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(54) TUBE BENDING APPARATUS

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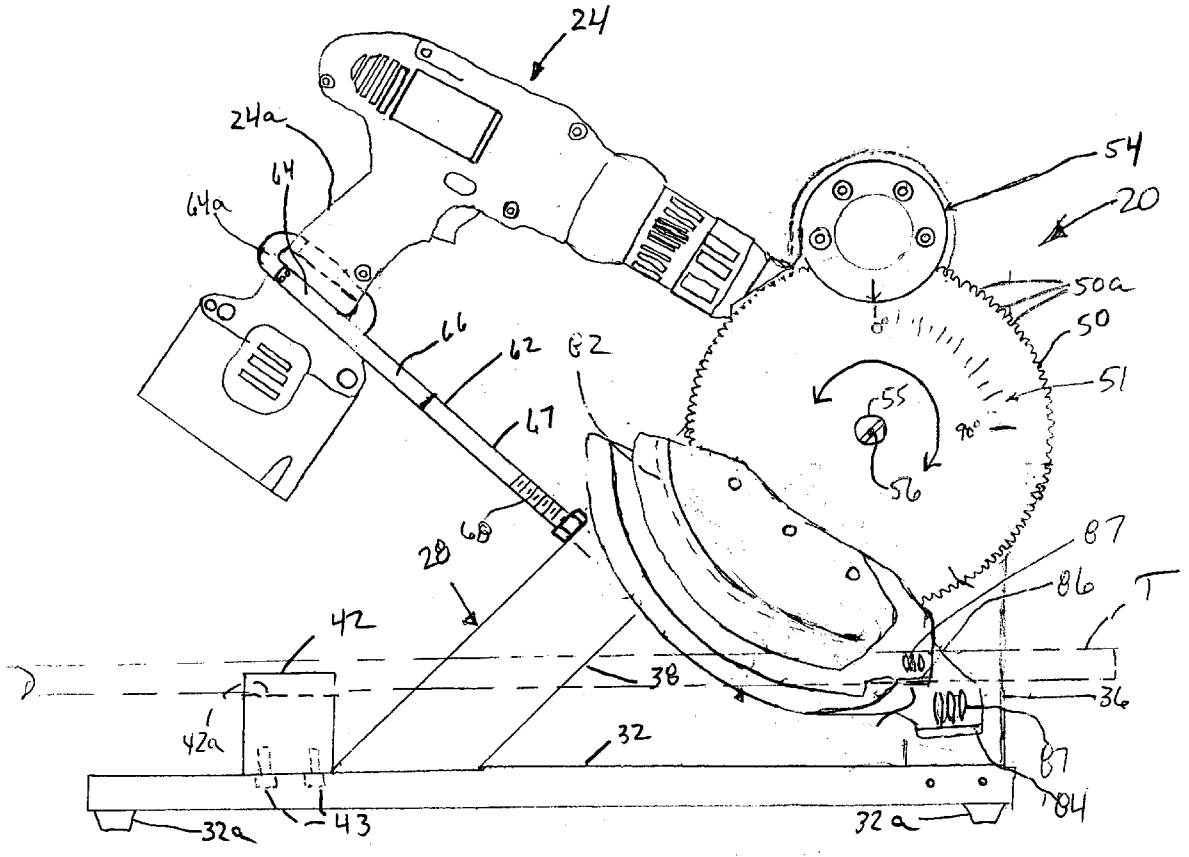
(57) ABSTRACT

A portable bending apparatus includes a frame, a major gear, a forming member, a workpiece guide and a gear mechanism. The major gear is mounted rotatably to the frame about a bending axis. The forming member is carried on a front side face of the major gear, the forming member having an arcuate forming surface and a restraint. The workpiece guide is mounted to the frame. The gear mechanism has an input connected to a geartrain connected to an output gear, the geartrain providing a speed reduction between the input and the output gear. The input is configured to receive rotary input from a handheld motorized driver, such as a portable drill. The output gear is enmesh with gear teeth of the major gear. When a workpiece to be bent is placed on the tube guide and within the restraint and against the forming surface, and the input receives rotary motion from the handheld motorized driver, the restraint and the forming surface are driven to orbit about the bending axis and the forming surface bends the workpiece braced between the restraint and the workpiece guide.



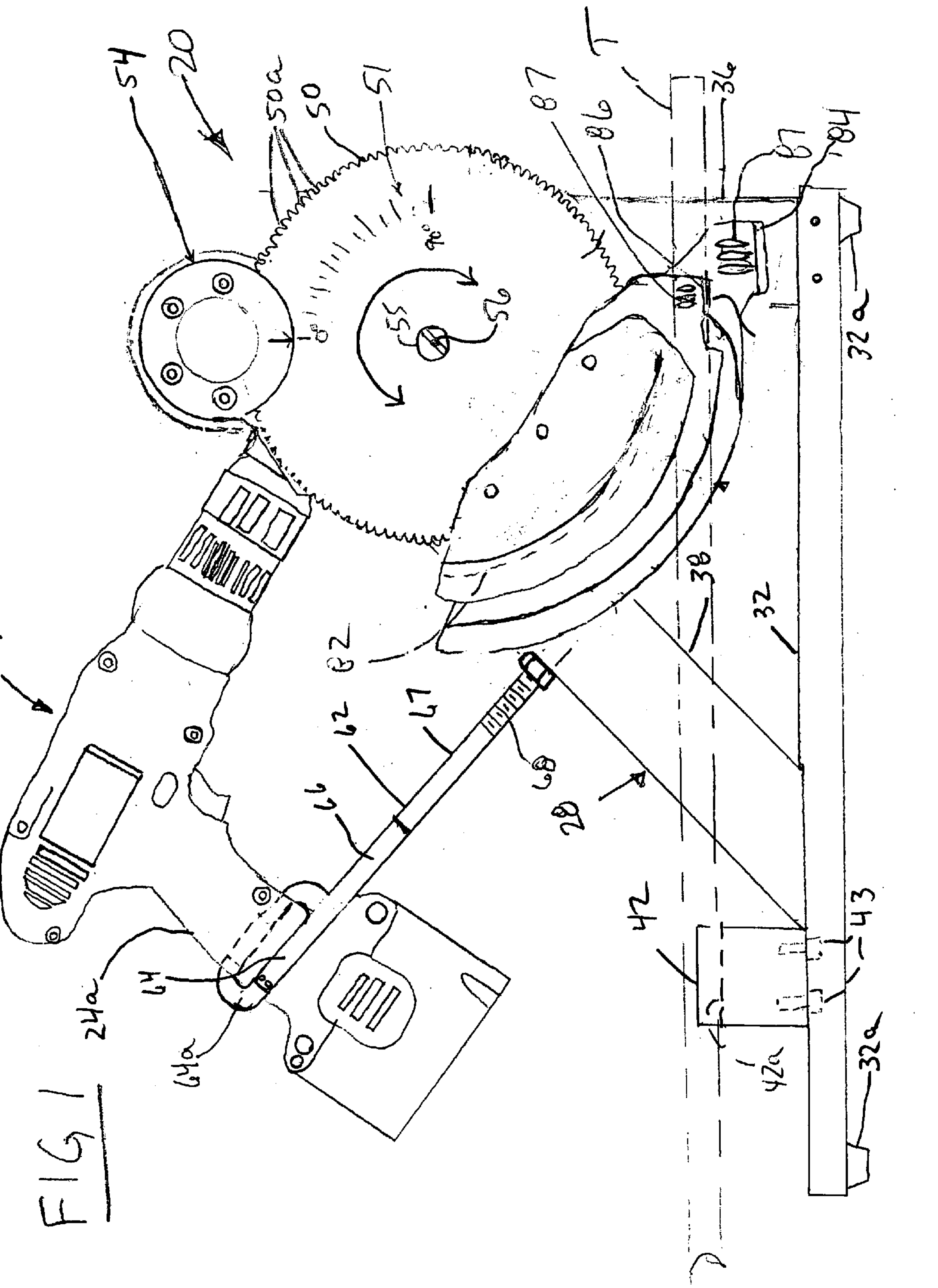

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FIG 1

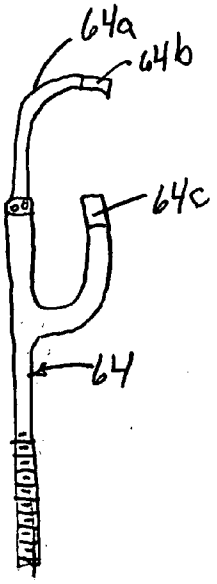


FIG 1A

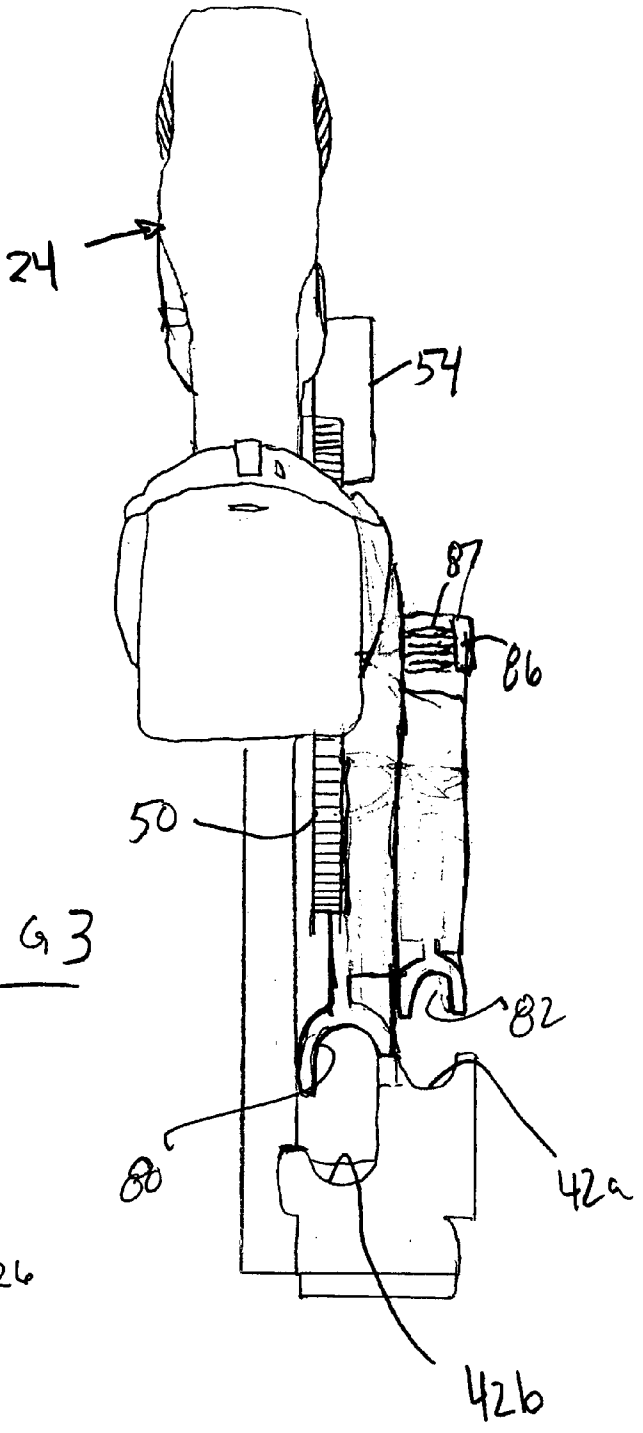


FIG 3

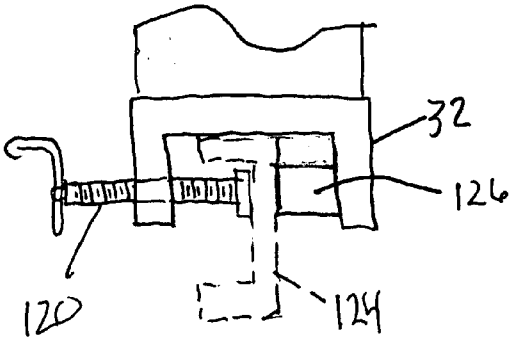


FIG 3A

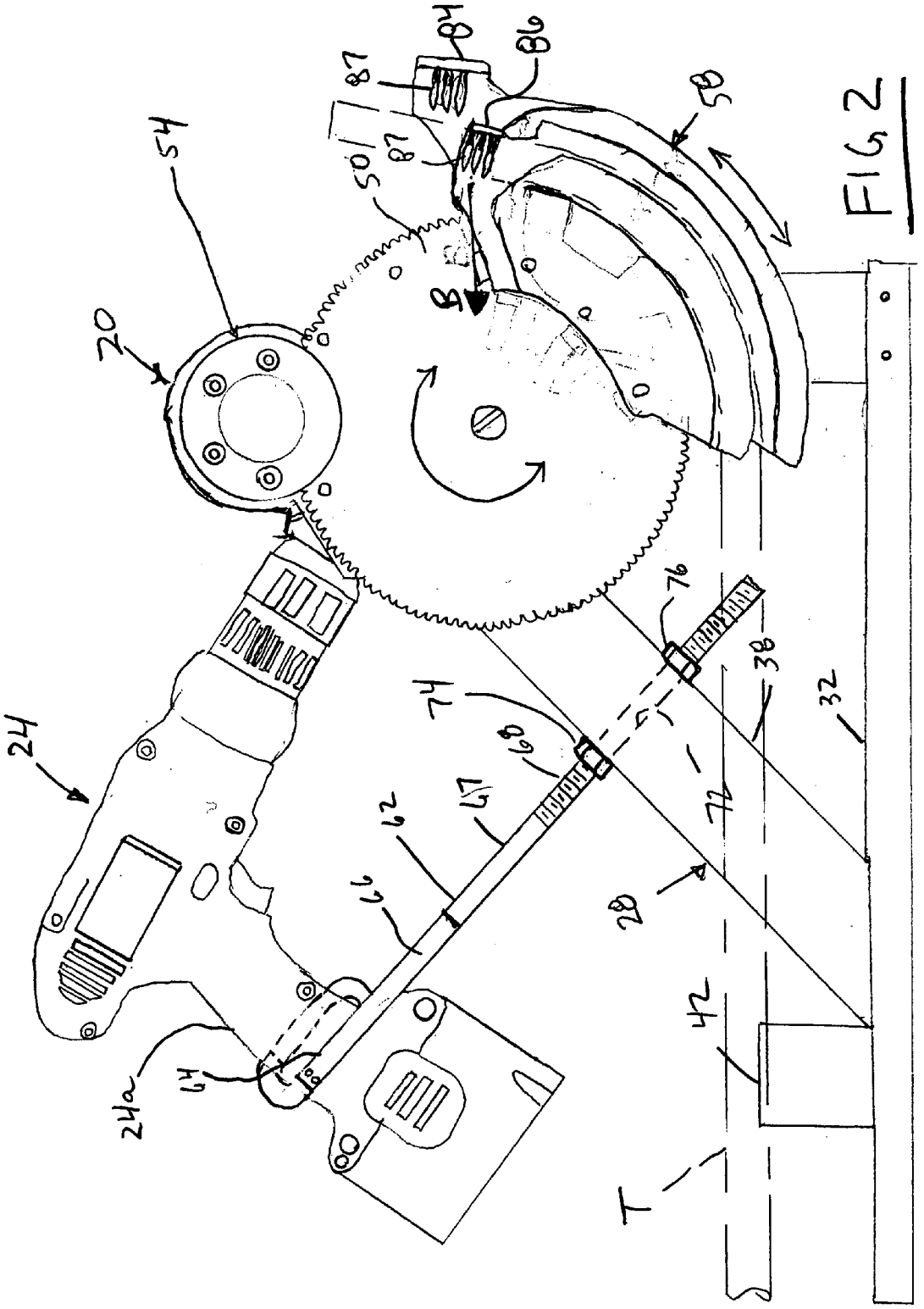


FIG 2

FIG 4A

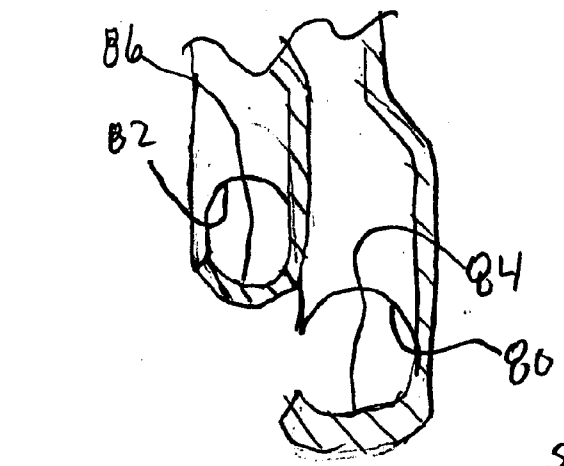
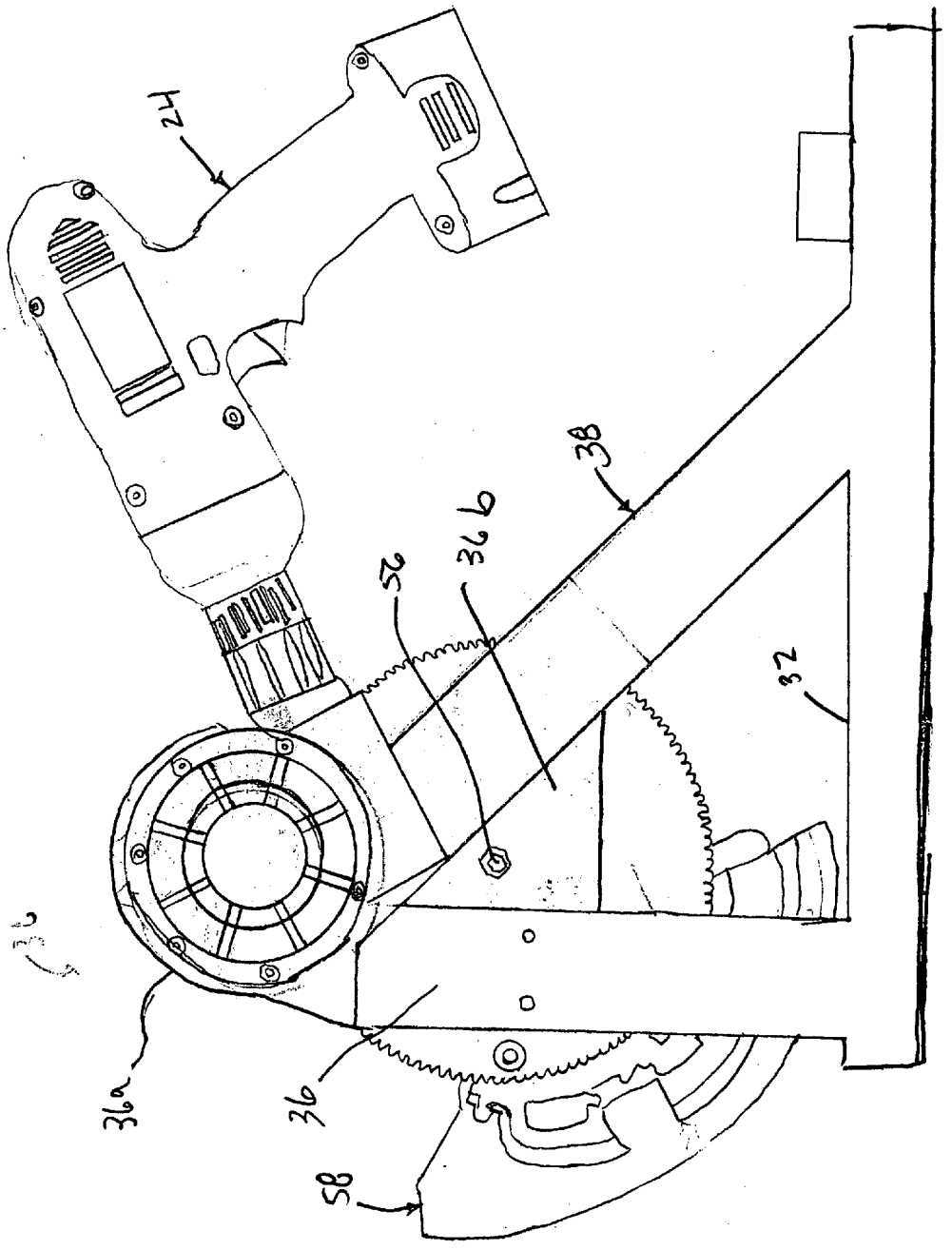


FIG 4

FIG 5



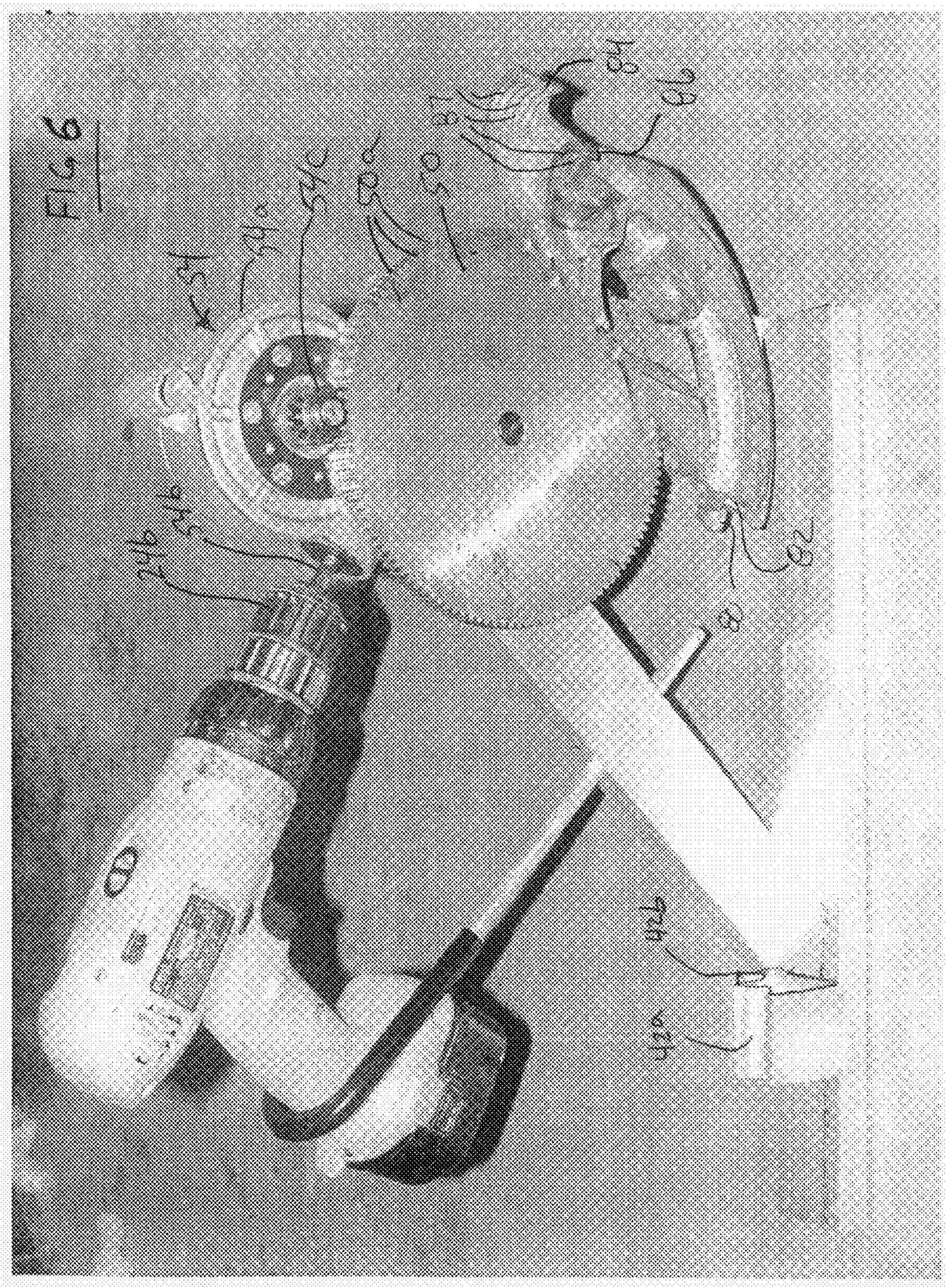


FIG 6

TUBE BENDING APPARATUS

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to tube bending apparatus. Particularly, the present invention is directed to an improved portable tube bending apparatus.

BACKGROUND OF THE INVENTION

[0002] Known tube bending apparatus typically comprise a mandrel and forming member components supported for relative angular displacement about a bending axis. The mandrel has a bending groove extending about the bending axis. A tube positioned between the mandrel and forming member is adapted to be bent during selected relative angular displacement of the mandrel and forming member about the bending axis. Relative angular displacement between the mandrel and forming member can be achieved in a number of different ways.

[0003] In some motor driven benders, the mandrel is mounted on a support and the forming member is mounted on the support for angular displacement relative to the mandrel and is so displaced by a motorized drive arrangement.

[0004] U.S. Pat. Nos. 5,022,249; 4,986,104; and 5,301,530 describe portable tube bending apparatus.

[0005] The present inventors have recognized that a need exists to improve the aforementioned tube benders and to provide a tube bender that is lightweight and easily portable, that is of a simplified construction, and that can bend tubes to variable bend radii.

SUMMARY OF THE INVENTION

[0006] The invention provides an improved portable bending apparatus for bending tubes or other elongated workpieces.

[0007] According to the preferred embodiment, the portable bending apparatus includes a frame, a major gear, a forming member, a tube guide and a gear mechanism. The major gear is mounted rotatably to the frame about a bending axis. The major gear has gear teeth on an outer perimeter thereof. The forming member is fixed to a front side face of the major gear, the forming member having at least one arcuate forming surface and a restraint. The tube guide is mounted to the frame. The gear mechanism has an input connected to a geartrain connected to an output gear. The geartrain provides a speed reduction between the input and the output gear.

[0008] The input is configured to receive rotary input from a handheld motorized driver, such as a portable drill. Alternately, a dedicated, permanently attached electric motor can be mounted to the frame.

[0009] The output gear is enmesh with the gear teeth of the major gear. When a workpiece to be bent is placed on the tube guide, or in some cases simply held by the operator, and within the restraint and against the forming surface, and the input receives rotary motion from the handheld motorized driver, the restraint and the forming surface are driven to orbit about the bending axis and the forming surface bends the workpiece braced between the restraint and the tube guide, or braced between the restraint and the operators hand.

[0010] Preferably, the frame comprises a base bar, a vertical column, and an angular brace. The vertical column is fixed at a base end to the base bar and at an elevated end to a gear mechanism support plate. The angular brace is fixed at a base end to the base bar and at an elevated end to the vertical column. The tube guide is mounted to the base bar.

[0011] A strut can be attached to the frame and extends to a position to engage a body of the motorized driver. The strut is sufficiently rigid to resist reaction torque exerted by the input on the motorized driver. The strut can include a hook end configured to engage a handle of the motorized driver.

[0012] While the present invention is advantageous in connection with portable, motor driven tube benders, it will be appreciated that the invention is applicable to bending other workpieces such as rods.

[0013] Numerous other advantages and features of the present invention will be become readily apparent from the following detailed description of the invention and the embodiments thereof, from the claims and from the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. **1** is a front elevational view of a tube-bending apparatus according to the invention, shown in an initial, tube-loaded orientation;

[0015] FIG. **2** is affront elevational view showing the apparatus of FIG. **1** in a final, tube-bent orientation;

[0016] FIG. **3** is a left side view of the apparatus of FIG. **2**;

[0017] FIG. **4** is a right side view of the apparatus of FIG. **2**;

[0018] FIG. **4**A is a sectional view taken generally along line **4**A-**4**A of FIG. **4**;

[0019] FIG. **4**B is a sectional view taken generally along line **4**A-**4**A of FIG. **4** of an alternate arrangement;

[0020] FIG. **5** is a rear elevational view of the apparatus of FIG. **2**; and

[0021] FIG. **6** is a front perspective view of the apparatus of FIG. **2** with portions removed for clarity; and

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0022] While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail preferred features of the invention. It will be understood, however, that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the specific form of the combination of features that are illustrated and described.

[0023] FIGS. **1** through **6** illustrate an exemplary form of the apparatus **20** of the present invention used to bend a tube T. The apparatus **20** is configured to be used with a portable motorized driver, such as a hand held drill **24**. Alternately, a dedicated, permanently mounted electric motor can be used. The illustrated portable drill is a battery powered drill. FIG. **1** illustrates the apparatus in an initial position with the tube T to be bent loaded into the apparatus. FIGS. **2**-**6** illustrate the apparatus **20** after it has been moved into a final position and the tube T has been bent approximately 90 degrees.

[0024] The apparatus includes a frame **28** comprising a base bar **32**, a vertical column **36**, and an angular brace **38**. The members **32**, **36**, **38** can be rectangular cross section members, solid or hollow. The members can be composed of steel or aluminum, or other material. The members **32**, **36**, **38** can be fastened together, cast together, welded together, or otherwise formed as a single unit. Four rubber feet **32***a* can be mounted to the base bar to support the frame **28** off of a horizontal surface.

[0025] A tube guide **42** is fixed to the base bar **32**, such as by fasteners **43**. Fastening is advantageous in that different guides for different size conduits or tubes can be attached as desired. A main gear **50** and a gear mechanism **54** are mounted to the column **36**. The main gear **50** is rotatably mounted to the column **36** by a bearing **55** about a bending axis **56**. The vertical column **36** can include widened portions or plates **36***a*, **36***b* (FIG. **5**) that are used to mount the gear mechanism **54** and the main gear **50**. The portions **36***a*, **36***b* can also be fixed to the angular brace **38** for rigidity. A forming member or shoe **58** is fixed to the main gear **50**. The shoe **58** can be fixed to the main gear **50** by use of fasteners or by welding. Fastening is advantageous in that different shoes for different size conduits or tubes can be attached as desired. Shoes can include one or more bending surfaces, for example for bending ½ inch, ¾ inch or 1 inch conduits.

[0026] The main gear **50** can include a bending angle scale **51** that indicates the degree of bending of a workpiece during operation of the apparatus.

[0027] A strut **62** (FIGS. **1** and **1**A) is adjustably fastened to the angular brace **38**. The strut **62** is preferably a sturdy steel or aluminum member. The strut **62** includes a U-shaped end portion **64** having a plastic covering **66**, and a shank **67**. The shank **67** can have a threaded region **68** that passes through a hole **72** (FIG. **2**) through the angular brace **38**. Nuts **74**, **76** (FIG. **2**) can selectively and fixedly locate the shank **67** on the angular brace **38**. The U-shaped end portion is configured to engage a handle **24***a* or other portion of the drill **24**. A strap **64***a* having a surface fastener such as a hook and loop fastening surface **64***b* can be connected to one arm of the U-shaped end and can pass over the handle **24***a* and attach to a hook and loop fastener **64***c* adhered to the other arm of the U-shaped end. As an alternate to the threaded region **68** and the nuts **74**, **76**, cotter pins or quick release pins that penetrate through the shank **67** through selectable holes along a series of spaced apart holes could be used. Alternatively the angular brace **38** could have a threaded hole to receive the threaded region **68**. In either case, the strut **62** is releasable to, adjustable toward and away from the handle **24***a* so that the drill **24** can be supported from the apparatus **20**.

[0028] The strut **62** resists opposite reaction torque on the drill handle **24***a* exerted by the gear mechanism **54** due to the drill driving the apparatus **20** and bending the tube T. This reduces the exertion required by an operator of the drill **24** and avoids a sudden twisting torque on the operator's wrist. Also, the strut supports the drill handle **24***a* vertically to resist the torque caused by gravity, i.e. the overhanging load of the weight of the drill about the drill chuck connection to the gear mechanism. This support also relieves the operator the exertion of holding up the drill.

[0029] The shoe **58** includes one or more forming surfaces. In the illustrated embodiment two forming surfaces **80**, **82** are provided. The forming surfaces are generally oriented with a concavity facing away from the bending axis **56**. The forming surface **80** is behind the forming surface **82** in FIG. **1** and also has a greater bending radius measured from the bending axis **56**. The forming surface **80** can be sized to bend a larger diameter tube, such as a 1 inch tube, than the forming surface **82**, such as a ¾ inch tube, since the bending radius is greater. Different forming surfaces can be provided to accommodate different sizes of tubing or other workpieces.

[0030] At an end of each bending surface **80**, **82** a restraint **84**, **86** is fixed to rotate with the bending surface **80**, **82**. Preferably, the restraints **84**, **86** are formed in unitary fashion with the shoe **58**. The restraints **84**, **86** are open, hook-like portions (FIG. **4**A) that allow easy loading and unloading of a tube into the restraint but underlies the loaded tube in a radial direction from the bending axis **56** to exert a radial inward bending force B (FIG. **2**) on the tube as the shoe **58** orbits about the bending axis **56**. The restraints **84**, **86** include gripping teeth **87** formed therein for preventing axial slipping of the tube within the restraint during bending.

[0031] FIG. **6** illustrates the tube guide **42** includes a higher support groove **42***a* in the foreground of FIG. **6** and a lower support groove **42***b* behind the support groove **42***a*.

[0032] Also, FIG. **6** illustrates the gear mechanism **54** having a cover removed for clarity. According to the exemplary embodiment, the gear mechanism **54** was salvaged from a POWERBLADE™ Cable Cutter Model 35-078 available from Ideal Industries Incorporated of Sycamore, Ill., USA. The mechanism includes a geartrain (not shown) within a housing **54***a*. According to the preferred embodiment the turn ratio or reduction of the gear mechanism is 40:1. An input such as an input shaft **54***b* is gripped by a chuck **24***b* of the drill **24**. The input shaft **54***b* communicates rotary energy to the geartrain. The geartrain communicates rotary energy at a reduced speed to an output gear **54***c*. The output gear **54***c* is enmesh with gear teeth **50***a* on the circumference of the main gear **50**. According to the preferred embodiment, the overall turn ratio or reduction between the drill **24** and the main gear **50** is 360:1.

[0033] In operation, the shoe **58** is rotated to a start position as shown in FIG. **1**. The tube is inserted beneath the selected bending surface **80**, **82** and into the respective restraint **84**, **86**. The tube can be supported on the respective groove **42***a*, **42***b* of the tube guide **42**. The tube is now loaded and ready for bending. The drill **24** is actuated to rotate the input shaft **54***b* which drives the geartrain, which drives the output gear **54***c*, which drives the main gear **50**, which orbits the shoe **58** to the position shown in FIG. **2**, or to any selected intermediate position between FIGS. **1** and **2** depending on the angular bend desired, wherein the drill on button is released to turn the drill off. Because an end of the tube was restrained in radial position by the respective restraint **84**, **86** and a straight end of the tube was braced on the tube guide **42**, the bending surface **80**, **82** pressing against the top half of the tube conformed the tube to the contour of the bending surface **80**, **82**. The bent tube T can be unloaded from the apparatus **20**.

[0034] As shown in the alternate section of FIG. **4**B, the restraints **84**, **86** can be hinged along lines **84***a*, **86***a* to open up by swinging about the directions **84** *b*, **86***b* for conduit placement. The restraints are arranged to swing away from the main gear **50** to open. Latches (not shown) can be provided as needed to hold the restraints in the closed position.

[0035] The apparatus **20** provides a portable tube bending apparatus that is configured in an easy to use upright configuration. The apparatus can be driven by a portable electric drill that is also oriented in an easy to use orientation, inclined upwardly toward the user. The apparatus illustrated uses a minimal frame that can be supported and/or attached to scaffolding or lift baskets of construction equipment so that electrical work can proceed effectively at hard to access locations. For attaching to external supports, the base bar **32** can be a channel as shown in FIG. **3**A wherein a side clamp member **120** is threaded into a side of the channel to clamp an external support member **124** within the channel. A block **126** can be fixed, fastened, or placed inside the channel to brace a back-

side of the support member **124**. A plurality of side clamp members **120** can be provided spaced along a length of the base bar **32**.

[0036] From the foregoing, it will be understood that numerous variations and modifications may be effected without departing from the true spirit and scope of the novel concept of the invention. It is to be understood that no limitation with respect to the specific method, apparatus, and product illustrated herein is intended or should be inferred. It is, of course, intended to cover by the appended claims all such modifications as fall within the scope of the claims.

The invention claimed is:

1. A portable bending apparatus for bending tubes, comprising:

a frame;

a major gear mounted rotatably to said frame about a bending axis, said major gear having gear teeth on an outer perimeter thereof;

a forming member carried on a front side of said major gear, said forming member having an arcuate forming surface and a restraint;

a tube guide mounted to said frame;

a gear mechanism having an input connected to a geartrain connected to an output gear, said geartrain providing a speed reduction between the input and the output gear, wherein said input is configured to receive rotary input from a motor;

said output gear enmesh with said gear teeth of said major gear; and

wherein when a tube to be bent is placed on said tube guide and within said restraint and against said forming surface and when said input receives rotary motion from a motor, said restraint and said forming surface are driven to orbit about said bending axis and said forming surface bends said tube between said restraint and said tube guide.

2. The portable bending apparatus according to claim **1**, wherein said frame comprises a base bar, a vertical column, and an angular brace, said vertical column fixed at a base end to said base bar and at an elevated end to said gear mechanism support plate, said angular brace fixed at a base end to said base bar and at an elevated end to said vertical column, said tube guide mounted to said base bar.

3. The portable bending apparatus according to claim **2**, further comprising a strut attached to said frame and extending to a position to engage a body of said motor to resist torque.

4. The portable bending apparatus according to claim **3**, wherein said strut includes a U-shaped end configured to engage a handle of said motor.

5. A portable bending apparatus for bending workpieces, comprising:

a frame;

a major gear mounted rotatably to said frame about a bending axis, said major gear having gear teeth on an outer perimeter thereof;

a forming member carried on a front side of said major gear, said forming member having an arcuate forming surface and a restraint;

a gear mechanism having an input connected to a geartrain connected to an output gear, said geartrain providing a speed reduction between the input and the output gear, wherein said input is configured to receive rotary input from a motor;

said output gear enmesh with said gear teeth of said major gear; and

wherein when a workpiece to be bent is placed within said restraint and against said forming surface and said workpiece is restrained at a reaction force position located along said workpiece on a side of said forming surface opposite said restraint and said input receives rotary motion from a motor, said restraint and said forming surface are driven to orbit about said bending axis and said forming surface bends said workpiece between said reaction force position and said restraint.

6. The portable bending apparatus according to claim **5**, wherein said frame comprises a base bar, a vertical column, and an angular brace, said vertical column fixed at a base end to said base bar and at an elevated end to said gear mechanism support plate, said angular brace fixed at a base end to said base bar and at an elevated end to said vertical column.

7. The portable bending apparatus according to claim **5**, wherein said workpiece comprises a tube and said apparatus comprises a tube guide at said reaction force position, mounted to said frame.

8. The portable bending apparatus according to claim **5**, further comprising a strut attached to said frame and extending to a position to engage a body of said motor to resist torque.

9. The portable bending apparatus according to claim **8**, wherein said strut includes a U-shaped end configured to engage a handle of said motor.

10. A portable bending apparatus for bending workpieces, comprising:

a frame;

a major gear mounted rotatably to said frame about a bending axis, said major gear having gear teeth on an outer perimeter thereof;

a forming member fixed to a front side of said major gear, said forming member having an arcuate forming surface and a restraint;

a gear mechanism having an input shaft connected to a geartrain connected to an output gear, said geartrain providing a speed reduction between the input shaft and the output gear, wherein said input shaft is configured to receive rotary input from a portable handheld motorized drill;

a portable handheld motorized drill having a chuck to engage said input shaft;

said output gear enmesh with said gear teeth of said major gear; and

wherein when a workpiece to be bent is placed within said restraint and against said forming surface and said workpiece is restrained at a reaction force position located along said workpiece on a side of said forming surface opposite said restraint and said input receives rotary motion from a handheld motorized drill, said restraint and said forming surface are driven to orbit about said bending axis and said forming surface bends said workpiece between said reaction force position and said restraint.

11. The portable bending apparatus according to claim **10**, wherein said frame comprises a base bar, a vertical column, and an angular brace, said vertical column fixed at a base end to said base bar and at an elevated end to said gear mechanism support plate, said angular brace fixed at a base end to said base bar and at an elevated end to said vertical column.

12. The portable bending apparatus according to claim **10**, wherein said workpiece comprises a tube and said apparatus comprises a tube guide at said reaction force position, mounted to said frame.

13. The portable bending apparatus according to claim **10**, further comprising a strut attached to said frame and extending to a position to engage a handle of said drill to resist reaction torque.

14. The portable bending apparatus according to claim **13**, wherein said strut includes a hook end configured to engage a handle of said drill.

15. The portable bending apparatus according to claim **10**, wherein said frame comprises a base bar, a vertical column, and an angular brace, said vertical column fixed at a base end to said base bar and at an elevated end to said gear mechanism support plate, said angular brace fixed at a base end to said base bar and at an elevated end to said vertical column and where said base bar comprises a clamp mechanism to secure said frame to external structure.

* * * * *