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(54) STITCH REGULATOR FOR A SEWING MACHINE

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(52) U.S. Cl. 112/117

(57) ABSTRACT

A stitch regulator (**50**) for use with a sewing machine (**34**) transported by a moveable platform (**26**) includes a housing (**52**) configured to be coupled to one of the sewing machine (**34**) and the moveable platform (**26**). An X-axis rate sensor (**92**) and a Y-axis rate sensor (**96**) determine movement of the sewing machine (**34**) on the moveable platform (**26**). A microcontroller (**118**) is contained in the housing (**52**) and is in communication with the sensors (**92, 96**). The microcontroller (**118**) generates a motor control signal (**126**) in response to the movement of the sewing machine (**34**) for input into a motor control input port (**88**) of the sewing machine (**34**).

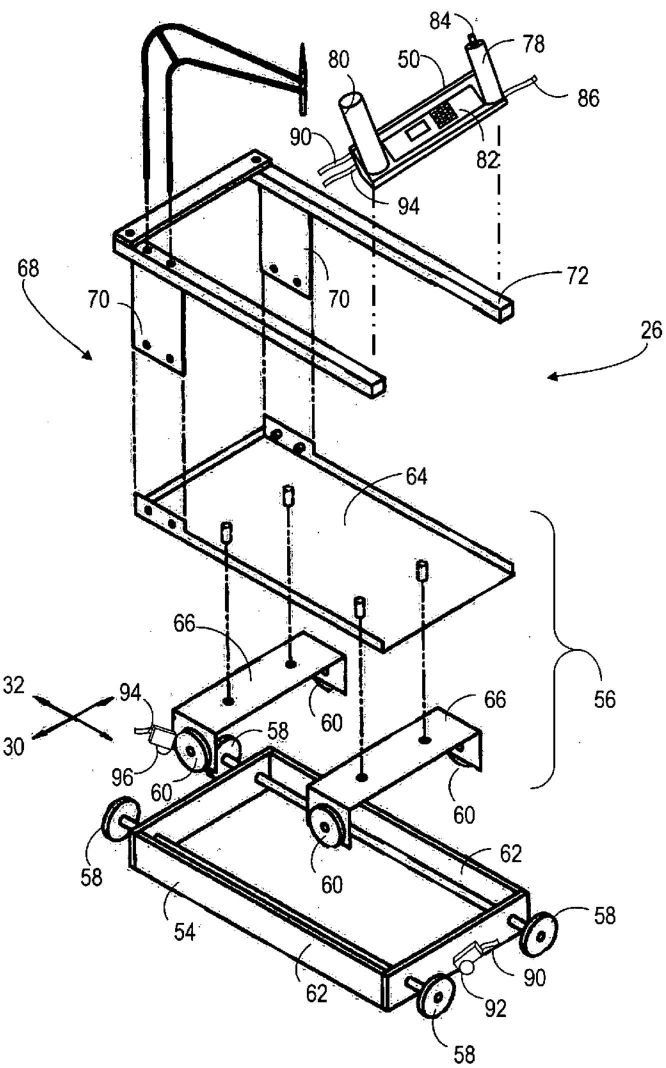
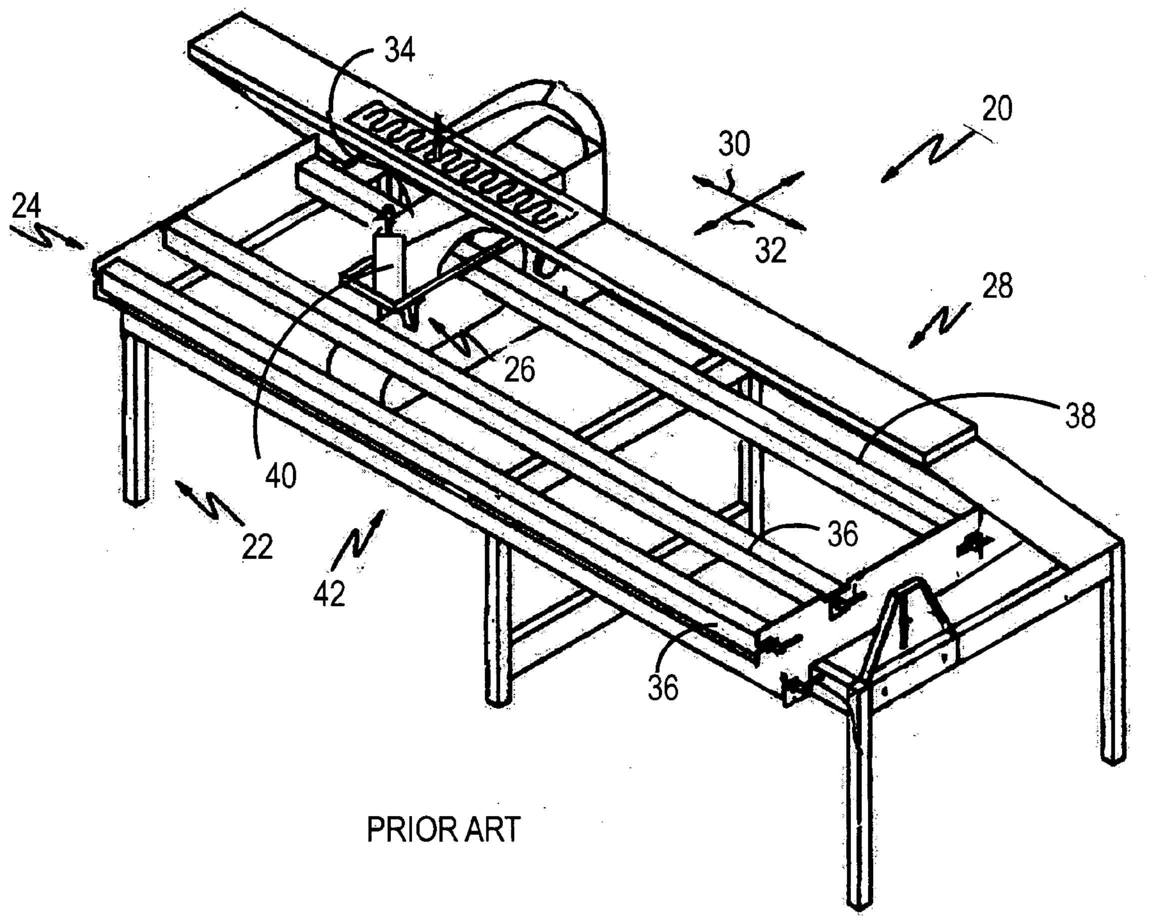


FIG. 1



PRIOR ART

FIG. 2

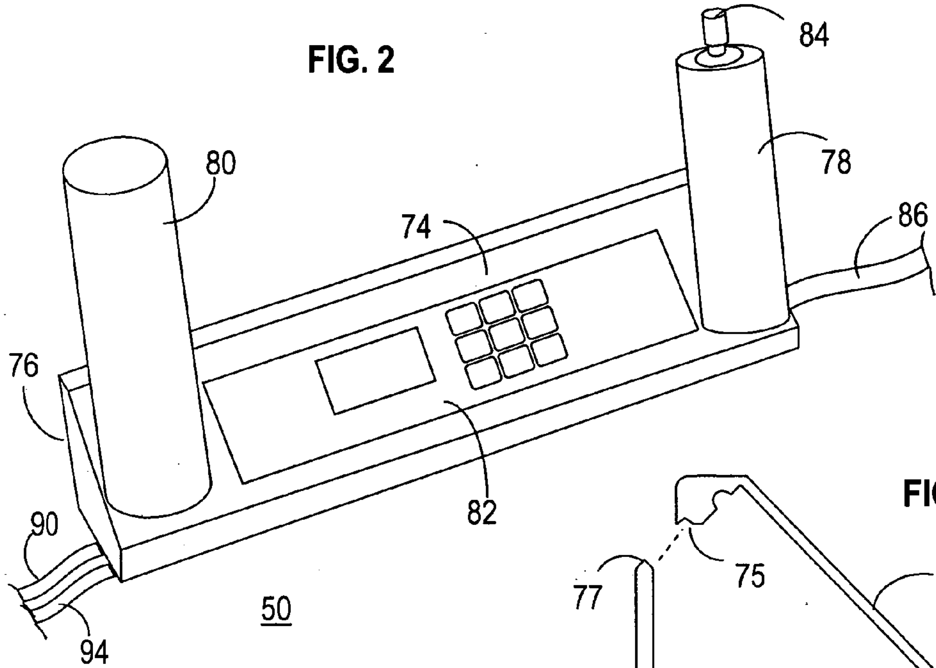


FIG. 3

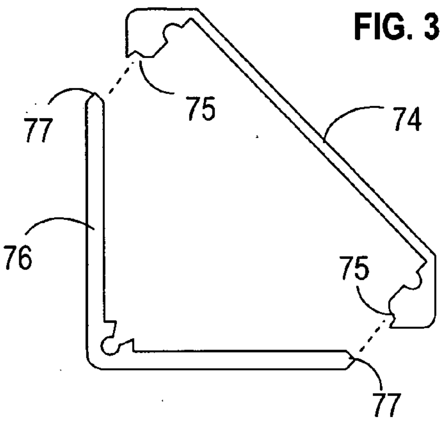


FIG. 5

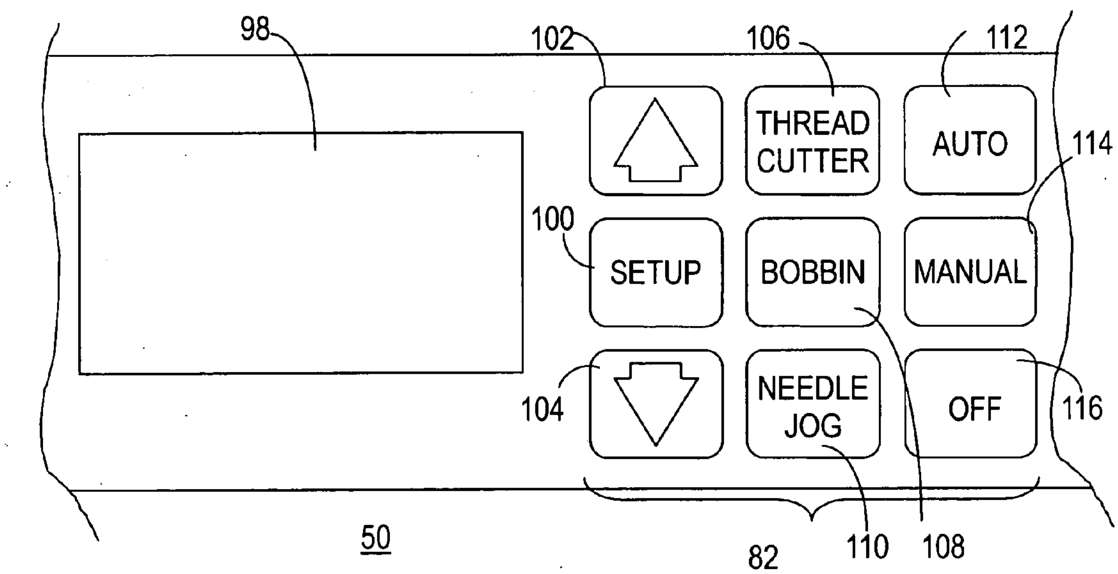


FIG. 4

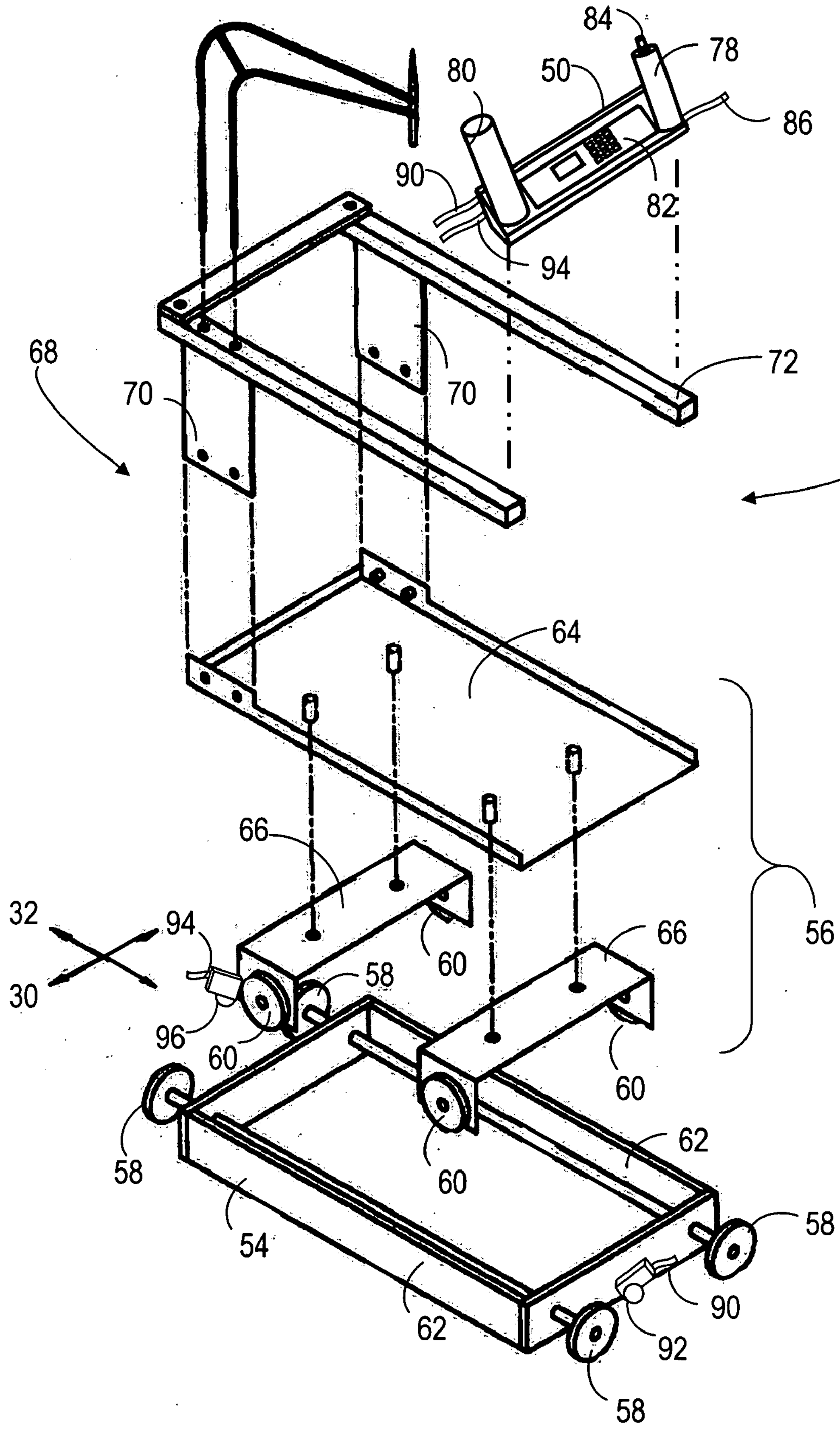
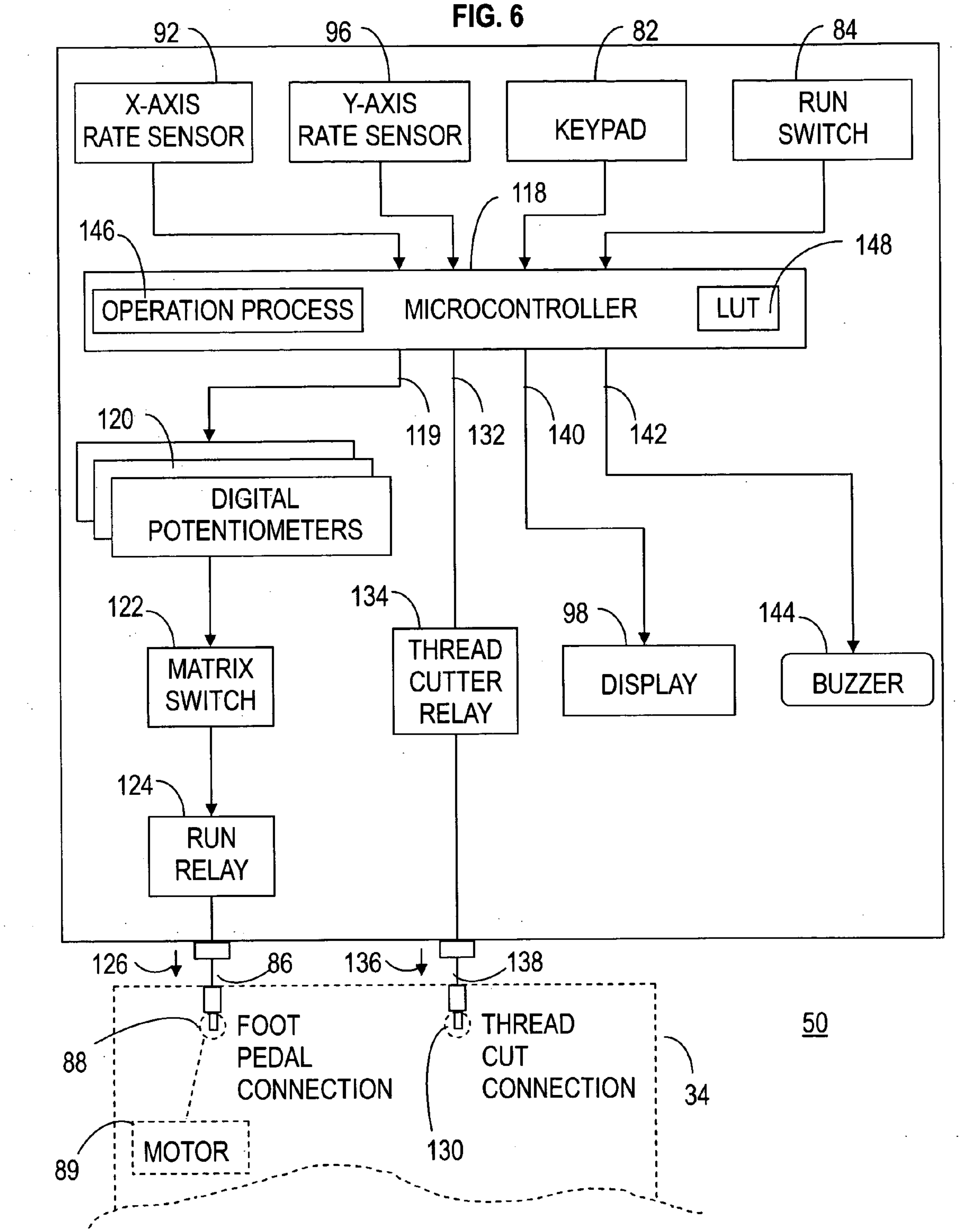

84
78
80
50
86
90
82
94
68
70
70
72
26
64
66
56
32
94
58
60
66
30
96
60
60
58
62
60
58
54
90
62
92
58

FIG. 6



92
96
82
84
X-AXIS RATE SENSOR
Y-AXIS RATE SENSOR
KEYPAD
RUN SWITCH
118
146
148
OPERATION PROCESS
MICROCONTROLLER
LUT
120
119
132
140
142
DIGITAL POTENTIOMETERS
122
134
98
144
MATRIX SWITCH
THREAD CUTTER RELAY
DISPLAY
BUZZER
124
RUN RELAY
126
86
136
138
88
FOOT PEDAL CONNECTION
THREAD CUT CONNECTION
50
34
89
MOTOR
130

FIG. 7

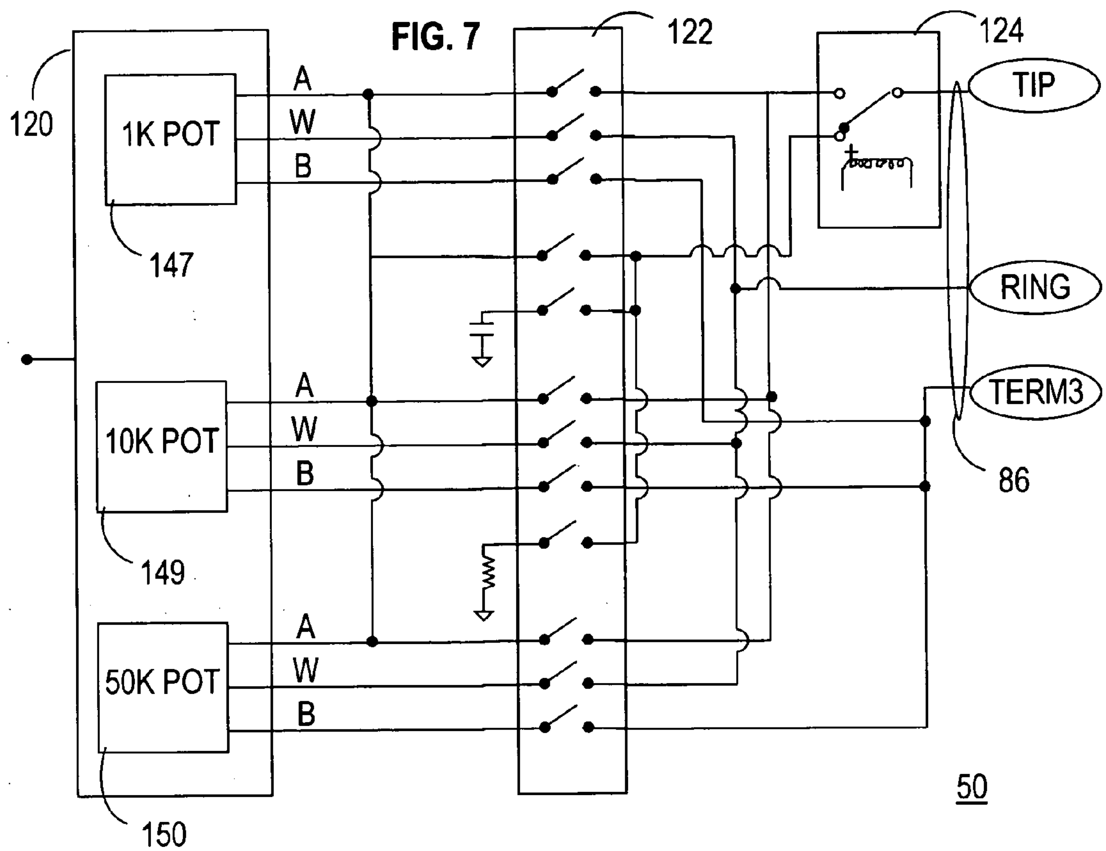
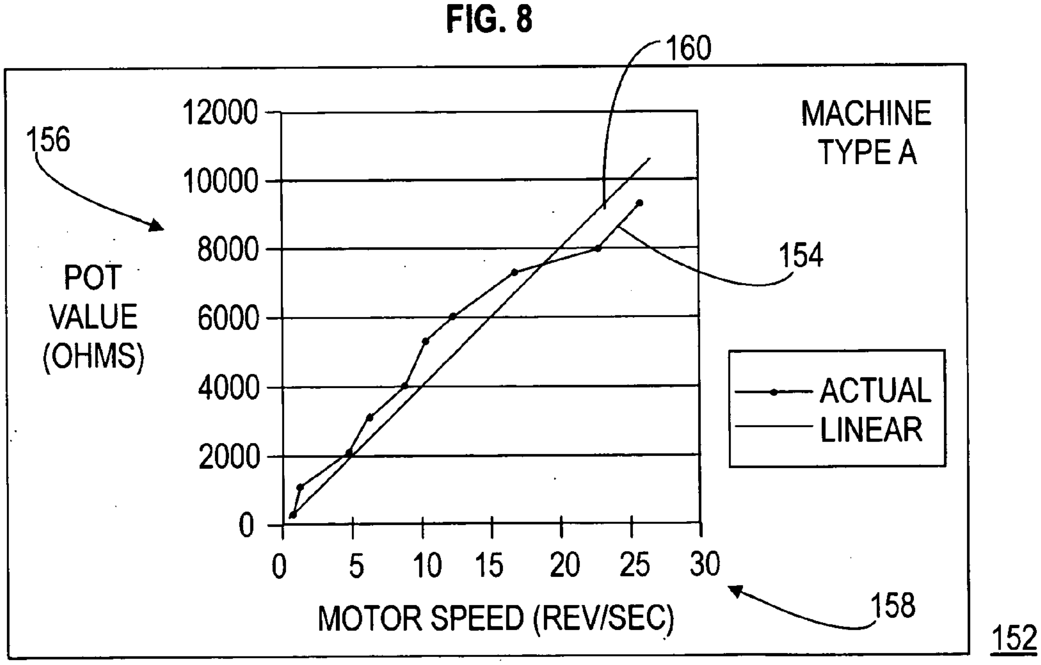

120
1K POT
147
10K POT
149
50K POT
150
A
W
B
A
W
B
A
W
B
122
124
TIP
RING
TERM3
86
50

FIG. 8


160
156
12000
10000
8000
6000
4000
2000
0
POT
VALUE
(OHMS)
MACHINE
TYPE A
154
ACTUAL
LINEAR
0
5
10
15
20
25
30
MOTOR SPEED (REV/SEC)
158
152

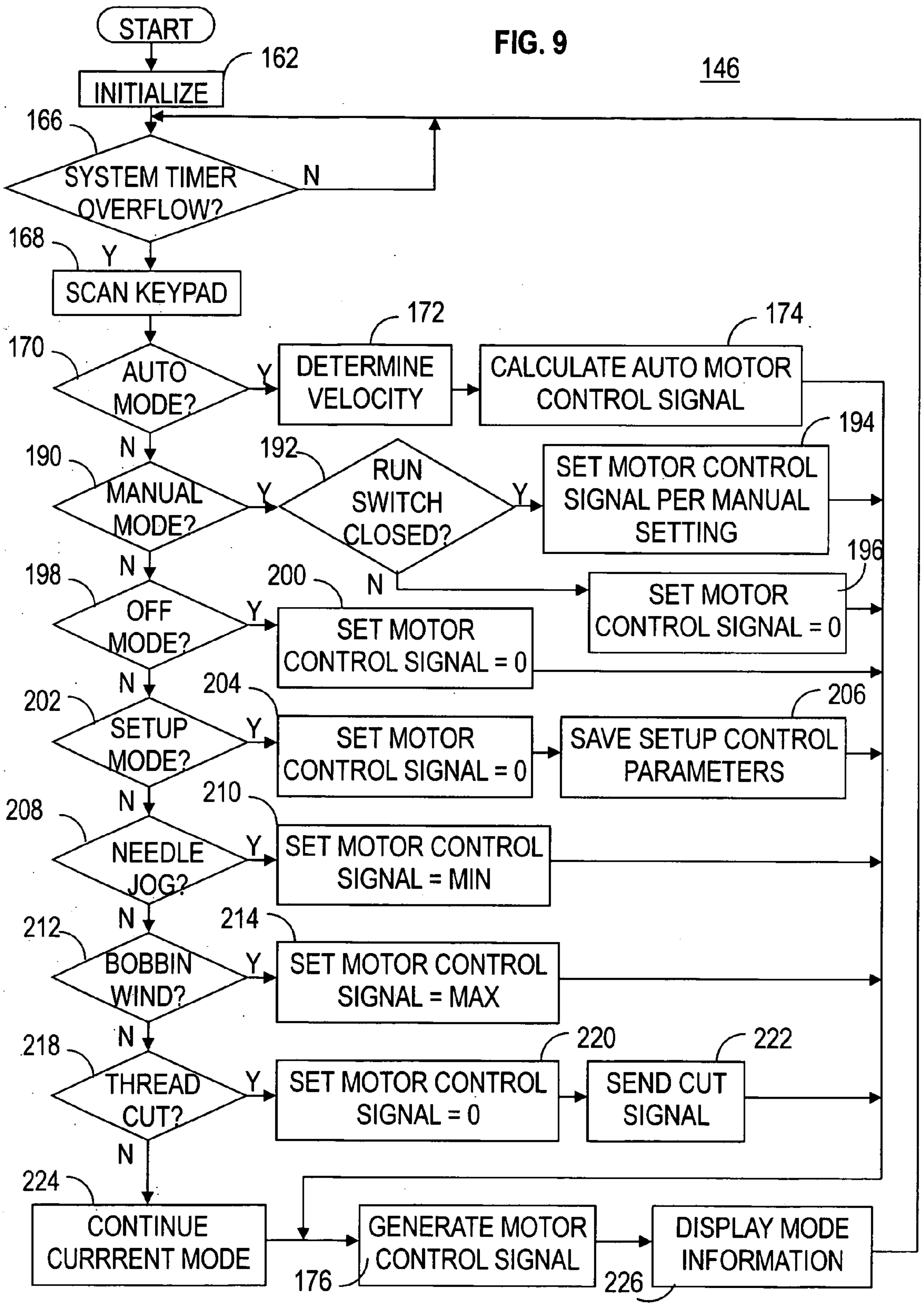

START
INITIALIZE
162
146
166
SYSTEM TIMER OVERFLOW?
N
168
Y
SCAN KEYPAD
170
AUTO MODE?
Y
172
DETERMINE VELOCITY
174
CALCULATE AUTO MOTOR CONTROL SIGNAL
N
190
MANUAL MODE?
Y
192
RUN SWITCH CLOSED?
Y
194
SET MOTOR CONTROL SIGNAL PER MANUAL SETTING
N
196
SET MOTOR CONTROL SIGNAL = 0
198
OFF MODE?
Y
200
SET MOTOR CONTROL SIGNAL = 0
N
202
SETUP MODE?
Y
204
SET MOTOR CONTROL SIGNAL = 0
206
SAVE SETUP CONTROL PARAMETERS
N
208
NEEDLE JOG?
Y
210
SET MOTOR CONTROL SIGNAL = MIN
N
212
BOBBIN WIND?
Y
214
SET MOTOR CONTROL SIGNAL = MAX
N
218
THREAD CUT?
Y
220
SET MOTOR CONTROL SIGNAL = 0
222
SEND CUT SIGNAL
N
224
CONTINUE CURRRENT MODE
176
GENERATE MOTOR CONTROL SIGNAL
226
DISPLAY MODE INFORMATION

FIG. 9

FIG. 10

DETERMINE VELOCITY OF THE PLATFORM

VELOCITY IN EACH DIRECTION:

X(VEL) = X(PVEL) - X(NVEL) 178

Y(VEL) = Y(PVEL) - Y(NVEL) 180

MAGNITUDE OF THE PLATFORM VELOCITY (INCHES/SEC):

T(VEL) = SQRT[X(VEL) * X(VEL) + Y(VEL) * Y(VEL)] 182

TARGET MOTOR SPEED (REVOLUTIONS/SEC):

RPS = T(VEL) * SPI 184

MOTOR CONTROL SIGNAL (DIGITAL POTENTIOMETER COMPUTED VALUE):

156 WIPER = LUT(RPS) 186

WHERE:

X(PVEL) = POSITIVE X PLATFORM VELOCITY (INCHES/SEC)
X(NVEL) = NEGATIVE X PLATFORM VELOCITY (INCHES/SEC)
Y(PVEL) = POSITIVE Y PLATFORM VELOCITY (INCHES/SEC)
Y(NVEL) = NEGATIVE Y PLATFORM VELOCITY (INCHES/SEC)
X(VEL) = X PLATFORM VELOCITY (INCHES/SEC)
Y(VEL) = Y PLATFORM VELOCITY (INCHES/SEC)
SQRT = SQUARE ROOT FUNCTION
SPI = USER ENTERED STITCH DENSITY (STITCHES/INCH)
LUT = LOOKUP TABLE CORRECTION FACTOR

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STITCH REGULATOR FOR A SEWING MACHINE

RELATED INVENTION

[0001] The present invention claims priority under 35 U.S.C. §119(e) to: "Speed Control for a Sewing Machine," U.S. Provisional Patent Application Ser. No. 60/632,563, filed 1 Dec. 2004, which is incorporated by reference herein.

TECHNICAL FIELD OF THE INVENTION

[0002] The present invention relates to the field of sewing machines. More specifically, the present invention relates to a stitch regulator for use with a sewing machine transported by a moveable platform relative to a piece of fabric.

BACKGROUND OF THE INVENTION

[0003] Quilting has been in practice for many years, initially for utilitarian purposes, and more recently as a way of artistic expression. The continued popularity of the craft has lead to the development of modern textiles, equipment, and labor-saving sewing devices.

[0004] Quilting typically entails sewing two layers of cloth with a layer of insulating batting in between, thus forming a quilt. Quilts may be formed in a variety of shapes and styles that are variously used to cover beds, to decorate walls, used as lap cloths, and so forth. Designs and patterns are typically sewn, or stitched, into a quilt by hand or with a sewing machine to secure the two layers of cloth and the layer of batting together. Complex designs and patterns are often hand-stitched by a skilled craftsperson. However, such hand-stitching can be too time consuming for a skilled craftsperson, and may be too challenging for those who are not as skilled at hand-stitching. In addition, hand-stitching may be difficult or even impossible for those with limited mobility of their fingers, such as for an individual who has arthritis. Thus, some individuals utilize machine sewing techniques to stitch a quilt.

[0005] Unfortunately, however, when using a sewing machine, the hobbyist must manipulate an unwieldy, multilayered fabric sandwich under the needle bar of the sewing machine. Such manipulation can be difficult, and cause puckering and stitching errors. Accordingly, market demand has lead to the development of quilting devices for holding the fabric to be quilted and moving the sewing machine relative to the fabric. A quilting table is one such quilting device.

[0006] **FIG. 1** shows a front perspective view of a prior art quilting table **20**. Quilting table **20** generally includes a frame **22**, a fabric support system **24** for holding the fabric to be quilted, a platform assembly **26**, and an overhead shelf **28**. Platform assembly **26** is moveable relative to a longitudinal dimension, or X-axis **30**, and a transverse dimension, or Y-axis **32**, of frame **22**. In general, platform assembly **26** supports and transports a conventional, household sewing machine **34**, for moving sewing machine **34** relative to the fabric.

[0007] Frame **22** generally holds one or more payout rollers **36**, onto which fabric is rolled, and a take-up roller **38**. Take-up roller **38** is typically directed through the throat of sewing machine **34** so that fabric suspended between payout rollers **36** and take-up roller **38** can be passed under the needle bar of sewing machine **34** for machine stitching. Platform assembly **26** typically includes two carriages, one sitting upon the other. One carriage moves in the longitudinal direction, i.e., along X-axis **30**, and the other carriage moves upon the first carriage in the transverse direction, i.e., along Y-axis **32**. Platform assembly **26** can then be manually manipulated by the user to impart a stitch pattern onto the fabric.

[0008] A handle **40** may be coupled to platform assembly **26** on a needle side **42** of quilting table **20** for manually translating the carriages of platform assembly **26** longitudinally and transversely relative to X-axis **30** and Y-axis **32**. In such a configuration, an individual may be located at and operate sewing machine **34** from needle side **42** of quilting table **20**. As such, the fabric and needle of sewing machine **34** are readily visible to the individual as the fabric is being stitched. In order to facilitate operation of sewing machine **34** from needle side **42** of quilting table **20**, handle **40** may include the capability to both turn off and turn on sewing machine **34**. In addition, handle **40** may include the capability to adjust an operational speed of sewing machine **34**.

[0009] Stitch regulators that provide the capability to both turn off and turn on, as well as to adjust the operational speed of, a sewing machine are known for utilization with a quilting table. One prior art stitch regulator includes a computer board located inside of the sewing machine and having a controller mounted thereon. The prior art stitch regulator further includes front and rear control panels and handle switches, two track sensors, and a needle position sensor. The stitch regulator is driven by software embedded inside a microchip. The track sensors measure the changing location of the needle as the sewing machine is moved on the platform assembly, and the needle position sensor recognizes if the needle is up or down. The stitching mode and other commands are set on the control panel. The controller uses the needle location data, the needle up/down data, and the entered stitching mode and other commands to determine when a stitch should be completed and sends a motor control signal to the sewing machine motor.

[0010] While such a stitch regulator can be useful for an operator, prior art stitch regulators suffer from a number of problems. For example, the stitch regulator discussed above requires installation of a portion of the device inside of the sewing machine. Therefore, it cannot be readily implemented with a number of sewing machines without invasive and costly modification to the sewing machines.

[0011] A further problem with prior art stitch regulators is that current stitch regulator systems are not necessarily accurate regarding stitch regulation across a variety of machine types. This inaccuracy occurs because the actual motor speed of a particular motor is affected by the characteristics of that motor. Consequently, a motor control signal input to a motor of one type of sewing machine might not cause the motor to operate at the same speed as when the motor control signal is input to a motor of a different type of machine. Therefore, stitch regulation could be inconsistent across a variety of machine types.

[0012] Another deficiency in the current stitch regulator systems is that the motor speed for each type of machine is not necessarily linear with the motor control signal. That is, sending a motor control signal that is twice the motor speed of a first motor control signal does not necessarily make the sewing machine motor run twice as fast as the first motor control signal. This situation can further lead to inconsistent stitch regulation at various operational speeds of a sewing machine.

SUMMARY OF THE INVENTION

[0013] Accordingly, it is an advantage of the present invention that a stitch regulator for use with sewing machine transported by a moveable platform is provided.

[0014] It is another advantage of the present invention that a stitch regulator is provided that yields consistent stitch regulation across a variety of sewing machine types.

[0015] Another advantage of the present invention is that a stitch regulator is provided that yields consistent stitch regulation across a wide variety of motor speeds for a sewing machine.

[0016] Yet another advantage of the present invention is that a stitch regulator is provided that is intuitive to utilize, is located exterior to a sewing machine, and is cost effectively manufactured.

[0017] The above and other advantages of the present invention are carried out in one form by a stitch regulator for use with a sewing machine transported by a moveable platform, the sewing machine having a motor control input port. The stitch regulator includes a housing configured to be coupled to one of the sewing machine and the moveable platform, and a sensor adapted for communication with the sewing machine for determining movement of the sewing machine on the moveable platform. A microcontroller is contained in the housing and is in communication with the sensor. The microcontroller generates a motor control signal in response to the movement of the sewing machine, for input into the motor control input port.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] A more complete understanding of the present invention may be derived by referring to the detailed description and claims when considered in connection with the Figures, wherein like reference numbers refer to similar items throughout the Figures, and:

[0019] **FIG. 1** shows a front perspective view of a prior art quilting table;

[0020] **FIG. 2** shows a front perspective view of a stitch regulator in accordance with a preferred embodiment of the present invention;

[0021] **FIG. 3** shows an exploded side view of a housing of the stitch regulator;

[0022] **FIG. 4** shows an exploded perspective view of a platform assembly with a stitch regulator mountable thereon;

[0023] **FIG. 5** shows a partial front view of the stitch regulator illustrating keypad controls;

[0024] **FIG. 6** shows a block diagram of the stitch regulator;

[0025] **FIG. 7** shows a block diagram of a portion of the stitch regulator;

[0026] **FIG. 8** shows a graph typifying a motor characteristic for a sewing machine;

[0027] **FIG. 9** shows a flow chart of a stitch regulator operation process; and

[0028] **FIG. 10** shows a table of formulas executed within the stitch regulator for determining a motor control signal for input into a sewing machine.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0029] The present invention provides a stitch regulator for use with a sewing machine. Such a stitch regulator may be utilized for controlling motor speed of a sewing machine mounted on a moveable platform assembly, such as that utilized on quilting table **20** (**FIG. 1**).

[0030] Referring to **FIGS. 2-4**, **FIG. 2** shows a front perspective view of a stitch regulator **50** in accordance with a preferred embodiment of the present invention. **FIG. 3** shows an exploded side view of a housing **52** of stitch regulator **50** (**FIG. 2**), and **FIG. 4** shows an exploded perspective view of a platform assembly, such as platform assembly **26**, with stitch regulator **50** mountable thereon. For clarity of the following discussion, stitch regulator **50** is utilized in connection with platform assembly **26** and sewing machine **34** (**FIG. 1**). However, it will become readily apparent that stitch regulator **50** is not limited for use with the particular platform assembly **26** and sewing machine **34** discussed herein, but may instead be adapted for use with a number of moveable platforms and sewing machine types.

[0031] Stitch regulator **50** includes housing **52** configured to be coupled to either of sewing machine **34** or platform assembly **26**. In this exemplary configuration, stitch regulator **50** may couple, or bolt, to platform assembly **26**. As mentioned above, platform assembly **26** supports and transports sewing machine **34** (**FIG. 1**) relative to X-axis **30** and Y-axis **32**. Platform assembly **26** generally includes a first carriage **54** and a second carriage **56**.

[0032] First carriage **54** includes first wheels **58** configured to engage with rails on frame **22** (**FIG. 2**) that allow movement of platform assembly **26** relative to X-axis **30**. Second carriage **56** includes second wheels **60** arranged perpendicular to first wheels **58** of first carriage **54**. Second wheels **60** engage with opposing rails **62** of first carriage **54** and allow movement of platform assembly **26** relative to Y-axis **32**. Sewing machine **34** (**FIG. 1**) is seated on a machine platform **64** that couples with second wheels **60** via carriage supports **66**. A support structure **68** is coupled to machine platform **64**. Support structure **68** includes a pair of uprights **70** and a framework **72**. Stitch regulator **50** is mountable to framework **72**.

[0033] Housing **52** of stitch regulator **50** includes a first section in the form of an angled facing plate **74** and a second section, or a rear section **76**. Angled facing plate **74** includes a first pair of longitudinal edges **75**, and rear section **76** includes a second pair of longitudinal edges **77**. In a preferred embodiment, angled facing plate **74** and rear section **76** are manufactured utilizing an aluminum extrusion process for cost effective fabrication. Second pair of longitudinal edges **77** forms a snap-fit connection with first pair of longitudinal edges **75** for ease of assembly.

[0034] Following assembly, housing **52** generally takes the form of a triangular prism. This shape facilitates the fit of stitch regulator **50** with quilting table **20** (**FIG. 1**), and allows clear visibility of the underlying head of sewing machine **34** and its needle.

[**0035**] A first handle **78** and a second handle **80** extend from facing plate **74**. Keypad controls **82**, in the form of a membrane keypad, are mounted on facing plate **74**, and a run switch **84** is mounted on first handle **78**. A first conductor **86** extends from stitch regulator **50** and couples to a motor control input port, conventionally known as a foot pedal connection **88** (see **FIG. 6**) of sewing machine **34** (**FIG. 1**). Foot pedal connection **88** is, in turn, in communication with a motor **89** (see **FIG. 6**), of sewing machine **34**. A second conductor **90** extends from stitch regulator **50** and is in electrical communication with a first sensor **92** coupled to first carriage **54**. A third conductor **94** extends from stitch regulator **50** and is in electrical communication with a second sensor **96**.

[**0036**] First and second sensors **92** and **96**, respectively, may be rotary optical encoders capable of measuring at least one direction of movement (e.g. X-axis **30**, Y-axis **32**) of platform assembly **26** and a velocity of movement. As such, first sensor **92** is referred to hereinafter as an X-axis rate sensor **92**. Similarly, second sensor **96** is referred to hereinafter as a Y-axis rate sensor **96**. This direction and velocity information can be provided to a microcontroller (discussed below) of stitch regulator **50** for providing position feedback of platform assembly **26**, hence sewing machine **34** (**FIG. 1**).

[**0037**] In general operation, a user selects the operational parameters of stitch regulator **50** via keypad controls **82**. The user can then manually translate platform assembly **26** by holding onto first and/or second handles **78** and **80**, respectively, to move sewing machine **34** relative to the underlying fabric held on quilting table **20** (**FIG. 1**). In an automatic mode, motor **89** of sewing machine **34** will run in response to the movement of platform assembly **26**, speeding up and slowing down in response to movement of platform **26**, in order to yield consistent stitches.

[**0038**] **FIG. 5** shows a partial front view of stitch regulator **50** illustrating keypad controls **82**. In a preferred embodiment, keypad controls **82** are formed utilizing a rugged, moisture resistant membrane keypad that may optionally include tactile and audible feedback. A single interconnecting flex cable extending from the membrane keypad can interconnect with a microcontroller (discussed below) of stitch regulator **50**. Stitch regulator **50** further includes a display **98** for presenting information pertaining to particular operational modes selected by a user through actuation of keypad controls **82**.

[**0039**] Keypad controls **82** include a number of user selectable buttons including a SETUP button **100**, an up arrow button **102**, a down arrow button **104**, a THREAD CUTTER button **106**, a BOBBIN button **108**, and a NEEDLE JOG button **110**. Additional buttons on keypad controls **82** include an AUTO mode button **112**, a MANUAL mode button **114**, and an OFF button **116**. Those skilled in the art will recognize that keypad controls **82** need not include all of the described buttons but may alternatively include a subset of the above-described buttons or additional buttons not described herein.

[**0040**] Selection of the various buttons of keypad controls **82** causes the generation by stitch regulator **50** of a motor control signal (discussed below). The motor control signal is input into sewing machine **34** (**FIG. 1**) via foot pedal connection **88** (**FIG. 6**) to appropriately drive motor **89** (**FIG. 6**) of sewing machine **34**. The specific function of each of these buttons will be described in connection with the flowchart of **FIG. 9**.

[**0041**] **FIG. 6** shows a block diagram of stitch regulator **50** for use with sewing machine **34** (shown in ghost form). Stitch regulator **50** includes a microcontroller **118** having parameter inputs that include X-axis rate sensor **92**, Y-axis rate sensor **96**, keypad controls **82**, and run switch **84**. Microcontroller **118** has a first output line **119** in communication with at least one digital potentiometer **120**. An output of digital potentiometers **120** is in communication with a matrix, or crosspoint, switch **122**, and matrix switch **122** is in communication with a run relay **124**. A motor control signal **126** is output from run relay **124** for input at foot pedal connection **88** via first conductor **86**.

[**0042**] Some sewing machines include a thread cut connection **130** that may be a connector port for a foot control. Through the utilization of a foot control, the user can send a thread cut signal to automatically sever threads, rather than through the conventional process of moving a mass of fabric to manually cut threads. As an alternative to the conventional foot control for thread cutting, microcontroller **118** has a second output line **132** in communication with a thread cutter relay **134**. A thread cut signal **136** is output from thread cutter relay **134** for input at thread cut connection **130** on sewing machine **34** via a conductor **138**.

[**0043**] In addition to the above, microcontroller includes a third output line **140** in communication with display **98**, and a fourth output line **142** in communication with a buzzer circuit **144** for optional audible signaling to a user.

[**0044**] In a preferred embodiment, microcontroller **118** is an integrated chip that contains all the components that make up a controller, such as a central processing unit (CPU), memory for a stitch regulator operation process **146** in the form of executable code, memory for data such as a lookup table (LUT) **148**, and one or more timers. Microcontroller **118** executes stitch regulator operation code **146** in response to inputs from, for example, X-axis rate sensor **92**, Y-axis rate sensor **94**, keypad **82**, and run switch **84**, and selectively outputs motor control signal **126**, thread cut signal **136**, associated text at display **98**, and optional audio at buzzer **144**.

[**0045**] **FIG. 7** shows a block diagram of a portion of the stitch regulator **50**. In particular, **FIG. 7** provides additional details of digital potentiometer **120**, matrix switch **122**, and run relay **124**. Stitch regulator **50** is adapted for use with a wide variety of sewing machine types. To that end, various digital potentiometers **120** are utilized because different sewing machine types call for very different values for maximum and minimum motor speed. As shown, digital potentiometer **120** includes a one kilo ohm potentiometer **147**, a ten kilo ohm potentiometer **149**, and a fifty kilo ohm potentiometer **150**. The specific potentiometers that make up digital potentiometer **120** in this configuration are not a limitation of the present invention, but can vary in accordance with various designs, motor specifications, potentiometer sensitivities, and the like.

[**0046**] Matrix switch **122** performs two functions. The first function of matrix switch **122** is to connect the proper one (or more) of potentiometers **147**, **149**, and **150** with foot pedal connection **88** (**FIG. 6**) on the different sewing machines. The second function of matrix switch **122** is to provide the proper motor control signal **126** (**FIG. 6**) for motor off. Different machines call for different control signals for motor off. For example, "machine A" may require an open circuit for motor off, "machine B" may require a short for motor off, and "machine C" may require a particular resistance, such as one hundred forty seven kilo ohms for motor off.

[0047] The three terminals (TIP, RING, TERM3) form the electrical interface of first conductor **86** for foot pedal connection **88** (**FIG. 6**) at sewing machine **34** (**FIG. 6**). Most sewing machines utilize mini audio type two terminal jacks (ring/tip). However, others use three terminals (tip/ring/term3). This particular jack is not a limitation of the present invention. Those skilled in the art will recognize that the present invention may be readily adapted to accommodate other types of connection ports for other sewing machines.

[0048] Run relay **124**, when energized, connects foot pedal connection **88** (**FIG. 6**) on sewing machine **34** (**FIG. 6**) to the correct digital potentiometer **120**, i.e., potentiometers **147**, **149**, and **150** through matrix switch **122**. When de-energized, run relay **124** connects foot pedal connection **88** to a motor off signal, again through matrix switch **122**. Consequently, run relay **124** is used in normal operation to provide motor control signal **126** to turn off motor **89** (**FIG. 6**) and/or to control its speed. In addition, if stitch regulator **50** loses power for any reason, run relay **124** will be de-energized, resulting in a motor off signal.

[0049] **FIG. 8** shows a graph **152** typifying a motor characteristic **154** for sewing machine **34** (**FIG. 6**). In this situation, motor characteristic **154** represents an actual potentiometer value **156** needed to obtain a particular motor speed **158**. In contrast, an ideal linear relationship **160** of motor speed **158** versus potentiometer value **156** is also illustrated in graph **152**.

[0050] It has been discovered that the relationship between a desired motor speed **158** and a potentiometer value **156** setting is not necessarily linear for each machine type. Nor is this relationship the same between various machines. Consequently, in order to adapt stitch regulator **50** for use with a variety of sewing machine types, each sewing machine is to be profiled, the results of the profiling being utilized to generate lookup table **148** (**FIG. 6**).

[0051] Profiling is accomplished, for example, by measuring the motor speed (e.g. revolutions per minute) of motor **89** (**FIG. 6**) as a function of motor control resistance. There are several methods for measuring motor speed. One such method calls for controlling a motor input signal with a digital potentiometer, and measuring the actual motor speed produced by the motor input signal to generate graph **152**. Consequently, lookup table **148** (**FIG. 6**) can be constructed to include an actual potentiometer value **156** (i.e., resistance) needed for a particular machine type that produces a desired motor speed **158**. Alternatively, or in addition, lookup table **148** can be constructed to include a potentiometer value difference between the actual potentiometer value **156** needed and the ideal potentiometer value typified by ideal linear relationship **160** for a desired motor speed **156**.

[0052] Profiling can be performed for a multiplicity of machine types, the results being stored in one or more lookup tables **148**, so that stitch regulator **50** can be implemented with a variety of industrial, long arm, and home sewing machines.

[0053] **FIG. 9** shows a flow chart of stitch regulator operation process **146**. Stitch regulator operation process **146** is executable code recorded in a memory element of microcontroller **118**.

[0054] Stitch regulator operation process **146** begins with a task **162**. At task **162**, stitch regulator **50** (**FIG. 2**) is initialized. Initialization task **162** occurs at system power up of stitch regulator **50**. System power up may occur in response to actuation of a separate power switch (not shown), in response to power up of sewing machine **34** (**FIG. 6**), or when one of AUTO mode button **112** (**FIG. 5**) and MANUAL mode button **114** (**FIG. 5**) is pressed.

[0055] In response to task **162**, a query task **166** is performed. At query task **166**, the system timer is monitored. When there is not a system timer overflow condition, process **146** loops back to an input of query task **166** to monitor for a system timer overflow condition. However, when a system timer overflow condition is detected at query task **166**, process **146** proceeds to a task **168**. Consequently, query task **166** causes an overall process loop to be initiated. The system timer may be set at fifty milliseconds. As such, the process loop may run about every fifty milliseconds, the loop traversing process **146**.

[0056] At task **168**, keypad controls **82** are scanned for keypad entry by a user and debounced. In response to task **168**, a series of query tasks may be performed to determine the nature of any keypad entry and a subsequent action executed by microcontroller **118** (**FIG. 6**).

[0057] For example, following task **168**, a query task **170** is performed. At query task **170**, microcontroller **118** determines whether AUTO mode button **112** (**FIG. 5**) has been selected. When AUTO mode button **112** has been selected process control proceeds to a task **172**. At task **172**, microcontroller **118** determines the velocity of sewing machine **34** (**FIG. 1**) transported on platform assembly **26** (**FIG. 4**).

[0058] Following task **172**, a task **174** is performed. At task **174**, microcontroller calculates motor control signal **126** (**FIG. 6**) for automatic operation. In response to calculation task **174**, process **146** proceeds to a task **176**.

[0059] Referring to **FIG. 10** in connection with tasks **174** and **176** of process **146**, **FIG. 10** shows a table **176** of formulas executed by microcontroller **118** for determining motor control signal **126** for input into sewing machine **34** (**FIG. 1**).

[0060] Table **176** includes a first velocity formula **178** for computing velocity of sewing machine **34** in a first direction, i.e., both directions of travel along X-axis **30** (**FIG. 4**), using input from X-axis rate sensor **92** (**FIG. 6**). In addition, table **176** includes a second velocity formula **180** for computing velocity of sewing machine **34** in a second direction, i.e., both directions of travel along Y-axis **32** (**FIG. 4**), using input from Y-axis rate sensor **96** (**FIG. 6**). These velocities result from movement, or lack thereof, of sewing machine by a user holding onto first and/or second handles **78** and **80**, respectively (**FIG. 3**), and manually manipulating sewing machine **34**.

[0061] Next, the result of first and second velocity formulas are utilized to compute a magnitude of the velocity of platform assembly **26** and sewing machine **34**, i.e. T(VEL), utilizing a magnitude velocity formula **182**. The magnitude of the velocity, T(VEL), computed using magnitude velocity formula **182** is input into a target motor speed formula **184**. Target motor speed, in revolutions per sec (RPS), is computed as a product of the magnitude of the velocity of platform assembly **26** and a user entered stitch density, in stitches per inch (SPI).

[0062] A digital potentiometer value **156** (**FIG. 8**) is computed as a function of the target motor speed and a potentiometer value, or correction factor, from lookup table **148** (**FIG. 6**) that relates to the particular motor characteristic **154** (**FIG. 8**) for sewing machine **34**. Digital potentiometer value **156** is computed using a potentiometer value formula **186**. The resulting potentiometer value **156**, i.e., WIPER, can then be communicated from microcontroller **118** to digital potentiometers **120** (**FIG. 6**) to generate motor control signal **126**.

[0063] Referring back to process **146** (**FIG. 9**), in response to the computation tasks **172** and **174**, task **176** is performed. At task **176**, motor control signal **126** is generated. In this iteration of process **146**, microcontroller **118** selectively controls potentiometers **120** to set potentiometers **120** to potentiometer value **156** to generate motor control signal **126**. This motor control signal **126** is communicated over first conductor **86** (**FIG. 6**) to foot pedal connection **88** (**FIG. 6**) via matrix switch **122** and the energization of run relay **124** (**FIG. 6**). Since process **146**, under the control of the system overflow timer at query task **166** is repeated approximately every fifty milliseconds, stitch regulator **50** can readily respond to the movement of sewing machine **34** in AUTO mode to produce the desired stitch density by variously speeding up or slowing down motor **89** (**FIG. 6**) in response to a manually manipulated platform velocity.

[0064] When in the AUTO mode, up and down arrow buttons **102** and **104**, respectively (**FIG. 6**), can be utilized to adjust the desired stitch density, i.e., the desired stitches per inch (SPI). Thus, in AUTO mode, the motor speed is set based on the x/y velocity measurement and a desired stitch density.

[0065] Referring back to query task **170**, when microcontroller **118** determines that AUTO mode button **112** has not been selected, process control proceeds to a query task **190**. At query task **190**, microcontroller **118** determines whether MANUAL mode button **114** (**FIG. 5**) has been selected. When MANUAL mode button **114** has been selected process control proceeds to a query task **192**. At task **192**, microcontroller **118** determines whether run switch **84** (**FIG. 2**) is closed. MANUAL mode allows a user to actuate motor **89** (**FIG. 6**) by actuating run switch **84**.

[0066] At task **192**, when microcontroller **118** determines that run switch **84** is closed, process **146** proceeds to a task **194**. At task **194**, motor control signal **126** (**FIG. 6**) is set to the pre-programmed speed. In the MANUAL mode, actuation of up and down arrow buttons **102** and **104**, respectively, adjust the pre-programmed manual motor speed. At task **192**, when microcontroller **118** determines that run switch **84** is open, i.e., not actuated by the user, process **146** proceeds to a task **196**. At task **196**, motor control signal **126** (**FIG. 6**) is set to off in accordance with the particular sewing machine utilized, as discussed above. Following either of tasks **194** and **196**, process **146** proceeds to task **176** to generate motor control signal **126** in accordance with the setting determined at either of tasks **194** and **196**.

[0067] Referring back to query task **190**, when microcontroller **118** determines that MANUAL mode button **114** has not been selected, process control proceeds to a query task **198**. At query task **198**, microcontroller **118** determines whether OFF button **116** (**FIG. 5**) has been selected. When OFF button **116** has been selected, process control proceeds to a task **200**. At task **200**, motor control signal **126** (**FIG. 6**) is set to off in accordance with the particular sewing machine utilized, as discussed above. Following task **200**, process **146** proceeds to task **176** to generate motor control signal **126**.

[0068] Referring back to query task **198**, when microcontroller **118** determines that OFF button **116** has not been selected, process control proceeds to a query task **202**. At query task **202**, microcontroller **118** determines whether SETUP mode button **100** (**FIG. 5**) has been selected. When SETUP mode button **100** has been selected, process control proceeds to a task **204**. At task **204**, motor control signal **126** (**FIG. 6**) is set to off in accordance with the particular sewing machine utilized, as discussed above. In addition, display **98** (**FIG. 2**) may be cleared. Following task **204**, process **146** proceeds to a task **206**.

[0069] In the SETUP mode, various menus are presented on display **98** (**FIG. 2**). These menus enable a user to select a machine type and a duration for a power off time out. This machine type is utilized to access lookup table **148** (**FIG. 6**) for potentiometer settings and/or a correction factor related to the motor characteristics of the particular sewing machine **34**. The power off time out is a safety feature that causes stitch regulator **50** to turn itself off after a settable number of minutes of inactivity. In the SETUP mode, up and down arrow buttons **102** and **104**, respectively (**FIG. 6**), are utilized to adjust the machine type selection and the power off time out. At task **206**, these setup control parameters are saved.

[0070] Following task **206**, program control proceeds to task **176** to generate motor control signal in the form of a motor off signal. Of course, it should be understood that task **206** need not be complete prior to generation of a motor off signal. Rather, generation of a motor off signal may be performed in conjunction with task **204**.

[0071] Referring back to query task **202**, when microcontroller **118** determines that SETUP mode button **110** has not been selected, process control proceeds to a query task **208**. At query task **208**, microcontroller **118** determines whether NEEDLE JOG button **110** (**FIG. 5**) has been selected. When NEEDLE JOG button **110** has been selected, process control proceeds to a task **210**. At task **210**, motor control signal **126** (**FIG. 6**) is set to a minimum motor speed value in accordance with the particular sewing machine utilized. This allows the needle to be raised out of the fabric surface. In this mode, motor **89** (**FIG. 6**) runs as long as NEEDLE JOG button **110** is held down. In response to task **210**, process **146** proceeds to task **176** to generate motor control signal **126** at a minimum motor speed setting.

[0072] Referring back to query task **208**, when microcontroller **118** determines that NEEDLE JOG button **110** has not been selected, process control proceeds to a query task **212**. At query task **212**, microcontroller **118** determines whether BOBBIN button **108** (**FIG. 5**) has been selected. When BOBBIN button **108** has been selected, process control proceeds to a task **214**. At task **214**, motor control signal **126** (**FIG. 6**) is set to a maximum motor speed value in accordance with the particular sewing machine utilized. This allows a bobbin to be wound. In this mode, motor **89** (**FIG. 6**) runs as long as BOBBIN button **108** is held down. In response to task **214**, process **146** proceeds to task **176** to generate motor control signal **126** at a maximum motor speed setting.

[**0073**] Referring back to query task **212**, when microcontroller **118** determines that BOBBIN button **108** has not been selected, process control proceeds to a query task **218**. At query task **218**, microcontroller **118** determines whether THREAD CUTTER button **106** (**FIG. 5**) has been selected. When THREAD CUTTER button **106** has been selected, process control proceeds to a task **220**. At task **220**, motor control signal **126** (**FIG. 6**) is set to off in accordance with the particular sewing machine utilized, as discussed above. In addition, a task **222** is executed. At task **222**, microcontroller **118** signals thread cutter relay **134** (**FIG. 6**) to send thread cut signal **136** (**FIG. 6**). In this configuration, thread cut signal **136** is a closure of thread cutter relay **134** causing a short across the thread cutter inputs of sewing machine **34** (**FIG. 1**) at thread cut connection **130** (**FIG. 6**). Following tasks **220** and **222**, process **146** proceeds to task **176** to generate motor control signal **126** as a motor off signal.

[**0074**] Referring back to query task **218**, when microcontroller **118** determines that THREAD CUTTER button **106** has not been selected, process control proceeds to a task **224**. At task **224**, microcontroller **118** continues operation in the current mode in accordance with the last buttons selected. In response to task **224**, process **146** proceeds to task **176** to generate motor control signal **126** in accordance with the current mode.

[**0075**] A task **226** is performed in connection with task **176**. At task **226**, the mode information is presented on display **98** (**FIG. 5**). Mode information may include, for example, a machine type and power off timeout in SETUP mode, notification of AUTO mode, desired stitch density, and current motor velocity when in the AUTO mode, and notification of MANUAL mode, pre-programmed motor speed, and on/off notification when in the MANUAL mode. Of course, those skilled in the art will recognize that the text presented in display **98** can take on a great variation in accordance with the programmer's preferences for data display.

[**0076**] Following task **226**, process **146** loops back to system timer query task **166** to monitor for a system timer overflow condition causing another overall process loop to be initiated. Thus, execution of stitch regulator operation process **146** enables a user significant options for operating sewing machine **34** mounted on a moveable platform, such as platform assembly **26** (**FIG. 4**).

[**0077**] In summary, the present invention teaches of a stitch regulator for use with a sewing machine transported by a moveable platform. The stitch regulator includes a microcontroller that uses velocity signals of the moveable platform, and then uses motor characteristics related to the type of sewing machine and a desired stitch density to calculate an accurate motor speed. Thus, the stitch regulator yields consistent stitch regulation across a variety of sewing machine types and across a wide variety of motor speeds for a sewing machine. The stitch regulator is located separate from the sewing machine for ready incorporation with a variety of sewing machines, moveable platforms, and quilting tables. In addition, the keypad controls of the stitch regulator are intuitive to utilize and the extruded housing, assembly, and membrane keypad results in a stitch regulator that is durable and cost effectively manufactured.

[**0078**] Although the preferred embodiments of the invention have been illustrated and described in detail, it will be readily apparent to those skilled in the art that various modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims. For example, the process steps discussed herein can take on great number of variations and can be performed in a differing order then that which was presented.

What is claimed is:

1. A stitch regulator for use with a sewing machine transported by a moveable platform, said sewing machine having a motor control input port, and said stitch regulator comprising:

a housing configured to be coupled to one of said sewing machine and said moveable platform;

a sensor adapted for communication with said sewing machine for determining movement of said sewing machine on said moveable platform; and

a microcontroller contained in said housing and in communication with said sensor, said microcontroller generating a motor control signal in response to said movement of said sewing machine, for input into said motor control input port.

2. A stitch regulator as claimed in claim 1 further comprising a handle extending from a facing plate of said housing for enabling manual movement of said sewing machine on said moveable platform relative to a piece of fabric.

3. A stitch regulator as claimed in claim 2 wherein said handle is a first handle, and said stitch regulator further comprises a second handle extending from said facing plate and spaced apart from said first handle.

4. A stitch regulator as claimed in claim 2 further comprising a run switch mounted on said handle and in electrical communication with said microcontroller, and actuation of said run switch enables provision of said motor control signal.

5. A stitch regulator as claimed in claim 1 wherein said housing comprises an angled facing plate.

6. A stitch regulator as claimed in claim 5 further comprising keypad controls mounted on said angled facing plate and in electrical communication with said microcontroller.

7. A stitch regulator as claimed in claim 1 wherein said housing comprises:

a first section having a first pair of longitudinal edges; and

a second section having a second pair of longitudinal edges that form a snap-fit connection with said first pair of longitudinal edges.

8. A stitch regulator as claimed in claim 1 wherein said housing is in the form of a triangular prism.

9. A stitch regulator as claimed in claim 1 wherein said sensor comprises:

a first sensor for determining velocity of said sewing machine in a first direction; and

a second sensor for determining said velocity of said sewing machine in a second direction, said second direction being orthogonal to said first direction.

10. A stitch regulator as claimed in claim 1 wherein said sewing machine includes a motor exhibiting a motor characteristic, and said microcontroller generates said motor control signal in response to said motor characteristic in combination with said movement of said sewing machine.

11. A stitch regulator as claimed in claim 10 wherein said stitch regulator is usable with a second sewing machine, said second sewing machine includes a second motor exhibiting a second motor characteristic, and said microcontroller generates a second motor control signal in response to said movement of said second sewing machine in combination with said second motor characteristic when said stitch regulator is in use with said second sewing machine.

12. A stitch regulator as claimed in claim 1 further comprising an input element in communication with said microcontroller, said microcontroller generating said motor control signal in response to a command entered at said input element in combination with said movement of said sewing machine.

13. A stitch regulator as claimed in claim 12 wherein said command comprises a desired stitch density, and said motor control signal is configured to regulate a speed of a motor of said sewing machine to achieve said desired stitch density.

14. A stitch regulator as claimed in claim 1 further comprising:

an outlet configured for communication with said motor control input port; and

at least two potentiometers interposed between said microcontroller and said outlet, said at least two digital potentiometers being selectively controlled by said microcontroller to generate said motor control signal.

15. A stitch regulator as claimed in claim 1 further comprising:

an outlet configured for communication with said motor control input port; and

a matrix switch interposed between said microcontroller and said outlet for receiving said motor control signal and directing said motor control signal to an output bus of said matrix switch selected by said microcontroller.

16. A stitch regulator as claimed in claim 1 wherein said sewing machine includes a thread cut control port, and said stitch regulator further comprises a thread cut control element contained in said housing and controlled by said microcontroller for generating a thread cut signal for input into said thread cut control port.

17. A stitch regulator for use with a sewing machine transported by a moveable platform, said sewing machine having a motor control input port, and said stitch regulator comprising:

a housing configured to be coupled to one of said sewing machine and said moveable platform, said housing having an angled facing plate;

a handle extending from said facing plate for enabling manual movement of said sewing machine on said moveable platform relative to a piece of fabric;

a sensor adapted for communication with said sewing machine for determining movement of said sewing machine on said moveable platform;

a microcontroller contained in said housing and in communication with said sensor; and

keypad controls mounted on said angled facing plate and in electrical communication with said microcontroller, said microcontroller generating a motor control signal in response to a command entered at said keypad controls in combination with said movement of said sewing machine for input into said motor control input port.

18. A stitch regulator as claimed in claim 17 wherein said handle is a first handle, and said stitch regulator further comprises a second handle extending from said facing plate and spaced apart from said first handle.

19. A stitch regulator as claimed in claim 17 wherein said housing further comprises a body section having a first pair of longitudinal edges that form a snap-fit connection with a second pair of longitudinal edges on said facing plate.

20. A stitch regulator as claimed in claim 17 wherein said housing is in the form of a triangular prism.

21. A stitch regulator for use with a sewing machine transported by a moveable platform, said sewing machine including a motor exhibiting a motor characteristic, and a motor control input port in communication with said motor, and said stitch regulator comprising:

a housing configured to be coupled to one of said sewing machine and said moveable platform;

a sensor adapted for communication with said sewing machine for determining movement of said sewing machine on said moveable platform;

a microcontroller contained in said housing and in communication with said sensor;

an outlet configured for communication with said motor control input port; and

at least two potentiometers interposed between said microcontroller and said outlet, said at least two digital potentiometers being selectively controlled by said microcontroller to generate a motor control signal in response to said motor characteristic in combination with movement of said sewing machine for input into said motor control input port.

22. A stitch regulator as claimed in claim 21 wherein said stitch regulator is usable with a second sewing machine, said second sewing machine includes a second motor exhibiting a second motor characteristic, and said microcontroller selectively controls said at least two digital potentiometers to generate a second motor control signal in response to said second motor characteristic in combination with movement of said second sewing machine when said stitch regulator is in use with said second sewing machine.

23. A stitch regulator as claimed in claim 21 further comprising a matrix switch interposed between said at least two potentiometers and said outlet for receiving said motor control signal and directing said motor control signal to an output bus of said matrix switch selected by said microcontroller.

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