewing machine and positioned for engaging the upper strand between the supply spool and the stitching mechanism;

an electromagnetic clutch mounted to the sewing machine having a driving and a driven end with the driving end fastened to prevent rotation thereof and the driven end coupled to said strand engaging mechanism, said electromagnetic clutch responsive to a first variable voltage signal for varying the retardation of rotation of the driven end to vary the tension applied to the strand and thus control the stitches formed by the sewing machine;

a housing mounted adjacent to the lower strand dispensing mechanism;

a plunger reciprocally mounted within said housing;

a brake pin attached to and reciprocally movable with said plunger, said brake pin having one end extending from said housing for contacting a bobbin of the lower strand dispensing mechanism and exerting a frictional drag thereon when said plunger moves said brake pin to an extended position;

biasing means positioned within said housing for biasing said plunger and said brake pin in a retracted position; and

signal responsive means mounted in said housing and responsive to a second variable electrical signal for moving said plunger and said brake pin to the extended position, the extending force exerted by said moving means varying in response to the electrical signal applied thereto.

5. A command responsive tensioning device according to claim 4 wherein said signal responsive means comprises an electromagnet and said plunger forms the core of said electromagnet, and the second variable electrical signal is in the form of a variable voltage amplitude, said electromagnet applying a force to said rod proportional to the voltage amplitude applied thereto.

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