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Gilmore

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[54] **PORTABLE CUTTING APPARATUS**

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[73] Assignee: **The United States of America as represented by the United States Department of Energy,** Washington, D.C.

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[51] **Int. Cl.**[4] **B24B 21/00**

[52] **U.S. Cl.** ..... **51/135 R;** 30/92; 30/166 R; 82/101; 83/651.1; 51/241 S; 51/328

[58] **Field of Search** ..... 51/99, 135 R, 142, 147, 51/170 R, 170 EB, 217 R, 217 P, 290, 241 R, 241 S, 328, DIG. 5; 125/21; 82/101; 269/32, 34, 156; 30/92, 166 R; 83/651.1, 794

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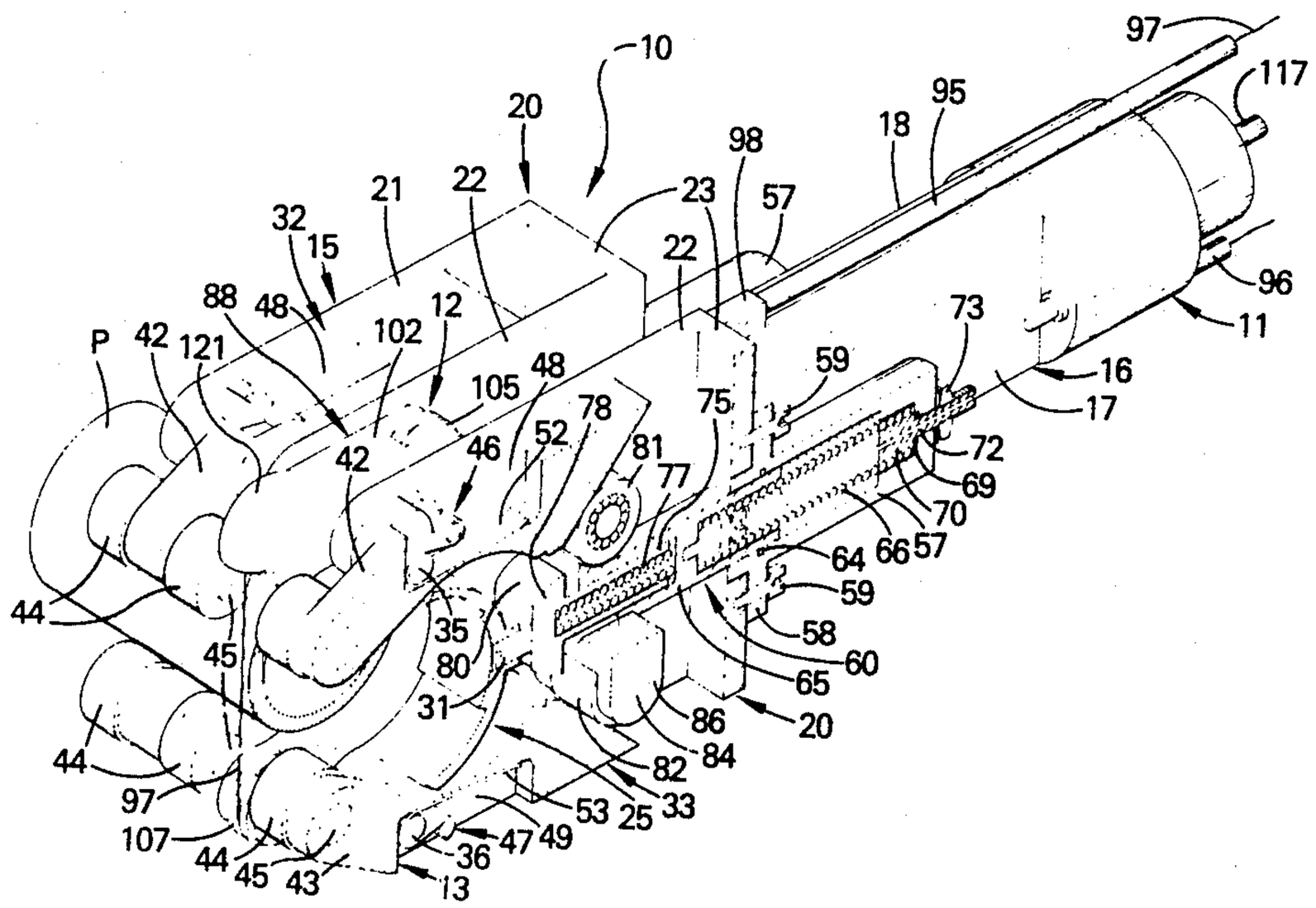
[57] **ABSTRACT**

A remotely operable, portable cutting apparatus detachably secured to the workpiece by laterally spaced clamp assemblies engageable with the workpiece on opposite sides of the intended line of cut. A reciprocal cutter head is mounted between the clamp assemblies and is provided with a traveling abrasive cutting wire adapted to sever the workpiece normal to the longitudinal axis thereof. Dust and debris are withdrawn from the cutting area by a vacuum force through a nozzle mounted on the cutting head.

15 Claims, 7 Drawing Figures



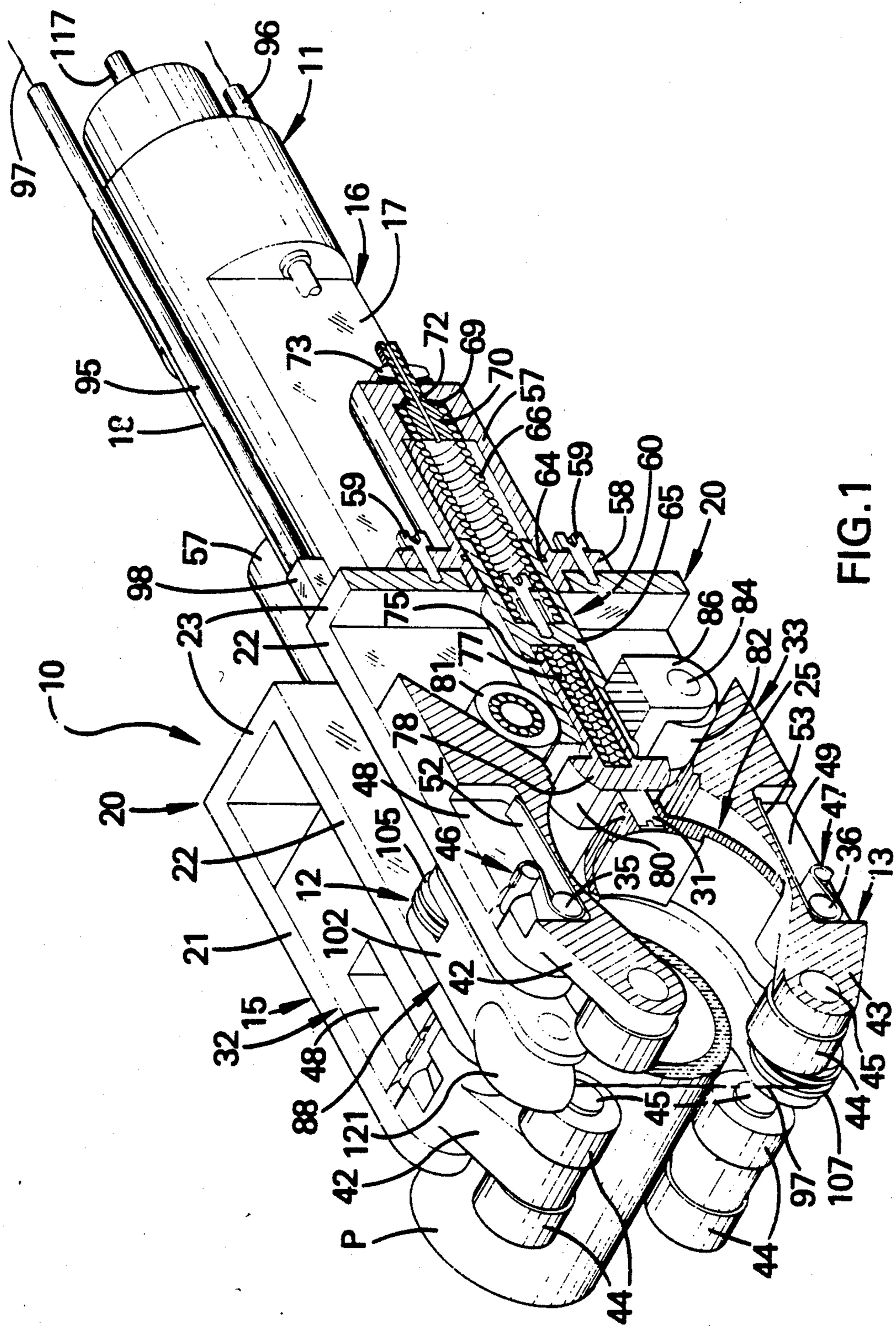

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FIG.1

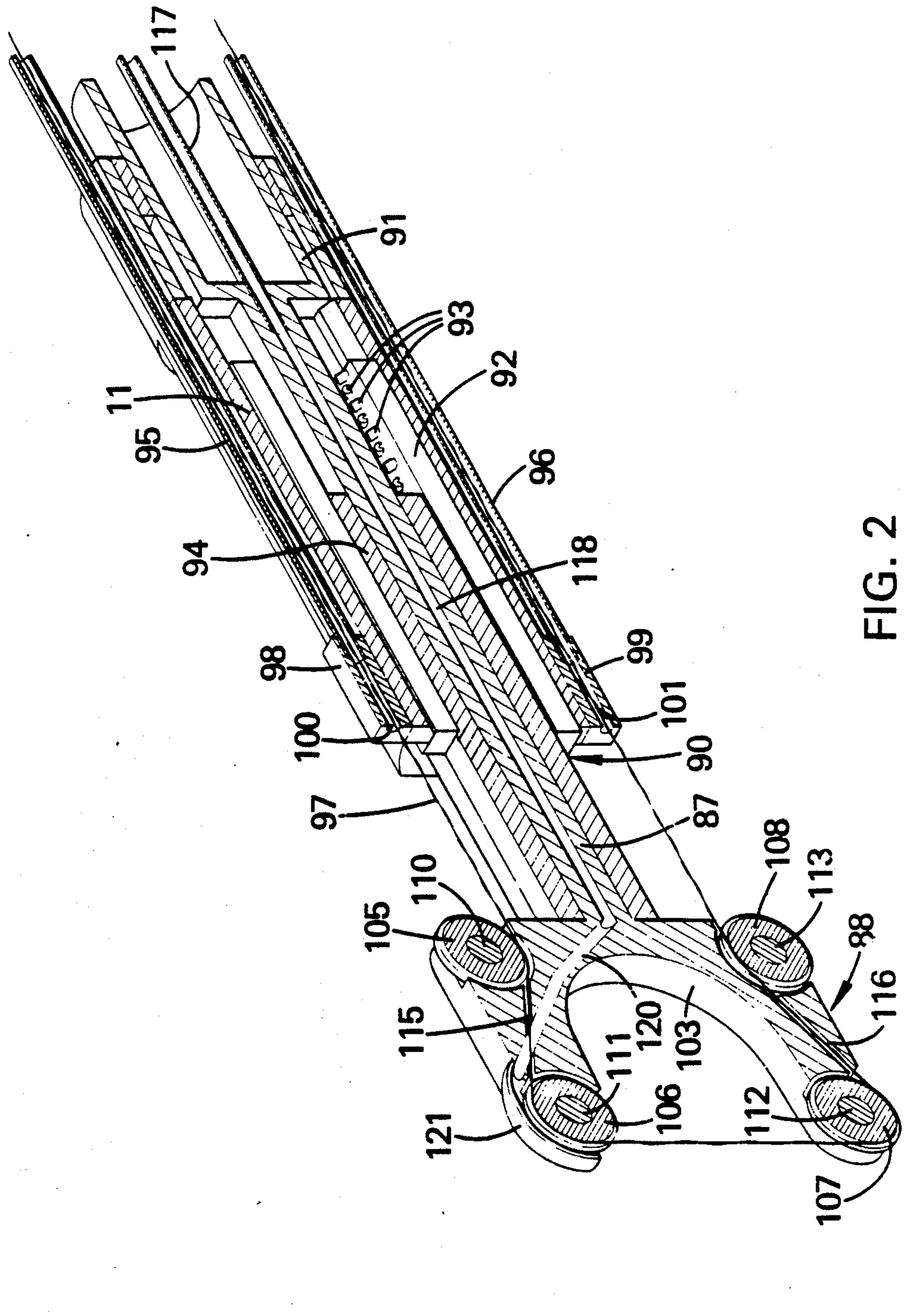
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FIG. 2

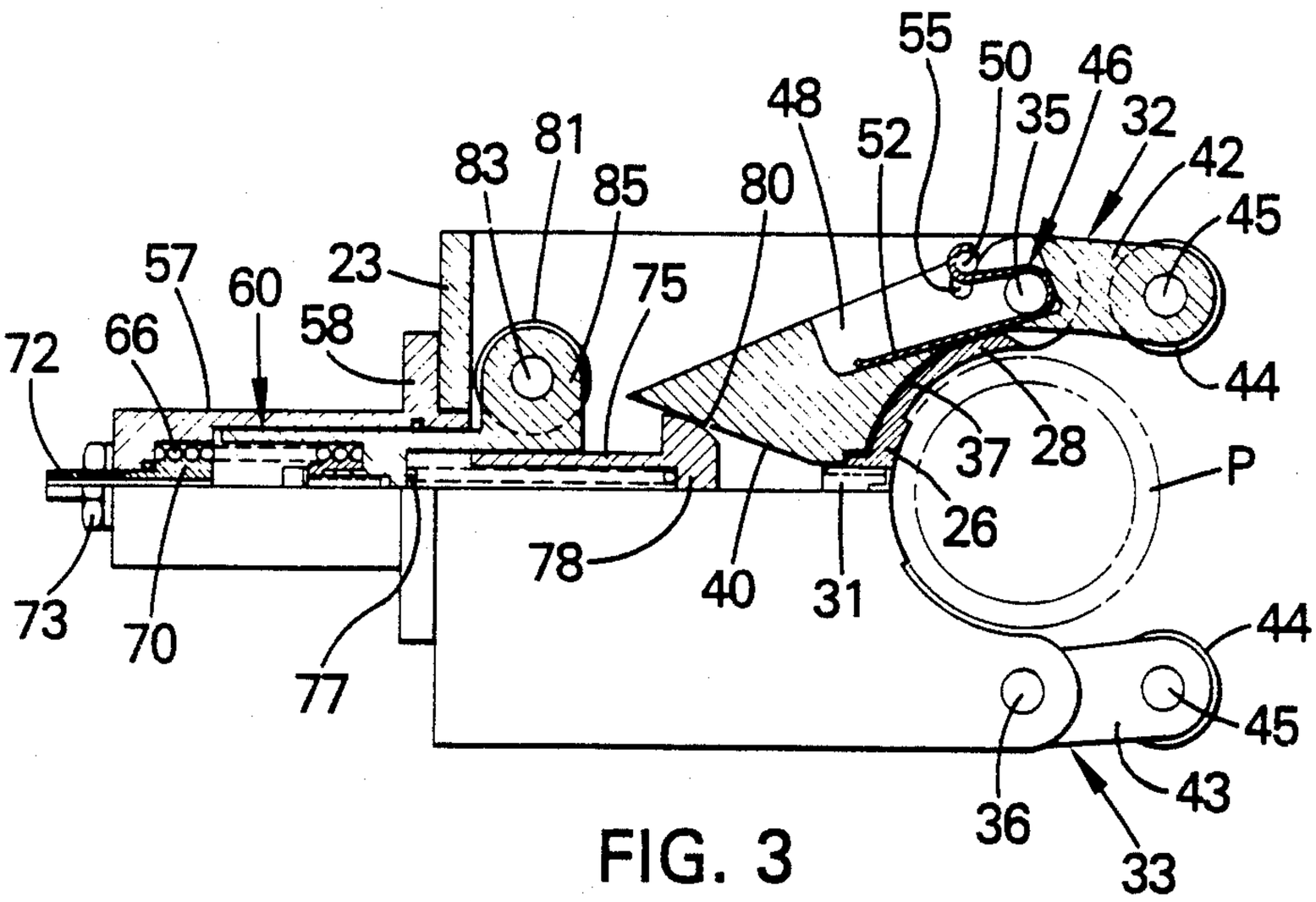
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FIG. 3

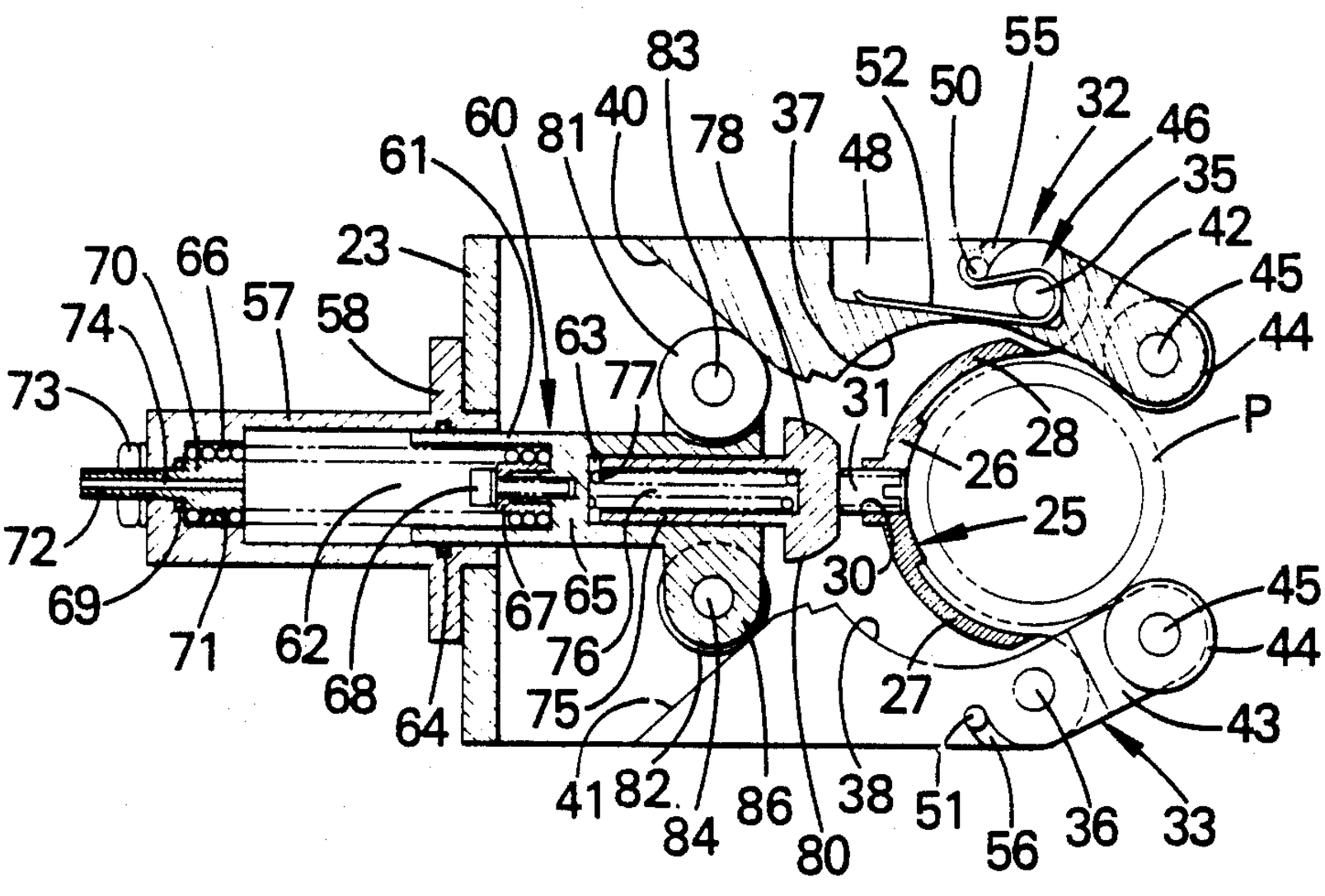
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FIG. 4

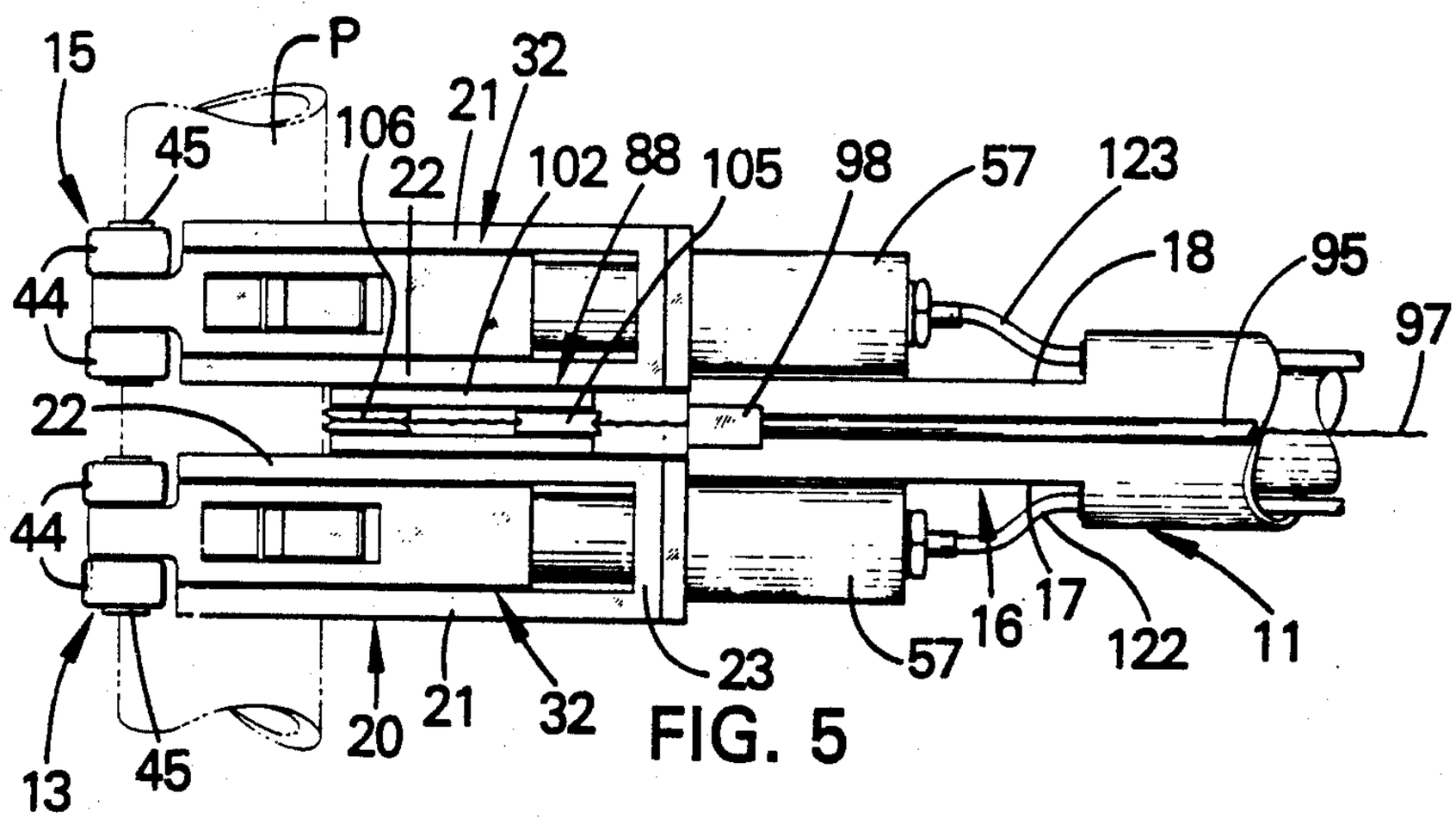

FIG. 5

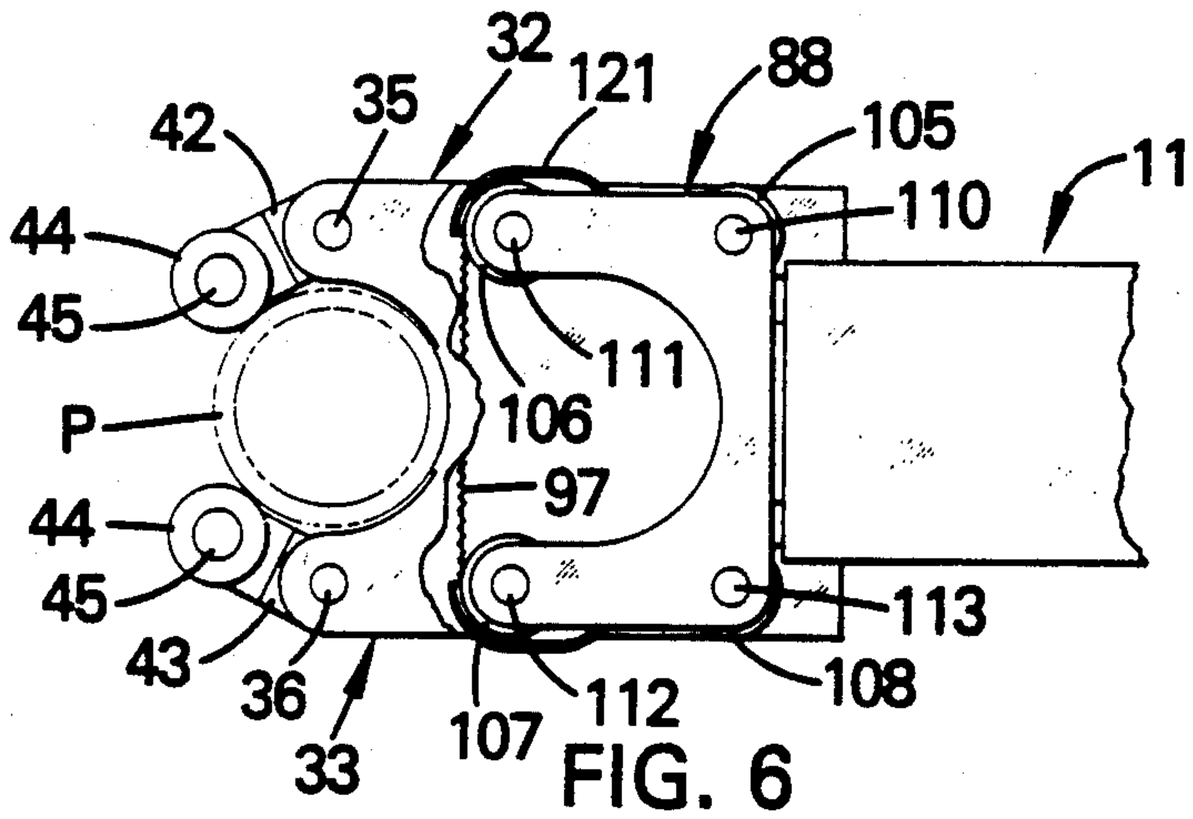

FIG. 6

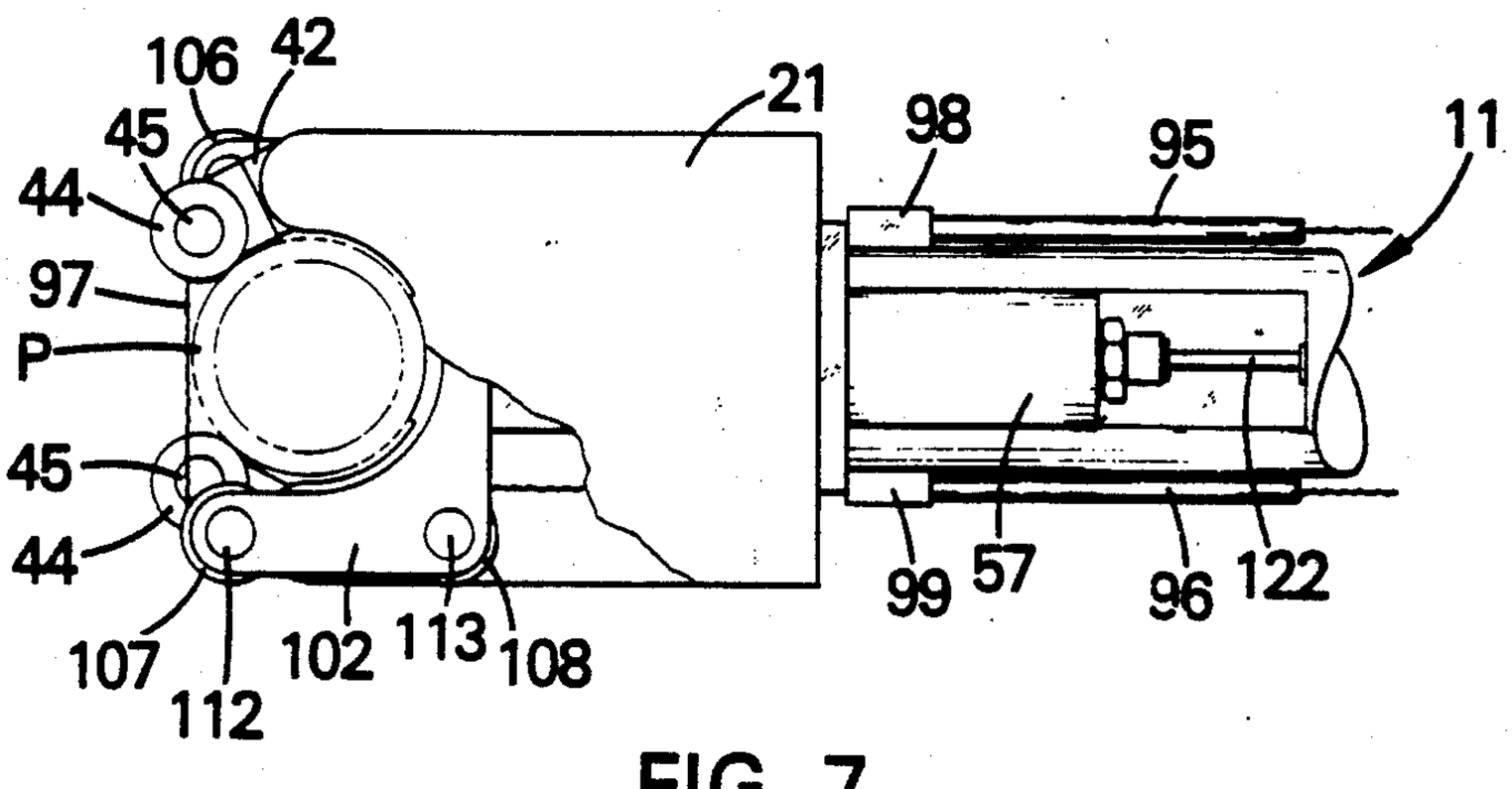

FIG. 7

PORTABLE CUTTING APPARATUS

The U.S. Government has rights in this invention pursuant to Contract No. DE-ACO6-76FFO2170 between the U. S. Department of Energy and Westinghouse Electric Corporation.

BACKGROUND OF THE INVENTION

This invention relates generally to a portable cutting apparatus and, more particularly, to a remotely controlled portable cutting apparatus detachably secured to the workpiece intended to be severed.

In nuclear reactor facilities, much of the maintenance and servicing must be done remotely to prevent radioactive contamination of the personnel performing these tasks. Such work is further complicated by space limitations due to the piping, accessory components and other hardware typically found in these environments. For example, the remote severing or removing of a section of a pipe located in a radioactive containment, such as a typical glovebox for example, and which is congested with auxillary hardware and piping poses problems. Conventional portable pipe cutters, while admirably serving the purposes for which they were designed, generally are not suited for these special applications. Generally, they incorporate metal removal tooling, such as milling, turning or reciprocating saws, which are large and bulky and usually are provided with single clamps that require manual attachment to the piping. Moreover, the motor and control components are in close proximity to the workpiece, contributing to the bulk and weight of the apparatus that must be handled. Also, these known pipe cutters often require stress-loaded power drive components causing wear and deterioration of their gears and shafts, accompanied by dulling and chattering of the cutting tools with consequent breakage and failure.

Accordingly, it is an object of the present invention to obviate the above-noted shortcomings by providing a new and improved portable cutting apparatus especially adapted for remote operation.

It is another object of this invention to provide the foregoing cutting apparatus with a novel tool clamping arrangement for firmly securing the workpiece on opposite sides of the intended cut and insuring absolute square cutting normal to the axis of the workpiece.

It is a further object of the present invention to provide a new and improved portable cutting apparatus which is simple and strong in construction, compact and lightweight, durable in use for repeated operations, and easily manipulated in space restricted areas.

These and other objects, advantages, and characterizing features of the present invention will become clearly apparent from the ensuing detailed description of an illustrative embodiment thereof, taken together with the accompanying drawings wherein like reference numerals denote like parts throughout the various views.

SUMMARY OF THE INVENTION

A portable cutting apparatus including an elongated frame having laterally spaced clamp assemblies for firmly attaching the cutting apparatus to the workpiece to be severed. The clamp assemblies each include a pair of pivotal jaws acutated to engage the workpiece on opposite sides of the intended line of cut. A reciprocal cutting head having a traveling cutting wire thereon is mounted on the frame between the clamp assemblies and, with the workpiece securely clamped, is advanced to the workpiece for severing the same.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view, partially in section, of a cutting apparatus constructed in accordance with this invention;

FIG. **2** is a perspective, longitudinal sectional view of the cutter mechanism of this invention;

FIG. **3** is a side elevational view, partially in section, showing the clamping arrangement forming a part of this invention in an open position;

FIG. **4** is a longitudinal sectional view, partially in elevation, showing the clamping arrangement in a closed position;

FIG. **5** is a top plan view of the cutting apparatus of FIG. **1**, showing the cutter mechanism in a retracted position;

FIG. **6** is a side elevational view, with parts broken away for clarity, showing the cutter mechanism immediately prior to advancement into the workpiece; and

FIG. **7** is a side elevational view, with parts broken away, showing the cutter mechanism immediately after a cutting operation.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in detail to the illustrative embodiment depicted in the accompanying drawings, there is shown in FIG. **1** a portable cutting apparatus, comprehensively designated **10**, comprising an elongated frame or mast **11** supporting a cutter mechanism **12** and a pair of dual-clamp assemblies **13** and **15** disposed on opposite sides of the cutter mechanism **12**. The cutter mechanism **12** and clamp assemblies **13** and **15** are movable along with the mast **11**, as well as relative thereto when actuated. The mast **11** is formed with a reduced width portion **16** having flat exterior opposite surfaces **17** and **18** for the attachment of other components thereto.

The clamp assemblies **13** and **15** are mirror images of each other and are identical in construction and operative in the same manner. Accordingly, it is believed that a detailed description of only one, say clamp assembly **13**, will suffice for both and the same reference numerals will be applied to identical elements. Clamp assembly **13** comprises a housing **20** having a pair of laterally spaced side walls **21** and **22** and a rear end wall **23**. The front end of housing **20** is open and supports an arcuately shaped shoe **25** of a generally C-shaped configuration in cross section adapted to engage the pipe P to be severed. As best shown in FIGS. **3** and **4**, shoe **25** is formed with a thick central portion **26** and thinner opposite end portions **27** and **28**. The central portion **26** is formed with a tapped opening **30** adapted to receive a threaded stop member **31**. The curved inner surface of shoe central portion **26** serves to automatically position the apparatus **10** relative to the pipe P when advanced thereto.

A pair of clamping jaws **32** and **33** are mounted within the housing **20** for pivotal movement about pivot pins **35** and **36** secured at their respective opposite ends in side walls **21** and **22**. The jaws **32** and **33** are formed with inner surfaces having forward arcuate portions **37** and **38** complementary in shape to the outer surface of shoe **25** and straight rear portions **40** and **41** retreating away from portions **37** and **38** at angles relative to a true horizontal in a diverging relation. The jaws **32** and **33** are provided with forward portions **42** and **43**, respec-

tively, extending at angles in a converging relation relative to the outer surfaces of the major portions of jaws **32** and **33**. The forward portions **42** and **43** are provided with dual anti-friction rollers **44**, respectively, on opposite sides thereof and are rotatably journaled on shafts **45** extending transversely through portions **42** and **43**.

Means are provided for biasing the jaws **32** and **33** in their open or non-clamping position shown in FIG. **3**. Such means include specially configurated leaf springs **46** and **47** in recesses **48** and **49** formed in the jaws **32** and **33**. These springs are anchored at their one ends about studs **50** and **51** and extend forwardly therefrom to and about pivot pins **35** and **36** and then rearwardly to form elongated portions **52** and **53** disposed against the bottom walls defining recesses **48** and **49**. The force exerted by spring portions **52** and **53** bias the rear portions of jaws **32** and **33** inwardly toward each other as shown in FIG. **3** to maintain the forward portions **42** and **43** in an open position. The studs **50** and **51** are affixed to the housing inner wall **22** and are accommodated in arcuate slots **55** and **56** formed in the jaws **32** and **33**.

The means for actuating jaws **32** and **33** to their closed or clamping positions includes a fluid cylinder **57** welded or otherwise fixedly secured to the flat portion **17** of mast **11** and having a flange **58** rigidly secured to the rear end wall **23** of housing **20** by fasteners **59**. The cylinder **57** is provided with a reciprocal piston assembly **60** having an elongated cylindrical body **61** formed with opposite cavities **62** and **63** separated by a central web **65**. An O-ring seal **64** is disposed in a suitable groove formed in the inner wall surface of cylinder **57** to provide a fluid tight seal between the piston assembly **60** and cylinder **57**. A helical tension spring **66** is disposed in the cavity **62** and is fixed at one end on a peripherally grooved retainer **67** secured in place against the web **65** by a fastener **68** threaded into the web **65**. The other end of the spring **66** is fixed on a peripherally grooved retainer **70** mounted in a cylindrical recess **71** formed in cylinder **57** near the outer end thereof. The retainer **70** is formed with an elongated threaded stem **72** projecting axially through the rear end of cylinder **57** for receiving a nut **73**. An O-ring seal **69** is disposed in a suitable groove about the stem **72** to provide pressure sealing between the latter and cylinder **57**. An axial passage **74** is provided in threaded stem **72** for directing fluid under pressure from a suitable source (not shown) into the cylinder **57**.

A plunger **75** is mounted in cavity **63** for reciprocal movement therein and is formed with a cavity **76** for receiving a helical compression spring **77** bearing at its one end against the end wall defining cavity **76** and at the other end against web **65**. The forward end of plunger **75** is formed with an enlarged head or bumper **78** adapted to engage stop **31**. The bumper head **78** is provided with a slightly curved peripheral surface **80** functioning as a cam for engagement with the opposite surface portions **40** and **41** of jaws **32** and **33** for pivoting them to initiate the clamping operation, as will hereinafter be more fully explained. The piston body **61** also is provided with upper and lower cam rollers **81** and **82** journaled for rotation on shafts **83** and **84** mounted in upper and lower brackets **85** and **86** forming a part of the piston assembly **60**.

The cutter mechanism **12** is mounted between the clamp assemblies **13** and **15** for bodily movement therewith and for reciprocal movement relative thereto. As best shown in FIG. **2**, the mechanism **12** comprises a

stem **87** mounted for reciprocal movement within the mast **11** and having an enlarged cutting head **88** at the forward end thereof. The stem **87** is provided with an enlarged diameter portion **91** at the rear end thereof which projects axially rearwardly past the end of mast **11**. A cross roller bearing slide **90**, of the type manufactured by Micro Slides Inc. of Westbury, N.Y., is interposed between the stem **82** and the wall of mast **11** to facilitate anti-friction sliding movement therebetween. The cross roller bearing slide **90** includes fixed rails **92** secured to the inner wall surface of mast **11** for supporting a plurality of angularly inclined roller bearings **93** and slide rails **94** moveable thereon and attached to the forward portion of stem **87**.

Upper and lower guide tubes **95** and **96** are located on the exterior of mast **11** for guiding the cutting wire **97** employed to sever the workpiece. These tubes **95** and **96** are connected at their forward ends to guide blocks **98** and **99** fixedly secured to the outer surface of the mast **11**. The guide blocks **98** and **99** are formed with through bores **100** and **101**, respectively, coaxially aligned with the guide tubes **95** and **96**.

The cutting head **88** includes a generally flat plate-like body **102** having a generally arcuately shaped cut-out section of generally semi-circular shape and defined by an inner curved wall surface **103**. The head **88** is provided with a pair of upper, longitudinally spaced, grooved pulleys **105** and **106** and a pair of lower, longitudinally spaced, grooved pulleys **107** and **108**. The pulleys **105–14 108** are mounted for rotation on shafts **110–113**, respectively, mounted on the cutting head **88** adjacent the four corners thereof. An internal passage **115** extends diagonally between the lower end of pulley **105** and the upper end of pulley **106**. Another passage **116** extends diagonally between the lower end of pulley **107** and the upper end of pulley **108**. Thus, a path for the cutting wire **97** is provided from a suitable source (not shown) through the inlet lower guide tube **96** to the upper end of pulley **108**, passage **116**, about pulley **107**, vertically upwardly to and about pulley **106**, passage **115**, the lower end of pulley **105** and return through outlet upper tube **96** to the source. Suitable means (not shown) are provided for feeding the wire at a high rate of speed through this path. Likewise, a suitable power means, such as a stepping electric motor for example, can be employed to advance and retract the stem **87**, as required.

In order to remove debris and dust resulting from the cutting operation, the apparatus **10** is provided with vacuum means. Such means include an elongated conduit **117** leading from a suitable vacuum source (not shown) and connected to the stem **87** which is formed with a central passage **118** coaxially aligned with the conduit **117**. A passage **120** is formed in cutting head **88** and communicates at its outer end with central passage **118** and at its inner end with a curved nozzle **121** directed downwardly toward the work area and along the vertical portion of the cutting wire **97**.

The cutting wire **97** preferably is formed from drawn and tempered high-tension material, such as stainless steel, to provide strength, durability and flexibility. The cutting wire **97** is coated with a desirable abrasive such as diamond, boron nitride, silicon carbide or aluminum oxide, for example. These abrasives can form with the selected material of the cutting wire a firm bond. The wire is advanced at speeds ranging from 1,000 to 3,500 surface feet per minute (sfm) for achieving smooth, severed edge finishes from 35 to 40 microinches.

In operation with the clamping jaws **32** and **33** in an open position (FIG. **3**) and the cutter head **88** retracted as shown in FIG. **5**, the cutting apparatus **10** is advanced in an axial direction to the workpiece, pipe P, until the central portion **26** of shoe **25** engages with pipe P. The shoe **25**, as well as the de-activated clamping jaws **32** and **33**, provide a natural socket for initial pipe engagement. Fluid under pressure is then directed from a suitable source (not shown) through conduits **122** and **123** and passages **74** into the two cylinders **57** to activate them in unison. The pressure in each cylinder **57** overcomes the bias of spring **66** to advance the piston assembly **60**, carrying plunger **75** therewith to initiate the clamping operation and pivot the jaws **32** and **33** about pins **35** and **36** by the camming action of bumper **78**. This action continues until the bumper **78** engages stop **31**, leaving the rear ends of jaws **32** and **33** sufficiently spread apart to permit engagement of cam rollers **81** and **82** therewith. Continued advancement of the piston assembly **60** compresses spring **77** within the plunger **75** while advancing the rollers **81** and **82** to effect further pivoting of jaws **32** and **33** until the several rollers **44** firmly engage the pipe P. The engagement of the laterally spaced upper and lower dual rollers **44** along the outer side of the pipe P and the shoe central portion **26** at the inner side thereof effects a three point, self-aligning clamping action firmly securing the apparatus **10** to the pipe P while accurately and precisely positioning the cutting head **88** for a true 90° square cut. The pivoting of jaws **32** and **33** compresses or otherwise loads the leaf springs **46** and **47** as shown in FIG. **4**.

Once the pipe is firmly clamped by jaws **32** and **33**, the abrasive cutting wire **97** is set in motion at the appropriate speed and cutting head **88** is advanced from its retracted position shown in FIG. **6** toward the pipe P. The traveling wire penetrates the inner side of the pipe and slices therethrough as the cutter head is advanced relative to the clamp assemblies **13** and **15**. The debris resulting from the cutting operation is gathered by a strong vacuum force through the nozzle **121**. The three-point dual clamping arrangement on opposite sides of the cutting head **88** prevents the severed pipe ends from pinching the traveling cutting wire **97** before the cut is completed.

After the cutting operation, the cutting head **88** is retracted and pressure from each cylinder **57** is vented, allowing the influence of springs **66** and **77** to return the piston assembly **60** to its normal, retracted position. The rollers **81** and **82** are retracted and disengaged from the rear ends of jaws **32** and **33**, in turn, disengaged from the pipe P and returned to their open position by virtue of the bias of leaf springs **46** and **47**. If a pipe section is to be removed, the cutting apparatus **10** is relocated to another position along the pipe to sever the pipe at such position, the severed section being maintained in place by one of the clamp assemblies **13**, **15**. The clamp assembly attached to the severed section remains clasped while the other clamp assembly can be disengaged, thereby permitting removal of the severed section by the retraction of the entire cutting apparatus **10**.

All operations, including cutting apparatus movement, clamp actuation, cutting wire travel, and cutter head feed are controlled by equipment and components located remotely from the workpiece, thereby permitting the use of conventional power sources, drives and feed arrangements, while protecting personnel. Moreover, this portable cutting apparatus is compact and lightweight, requiring a radial clearance of only about

1.5 inches beyond the outer surface of the pipe P, whether the latter is of a 2 inch diameter as depicted in the drawings or substantially larger, such as an 8 inch diameter pipe for example. Additionally, the apparatus **10** is operative under substantially vibration free, low-powered loadings to enhance long-term, repeatable service. Also, it should be appreciated that the apparatus **10** can be employed in any angular orientation so that the cutting wire can travel vertically downwardly or horizontally, if desired, or at any angular attitude relative to a true vertical or horizontal.

From the foregoing, it is apparent that the objects of the present invention have been fully accomplished. As a result of this invention, a remotely operated and controlled portable cutting apparatus is provided for detachable engagement with the workpiece to be severed. The clamping arrangement provides for three-point contact on either side of the intended line of cut to effect self alignment in a manner positioning the cutting wire precisely normal to the axis of the workpiece. This arrangement produces a straight, square cut and precludes the severed pipe edges from pinching the traveling cutting wire.

The foregoing description of a preferred embodiment of this invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and obviously many modifications and variations are possible in light of the above teaching. The embodiment was chosen and described in order to best explain the principles of this invention and its practical application to thereby enable others skilled in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto.

I claim:

1. A portable pipe cutting apparatus comprising: an elongated frame, a pair of laterally spaced clamp assemblies mounted on said frame, each of said clamp assemblies comprising a pair of clamping jaws mounted on said frame for pivotal movement between an inoperative position and a work engaging position, means normally biasing said jaws into said inoperative position, means for actuating said jaws into said work engaging position to clamp a workpiece therebetween, a reciprocal cutter mechanism mounted on said frame between said clamp assemblies and including a traveling cutting wire, and means for advancing said cutter mechanism relative to said clamp assemblies to bring said cutting wire into engagement against said workpiece for severing said workpiece.

2. A cutting apparatus according to claim **1**, wherein said clamping jaws of each clamp assembly are mounted for pivotal movement about parallel axes extending generally normal to the longitudinal axes of said jaws.

3. A cutting apparatus according to claim **1**, wherein said clamping jaws are elongated members formed with opposed cam surfaces adjacent one ends thereof and provided with a pair of laterally spaced work engaging elements, respectively, at the other ends thereof.

4. A cutting apparatus according to claim **3**, wherein said actuating means comprises first cam means engagable with said opposed cam surfaces for initiating pivotal movement of said jaws about said axes and second cam means axially spaced from said first cam means and engagable with said cam surfaces for completing pivotal movement of said jaws for swinging said work engaging

elements into pressure clamping engagement against said workpiece.

5. A cutting apparatus according to claim **4**, including an actuator having a reciprocal piston, a plunger mounted in said piston, said first cam means formed on the distal end of said plunger and said second cam means mounted on said piston rearwardly of said first cam means.

6. A cutting apparatus according to claim **1**, including a shoe mounted adjacent the leading end of said frame and engagable with said workpiece for self-orienting said apparatus relative to said workpiece.

7. A cutting apparatus according to claim **6**, wherein said shoe has a workpiece engaging surface complementary to the shape of said workpiece.

8. A cutting apparatus according to claim **6**, wherein said shoe and said jaws of each assembly in said work engaging position form a three point engagement with the workpiece on opposite sides of the intended line of cut.

9. A cutting apparatus according to claim **1**, including vacuum means on said cutter mechanism for removing debris resulting from a cutting operation.

10. A cutting apparatus according to claim **9**, wherein said vacuum means includes a passage formed in said cutter mechanism and terminating at one end thereof in a nozzle on said cutting head and communicating at the other end thereof with conduit means connected to a vacuum source.

11. A cutting apparatus according to claim **1**, including a plurality of pulleys mounted on said cutting head for guiding said cutting wire in a predetermined path.

12. A cutting apparatus according to claim **11**, wherein a portion of said traveling cutting wire path lies in a plane normal to the longitudinal axis of said workpiece.

13. A cutting apparatus according to claim **1**, wherein said cutting wire is coated with a layer of abrasive material.

14. A cutting apparatus according to claim **1**, wherein said cutting wire travels at a speed ranging from 1,000 to 3,500 surface feet per minute.

15. A cutting apparatus according to claim **1**, wherein said biasing means comprises a leaf spring associated with each clamping jaw, each leaf spring fixedly secured at one end and having a portion at the other end thereof bearing against said associated jaw.

* * * * *