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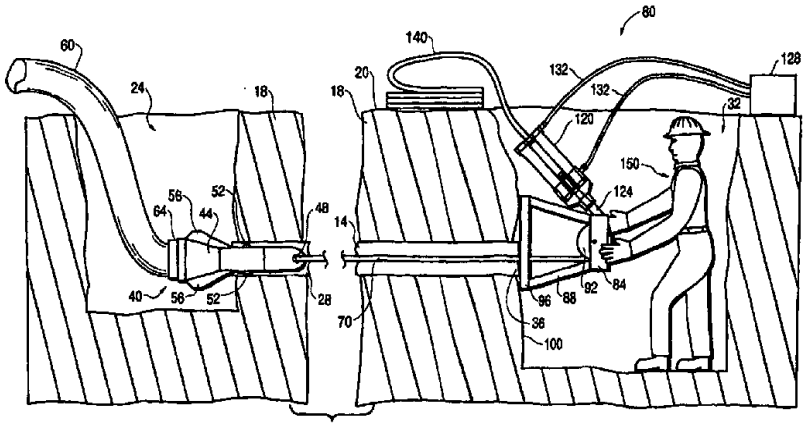

(57) Abstract

A pipe parting mole (40) including a length of cable (70) that is engageable to the mole (40) and a cable pulling device engagement system generally includes a reaction plate (96) and an annulus type member (124) for removably engaging the cable pulling device therewithin. A cable pulling frame (84) may be used to facilitate the removal of the cable (70) from a relatively small hole (32) that is created at the pulling end (36) of the pipe (14).

Specification

DEVICE FOR TRENCHLESS REPLACEMENT OF UNDERGROUND PIPE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to devices and methods for the trenchless replacement of underground pipes and more particularly to pipe splitting devices and cable pulling devices and methods for splitting and expanding existing pipe to facilitate the replacement thereof with new pipe.

Description of the Prior Art

Trenchless technology for the replacement of underground pipe is not new, and the standard equipment and methods generally used are well known. This standard equipment for this technology is very large, heavy, and therefore requires additional large, heavy duty equipment for the transportation to, and the placement thereof on site, and the operation thereof on site.

There are several methods of propelling a pipe bursting, and/or cracking and expanding device, and pulling a new pipe through an existing pipe. The most commonly used methods are large cable winches, and/or rod pushers or pullers that are usually hydraulically powered, and often used with a pneumatic percussive device helping to drive the pipe breaking device. Winches give continuous motion during pulling, while rod pushers/pullers generally give cycled motion in which they pull, then a rod must be either added or removed, before the return stroke, and next pull stroke. Sometimes rod pushers are converted to cable pullers, eliminating the need for rod removal.

Winches and rod pushers/pullers that can produce pulling forces of up to 75 tons can themselves weigh 2 to 5 tons and must be handled and placed in position to pull; they are powered by correspondingly heavy duty equipment, cranes, trucks, and back-hoes, etc. They also need large excavations, such that the support equipment can take up enough room so as to create traffic problems and even require street closures.

This also means that only large companies with large financial resources can afford the equipment necessary to replace underground pipes, and because the costs and maintenance on this equipment can be high, their prices are also high. Therefore the use of this prior art trenchless technology has been limited mainly to the 6 inch or above size pipe of municipal or corporate supply and sewer lines, and is used mainly by large contractors.

SUMMARY OF THE INVENTION

Equipment and methods is a cable puller, and/or rod puller/pusher, that can be easily built in several sizes, sized to the strength of the cable to be pulled, and componentized, so that no component weighs more than 75 lbs. One may can now move all the equipment necessary to pull up to 150,000 pounds (75 tons), in one average sized pick-up truck and hand carry it to remote areas normally inaccessible to the larger prior art equipment. Especially in the vast 4" diameter home lateral pipe field. This is a market which has, up to now been relatively untouched by the trenchless method of pipe replacement.

The equipment of this invention, is of modular design and needs no bolting, or tools to assemble. It will fit into an excavation hole that is 2 feet wide and 3.5 feet long, for the small pullers (24 tons) and 2' x 4.5 feet long for the largest puller (75 + tons) the entrance hole for the replacement pipe need be only as long as the radius bend, that the polyethylene pipe size used, requires.

In a first aspect the present invention provides a device for the trenchless replacement of in-situ pipe, comprising:

a mole;

a length of cable, said cable being engagable to said mole;

a cable pulling device being releasably engagable to said cable; a cable pulling device engagement means functioning to provide a mounting structure for said cable pulling device;

wherein said cable pulling device includes a hydraulically operated cable engagement mechanism that functions to pull said cable in a plurality of repeated cyclic pulling strokes; and

wherein said cable pulling device is formed with a slotted cable insertion means for the sideways insertion of said cable within said cable pulling device; and

wherein said cable pulling device engagement means includes a cable pulling frame including frame members that are disposed to allow said frame to be mounted to a side of said cable.

In a second aspect the present invention provides a device for the trenchless replacement of in-situ pipe, comprising:

a mole;

a length of cable, said cable being engagable to said mole;

a cable pulling means including a cable pulling device including a hydraulically operated cable engagement mechanism and a cable pulling device engagement means functioning to provide a mounting structure for said cable pulling device, including an annulus member including a cable passage bore formed therethrough and a cable insertion slot formed through portions of said annulus member for the sideways insertion of said cable within said cable passage bore of said annulus member;

said cable pulling device engagement means further including a reaction plate having an enlarged surface for disbursing a reaction force against a cable pulling force generated by said cable pulling device, and a cable pulling frame, said cable pulling frame being mountable to said reaction plate and said annulus being mountable to said cable pulling frame.

In a third aspect the present invention provides a cable pulling device engagement frame comprising:

an annulus member including a cable passage bore formed therethrough and a cable insertion slot formed through portions of said annulus member for the sideways insertion of a cable within said cable passage bore of said annulus member;

a reaction plate having an enlarged surface for disbursing a reaction force against a cable pulling force generated through said annulus member.

IN THE DRAWINGS

Fig. 1 is a side elevational view depicting the utilization of the present invention in a trenchless replacement operation:

Fig. 2 is a side elevational view of a first pipe splitting device or mole of the present invention;

Fig. 3 is an end elevational view of the mole depicted in Fig. 2;

Fig. 4 is a side elevational view of an alternative mole of the present invention;

Fig. 5 is an end elevational view of the mole depicted in Fig. 4;

Fig. 6 is a side elevational view of a four legged cable pulling frame of the present invention;

Fig. 7 is an end elevational view of the cable pulling frame depicted in Fig. 6;

Fig. 8 is a side elevational view of a frame mounting plate of the present invention;

Fig. 9 is a side elevational view of a cable pulling device of the present invention;

Fig. 10 is an enlarged view of the cable engaging collet of the cable puller depicted in Fig. 9;

Fig. 11 is a perspective view depicting the insertion of the cable pulling device nose piece within an annulus member;

Fig. 12 is a side elevational view of a three-legged mounting frame of the present invention;

Fig. 13 is an end elevational view of the mounting frame depicted in Fig. 12;

Fig. 14 is a side elevational view of another mounting frame embodiment of the present invention;

Fig. 15 is an end elevational view of the mounting frame depicted in Fig. 14;

Fig. 16 is an exploded perspective view of a further cable pulling device mounting system of the present invention;

Fig. 17 is an end elevational view of the annulus member depicted in Fig. 16; and

Fig. 18 is a side elevational view of the annulus member depicted in Fig. 17.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a side elevational view depicting the use of the trenchless pipe replacement device of the present invention. As depicted therein, an existing pipe 14 that is being replaced is disposed within earth 18 beneath the ground level surface 20. A first hole 24 has been dug to reveal a first end 28 of the pipe 14, and a second hole 32 has been dug to reveal a second end 36 of the pipe 14. A pipe parting and expanding device 40 referred to herein as a mole, is inserted within the first pipe end 28. The mole 40 includes a generally tapered body portion 44, a nose portion 48, one or more pipe scoring wheels 52 and one or more pipe parting fins or blades 56

disposed along the body portion 44. A length of replacement pipe 60 is removably engaged to the rearward end 64 of the body portion 44 of the mole 40. A detailed description of the mole 40 is presented herebelow.

A mole pulling cable 70 is passed from the second end of the pipe 36, through the pipe 14 to a pinned engagement with the nose 48 of the mole 40. The cable 70 is utilized to pull the mole 40 through the pipe 14, parting and enlarging the pipe 14 as it is pulled therethrough. The replacement pipe 60 is pulled behind the mole 40, such that when the mole 40 has been pulled entirely through the pipe 14, the replacement pipe 60 will reside in place within the parted, expanded pipe 14 to functionally replace it.

A light weight cable pulling system, generally designated 80, is disposed within the second hole 32 proximate the second end 36 of the pipe 14. The preferred cable pulling system 80 includes a cable pulling frame member 84 having leg members 88 and a rotatable cable pulley 92 mounted thereto. A frame bracing reaction plate 96 is positioned against the side wall 100 of the hole 32 to provide a strong, firm surface for reactive cable pulling forces, as described herebelow. The reaction plate 96 is formed with a cable passage slot 104 (not shown in Fig. 1) for passage of the cable 70 therethrough. The cable 70 therefore passes through the plate slot 104 and around the cable pulley 92 to a cable pulling device 120 that is next described.

The cable pulling device 120 is removably mounted to a generally cylindrical, slotted mounting socket or annulus 124 that is fixedly engaged to the frame 84. The cable pulling device 20 is preferably a hydraulic device which is operated utilizing a portable hydraulic pump 128 having hydraulic lines 132 leading therefrom to the cable pulling device 120. The cable pulling device 120 includes a cable pulling collet which releasably engages the cable for repeatable short pulling strokes. End portions of the cable 70 may be disposed in a coil 140 upon the ground surface 20.

It is therefore to be understood that an operator 150, having engaged the cable 70 to the mole 40, will pass the cable through the plate slot 104, around the pulley 92 into the slotted annulus 124 and into operative engagement within the cable puller 120 that is mounted in the socket 124. Thereafter, the operator 150 will activate the pump 128 and then activate the cable puller 120 to complete a first cable pulling stroke of perhaps 3 to 6 inches depending upon the travel of the hydraulic pulling device 120, as is discussed in greater detail herebelow. Repeated pulling strokes of the puller 120 ultimately pulls the mole 40 entirely through the pipe 14, until the mole 40 protrudes past the second end 36 of the pipe 14, whereupon the replacement pipe 60 has been pulled entirely through the parted, expanded pipe 14, in operational replacement

thereof. The mole 40 is then disengaged from the replacement pipe 60. The cable pulling system 80 is then removed from the hole 32, appropriate pipe fixturing and jointing is accomplished at both ends of the replacement pipe, and the holes 24 and 32 can then be refilled.

It is therefore to be understood that the modular, light weight, pipe replacement system of the present invention allows a single worker to easily take all steps necessary to accomplish the replacement of a length of buried, pre-existing pipe. The various components of the system, the mole 40, the replacement pipe 60, the cable 70, the plate 96, the frame 92, the cable pulling device 120 and the pump 128 are all compact, light weight components that can be easily transported in a light duty pickup truck, and hand carried to, placed and assembled into the pulling hole by one man.

A first preferred mole of the present invention is depicted in Figs. 2 and 3, wherein Fig. 2 is a side elevational view and Fig. 3 is an end view taken from the nose 48 of the mole 40. Components of the mole previously identified are numbered identically. As depicted in Figs. 2 and 3, the mole 40 includes a generally tapered nose portion 48, having a cable engagement bore 136 formed therethrough. The mole 40 further includes a generally cylindrical center portion 140, the tapered body portion 44, and the rear portion 64 which includes an integrally formed, rearwardly projecting cylindrical replacement pipe attachment shoulder 148. As is best seen in Fig. 2, the end 152 of the length of replacement pipe 60 fits over the shoulder 148 and a cylindrical pipe retaining sleeve 156 is placed outside of the pipe end 152. A plurality of pipe engagement screws 160 which project through the sleeve 156 and through holes formed in the end 152 of the pipe 60, are threadably engaged within the rearwardly projecting shoulder 148. Through use of the sleeve 156 and screws 160, the end 152 of the pipe 60 is removably engaged to the rearward portion 64 of the mole 40. A bore 164 is preferably formed within the rearward end 64 of the mole 40. The bore 164 has inwardly tapered sidewalls 168 for a mating engagement with a tapered forward end of a standard impact driver (not shown). The use of such an impact driver to percussively drive a mole forward into a pipe is well known in the prior art. The inventors have found that the use of an impact driver is not necessary to part and replace ordinary lengths of pipe. However, where the pipe includes various types of clamps and joints that can strengthen the pipe at the location of such clamps and joints, the use of an impact driver to aid in moving the mole 40 through the pipe, may be beneficial.

The pipe parting blades 56 are preferably disposed within a blade holding slot 184 formed in the tapered body 44 and cylindrical section 140 of the mole 40, and blade retaining pins 188 are disposed in retaining pin bores formed through the tapered portion 44 and the inner

portions of the blades 56. The blades 56 are preferably formed of a hardened steel and are sharpened on the outer edge 180 to facilitate the pipe parting function of the blades 56.

The pipe scoring wheels 52 are preferably engaged in a scoring wheel holding member that is disposed within a scoring wheel slot 192 cut into the cylindrical portion 140 of the mole 40, and retaining pins 196 which project through retaining pin bores are utilized to hold the scoring wheel mechanisms in place. It is therefore to be understood that both the scoring wheels 52 and the blades 56 are removably engagable with the mole 40, such that they can be easily replaced when it is necessary to do so.

An alternative mole 220 is depicted in Figs. 4 and 5, wherein Fig. 4 is a side elevational view and Fig. 5 is an end elevational view. The mole 220 includes a tapered nose portion 224 having a cable engagement bore 228 formed therethrough. A generally cylindrical body portion 232 having a central axis 236 is integrally formed with the nose portion 224. A non-concentrically tapered body portion 240 is formed rearwardly of the cylindrical portion 232. The tapered portion 240 is excentrically formed such that one external surface 244 is a straight line extension of the cylindrical surface 248 of the cylindrical portion 232. The opposite surface 252 of the tapered portion 240 is flared outwardly relative to the surface 256 of the cylindrical portion 232. It is therefore to be understood that the surfaces 244, 248 and 256 are parallel to the center line 236, whereas the surface 252 diverges from the center line 236 toward the rearward portions of the mole 220.

A rearward portion 260 of the mole 220 includes a rearwardly extending replacement pipe engagement shoulder 264 and a pipe engagement sleeve 268, which together cooperate with pipe retaining screws 272 to hold a leading edge of a section of replacement pipe 278. A generally tapered impact driver bore 282 is preferably formed in the rearward end 260 of the mole 220 to provide a mating engagement with a tapered nose portion of an impact driver (not shown), as has been described hereabove with regard to mole 40, depicted in Figs. 2 and 3. A pair of pipe scoring wheels 288 and 292 are disposed in a scoring wheel retaining mechanism that is held in place by a pin 296. The pipe scoring wheels 288 and 292 are preferably arranged such that the first wheel 288 scores the pipe a first distance into its interior wall, and the second scoring wheel 292 scores the pipe in the same track an additional distance into the interior wall of the pipe to facilitate the parting of the pipe. A pipe parting blade 300 having a sharpened edge 304 is disposed within the tapered side 252 of the mole 220 to part the pipe along the line scored by the wheels 288 and 292. A blade retaining pin 308 facilitates the replaceable engagement of the blade 300 with the mole 220. In the preferred embodiment, another pipe

scoring wheel 316 is disposed on the straight, opposite side of the mole 220 from the two scoring wheels 288 and 292. The pipe scoring wheel 316 is replaceably engaged utilizing a wheel retaining pin 320 in the manner previously described herein. Additionally, a hardened steel skid plate 328 is engaged to the straight side of the mole 220 utilizing an engagement slot 332 that is formed axially into the lower surface of the mole 220. The scoring wheel 316 further facilitates the parting of the pipe when it is expanded by the non-concentric tapered portion 240, and the hardened steel skid plate 328 provides a longer useful lifetime to the mole 220. A cable pulling frame 84 is next described.

The cable pulling frame 84 as depicted in Figs. 6 and 7, includes a generally U-shaped base member 400 which is preferably made from three pieces of rectangular steel stock that are welded together at their ends. Significantly, a fourth frame member that would create a square base is omitted, such that a gap 404 is provided. The gap 404 facilitates the placement of the frame 84 onto an existing length of cable 70 that projects outwardly from the end 36 of the pipe 14. A plurality of reaction plate alignment pins 406 project from the base member 400 for the aligned engagement of the frame 84 with the reaction plate 96, as is described hereinbelow. An inner end 408 of each of the leg members 88 is engaged, such as by welding, to a corner of the U-shaped base member 400 to create a stable frame structure. The outer ends 412 of the leg members 88 are engaged together by frame members 416, such as by welding, to form a strong stable structure. The leg members 88 and frame members 416 are preferably made from rectangular, tubular steel stock. The cable pulley 92 is rotatably mounted to an axle 424 that is engaged to the frame members 416. The annulus 124 is a generally cylindrical tubular member having a cable passage bore 428 formed therethrough, and an outer portion of its sidewall is removed to form a cable passage slot 430. The slot 430 functions such that the cable 70 may be placed into bore 428 of the annulus 124 from its side through the slot 430; whereby it is not necessary to thread the end of the cable through the annulus 124. As is best seen in Fig. 11 and described in detail hereinbelow, a mounting shoulder 434 projects into the slotted bore 428 of the annulus 124 to facilitate the removable mounting of the cable pulling device 120 therewithin.

The frame bracing reaction plate 96 of the present invention is depicted in Fig. 8. The reaction plate is a generally rectangular or square flat member that is preferably formed from a strong, light weight metal, such as an aluminum alloy. The reaction plate serves to provide a firm footing for the base member 400 of the cable pulling frame 84; thus, the plate 96 is formed with a sufficient thickness to reactively withstand the cable pulling forces that the frame 84 places against the wall 100 of the pipe access hole 32. A cable passage slot 104 is formed from

a side of the plate 96 towards its center. The slot 104 permits the plate 96 to be installed around cable 70 that is already engaged to a mole 40 and projects outwardly through the end 36 of a pipe 14. A plurality of frame engagement holes 439 are formed in the plate 96 to matingly engage the base plate alignment pins 406 of the cable pulling frame 84 for the aligned engagement of the frame 84 with the base plate 96. In the field it is not always possible to place the reaction plate 96 in a preferred, vertical manner as depicted in Fig. 8, and it may be necessary to place the reaction plate in a rotated manner. It would, however, still be desirable to place the mounting frame in a generally vertical orientation. To achieve this, additional sets of mounting holes 439A and 439B are advantageously formed in the reaction plate 96 to provide rotated mounting hole configurations into which the mounting pins 406 can be inserted to achieve a more nearly vertical mounting of the frame 84 with a rotated reaction plate 96.

It is to be understood that a significant feature of the frame member 84 is that a mole-attached cable 70 can be wrapped around the pulley 92, such that the interior portion 440 of the cable 70 projects between the legs 88 of the frame 84 and the outer end portion 444 of the cable 70 projects upwardly through the annulus 124 for engagement to a cable pulling device 120. Other and different frame construction configurations can readily be developed which provide the strength and stability of the frame member 84, and such alternative frame members are described hereinbelow.

A cable pulling device that is suitable for use in the present invention is depicted in a side elevational view in Fig. 8 and a cable engaging collet of the cable puller is depicted in Fig. 9. The cable puller 120 is preferably formed with two parallelly disposed hydraulic pistons 510 having outer piston housings 512 that are mounted at their rearward ends 514 to a rear end fixture 516. A forward end fixture 528 is engaged to the forward ends of the outer housings 512. The hydraulic lines 132 are engaged to the end fixtures 516 and 528 through a suitable coupling 518 such that hydraulic fluid passes through the hydraulic lines 132, through the end fixtures 516 and 528 and into the two hydraulic pistons 510. Hydraulic push rods 524 project outwardly from the forward end fixture 528 and are fixedly engaged to a front end block 536. A slotted, generally cylindrical nose piece 540 is engaged to the front end block 536. The nose piece 540 is formed with a cable passage slot 544 cut through a side of the nose piece 540, and the outer diameter of the nose piece 540 is sized to mount within the shoulder 434 of the slotted annulus 124 of the frame member 84, as is described hereinbelow with the aid of Fig. 11. A generally U-shaped cable passage slot, generally denoted by the numeral 550 is formed in each of the front end block 536, forward end fixture 528 and the rear end fixture 514, such that the cable 70 can

be installed within the cable pulling device 120 from its side. That is, it is not necessary to thread an end of the cable 70 through the cable pulling device 120.

A plurality of cable pulling collets 560 are removably engaged within the cable passage slot 550 of the forward end fixture 528. As depicted in Fig. 10, each collet 560 is formed with a concave inner face 564 having a plurality of cable engaging ridges 568 cut into the inner surface thereof. The cable engaging ridges 568 are cut in a saw-tooth manner to create a one-way cable engagement surface. Collet retaining pins 576 are disposed in the front end fixture 528 to facilitate the replacement of collet members 560 when necessary. The gripping motion of the collets is enhanced by a collet biasing spring 578 that is engaged to the front end fixture and causes the collets to move in a synchronous manner to engage and disengage the cable 70. A preferred cable pulling device 120 utilizes two collets 560 disposed around the cable 70 to effectively engage the cable while permitting the easy side wise installation of the cable 70 within the collets 560. A device that is preferably used as the cable puller 120 is designed as a bridge cable tensioning device, used in the bridge construction industry, such as is manufactured and sold by the Chowder Machine Company of the State of Washington. Such devices are light weight as compared to their pulling capability, generally pulling in excess of 1 ton per pound of weight, such that a 75 pound device 120 can place a 75 ton pulling force on the cable 70. Typical prior art winches, etc., that produce such force levels can themselves weigh 2-5 tons. Thus a significant advantage of the present invention is the use of the light weight bridge cable tensioning device as a cable pulling device 120, which allows a single man to install and operate the present invention in the small hole 32.

It is therefore to be understood that when hydraulic pressure is applied to the two piston members 510, that the outer housing portions 512 of the pistons 510 will move laterally rearwardly 580 relative to the piston rods 524 and the front end block 536. It is also to be realized that when the nose piece 540 of the cable pulling device 120 is mounted in the annulus 124 of the frame 84, that the front end block 536 will remain stationary while the forward end fixture 528 and the two piston outer housings 512 will move rearwardly. Additionally, it is to be understood that the collet members 560 are disposed within the movable forward end fixture 528, and that when the collets 560 move rearwardly relative to the cable 70, that the saw-tooth ridges 568 of the collets 560 will grab the outer surface of the cable 70 and pull it rearwardly. Finally, after the piston housings 512 have traveled rearwardly to the extent of a piston stroke, the housings 512 will return to the forward position and, significantly, the collet ridges 568 will release their hold upon the cable and slide forwardly along the surface of the cable 70. Thus,

with each repeatable, rearward cable pulling stroke of perhaps three to six inches, depending upon the piston travel 580 of the cable pulling device 120, the collet ridges 568 will pull the cable 70 rearwardly. Thereafter, upon the return stroke of the cable pulling device 120, the cable 70 will remain stationary while the collets 560 slide along its outer surface. Thus, each cable pulling stroke will pull the cable rearwardly, until, ultimately, the cable with its attached pipe parting mole will be pulled entirely through the pipe 14.

A detailed depiction of the mounting of the cable puller nose piece 540 within the annulus 124 is provided in Fig. 11. As depicted therein, the cable passage slot 430 is formed through the sidewall of the annulus 124 to permit the side wise mounting of a cable 70 into the cable passage bore 428. A shoulder 434 projects inwardly into the cable passage bore 428 to provide a stop on the inward insertion of the cable puller nose piece 540 within the cable passage bore 428, and the outer diameter of the nose piece 540 is sized to slidably fit within the cable passage bore 428 until the front surface 584 of the nose piece 540 rests against the shoulder 434.

As has been described hereinabove, the preferred method for installing the various components of the present invention upon a cable 70 is the side wise insertion of the cable 70 through the mounting slots 430 and 544 of the annulus 124 and nose piece 540 respectively. As depicted in Fig. 11, a preferred orientation of the annulus 124 and nose piece 540, following the insertion of the cable 70 within the cable mounting slots 430 and 544 respectively, is to rotate 588 the cable puller slot 544 through a 90 or more degree angle relative to the annulus slot 430. Thereafter, when the nose piece 540 is inserted within the annulus bore 428, the cable 70 will become locked into the mated structure. That is, if the two slots 544 and 430 are aligned, then the cable 70 can escape through the aligned slots, whereas the rotation 588 of the nose piece 540 relative to the annulus 124 creates a cable enclosing mated configuration. The inventors have found that the preferred, rotated mounting configuration maintains the cable 70 in proper alignment within the cable pulling collets 560, which improves the performance and reliability of the device.

Figs. 12 and 13 depict an alternative, three-legged cable pulling frame 600 of the present invention, wherein Fig. 12 is a side elevational view and Fig. 13 is an end elevational view. As depicted in Figs. 12 and 13, the three-legged cable pulling frame 600 includes a first base leg 604, a second base leg 608 and a top leg 612, each of which is preferably formed from rectangular tubular steel stock. The front ends 616 of each of the legs 604, 608 and 612 are engaged, such as by welding to a front mounting plate 620, and a cable passage slot 624 is formed upwardly through the plate 620, such that a cable 70 is mountable therethrough. Further

structural members 630 are utilized to engage the rearward ends 634 of the leg members 604, 608 and 612 together, such as by welding, to form a strong structure. A pulley 640 is rotatably mounted upon an axle 644 that is mounted within axle bores 648 formed through a pulley mounting plate 656 that is engaged, such as by welding, to the leg members 604, 608 and 612 and the frame members 630. It is to be realized that such a mounting plate 656 is disposed on each side of the pulley 640 to engage both ends of the axle 644. An annulus mounting plate 670 having a cable passage slot 674 formed therein is engaged, such as by welding, to the upper ends 676 of the frame members 530, and a slotted cylindrical annulus 680 is fixedly engaged, such as by bolting or welding to the annulus mounting plate 670. The annulus 680 is preferably similar in design to the annulus 124 described above. Thus the annulus slot and the mounting plate slot 674 are aligned to permit the sideways mounting of a cable 70 therewithin.

A single reaction plate mounting pin 682 is formed on the plate 620 to facilitate the mounting of the frame 600 with a mating bore (such as mounting pin bores 439) formed in a reaction plate, to which the frame 600 is removably engaged in a manner described hereinabove with regard to frame 84 and reaction plate 96. To further facilitate the engagement of the plate 620 with a reaction plate 96, a generally cylindrical cable guide member 684 is engaged within the slot 624. The guide member is also formed with a slotted cable passage bore 686 to permit the sideways insertion of the cable 70 therewithin. The guide member 684 is preferably formed with a smaller diameter portion 688 for mating insertion within the slot 624 of the plate 620, and a larger, outer diameter portion 690 for mating insertion within the cable mounting slot 104 of a reaction plate 96. In the preferred embodiment, the guide 684 is preferably formed from aluminum to provide a soft guide surface for interaction with the outer surface of the cable 70.

As compared with the four-legged cable pulling frame depicted in Figs. 6 and 7, the three-legged frame of Figs. 12 and 13 is generally lighter in weight and shorter in length. These features are generally advantageous because the lighter weight facilitates easier installation and manipulation by a user, and the shorter length facilitates the installation of the frame 600 in a smaller hole 32 than the longer legged frame 84. It is to be realized that the frame 600, like the frame 84, is mountable upon a pre-installed cable 70, such that the extending end of the cable 70 may be inserted within the cable mounting slots 684 and 624, wrapped around the pulley 640 and installed within the cable mounting slot 674 of the plate 670 and within the slotted annulus 680.

Still another cable pulling frame 700 of the present invention is depicted in Figs. 14 and 15, therein Fig. 14 is a side elevational view and Fig. 15 is an end elevational view. As depicted

in Figs. 14 and 15, the frame 700 includes a left plate member 704 and a right plate member 708 that are fixedly engaged at a forward edge 712 to a front plate 716. The engagement may be by welding, threaded bolts or other conventional means. The front plate 716 is formed with an upwardly projecting cable insertion slot 720 and a reaction plate mounting pin 724, which is similar to mounting pin 682 of frame 600 and which mounts into a mating bore (such as bores 439) formed in a reaction plate. As with frame 600, a slotted guide member 730 may be engaged within the slot 720, which guide member 730 has an enlarged outer diameter portion 732 to slidably fit within a cable slot 104 formed in a reaction plate 96. A cable pulley 740 is rotatably mounted upon an axle 744 that projects through axle mounting holes 748 formed through the side plates 704 and 708. An annulus mounting plate 760 is fixedly engaged, such as by welding or threaded bolts to the top portions 764 of the side plates 704 and 708, and a cable mounting slot 770 is cut into the plate 760 for insertion of the cable 70 therethrough. A slotted annulus 780, similar in design to annulus 124, is mounted upon the plate 760, such as by welding or the utilization of threaded bolts, to provide for the mounting of a nose piece 540 of a cable pulling device 120 therewithin.

Frame 700 is generally easier to fabricate than frame 600, although its overall dimensions are quite similar. Frame 700 generally consists of fewer components than frame 600 and is easier to assemble, whether by welding or the use of threaded bolts. It is to be understood that the frame 700, like frame 600 and frame 84, may be mounted upon a projecting end of an in-place cable 70, such that the cable 70 is mounted sideways into the cable insertion slots and wrapped around the pulley 740, as has been described in detail hereabove.

A further embodiment of the present invention is depicted in Figs. 16, 17 and 18, in which Fig. 16 is an exploded perspective view, Fig. 17 is an end elevational view of an adapted annulus member 800 and Fig. 18 is a side elevational view of the annulus member 800 depicted in Fig. 17. As depicted in Fig. 16, a generally rectangular reaction plate 804 is formed with a cable insertion slot 808 therewithin. Generally cylindrical annulus member 800 is formed with an inner, generally cylindrical nose portion 820, having an outer diameter that is sized for insertion within the width of the slot 808. The annulus member 800 further includes an enlarged body portion 828 having a diameter that is significantly larger than the diameter of the nose portion 820, such that the enlarged portion 828 provides a large contact area 832 (shown in phantom upon the surface of the reaction plate 804) when the nose 820 of the annulus member 800 is inserted within the slot 808 of the reaction plate 804. A cable passage bore 840 is formed axially through the annulus member 800 and a cable mounting slot 848 is cut through the side of

the member 800, such that the cable 70 may be sideways inserted into the cable bore 840. As with the annulus member 124, described hereinabove, the center bore 840 is formed with a diameter sized for the insertion of the nose piece 540 of a cable pulling device 120, and an inwardly projecting shoulder 856 is formed within the bore 840 to form a stop on the inward insertion of the nose piece 540 within the bore 840. It is therefore to be understood that the embodiment depicted in Figs. 16, 17 and 18 facilitates the direct usage of the cable pulling device 120 in a horizontal orientation within an access hole 32, or within a pre-existing space, such as a large sewer main or a building basement, where it is not necessary to reorient the cable vertically out of a hole, such as hole 32 depicted in Fig. 1.

In some working environments, a backward pulling force such as cable stretch or plastic pipe stretch may exist upon the cable 70 such that the cable may be pulled backwardly into the pipe 14 between the pulling strokes of the cable pulling device 120. In such a situation, a retaining collet may be inserted within the bore 428 of the annulus 124. Such a retaining collet includes two or more collet members such as collet members 560, held within a slotted cylindrical member, and which collets have reverse sawtooth ridges that grip the cable upon its movement backwards within the annulus.

Upon consideration of the various preferred embodiments described in detail hereinabove, it is to be understood that a generalized description of the present invention includes a mole, a cable attachable to the mole for pulling it through a pipe, a cable pulling device that is engagable to the cable and a cable pulling device engagement means which functions to provide a reactive support for the cable pulling device. In various embodiments, the cable pulling device engagement means includes the reaction plate and an annulus type member for holding the cable pulling device and may further include the various mounting frames and their components depicted and described herein. Significant features of the mole of the present invention include a plurality of pipe scoring wheels wherein two such wheels may be located on one side of the mole for enhanced pipe scoring, and wherein pipe scoring wheels can be located at 180° opposite surfaces of the mole for enhanced pipe scoring and parting of the pipe along the opposing scored lines. The preferred cable pulling device of the present invention is a hydraulic bridge cable tensioning device that operates in a cyclic cable pulling manner, having repeatable short pulling strokes. The cable is sideways mountable within the cable pulling device for ease of mounting and assembly. The cable pulling frames components and annulus are formed with cable mounting slots, such that these components may also be sideways mounted upon the cable for ease of assembly of the device.

The significant advantages of the present invention are its relatively small, light weight components which allow a single operator to transport, install and operate the device for trenchless replacement of underground pipe. The relatively low cost of the components permit individual contractors and small companies to effectively compete in a marketplace that heretofore has been reserved for large companies having the manpower and resources to purchase and transport the relatively large and expensive components that heretofore have been necessary to conduct the trenchless replacement of underground pipe.

While the present invention has been shown and described with regard to its preferred embodiments, it will be understood by those skilled in the art that alterations and modifications in form and detail may be made therein without departing from the true spirit and scope of the invention. It is therefore intended that the following claims cover all such alterations and modifications that encompass the true spirit and scope of the invention.

For the purposes of this specification it is to be clearly understood that the word "comprising" means "including but not limited to", and that the word "comprises" has a corresponding meaning.

It is to be understood that, if any prior art information is referred to herein, such references does not constitute an admission that the information forms a part of the common general knowledge in the art, in Australia or any other country.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A device for the trenchless replacement of in-situ pipe, comprising:

a mole;

a length of cable, said cable being engagable to said mole;

a cable pulling device being releasably engagable to said cable; a cable pulling device engagement means functioning to provide a mounting structure for said cable pulling device;

wherein said cable pulling device includes a hydraulically operated cable engagement mechanism that functions to pull said cable in a plurality of repeated cyclic pulling strokes; and

wherein said cable pulling device is formed with a slotted cable insertion means for the sideways insertion of said cable within said cable pulling device; and

wherein said cable pulling device engagement means includes a cable pulling frame including frame members that are disposed to allow said frame to be mounted to a side of said cable.

2. A device as described in claim 1 wherein said cable engagement mechanism functions to engage said cable in a pulling stroke, release said cable in a recovery stroke, and engage said cable in a further pulling stroke, whereby said cable pulling device conducts a repeatable cycle of pulling and releasing of said cable.

3. A device as described in claim 2 wherein said cable pulling device includes a plurality of cable engaging collets that function to engage said cable on a said pulling stroke and to release said cable on a said recovery stroke.

4. A device as described in claim 3, wherein at least one pair of cable engaging collets functions to engage said cable on a said pulling stroke and to release said cable on a said recovery stroke; and wherein at least one further pair of collets is provided that function to engage said cable on said recovery stroke and release said cable on said pulling stroke.

5. A device as described in claim 1 wherein said cable pulling device engagement means includes an annulus member including a cable passage bore formed therethrough and a cable insertion slot formed through portions of said annulus member for the sideways insertion of said cable within said cable passage bore of said annulus member.

6. A device as described in claim 5 wherein said annulus member includes a cable pulling device holding means for releasably holding a portion of said cable pulling device therewithin.

7. A device as described in claim 1 wherein said cable pulling device engagement means includes a reaction plate having an enlarged surface for disbursing a reaction force against a cable pulling force generated by said cable pulling device.

8. A device as described in claim 7 wherein said cable pulling device engagement means includes an annulus member that is releasably engagable with said cable pulling device, and wherein said annulus member is mountable in relation to said reaction plate such that said reaction plate disburses cable pulling forces exerted on said annulus by said cable pulling device.

9. A device as described in claim 8 wherein said cable pulling device engagement means includes a cable pulling frame, said cable pulling frame being mountable to said reaction plate, and said annulus being mountable to said cable pulling frame.

10. A device as described in claim 9 wherein said cable pulling frame includes a plurality of frame members and a rotatable cable pulley being mounted to said frame members.

11. A device as described in claim 10 wherein said frame members are disposed to provide a cable mounting gap that allows said frame to be mounted to a side of said cable.

12. A device as described in claim 10 wherein said frame members are disposed to provide a cable engagement path in relation to said frame, such that a side portion of

said cable can be mounted within said cable pulling frame and around said pulley and into said annulus.

13. A device as described in claim 12 wherein said annulus is formed with a cable mounting slot, such that a side portion of said cable can be mounted into said annulus member.

14. A device as described in claim 13 herein said frame includes a plurality of leg members that are engaged at an inner end thereof to a base member, and said leg members are engaged at an outer end thereof to further frame members that engage said pulley.

15. A device as described in claim 1 wherein said mole includes a nose portion being engagable to said cable, a tapered body portion and a replacement pipe engagement portion, said mole further including at least two pipe scoring wheels and at least one pipe parting blade, said wheels and said blade and said tapered portion acting to score, part and expand said pipe for the replacement thereof with a length of replacement pipe.

16. A device as described in claim 15 wherein one said pipe scoring wheel is engaged in axial alignment with a pipe parting blade and another of said pipe scoring wheels is engaged within said mole on an opposite surface of said mole from said first pipe scoring wheel.

17. A device for the trenchless replacement of in-situ pipe, comprising:

a mole;

a length of cable, said cable being engagable to said mole;

a cable pulling means including a cable pulling device including a hydraulically operated cable engagement mechanism and a cable pulling device engagement means functioning to provide a mounting structure for said cable pulling device, including an annulus member including a cable passage bore formed therethrough and a cable insertion slot formed through portions of said annulus member for the sideways insertion of said cable within said cable passage bore of said annulus member;

said cable pulling device engagement means further including a reaction plate having an enlarged surface for disbursing a reaction force against a cable pulling force generated by said cable pulling device, and a cable pulling frame, said cable pulling frame being mountable to said reaction plate and said annulus being mountable to said cable pulling frame.

18. A device as described in claim 17 wherein said cable engagement mechanism functions to engage said cable in a pulling stroke, release said cable in a recovery stroke, and engage said cable in a further pulling stroke, whereby said cable pulling device conducts a repeatable pulling and releasing cycle of said cable; said cable pulling device including a plurality of cable engaging collets that function to engage said cable on a said pulling stroke and to release said cable on a said recovery stroke, and wherein said cable pulling device is formed with a slotted cable insertion structure for the sideways insertion of said cable within said cable pulling device.

19. A device as described in claim 18 wherein said cable pulling frame includes a plurality of frame members and a rotatable cable pulley being mounted to said frame members; and wherein said frame members are disposed to provide a cable engagement path in relation to said frame, such that said cable can be sideways mounted within said cable pulling frame and around said pulley and into said annulus.

20. A device as described in claim 19 wherein said mole includes a nose portion being engagable to said cable, a tapered body portion and a replacement pipe engagement portion, said mole further including at least two pipe scoring wheels and at least one pipe parting blade, said wheels and said blade and said tapered portion acting to score, part and expand said pipe for the replacement thereof with a length of replacement pipe.

21. A device as described in claim 20 wherein one said pipe scoring wheel is engaged in axial alignment with a pipe parting blade and another of said pipe scoring wheels is engaged within said mole on an opposite surface of said mole from said first pipe scoring wheel.

22. A cable pulling device engagement frame comprising:

an annulus member including a cable passage bore formed therethrough and a cable insertion slot formed through portions of said annulus member for the sideways insertion of a cable within said cable passage bore of said annulus member;

a reaction plate having an enlarged surface for disbursing a reaction force against a cable pulling force generated through said annulus member.

23. A device for the trenchless replacement of in-situ pipe substantially as herein described with reference to the accompanying drawings.

24. A cable pulling device engagement frame substantially as herein described with reference to the accompanying drawings.

Dated this 28th day of March 2001
ROBERT WARD CARTER AND
ROBERT WILLIAMS CARTER
By their Patent Attorneys
GRIFFITH HACK

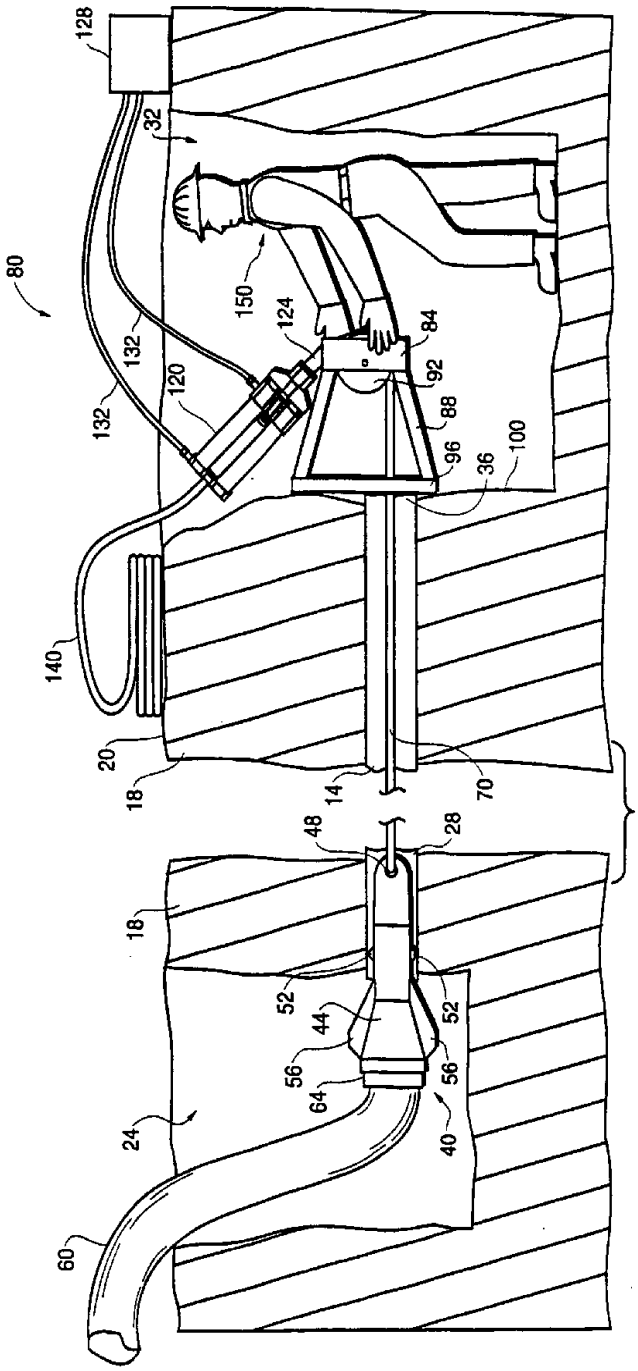
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FIG.1

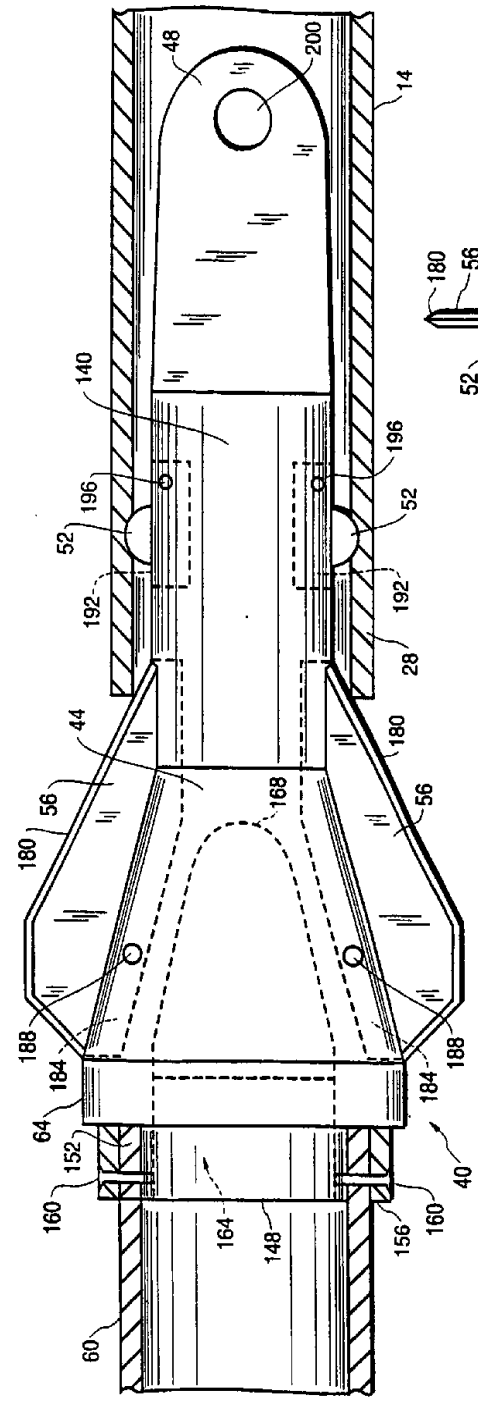
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FIG.2

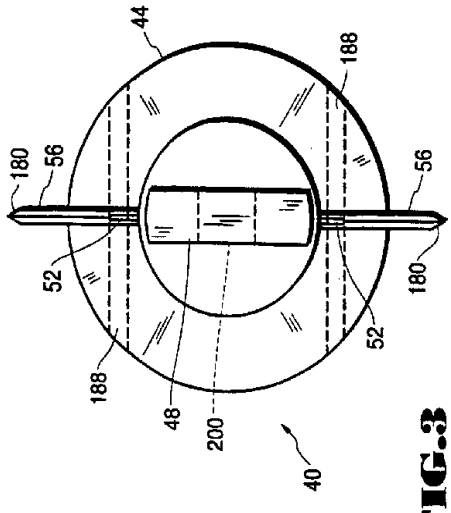
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FIG.3

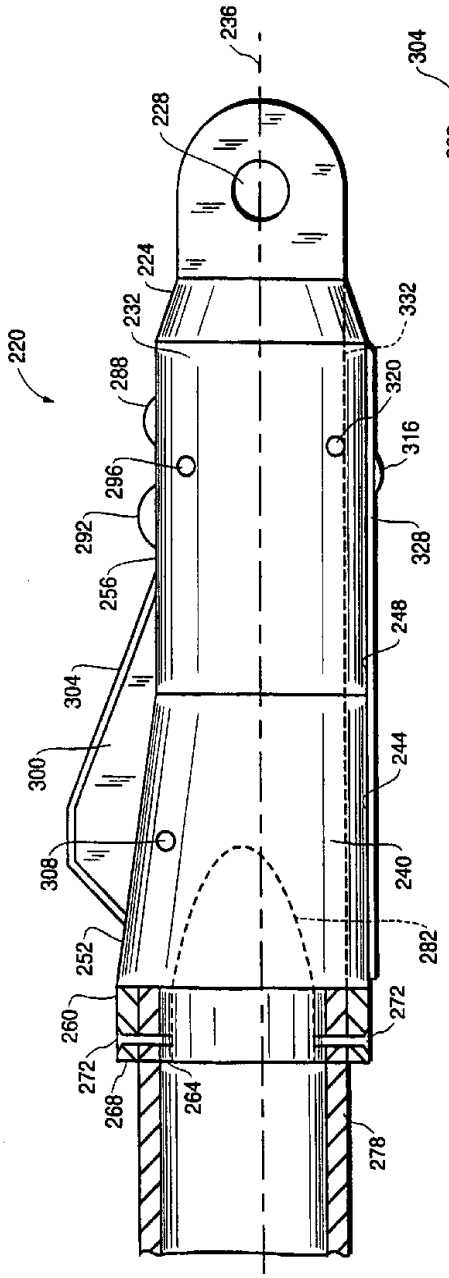
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FIG.4

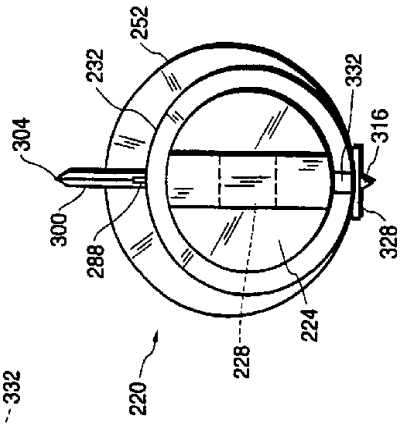
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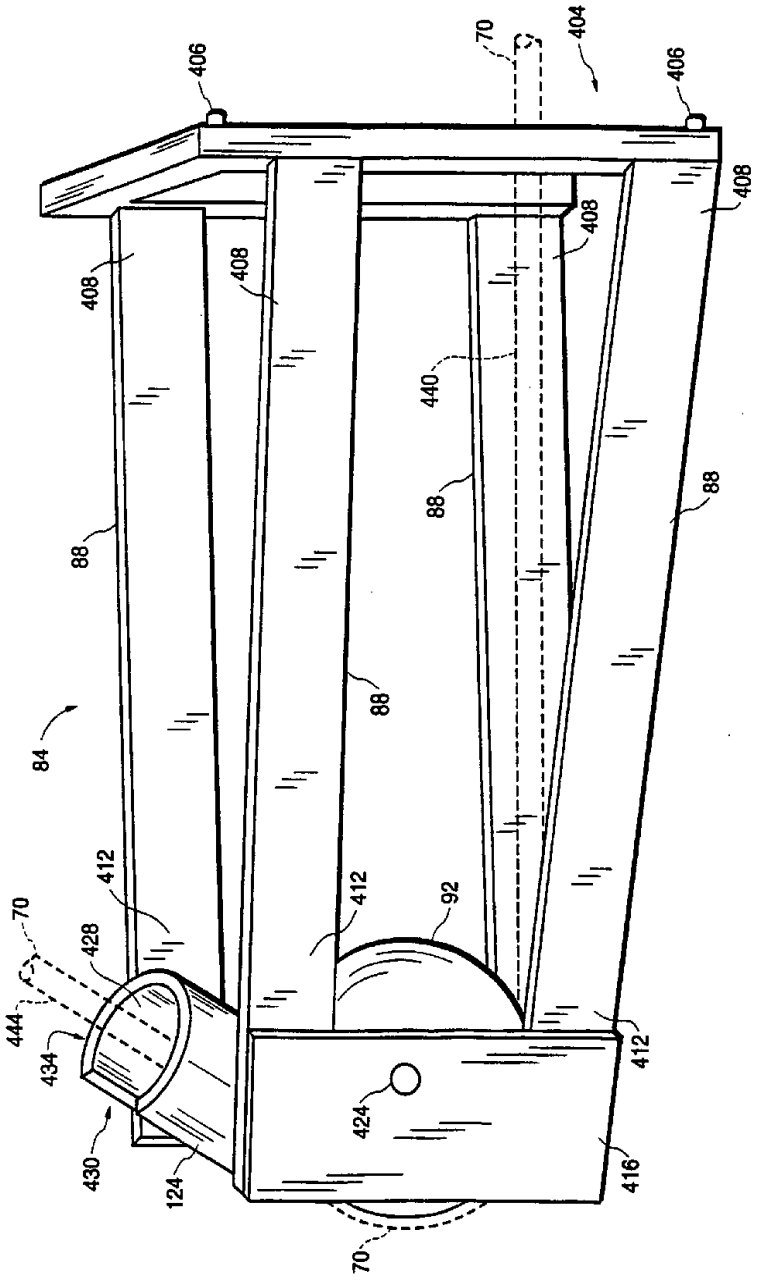
FIG.5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70

FIG.6

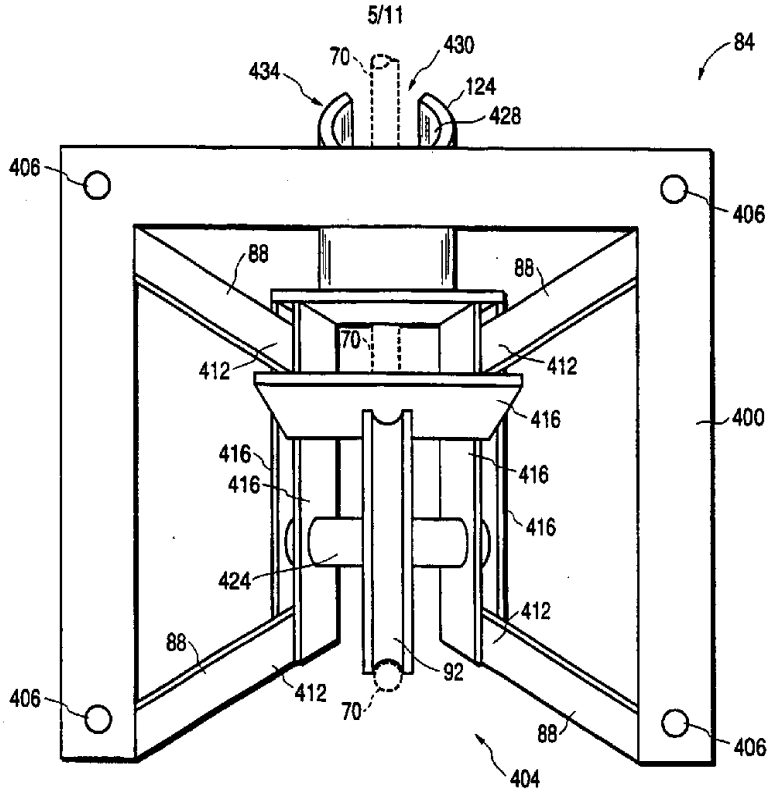
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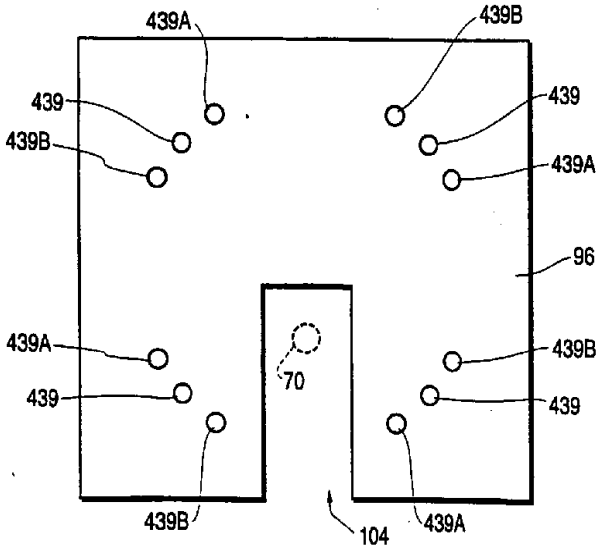
FIG.7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104
439A

FIG.8

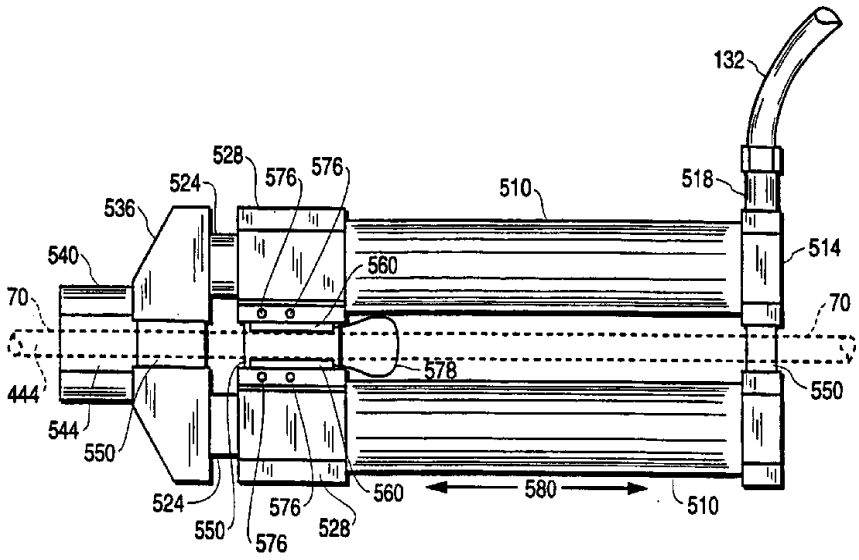
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FIG.9

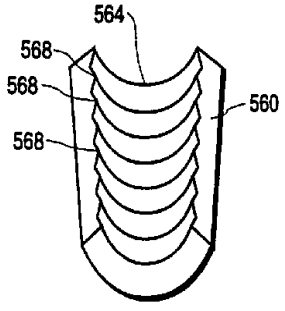
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FIG.10

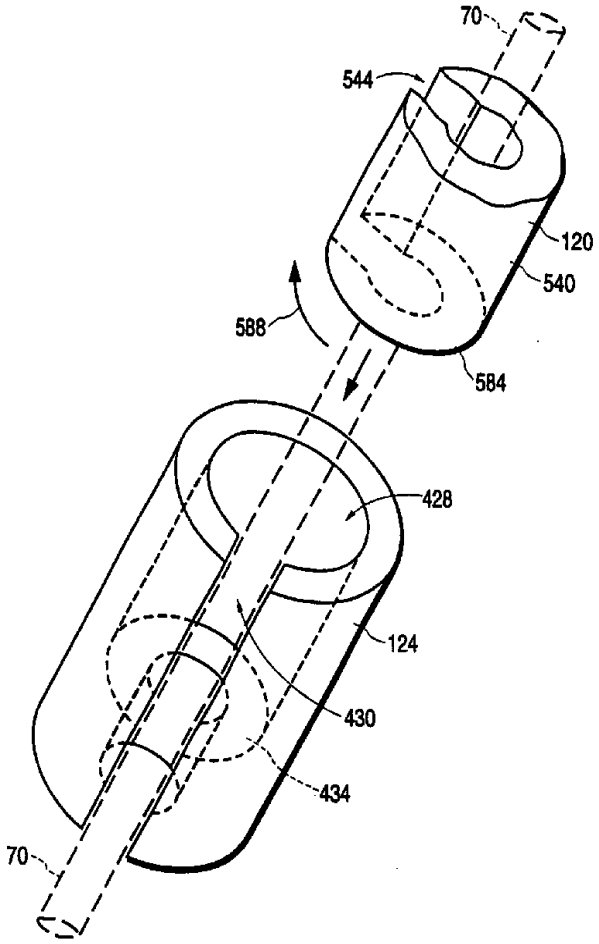

FIG.11

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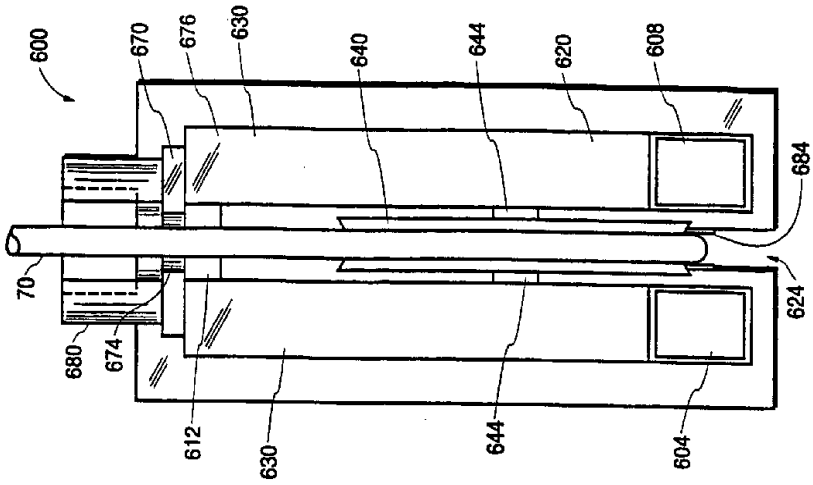
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FIG.13

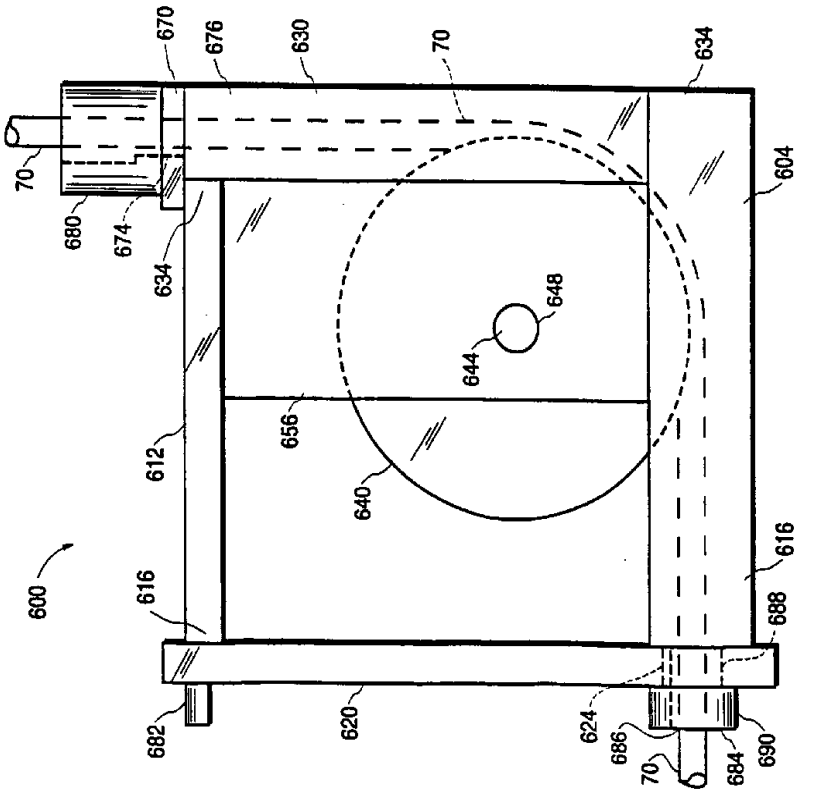
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FIG.12

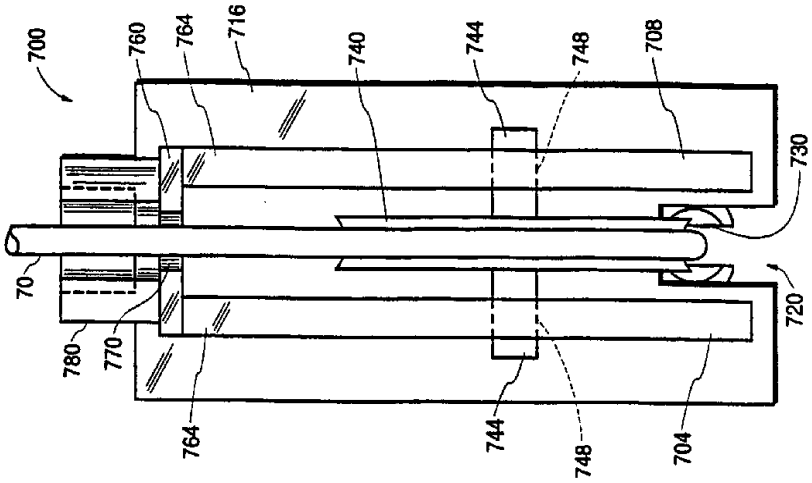
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FIG.15

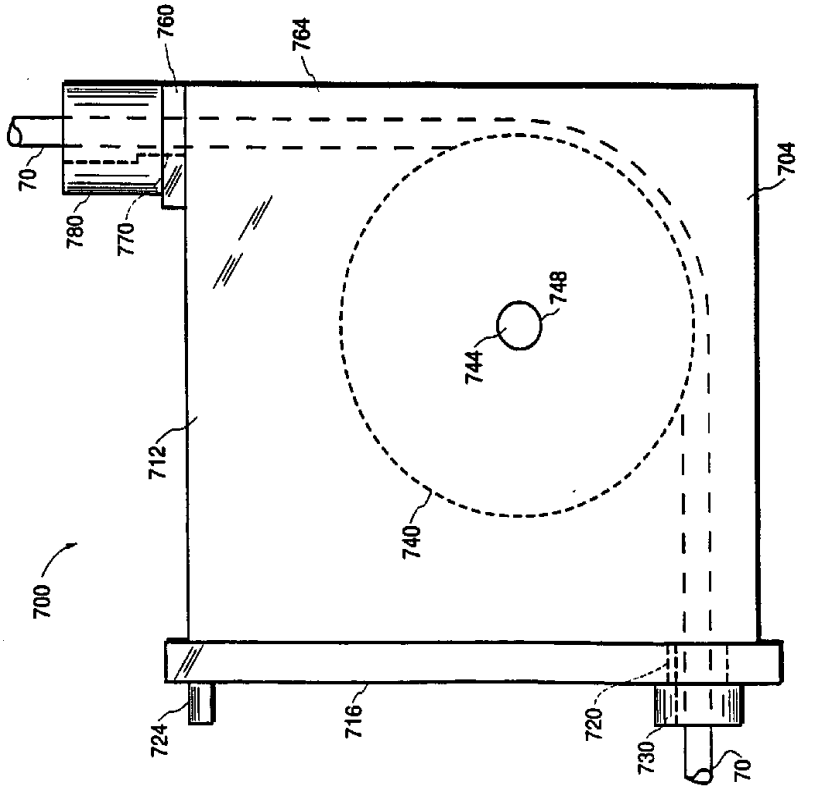
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FIG.14

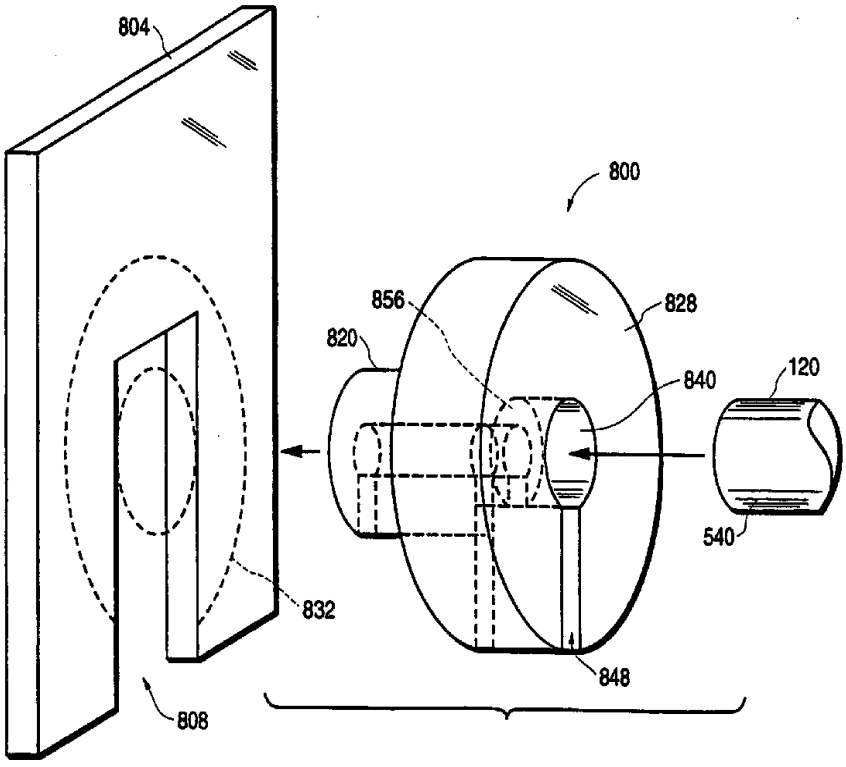

FIG.16

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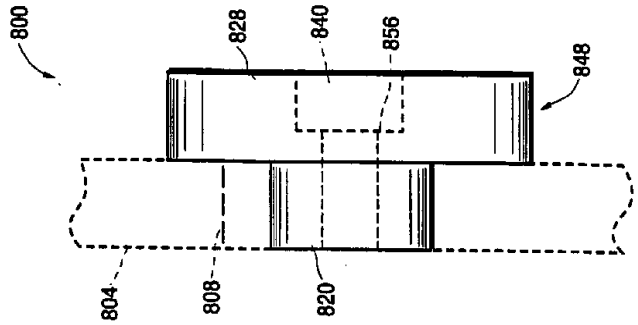

FIG.18

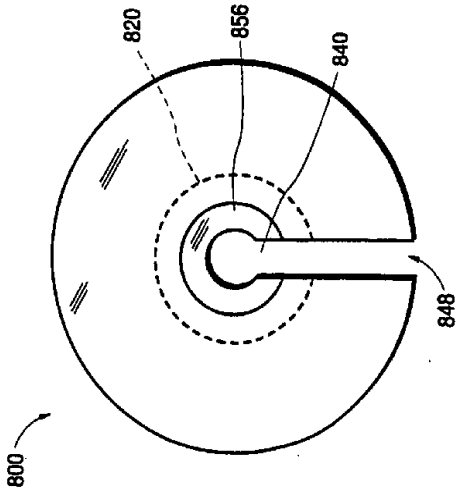

FIG.17