Aug. 23, 1960 C. J. WHEELER 2,950,035

METHOD FOR PARTING ELONGATED FRACTURABLE MEMBERS

Filed May 22, 1959 4 Sheets-Sheet 1

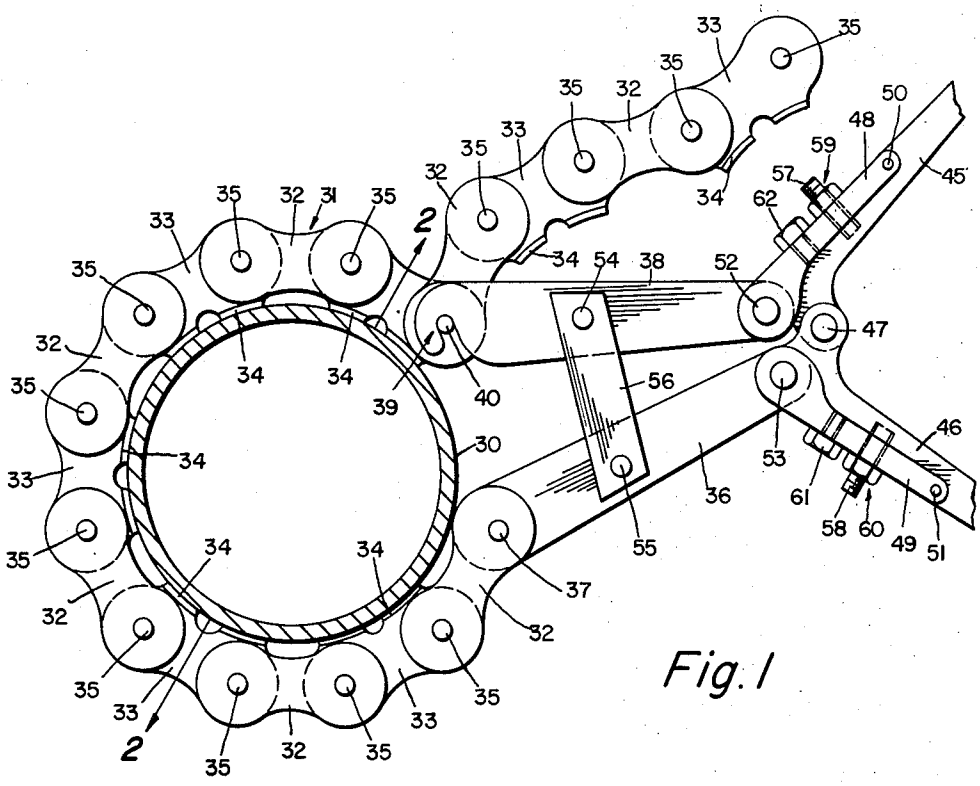


Fig. 1

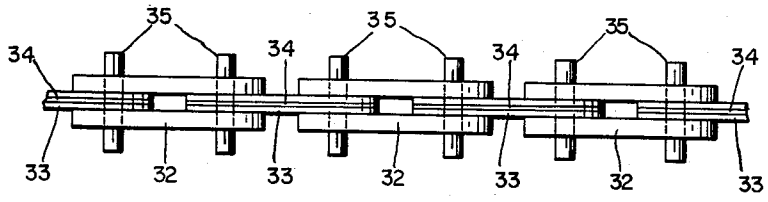


Fig. 2

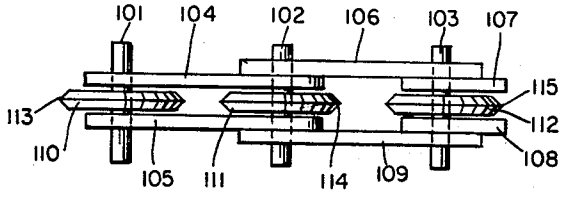


Fig. 3

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Filed May 22, 1959 4 Sheets-Sheet 2

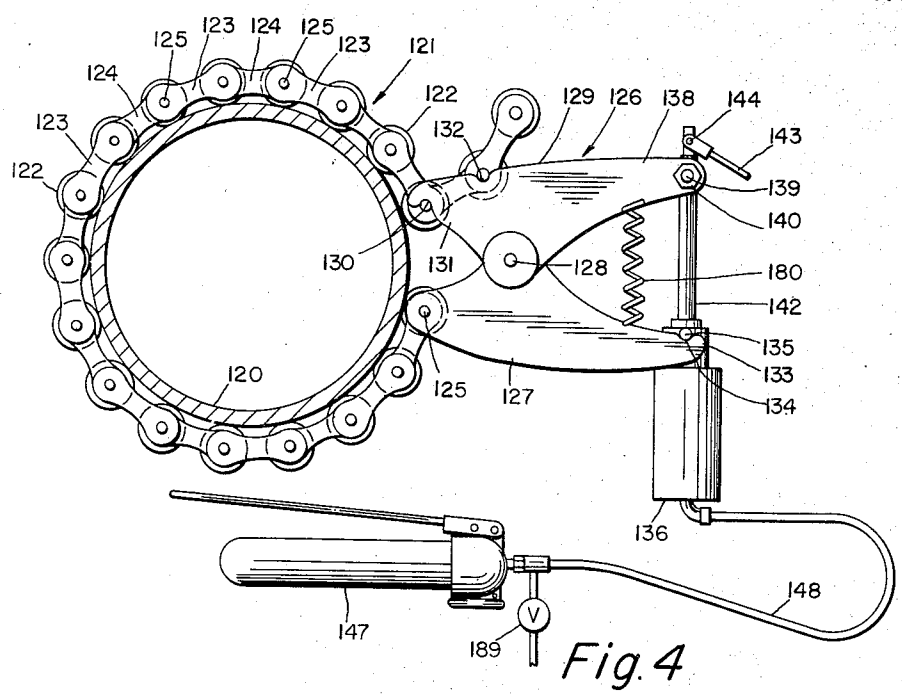


Fig. 4

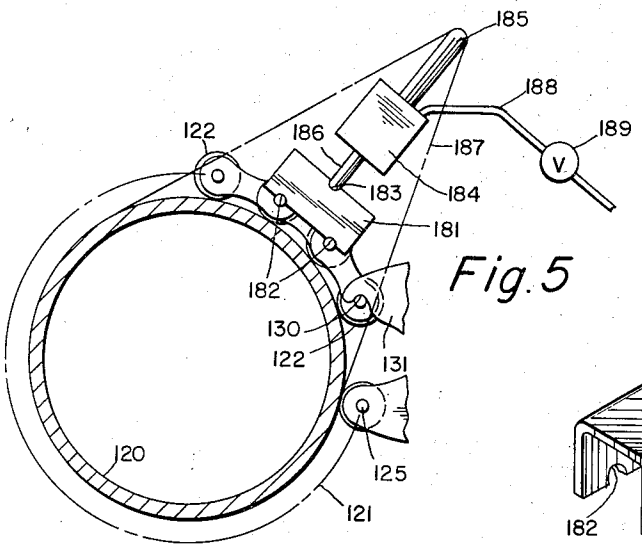


Fig. 5

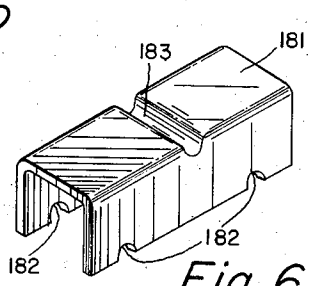


Fig. 6

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METHOD FOR PARTING ELONGATED FRACTURABLE MEMBERS

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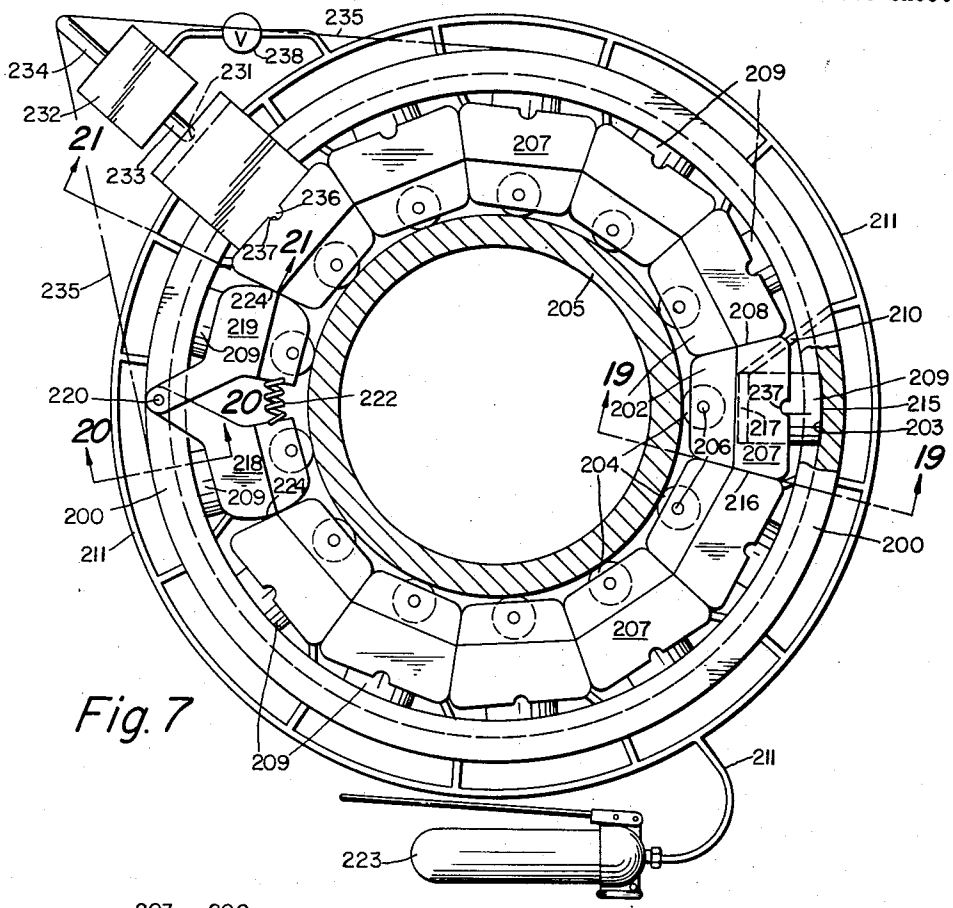


Fig. 7

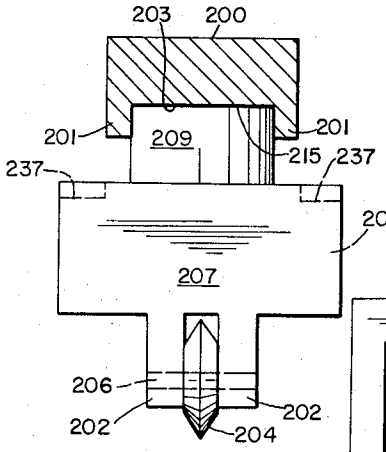


Fig. 8

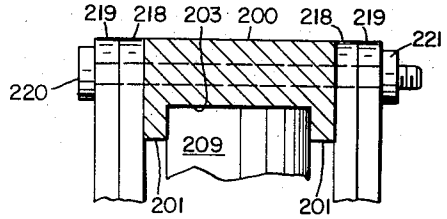


Fig. 9

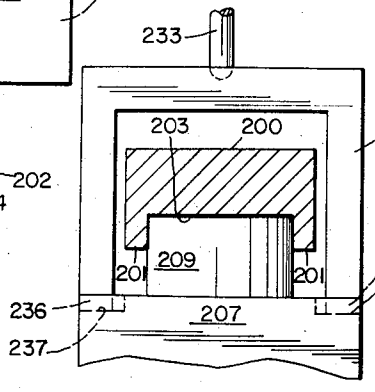


Fig. 10

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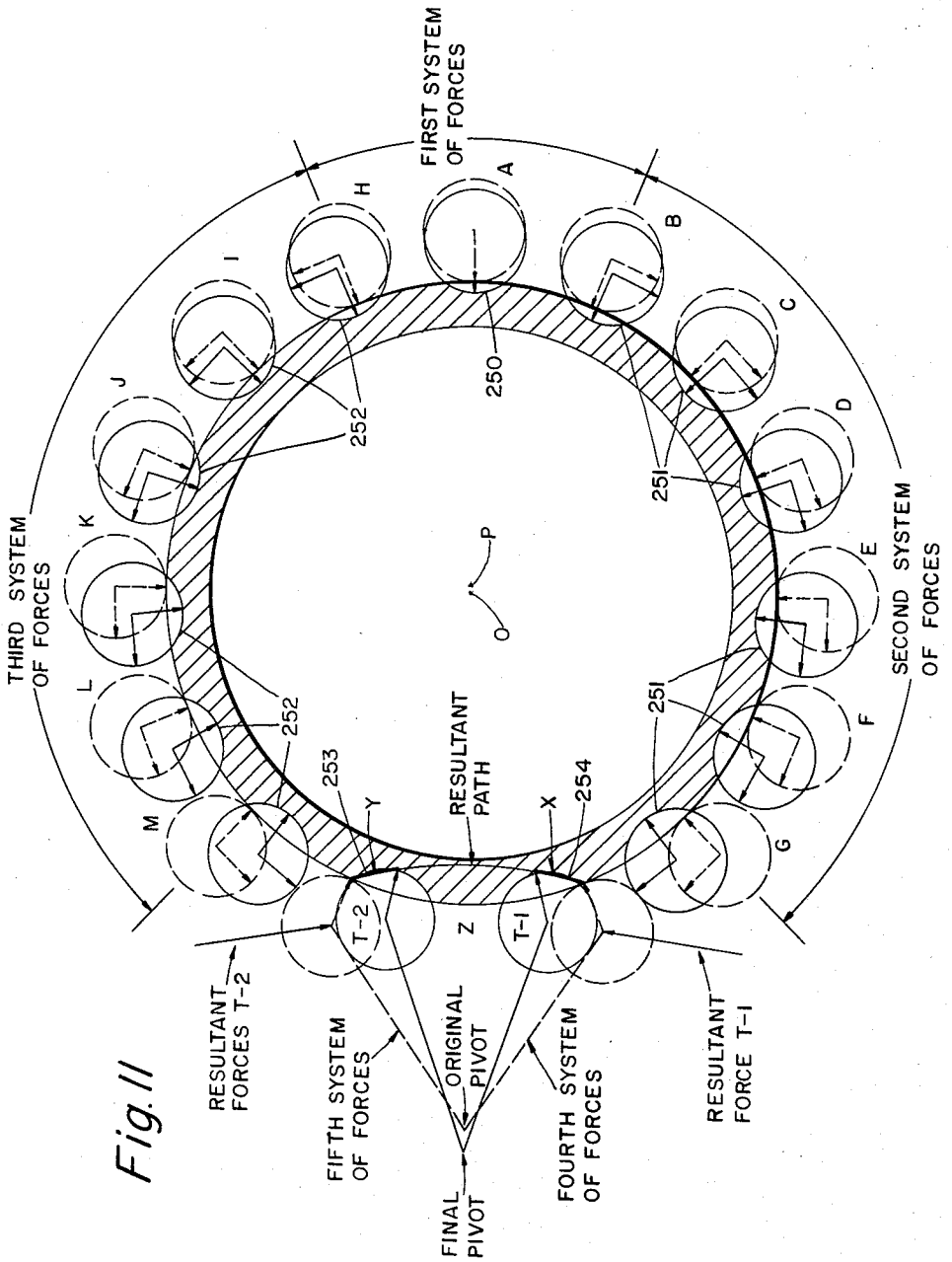


Fig. 11

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2,950,035

METHOD FOR PARTING ELONGATED FRACTURABLE MEMBERS

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Filed May 22, 1959, Ser. No. 815,062

8 Claims. (Cl. 225—1)

This invention relates to the parting of elongated fracturable members.

This application is a continuation-in-part of my prior application Serial No. 578,208, filed April 16, 1956, now abandoned, and of my prior application Serial No. 758,392, filed September 2, 1958.

While not limited thereto, the invention is particularly useful in parting or cutting elongated fracturable members, such as cast iron pipe, cast iron soil pipe, AWWA water main pipe, tile chimney flue liners, clay pipe, concrete pipe, terra cotta pipe, transite pipe, whether of circular, oval or other cross-sectional shape. The cutter is likewise capable of cutting glass tubing and rods.

The invention may be hand-operated or hydraulically operated. A hand-operated cutter will part or cut

2" thru 6" standard or extra heavy soil pipe
2" thru 15" glazed tile
2" thru 6" acid proof pipe
2" thru 6" asbestos cement pipe, round or oval
2" thru 18" tile or terra cotta
2" thru 8" transite sewer or vent pipe
2" thru 6" corrosion resistant pipe
2" thru 8" Duriron
Chimney flue liners, square or round
6" transite pressure pipe

The hydraulically operated cutter is capable of cutting

4" thru 12" class 150 AWWA water main (regular or cement lined)
4" thru 8" class 250 AWWA water main
4" thru 12" cement lined cast iron water main
4" thru 36" glazed tile
4" thru 12" asbestos cement pipe
4" thru 15" standard or extra heavy soil pipe
6" thru 36" terra cotta or tile pipe
4" thru 12" transite pressure pipe, round or oval

In this application the pipes and rods above referred to will be characterized as elongated fracturable members.

An object of the invention is to part or cut an elongated fracturable member by subjecting the outer peripheral surface thereof to a system of radially and peripherally directed forces and increasing said system of forces until the elongated fracturable member fractures or is parted.

Another object is the parting of an elongated fracturable member by subjecting the outer peripheral surface thereof to at least five systems of radially and peripherally directed forces and of increasing said forces until the member fractures or is parted.

Another object is the parting of an elongated fracturable member by subjecting the outer peripheral surface thereof to at least six systems of radially and peripherally directed forces and of increasing said forces until the member fractures or is parted.

Another object of the invention is the parting of an elongated fracturable member by subjecting the outer peripheral surface thereof to a plurality of cutting means, including the blade type or the rotary type, and of pressing the cutting means against said outer peripheral surface by at least five systems of radially and peripherally directed forces and of increasing said forces until the elongated fracturable member fractures or is parted.

Another object is the parting of an elongated fracturable member by making a plurality of indentures around the outer peripheral surface thereof with the indentures being spaced apart in an annular direction and with the size of said indentures gradually increasing from one side of the elongated fracturable member to the opposite side thereof.

Another object is the parting of an elongated fracturable member by subjecting the outer peripheral surface thereof to at least five systems of radially and peripherally directed forces and of hydraulically controlling said systems of forces by successive pulses gradually increasing in magnitude upon each pulse.

Another object is to part an elongated fracturable member by subjecting the outer peripheral surface thereof to at least five systems of radially and peripherally directed forces by means of a cutter chain having terminal cutter means which are spaced apart from each other and which are controlled by at least two of said five systems of forces, with said two systems of forces directing said terminal cutter means in resultant paths and with each path comprising a movement which is disposed on spaced apart sections of a line extending between said two spaced cutter means inside of the outer peripheral surface of said elongated fracturable member and with said spaced sections of said paths being angularly misaligned with respect to each other.

Another object of the invention is the method wherein the skew moving cutter means cuts mostly on the front or leading side thereof and less on the trailing side and wherein the substantially radially moving cutter means cuts substantially equally on both the leading and trailing sides.

Another object of the invention is the method wherein the skew moving cutter means comprising both an inwardly directed radial movement and a peripherally directed movement appear to make deeper indentures than the indentures made by the substantially inwardly radially moving cutter means.

Another object of the invention is the method wherein at least one of the terminal cutter means makes a radially and peripherally directed skew indenture in opposition to a substantially radially directed indenture made by an intermediate cutter means on the opposite side of the fracturable member.

Another object of the invention is the provision of apparatus and method for parting elongated fracturable members.

Other objects and a fuller understanding of this invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawing, in which:

Figure 1 is a fragmentary side view of a cutting or parting apparatus illustrating the method of parting a pipe which is shown in section;

Figure 2 is a fragmentary plan view, taken along the line 2—2 of Figure 1;

Figure 3 is a fragmentary view similar to Figure 2 showing rotary cutter means instead of blade means employed in the method and apparatus;

Figure 4 is a side view of a hydraulic cutting or parting apparatus illustrating the method of parting a pipe which is shown in section;

Figure 5 is a fragmentary view of Figure 4 and shows in addition thereto an extra force means to force a selected cutting means against the pipe to be parted;

Figure 6 is a perspective view of a saddle used in applying the force to the cutter means;

Figure 7 is a side view of apparatus for parting an elongated fracturable member by means of hydraulic pressure;

Figure 8 is a view taken along the line 19—19 of Fig.

ure 7 and shows principally one of the hydraulic wedging units;

Figure 9 is a view taken along the line 20—20 of Figure 7 and shows principally the lever arms upon which the terminal hydraulic units are pivotally mounted;

Figure 10 is a view taken along the line 21—21 of Figure 7 and shows principally the arrangement for applying a separate external force to a selected hydraulic wedging unit; and

Figure 11 is a diagrammatic illustration of the method for parting an elongated fracturable member.

It will be appreciated that apparatus of this invention includes preferably a plurality of spaced, uniformly circumferentially distributed cutter edges, and means to apply radially directed pressure thereto. Generally, this means may comprise a variety of pressure sources including, for example, purely mechanical, electrical or hydraulic devices, or some combination thereof. Hence, it will be understood that different means may be employed to apply pressure to a series of cutter edges peripherally disposed around an article to be cut whereby a concentrated, resultant, inwardly radially directed article-cutting force is achieved.

It generally is preferred to utilize as this means a pressure clamp adapted to engage the cutter linkage, e.g., with the two jaws of the clamp, and by movement of the jaws to effect the application of tension to said linkage while disposed about the pipe or other article to be cut, thus imparting a concentrated pipe constricting squeeze cutting pressure sufficient to shear cut the pipe wall. A specifically preferred means for applying pressure to the cutter edges is a compound leverage pressure clamp mechanism of the type usually employed in a manually operated bolt cutter. Such a device typically includes two handles which are pivotally connected to each other near one end and each of which pivotally supports an adjustable second pivot arm, each of the second pivot arms in turn, pivotally supporting a third pivot arm. These third pivot arms, each pivotally secured at one end thereof to the second pivot arm are fixedly, yet pivotally, connected to each other intermediate their ends. The free ends of the third pivot arms comprise the jaws of the pressure clamp which, by means of a thus greatly multiplied leverage power, are able to exert tremendous force therebetween.

It will thus be understood that a specifically preferred apparatus of this invention, especially adapted for the cutting of cast iron pipe comprises a cutter assembly, including a plurality of spaced, pivotally mounted cutters connected into a non-extensible chain, typically a so-called roller chain as used in sprocket gear drive devices, adapted to encircle the pipe where cutting is desired and to apply thereto inwardly directed radial and peripheral pressure sufficient to cut the pipe quickly and accurately while the cutters are stationary with respect to the pipe, one end of the linkage being connected to one jaw of a pressure clamp means, especially a compound leverage pressure clamp, the other jaw of the clamp engaging the linkage at a point dictated by the size of the pipe to be cut, that is, at a point on the linkage sufficiently removed from the point of engagement of the first-mentioned clamp jaw to include therebetween a linkage length substantially equal to the circumference of the pipe to be cut, the clamp being adapted to apply tension to the linkage thereby to impart to the pipe wall a linearly concentrated, radially directed pressure around the circumference of the pipe to effect cutting or parting thereof.

Reference is now made more particularly to the accompanying drawing wherein Figure 1 illustrates apparatus embodying the invention disposed in place around a pipe 30. As shown, the apparatus comprises a flexible non-extensible metallic cutter chain or linkage, indicated generally at 31, encircling the pipe 30 and including a plurality of alternatingly spaced, connecting links 32 and cutters 33, the latter being provided with curved cutter edges 34 conforming generally to the external surface of all pipe, all pivotally connected via metallic pins 35. One end of the linkage 31 is pivotally secured to one jaw 36 of a compound leverage pressure clamp at 37, there being provided a circular cutter at this junction. The other jaw 38 of the clamp engages, by means of hook 39, or other engageable means (not shown) linkage pin 40, thus to constrict the linkage 31 to a pipe wall-shearing pressure around the pipe 30.

By applying pressure to bring together the clamp handles 45 and 46, pivoted about point 47, the force applied is multiplied via the compound leverage mechanism comprising elements 48 and 49 pivoted to handles 45 and 46 at points 50 and 51, and jaw members 36 and 38 pivotally secured at 52 and 53, respectively, to elements 48 and 49, the jaw members being pivotally joined intermediate their ends at points 54 and 55 by crossbar 56. Threaded upstanding studs 57 and 58, secured to handles 45 and 46, respectively, threadably engage outward movement limit nuts 59 and 60, respectively. To adjust the angular relationship between element 48 and handle 45, and element 49 and handle 46, respectively, in combination with studs 57 and 58, bolts 61 and 62 threadably engage elements 48 and 49, respectively, and bear against handles 45 and 46, respectively.

Figure 2 is a fragmentary plan view taken along the line 2—2 of Figure 1, wherein pins 35 connect cutters 33, having cutting edges 34, with connecting links 32.

Figure 3 illustrates, in a fragmentary view similar to Figure 2, the mounting of rotary cutter elements on the chain. As indicated in Figure 3, pins 101, 102 and 103 connect links 104, 105, 106, 107, 108 and 109 and rotary cutters 110, 111, and 112, having, respectively, cutting edges 113, 114 and 115.

The various cutters described herein may be formed of suitable metal, alloy, or other high strength material capable of transmitting pressure to the pipe or other article to be cut without cracking, shattering, or too rapid dulling. Illustrative of suitable materials are various high strength steels including high carbon steels and low or medium carbon steels. It will be understood, of course, that as a practical matter the particular steel employed in forming the cutters and cutting edges is dictated by a consideration of the hardness, brittleness, availability, etc. The angle included between the surfaces defining a cutting edge generally may be varied also, a typically preferred angle being about 45 degrees.

The Figure 4 is directed to a hydraulically controlled cutter chain and this embodiment of the invention comprises a flexible, non-extensible cutter chain engageable at spaced points by chain-engaging means movable to tighten the chain around the article to be cut in response to hydraulic pressure greatly magnified over that applied and provided by apparatus comprising, in combination, a hydraulic pump including a first piston movably disposed in a first cylinder operatively connected to a second piston of substantially increased cross-section disposed in a second cylinder, said second piston operatively applying fluid pressure to said chain-engaging means when disposed about the article to be cut. The two pistons and cylinders and operative fluid connection therebetween may comprise a single unitary structure wherein the pump and pressure-applying piston are embodied in a single apparatus element as in the case of the hydraulic pressure-applying elements shown in United States Patent No. 2,821,877 of Swanson.

Alternatively and preferably, the hydraulic pressure-applying means comprises a hydraulic pump such as a hand or foot-operated, or power-operated, pump capable of applying the necessary pressure, e.g., a No. 1715 hydraulic hand pump (Greenlee) or an electrically-operated hydraulic pump, such as the Blackhawk Porto-Power, high pressure hydraulic pump, Model P2, manufactured

by the Black Hawk Manufacturing Company. Other types of hydraulic pumps of smaller or larger sizes also may be used, e.g., as shown in Catalog K of the Strong, Carlisle & Hammond Company, pages 76, 85, 400, 979 and 980.

When a separate hydraulic pump is used, for example, a commercially available hydraulic pump of the type indicated, the second hydraulic element comprises a piston of increased cross-sectional area operatively disposed in a cylinder, thus constituting a hydraulic actuator, with a pressure-resistant fluid circuit between the pump and hydraulic element as provided by a flexible, pressure-resistant hose of any convenient length, e.g., several feet, typically four to eight feet. Such a length permits positioning the hydraulic pump away from the immediate situs of cutting in a convenient manner for operation yet permits application of cutting pressure where it is desired. Typical of suitable hose is Blackhawk Port-Power hose resistant to 10,000 p.s.i. or greater internal pressure. Such hose generally is employed with protective metal guards adjacent its ends.

The chain-engaging means may take various forms and may be incorporated as part of the hydraulic pump or elsewhere in the hydraulic circuit. A presently preferred embodiment of the invention comprises a pressure clamp to which pressure is applied by hydraulic means described. More specifically preferred is a pair of heavy duty clamp jaws pivotally connected intermediate their ends with one end of the jaws adapted to engage the cutter chain while at, or adjacent, the other end is provided with means operatively to engage a hydraulic actuator whereby movement of the actuator under the influence of hydraulic pressure applied by the pump connected thereto provides the substantial and greatly magnified pressure necessary to cut the hollow article. It will be appreciated that by properly proportioning the hydraulic elements with due consideration to the strength of the materials used, any desired increase in pressure for cutting can be provided.

With reference more particularly to the drawing, in Figure 4 there is illustrated a hydraulic cutter of this invention disposed in operative position about a pipe **120** to be cut. As there shown, the cutter comprises a cutter chain, indicated generally at **121**, including a plurality of uniformly-spaced, identical cutting edges or cutters **122**, pivotally joined into a flexible, non-extensible chain by a plurality of external links **123** and internal links **124** via transverse pins **125** extending through the links **123** and **124** and cutters **122**, and projecting on both sides thereof. This, it will be appreciated that chain **121** is adapted to be tightened around the pipe **120** to be cut and thereby, without rotation or oscillation thereabout, to apply radially-directed, article-cutting pressure at uniformly circumferentially distributed points in response to application of hydraulic pressure by a hydraulic pressure clamp, especially a hydraulic pressure clamp designated generally by the numeral **126** in Figure 4.

Pivotally connected to one end of cutter chain **121** via pin **125** is a first clamp jaw **127** comprising two similar heavy metal elements of the shape indicated, spaced apart along the common pivot **128** a distance sufficient to fit within two elements of a second clamp jaw **129**. The second clamp jaw **129**, pivotally secured to the first clamp jaw **127** via the common pivot pin **128** intermediate their ends, since it is made up of two spaced apart elements, is provided with an opening for receiving, guiding, and engaging the excess cutter chain beyond that necessary to surround the article **120**, as is dictated by the chain length ending at pin **125** retained in a detent **130** in the forward lip **131** of jaw **129**. There also are provided two identical detents **132** in jaw **129** which are spaced apart to receive therebetween the cutter chain **121** but to retain a pin **125** via its projection through the chain. Embodied in the opposite end **133** of jaw **127** is a detent or hook **134** removably receiving a transverse pin **135** of a hydraulic pressure cylinder indicated generally at **136**, the ends **133** being bent outwardly and parallel to accommodate therebetween the pin **135**. Between the ends **138** of jaw **129** is pivotally secured a transverse pin **139** engaging a nut **140**.

Threadably engaged in nut **140** is a pin **142**, threaded for at least a portion of its length and carrying at its upper end extending upwardly through the nut **140** a pivotally-secured handle **143**, secured thereto via pin **144**, for turning pin **142** therein.

At its lower end, pin **142** is fitted into the upper end of a piston operatively disposed in cylinder **136** whereby fluid under pressure as from a hydraulic pump, designated generally at **147** in fluid connection therewith via hose **148**, exerts pressure on pin **142** in transmitting pressure pivotally to spread ends **133** and **138** about pin **128**, thereby drawing together the opposite ends and tightening the chain **121** about pipe **120**.

If desired, a tension spring **180** can be secured between the ends **138** and **133** of the jaws **127** and **129** to facilitate opening of the jaws when hydraulic pressure is released. It will be understood, of course, that in operation, the application of hydraulic pressure is continued until the article to be cut is severed at which time an appropriate pressure release valve on the pump can be opened to permit return of the hydraulic fluid to the pump reservoir. The operation of the hand pump is such that pulsating forces are applied to the chain to part the pipe. The forces are progressively increased with a pause between each pulse. This pulsing action with a pause between each pulse aids in parting the pipe.

Figure 5 shows the application of an external force which is characterized in the claims as a sixth system of forces for forcing at least a selected rotary cutter means disposed next adjacent to one side of a terminal cutter means against the elongated fracturable member to be fractured. The arrangement comprises a saddle **181** which has spaced side flanges provided with detents **182** which engage the pins **125** of the rotary cutter chain **121**. The top surface of the saddle is provided with a detent **183** into which is mounted a piston **186** of a hydraulic cylinder **184** which supplies the separate force for forcing the selected rotary cutter means against the outer peripheral surface of the elongated fracturable member. The arrangement of the piston and cylinder may be of any design and the upper end of the cylinder is provided with a handle **185** around which is mounted a tension chain **187** that wraps around the elongated fracturable member to be fractured. The cylinder **184** is adapted to be connected to the hand-operated pump **147** of Figure 4 by means of a conduit **188** and a valve **189**. When the valve is open, the cylinder is provided with fluid from the outlet of the pump **147**. In this embodiment of the invention, the pump operates both the hydraulic unit for the jaws, as well as the piston **186** for pressing the saddle **181** against the pins **125** of the cutter chain **121**.

The arrangement of Figure 5 is employed for the parting of large pipe and the application of the pressure seems to work best when the forces are applied to the cutter means which are located next adjacent to one of the terminal cutter means connected to at least one of the jaws of the hydraulically operated tool. However, it is to be understood that the separate pressure means may be applied to any two of the cutter elements located any place around the outer peripheral surface of the elongated fracturable member which is to be parted.

The Figures 7, 8, 9, and 10 illustrate a method and apparatus for parting an elongated fracturable member. As illustrated best in Figure 7, the arrangement and method comprise an annular ring **200** which surrounds the elongated fracturable member (pipe) **205** which is to be parted. The annular ring **200** has inwardly directed flanges **201** providing a channel **203** therebetween. Mounted between the channel **203** and the outside peripheral surface of the pipe **205** are a plurality of hydraulic wedge units **207**, each having a rotary cutter means **204**.

Each of the hydraulic wedge units **207** comprises a cylinder unit **208** and a piston **209** forming a piston chamber **217** which is supplied with fluid under pressure through a duct **210** from a fluid conduit system **211** operated by a pump **223**. The outer end of the piston **209** is provided with an arcuate sliding surface **215** which slides circumferentially against the channel **203**. The inner end of the cylinder arrangement **208** is provided with two spaced flanges **202** between which a rotary cutter means **204** is mounted upon a cross-pin **206** (see Figure 8). The sides of the cylinder arrangement **208** are provided with wedging edges **216** which extend in a radial direction and are arranged to engage the wedging edge of the next adjacent hydraulic wedge unit. The hydraulic wedge units **207** are all identical except the two terminal units which are arranged to be pivotally connected to the annular ring **200** by means of side pivot arms **218** and **219**, respectively. As illustrated, the two arms may be pivotally connected to the annular ring by means of a cross-pin **220** and a nut **221**. Between the two terminal hydraulic wedge units **207** is mounted a spring **222** which forces all the hydraulic wedge units away from the outer surface of the pipe being cut. The sides of the terminal wedge units are made arcuate so that the two terminal hydraulic wedge units may arcuately slide with reference to the edges of the hydraulic units against which they engage.

In operation, when fluid pressure is supplied to all of the hydraulic wedging units, the rotary cutting means **204** are pressed against the outer peripheral surface of the pipe which is to be parted. To part the pipe, it is only necessary to apply the pressure until the pipe is fractured. As the rotary cutters are pressed inwardly against the pipe, the hydraulic wedging units are forced both in a radial direction against the pipe and in a circumferential direction around the pipe. All of the hydraulic units work the same except the two terminal units which are pivotally connected to the outer annular ring.

The Figure 10 shows a saddle **230** which may be mounted over the outer annular ring **200** and engages the sides of the cylinder arrangement **208** whereby an extra force may be applied to the saddle **230** by means of a cylinder and piston arrangement **232** and **233**. The piston **233** is arranged to fit into a detent **231** on top of the saddle **230**. The saddle may also have side projections **236** which fit into detents **237** on the top edges of the cylinder arrangement **208**. The cylinder **232** is provided with a handle **234** around which a chain **235** is mounted and extends around the outer surface of the annular ring **200**. The cylinder and piston arrangement **232** and **233** may be connected to the fluid conduit **211** through means of a valve **238** so that when the pump **223** is operated, the separate force supplied by the cylinder and piston arrangement **232** and **233** may be applied to the wedge unit next adjacent to a terminal wedging unit, although the separate force may be applied to any wedge unit.

The Figure 11 shows the method of parting an elongated fracturable member in a general direction substantially perpendicular to the longitudinal centerline of the member by pressure subjecting the outer peripheral surface to a plurality of cutting means disposed peripherally apart from each other and extending around the elongated fracturable member. The method comprises the steps of positioning the plurality of cutter means around the outer peripheral surface of the pipe with the cutter means spaced apart from each other in a peripheral direction and with the cutter means lying in a plane substantially perpendicular to the longitudinal centerline of the elongated fracturable member. The cutter means may be of the rotary or blade type. The method further provides for the selecting of at least two cutting means of said plurality as first and second terminal cutting means, and positioning the first and

second terminal cutting means peripherally apart from each other, leaving a peripheral gap Z therebetween having a peripheral dimension less than one-half of the perimeter of the outer peripheral surface and with the remainder of the cutting means extending substantially around the outer peripheral surface. In Figure 11, the first and second terminal cutting means are identified by the reference characters T–1 and T–2 and the remainder of said cutting means are identified by the reference characters A, B, C, D, E, F, G, H, I, J, K, L, and M. Preferably the peripheral distance between T–1 and T–2 should be less than one-third of the perimeter of the outer peripheral surface although in actual practice it is best that the first and second terminal cutting means be as close as possible and not much farther apart than the distance occupied by two to four cutting means. In any event, the peripheral distance between the cutter means G and M is preferably less than one-half the outer perimeter. This affords an insurance that the peripheral distance between the terminal cutting means T–1 and T–2 will be less than one-half the outer perimeter.

The method further comprises the steps of simultaneously applying at least first, second, third, fourth and fifth systems of inwardly directed forces to the cutter means for urging the cutter means to make contact engagement against the outer peripheral surface. As illustrated in Figure 11, the first system comprises substantially a radially directed force applied to the cutter means A, which is characterized as an intermediate cutting means and is located on a side of said outer peripheral surface opposite from the gap Z for urging the cutter means A to move in a substantially radial direction against the outer peripheral surface to make a substantially straight radially directed (non-skew) indenture **250** therein with the cutter means A remaining substantially stationary in a peripheral direction with respect to the outer peripheral surface.

In Figure 11, the rotary cutting means A is characterized as the intermediate cutting means but in the event that there are an even number of rotary cutting means, then the intermediate cutting means may comprise at least two rotary cutting means instead of one. In fact, when the diameter of the rotary cutting means is small compared with the diameter of the outer peripheral surface, then the intermediate cutting means may comprise two or more cutter means instead of one. Therefore in the claims, the term "intermediate cutting means" may comprise one or more cutter means.

The second system comprises a first series of resultant forces, each comprising a radially directed force and a clockwise peripherally directed force. The second system of forces is applied in Figure 11 to the rotary cutter means B, C, D, E, F and G. These cutter means are disposed to one side of the intermediate cutter means A and are forced to gradually creep on the outer peripheral surface to make a series of skew directed indentures **251** in the outer peripheral surface. The skew directed indentures **251** are spaced peripherally apart from each other and extend in a clockwise peripheral direction toward the gap Z. The dotted circles show the position of the rotary cutter means B, C, D, E, F and G before the pressure is applied and the full circles show the position of these cutter means after the pressure is applied. The dotted arrows which are at right angles with respect to each other show respectively the direction of the radially directed forces and the circumferentially directed forces. The full arrows show the direction of the radially directed forces and the circumferentially directed forces after the rotary cutting means have made the indentures therein. The length of the arrows do not necessarily represent the magnitude of the forces. The movement of the cutter means between the two sets of arrows (dotted and full line) is not necessarily a straight directed skew but may be properly described as a convex skew (convex arcuate

path) looking in the direction from the outside of the pipe to the inside of the pipe.

The third system comprises a second series of resultant forces, each comprising a radially directed force and a counterclockwise peripherally directed force. The third system of forces is applied in Figure 11 to the rotary cutter means H, I, J, K, L and M. These cutter means are disposed to one side of the intermediate cutter means A and are forced to gradually creep on the outer peripheral surface to make a series of skew directed indentures **252** in the outer peripheral surface. The skew directed indentures **252** are spaced peripherally apart from each other and extend in a counterclockwise peripheral direction toward the gap Z. The dotted circles show the position of the rotary cutter means H, I, J, K, L and M before the pressure is applied and the full circles show the position of these cutter means after the pressure is applied. The dotted arrows show the direction of the radially directed forces and the circumferentially directed forces prior to the cutting operation. The full arrows show the direction of the radially directed forces and the circumferentially directed forces after the rotary cutting means have made the indentures therein. The movement of the cutter means between the two sets of arrows is not necessarily a straight directed skew but may be properly described as a convex skew (convex arcuate path) looking in the direction from the outside of the pipe toward the inside of the pipe.

The fourth system comprises a radially directed force and a clockwise peripherally directed force and the fifth system comprises a radially directed force and a counterclockwise peripherally directed force, which are effected by the squeezing movement of the pivotally mounted jaws or hydraulic wedging units. The fourth system of forces is represented by a resultant force T–1 and the fifth system of forces is represented by a resultant force T–2 in Figure 11. The resultant forces T–1 and T–2 are applied, respectively, to the terminal cutter means T–1 and T–2 for urging them to gradually creep on the outer peripheral surface to make opposing skew directed indentures **253** and **254** therein. The movement of the cutter means T–1 and T–2 to make the indentures **253** and **254** may be described as a concave skew (concave arcuate path) looking in the direction from the outside of the pipe toward the inside of the pipe. These indentures **253** and **254** are spaced peripherally apart from each other and extend, respectively, toward each other in resultant paths, with each path comprising a movement which is disposed on spaced apart sections X and Y of an arcuate line extending across the gap Z inside of the outer peripheral surface and between the first and second terminal cutting means T–1 and T–2. The spaced apart sections X and Y are angularly misaligned with respect to each other. That is to say, tangents to these spaced apart sections do not lie in the same straight line, but the tangents would be angularly disposed with respect to each other. In carrying out the method, the magnitude of the forces is increased until the plurality of cutting means fractures the elongated fracturable member without substantially relative peripheral movement of the intermediate cutting means and the elongated fracturable member.

The indenture **250** at A is generally shallow and the indentures **251** at B, C, D, E, F and G and the indentures **252** at H, I, J, K, L, and M gradually increase in size (depth) as they approach the terminal cutter means T–1 and T–2. The indentures **253** and **254** are generally the deepest and largest. In Figure 11, the depth of the indentures is magnified in order to illustrate the method, but in actual practice the depth of the indentures is shallow, especially for tile and other brittle material.

As noted above, the cutting means, except the intermediate cutting means, creep peripherally during the cutting or parting operation. The amount of the creep is less than one revolution of the rotary cutting means. In the case of blade cutting means the amount of the creep is less than the distance of a chain link between the cross pins which interconnect the links of the chain.

While not bound thereby, it is believed that the method of cutting or parting of the fracturable member in accordance with the present invention without relative rotation or oscillation of the cutting means and the fracturable member other than the creeping movement, resides in the fact that the five system of forces set up in the body of the fracturable member opposing stresses which collide head-on with each other, aided by the fact that the cutting means, in addition to initiating a series of peripherally spaced indentures, are working against a frontal incline surface (front side of indentures) which tend to increase the magnitude of the stresses and thereby multiply the pressure or impact of the head-on collision of the stresses. Beginning at cutting means A, where the direction of the stresses are substantially radial, the cutting means B, C, D, E, F and G and the cutting means H, I, J, K, L, and M, respectively, set up, in addition to the radial stresses, a series of peripherally directed forces toward the gap Z, and these series of peripherally directed stresses collide head-on with the opposing stresses set up by the terminal cutting means T–1 and T–2. While the head-on collision of stresses are occurring, the cutting means are initiating the series of peripherally spaced indentures and the stresses set up by the cutting means working against the frontal incline surface aid in bringing about the fracture which when once started follows a path defined by the stresses around the fracturable member. The series of peripherally spaced indentures leave full-wall sections therebetween. When a fracture occurs at one or more of the indentures, it extends peripherally across these full-wall sections making a complete fracture in a path around the entire fracturable member substantially perpendicular to the longitudinal centerline or axis of the fracturable member. In operation, the depth of the indentures are gradually increased until the induced stresses reach such a high value as to exceed the physical breaking strength of the wall sections at which point fracture occurs. The concave directed skews of the terminal cutting means and the convex directed skews of the other cutting means B to G and H to M accounting in part for the conflict of stresses. Any squeezing arrangement or method other than that disclosed herein wherein at least one of the terminal means makes a radially and peripherally directed skew indenture in opposition to a substantially radially directed indenture made by an intermediate cutter means on the opposite side of the fracturable member comes within the scope of the invention. The sixth system of forces appears to work best when it is applied to the fracturable member next adjacent the terminal cutting means, although it may be made at other locations. This tends to support the theory of the collision of the opposing stresses.

The skew moving cutter means at the locations B, C, D, E, F, and G and H, I, J, K, L, and M and at the terminal cutter means T–1 and T–2 appear to make deeper indentures than the indenture made by the substantially radially moving cutter means at location A, because the skew moving cutter means cuts mostly on the front or leading side thereof and less on the trailing side, whereas with the substantially radially moving cutter means at A, cuts substantially equally on both the leading and trailing sides.

For a 14 inch steel pipe with 27 rotary cutter means in contact, cutter diameter approximately $1\frac{23}{32}$ inch; cross pins on approximately $1\frac{3}{4}$ inch centers, and approximately $2\frac{5}{8}$ inch between terminal cutter means, the length of chord across indentures were as follows:

	Inches
(1) At intermediate cutter means	0.50
(2) At successive cutter means	0.51
(3) Do	0.52
(4) Do	0.54

	Inches
(5) At successive cutter means	0.56
(6) Do	0.59
(7) Do	0.63
(8) Do	0.65
(9) Do	0.69
(10) Do	0.72
(11) Do	0.76
(12) Do	0.81
(13) Do	0.87
(14) At terminal cutter means	0.93

For a 24 inch tile with 71 rotary cutter means in contact, cutter diameter approximately 1⅛ inch; cross pins on approximately 1¼ inch centers, and approximately 2⅝ inch between terminal cutter means, the length of indenture chord at intermediate cutter chain was approximately 0.200 inch and at terminal cutter means 0.500 inch with lengths of chords for indentures therebetween gradually increasing from intermediate indenture to terminal indenture.

In Figure 11, the focal center for the circumference which passes through the bottom of the indentures appears to shift a small amount to a new center P along a radial line from the true center O of the cutter means in their original position toward the location of the cutter means A.

The method above described may be carried out by rotary cutting elements or by blade cutting elements and the forces for carrying out the method may be applied either by a chain or by a plurality of hydraulic wedging units shown in Figure 7.

The process also involves the application of a sixth system of forces which is not shown in Figure 11, but which sixth system of forces may be applied by the arrangement shown in Figures 5 and 7, wherein cutting elements next adjacent to the termnial cutting elements are applied with additional force.

Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. Method of parting an elongated fracturable member comprising the steps of, making a first and second series of discontinuous indentures spaced peripherally apart from each other and extending around the outer peripheral surface of said elongated fracturable member with said indentures lying in a plane substantially perpendicular to the centerline of said elongated fracturable member and with the first series of indentures extending in a clockwise direction from a first place to a second place on said outer surface, whereby the peripheral distance between said first and second places is greater than one-fourth and less than one-half of the perimeter of said outer peripheral surface, and with said second series of indentures extending in a counterclockwise direction from said first place to a third place on said outer surface, whereby the peripheral distance between said first and third places if greater than one-fourth and less than one-half of the perimeter of said outer peripheral surface, and whereby the peripheral distance between said second and third places is less than one-half of the perimeter of said outer peripheral surface, increasing the size of said discontinuous indentures beginning with a minimum amount at said first place and increasing same to a gradually larger amount in both said series until a maximum amount is attained at said second and third places, and continuously increasing the size of said discontinuous indentures until said elongated fracturable member fractures.

2. Method of parting an elongated fracturable member comprising the steps of, making a first and second series of discontinuous indentures spaced peripherally apart from each other and extending around the outer peripheral surface of said elongated fracturable member with said indentures lying in a plane substantially perpendicular to the centerline of said elongated fracturable member and with the first series of indentures extending in a clockwise direction from a first place to a second place on said outer surface, whereby the peripheral distance between said first and second places is greater than one-fourth and less than one-half of the perimeter of said outer peripheral surface, and with said second series of indentures extending in a counterclockwise direction from said first place to a third place on said outer surface, whereby the peripheral distance between said first and third places is greater than one-fourth and less than one-half of the perimeter of said outer peripheral surface, and whereby the peripheral distance between said second and third places is less than one-half of the perimeter of said outer peripheral surface, increasing the size of said discontinuous indentures beginning with a minimum amount at said first place and increasing same to a gradually larger amount in both said series until a maximum amount is attained at said second and third places, controlling the making of the indenture at said first place by substantially a radially directed force, controlling the making of the indenture at said second place by a concave clockwise skew directed force, controlling the making of the indenture at said third place by a concave counterclockwise skew directed force, controlling the making of the indentures between said first and second places by convex clockwise skew directed forces, controlling the making of the indentures between said first and third places by convex counterclockwise skew directed forces, and continuously increasing the size of said discontinuous indentures until said elongated fracturable member fractures.

3. Method of parting an elongated fracturable member comprising the steps of simultaneously making a first, second, third, fourth and fifth indenture means, spaced peripherally apart from each other and extending around the outer peripheral surface of said elongated fracturable member with said indenture means lying in a plane substantially perpendicular to the centerline of said elongated fracturable member; with said first indenture means being made substantially by an inwardly directed radial movement at a first location; with said second indenture means comprising a series of discontinuous indenture means extending around the peripheral outer surface of the elongated fracturable member for a peripheral distance greater than one-fourth and less than one-half the perimeter thereof and located to one side of said first indenture means and each said second indenture means being made by an inwardly directed radial movement and a clockwise directed peripheral movement; with said third indenture means comprising a series of discontinuous indenture means extending around the peripheral outer surface of the elongated fracturable member for a peripheral distance greater than one-fourth and less than one-half the perimeter thereof and located on the other side of said first indenture means and each said third indenture means being made by an inwardly directed radial movement and a counterclockwise directed peripheral movement; with said fourth and fifth indenture means located substantially opposite from said first indenture means and disposed between the series of said second and third indenture means with said fourth indenture means being made by an inwardly directed radial movement and a clockwise directed peripheral movement and with said fifth indenture means being made by an inwardly directed radial movement and a counterclockwise directed peripheral movement, and continuously increasing the size of said indenture means until said elongated fracturable member fractures.

4. A method of fracturing and parting an elongated fracturable member comprising a first step of substantially

simultaneously applying to the outer peripheral surface of said fracturable member first, second, third, fourth, and fifth systems of inwardly directed forces spaced peripherally apart from each other around said fracturable member and lying in a plane substantially perpendicular to the centerline thereof to induce in said fracturable member a plurality of internal penetrating stresses in said plane with said first system of forces being applied to said outer surface at a first place, with said fourth system of forces being applied at a second place in a clockwise direction from said first place and having a peripheral distance therefrom greater than one-fourth and less than one-half of the perimeter of said outer surface, with said second system of forces being applied at a plurality of separate places extending in a clockwise direction between said first place and said second place, with said fifth system of forces being applied at a third place in a counterclockwise direction from said first place and having a peripheral distance therefrom greater than one-fourth and less than one-half of the perimeter of said outer surface and with said third system of forces being applied at a plurality of separate places extending in a counterclockwise direction between said first place and said third place, a second step of substantially simultaneously increasing the magnitude of all said forces and the intensity of said internal stresses respectively at said places where said forces are applied to said outer surface, said increasing of the magnitude in said second step of said first system of forces comprising maintaining the application of said first system of forces at said first place substantially in a fixed position relative to said outer surface to intensify the internal stresses thereat in substantially a radial direction, said increasing of the magnitude in said second step of said fourth and second system of forces comprising urging the application of said fourth and second system of forces respectively at said second place and at the places between said first and second places to creep clockwise relative to said outer surface to intensify the internal stresses respectively thereat in substantially a radial and peripheral clockwise skew direction, said increasing of the magnitude in said second step of said fifth and third system of forces comprising urging the application of said fifth and third system of forces respectively at said third place and at the places between said first and third places to creep counterclockwise relative to said outer surface to intensify the internal stresses respectively thereat in substantially a radial and peripheral counterclockwise skew direction, and a third step of further substantially simultaneously increasing the magnitude of all said forces to intensify said internal stresses until the intensified stresses fracture and part said fracturable member.

5. A method of fracturing and parting an elongated fracturable member comprising a first step of substantially simultaneously applying to the outer peripheral surface of said fracturable member first, second, third, fourth, and fifth systems of inwardly directed forces spaced peripherally apart from each other around said fracturable member and lying in a plane substantially perpendicular to the centerline thereof to induce in said fracturable member a plurality of internal penetrating stresses in said plane with said first system of forces being applied to said outer surface at a first place, with said fourth system of forces being applied at a second place in a clockwise direction from said first place and having a peripheral distance therefrom greater than one-fourth and less than one-half of the perimeter of said outer surface, with said second system of forces being applied at a plurality of separate places extending in a clockwise direction between said first place and said second place, with said fifth system of forces being applied at a third place in a counterclockwise direction from said first place and having a peripheral distance therefrom greater than one-fourth and less than one-half of the perimeter of said outer surface and with said third system of forces being applied at a plurality of separate places extending in a counterclockwise direction between said first place and said third place, a second step of substantially simultaneously increasing the magnitude of all said forces and the intensity of said internal stresses and at the same time making a plurality of discontinuous indentures respectively at said places where said forces are applied to said outer surface, said increasing of the magnitude in said second step of said first system of forces comprising maintaining the application of said first system of forces at said first place substantially in a fixed position relative to said outer surface to intensify the internal stresses and to enlarge said indenture thereat in substantially a radial direction, said increasing of the magnitude in said second step of said fourth and second system of forces comprising urging the application of said fourth and second system of forces respectively at said second place and at the places between said first and second places to creep clockwise relative to said outer surface to intensify the internal stresses and to enlarge the indentures respectively thereat in substantially a radial and peripheral clockwise skew direction, said increasing of the magnitude in said second step of said fifth and third system of forces comprising urging the application of said fifth and third system of forces respectively at said third place and at the places between said first and third places to creep counterclockwise relative to said outer surface to intensify the internal stresses and to enlarge the indentures respectively thereat in substantially a radial and peripheral counterclockwise skew direction, and a third step of further substantially simultaneously increasing the magnitude of all said forces to intensify said internal stresses and to enlarge said indentures until the intensified stresses fracture and part said fracturable member.

6. A method of fracturing and parting an elongated fracturable member comprising a first step of substantially simultaneously applying to the outer peripheral surface of said fracturable member first, second, third, fourth, and fifth systems of inwardly directed forces spaced peripherally apart from each other around said fracturable member and lying in a plane substantially perpendicular to the centerline thereof to induce in said fracturable member a plurality of internal penetrating stresses in said plane with said first system of forces being applied to said outer surface at a first place, with said fourth system of forces being applied at a second place in a clockwise direction from said first place and having a peripheral distance therefrom greater than one-fourth and less than one-half of the perimeter of said outer surface, with said second system of forces being applied at a plurality of separate places extending in a clockwise direction between said first place and said second place, with said fifth system of forces being applied at a third place in a counterclockwise direction from said first place and having a peripheral distance therefrom greater than one-fourth and less than one-half of the perimeter of said outer surface and with said third system of forces being applied at a plurality of separate places extending in a counterclockwise direction between said first place and said third place, a second step of substantially simultaneously increasing the magnitude of all said forces and the intensity of said internal stresses and at the same time making a plurality of discontinuous indentures respectively at said places where said forces are applied to said outer surface, said increasing of the magnitude in said second step of said first system of forces comprising maintaining the application of said first system of forces at said first place substantially in a fixed position relative to said outer surface to intensify the internal stresses and to enlarge said indenture thereat in substantially a radial direction, said increasing of the magnitude in said second step of said fourth and second system of forces comprising urging the application of said fourth and second system of forces respectively at said second place and at the places between said first and second places to creep clockwise relative to said outer surface to intensify the internal stresses and to enlarge the indentures respectively thereat in substantially a radial and peripheral clockwise skew direction, said increasing of the magnitude in said second step of said fifth and third system of forces comprising urging the application of said fifth and third system of forces respectively at said third place and at the places between said first and third places to creep counterclockwise relative to said outer surface to intensify the internal stresses and to enlarge the indentures respectively thereat in substantially a radial and peripheral counterclockwise skew direction, and a third step of further substantially simultaneously increasing the magnitude of all said forces to intensify said internal stresses and to enlarge said indentures until the intensified stresses fracture and part said fracturable member.

creep clockwise relative to said outer surface to intensify the internal stresses respectively thereat in substantially a radial and peripheral clockwise skew direction, said increasing of the magnitude in said second step of said fifth and third system of forces comprising urging the application of said fifth and third system of forces respectively at said third place and at the places between said first and third places to creep counterclockwise relative to said outer surface to intensify the internal stresses respectively thereat in substantially a radial and peripheral counterclockwise skew direction with the counterclockwise skew direction at said third place being opposite and angularly disposed with respect to the clockwise skew direction at said second place, and a third step of further substantially simultaneously increasing the magnitude of all said forces to intensify said internal stresses until the intensified stresses fracture and part said fracturable member.

7. A method of fracturing and parting an elongated fracturable member comprising a first step of substantially simultaneously applying to the outer peripheral surface of said fracturable member first, second, third, fourth, and fifth systems of inwardly directed forces spaced peripherally apart from each other around said fracturable member and lying in a plane substantially perpendicular to the centerline thereof to induce in said fracturable member a plurality of internal penetrating stresses in said plane with said first system of forces being applied to said outer surface at a first place, with said fourth system of forces being applied at a second place in a clockwise direction from said first place and having a peripheral distance therefrom greater than one-fourth and less than one-half of the perimeter of said outer surface, with said second system of forces being applied at a plurality of separate places extending in a clockwise direction between said first place and said second place, with said fifth system of forces being applied at a third place in a counterclockwise direction from said first place and having a peripheral distance therefrom greater than one-fourth and less than one-half of the perimeter of said outer surface and with said third system of forces being applied at a plurality of separate places extending in a counterclockwise direction between said first place and said third place, a second step of substantially simultaneously increasing the magnitude of all said forces and the intensity of said internal stresses and at the same time making a plurality of discontinuous indentures respectively at said places where said forces are applied to said outer surface, said increasing of the magnitude in said second step of said first system of forces comprising maintaining the application of said first system of forces at said first place substantially in a fixed position relative to said outer surface to intensify the internal stresses and to enlarge said indenture thereat in substantially a radial direction, said increasing of the magnitude in said second step of said fourth and second system of forces comprising urging the application of said fourth and second system of forces respectively at said second place and at the places between said first and second places to creep clockwise relative to said outer surface to intensify the internal stresses and to enlarge the indentures respectively thereat in substantially a radial and peripheral clockwise skew direction, said increasing of the magnitude in said second step of said fifth and third system of forces comprising urging the application of said fifth and third system of forces respectively at said third place and at the places between said first and third places to creep counterclockwise relative to said outer surface to intensify the internal stresses and to enlarge the indentures respectively thereat in substantially a radial and peripheral counterclockwise skew direction and with the indentures at said second and third places respectively being larger than the indenture at said first place, and a third step of further substantially simultaneously increasing the magnitude of all said forces to intensify said internal stresses and to enlarge said indentures until the intensified stresses fracture and part said fracturable member.

8. A method of fracturing and parting an elongated fracturable member comprising a first step of substantially simultaneously applying to the outer peripheral surface of said fracturable member first, second, third, fourth, and fifth systems of inwardly directed forces spaced peripherally apart from each other around said fracturable member and lying in a plane substantially perpendicular to the centerline thereof to induce in said fracturable member a plurality of internal penetrating stresses in said plane with said first system of forces being applied to said outer surface at a first place, with said fourth system of forces being applied at a second place in a clockwise direction from said first place and having a peripheral distance therefrom greater than one-fourth and less than one-half of the perimeter of said outer surface, with said second system of forces being applied at a plurality of separate places extending in a clockwise direction between said first and said second place, with said fifth system of forces being applied at a third place in a counterclockwise direction from said first place and having a peripheral distance therefrom greater than one-fourth and less than one-half of the perimeter of said outer surface and with said third system of forces being applied at a plurality of separate places extending in a counterclockwise direction between said first place and said third place, a second step of substantially simultaneously increasing the magnitude of all said forces and the intensity of said internal stresses and at the same time making a plurality of discontinuous indentures respectively at said places where said forces are applied to said outer surface, said increasing of the magnitude in said second step of said first system of forces comprising maintaining the application of said first system of forces at said first place substantially in a fixed position relative to said outer surface to intensify the internal stresses and to enlarge said indenture thereat in substantially a radial direction, said increasing of the magnitude in said second step of said fourth and second system of forces comprising urging the application of said fourth and second system of forces respectively at said second place and at the places between said first and second places to creep clockwise relative to said outer surface to intensify the internal stresses and to enlarge the respective indentures thereat in substantially a radial and peripheral clockwise skew direction with the clockwise skew direction at said second place being concave, said increasing of the magnitude in said second step of said fifth and third system of forces comprising urging the application of said fifth and third system of forces respectively at said third place and at the places between said first and third places to creep counterclockwise relative to said outer surface to intensify the internal stresses and to enlarge the respective indentures thereat in substantially a radial and peripheral counterclockwise skew direction with the counterclockwise skew direction at said third place being concave and being opposite and angularly disposed with respect to the concave clockwise skew direction at said second place and with the indentures at said second and third places respectively being larger than the indenture at said first place, and a third step of further substantially simultaneously increasing the magnitude of all said forces to intensify said internal stresses and to enlarge said indentures until the intensified stresses fracture and part said fracturable member.

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