United States Patent

[11] 3,596,618

[72] Inventors **Henry T. Goldbach**
Little Ferry;
James V. Molnar, Parsippany; Robert C. Hauf, West Patterson; Robert W. Graft, Somerville, all of, N.J.

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[45] Patented **Aug. 3, 1971**
[73] Assignee **The Singer Company**
New York, N.Y.

[54] **AUTOMATIC BUTTONHOLE MECHANISMS FOR ZIGZAG SEWING MACHINES**
5 Claims, 17 Drawing Figs.

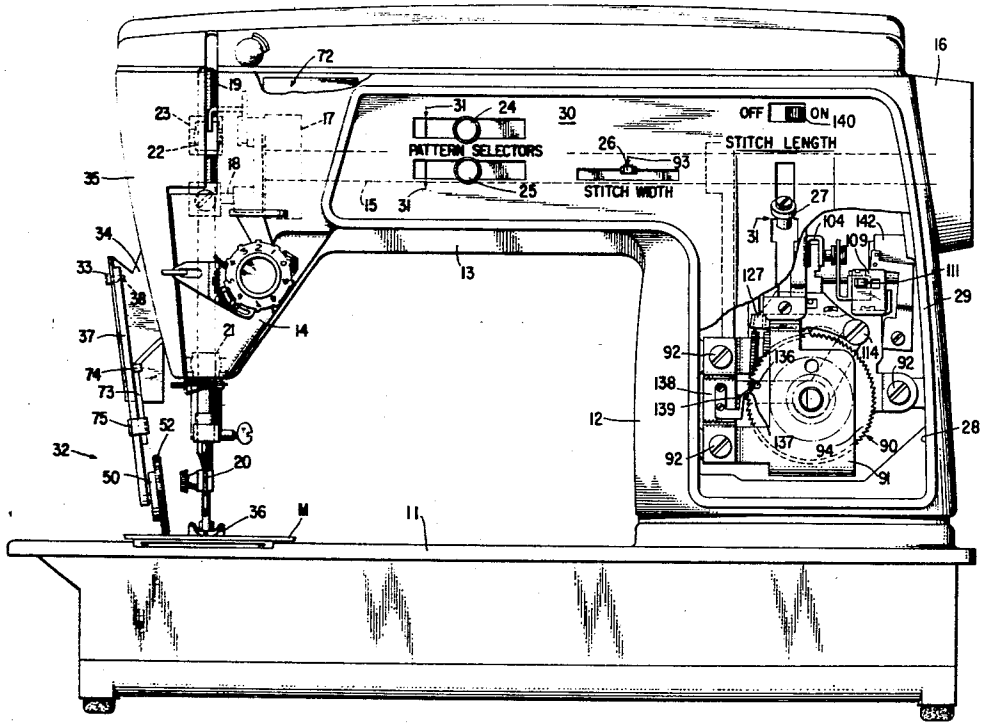
[52] **U.S. Cl.** **112/158,** 356/167
[51] **Int. Cl.** **D05b 3/02**
[50] **Field of Search** 112/158, 73, 109, 111; 356/167

[56] **References Cited**
UNITED STATES PATENTS

3,113,537	12/1963	Bono	112/158
3,503,350	3/1970	Buan et al.	112/158
3,518,954	7/1970	Blackwood et al.	112/158

Primary Examiner—Richard J. Scanlan, Jr.
Attorneys—Marshall J. Breen, Chester A. Williams, Jr. and Robert E. Smith

ABSTRACT: A buttonhole mechanism having a wheel, which rests upon the material being sewn so that the wheel turns as the material is being fed, to provide sensing pulses at preset intervals which control electromechanisms for proper operation of a compact buttonholing assembly of a household zigzag sewing machine. When an operator sets a single-switching device, the buttonholing assembly is coupled to all of the sewing machine controls requiring variation during the stitching of the buttonhole.



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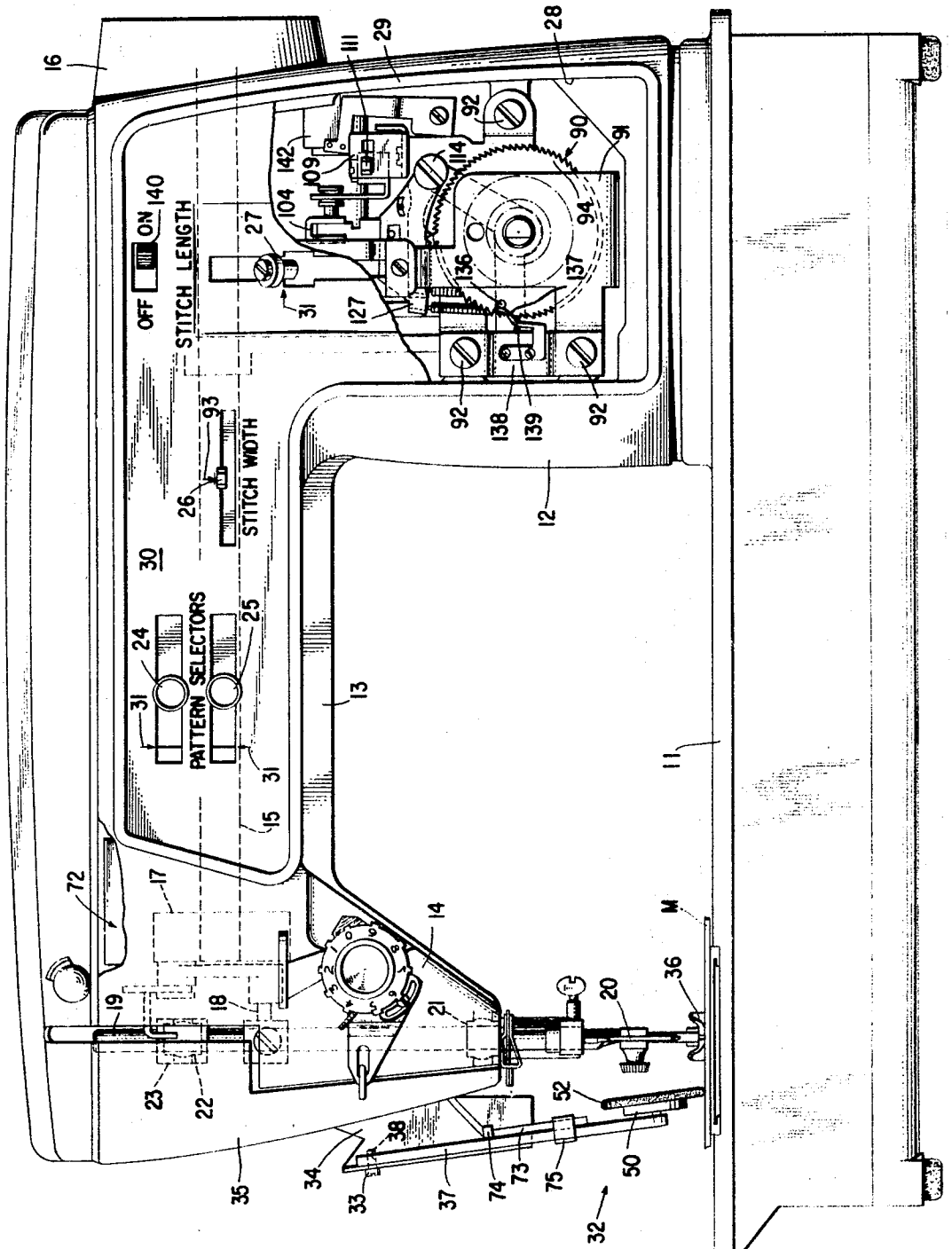


Fig. 1

INVENTORS.
Henry T. Goldbach,
Robert W. Graft,
Robert C. Hauf,
James V. Molnar

BY

Marshall J. Breen
ATTORNEY

WITNESS:
Patrick McDonnell

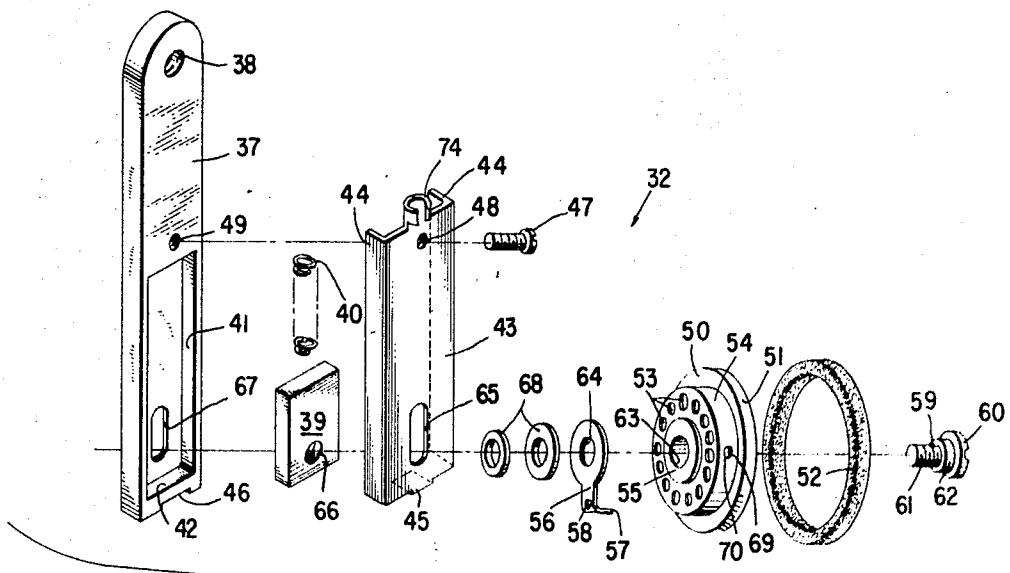


Fig. 2

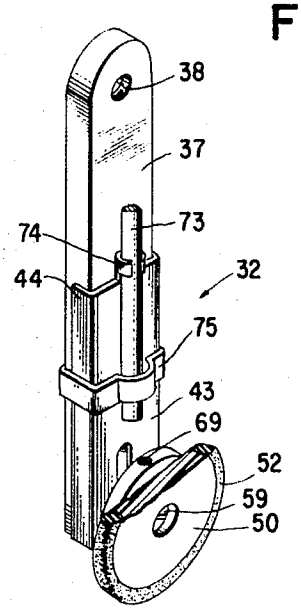


Fig. 3

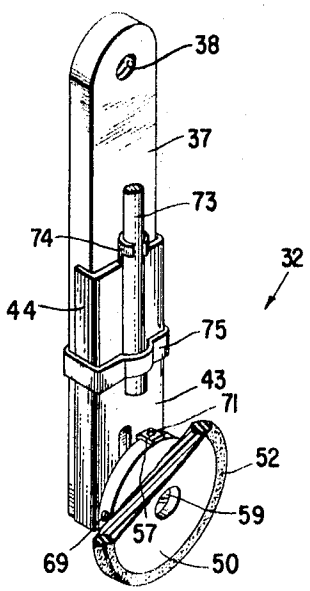


Fig. 4

INVENTORS.
Henry T. Goldbach
Robert W. Graft
Robert C. Hauf
James V. Molnar

BY

Marshall J. Breen
ATTORNEY

WITNESS:
Patrick McDonnell

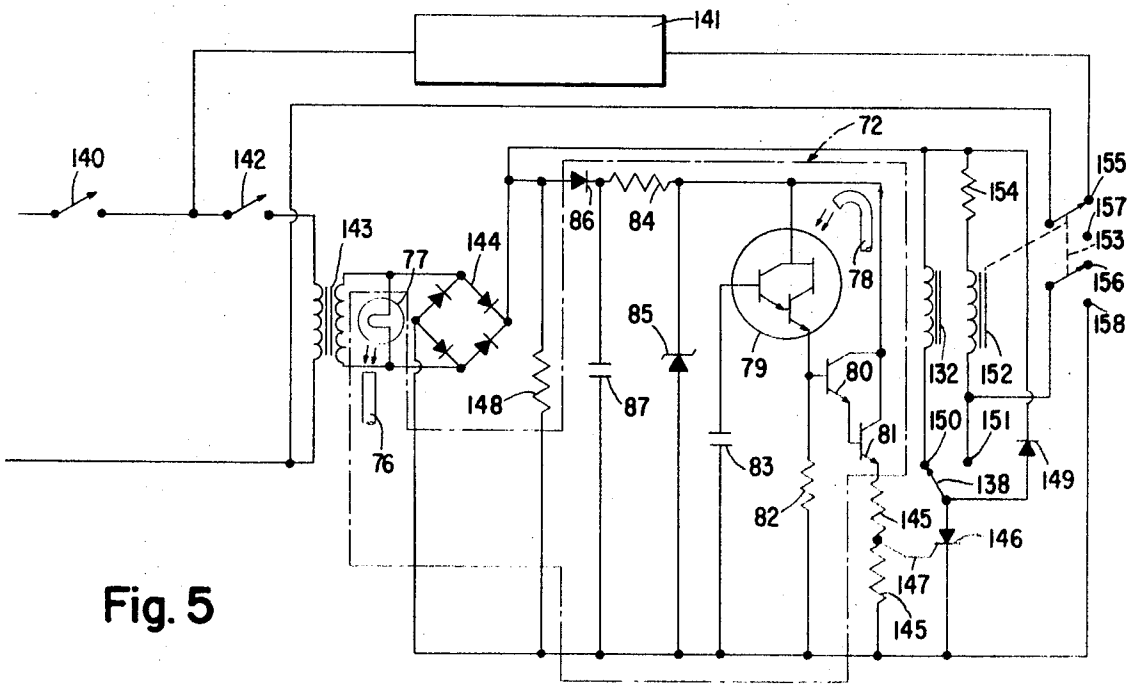
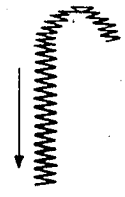


Fig. 5

Fig. 6



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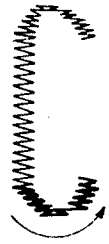

Fig. 8

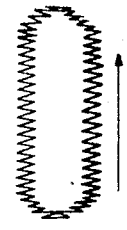

Fig. 9

INVENTORS.
Henry T. Goldbach,
Robert W. Graft,
Robert C. Hauf,
James V. Molnar

BY

Marshall J. Breen
ATTORNEY

WITNESS:
Patrick McDonnell

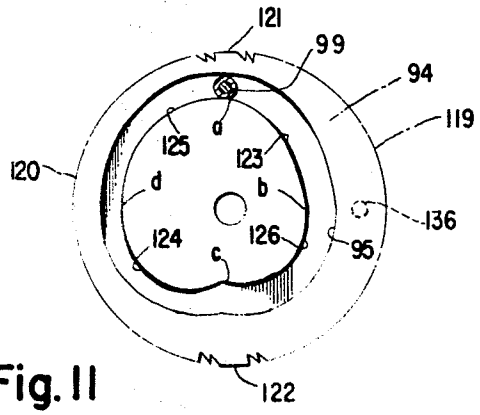

Fig. 11

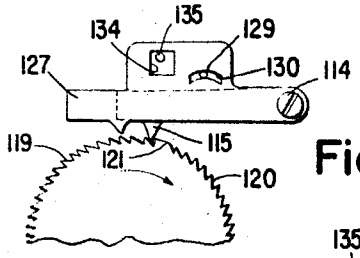

Fig. 12

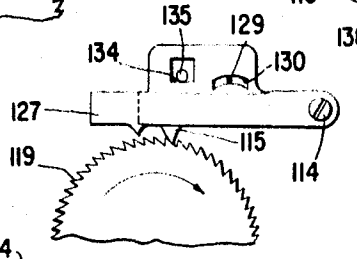

Fig. 13

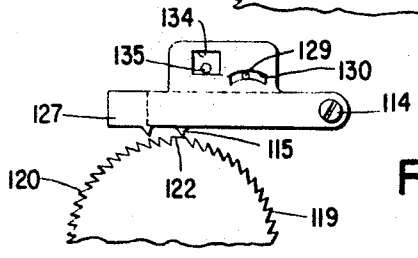

Fig. 14

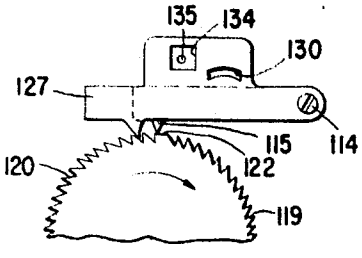

Fig. 15

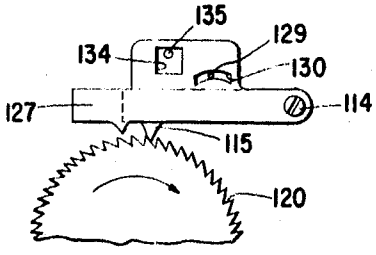

Fig. 16

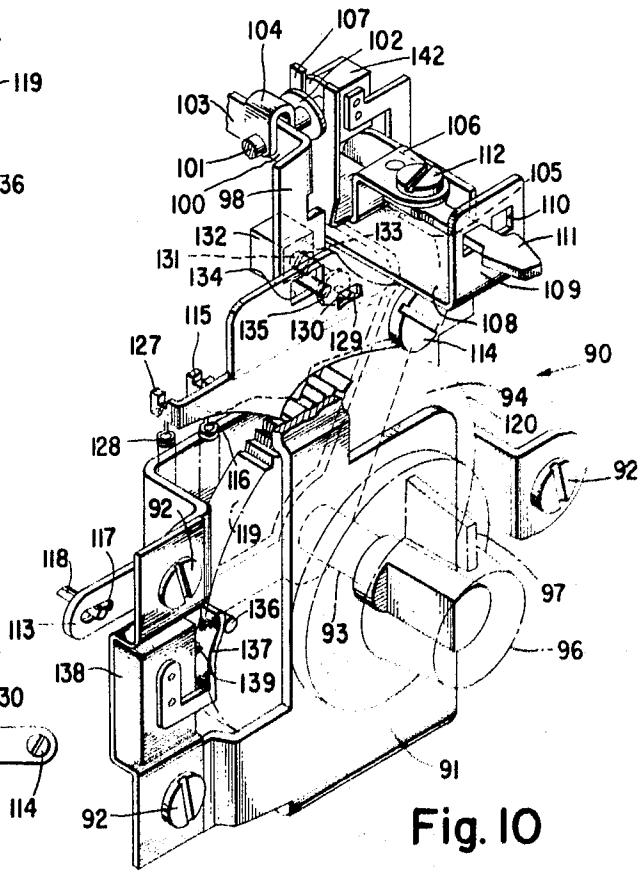

Fig. 10

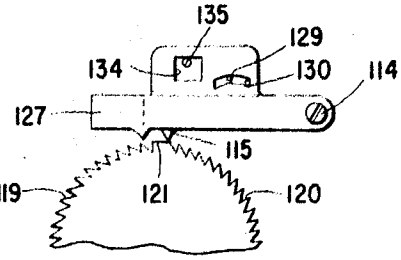

Fig. 17

INVENTORS.
Henry T. Goldbach,
Robert W. Graft,
Robert C. Hauf,
James V. Molnar

BY

Marshall J. Breen
ATTORNEY

WITNESS:

AUTOMATIC BUTTONHOLE MECHANISMS FOR ZIGZAG SEWING MACHINES

BACKGROUND OF THE INVENTION

It has long been recognized that a buttonhole may be formed on a zigzag sewing machine having controls for the width and the lateral position of the needle jogging, and controls for the forward and the reverse direction of the feed of the work being stitched by manually setting the various machine controls at each stage of the buttonhole stitch formation, wherein the above buttonhole usually has four parts comprising the opposite ends and the opposite side stitches. With this arrangement, however, buttonhole stitching is a tedious operation and the appearance of the buttonhole reflects the skill and dexterity of the machine operator.

It is also known in the art to provide buttonholing mechanisms associated as a part of a pattern cam arrangement for a needle jogging and work feeding mechanism of the sewing machine for automatically varying the pattern cam operation so as to produce the buttonhole stitch formation. These mechanisms introduce further complexity into the already critical area of the patterning mechanism of a zigzag machine and therefore, involve considerable expense. U.S. Pat. No. 3,113,537 of Bono discloses a zigzag sewing machine having mechanism of the above mentioned type for automatically sewing a buttonhole, whereby a device is slidably attached to the presser foot to move together with the material being sewn between an adjustable preset point and a fixed point to obtain the desired size of the buttonhole. The above device controls the operation of the sewing machine during the formation of the buttonhole, whereby a light under the control of the device may be used to excite a photosensitive element to change the operation of the sewing machine from one condition to another.

A compact buttonholing assembly, which is separate and remote from the needle jogging mechanism of a household zigzag sewing machine, is disclosed in a copending application, Round End Buttonhole Mechanism for Zigzag Sewing Machines, Ser. No. 739,051, filed June 21, 1968, of Blackwood et al., now U.S. Pat. No. 3,518,954, and assigned to the assignee of this invention. The above buttonholing assembly, upon operator initiation of each half of a buttonhole stitching operation, is driven by a sewing machine actuating mechanism to shift a single-operating member. By the setting of a single-switching device, the operating member is coupled to all of the sewing machine controls requiring variation during the stitching of the buttonhole so as to effect the stitching sequence necessary for the formation of the buttonhole.

SUMMARY OF THE INVENTION

This invention relates to a buttonholing mechanism which may be applied to any household zigzag sewing machine having controls for the width and the lateral position of the needle jogging, and controls for the forward and the reverse direction of the feed of the material being stitched. The buttonholing mechanism uses the motion of the material being fed to regulate the above sewing machine controls to effect the stitching sequence necessary for the formation of the buttonhole. A wheel, which rests upon the material, is turned by the feeding motion of the material, whereby the wheel provides sensing pulses at proper points to control electromechanisms for proper operation of a buttonholing assembly. The buttonholing assembly is coupled to the sewing machine controls by the machine operator setting a single-switching device.

It is an object of this invention to provide a buttonholing mechanism for a household zigzag sewing machine which is distinct and preferably remote from the zigzag mechanism of the sewing machine.

Another object of this invention is to provide a buttonholing mechanism for a sewing machine which is effective when the machine operator sets a single-switching device to automatically control the stitching sequence necessary for the formation of the entire buttonhole so that any other manual manipulation of the buttonholing mechanism is eliminated.

Still another object of this invention is to provide a buttonholing mechanism for a sewing machine which uses the feeding motion of the material as a feedback control of the mechanism so that improper, erratic feeding and material slippage may be compensated for during the formation of the buttonhole.

A further object of this invention is to provide a wheel which translates the linear motion of the material into rotary motion, whereby for a given buttonhole length, the wheel rotates through a corresponding angular displacement to provide sensing pulses at preset intervals for controlling the formation of the buttonhole to insure that all buttonholes, when desired, may be the same size, and also to prevent over running of the stitches at the completion of the buttonhole.

A still further object of this invention is to provide an optical-electronic sensing device to effect the sewing machine mechanisms for a proper stitching sequence during the formation of the buttonhole.

BRIEF DESCRIPTION OF THE DRAWINGS

Having in mind the above and other objects that will be evident from an understanding of this disclosure, the invention comprises the devices, combinations and arrangements of parts as illustrated in the presently preferred embodiment of the invention which is hereinafter set forth in such detail as to enable those skilled in the art readily to understand the function, operation, construction and advantages of it, when read in conjunction with the accompanying drawings in which:

FIG. **1** represents a front elevational view of a sewing machine with portions of the machine frame broken away illustrating the buttonhole mechanism of the present invention applied thereto,

FIG. **2** represents an exploded perspective view of the wheel assembly of the present invention,

FIG. **3** represents a fragmentary perspective view of the wheel assembly, such view showing the wheel hub reflective member in its top position directly underneath the light guide,

FIG. **4** represents a fragmentary perspective view of the wheel assembly, such view showing the tab reflective member in its top position directly underneath the light guide,

FIG. **5** represents a schematic wiring diagram of the electrical circuit for the buttonhole mechanism of the present invention,

FIGS. **6**, **7**, **8** and **9** represent in sequence, the manner in which the stitching of a buttonhole is accomplished using the mechanism of this invention,

FIG. **10** represents a fragmentary perspective view of the buttonholing assembly of this invention,

FIG. **11** represents an elevational view of the cam disk of the buttonholing assembly,

FIGS. **12**, **13**, **14**, **15**, **16** and **17** represent in sequence, the manner in which the cam disk is rotated by the pawls of this invention during the formation of the buttonhole.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, the buttonholing mechanism of this invention is illustrated in FIG. **1** as embodied in a zigzag sewing machine of the type having a vertical cam stack which forms the subject of the U.S.Pat. No. 2,862,468, Dec. 2, 1958, of R. E. Johnson to which reference may be had for a detailed description. The sewing machine comprises a frame including a bed **11**, a hollow standard **12** rising from the bed **11**, a bracket arm **13** extending from the hollow standard **12** and terminating in a sewing head **14** which overhangs the bed **11**. Journaled in the bracket arm **13** is a main shaft **15** which carries a balance wheel **16**. A drive motor (not shown) is preferably carried within the rear portion of the hollow standard **12**.

Within the sewing head **14**, the main shaft **15** carries a conventional crank mechanism indicated generally at **17** which is connected to a stud **18** secured on a needle bar **19** to the lower extremity of which a needle **20** is clamped. The crank mechanism **17** imparts endwise reciprocating motion to the needle bar **19**. To provide for zigzag stitching, the needle bar **19** is endwise slidable in a spherical bearing **21** in the lower extremity of the sewing head **14** and is slidably constrained in a similar spherical bearing **22** in a gate **23** which is pivoted in the sewing head **14** in pintles (not shown). A linkage (not shown), which is pivotally connected to the needle bar gate **23**, serves to impart to the needle bar gate **23** lateral vibratory movements so as to swing the needle **20** laterally in the formation of zigzag stitches.

Lateral jogging movement is imparted to the needle bar gate **23** by way of the linkage from a needle jogging mechanism (not shown) which includes provision for controlling the neutral position of needle vibration, and provides for the sewing of cam controlled patterns of zigzag stitching, whereby it will be understood, that the buttonholing mechanism of this invention is applicable to any sewing machine having a zigzag mechanism of the type in which the neutral position of needle vibration may be regulated. The needle jogging mechanism is influenced by a front and a rear cam follower lever (not shown) which may be shifted to cooperate with selected ones of a variety of abutment means (not shown) located in the bracket arm **13** by the depression and adjustment of the lateral position of control buttons **24** and **25**, respectively. This cam follower position selecting mechanism forms the subject of a copending U.S. Pat. No. 3,503,350, filed Nov. 20, 1967, assigned to the assignee of this invention, to which reference may be had for a detailed explanation thereof.

A handle **26**, which is secured to a bight controlling lever (not shown) of the type disclosed in above U.S. Pat. No. 2,862,468, provides a finger grip for effecting bight adjustment.

Cooperating with the needle **20** in the formation of stitches is a conventional loop taker (not shown) which may be driven in timed relation with the needle reciprocation by means connecting the loop taker with the main shaft **15**. Also driven from the main shaft **15** is a work-feeding mechanism (not shown) which may be of the conventional drop feed variety. A feed regulating handle **27** is connected to the work-feeding mechanism to provide operator-influenced control of the stitch length provided by the work-feeding mechanism. The range of adjustment of the work-feeding mechanism is such as to provide for feed of the work in either direction toward or away from the operator with respect to the sewing needle **20**.

In the sewing machine, the standard **12** and bracket arm **13** are formed in the front wall with an opening **28** which is bounded by a protruding rib **29**. The opening **28** is closed by a cover or escutcheon **30** through which the controls **24** and **25** for cam follower position selection, the controller **26** for the width of zigzag stitching, and the feed-regulating handle **27** project. Any desired indicia may be provided on the cover or escutcheon plate **30** for facilitating the setting of the controls, and as illustrated in FIG. **1**, special indicia **31** may be provided to facilitate the settings necessary for use of the buttonholing mechanism.

The construction of the sewing machine thus far described is similar to that described in greater detail in the above referenced U.S. Pat. No. 2,862,468, which is modified to include the cam follower position selecting mechanism which is described in greater detail in the above referenced U.S. Pat. No. 3,503,350, to both of which reference may be had. A detailed description of the buttonhole mechanism of the present invention is set forth below.

The buttonhole mechanism, as shown in FIG. **1**, comprises a sensing wheel assembly **32** which provides sensing pulses at preset intervals to an opto-electronic system **72** for controlling the electromechanisms of a buttonholing assembly **90** which is coupled to the sewing machine controls for automatically forming the stitching sequence necessary for the formation of an entire buttonhole. The wheel assembly **32** is connected by a screw **33** to a support bracket **34** which is mounted on the face cover plate **35** of the sewing machine head **14**. The support bracket **34** extends outwardly and downwardly from the face cover plate **35**, thereby positioning the wheel assembly **32** adjacent to the sewing machine presser foot **36** so that the wheel assembly **32** rests on the material M being sewn.

As shown in FIG. **2**, the wheel assembly **32** comprises a bar-like support member **37** having a threaded which receives the screw **33** to secure the support member **37** to the support bracket **34**. A slide **39** and a spring **40** are positioned within a recess **41** formed in the support member **37** so that the spring **40** engages the slide **39** to continuously force the slide **39** downwardly towards the bottom wall **42** of the recess **41**. A cover **43** encloses the spring **40** and the slide **39** within the recess **41**, wherein the spring biased slide **39** is substantially limited to an upward and downward movement. The legs **44** of the cover **43** are positioned over the edges of the support member **37**, and a tab **45** of the cover **43** is positioned in a groove **46** formed in the support member **37** so that only a single screw **47**, which passes through an aperture **48** formed in the cover **43** and is screwed into a threaded aperture **49** formed in the support member **37**, secures the cover **43** to the support member **37**.

A freely rotatable wheel **50**, which is secured to the support member **37**, is used to translate the linear motion of the material M into rotary motion. The perimeter of the wheel flange **51** is grooved to receive a rubber O-ring **52** to provide traction between the wheel **50** and the material M. Detent-receiving holes **53** are formed in a side of the wheel hub **54**, near the edge thereof. The holes **53** are closely spaced around a boss **55** formed on the same side of the hub **54**, the boss **55** being positioned on a central portion thereof.

A rotatable arm **56**, having a perpendicularly extending tab **57**, is positioned against the boss **55** with the tab **57** overlying a portion of the perimeter of the hub **54**. The arm **56** is resilient so that a detent **58** formed therein may coact with one of the detent-receiving holes **53** to secure the arm **56** to the hub **54**, thereby causing the arm **56** to rotate together with the wheel **50**. For a given buttonhole length, the tab **57** is moved manually around the hub **54** against the action of the detent means **53**, **58** to a desired position, at which point the detent **58** is engaged in one of the holes **53** to hold fast the arm **56** and maintain the tab **57** in the desired position.

A screw **59** secures the wheel **50** and arm **56** to the support member **37**. The screw **59** has an enlarged head **60**, a threaded end portion **61** and a hub portion **62** located between the head **60** and the threaded portion **62**. The screw **59** passes through a stepped hole **63** formed through the center of the wheel **50** so that the screw head **60** is positioned within the larger opening of the hole **63** and below the outer surface of flange **51**, as shown in FIGS. **3** and **4**, with the hub portion **62** extending through the smaller opening of the hole **63**. A hole **64**, formed through an enlarged portion of the arm **56**, receives the screw hub portion **62** so that the wheel boss **55** and the arm **56** both rest on the hub portion **62**. The threaded portion **61** passes through a vertical slot **65** formed in the cover **43**. Accordingly, the screw **59** is screwed into a threaded aperture **66** formed through the slide **39** so that the free end of the threaded portion **61** passes through the slide **39** and extends through a vertical slot **67** formed in the back wall of the support member recess **41**, whereby slot **67** is parallel to slot **65**.

The screw **59** is tightened until the hub portion **62**, which is larger than the width of the slot **65**, abuts the cover **43**. Then, the screw **59** is slightly loosened to permit the screw **59**, while holding the wheel **50**, to slide up and down in the slots **65**, **67** against the pressure of the spring **40** which acts upon the slide **39** in which the screw **59** is secured to limit the up and down movement. This up and down movement allows the wheel **50** to adjust itself to materials of different thickness whereby, due to the pressure of the spring **40**, the O-ring **52** will always rest on the material being sewn. Conventional means may be used to retain the screw **59** in the support member **37**, such as flat-

tening the free end of the threaded portion **61**. If needed, washers **68** may be placed on the screw hub portion **62** between the cover **43** and the arm **56** to position the arm **56** flatly against the wheel boss **55** for better operation of the detent means **53, 58** and also to reduce the friction between the arm **56** and the cover **43** for free rotation of the wheel **50** and arm **56** when they are secured together by the detent means **53, 58**.

A reflective member **69**, such as a small piece of reflective aluminum foil, is secured by conventional means within a recess **70** formed in the perimeter of the wheel hub **54**. Another reflective member **71** is secured by conventional means on the tab **57**. The relationship between the reflective members **69, 71** is such that the reflective member **71** may be positioned directly above the reflective number **69** whereby in this position the reflective members **69, 71** are parallel to each other. The reflective member **71** may be given different angular displacements from the reflective member **69** by an operator rotating the tab **57** relative to the wheel **50**. The angular displacement between the reflective members **69, 71** determines the length of a buttonhole being sewn, where the buttonhole length is equal to the circumferential length of the arc on the O-ring **52** located between the reflective members **69, 71**.

In order to utilize the wheel assembly **32**, as described above, with its reflective members **69, 71**, the opto-electronic system **72** was developed using conventional fiber optic strands joined together side by side to form a light guide **73** to conduct light to and from the wheel hub **54**. The light guide **73**, as shown in FIGS. **1, 3** and **4**, contains approximately 32 adjacent fiber optic strands of ten mil fibers held together within a protective covering.

A clip **74** secures the light guide **73** to the wheel assembly cover **43** with the light guide extending downwardly towards the top of the wheel hub **54**. An additional clip **75**, as shown in FIG. **1**, secures the light guide **73** to the support member **37** so that when either of the reflective members **69, 71** is rotated to its top position on the wheel hub **54**, the light guide **73** is held perpendicular to the top positioned reflective member with the end of the light guide **73** being suspended directly above and parallel to the top positioned reflective member. FIG. **3** shows the reflective member **69** in its top position, and FIG. **4** shows the reflective member **71** in its top position.

The light guide **73** is bifurcated within the sewing machine head **14** so that one branch **76**, containing approximately 16 fiber optic strands, terminates at a small light source **77**, shown in FIG. **5** which is located inside the bracket arm **13**. Though a conventional sewing machine light may be used for the small light source **77**, an auxiliary light is preferred because it emits less heat and because it represents an approximate point source for better light intensity at the wheel assembly **32**. The other branch **78**, containing the remaining approximately 16 fiber optic strands, terminates at a photosensitive transistor **79** hereinafter called a photocell, such as an NPN Planar Silicon Photo-Darlington Amplifier, shown in FIG. **5**, which also is located within the bracket arm **13**. The photocell **79** may be cemented in a wooden cube which is painted black to allow the photocell **79** to be used at maximum sensitivity without being affected by stray outside light entering at places other than through the light guide **73**. The ends of the light guide **73** are capped by dipping them into a Lucite solution and allowing them to dry to yield a low-light loss at each terminus.

With the above arrangement of the light guide **73**, light from the light source **77** is picked up by the branch **76** and is carried by the light guide **73** to the perimeter of the wheel hub **54**. At the instant one of the reflective members **69, 71** passes directly underneath the light guide **73**, the light is picked up through reflection off the reflective member by the other half of the fiber optic strands of the light guide **73** which forms the branch **78**, and is carried by the branch **78** to the photocell **79**. The electrical circuit, shown in FIG. **5** uses the photocell **79** as a detection device.

As shown above, the light source **77**, the light guide **73** and the photocell **79** form the major components of the opto-electronic system **72**. Referring to FIG. **5**, the photocell **79** also incorporates a two-stage amplifier in a Darlington configuration to produce a very high-current gain. Two more stages of amplification in a Darlington configuration were added externally to the photocell **79** in the form of transistors **80, 81** to increase the sensitivity of the overall circuit even more, thereby compensating for the light loss in the fiber optic strands, which is normally 10 percent per foot.

A conventional resistor **82** and a conventional condenser **83** were added to the circuit to permit proper operation of the photocell **79**. A conventional resistor **84** and a conventional Zener diode rectifier **85** were added to the circuit for proper voltage regulation. Other conventional components of the opto-electronic system **72**, which are needed for proper operation, are a diode rectifier **86** and a condenser **87**. The function of the above conventional components in the circuit shown in FIG. **5** is well known in the art, whereby these components are normally used with photocells.

Before describing the remaining components of the circuit shown in FIG. **5**, it is necessary for a better understanding of the circuit to discuss first the buttonholing assembly **90**. The buttonholing assembly **90** is a modification of the built-in buttonholer of a two-step design described in the above referenced U.S. Pat. No. 3,518,954. The buttonholing assembly **90**, shown in FIGS. **1** and **10**, is preferably carried in the sewing machine frame within the lower front portion of the hollow standard **12**. A generally U-shaped bracket **91** is secured to the standard by screw means **92**. A stud shaft **93** is journaled between the walls of the bracket **91**. Secured on the stud shaft **93** is a cam disk **94** having a face cam groove **95** formed in the rear wall thereof, as shown in FIG. **11**. The stud shaft **93** protrudes through the cover or escutcheon **30** and externally thereof a knob **96** is secured to the stud shaft **93** The knob **96** is preferably formed with a radial tab **97**

A single-operating member **98** is slidably secured to the rear wall of bracket **91** and to the stud shaft **93** to constrain the single-operating member **98** to move in a predetermined path. The single-operating member **98** is positioned adjacent to the rear wall of the cam disk **94**. A roller follower **99**, shown in FIG. **11**, is connected to the single-operating member **98** and tracks the face cam groove **95** in the cam disk **94** to impart movement to the single-operating member **98** between two extreme positions along its constrained path.

The single-operating member **98** is formed with a rearwardly extending finger **100** at its upper extremity. The finger **100** is apertured to accommodate a slidable pin **101** which is formed with a pair of spaced annular head flanges **102**. A lever **103**, which is fulcrummed on a stud (not shown) by which the feed regulating member (not shown) is pivoted to the machine frame, is formed with a clevis **104** on one end thereof through which apertures are formed to receive the pin **101**. The finger **100** is positioned between the legs of the clevis **104**.

The bracket **91** is formed with an offset arm **105** to which is threaded a fulcrum screw (not shown) for a leaf spring keeper level **106**. The spring keeper level **106** includes an upstanding bifurcated arm **107** which engages between the head flanges **102** of the pin **101**. Also mounted on the offset arm **105** of the bracket **91** is a stop member **108** formed with an upturned extremity **109** in which a U-shaped aperture **110** is formed. A handle **111**, which is secured to the leaf spring keeper level **106** by a screw **112**, extends through the U-shaped aperture **110** and thus provides for the setting of two distinct positions of the pin **101** relatively to the single-operating member **98**.

In both of the possible positions of the pin **101**, the pin **101** will be engaged in the aperture of the single operating member **98** and in the clevis apertures of the lever **103**, but the handle **111** does provide for an axial shift of the pin **101** into and out of a position of engagement with an aperture which is formed in a plate (not shown) which is connected to the feed-regulating member. By this arrangement, the single-operating member **98** is constantly in operative connection with the

lever **103** which provides for control of the neutral position of needle vibration during buttonholing, but by way of the handle **111** the single-operating member may be selectively coupled with the feed regulating member. As the single-operating member **98** is shifted between its two extreme positions, the lever **103** is also shifted, thereby alternately causing the release of the rear cam follower lever for an engagement with the abutment means, or the engagement of the rear cam follower lever to shift the rear cam follower lever out of engagement with the regular abutment means into a special position suitable for producing a portion of the buttonhole.

As shown in FIG. **10**, a bellcrank lever **113** is fulcrummed on the stud shaft **93** and has pivoted at one extremity, by a shouldered screw **114**, a pawl **115** which is biased by a spring **116** into engagement with the periphery of the cam disk **94**. The other extremity of the bellcrank lever **113** is slotted as at **117** and accommodates a pin **118** which extends from a block (not shown) secured to a feed lift actuating pitman (not shown) which imparts a continuous oscillating motion to the pawl **115**. The cam disk **94** is moved by the continuously moving pawl **115**. Since the cam disk **94** is driven by the upward movements of the feed lift pitman, and since such feed lift actuation is conventionally timed to occur as the needle **20** emerges from the material M, the increments of motion of the cam disk **94**, when driven, will occur while the needle **20** is out of the material M.

The construction of the buttonholing assembly **90** thus far described is similar to that described in greater detail in the above referenced patent application Ser. No. 739,051 to which reference may be had. The main difference between these buttonholing assemblies is in the construction of the cam disk, whereby the cam disk of U.S. Pat. No. 3,518,954 has ratchet teeth cut in only the second and fourth quadrants to perform an operation that is all purely mechanical. To form a buttonhole according to the above U.S. Pat. No. 3,518,954, the operator sets the sewing machine controls to engage the mechanism of the buttonholer and turns a dial on the sewing machine standard to a first indicated position to bring the ratchet teeth of the second quadrant into cooperative relationship with the driving pawl. Upon running the machine, the pawl coacts with the first set of ratchet teeth to rotate the dial 90° to a first stop position, thereby completing the rounded top of the buttonhole, similar to that shown in FIG. **6**. The machine continues sewing down the left-hand side of the buttonhole until the desired length is reached, similar to that shown in FIG. **7**, at which point the operator again turns the dial 90° to a second indicated position to bring the ratchet teeth of the fourth quadrant into cooperative relationship with the driving pawl. The pawl coacts with the second set of ratchet teeth to rotate the dial another 90° to a second stop position, thereby finishing the bottom of the buttonhole, similar to that shown in FIG. **8**. The machine continues sewing up the right-hand side of the buttonhole until the buttonhole is finished, similar to that shown in FIG. **9**, at which point the operator must watch and stop the machine, otherwise the top of the buttonhole will be overrun.

The modified cam disk **94** of the present invention has ratchet teeth groups **119** and **120** arranged almost all around the cam disk periphery, except for two plain peripheral surface spots **121**, **122** approximately 180° apart. Each of the diametrically opposed spots **120**, **121** was formed on the cam disk **94** by omitting one tooth cut therein. With reference to FIG. **11**, the cam groove **95** in the cam disk **94** was not modified, whereby a gradual change of the cam groove radius is provided, which is tracked by the roller follower **99** during each interval of cam drive by way of the pawl **115**, i.e., with the cam groove **95** decreasing in radius within the portion **123**, located between points *a* and *b*, while the ratchet teeth group **119** is engaged by the pawl **115**, and the cam groove **95** increasing in radius within the portion **124**, located between points *c* and *d*, while the ratchet teeth group **120** is engaged by the pawl **115**. Each portion of the cam groove **95** tracked by the roller follower **99** between the quadrant portions **123** and **124** may be substantially of constant radius, where the portion **125**, located between points *d* and *a*, has a larger radius than the portion **126**, located between points *b* and *c*. If preferred, the radii of portions **125**, **126** may be increased or decreased only slightly to remove the lost motion between the parts before the cam groove portions **123**, **124** become effective.

A second pawl **127** was added to further modify the buttonholing assembly **90**. The pawl **127** is positioned adjacent to the pawl **115** and is pivoted at one end of the bellcrank lever **113** by the shouldered screw **114**, similar to pawl **115**. The pawl **127** is biased by a spring **128** towards the periphery of the cam disk **94** so that at the time the pawl **127** engages the cam disk **94**, the claw of the pawl **127** is mechanically ahead of the claw of the pawl **115** by two ratchet teeth of the cam disk **94**. However, the pawl **127** is normally held off the ratchet teeth groups **119**, **120** by a pin **129** extending through a slot **130** formed in the pawl **127**. The slot **130** permits continuous oscillating movement of the pawl **127** by the bellcrank lever **113** while the pawl **127** is being held off the cam disk **94** by the pin **129**. The pin **129** is secured to the end of a plunger **131** of a solenoid **132**, whereby a spring **133** biases the plunger **131** into an extended position outwardly of the solenoid so that the pin **129** is engaged in the slot **130** of pawl **127**.

An aperture **134** is formed in the pawl **127** to receive a pin **135** which is secured to the single-operating member **98**. The aperture **134** is large enough to permit unrestrained movement of the pin **135** when the pin **135** is shifted with the single-operating member **98** between its two extreme positions, as will be described hereinbelow.

A pin **136** is secured on the face of the cam disk **94** to coact with a spring finger **137** secured to a microswitch **138**. The pin **136** is positioned in a set relationship with the cam disk spot **121** so that when the pawl **115** abuts the spot **121** during the formation of the second half of the buttonhole, the pin **136** has been rotated into an abutting contact with the spring finger **137**, thereby forcing the spring finger **137** against the pushbutton **139** of the microswitch **138** to trigger the microswitch **138**.

Referring again to FIG. **5**, when the machine power switch **140** is closed by moving the switch **140** to the ON position as shown in FIG. **1**, an AC current flows from a convention source (not known) through the motor-controller assembly **141** and permits a current to flow through the sensing circuit of the buttonholing mechanism when a microswitch **142** is closed. Microswitch **142**, as shown in FIGS. **1** and **10**, is held open by the outer flange **102** of the pin **101** abutting its pushbutton and is activated by the buttonhole assembly handle **111** which determines the position of the pin **101**. The microswitch **142** is closed when the handle **111** occupies the left-hand position as illustrated in the drawings, whereby the outer flange **102** has been moved out of abutment with the pushbutton by the handle **111**. When the microswitch **142** is closed, the AC current flows through the stepdown transformer **143** from which a low voltage is supplied to the light source **77** and to the full wave bridge rectifier **144**. The full wave bridge rectifier **144** supplies a DC current to the opto-electronic system **72**.

When the photocell **79** is activated, the current from the opto-electronic system **72** flows through the resistors **145**, through a Silicon controlled rectifier **146** hereinafter called an SCR, through the microswitch **138** positioned at point **150** and through the solenoid **132**. The resistors **145** control the amount of current flowing through the gate **147** of the SCR **146**. A conventional resistor **148** and a conventional freewheeling diode rectifier **149** positioned across the load of the solenoid **132** were added to the circuit to permit proper operation of the solenoid **132**.

When the solenoid **132** is activated by the opto-electronic system **72**, the plunger **131** is retracted, thereby moving the pin **129** out of the pawl slot **130** to release the pawl **127**. Even though the photocell **79** is no longer activated, the SCR **146** normally will continue to be energized, thereby maintaining the solenoid **132** in an activated condition. However, the full wave bridge rectifier **144** supplies a varying DC current to the

SCR 146, where the current at one point is low enough to discharge the SCR 146, thereby causing the solenoid 132 to be deactivated, whereby the solenoid spring 133 forces the plunger 131 into its extended position so that the pin 129 may be engaged again in the pawl slot 130.

After forming the second round end (bottom) of the buttonhole, shown in FIG. 8, the microswitch 138 is triggered by the cam disk pin 136 so that the microswitch 138 moves from point 150 to point 151. When the photocell 79 is activated at the completion of the buttonhole, the current from the opto-electronic system 72 flows through the resistor 145, through the SCR 146, through the microswitch 138 now positioned at point 151, through the relay 152 which controls the latching contacts 153 and through a conventional resistor 154. The conventional resistor 154 and the conventional freewheeling diode rectifier 149, which is now positioned across the load of the relay 152, permit proper operation of the relay 152.

When the relay 152 is activated by the opto-electronic system 72, the latching contacts 153 are moved from a normally closed position at points 155, 156 to a normally opened position at points 157, 158. With the latching contacts 153 positioned at point 157, the circuit of the motor-controller assembly 141 is opened thereby cutting power to the sewing machine motor 141 and stopping the sewing machine. At the same time, with the latching contacts 153 positioned at point 158, the SCR 146 is short circuited and therefore is discharged so that the SCR 146 may be in readiness for the formation of the next buttonhole.

The power to the sewing machine motor 141 will remain off until the power to the relay 152 is interrupted. If the operator does not desire to make any more buttonholes, the buttonholing assembly handle 111 may be moved to the right-hand position. This operation opens the microswitch 142 and cuts the power to the relay 152 to return the latching contacts 153 to the normally closed position at points 157, 158, whereby the power to the motor 141 is restored so that the normal functions of the sewing machine may be preformed. If the operator desires to make additional buttonholes, the operator turns the knob 96 to a start position indicated by the tab 97. This operation moves the pawl 115 off the spot 121 into engagement with the first tooth of the ratchet teeth group 119, and also moves the pin 136 out of contact with the spring finger 137 to release the microswitch pushbutton 139. When the pushbutton 139 is released, the microswitch 138 returns to point 150, thereby cutting the power to the relay 152 to return the latching contacts 153 to the normally closed position at points 157, 158, whereby the power to the motor 141 is restored so that the buttonholing functions of the sewing machine may be preformed.

With particular reference to FIGS. 6, 7, 8 and 9, the operation of the buttonholing mechanism of this invention in the sewing machine illustrated in the accompanying drawings will now be described. The material M on which the buttonhole is to be sewn is placed under the presser foot 36 with the O-ring 52 of the wheel assembly 32 resting on the material M. The wheel 50 is rotated by the operator until the reflective member 69 is directly underneath the end of the light guide 73, as shown in FIG. 3, thereby establishing a reference point for starting and finishing the buttonhole. The tab 57 is rotated by the operator relative to the wheel 50 to set the reflective member 71 in a desired angular displacement from the reflective member 69 to determine the length of the buttonhole.

When the sewing machine controls are set for normal stitching operations, the handle 111 will occupy the right-hand position, the pin 101 will be out of engagement with the aperture in the plate on the feed-regulating member, and the outer flange 102 of the pin 101 will abut the pushbutton of the microswitch 142 to hold microswitch 142 in the open position. To produce a buttonhole using the buttonholing assembly 90, the handle 111 must first be shifted into the left-hand position, as illustrated in FIGS. 1 and 10, whereby the microswitch 142 is closed. As the pin 101 is not in alignment with the plate aperture, the leaf spring keeper lever 106 will yield and provide a biasing force urging the pin 106 against the plate. When the feed regulating handle 27 is shifted to bring the plate aperture into alignment with the pin 106, where the feed regulating handle 27 is positioned opposite the indicia 31 as shown in FIG. 1, the pin 106 will snap into an engaged position. The bight adjusting handle 26 is set at the indicia 31, shown in FIG. 1, to obtain a bight of slightly less than half the capacity of the needle jogging mechanism. The control buttons 24 and 25 are also set with respect to the indicia 31 so that as the width or bight of zigzagging is decreased to zero, the needle 20 will occupy a position on the right-hand side of the field of zigzag stitches.

To form the buttonhole, the knob 96 is turned to the start position, indicated by the tab 97 being opposite an indicia (not shown) on the escutcheon 30. In the start position, as shown in FIG. 12, the driving pawl 115 is engaged in the first tooth notch of the ratchet teeth group 119, whereby the pawl 127 is held out of driving contact with the disk cam 94 by the pin 135 being engaged in the aperture 134 and also by the pin 129 being engaged in the slot 130 whereby the pawl 127 does not engage the ratchet teeth group 119. In the starting position, the cam disk pin 136 does not engage the spring finger 137 which is secured to the microswitch 138.

The closing of the machine power switch 140, by the operator, activates the light source 77. Because of the reflective member 69 in the start position is directly underneath the end of the light guide 73, as shown in FIG. 3, the light carried by one-half of the light guide 73 from the light source 77 is picked up through reflection off the reflective member 69 by the other half of the light guide 73. The light is carried to the photocell 79, thereby activating the opto-electronic system 72 which in turn activates the solenoid 132 which retracts the pin 129 from the pawl slot 130. However, the pawl 127 is not released, the pawl 127 being held by the pin 135 which is engaged in the pawl aperture 134. As the beginning of the first round end of the buttonhole is being sewn by the sewing machine, the wheel 50 is being rotated by the linear motion of the material M. Once the reflective member 69 is moved from its position underneath the light guide 73, the SCR 146 is discharged, thereby deactivating the solenoid 132 so that the solenoid spring 133 forces the pin 129 into its extended position, whereby, with the pawl 127 being in the held position, the pin 129 is engaged again in the pawl slot 130.

The ratchet teeth group 119 cooperates with the driving pawl 115 to index the cam disk 94 in a series of stepwise increments extending over a number of stitches so that the roller follower 99, shown in FIG. 11, will track the cam groove portion 132 and thereby shift the single-operating member 98 and the pin 135 secured thereon, from the upper to the lower extreme position. In the lower extreme position of the single-operating member 98, the pawl 127 is held out of driving contact with the disk cam 94 only by the pin 129 being engaged in slot 130, as shown in FIG. 13. The movement of the single-operating member 98 from one extreme to another will carry the feed-regulating member gradually from a position of rearward work feed control through a position of zero feed of the work and into a position of forward feed of the work. Simultaneously, the needle 20 will be shifted from the position on the right-hand side to a position on the left-hand side of the field of zigzag stitches. This operation will produce the round end of the buttonhole, shown in FIG. 6.

At the completion of the round end of the buttonhole, the reflective member 69 again is positioned directly underneath the end of the light guide 73, as shown in FIG. 3, so that the opto-electronic system 72 is activated, which in turn activates the solenoid 132 to retract the pin 129 from the pawl slot 130, thereby releasing the pawl 127. The spring 128 forces the pawl 127 into engagement with the ratchet teeth group 119 while the pawl 115 continues to index the cam disk 94. The sewing machine remains in the position of adjustment to produce a straight seam of zigzag stitches because the roller follower 99 tracks the cam groove portion 126 which has a constant radius.

As the straight seam of zigzag stitches is being sewn, the wheel **50** continues to be rotated by the linear motion of the material M, so that the reflective member **69** is moved from its position underneath the light guide **73**. Again the SCR **146** is discharged, thereby deactivating the solenoid **132** so that the solenoid spring **133** forces the pin **129** into its extended position against the pawl **127**. As the bellcrank lever **113** imparts continuous motion to the pawl **127**, the pawl **127** is raised and lowered by the ratchet teeth group **119**. When the pawl **127** is in the raised position, the pin **129** is in alignment with the extreme right end of slot **130**, as shown in FIG. **10** and FIGS. **12—17**, so that the solenoid spring **133** again forces the pin **129** into the pawl slot **130**. With the pin **129** engaged in the pawl slot **130**, the pawl **127** still slightly engages the ratchet teeth group **119** but is held out of driving contact with the cam disk **94** so that the pawl **127** cannot index the disk cam **94**.

When the pawl **115** thereafter in moving over the spot **122** of the cam disk **94** ceases to index the cam disk **94**, as shown in FIG. **14**, the sewing machine will still remain in the position of adjustment to continue to produce the straight seam of zigzag stitches which constitutes one side of the buttonhole as illustrated in FIG. **7**. During this time, the wheel **50** continues to be rotated by the linear motion of the material M, whereby the reflective member **71** on the tab **57** is being moved closer to the light guide **73**.

When the reflective member **71** is rotated to a position directly underneath the end of the light guide **73**, as shown in FIG. **4**, the light carried by one-half of the light guide **73** from the light source **77** is picked up through reflection off the reflective member **71** by the other half of the light guide **73**. The light is carried to the photocell **79**, thereby activating the opto-electronic system **72** which in turn activates the solenoid **132** which retracts the pin **129** to release the pawl **127**, in the manner stated above. The spring **128** forces the pawl **127** into a driving engagement with the ratchet teeth group **120**, as shown in FIG. **15**. The pawl **127** rotates the cam disk **94** so that the spot **122** is moved out of abutment with the pawl **115**, whereby the ratchet teeth group **120** is brought into engagement with the pawl **115**.

At first, both the pawls **115**, **127** cooperate with the ratchet teeth group **120** to index the cam disk **94** to form the second round end (bottom) of the bottomhole, whereby the wheel **50** continues to be rotated by the linear motion of the material M. Once the reflective member **71** is moved from its position underneath the light guide **73**, the SCR **146** is discharged, thereby deactivating the solenoid **132** so that the solenoid spring **133** forces the pin **129** into its extended position against the pawl **127**. The solenoid spring **133** again forces the pin **129** into the pawl slot **130** when the continuously moving pawl **127** is raised by the ratchet teeth group **120**, in the manner set forth above, so that the pawl **127** is held out of driving contact with the disk cam **94**, whereby the pawl **127** still slightly engages the ratchet teeth group **120**.

The pawl **115** continues to index the cam disk **94** in a series of steps extending over a number of stitches, during which time the cam groove portion **124** will shift the single-operating member **98** and the pin **135** secured thereon, from the lower extreme position toward the upper extremity of the range of positions. The pin **135**, in the raised position within the pawl aperture **134**, cooperates with the pin **129** to support the pawl **127** so that the pawl **127** is held out of driving contact with the disk cam **94**, as shown in FIG. **16**, whereby the pawl **127** does not engage the ratchet teeth group **120**. The movement of the single-operating number **98** from the lower extreme to the upper extreme position will carry the feed-regulating member gradually from a position of forward work feed control through a position of zero feed of the work and into a position of rearward feed of work. Simultaneously, the needle **20** will be shifted from the position on the left-hand side to a position on the right-hand side of the field of zigzag stitches. The opposite end of the buttonhole will be produced automatically during this second series of motions of the cam disk **94**, as illustrated in FIG. **8**.

At the completion of the bottom of the buttonhole, the reflective member **71** again is positioned directly underneath the end of the light guide **73**, as shown in FIG. **4**, so that the opto-electronic system **72** is activated, which in turn activates the solenoid **132** to retract the pin **129** from the pawl slot **130**. However, the pawl **127** is not released, the pawl **127** being held by the pin **135** which is engaged in the pawl aperture **134**. The pawl **115** continues to index the cam disk **94**. The sewing machine remains in the position of adjustment to produce a second straight seam of zigzag stitches because the roller follower **99** tracks the cam groove portion **125** which has a constant radius. As the second straight seam of zigzag stitches is being sewn, the wheel **50** continues to be rotated by the linear motion of the material M, so that the reflective member **71** is moved from its position underneath the light guide **73**. Again the SCR **146** is discharged, thereby deactivating the solenoid **132** so that the solenoid spring **133** forces the pin **129** into its extended position, whereby with the pawl **127** being in the held position, the pin **129** is engaged again in the pawl slot **130**.

When the pawl **115** thereafter in moving over the spot **121** of the cam disk **94** ceases to index the cam disk **94** as shown in FIG. **17**, the cam disk pin **136** triggers the microswitch **138**. The sewing machine still remains in the position of adjustment to feed the work in the reverse direction and continues to produce the second straight line of zigzag stitches comprising the opposite side of the buttonhole, whereby the sides of the buttonhole are parallel. During this time, the wheel **50** is still being rotated by the linear motion of the material M, whereby the reflective member **69** on the wheel hub **54** is being moved closer to the light guide **73**.

When the reflective member **69** is rotated to a position directly underneath the end of the light guide **73**, as shown in FIG. **3**, the light carried by one-half of the light guide **73** from the light source **77** is picked up by the other half of the light guide **73**, this time through reflection off the reflective member **69**. The light is carried to the photocell **79**, thereby activating the opto-electronic system **72** which in the present circuit activates the relay **152** which moves the latching contacts **153** to the normally opened position at points **157**, **158** to stop the sewing machine by cutting power to the motor **141** and also to discharge the SCR **146**, in the manner stated above. At this point, the side stitching has reached the initially formed end of the buttonhole so that the buttonhole has been completed, as shown in FIG. **9**. When the cam disk **94** is in the latter position, as shown in FIG. **17**, the buttonholing assembly **90** will have no effect upon the needle jogging mechanism of the sewing machine and thus, if the buttonholing assembly **90** is decoupled from the feed regulating member by a shift of the handle **111** to the right to urge the pin **101** out of engagement with the plate aperture and also to open the microswitch **142** to restore power to the motor **141** as set forth above, the buttonholing assembly **90** will have no effect whatever on the entire range of the zigzagging capability of the needle nor upon the entire range of manually controllable positions of the work-feeding mechanism of the sewing machine.

Numerous alterations of the structure herein disclosed will suggest themselves to those skilled in the art. However, it is to be understood that the present disclosure relates to a preferred embodiment of my invention which is for purposes of illustrations only and not to be construed as a limitation of the invention.

Having thus set forth the nature of the invention, what I claim herein is:

1. In a zigzag sewing machine having an endwise reciprocatory needle bars, mechanism for jogging said needle bar laterally to produce zigzag stitches including a member regulating the neutral position of needle jogging motion, a work-feeding mechanism including a feed-regulating member having a range of positions corresponding to forward and reverse directions of work feed, and actuating mechanism in said sewing machine operatively connected to impart endwise reciprocatory and laterally vibratory movements to said nee-

dle bar and movements to said work-feeding mechanism in timed relation thereto, a buttonholing mechanism comprising rotary cam means supported on said sewing machine, a single-operating member guided to move between extreme positions along a constrained path, a follower carried by said operating member in tracking relation with said rotary cam means, linkage in said sewing machine operatively connecting said member regulating the neutral position of needle jogging motion with said single-operating member in only one extreme position of said operating member, a manually separable connection between said single-operating member and said feed-regulating member, drive means operated by said sewing machine actuating mechanism for imparting turning movement in stepwise increments to said rotary cam means in first and second spaced portions of said rotary cam means, said first and second spaced portions rotary means, and the intervals between said spaced portions defining the periphery of said rotary cam means, operator-influenced handle means secured to said rotary cam means for turning said rotary cam means through one interval so that said drive means engage said first portion, and means responsive to movement of the work for turning said rotary cam means through the other interval so that said drive means engage said second portion.

2. A buttonholing device according to claim 1 wherein said drive means comprises an oscillatory pawl operated by said sewing machine actuating mechanism, said rotary cam means comprising a cam disk having ratchet teeth on said first and second portions arranged almost all around the cam disk periphery and formed to accommodate stepwise engagement of said oscillating pawl, said intervals being two plain, diametrically opposed peripheral surface spots.

3. A buttonholing device according to claim 2 wherein said means responsive to movement of the work comprises a second oscillating pawl operated by said sewing machine actuating mechanism, releaseable means for holding said second pawl out of driving contact with said cam disk, an electrical circuit operating said releasable means, and means for providing sensing pulses at a preset position to said electrical circuit for controlling said releaseable means, whereby at said preset position said releaseable means release said second pawl so that said second pawl engages said ratchet teeth of said second portion of said cam disk to turn said cam disk through one surface spot so that said first-mentioned pawl engages said ratchet teeth of said second portion of said cam disk.

4. A buttonholing device according to claim 3 wherein said releaseable means comprises a solenoid having a spring biased plunger, a pin being secured to said plunger and extending through slot means formed in said second pawl, said slot means permitting continuous oscillating movement of said second pawl while said second pawl is being held off said cam disk by said pin, whereby at said one preset position said solenoid is activated to retract said plunger, thereby moving the pin out of the slot means to release said second pawl.

5. A buttonholing device according to claim 1 having second means responsive to movement of the work for stopping the sewing machine at the completion of the buttonhole comprising abutment means on said rotary cam means, said abutment means being turned to a predetermined position to control an electrical switch of a first electrical circuit, said electrical switch permitting said first electrical circuit to operate a relay, said relay controlling latching contacts of a second electrical circuit, said second circuit operating the sewing machine motor, and means for providing sensing pulses at the completion of the buttonhole to said first electrical circuit for activating said relay when said abutment means are in said predetermined position, whereby the activated relay moves said latching contacts to an opened position thereby opening said second electrical circuit to cut power to the sewing machine motor and stopping the sewing machine.