Oct. 29, 1968

E. F. KELM

3,407,850

WIRE BENDING APPARATUS

Filed Nov. 25, 1966

6 Sheets-Sheet 1

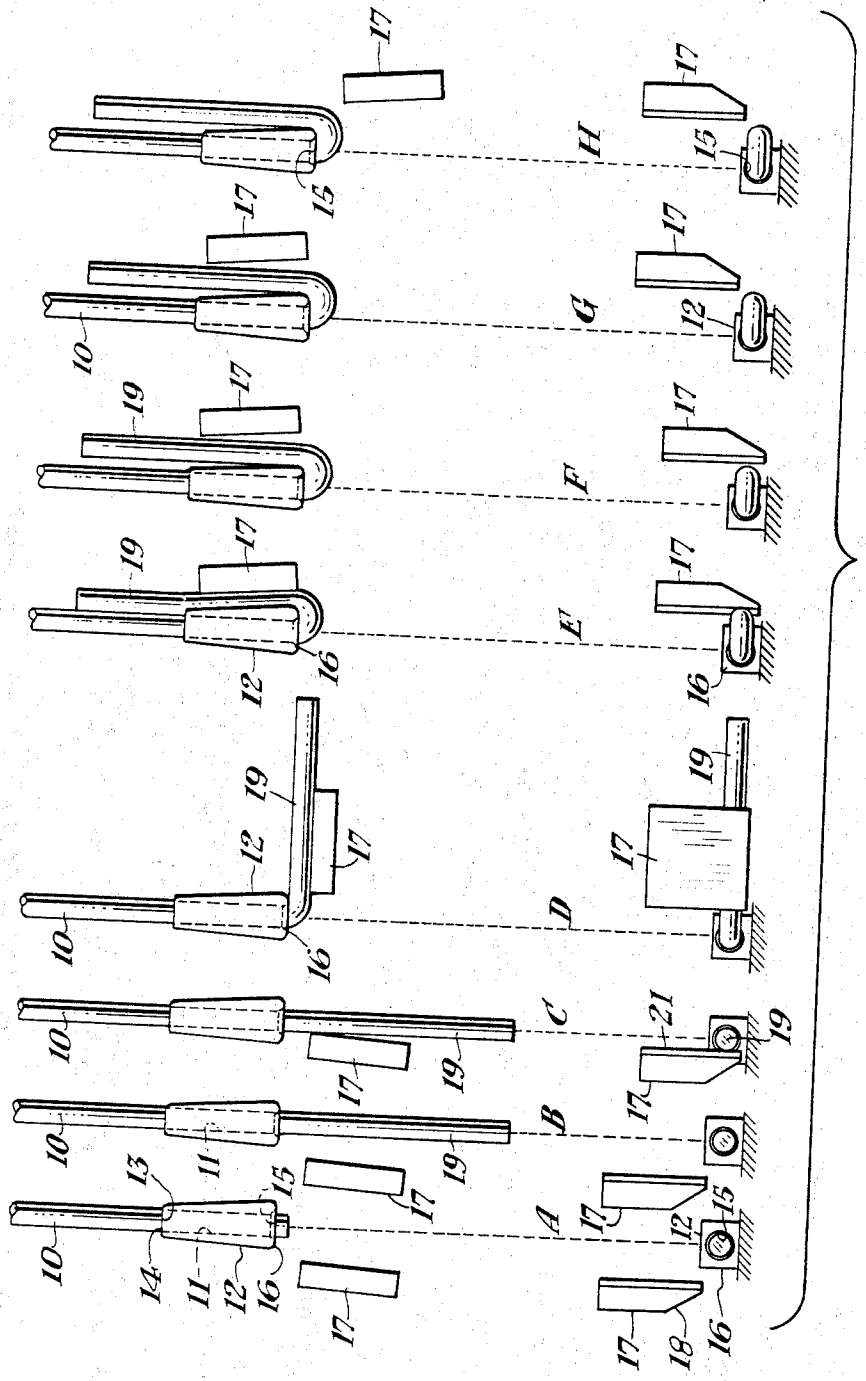


Fig. 1.

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WIRE BENDING APPARATUS

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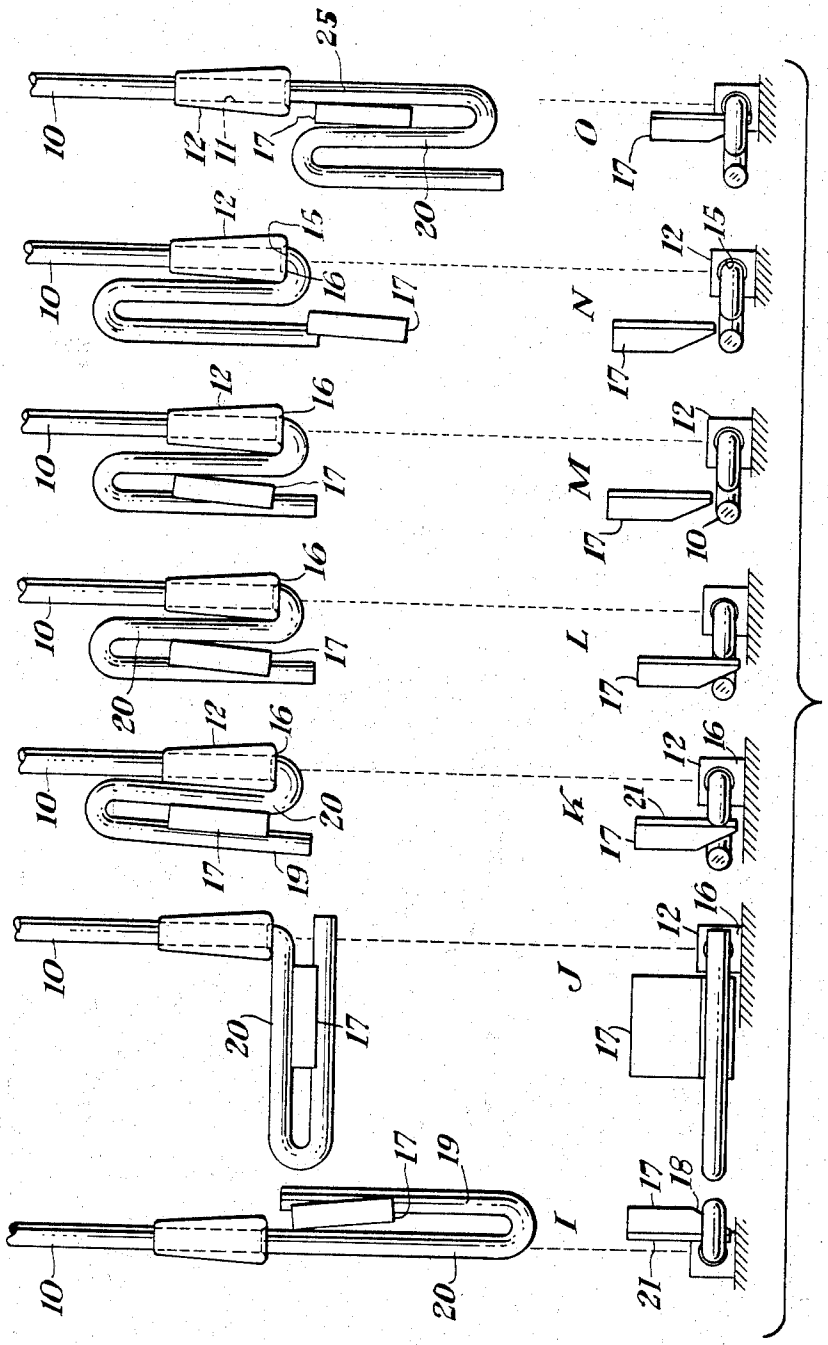


Fig. 2.

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WIRE BENDING APPARATUS

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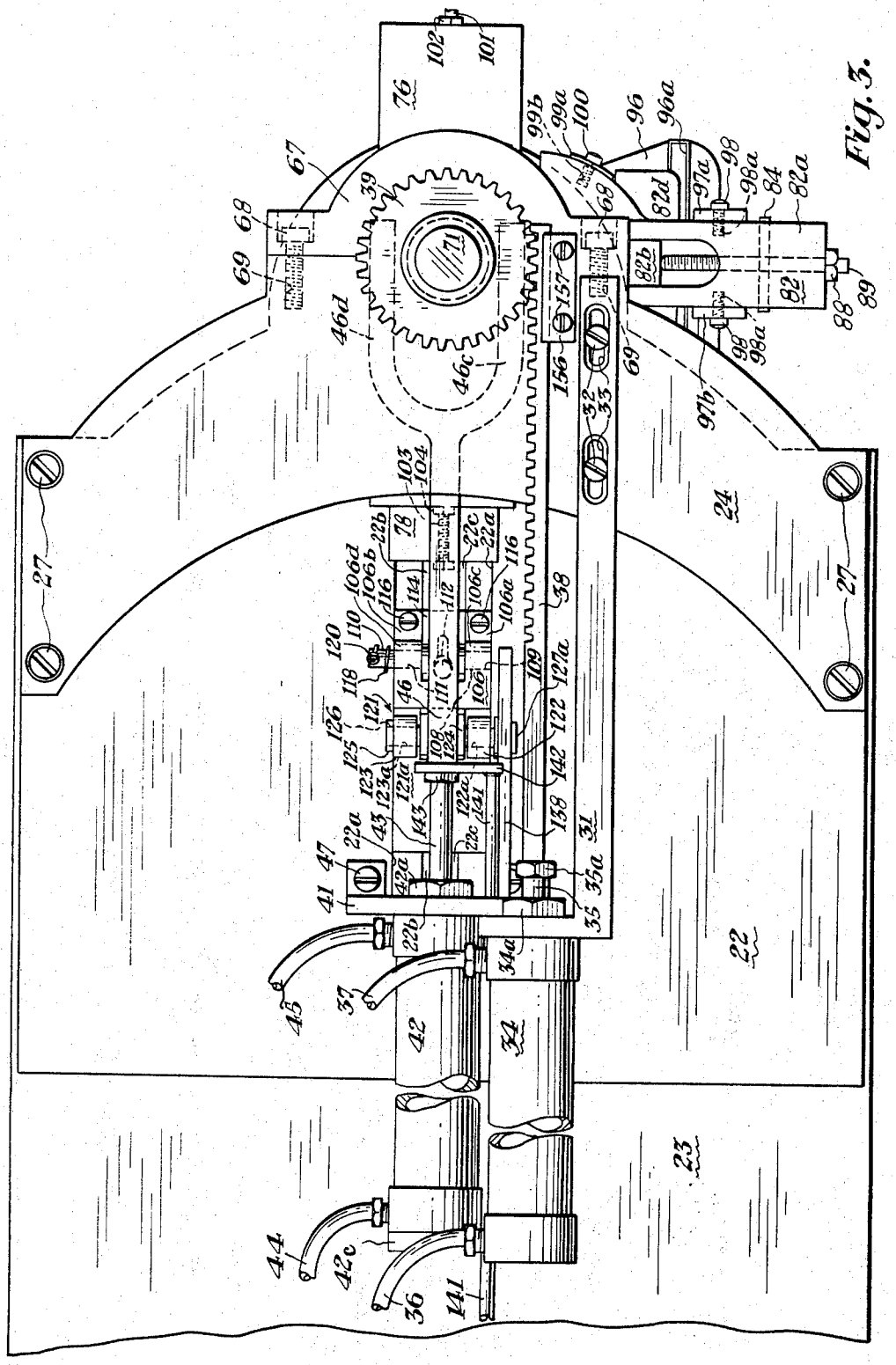


Fig. 3.

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WIRE BENDING APPARATUS

Filed Nov. 25, 1966 6 Sheets-Sheet 4

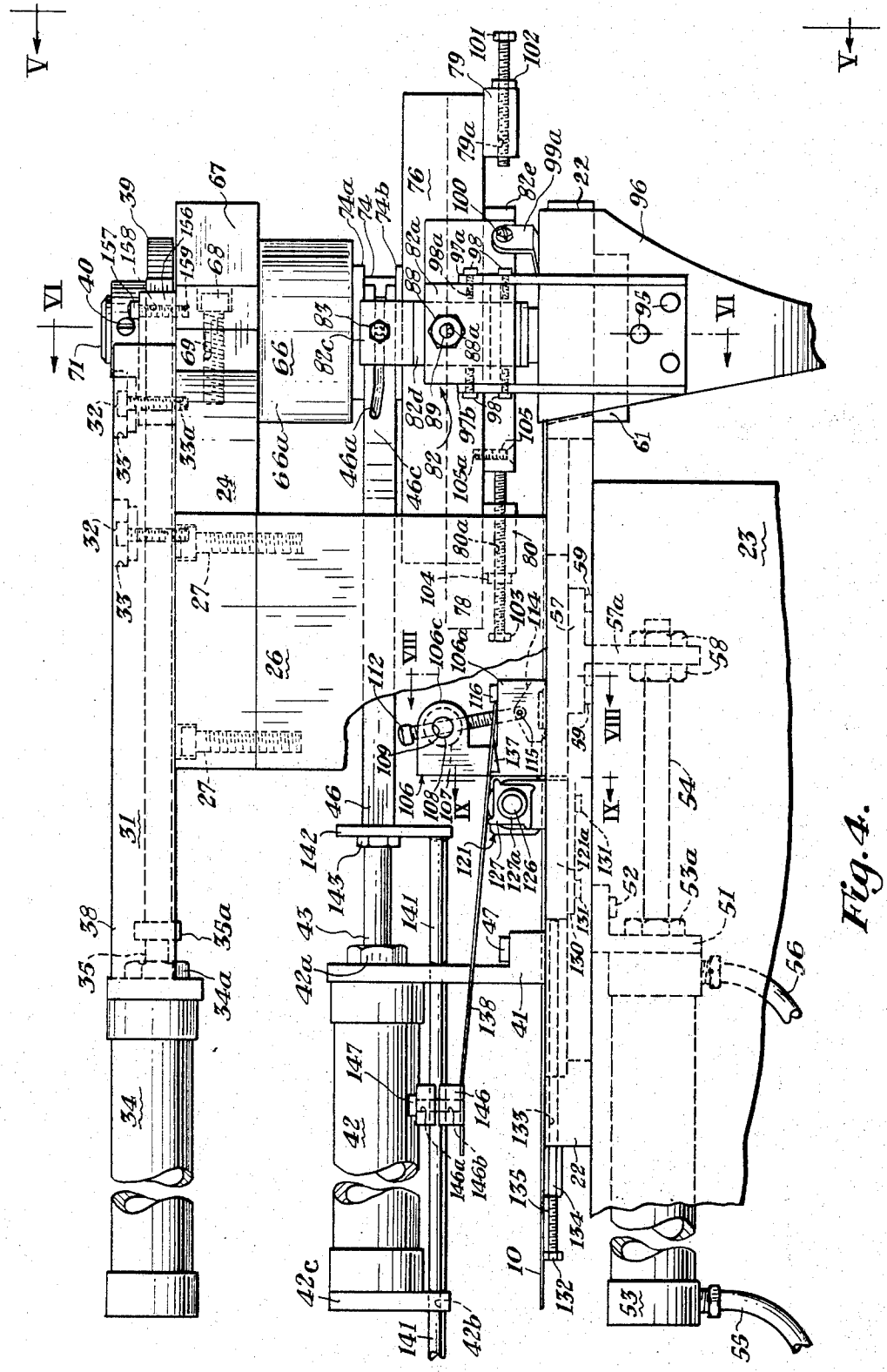


Fig. 4.

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WIRE BENDING APPARATUS

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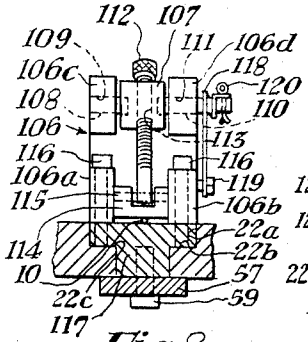


Fig. 8.

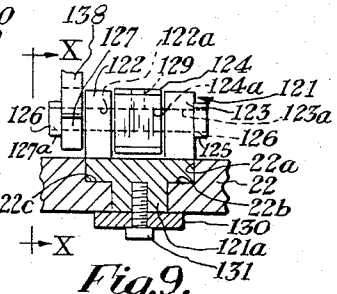


Fig. 9.

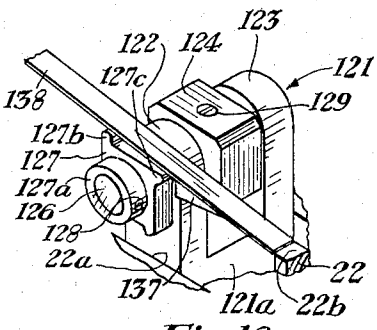


Fig. 10.

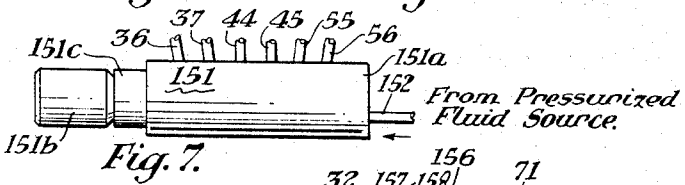


Fig. 7.

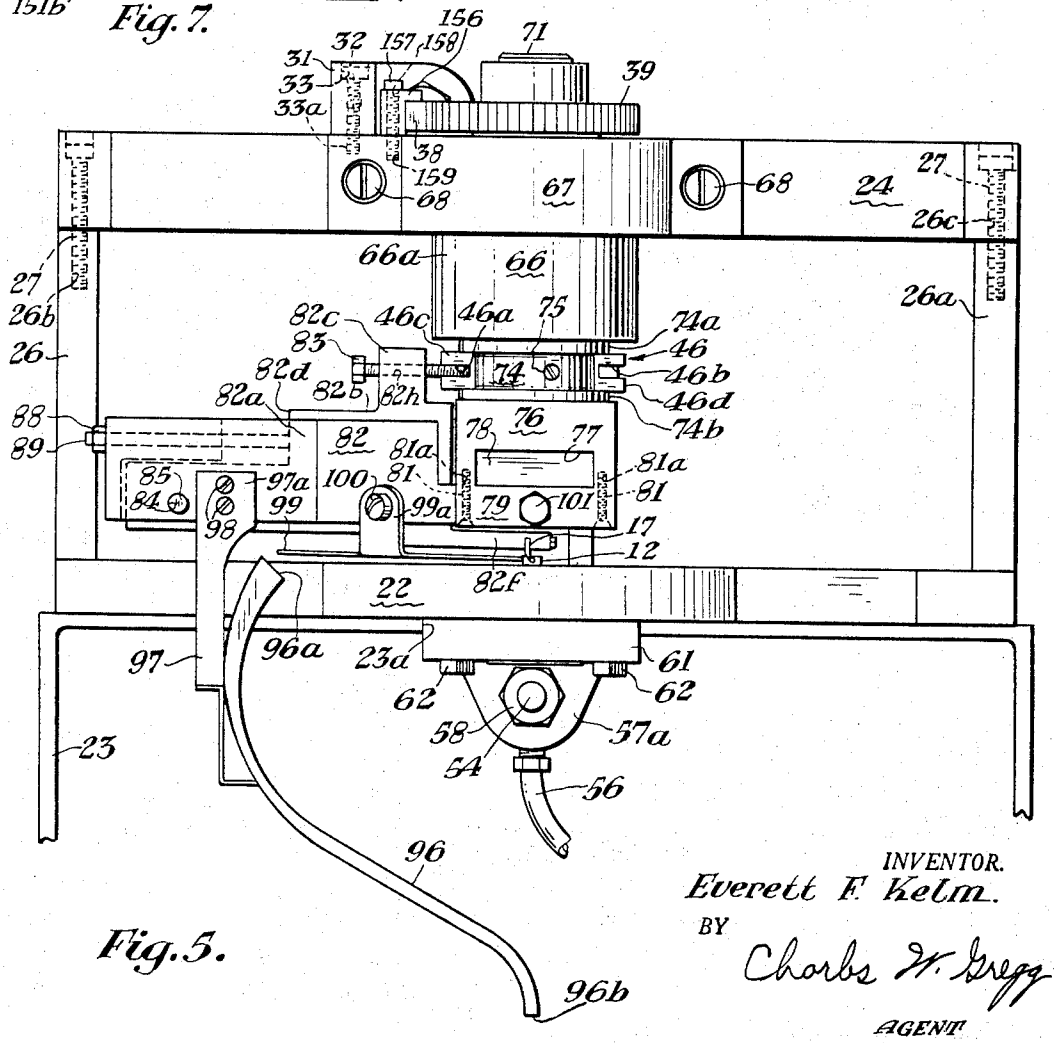


Fig. 5.

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WIRE BENDING APPARATUS

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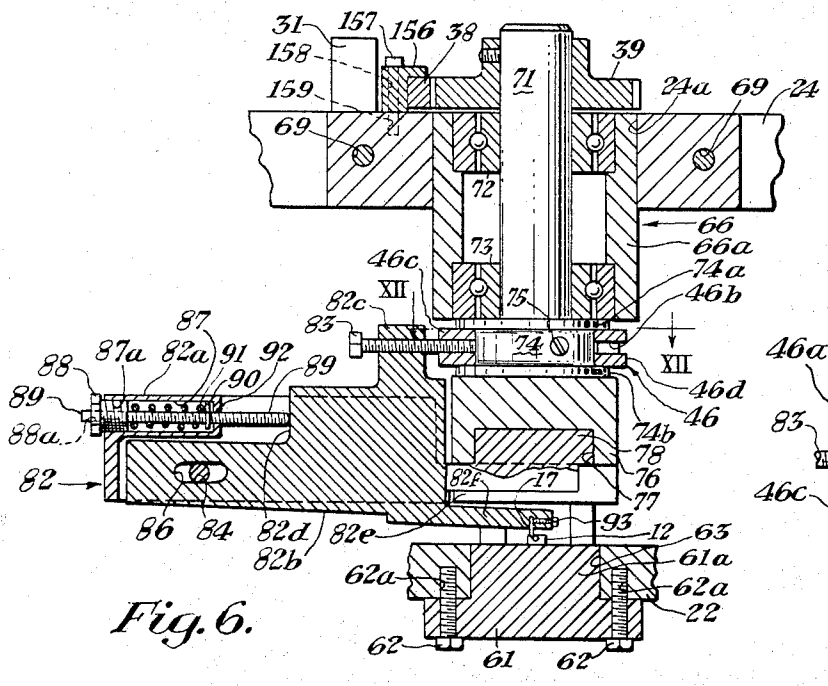


Fig. 6.

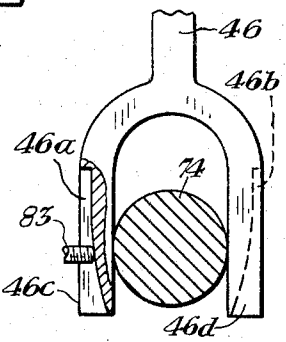


Fig. 12.

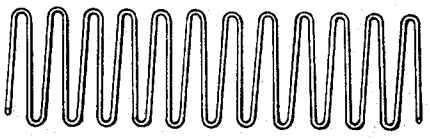


Fig. 13.

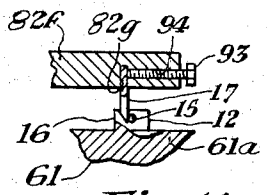


Fig. 11.

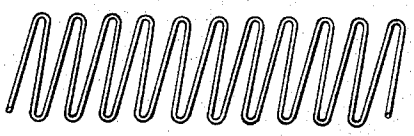


Fig. 14.

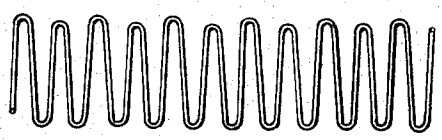


Fig. 17.

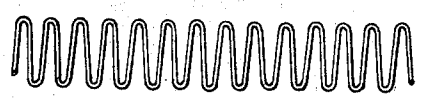


Fig. 15.

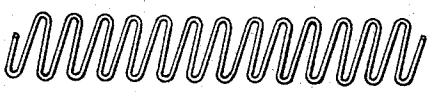


Fig. 16.

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3,407,850

WIRE BENDING APPARATUS

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Filed Nov. 25, 1966, Ser. No. 596,948
8 Claims. (Cl. 140—71)

The present invention relates to wire bending apparatus and particularly to apparatus for bending wire into preselected sinuous or serpentine shapes or configurations. Still more specifically the present invention relates to apparatus for bending wire to provide ribbons or strips of bent wire wound or formed, along the length of such strips or ribbons, in preselected sinuous or serpentine patterns.

For the purpose of providing electric heating elements, for example, it is often desired to bend electrical resistance conductors or wires into patterns having wavy or sinuous forms, that is patterns in which said conductors or wires bend in and out, or one way and the other, in a serpentine manner. It is accordingly the primary object of the present invention to provide a new and novel apparatus or machine for bending wire, such as electrical resistance wire for example, into various selected serpentine shapes.

It is another object of the present invention to provide an apparatus which bends wire into sinuous strips or ribbons of wire and which can be readily adjusted to vary the sinuous configurations of different parts of said strips or ribbons, or of different ones of said strips or ribbons.

In accomplishing the above objects of the invention, apparatus is provided which feeds successive lengths or sections of wire through a wire guide, which bends each such section or length of wire about the end of the wire guide in a direction opposite to that in which the immediately preceding length was bent, and which sequentially repeats such bending operations to provide a ribbon or strip of bent wire having a preselected serpentine configuration. The apparatus further includes means for varying said lengths of wire so that said serpentine configuration can be varied.

Other objects and characteristic features of the invention will become apparent as the description proceeds.

The invention will best be understood with reference to the accompanying drawings wherein:

FIGS. 1 and 2 when arranged from left to right in numerical order comprise a schematic diagram of sequential steps performed by the apparatus embodying the invention to bend wire into desired preselected patterns.

FIG. 3 is a top plan view of the wire bending apparatus;

FIG. 4 is a side elevational view of the apparatus;

FIG. 5 is a front elevational view of the apparatus taken generally along line V—V of FIG. 4;

FIG. 6 is a sectional view taken generally along the VI—VI of FIG. 4;

FIG. 7 is a view of a programmer included in the apparatus embodying the invention, such programmer being illustrated substantially in block form;

FIG. 8 is a front view of the wire feeding means of the wire bending apparatus, such view being taken generally along line VIII—VIII of FIG. 4;

FIG. 9 is a front view of a bumper device and associated ratchet of the wire bending apparatus, such view being taken generally along line IX—IX of FIG. 4;

FIG. 10 is an isometric view of the device of FIG. 9 taken somewhat along line X—X of such figure;

FIG. 11 is a fragmentary detail view of a part of the wire bending apparatus and illustrating the wire guide, and the wire forming tool and its method of support;

FIG. 12 is a detail view, partially in cross-section, of

the fork employed in the actuation of the wire forming tool of FIGS. 6 and 11, such view being taken generally along line XII—XII of FIG. 6;

FIGS. 13 through 17 are views illustrating only several of many different patterns or configurations into which wire may be bent by the apparatus of the invention.

Similar reference characters refer to similar parts in each of the figures of the drawings.

Referring first to FIGS. 1 and 2 of the drawings arranged from left to right as previously mentioned, the sequential steps performed by the apparatus in bending wire are illustrated. Such sequential steps are successively designated A through O and each view located at the top of FIGS. 1 and 2 is associated with or corresponds to the view immediately therebelow. This will be readily apparent by a brief glance at said figures of drawings. The views at the top of FIGS. 1 and 2 are top views illustrating sequential operation of certain parts of the apparatus during the bending of wire by such apparatus, while the respectively associated views at the bottom of such drawing figures comprise front elevational views illustrating said operation. It is to be understood that the views of the components or parts illustrated in FIGS. 1 and 2 of the drawings are not intended to dimensionally illustrate structure of the apparatus embodying the invention but are only for the purpose of diagrammatically illustrating sequential operational steps performed by certain parts of said apparatus.

Referring now to FIGS. 1 and 2 of the drawings in further detail, as shown in step A, the end of a wire **10** extends through a wire passage **11** embodied in a wire guide **12**. Wire **10** extends through passage **11** in a direction from a passage entrance orifice **13**, at an entrance end **14** of wire guide **12**, toward an exit orifice **15** of said passage at an exit end **16** of such wire guide. A wire forming or bending tool **17**, having a beveled or blade-like bottom edge **18**, is illustrated in step A as initially disposed in a position just beyond and laterally adjacent to a first side of exit orifice **15**.

It is pointed out that, for purposes of simplification of the drawings, the reference characters are not included in all the operational steps illustrated in FIGS. 1 and 2 but are included only where deemed expedient for a ready understanding of the sequential operation of the apparatus.

In step B, a preselected section or length **19** of wire **10** is fed through passage **11**. In step C, bending or forming tool **17** is actuated or moved downwardly and laterally so that the straight side **21** of tool **17** contacts one side of length **19** of wire **10**. In steps D and E, tool **17** is moved or swings through a predetermined path of travel extending in a counterclockwise direction about exit end **16** of guide **12**, to bend length **19** of wire **10** about exit end **16** of such guide. In step F, tool **17** is moved laterally out of contact with length **19** of wire **10**. In step G, tool **17** is actuated upwardly so that it will be clear of wire **10** when a succeeding length of such wire is fed through wire guide **12**. In step H, tool **17** is moved lineally to a position just beyond a second side of exit orifice **15**, such second side being opposite to the previously mentioned first side of such orifice.

In step I, a succeeding section or length **20** of wire **10** is fed through passage **11** and, immediately thereafter, tool **17** is actuated or moved downwardly and laterally so that the blade-like or beveled edge **18** of such tool enters the space between lengths **19** and **20** of wire **10**, and so that side **21** of tool **17** contacts length **20** of wire **10**. It will be noted that the side of wire **10** contacted by side **21** of said tool is, at this time, the side of such wire opposite to that previously contacted by side **21** of said tool.

In steps J and K tool **17** is moved or swings through a

predetermined path of travel, extending in a circular arc in a clockwise direction about exit end **16** of guide **12**, to bend length **20** of wire **10** about exit end **16** of such guide. It will be noted that said circular path of travel overlaps, at its starting end, the starting end of the previously mentioned circular path of travel, such overlap comprising a distance approximately equal to the diameter of passage **11** embodied in wire guide **12**. This will be readily apparent by a brief study of FIGS. 1 and 2 of the drawings.

In step L, tool **17** is moved laterally out of contact with section or length **20** of wire **10**. In step M, tool **17** is actuated upwardly so that it will again be clear of wire **10** when a succeeding length or section of such wire is fed through wire guide **12**. In step N, tool **17** is moved lineally to its position initially discussed in conjunction with step A, that is, to its position just beyond and laterally adjacent to said first side of exit orifice **15**. In step O, a further succeeding section **25** of wire **10** is fed through passage **11** and, immediately thereafter, tool **17** is moved downwardly and laterally so that edge **18** of such tool enters the space between lengths **20** and **25** of wire **10**. Steps D through O are then successively repeated in the sequence described to bend section **25**, and similar succeeding sections, to add additional lengths, similar to lengths **19** and **20**, to the sinuous ribbon or strip of wire being formed.

It is pointed out that in steps E and K the lengths of wire **19** and **20**, respectively, are illustrated as being pressed fully against the somewhat triangularly shaped wire guide **12**. This is done so that the inherent resiliency of wire **10** will only return said lengths of wire to the positions illustarted in steps F and L, respectively. It may be desired, of course, that wire **10** not be bent completely into a series of U shapes and, under such conditions, the circular arcs of travel of tool **17** may be accordingly reduced in length. It is further pointed out that the sinuous configurations or patterns imparted to wire **10** by the bending operations can be considerably varied by sequentially varying the lengths of succeeding lengths or sections of wire, such as **19** and **20**, fed through passage **11**. This will be further discussed hereinafter in this description.

Referring now to FIGS. 3 through 6 of the drawings, there is secured to the top surface of an inverted U-shaped support **23** a main platform **22**. A pair of upright legs or supports **26** and **26***a* are mounted upon the top surface of platform **22** as by welding, for example, or supports **26** and **26***a* may be secured to said surface of platform **22** by bolts if so desired. A somewhat semi-circular shaped second platform **24** is secured to the top of supports **26** and **26***a* by threaded bolts such as **27** secured into cooperating threads in holes such as **26***b* and **26***c* provided in the tops of legs **26** and **26***a*. It will be readily understood that the bottoms of the upright portions of inverted U-shaped support **23** are intended to rest upon a suitable table or bench, or if of sufficient length, they may rest upon the floor. It is also pointed out that the forward center portion of support **23** is provided with a relatively wide slot **23***a* (FIG. 5) for a purpose to be hereinafter discussed.

The front edge of platform **24** is provided with a semi-circular recess **24***a* (FIG. 6) in which is inserted a sleeve portion **66***a* of a bearing assembly **66**. A semi-circular clamping member **67** having a semi-circular recess, similar to recess **24***a* provided in the front edge of paltform **24**, securely clamps bearing assembly **66** to platform **24**, said member **67** partially surrounding the outer circumference of bearing assembly **66** and being secured to platform **24** by threaded bolts such as **68** screwed into cooperating threads provided in holes such as **69** provided in the front edge of platform **24**. By such arrangement it is readily apparent that bearing assembly **66** can be securely clamped within the semi-circular recessed portions of platform **24** and clamping member **67**.

As best illustrated in FIG. 6, bearing assembly **66** comprises the above mentioned sleeve portion **66***a*, in which is retained the races of upper and lower ball bearings **72** and **73**, respectively. An axle **71** extends through the inner portions of ball bearings **72** and **73** and is thus free to rotate within sleeve **66***a* of bearing assembly **66**. The pinion **39** of a rack and pinion gear assembly **38–39** is secured to the top end of axle **71** by a set screw **40** (FIG. 4). A spool or reel-shaped wheel **74** having upper and lower flanges **74***a* and **74***b*, respectively, is secured to the lower end of axle **71** by a set screw **75** (FIGS. 5 and 6). It is thus apparent that any rotation of pinion **39** will impart, through axle **71**, similar rotation of spool or wheel **74**.

A first motor means, shown as a reciprocative pressurized fluid actuated motor comprising the usual fluid pressure cylinder **53** and an associated piston rod **54** (FIG. 4) is disposed longitudinally parallel with and vertically below the centerline of platform **22**, and is secured to such platform by an L-shaped bracket **51** fastened to the bottom surface of the platform by bolts such as **52**, such bracket being secured to cylinder **53** by the usual stop nut **53***a* associated with cylinder **53** and surrounding piston rod **54**. A second motor means, also shown as a reciprocative pressurized fluid actuated motor comprising a cylinder **42** and an associated piston rod **43** (FIGS. 3 and 4) is disposed parallel with said first motor means vertically above said centerline of platform **22**, and is fastened to such platform by an L-shaped bracket **41** secured to the top surface of the platform by bolts such as **47**, such bracket being fastened to cylinder **42** by the usual stop nut **42***a* associated with cylinder **42** and surrounding piston rod **43**. A third motor means, which is also shown as a reciprocative and pressurized fluid actuated motor comprising a cylinder **34** and an associated piston rod **35** (FIGS. 3 and 4) is disposed parallel with said first and second motor means, but offset from said centerline of platform **22** as shown in FIG. 3. Said third motor means is supported by an elongated L-shaped bracket **31** which is fastened to the top surface of platform **24** by bolts such as **32** extending through slots such as **33** (FIGS. 3, 4 and 5) provided in bracket **31** and screwed into cooperating threads provided in holes such as **33***a* (FIGS. 4 and 5) provided in the top of platform **24**. Bracket **31** is secured to cylinder **34** by stop nut **34***a* associated with cylinder **34** and surrounding piston rod **35**. It is apparent that by providing the slots such as **33** in bracket **31** the position of motor means **34–35** can be longitudinally adjusted parallel with the centerline of platform **22**.

Pressurized fluid for actuation of piston rod **35** of fluid cylinder **34** is supplied to first and second ends of such cylinder through fluid conduits **36** and **37**, respectively (FIG. 3). Similarly, pressurized fluid for actuation of piston rod **43** of fluid cylinder **42** is supplied to first and second ends of that cylinder through fluid conduits **44** and **45**, respectively (FIG. 3). Piston rod **54** of fluid cylinder **53** is actuated by pressurized fluid supplied to first and second ends of cylinder **53** through fluid conduits **55** and **56**, respectively (FIG. 4). The ends of conduits **36**, **37**, **44**, **45**, **55** and **56**, opposite to the ends thereof connected to their respective fluid cylinders, are connected to a fluid pressure programmer **151** (FIG. 7) discussed below.

Programmer **151** comprises a pressurized fluid control assembly **151***a* and motor means **151***b* for driving said assembly through a suitable gear reduction box **151***c*. Motor means **151***b* is preferably an electric motor which may be energized from a suitable source of electric current not shown in the drawings for the purpose of simplification thereof. When motor means **151***b* is energized, it drives the fluid control assembly **151***a* through gear reduction box **151***c*, and conduits **36**, **37**, **44**, **45**, **55** and **56** are selectively connected to a pressurized fluid source or to atmosphere through a series of valves in control assembly **151***a*, such valves selectively actuated in accordance with a predetermined program to be discussed further hereinafter. Fluid control assembly **151***a* and its

associated pressurized fluid control valves are connected to a suitable source of pressurized fluid by a fluid conduit **152**. Programmers such as **151** are well known and, therefore, the programmer is not shown in detail in the drawings but is shown in block form. The manner of operation of programmer **151** will be readily apparent to those skilled in the art.

The top surface of an elongated rectangular support member **76** is affixed at its center to the bottom of flange **74***b* of spool or wheel **74** (FIGS. 4, 5 and 6) in any convenient manner such as by welding, for example. The bottom of support member **76** is provided with a recessed portion or slideway **77** in which is disposed a rectangular slide member or bar **78**, such member fitting snugly but longitudinally movable within slideway **77**. Slide member **78** is retained in slideway **77** by cross members **79** and **80** (FIGS. 4 and 5) which are secured to the bottom of the front and rear ends, respectively, of support member **76** by screws such as **81** (FIG. 5) screwed into threaded holes such as **81***a* provided in the bottom of member **76**. There is affixed to the bottom of slide member **78** a support portion **82***e* (FIGS. 4 and 6) of a wire bending tool actuating assembly **82**, such support portion **82***e* being secured to the bottom of member **78** by screws such as **105** screwed into cooperating threads provided in holes such as **105***a* extending upwardly in the bottom of slide member **78**.

Wire bending tool actuating assembly **82** comprises an outer member **82***a*, of which the above-mentioned support portion **82***e* forms a part, and an inner member **82***b* (FIGS. 3, 5 and 6) which, as best illustrated in FIG. 6, fits snugly but movably within member **82***a*. A pivot pin **84** extends through a slot **86** provided in member **82***b* and through holes such as **85** provided in the sidewalls of member **82***a*. Pivot pin **84** fits tightly within the holes such as **85** but, slot **86** is slightly wider than the diameter of said pin and, therefore, member **82***b* may be moved rotatively about said pin and, to a limited extent, longitudinally within member **82**. Inner member **82***b* has an upper extension **82***c* (FIGS. 5 and 6) which is provided with a threaded hole **82***h* (FIG. 5) extending therethrough and through which is screwed an actuating pin **83**. The purpose of pin **83** will be discussed later in the description. Member **82***b* is also provided with a lower extension **82***f* which will be discussed later in conjunction with FIG. 11 of the drawings.

As illustrated in FIG. 6, one end of outer member **82***a* of assembly **82** is provided with a relatively large diameter orifice or hole **87** having a threaded end **87***a*. At the opposite end of hole **87** a hole **92** of a substantially smaller diameter is provided. A pin **89** extends through holes **87** and **92** and is longitudinally movable therein to an extent limited by a collar or nut **90** screwed onto threads provided on the end of pin **89** extending through hole **92**. A coil spring **91** surrounds pin **89** within orifice **87** and a first end of such spring bears against said collar or nut **90**. A threaded sleeve **88** is screwed into threaded end **87***a* of orifice **87** and bears against the second end of coil spring **91** to cause compression of such spring between sleeve **88** and collar or nut **90**. Sleeve **88** includes a nut-like head portion which remains outside of orifice **87** and is used for turning the sleeve and thereby screwing such sleeve into or out of the threaded end **87***a* of orifice **87**. The outer or unthreaded end of pin **89** extends through the hole **88***a* of sleeve **88** and is longitudinally movable therein. The other end of pin **89** bears against a facing surface **82***d* of a recessed portion of inner member **82***b* of assembly **82**. By the arrangement just described it will be readily apparent that member **82***b* is resiliently biased, by spring **91** and the associated pin **89**, rotatively downwardly about pivot pin **84** and longitudinally in one direction within member **82***a*. The biasing force supplied to member **82***b* may be somewhat varied by adjusting the depth sleeve **88** screwed into orifice or hole **87**.

As shown in FIGS. 5 and 6, and as illustrated in detail in FIG. 11, the lower extension **82***f* of member **82***b* of assembly **82** is provided with a slot **82***g* in which is inserted the upper edge of previously discussed wire bending or forming tool **17**, such tool being securely held within slot **82***g* by a set screw **93** screwed into cooperating threads provided in a hole **94** provided in the end of extension **82***f*. There is also shown in FIG. 11 exit orifice **15** in exit end **16** of wire guide **12** as previously discussed in conjunction with FIGS. 1 and 2 of the drawings. Wire guide **12** is held in the position illustrated by being securely affixed to the top surface of an upper portion **61***a* of a support member **61** attached to the bottom of platform **22** by bolts such as **62** screwed into threaded holes such as **62***a* provided in the bottom of said platform. The upper portion **61***a* of member **61** extends upwardly through a hole **63** provided in platform **22**.

By the foregoing discussion of wire bending tool actuating assembly **82** and the associated apparatus including wire bending tool **17** per se, it will be apparent that any rotation of axle **71** will impart similar rotative movement to the entire assembly **82** to cause tool **17** to swing about the exit end **16** of wire guide **12** as previously discussed in conjunction with FIGS. 1 and 2 of the drawings. Similarly, any movement of member **82***b* of assembly **82** about said pivot pin **84** will impart a corresponding movement to wire forming or bending tool **17**. This will be further discussed hereinafter in conjunction with an operational example of the invention.

There extends down through platform **22**, parallel with the sides thereof and along a portion of the centerline of such platform, an elongated slideway **22***a*. As illustrated in FIGS. 8 and 9, slideway **22***a* is substantially T-shaped in cross section thereby providing shoulder portions **22***b* and **22***c* upon which rest, in sliding relationship therewith, a support member **117** of a wire feeding assembly **106** (FIG. 8) and a support portion **121***a* of a bumper block assembly **121** (FIG. 9) both of which will be discussed in detail hereinafter. Member **117** is held in slideway **22***a* by a bottom member **57** which is fastened to the bottom of member **117** by screws such as **59** (FIGS. 4 and 8) screwed into threaded holes provided in the bottom of member **117**. As illustrated in FIG. 8, member **57** is greater in width than the bottom portion of slideway **22***a* and, therefore, prevents member **117** from rising out of such slideway. Member **57** includes a downwardly extending lug portion **57***a* (FIGS. 4 and 5) to which is fastened, by nuts such as **58**, the outward end of piston rod **54** associated with cylinder **53**, such end of piston rod **54** being threaded for receipt of said nuts. It is apparent that in any linear motion of piston rod **54** will impart a similar motion to member **117** within slideway **22***a* of platform **22**.

The support portion **121***a* of the above mentioned bumper block assembly **121** is held in slideway **22***a* by a bottom member **130** which is fastened to the bottom of portion **121***a* by screws such as **131** (FIGS. 4 and 9) screwed into threaded holes provided in the bottom of portion **121***a*. As illustrated in FIG. 9, member **130** is greater in width than the bottom portion of slideway **22***a* and, thereby, assembly **121** is prevented from rising out of such slideway. As shown in FIG. 4 a relatively long screw **135** is screwed through cooperating threads provided in a hole **133** extending horizontally through the rear of platform **22** into slideway **22***a* thereof. Screw **135** is provided with a head portion **132** by which the screw may be turned, and a lock nut **134** is threaded on screw **135** at the rear of platform **22**. The inner end of screw **135** bears against the rear of support portion **121***a* of bumper block assembly **121** and, thereby, limits the rearward position of such assembly. Such position may, however, be selectively adjusted by loosening lock nut **134** and screwing screw **135** further into or out of threaded hole **133**.

As shown in FIGS. 3, 4 and 8, the above mentioned wire feed assembly **106** is secured to support member **117** by screws such as **116** extending through holes provided in base portions **106***a* and **106***b* of assembly **106**, and screwed into cooperatively threaded holes provided in the top of member **117**. Assembly **106** further includes forwardly projecting upper portions **106***c* and **106***d* through which extend holes **109** and **111**, respectively. A pivotable support **107** is disposed between portions **106***c* and **106***d* by means of pivot pins **108** and **110** extending through said holes **109** and **111**, respectively, and rotatable therein. Pivot pins **108** and **110** are force fitted into holes provided in the respectively associated sides of support **107** and thereby such support and pins are unitarily rotatable within the upper part of assembly **106**. Pivot pin **110** is somewhat longer than pivot pin **108** and projects out of its associated hole **111** for a short distance. As best shown in FIG. 8 one end of spring **118** is secured to base portion **106***b* of assembly **106** by a pin **119** secured to such base portion in any convenient manner. Spring **118** then extends upwardly and is coiled around the projecting part of pivot pin **110**, the other end of such spring being secured to pin **110** by a cotter key **120** secured in a hole extending diametrically through the end of pin **110**. It is apparent that by such arrangement support **107** is resiliently biased against free rotation thereof. Support **107** is provided with a wire feed shoe or foot support screw **112** which is screwed downwardly through a threaded hole **113** provided in support **107**. The bottom end of support screw **112** carries a pivot pin **115** upon which is pivotally mounted a wire-feed foot or shoe **114**.

As illustrated in FIG. 8 wire-feed shoe or foot **114** is biased by spring **118** downwardly against wire **10** extending under the bottom of such shoe or foot and, as will be readily apparent from a brief study of FIG. 4, a forward movement of assembly **106** (in the right hand direction when viewing FIG. 4) will cause said shoe or foot to supply a sufficient clamping action of wire **10** between the foot and member **117** to impart a corresponding forward movement of such wire. On the other hand, a rearward movement of assembly **106** will permit wire **10** to slide between shoe or foot **114** and member **117**, and no movement of wire **10** will take place at such time. This will be further discussed hereinafter in conjunction with an operational example of the invention. It is believed expedient to point out at this time, however, that the clamping action of wire-feed foot or shoe **114** can be adjusted, if necessary, by screwing support screw **112** further through or out of support **107**. Such adjustment may be required, for example, when the wire to be bent is changed to a wire of a different diameter.

Referring now to FIGS. 9 and 10 of the drawings in conjunction with FIGS. 3 and 4, the bumper block assembly **121** will be described and discussed.

Bumper block assembly **121** is employed for the purpose of limiting the rearward movement of wire feeding assembly **106** in various selected sequential combinations to vary the configurations into which the wire, such as **10**, is bent, as hereinafter further discussed. Such bumper assembly comprises the previously mentioned support portion **121***a* which is slidably movable within slideway **22***a* of platform **22**, and upright portions **122** and **123** which carry the bumper block **124** per se. Bumper block **124** may have various shapes but is shown in the drawings as a substantially rectangular oblong block which has an axle **126** extending through a hole **126***a* in the center of the block and to which the block is immovably secured by a set screw **129**. Axle **126** extends through and beyond the ends of holes **122***a* and **123***a* provided in upright portions **122** and **123**, respectively, of assembly **121** and such axle is free to rotate in said holes. A rectangular ratchet wheel **127**, having a collar portion **127***a* and teeth such as **127***b*, fits over one end of axle **126** and is secured thereto, as illustrated in FIG. 10, by a set screw **128** extending through collar portion **127***a* of the ratchet wheel. A collar **125** (FIG. 9) fits over the other end of axle **126** and may be secured thereto in a manner similar to that described for collar portion **127***a* of ratchet wheel **127**. By such arrangement it is apparent that bumper block **124** or ratchet wheel **127** may be readily changed or replaced with a minimum of trouble. The purpose of at times changing such members will become apparent hereinafter. A leaf spring **138** bears resiliently downward against ratchet wheel **127** and is provided at one end thereof with a pawl click or ratchet **137** which at times engages, as hereinafter discussed, the teeth such as **127***b* of ratchet wheel **127**. Spring **138** and its associated ratchet or pawl **137** will be discussed in more detail hereinafter.

Referring to FIGS. 3 through 6, and as best illustrated in FIG. 3, the gear teeth provided at one end of rack **38** of the previously mentioned rack and pinion gear assembly **38–39** mesh with the gear teeth of pinion gear **39** of such assembly. The other end of rack **38** is securely connected to the outer end of piston rod **35** associated with cylinder **34** by a suitable coupling device **35***a* or in any other suitable manner, such as by welding for example. A rack guide member **156** is secured to platform **34** by bolts such as **157** inserted in holes such as **158** (FIGS. 4, 5 and 6) extending through said guide member and screwed into cooperatively threaded holes **159** provided in the top of platform **24**. Guide member **156** maintains the teeth of rack **38** in mesh with the teeth of pinion gear **39**, as is readily apparent. The purpose of rack and pinion gear assembly **38–39** and the associated apparatus will be discussed further hereinafter.

The outer end of piston rod **43** associated with cylinder **42** is securely fastened as by a nut **143** to the single end (FIGS. 3 and 4) of a fork-shaped member **46** which is divided at its other end into two prong-like portions **46***c* and **46***d* (FIGS. 3 and 13) discussed hereinafter. There is also secured between nut **143** and said single end of member **46**, a support member **142** for an actuating rod **141** for the previously mentioned leaf spring **138**, one end of such actuating rod being secured to support member **142** by welding for example. The other end of rod **141** extends through a hole **42***b* provided in base portion **42***c* of cylinder **42** (FIG. 4), such rod fitting snugly but longitudinally movable within such hole and such rod thereby being guided and supported at said other end thereof. The end of previously mentioned leaf spring **138** opposite to the end thereof carrying ratchet **137** is provided with a split clamp **146** which is securely attached to spring **138** in any convenient manner. A bolt such as **147** extends through a hole **146***a* in the upper half of split clamp **146** and is screwed into cooperating threads provided in a hole **146***b* in the lower half of such clamp (FIG. 4) so that the position of clamp **146** on rod **141** can be selectively varied. By the arrangement first described, bolt **147** can be screwed into hole **146***b* and tightened to secure clamp **146** to rod **141**. Therefore, any reciprocative movement of piston rod **43** associated with cylinder **42** will cause a corresponding movement of rod **141** and thereby, leaf spring **138**. The path of movement of leaf spring **138** can be adjusted, however, by changing the position of clamp **146** on rod **141**. This will be readily apparent by a brief reference to FIG. 4 of the drawings.

As illustrated in FIGS. 4, 5 and 6, the prong portions **46***c* and **46***d* of member **46** extend snugly but movably between the flanges **74***a* and **74***b* of previously discussed spool-shaped wheel **74** and, as viewed in FIGS. 5 and 6 of the drawings, on the left and right hand sides, respectively, of wheel **74**. As further discussed later, flanges **74***a* and **74***b* thereby act as guides for the pronged ends **46***c* and **46***d* of member **46**. As illustrated in detail in FIG. 12, prong portion **46***c* of member **46** is provided with a slot or groove **46***a* which gradually tapers in depth from the free or front end of portion **46***c* toward the rear thereof. Similarly, portion **46***d* of member **46** is pro-

vided with a slot or groove **46***b* which gradually tapers in depth from the free or front end of portion **46***b* toward the rear thereof. As shown in FIG. 4, groove **46***a* also slants upwardly adjacent the rear thereof. It will be understood that groove **46***b* also slants upwardly toward its rear in a manner identical to that illustrated for groove **46***a*. The end of the previously mentioned actuating pin **83** for inner member **82***b* of wire bending tool actuating assembly **82** extends, at various times and as shown in FIG. 12, into said grooves **46***a* and **46***b*. This will be further discussed hereinafter in an operational example of the invention.

A wire guide plate **99** (FIGS. 3, 4 and 5) is fastened to outer member **82***a* of wire bending tool actuating assembly **82** by a screw **100** which passes through a hole provided in an upturned lug portion **99***a* of plate **99** and is screwed into cooperating threads in a hole **99***b* (FIG. 3) provided in said member **82**. Wire guide plate **99** is disposed horizotnally above and slightly spaced from the top surface of platform **22**, such guide plate covering an area of said surface extending from a point adjacent the exit end of wire guide **12** (FIG. 5) to a point adjacent an entrance end **96***a* of a wire guide chute **96** to be discussed. Guide plate **99** is provided for the purpose of maintaining, to the extent possible, formed or bent wire down against the top surface of platform **22** and to guide such wire to said entrance end **96***a* of said wire guide chute **96**.

Wire guide chute **96** (FIGS. 3, 4 and 5) is a thin, hollow and curved chute which tapers in width (FIG. 4) from upper entrance end **96***a* toward a lower exit end **96***b* thereof. As mentioned, the chute is curved, as illustrated in FIG. 5, so that its exit end **96***b* is, as nearly as practicable, directly vertically below wire guide **12**. Entrance end **96***a* of the chute is, as viewed in FIG. 5, disposed adjacent the left hand edge of guide plate **99**. Chute **96** is supported in such position by a suitable support member **97** which is fastened to the chute by rivets such as **95** (FIG. 4) extending through such support member and secured to chute **96**. Alternatively, chute **96** may be secured to member **97** by welding if desired. Member **97** is fastened to member **82***a* of assembly **82** by screws such as **98** extending through suitable holes provided in upper extensions **97***a* and **97***b* (FIGS. 3 and 4) of member **97** and screwed into cooperating threads in suitable holes such as **98***a* provided in said member **82***a*.

As best illustrated in FIGS. 4 and 5, sliding motion of slide member **78** and support portion **82***e* of assembly **82** is adjustably limited by screws **101** and **103** screwed through threaded holes **79***a* and **80***a* (FIG. 4) provided in cross-members **79** and **80**, respectively. Lock nuts **102** and **104** are provided on screws **101** and **103**, respectively, and such screws can be screwed through their respectively associated members **79** and **80** to a desired distance and lock nuts **102** and **104** then tightened to hold such screws in the positions selected. The ends of screws **101** and **103** may then contact opposite ends of support member **82***e* to limit sliding movement thereof and of member **78** as mentioned above. This will also be discussed further hereinafter.

Referring now to FIGS. 13 through 17 of the drawings, there are illustrated therein several of many different configurations or shapes into which wire may be bent by the wire bending apparatus embodying the invention, some of such different shapes being attained by selectively varying the length of successive sections of wire in predetermined repetitive sequences as discussed hereinafter.

FIG. 13 is a fragmentary view of wire bent by the apparatus of the present invention and in which all of the sections of wire are of the same length. FIG. 14 is a fragmentary view similar to FIG. 13 but in which succeeding sections of wire vary in length, that is, in which every second section of wire is of the same length, but each section differs in length from its immediately preceding and succeeding sections. It will be noted that, by varying the length of such sections of wire in such sequence, the sinuations of the ribbon or strip of bent wire slope, rather than as in FIG. 13, extend substantially normal to the longitudinal dimension of the strip or ribbon of bent wire.

FIGS. 15 and 16 comprise fragmentary views of ribbons or strips of bent wire similar to those shown in FIGS. 13 and 14, respectively, but in which the sections forming the ribbon or strip of wire are substantially shorter in length than in FIGS. 13 and 14.

FIG. 17 comprises a fragmentary view of a ribbon or strip of bent wire formed by successively feeding two equal length sections through wire guide **12** and then two successive sections, equal in length to each other but of a different length than the first mentioned sections, through said guide. Such operations were sequentially repeated with the sections of every second pair of sections being equal to each other in length.

In the light of the above brief discussion of the several specific examples of the different shapes of strips or ribbons of bent wire which can be formed by the apparatus by varying the length of successive sections of wire in preselected sequences, it will be readily apparent that numerous additional shapes or configurations of strips of bent wire can be formed by other variations in the lengths of successive sections of wire fed through wire guide **12**.

With reference to FIGS. 3 through 12 of the drawings taken in conjunction with FIGS. 1 and 2 thereof, a detailed operational example of the invention will now be given.

It will be assumed that wire **10** (FIG. 4) from a suitable source, such as a reel of wire, extends from the rear end (the left hand end as shown in FIG. 4) of platform **22** and along the center of the top surface of such platform, under the shoe or foot **114** of wire feeding assembly **106**, and thence further towards the front end of platform **22** and through wire guide **12**. It will be further assumed that motor **151***b* of programmer **151** (FIG. 7) is connected to a suitable source of electrical energy and that the fluid control assembly **151***a* of programmer **151** is thus being driven to selectively supply pressurized fluid to conduits **36**, **37**, **44**, **45**, **55** and **56** in accordance with the preselected program for operation of the wire forming apparatus, and that such apparatus is, therefore, being actuated to provide a strip of bent wire such as shown on FIG. 14 of the drawings. The apparatus is shown in the drawings as in a position such as illustrated in step L of FIG. 2. That is pressurized fluid has just been supplied through conduit **44** to cylinder **42** and piston rod **43** is moving to its extended position and, thereby, moving member **46** in the right hand direction as viewed in FIGS. 3 and 4 of the drawings. As best illustrated in FIGS. 4 and 12, prong portion **46***c* of member **46** has moved sufficiently to cause actuating pin **83** to enter groove **46***a* and be moved in the left hand direction by the bottom of such groove bearing against the end of pin **83** and as a result of the diminishing depth of such groove. Inner member **82***b* of wire bending assembly **82** on which pan **83** is supported has, therefore, been moved by pin **83** against the biasing pressure of coil spring **91** (FIG. 6) a corresponding distance in the left hand direction. Wire forming tool **17** has thus been moved laterally away from a previously bent section of wire **10**, such as section **20** of such wire illustrated in step L of FIG. 2.

Pressurized fluid is being supplied over conduit **44** to cylinder **42** at such time, and piston rod **43** and member **46** continue their previously mentioned right hand movement. Actuating pin **83** is, thereby, moved further towards the rearward wall of groove **46***a* and subsequently upward by the upwardly sloping rear portion of such groove. This causes the end of member **82***b*, on which pin **83** is supported, to pivot upwardly about pivot pin **84** and press further against the biasing pressure of spring **91**. As illustrated in step M of FIG. 2, forming tool **17** is thereby raised upwardly to clear wire **10**.

When pin **83** is contacted by the rear wall of groove **46***a*

provided in prong portion 46*c* of member 46, such pin and its entire associated assembly 82, including wire guide plate 99 and wire guide chute 96, are moved forward or, viewing FIG. 4, in a right hand direction. At such time, slide member 78 is correspondingly moved along slideway 77 in support member 76 and carries along with it support portion 82*e* of assembly 82. Such movement continues until the forward or right hand end of support portion 82*e* contacts the end of screw 101 protruding from cross member 79. It is thus apparent that, at such time, the limits of movement of pin 83 and assembly 82, as well as the parts associated therewith, may be varied by the adjustment of screw 101 further through or out of cross member 79. At the end of the above described movement of assembly 82, wire forming tool 17 is in the position illustrated in step N of FIG. 2 of the drawings, that is, tool 17 has been moved linearly to its previously discussed portion adjacent the exit end 16 of wire guide 12.

Following the completion of the movement of piston rod 43 to its extended position, and the corresponding movement of member 46 and associated apparatus as discussed above, pressurized fluid is supplied by programmer 151 to conduit 55 while conduit 56 is connected to atmosphere by such programmer. Piston rod 54 of cylinder 53 is thus actuated to its extended position (in a right hand direction as viewed in FIG. 4) and wire feed assembly 106 is moved in a corresponding direction to feed a succeeding section of wire 10 through wire guide 12 as shown in step O of FIG. 2. The length of such section is controlled by the distance support member 117 of assembly 106 is moved along slideway 22*a* of platform 22 (see FIG. 4). Immediately following the feeding of said succeeding section of wire 10 through guide 12, pressurized fluid is supplied to conduit 45 and conduit 44 is connected to atmosphere by programmer 151. Piston rod 43 is thereby moved to its retracted position or, viewing FIG. 3, in the left hand direction. Member 46 is correspondingly moved and pin 83 of assembly 82 is, thereby, moved completely out of groove 46*a* of prong portion 46*c* of member 46. During such movement, pin 83 is first moved downwardly by the slope of the rearward portion of groove 46*a* (FIG. 4) and, as said movement of member 46 continues, pin 83 is moved through the portion of groove 46*a* of increasing depth (FIG. 12). At such time, the pressure of coil spring 91 against member 82*b* maintains the end of pin 83 against the bottom of groove 46*a*, and member 82*b* is thus, viewing FIGS. 5 and 6, moved in the right hand direction. Tool 17 is moved, at this time, downwardly and laterally to the position also illustrated in step O of FIG. 2.

During the retraction of piston rod 43 discussed above, actuating rod 141 associated with leaf spring 138 is, viewing FIG. 4, moved in the left hand direction, and spring 138 is, thereby, correspondingly moved. During such movement and subsequent to the passing of spring 138 beyond the point illustrated in FIG. 4, ratchet 137 on the bottom of leaf spring 138 engages one of the teeth such as 127*b* provided on ratchet wheel 127 of bumper block assembly 121 (FIG. 10) and wheel 127 and bumper block 124 are, thereby, turned one quarter of a complete revolution. A different face of the bumper block is thus faced in the forward direction (right hand direction as viewed in FIG. 4). As previously mentioned, bumper block 124 has an ablong rectangular configuration and, therefore, the distance which wire feed assembly 106 can be moved in the rearward direction (left-hand direction as viewed in FIG. 4) has been altered. At some point in time subsequent to the said quarter rotation of bumper block 124 and prior to another movement of member 46, programmer 151 supplies pressurized fluid to conduit 56 and connects conduit 55 to atmosphere (FIG. 4). Piston rod 54 is thereby retracted and wire feed assembly 106 is moved rearwardly (in the left hand direction viewing FIG. 4) until it rests against the face of block 124 then facing forward. Such rearward position of assembly 106 is different than that previously occupied by the assembly due to said quarter rotation of bumper block 124 and, therefore, when assembly 106 is subsequently again actuated to feed another length of wire through wire guide 12, Such length will be different than the length of wire previously fed through said guide.

Subsequent to the quarter revolution of bumper block 124 as discussed above, programmer 151 supplies pressurized fluid to conduit 36 and connects conduit 37 to atmosphere. Viewing FIG. 3, piston rod 35, associated with cylinder 34, and rack 38 are thereby moved to the right, and pinion gear 39 is thereby rotated slightly greater than 180 degrees in a counterclockwise direction. Such rotation of pinion gear 39 causes a corresponding rotation of assembly 82 and its associated apparatus, and tool 17 thereby bends, about exit end 16 of wire guide 12, the length of wire previously fed therethrough. Such operation is similar to steps D and E illustrated in FIG. 1 of the drawings.

Following the bending operation discussed above, pressurized fluid is again supplied through conduit 44 to cylinder 42 and conduit 45 is connected to atmosphere. Member 46 is, thereby, again moved in the forward direction (right hand direction when viewing FIGS. 3 and 4). During such movement, actuating pin 83 enters groove 46*b* provided in prong portion 46*d* of member 46 and is moved along the length of such groove. The diminishing depth of groove 46*b* and the rearward upward slope thereof actuates pin 83 and, thereby, assembly 82 and the associated apparatus, in a manner similar to that previously described in conjunction with the movement of pin 83 through groove 46*a* of member 46. Thus, during such movement of assembly 82, tool 17 is first moved laterally away from the length of wire just bent, and then moved upwardly and subsequently forward (in the right hand direction viewing FIG. 4). Such forward movement of pin 83 and assembly 82 is caused by the rear wall of groove 46*b* contacting pin 83 and forcing such pin and assembly 82 in said direction. At such time, the distance of movement of said parts is limited by the point of adjustment of set screw 103 in cross member 80. The end of support portion 82*e* contacts the end of set screw 103 and, thereby limits the sliding movement of slide member 78 along slideway 77 in support member 76 (FIG. 4). The operation of tool 17 at such time is similar to that illustrated in steps F, G and H of FIG. 1.

During the forward movement of piston rod 43 and member 46 discussed above, actuating rod 141 moves leaf spring 138 in a corresponding direction (right hand direction viewing FIG. 4) and ratchet 137 on the bottom of the leaf spring slides over ratchet wheel 127 without causing rotation thereof. It is pointed out that spring 138 normally bears downward against ratchet wheel 127 to maintain such wheel in the position to which it was last turned and in a position such that one of the faces of bumper block 124 faces forwardly.

Subsequent to the movement of pin 83 in groove 46*b* as described above, pressurized fluid is again supplied to conduit 55 (FIG. 4) and conduit 56 is connected to atmosphere. Wire feed assembly is, thereby, again actuated to feed a succeeding section of wire through wire guide 12. Following such feeding of the succeeding section of wire, pressurized fluid is again supplied to cylinder 42 to cause retraction of piston rod 43 and movement of member 46 in the left hand direction (FIG. 4). Forming tool 17 is thereby actuated to its position illustrated in step I of FIG. 2, such step also illustrating the succeeding section of wire such as 20 fed through guide 12. It will be noted that forming tool 17 is, at such time, on the side of orifice 15 of exit end 16 of guide 12 opposite from that illustrated in step O of FIG. 2. The above mentioned retraction of piston rod 43 also causes another quarter revolution of bumper block 124 and, upon the next rearward movement of wire feed assembly 106, such assembly will be moved to its position which is

occupied prior to the feeding of the length of wire, such as **25**, mentioned above in conjunction with step O of FIG. 2. Thus, the next length of wire fed through guide **12** will be similar in length to said length **25**.

Subsequent to the actuation of tool **17** to the position such as illustrated in step I of FIG. 2, pressurized fluid is supplied through conduit **37** to cylinder **34** and conduit **36** is connected to atmosphere. Rack **38** is, thereby actuated to its position illustrated in FIG. 3. During such movement of rack **38**, pinion gear **39** and the wire forming assembly **82** are rotated slightly greater than **180** degrees in a clockwise direction (viewing FIG. 3) and forming tool **17** bends the length of wire, such as length **20** illustrated in steps I, J and K about the end of wire guide **12**. This operation is similar to that illustrated in steps J and K of FIG. 2. Thereafter, the apparatus repeatedly operates in the sequence described to add additional lengths of bent wire to the strip or ribbon of bent wire being formed, and until the desired length of such strip or ribbon is attained. At such time motor **151***b* of programmer **151** is de-energized and further bending of the wire, such as **10**, is thereby terminated.

Although there is herein shown and discussed only one form of apparatus embodying the invention, it will be understood that various changes and modifications may be made therein without departing from the spirit and scope of the appended claims.

What is claimed is:

1. Apparatus for bending wire into a preselected sinuous pattern, such apparatus comprising,

(A) a stationary wire guide embodying a wire passage including wire entrance and exit orifices for wire entrance and exit ends of such guide,

(B) first motor means for periodically feeding straight sections of said wire through said passage and beyond the exit end of such guide, the length of each such section being controlled in accordance with said preselected pattern,

(C) a wire bending tool initially disposed in a first position adjacent a first side of the exit orifice of said passage,

(D) second motor means for actuating said tool into and out of contact with opposite sides of alternate sections of said wire fed through said passage, and for actuating said tool in first or second linear paths of travel extening parallel with the length of said passage,

(E) third motor means for actuating said tool in third and fourth partially overlapping paths of travel extending in circular arcs in first and second opposite directions from the exit orifice of said passage toward first and second opposite sides of said guide, respectively,

(F) a programmer, and

(G) means controlled by said programmer for energizing said motor means in a repetitive predetermined sequence to, sequentially,

(a) feed one of said sections of wire through and beyond the exit end of said guide,

(b) actuate said tool into contact with one side of said one section of wire,

(c) actuate said tool in said third path of travel to bend said one section of wire about the exit end of said guide,

(d) actuate said tool out of contact with said one section of wire,

(e) actuate said tool in said second path of travel to a second position adjacent the side of the exit orifice of said passage opposite said first side of such orifice,

(f) feed a succeeding section of said wire through and beyond the exit end of said guide,

(g) actuate said tool into contact with the side of said succeeding section of wire opposite said one side of the immediately preceding section of wire,

(h) actuate said tool in said fourth path of travel to bend said succeeding section of wire about the exit end of said guide,

(i) actuate said tool out of contact with said succeeding section of wire,

(j) actuate said tool in said first path of travel to return such tool to its said first position and, thereafter,

(k) continuously repeat the energization of said motor means in said predetermined sequence to bend said wire into said preselected sinuous pattern.

2. Apparatus in accordance with claim **1** in which said motor means include pressurized fluid energized motors.

3. Apparatus in accordance with claim **1** in which the lengths of said sections of wire are uniform.

4. Apparatus in accordance with claim **1** in which the lengths of said sections of wire vary in a predetermined repetitive sequence.

5. Apparatus for bending wire at intermittent points along the length thereof to form a bent length of such wire having a preselected sinuous or sepentine configuration, such apparatus comprising,

(A) a stationary longitudinal wire guide embodying a wire passage extending longitudinally therethrough and including wire entrance and exit orifices at wire entrance and exit ends of said guide, respectively,

(B) a first reciprocative motor,

(C) means actuable by said motor for periodically feeding sections of said wire through said passage and out of said exit orifice, the length of each such section being controlled in accordance with said preselected serpentine configuration for said bent length of wire,

(D) a wire forming tool including a blade-like end for contacting a side of each of said sections of wire for bending each such section about the exit end of said wire guide, said end of such tool being alternately positionable to first and second positions located beyond said exit orifice laterally adjacent to first and second opposite sides, respectively, of such orifice,

(E) a second reciprocative motor,

(F) means actuable by said second motor for alternately moving said tool through first and second linear paths of travel extending parallel with the length of said passage and thereby said blade-like end of such tool alternately to said first and second positions, respectively, and thereafter into and out of contact with an opposite side of each alternate one of said sections of wire fed through said passage,

(G) a third reciprocative motor,

(H) means actuable by said third motor for moving said tool in third or fourth partially overlapping paths of travel, said third path extending in a circular arc in a direction from said first position towards the side of said guide opposite said first side of the orifice, and said fourth path extending in a circular arc in a direction from said second position toward the side of said guide opposite said second side of the orifice,

(I) a programmer, and

(J) means controlled by said programmer for selectively energizing said motors in a preset sequence to, sequentially,

(a) actuate said first means to feed a section of said wire through said guide,

(b) actuate said second means to move said end of said tool into contact with the side of said section of wire adjacent said first side of said exit orifice,

(c) actuate said third means to move said tool through said third path of travel and bend said

section of wire about the exit end of said guide,

(d) actuate said second means to move said end of said tool out of contact with said section of wire and through said second path of travel to said second position,

(e) actuate said first means to feed a succeeding section of said wire through said guide,

(f) actuate said second means to move said end of said tool into contact with the side of said succeeding section of wire adjacent said second side of said exit orifice,

(g) actuate said third means to move said tool through said fourth path of travel and bend said succeeding section of wire about the exit end of said guide,

(h) actuate said second means to move said end of said tool out of contact with said succeeding section of wire and through said first path of travel to said first position, and

(i) thereafter repetitively energize said motors in said preset sequence to form said bent length

of wire having a sinuous or sepentine configuration.

6. Apparatus in accordance with claim 5 in which said motors are of a type which are energized by pressurized fluid.

7. Apparatus in accordance with claim 5 in which the lengths of said sections of wire are identical.

8. Apparatus in accordance with claim 5 in which the lengths of said sections of wire vary in a predetermined repetitive sequence.

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