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(54) **MACHINE AND METHOD FOR FORMING ARCHED ROOF VERTICAL WALL SELF SUPPORTING METAL BUILDINGS**

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(73) Assignee: **MIC Industries**, Reston, VA (US)

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Related U.S. Patent Documents

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(64) Patent No.: **5,249,445**
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Appl. No.: **07/872,005**
Filed: **Apr. 22, 1992**

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(52) **U.S. Cl.** **72/8.3**; 72/129; 72/168; 72/177
(58) **Field of Search** 72/7.1, 129, 9.1, 72/177, 178, 173–175, 168, 139, 12, 307, 8.3

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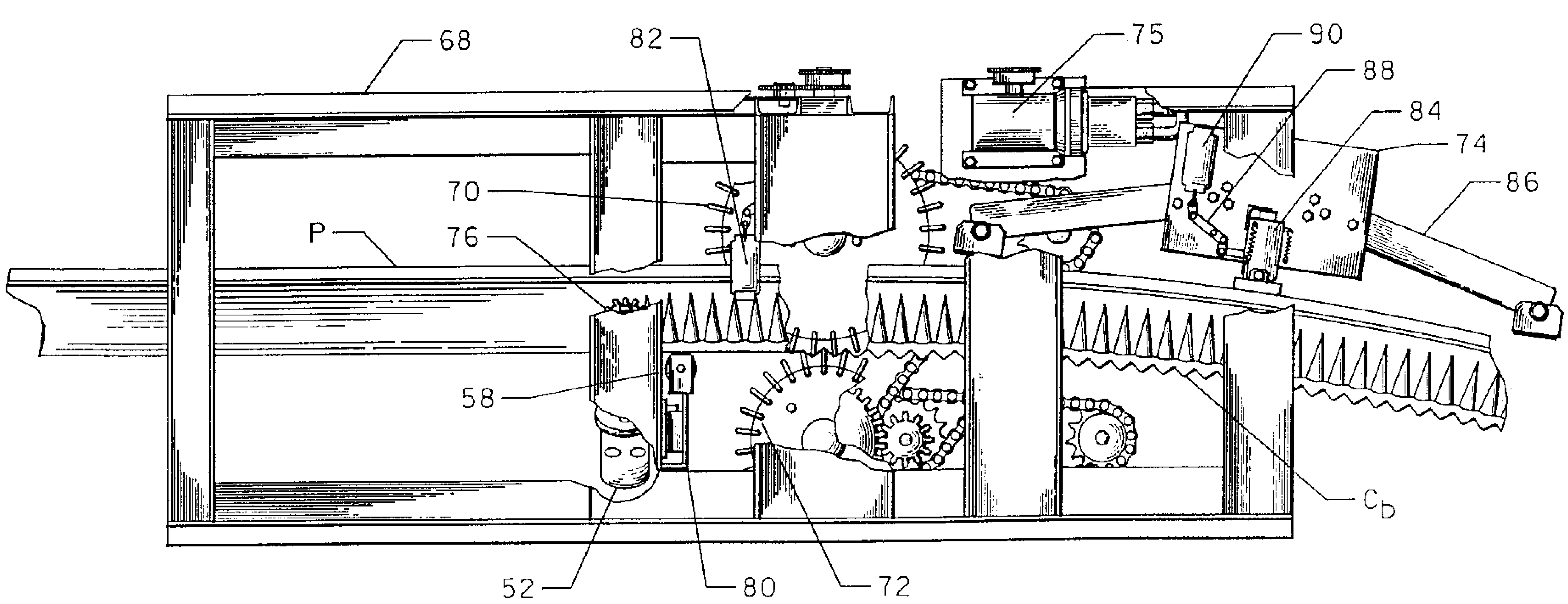
(57) **ABSTRACT**

A mobile metal building forming machine forms panels of predetermined length from a coil of flat metal and then the formed panels are continuously crimped on their side edges for strength and are selectively curved by crimping the bottom of the panel. The crimping and curvature are automatically controlled so that building panels with vertical walls and an arched roof may be formed. A moveable crimping roll is automatically portioned to control the curvature and the roll is chain driven so that it may be moved without affecting its rotational drive.

28 Claims, 12 Drawing Sheets



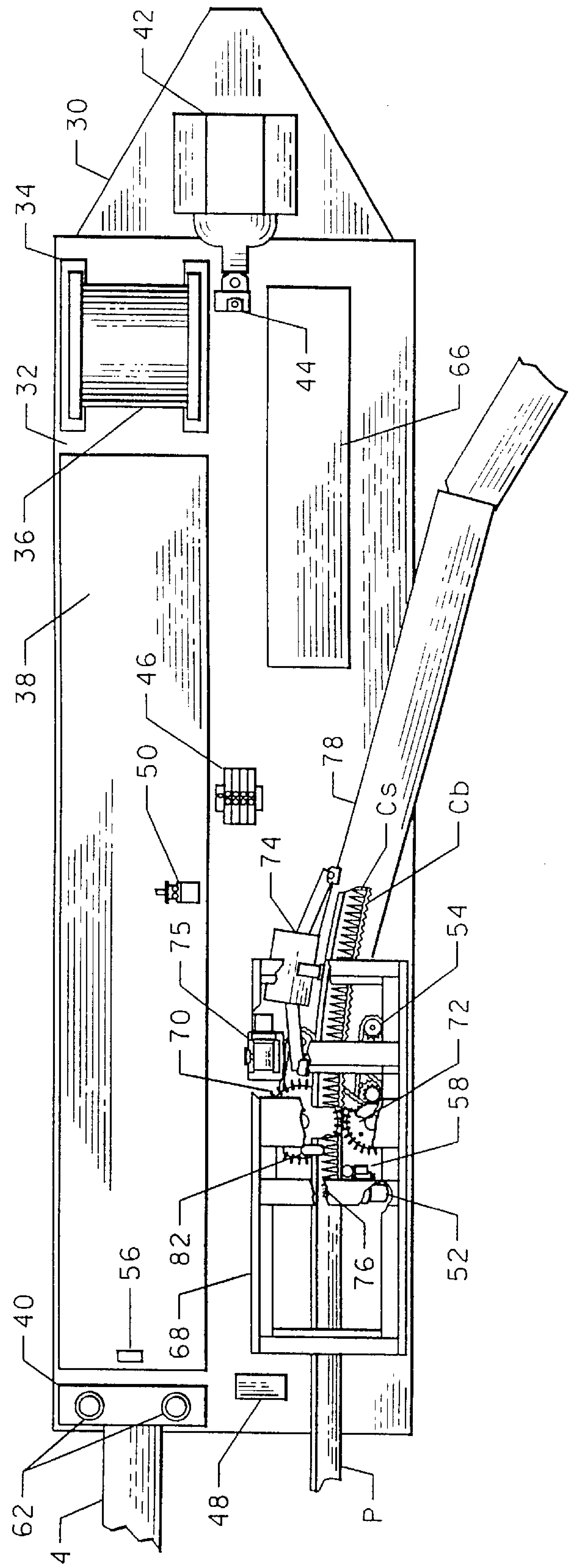

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FIGURE 1

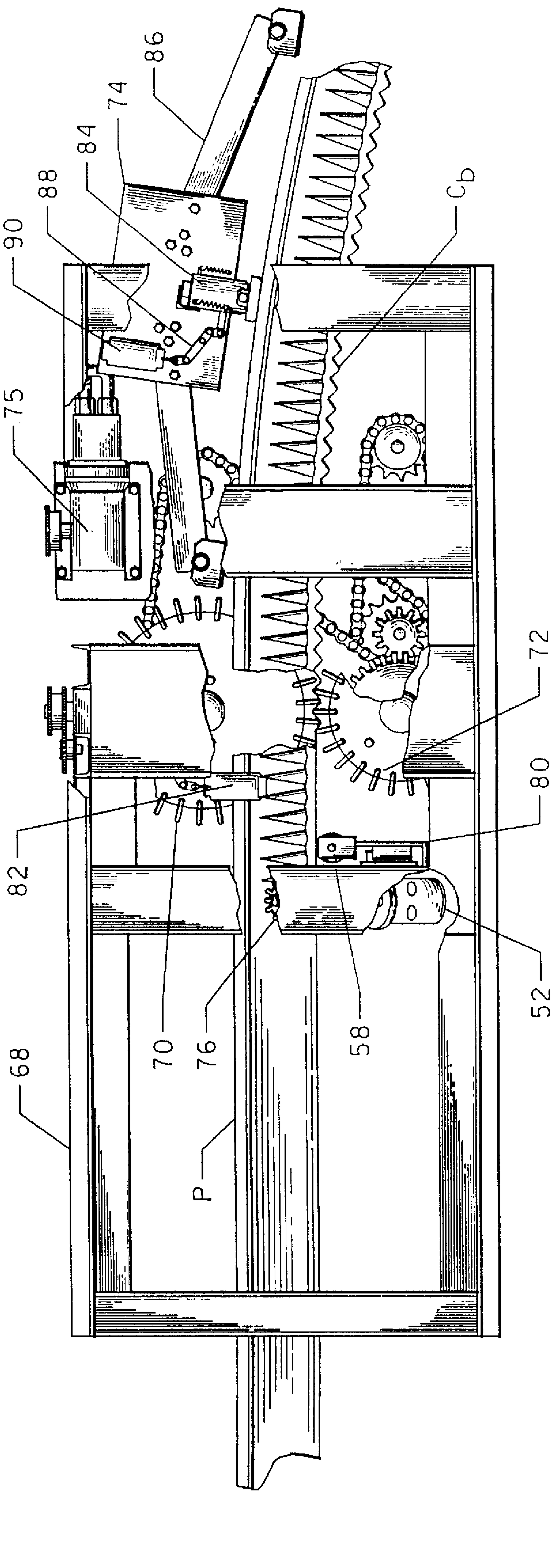
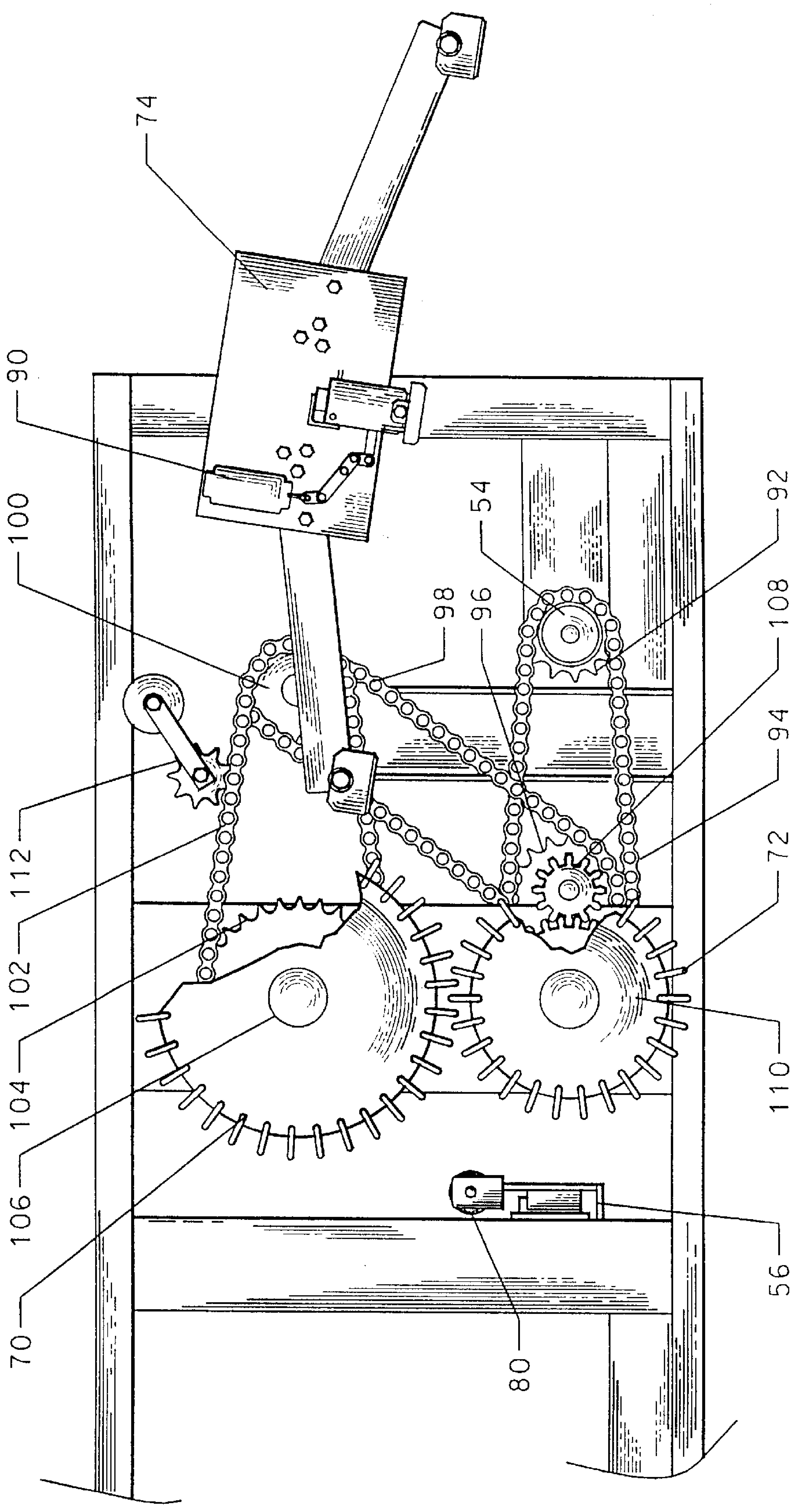


FIGURE 2



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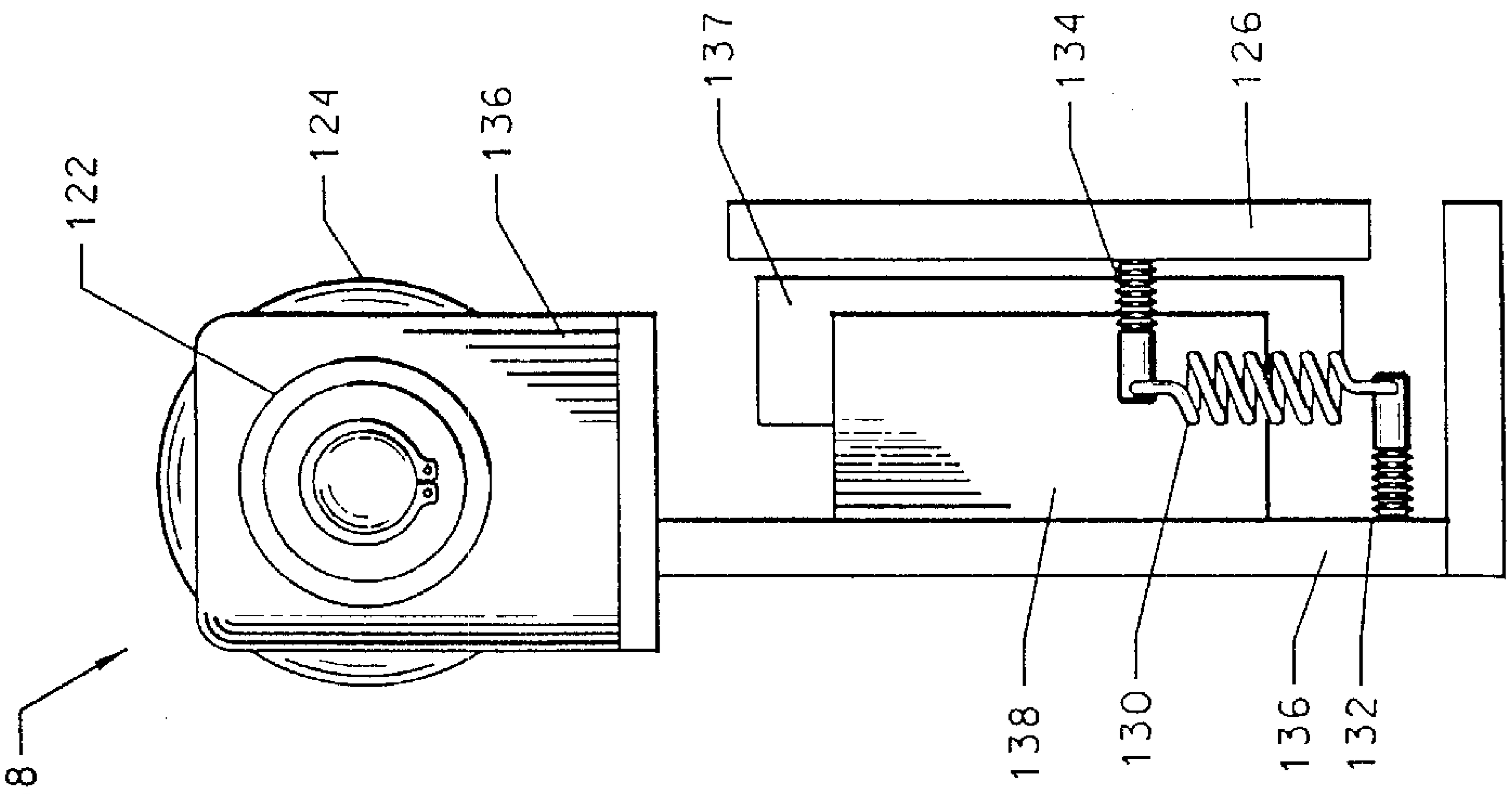


FIGURE 5

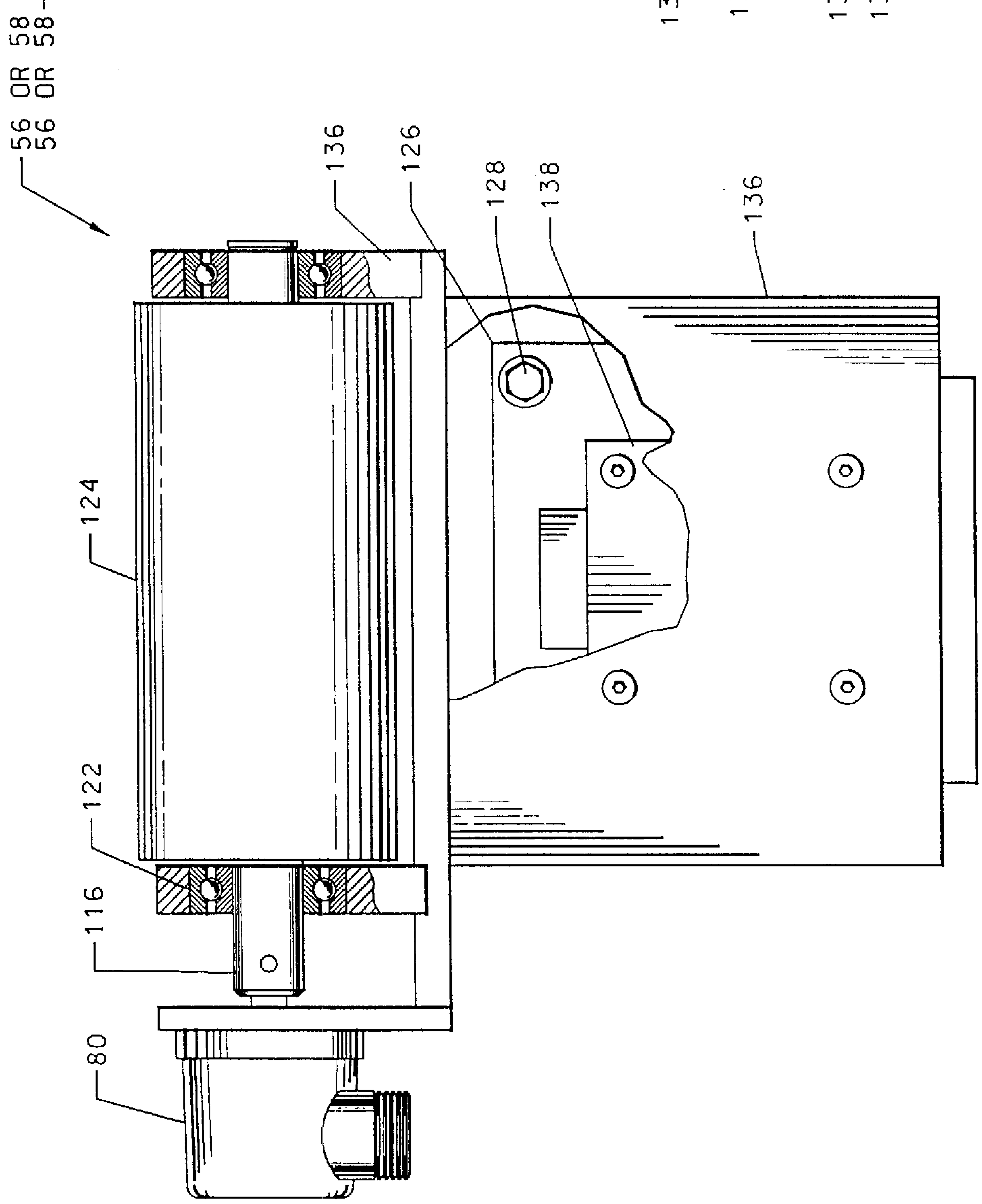


FIGURE 4

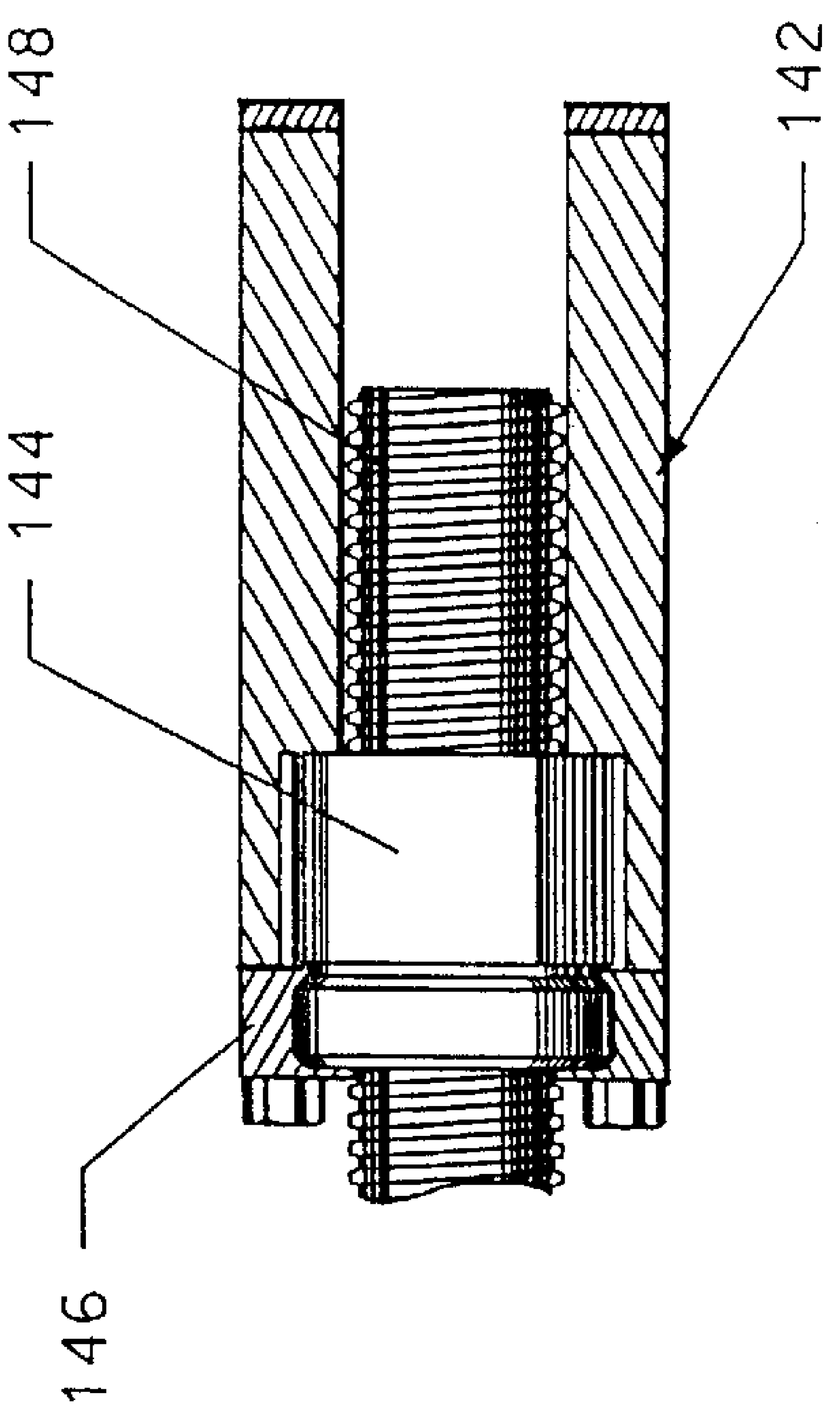
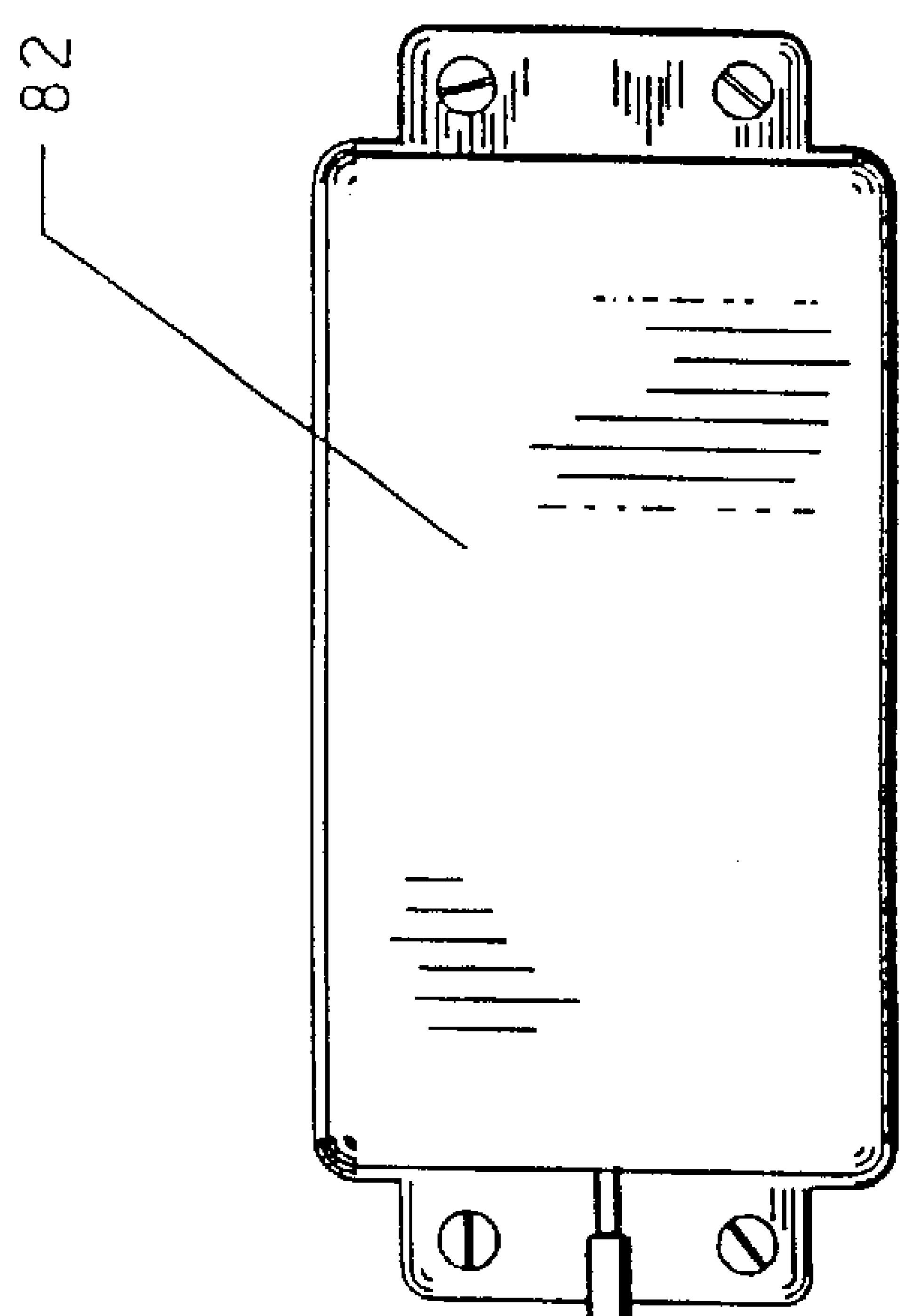


FIGURE 7



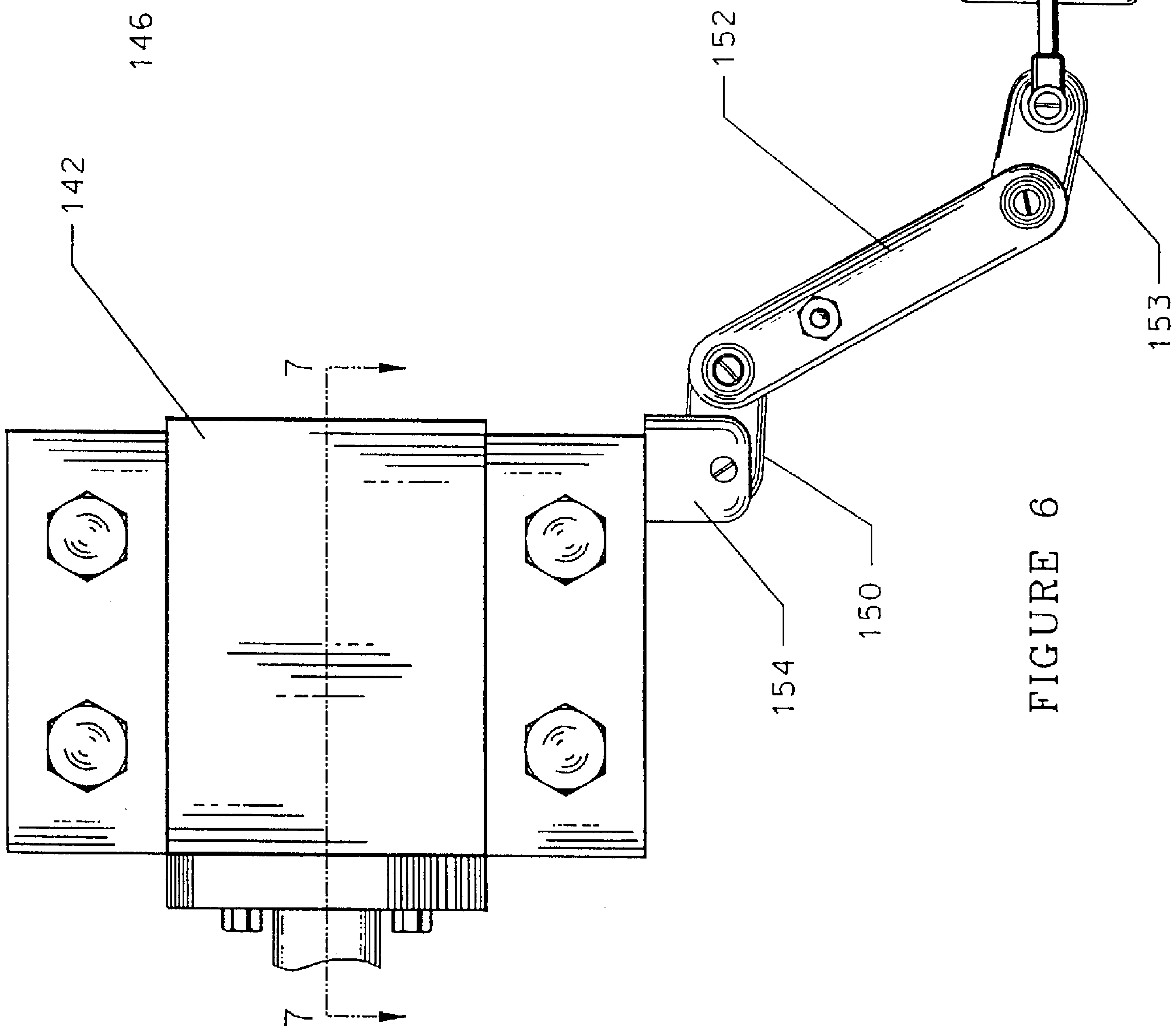


FIGURE 6

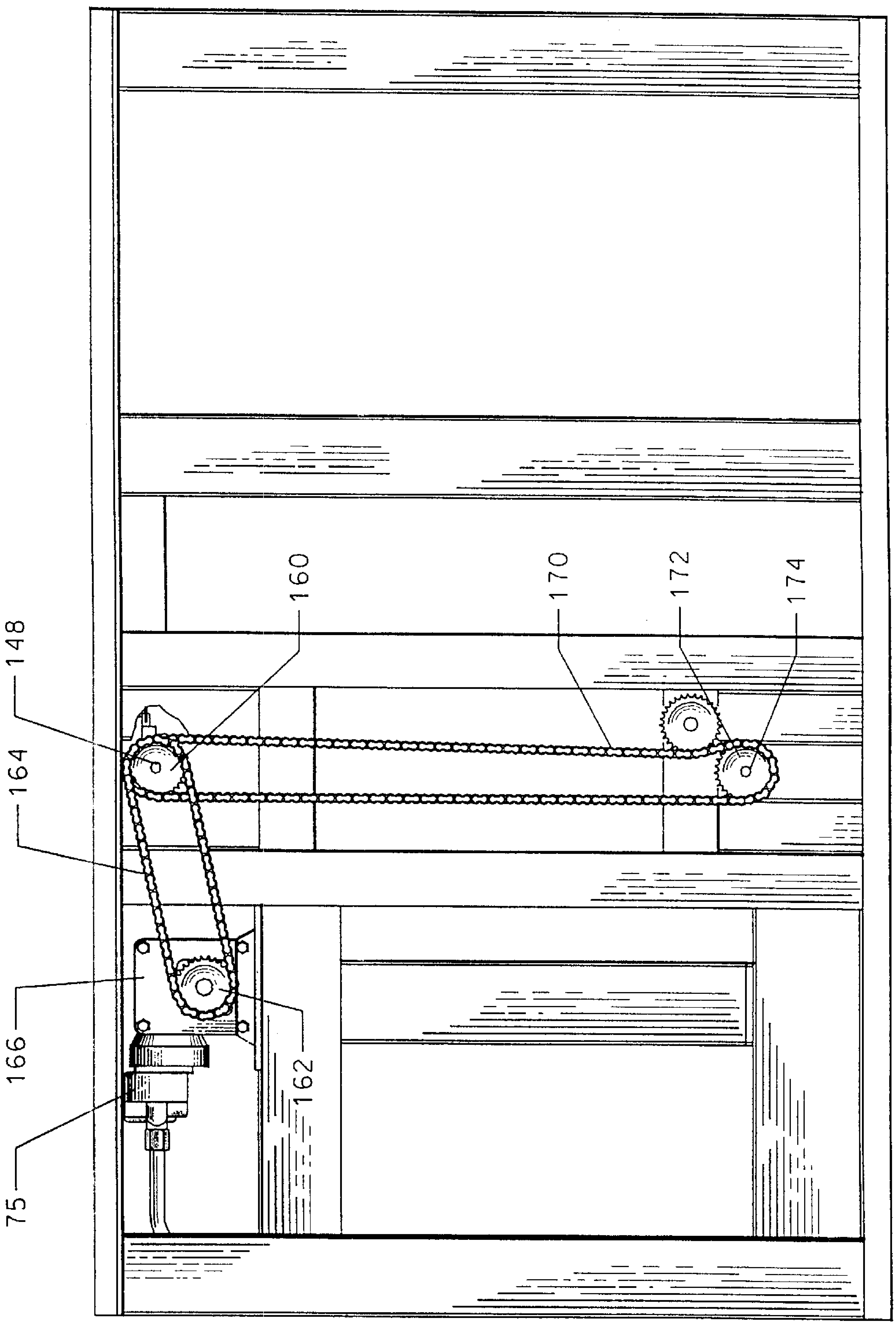


FIGURE 8

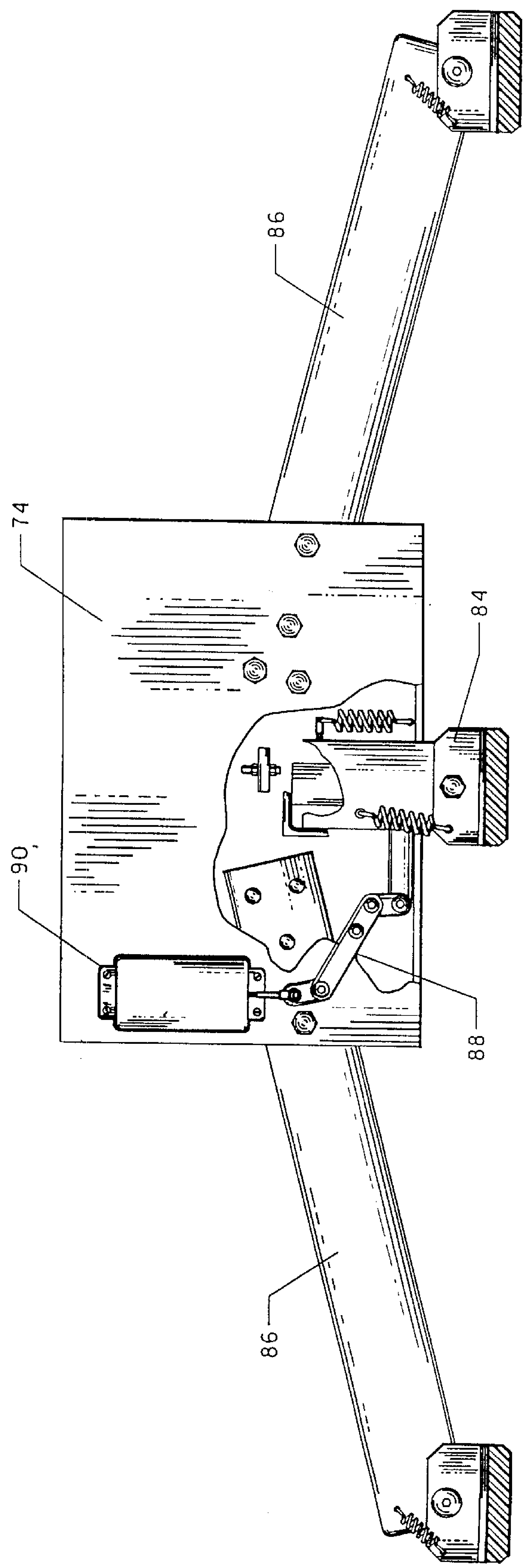
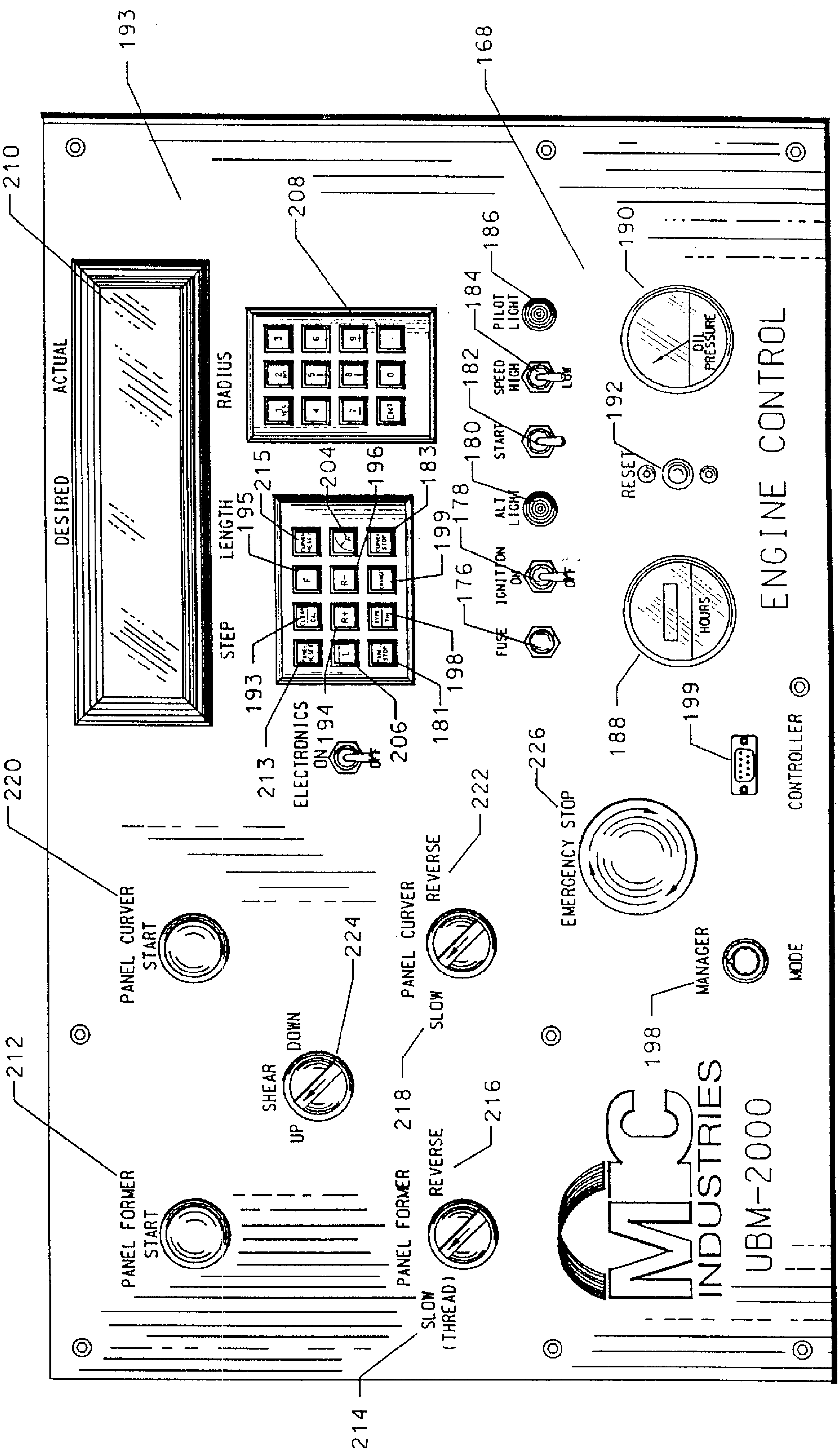


FIGURE 9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DESIRED
ACTUAL
RADIUS
LENGTH
STEP
PILOT LIGHT
SPEED HIGH LOW
START
ALT LIGHT
IGNITION ON OFF
FUSE
RESET
OIL PRESSURE
HOURS
ENGINE CONTROL
ELECTRONICS ON OFF
CONTROLLER
EMERGENCY STOP
MANAGER
MODE
PANEL CURVER START
PANEL CURVER REVERSE
SLOW
SHEAR
UP
DOWN
PANEL FORMER START
PANEL FORMER REVERSE
SLOW (THREAD)
MC INDUSTRIES
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FIGURE 10

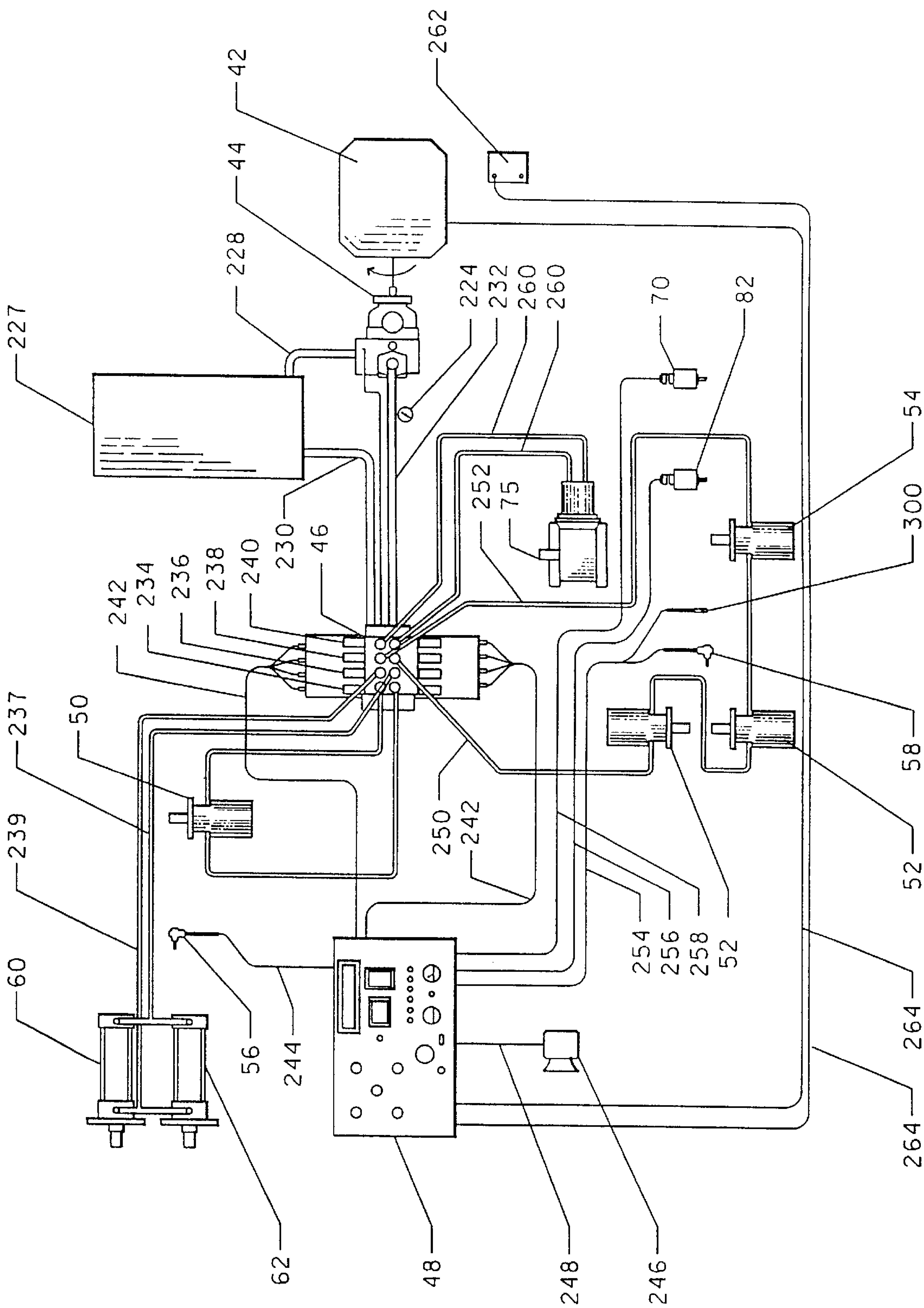
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FIGURE 11

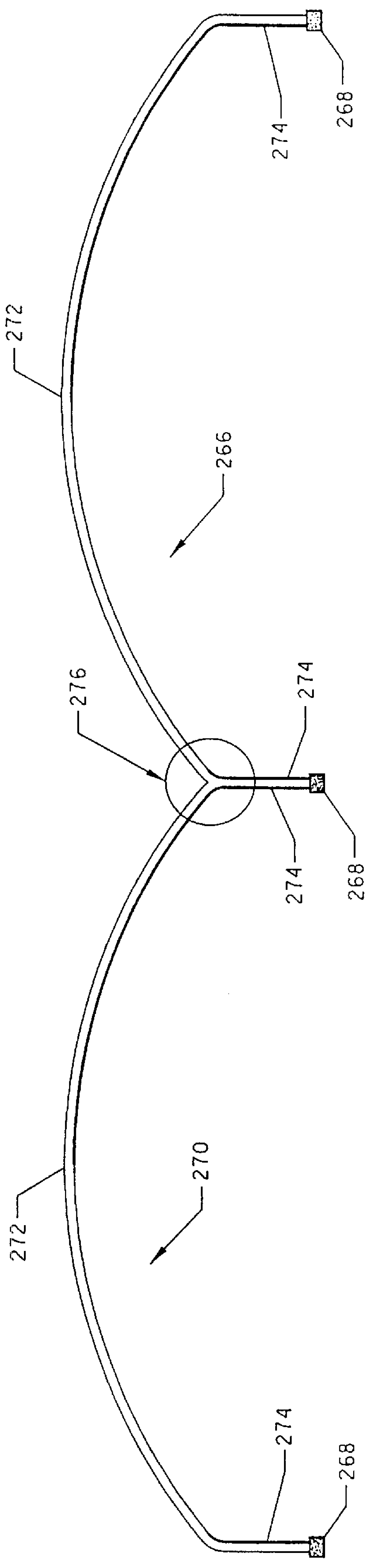

FIGURE 12

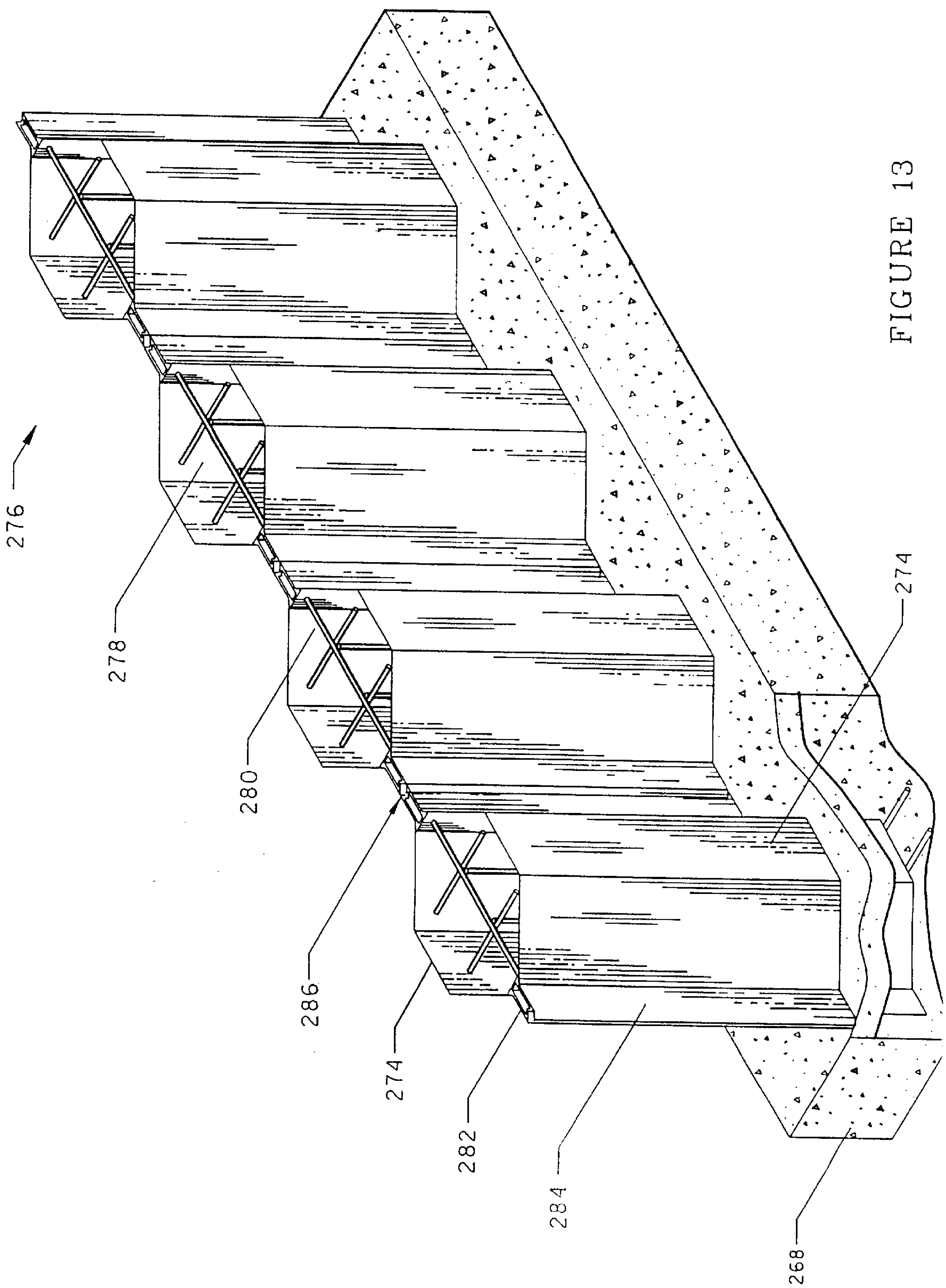

FIGURE 13

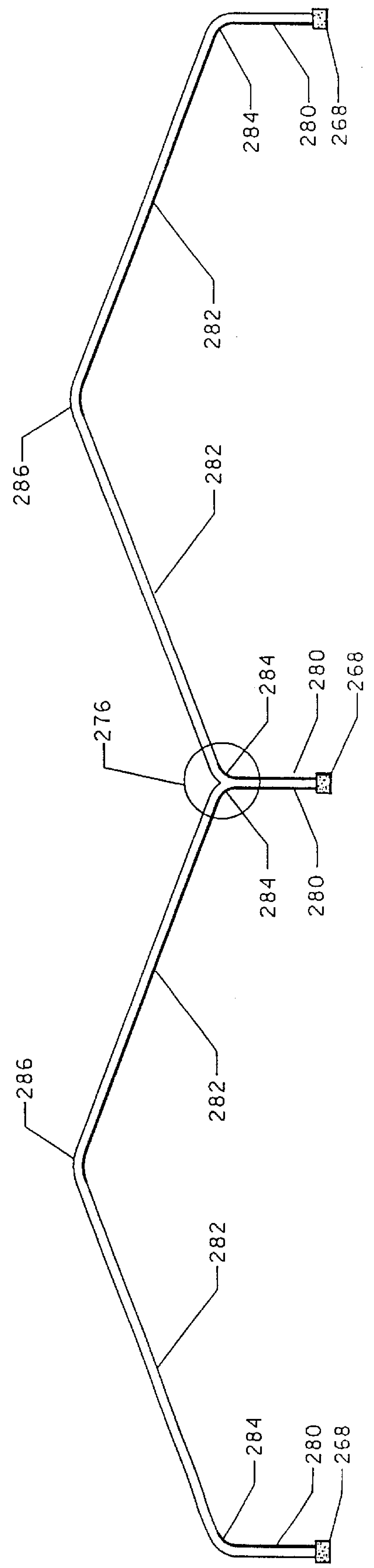
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FIGURE 14

MACHINE AND METHOD FOR FORMING ARCHED ROOF VERTICAL WALL SELF SUPPORTING METAL BUILDINGS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF INVENTION

1. Field of the Invention

This invention relates to improvements in machines and methods for constructing metal building and building configurations, and more particularly relates to arched roof, vertical wall, self supporting metal buildings formed of adjacent seamed together panels and a method and machine for forming such panels.

2. Background and Prior Art

It is known in the prior art to make metal buildings from adjacent formed metal building panels which are arched or curved, assembled side by side and seamed together. See for example, Knudson U.S. Pat. No. 3,902,288 (1975) for showing of such building in which the roof panels are completely curved or arched and extend to the foundation. In such buildings the roof panels continue as the side walls of the building and the basic building construction is in the shape of a continuous arch or semi-circle when viewed from the end. A machine for making the metal panels for such building in which the formed panels are corrugated not only on the side edges of the box, but also on the bottom to create the curvature is shown in Knudson U.S. Pat. No. 3,842,647 (1974). A method of building the building by adjacent panels which are seamed together is disclosed in Knudson U.S. Pat. No. 3,967,430 (1976). A seamer for forming the seams between the adjacent panels of the prior Knudson patents is shown in Knudson U.S. Pat. No. 3,875,642 (1975). The prior art represented by the Knudson patents is owned and has been commercialized by MIC Industries, Inc. of Reston, Va. in its mobile K-Span® machines.

An arched building construction i.e., construction of which walls and roof are completely arched has advantages, but also, a number of limitations. One limitation is the absence of vertical walls which limits the use of vertical space. Often users of metal buildings want vertical walls both for aesthetic purposes and to allow more use of space near the edges of the building. Additionally, known prior art machines had a limitation on the thickness of steel used in forming the metal panels, because of machine limitations. The basic size and strength of such metal buildings is also limited by local wind and live load limitations as established by building codes throughout the nation and the world. As these building code standards become more conservative, a builder is effectively limited to only certain size buildings. The complete arched building must be limited in size in order to prevent overloading such as could occur from extensive wind loads produced by hurricanes. However, when the total roof height is reduced to approximately one-fifth of the total building width, hurricane force winds to not affect the building as much, because of reduced frontal area. Thus, there is a need in the art for a metal building formed of continuous panels which is not completely arched but has straight vertical walls while utilizing the economy of the seamed panel construction of the prior art. Such vertical wall buildings would satisfy a need in the art for space, economy, usefulness and strength.

In addition to the prior art discussed above, Knudson U.S. Pat. No. 4,039,063 (1977) discloses a run out apparatus and method for handling formed panels to produce arched metal buildings. As shown in the patent run out tables can be positioned to collect the curved panels. Additional patents exist in the art for forming and assembing relatively wide panels for arched metal buildings, see Knudson U.S. Pat. No. 4,364,253 (1982) U.S. Pat. No. 4,505,143 (1985), U.S. Pat. No. 4,505,084 (1985) and the seamer therefor in Knudson U.S. Pat. No. 4,470,146 (1984). These patents are owned by and commercialized in M.I.C.'s Super Span® mobile metal forming machines. In the prior art the radius of the arch could only be adjusted by manual means. Furthermore, the radius of the arch could only be adjusted to a desired curvature when there was no material in the machine. The procedure for radius adjustment included setting dials to a reference number to form a predetermined length of metal then forming the metal and comparing it to a radius gauge that must be made from a plywood template or a similar radius measuring device. If after inserting a piece of metal in the machine and curving it, the radius is incorrect, the operator must dial a new set of numbers and rely on experience and rules of thumb to help him achieve the proper radius. In order to achieve the proper curvature for arched panels, up to 500 pounds or more of metal may be wasted by bending them to the wrong curvature, depending on how skilled the machine operator is. Thus, there is need in the art to provide for automatically and controllably adjusting the radius of curvature and to be able to accomplish that with material in the machine, so that no material is wasted reaching the desired curvature.

Another drawback in the prior art is that the dials set to control the radius of the panel independently operate on the top side of the panel or the bottom side. Failure to adjust the two dials properly will cause the curved panel to distort and produces panels which are unacceptable for building use and must be scrapped. Distortion is sometimes termed "cork-screwing." Thus, there is need in the art to allow automatic and continuous adjustment of the curvature of the panels by a semi-skilled operator.

Another deficiency in the prior art arched panel forming machines is that they do not produce straight sections and curved sections together on the same panel. Furthermore, straight panels formed separately and used as vertical wall building panels are weak because they are not crimped. In other words with the existing technology, crimping just the sidewalls of the panels cannot be accomplished. But there is a need in the art to provide for a crimping of the side walls of straight panels used as vertical building walls.

Furthermore, the prior known machines for producing arched metal building panels have main crimping rollers which when being adjusted separate from each other causing diminished contact area of the gears resulting in significant premature gear wear. Also, when the crimping rolls of the prior art become separated, it is very difficult to re-engage the gears without physically guiding them into position which requires the machine operator to adjust the machine with moving machine parts, which is unsafe. Furthermore, when the main rolls are separated and the gear teeth are so far out of mesh, the gear backlash is severe, causing the main crimpers to turn out of time with each other and results in unacceptable finished panels. There is a need in the art for an improved drive train of the main crimping rolls which eliminates the above mentioned problems and allows for an extremely smooth trouble-free automatic crimping operation.

In the prior art, the operation of the machine was manual and the hydraulic system was adequate, however, it is desirable to allow simultaneous use of components and automatic and continuous adjustment of the crimping operation while allowing the hydraulic control of the panel former, shear blade and other controls. Thus there is a need in the art for automatic controls from a control panel so that a semi-skilled operator can automatically control the forming machine to produce panels of any desired curvature including portions of which that are straight and not curved.

There is also need in the art for an improved building method for joining multiple buildings together and providing column support for the side walls without significant conditional components.

SUMMARY OF THE INVENTION

This invention provides a machine for forming panels to make buildings in which a portion of the panels are curved and the curvature is automatically controlled. The machine also makes panels which are strengthened by crimping and which panels may have a straight as well as a curved portion so that the panels can be used to construct a building with an arched roof and vertical walls. Automatic control of the machine is through hydraulics and a microprocessor controlled by measuring and monitoring of the panels formed. The curvature of an arched portion of the panel is controlled by the extent of crimping of the bottom of the panel and extent of crimping is determined by the automatically controlled spacing of main crimping rolls. Moreover, the controls are operable during forming of the panels and with the panels in the crimping rolls. Automatic positioning of the crimping rolls is accomplished without premature wear on the roll drive gears or undue backlash, i.e., it is accomplished with an extremely smooth, trouble-free drive train. The hydraulics of the system together with the electrical control features allow the machine to be operated by a semi-skilled worker without a great deal of experience.

The invention also includes a building method and a building construction in which multiple buildings are joined together without additional columnar support, i.e., using the side walls as columns. This is accomplished by assembling two vertical panels back to back to provide a stiff column with an extruded fastening member reinforcing bars and concrete within the space between the vertical panels.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top plan view of the machine of this invention illustrating the general arrangement of the component parts and with some portions broken away and other positions shown only schematically for clarity.

FIG. **2** is a partial top plan view of the machine of this invention with portions broken away for illustrating the main crimping rolls and the controls thereof.

FIG. **3** is a view somewhat similar to FIG. **2** but with different elements removed for showing the drive train for the main crimping rolls.

FIG. **4** is a front elevation view showing the positioning of a measuring device for measuring the amount of panel which has passed a predetermined point.

FIG. **5** is an end elevation view of the assembly shown in FIG. **4**.

FIG. **6** is a top plan view with a portion broken away of an assembly of the device for moving the crimping rolls and accurately measuring its position.

FIG. **7** is a sectional view taken along lines **7**—**7** of FIG. **6**.

FIG. **8** is a side elevation view illustrating the drive for moving the main crimping rolls with portions broken away for the aid of clarity.

FIG. **9** is a top plan view of the radius measuring device with covers removed.

FIG. **10** is an end elevation view illustrating the control panel for control of the machine from one spot by semi-skilled operator.

FIG. **11** is a schematic diagram illustrating the connections from the hydraulic and electrical systems for the automatic control of the entire machine.

FIG. **12** is a schematic end elevation view of one shape of a building that can be made using this invention.

FIG. **13** is a perspective view illustrating a detail of the building of FIG. **12** showing the assembly where the building is assembled, and illustrating the self support.

FIG. **14** is a schematic end elevation view of another shape of building which can be made using this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows the general arrangement of the machine of this invention which is preferably mounted on a trailer **30** so as to be mobile and moveable to an on site location for forming the metal panels which will be used in erecting the buildings. The components of the machine are assembled on a deck **32** of the trailer and include a roll holder **34**, for holding a roll **36** of sheet metal of appropriate gauge from which the building panels are formed. Along one side of the machine adjacent to the supply roll of metal there is a roll forming machine **38** which includes a plurality of metal forming rolls for forming the sheet metal into a desired configuration. Since this roll forming machine is known in the art mentioned above it need not be shown or described. The cross sectional shape of the metal leaving the forming rolls may be that known in the art and as shown in the prior patents identified above, wherein there are different shaped panels which are assembled side by side with the edges crimped together by a seamer, also as known in the art. At the end of the roll forming station there is a hydraulically operated shear **40** for shearing the desired and measured length of the formed panel.

An internal combustion engine **42** (preferably a diesel engine) is mounted on the trailer for supplying hydraulic power via a hydraulic pump **44**. A main hydraulic valve **46** is mounted on the trailer for controllably feeding hydraulic fluid for various hydraulic actuators. An operator control panel **48** includes various controls, readout panel and a microprocessor.

Panel forming rolls of the panel roll forming section **38** are powered by a hydraulic motor **50**. Other hydraulic motors **52** are provided for crimping the side of the formed panel P and forming the crimp C_s as is known in the prior art. Another hydraulic motor **54** is provided for driving the panel bottom crimping rolls to provide a bottom crimp which determines the curvature of the panel, the bottom crimp being shown as C_b.

A panel length measuring device **56** is provided for measuring the length of the formed panels electronically from the roll forming machine. Another substantially identical panel length measuring device **58** is positioned on the other side of the machine for measuring the length of the formed panel being fed to a crimping and curving section **68**.

The hydraulic shear **40** is operated by hydraulic cylinders **62**. Run out support tables **64** are positioned adjacent to the shear and in line with the roll forming section **38** to support the formed panel. The trailer will have appropriate racks **66** for storing the support tables **64** and **78** and other essentials equipment while the trailer is being transported.

On the side of the trailer opposite the roll forming section **38** is the crimping and panel curving section **68**. The bottom crimping to produce the crimp C_b is accomplished by a pair of crimping rolls **70** and **72**. A curvature measuring device **74** contacts the panel following the bottom crimping rolls to determine the radius or degree of curvature that the bottom crimping is causing the panel to assume. Because the bottom crimping controls the degree of curvature and the degree of bottom crimping is controlled by the distance between the axis of the crimping rolls **70** and **72**, movement of one crimping roll relative to the other determines the degree of curvature. Hydraulic motor **75** is provided to move crimping roll **70** relative to roll **72** to control the degree of curvature. The side crimping for the side of the panel is provided by side crimping rolls **76** driven by motors **52**. Run out tables **78** are provided for receiving the formed panel.

The crimping rolls **70** and **72** can be completely disengaged from the bottom of the panel P in which case the panel will not have curvature (i.e., crimp C_b will be absent) and the panel will be straight, but will be straightened by the side crimps C_s. By automatically controlling the engagement and position of the crimping rolls the formed panel may have a straight section or sections and a curved section or sections with the degree of curvature or the radius of the curved section being accurately and automatically controlled. When it is desirable to have a building with vertical side walls the panels formed by the machine of this invention can be set to provide formed panels with straight sections either with an arched roof or straight (sloping) roof with a radius or curved section between the walls and at the apex of the roof. All methods for controlling this machine and the formed shapes described are all programmably controlled. The panels formed by the machine of this invention may be seamed together by seamers as taught in the prior art.

As shown in FIG. **2** an electronic encoder **80** is associated with panel length measuring device **58** and is used for measuring the length of panel which is run through the side crimping rolls. Another electronic encoder **82** is used for determining the position of the crimping rolls relative to each other, i.e., the depth of crimp if any. The curvature measuring assembly **74**, also detailed in FIG. **9** includes measuring assembly **84** which, when contacting the curved panel, will measure the curvature, This is achieved by when the fixed arms **86** contact the panel within a fixed distance, the vertical or height dimension of the arc length will be determined by assembly **84**. The mechanical linkage **88** will position the electronic encoder **90**. This encoder will send the electronic information back to the microprocessor for further controlling the machine.

The rotational drive of the crimping rolls is shown in FIG. **3**. The crimping roll hydraulic motor **54** drives the shaft to which sprocket **92** is fixed and sprocket **92** drives chain **94** trained over sprocket **96**. There are two sprockets **96** spaced side by side on the shaft and chain **98** is trained over one of them and sprocket **100**. Another sprocket **100** on the same shaft carries drive chain **102** trained around sprocket **104** fixed to drive shaft **106** of crimping roll **70**. A pinion **108** is fixed to the shaft of sprocket **96** and a drive gear **110** is fixed to the drive shaft of crimping roll **72** for the drive of that roll. A tension assembly **112** is provided for tensioning chain **102** which is variably positioned due to the position adjustment of roll **70** under the control of motor **75**.

In the prior machines of this type crimping rolls were driven by three spur gears directly coupled. When the main crimping roller moved away from the gears the contact ratio was small and the gears suffered premature wear and failure. With the present construction the main crimping rolls **70** and **72** are mechanically coupled but complete freedom of movement is allowed without affecting the timing and without gear backlash.

FIGS. **4** and **5** show the measuring device assembly such as **56** and **58** for electronically measuring the length of formed panels. The encoder **80** is connected through a water tight plug and harness **114** to the microprocessor. The measuring roller of cylindrical shape **124** rolls freely via bearings **122**. This roller is machined from phenolic material which is very wear resistant and provides adequate friction needed for accurately measuring the panels. The support and mounting for the assembly includes a mounting plate **126** secured to the frame of the machine by bolts **128**. The measuring device is movably mounted and biased by extension spring **130** attached to spring tab **132** on mounting plate **126** and tab **134** on a moveable frame **136** of the measuring roll. Moveable block **138** slides on a rail **137** so that the frame **136** carrying the roll **124** can move up and down always being pressed against the underside of the panel P by the bias from spring **130**.

For moving the crimping roll **70** it is mounted to a plate and moveable thrust block **142**, see FIGS. **6** and **7**. A bronze nut **144** and retaining flange **146** is assembled to an Acme threaded rod **148**, which is rotated by motor **75**. This threaded rod rides within the nut **144** and allows the thrust block to move radially of the rollers giving the crimper its desired movement ranges. The use of the nut allows very slow rotation for example 1 to 2 rpms and very high speed returns around 40 to 50 rpm. As the thrust block **142** is moved radially it in turn moves mechanical links **150**, **120** and **153** which are connected to the thrust block by clevis **154** and also connected to the encoder **82** to determine the position of the crimping rolls.

FIG. **8** shows the drive for both ends of the shaft of lower crimping roll **70** which are moved together to the same position. Sprocket **160** is attached to shaft **148** and is driven by chain **164** trained around sprocket **162** which in turn is connected to a gear reduction unit **166** driven by hydraulic motor **75**. Another sprocket chain **170** is trained around another sprocket **160** and a further sprocket **172** on shaft **174**. Shaft **174** is similar to shaft **148** and controls the other end of roll **70**. Both of these shafts are the ends of the threaded rods **148**. With the proper position of the crimping rolls the accuracy of the finished panels can be accomplished to eliminate the waste typically obtained as a result of using the prior art machines.

FIG. **9** illustrates the control panel **48** which also houses the microprocessor. Portion **168** of control panel **48** is for the engine control and includes fuse **176** and ignition switch **178**, an alternator indicator **180** and a starter switch **182**. The engine motor which is preferably a diesel engine may be controlled at either high or low speeds through control **184** and has a pilot light **186** to indicate the ignition is on. The number of hours the engine has operated is indicated on gauge **188** and the engine oil pressure is indicated on gauge **190**. Reset button **192** is utilized to reset the control. In the upper right portion of control panel **48** is the microprocessor control panel **193** which includes an increase radius button **194** and a decrease radius button **196**. Building type may be controlled by pushing building type button **198** and entering digits corresponding to the building type, i.e., the shape of the panel to be formed. Conversion of English to metric units is accomplished through the manager mode key switch **198**. The thickness may be entered into the microprocessor for controls by pressing the F key **195** and the THK button **198** and the particular thickness on the keypad **208**. A display panel **210** is used to display the actual and desired radius and the length. It is also used to display all control and error functions of the microprocessor. For setting a particular length or radius control buttons **204** and **206** are pushed and then the length or radius is set using entry into the microprocessor via the keypad **208**.

Control of the panel feed through the panel forming assembly **38** is accomplished by control buttons **212, 214** and **216**. Button **214** is the panel feed slow button for initial feeding of the panel into the assembly to be sure everything is correct. The panel former start **214** is used to feed the panel at high speed through the panel former. It shuts off automatically when the desired length is achieved. Panel reverse button **216** is for reversing the forming rolls to feed the panel back out of the former.

The switches on the panel **48** for the curver section **68** have the same functions, namely, feeding the panels slow **218** through the curver, reversing the curver **222** or running it at high speed (normal) **220**. The hydraulic shear **40** is operated up and down by a control **224** and the entire machine may be shut down by an emergency stop control **226**. A computer RS232 serial port **199** is used to communicate the microprocessor with a personal computer. Switches **213** and **215** are used to reset the panel former and curver respectively. Buttons **181** and **183** are used to temporarily stop the panel former and curver respectively. Button **199** is used to change any function when the machine is running. A clear/calibrate button **193** is used to clear entries and calibrate the machine. The manager mode **198** will allow the operator to check and/or change one hundred different operating parameters of the machine.

FIG. **11** is a schematic illustration of the components for controlling the machine. The engine **42** drives the main hydraulic pump **44** which receives hydraulic fluid through line **228** from reservoir **227**. Variable volume piston pump **44** pumps hydraulic fluid through line **232** to the main hydraulic valve **46**. The pressure is measured and monitored via gauge **224**. The main hydraulic valve has four sections **234, 236, 238** and **240**. Hydraulic valve section **234** controls the operation of the panel forming drive motor **50** and is controlled by control buttons **212, 214**, and **216** on control panel **48** and inputs from the microprocessor. Section **236** of the main hydraulic control valve **46** is for controlling the operation of hydraulic shear **40** by operating the hydraulic cylinders **62** for operating the shear and moving the shear either up or down via hydraulic lines **237** and **239** as shown. Control valve section **238** is for controlling the drive of the crimper roll drive motors **52** and **54**. The hydraulic fluid is passed through lines **250** to motors **52** and **54** and back through lines **252**. The motors rotate the crimping rolls as previously described. Hydraulic valve section **240** controls the crimping roll positioning motor **75** through hydraulic lines **260** to move the crimping roll **70** toward or away from roll **72** in order to control the degree of curvature from a straight panel to a panel with a desired radius.

An audible alarm **246** is connected via electrical line **248** to the microprocessor and main control panel **48**.

The microprocessor controls all four valve sections **234, 236, 238, 240** through signals sent via electrical harness **242**.

The panel length measuring device **58** sends signals to the microprocessor through harness **244** and the microprocessor then controls the speed and duration of drive via motor **50** according to that preset for panel length by the control panel.

Similarly, the length measuring device **58** feeds signals through electrical lines **254** to the microprocessor incorporated behind the control panel **48** and signals are fed via line **242** to control valve portion **238** to control the amount and the drive of the motors **52, 52** and **54** and hence the length passing through the crimper rolls. The curvature detected by radius measuring device **74** is fed through harness **258** to the microprocessor and the microprocessor sends back signals to control valve **240** to control crimping roll positioning motor **75** to position the crimping roll and control the radius. The position of the crimping roll **70** is detected by encoder **82** which feeds its signal through line **256** to the microprocessor which in turn sends signals to valve section **240** to accurately determine the position and hence further control motor **75** to position the crimping roll.

Operation of the machine will now be described. The machine starts with a coil of flat steel on roll **36** positioned on trailer **30**. Under the control of panel switches **212, 214** and **216** the steel is fed through the panel forming section **38** driven by hydraulic motor **50** to an extent determined by the length entered in via keypad **208** and length button **206** in the control panel. As the panels are formed the sensor **56** electronically measures the panels as they are coming off the roll forming line sending input signals through a line **244** back to a control panel and microprocessor **48**. When the desired length is achieved the motor **50** shuts down automatically and the controls signal the operator to shear the panel via shear **40**. The operator then operates shear control button **214** to shear the panel and the sheared panel rests on run-out table **64** supplied with the machine. The table **64** will hold the panels until they are ready to be curved through the curving section **68**. The machine is capable of producing multiple different panels depending upon the shape of the rolls in section **38**. A panel 24 inches wide or 22 inches wide may be formed with a coil **36** inches wide, a panel 12 inches wide or 16 inches wide may be formed from, a 24 inch panel and a 20 inch panel may be formed from a 36 inch wide coil.

The formed panel is then fed back through the curving assembly **68** and the sides are crimped via side crimping roll **76** under the control of motors **52**. The operator then enters the desired radius by pushing the radius button **204** and the keypad may be used to set the radius. Encoder **82** will determine the position of the main crimping roll **70** relative to roll **72**. The operator then inserts the panel into the curving section and starts the curving process using buttons **218** to start and then switching to button **220**. The side crimping motor **52** will drive the panel through the curving section under hydraulic power and the main crimping rolls **70, 72** are also hydraulically operated for rotational drive by motor **54**. The encoder **74** will rest on the crimped panel and measure the appropriate radius. If the radius measured does not match as the desired radius entered into the microprocessor the encoder **74** will send the signal back to the main panel through line **258** which will operate valve **240** to cause motor **275** to reposition crimping roll **70**. The encoder **82** receives a signal from the microprocessor through line **256** informing the controller that a new radius will be used. This is then stored into the microprocessor for future reference. The crimping roll **70** is adjusted to the desired radius and when this is achieved the microprocessor will alert the operator and the panels continue to be formed, and they rest on layout tables **78**.

In order to construct special buildings with a portion of the panel straight and other portions having one or more desired radius of curvature, the operator inputs the information into the control panel microprocessor **48** to send signals to the encoders **74, 58** and **82** to control the curving section. For example, if the operator wants a straight wall, a curved roof and straight wall, the first input from the control panel would be the straight wall length; this could be inputted through the numerical keypads **208**. The desired curvature of arch could also be inputted followed by input for the final straight section. Also, certain building types which are recurring are given codes which can be inputted to the microprocessor after pressing the "Type" button **198**. The machine can measure through the measuring device **58** the appropriate length of a straight portion of the panel P. At this point only the side flanges are crimped leaving the center bottom untouched so that it is not curved. When the desired length is achieved the microprocessor tells the drive motors to stop. At this point the crimping roll **70** will move in a position via hydraulic motor **75** and its gear reducer. The microprocessor then commands the drive to continue forming the panels in an arch shaped section while carrying the straight wall across the run out table. Once the proper arch length is achieved, the machine stops again so that the main crimping roll can pull away from the panel and allow a third and last section to be formed as a straight section. The microprocessor will control all these functions including proper delay times, proper radius and proper length of the panels. The control panel **48** also includes manual overrides **194** and **195** to allow the operator to make emergency adjustments to radius control. These override switches control valve **240** to feed motor **75**.

Building type button **196** can give the operator flexibility when choosing a desired building type inputting a single command via keypad **208**. The thickness entry via keys **195** and **198** is primarily for the memory of the microprocessor.

FIG. **12** shows one type of building **226** that can be built using this invention. A panel span **270** has an arched roof **272** sandwiched between two vertical wall portions **274**. In this case the entire building **266** is formed by assembling panel sections side by side as shown in FIG. **12** in which the vertical side walls **274** are back to back and attached together forming a common vertical wall **276**. This building can also be used as a single or multiple unit. The assembly may conveniently be erected on footings or foundations **268** as is known in the art.

A detail of the common vertical wall **276** is shown in FIG. **13**. The panels when assembled together form a section with cavities of hexagonal or honeycomb shape **278**. Reinforcing bar assemblies **280** may be placed in these cavities and the cavities may be filled with concrete (not shown) for rigidity and support. Extruded aluminum panels **282** may be assembled between the panels and attached by fasteners **284** to secure the panels together in a back to back manner. Electrical conduits may be passed through cavities **286** in the extruded members or may be passed through certain of the cavities **278** which then would not be filled with concrete.

FIG. **14** depicts another form of completed building structure. These buildings are formed using straight vertical walls **280**, separated from the sloping straight roof portion **282** by a curved section **284**. A small curved section **286** at the apex of the building will complete the shape. Two or more buildings can be constructed by using the vertical column support **276** as previously described. This concrete vertical column can also be used on straight vertical walls in single buildings as well.

As can be seen this invention provides a unique machine for automatically and controllably forming sheet metal into panels for metal buildings together with a unique method for forming desired panels and a new building type. It is the intention therefore to be limited only by the scope of the appended claims.

What is claimed is:

1. A machine for automatically and controllably forming sheet metal into panels for metal buildings having combined

walls and roof panels, at least a portion of which are arched or curved; the machine comprising;

a) roll forming means for roll forming sheet metal material into a desired panel profile having a central bottom portion between upturned lateral edge portions;

b) shear means adjacent the roll forming means for shearing the roll formed panel;

c) crimping means for continuously crimping by bending small folds in the bottom portion of formed sheared panel lengths fed through the crimping means to provide a curvature of the formed panels, the depth of the folds establishing the curvature;

d) panel curvature measuring means for measuring the curvature of bottom crimped formed panels; and;

e) automatic digital control means for controlling the crimping means to vary the control the extent of curvature of the formed panels by varying the depth of the folds, the automatic digital control means being at least partially responsive to the measuring means and a control input setting of desired curvature.

2. A machine as defined in claim **1** further comprising; means for automatically and controllably adjusting the crimping means only so that the sheared panel bottom portion is not crimped and a corresponding portion of the formed panel is straight.

3. A machine as defined in claim **2** further comprising; additional crimping means for crimping the edge portions of the formed panels, and length measuring means connected to control means for continuously and automatically measuring the length of formed panels passing through the crimping means.

4. A machine as defined in claim **1** wherein the crimping means includes a pair of crimping rolls sandwiching the bottom of the formed panel, a moveable block mounting at least one crimping roll so that the crimping rolls may be positioned toward or away from each other, means controlling movement of the block responsive to the control means.

5. A machine as defined in claim **4** wherein the bottom crimping rolls are driven by chains.

6. A machine as defined in claim **1** wherein the control means includes a control panel, a microprocessor and hydraulic and electrical circuits.

7. A machine as defined in claim **6** wherein the control panel allows adjustment of the curvature length of curved portion, and length of straight portion of a formed panel.

8. A machine as defined in claim **7** wherein the control panel includes automatic shut down means and a computer connection.

9. A machine as defined in claim **1** wherein the machine is further mounted on a wheel vehicle for mobility.

10. A machine as defined in claim **9** further comprising hydraulic activated shear means mounted on the vehicle for shearing desired length of the formed metal panel.

11. A method of making panels for a self-sustaining building formed of such panels seamed together side by side, the method comprising;

a) roll forming sheet metal from a roll of sheet metal into a desired cross-sectional configuration having side edges and a bottom;

b) shearing the formed configuration at a desired and predetermined length;

c) crimping by placing small indentations to the side edges of the predetermined length of formed configuration to add strength;

d) curving the sheared lengths of roll formed sheet metal by automatically and controllably crimping by placing small indentations to the bottom of the formed configuration to add strength and to provide a predetermined curvature for a portion of the predetermined length to provide a building panel having a curved roof portion and straight vertical wall portions on opposite sides of the roof portion, the depth of the indentations establishing the curvature; and

e) measuring the curvature and the predetermined length of the crimped panel and using such measuring and a predetermined setting of curvature for continuously and automatically controlling the depth of the indentations during crimping without removing the panel from the crimping step.

12. A machine for automatically and controllably forming sheet metal into panels for metal buildings having combined walls and roof panels, at least a portion of which are arched or curved, the machine comprising;

a) a plurality of metal forming rolls arranged to form sheet metal material into a desired panel profile having a central bottom portion between upturned lateral edge portions;

b) a movable shear blade adjacent said plurality of metal forming rolls, wherein said moveable shear blade cooperates with an other severing implement to cut said panel;

c) crimping rollers for continuously crimping by bending small folds in the bottom portion of said cut panel lengths fed through said crimping rollers to provide a curvature to said formed panels, the depth of the folds establishing the curvature;

d) a curvature gauge for measuring the curvature of bottom crimped formed panels, and;

e) an automatic digital controller to control the crimping rollers to vary the depth of the folds produced by said crimping rollers to control the extent of curvature of the formed panels, the automatic digital controller being at least partially responsive to said curvature gauge and a control input setting of desired curvature.

13. A machine as defined in claim 12 further comprising said digital controller automatically and controllably adjusts the crimping rollers so that a portion of the formed panel is straight.

14. A machine as defined in claim 12 further comprising:

additional crimping rollers for crimping the edge portions of the formed panels, and length measurement devices connected to said digital controller for continuously and automatically measuring the length of the formed panels passing through the crimping rollers.

15. A machine as defined in claim 12 wherein the crimping rollers include a pair of crimping rollers sandwiching the bottom of the formed panel, a moveable block mounting at least one crimping roller so that the crimping rollers may be positioned toward or away from each other, and a motor to control movement of the block in response to said digital controller.

16. A machine as defined in claim 15 wherein the bottom crimping rollers are driven by chains.

17. A machine as defined in claim 12 wherein the digital controller includes a control panel, a microprocessor and hydraulic and electrical circuits.

18. A machine as defined in claim 17 wherein the control panel allows adjustment of the curvature length of curved portion, and length of straight portion of a formed panel.

19. A machine as defined in claim 18 wherein the control panel includes automatic shut down means and a computer connection.

20. A machine as defined in claim 12 wherein the machine is further mounted on a wheeled vehicle for mobility.

21. A machine as defined in claim 20 further comprising hydraulic activated shear blades mounted on the vehicle for cutting a desired length of the formed metal panel.

22. A method of making panels for a self-sustaining building formed of such panels seemed together side by side, as in claim 11, wherein said side edge crimping is performed by at least two crimping rollers sandwiching at least one edge portion of said formed panels.

23. A method for making panels, as in claim 11, wherein said depth of the crimping indentations is controlled by a digital controller.

24. A method of making panels, as in claim 11, wherein said panels are formed by a machine mounted on a wheeled vehicle for mobility.

25. A method for making panels, as in claim 23, wherein the depth of said bottom crimping indentations is controlled independently of the depth of said edge crimping indentations.

26. A method for making panels, as in claim 11, wherein said bottom crimping indentations in a single formed panel have a plurality of depths.

27. A method for making panels, as in claim 11, wherein said roll forming, crimping and curving steps are performed on a machine mounted to a wheeled vehicle.

28. A machine as defined in claim 12, wherein said curvature gauge measures the radius of said panel.

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