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APPARATUS FOR CUTTING OIL WELL TUBING AND THE LIKE

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2 Sheets-Sheet 1

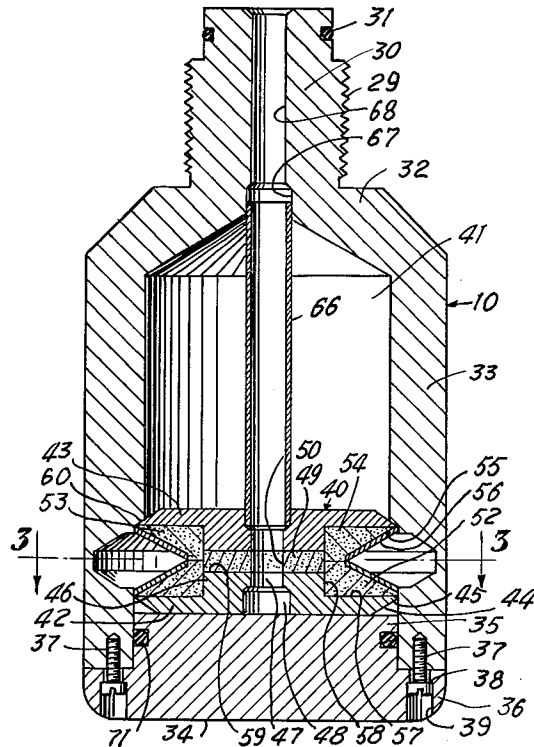
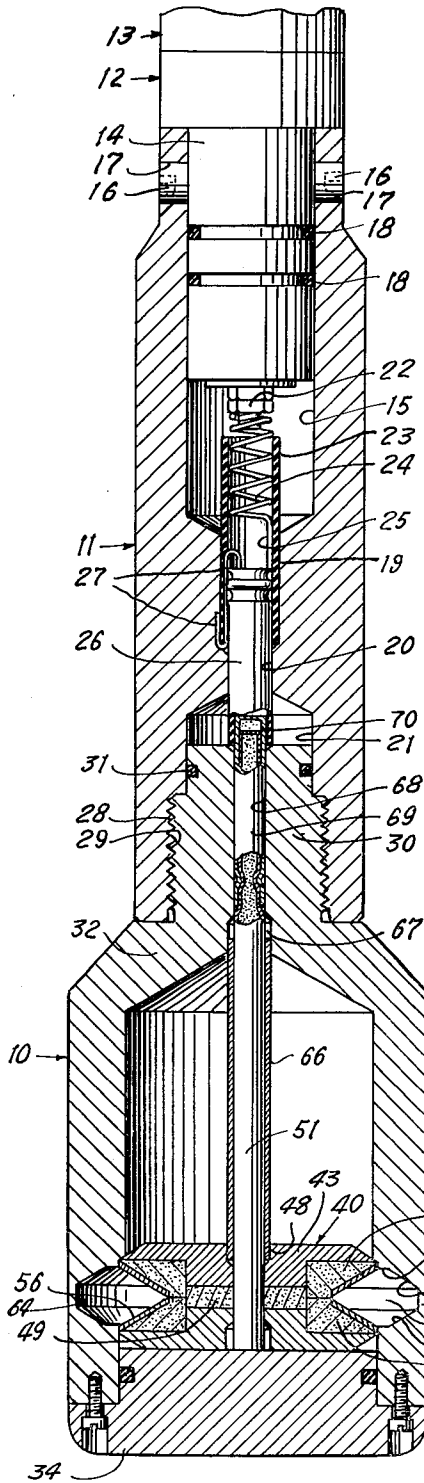


Fig. 2

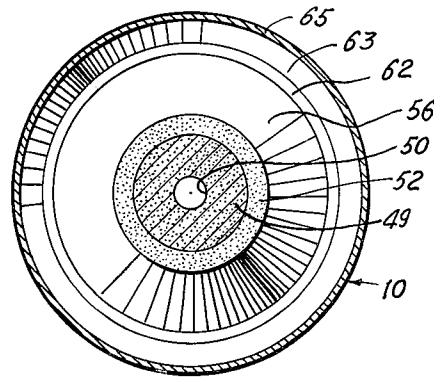


Fig. 3

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Fig. 1

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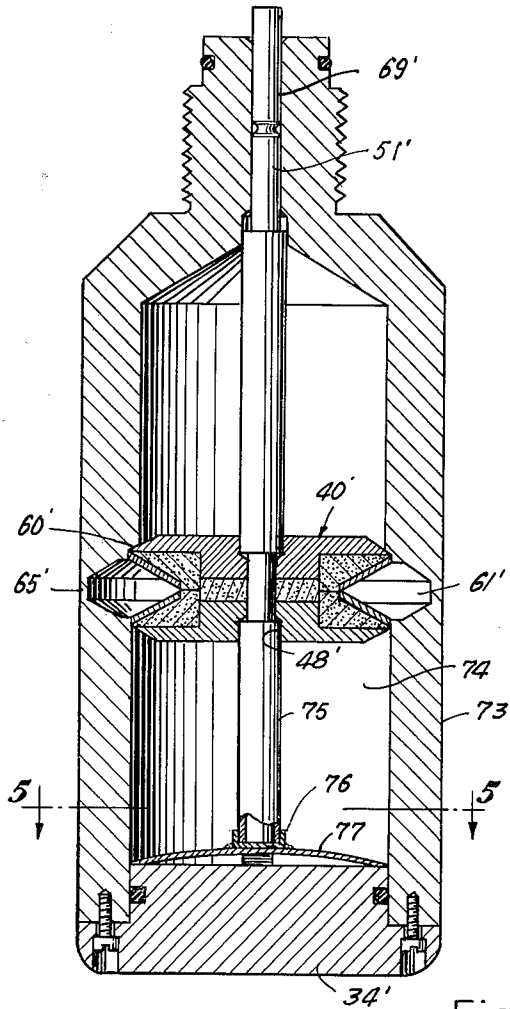


Fig. 4

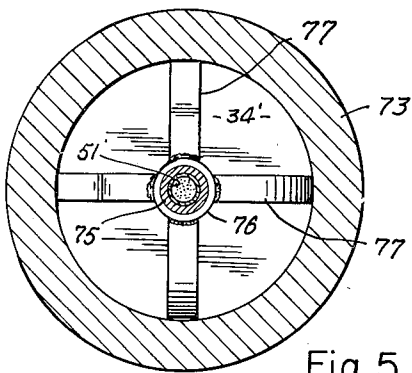


Fig. 5

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## APPARATUS FOR CUTTING OIL WELL TUBING AND THE LIKE

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4 Claims. (Cl. 102—20)

This invention relates to apparatus for cutting or severing oil well tubing and the like, which apparatus is frequently referred to in the industry as a tubing cutter.

In practice of permanent-type well completion methods, after the well has been drilled, the well casing is set and cemented in place. Thereafter, control equipment is installed at the well head and tubing is lowered into the casing and suspended therein with the bottom of the tubing at or slightly above the level of the productive earth formation. The drilling fluids are removed and replaced by a lighter, clean fluid and well perforating equipment is lowered through the tubing and out of the bottom thereof. The perforating apparatus is fired to produce the usual perforations through the casing into the productive zone and thereafter withdrawn from the well through the tubing. The lower end of the tubing may be provided with a bull plug, valve, or other arrangement which, if left in place, would prevent the emergence of the perforating apparatus from the lower end of the tubing. Such bull plug, valve, or other obstruction must be removed from the end of the tubing in order that the perforating operation may be accomplished.

In oil field salvage work or work-over operations, it is often necessary to cut tubing that has become stuck in a well so that it may be removed therefrom or to sever a section of tubing containing an obstruction.

Tubing cutters of various types have heretofore been used for removing bull plugs, tubing stops, or other obstructions from the ends of tubing strings, for cutting tubing stuck in wells and generally for cutting any tubing. One such tubing cutter consists generally of a housing that can be lowered through the tubing from the surface of the earth to the level where the tubing is to be cut. The housing contains an annular shaped explosive charge which, upon detonation, produces a planar cutting jet that is directed radially outwardly from the housing to impinge upon the interior of the tubing and to cut through the tubing walls. Such a tubing cutter has not been entirely successful because the forces of explosion have been poorly controlled with the result that the ends of the tubing near the cut are excessively flared or split and curled outwardly to form an enlargement of the tubing interfering with or preventing its removal from the well. Moreover, such known device has left an objectionable quantity of debris in the well to interfere with subsequent operations.

It is therefore an object of the present invention to provide an improved tubing cutter of the foregoing type that can be lowered into tubing on a wire line and fired to produce a clean cut through the tubing without unduly flaring the ends of the tubing or damaging the surrounding well casing.

A further object of the invention is to provide a tubing cutter employing a quantity of explosive material sufficient to cut through the tubing but insufficient to cut through or damage the surrounding casing.

Another object of the invention is to provide a tubing cutter which, after it has been fired, may be retrieved with its housing largely intact by withdrawal through the tubing and which leaves in the well a minimum of debris.

Another object of the invention is to provide a tubing cutter that may be transported and handled without undue hazard.

A still further object of the invention is to provide a tubing cutter that is simple to manufacture and assemble and easy to use in the field.

The foregoing objects of the invention are achieved, in general, in apparatus for cutting oil well tubing and the like which includes a vertical, cylindrical, sealed housing having pressure-resistant top, bottom and side walls, and means for lowering the housing in oil well tubing. A shaped explosive charge is mounted within the housing, the charge having a circular, horizontal cross-section and an outwardly-opening, annular, lined cavity formed in the outer periphery thereof and being adapted upon being fired to produce a radially expanding planar cutting jet. The shaped explosive charge is mounted in the housing and oriented to direct the planar jet laterally to cut the housing and the surrounding well tubing. Means is provided for firing the charge from the surface of the earth.

In accordance with one aspect of the invention, the side wall of the housing opposite the annular, lined cavity of the shaped explosive charge provides a horizontal, annular groove opening inwardly of the housing and having a thin section bounding the outer periphery of the groove. It is through this thin section that the planar jet cuts and proceeds outwardly to sever the tubing. The groove may be so formed as to cooperate with the shaped explosive charge to provide the requisite stand-off in which the cutting jet may properly form. The walls of the groove may be inclined to aid in reducing flaring of the tubing, as will be explained more fully as the description proceeds.

In another aspect of the invention, the shaped charge is located a substantial distance below the top wall of the housing whereby the housing and the shaped charge define therebetween a substantially unobstructed space providing an expansion chamber for products of the explosion that do not directly enter the jet, in which space the energy of such products is effectively dissipated to minimize damage to the well tubing and casing. Such expansion chamber may be provided either above or below the shaped charge and within the housing, or expansion chambers may be provided both above and below the shaped charge.

Advantageously, a tubing cutter may include the invention in both of the foregoing aspects with more than merely additive advantages.

The invention will be described with greater particularity, and other of its aims, objects and advantages will be brought out in the following detailed description taken in connection with the drawings.

In the drawings:

FIG. 1 is an axial sectional view of the lower portion of a well tool assembly including an exemplary tubing cutter device embodying the principles of the invention;

FIG. 2 is a detailed axial section view of the cutter device shown in FIG. 1;

FIG. 3 is a sectional view along the line 3—3 of FIG. 2;

FIG. 4 is a detailed axial sectional view of another form of cutter device in accordance with the invention; and

FIG. 5 is a sectional view along the line 5—5 of FIG. 4.

Referring to FIG. 1, the assembly therein shown has a cutter head generally designated by the numeral 10. The cutter head is threadedly connected at its upper end to a firing head 11. The latter is secured to an adapter sub 12 which is attached to a conventional casing collar locator 13, only the lower end of the latter component being indicated in FIG. 1. In accordance with common practice, the casing collar locator is suitably connected to a rope socket (not shown) to which is attached the

usual conductor cable (not shown) by which the apparatus is lowered into the well tubing to be severed and by which firing current is delivered to the apparatus.

The adapter sub 12 has an axially depending, cylindrical projection 14 fitted snugly within a cylindrical bore 15 formed in the upper end of the firing head. Allen-head cap screws 16—16, threaded into the depending projection 14 and passing through holes 17—17 in the firing head, securely fasten the firing head to the adapter sub. O-rings 18—18 seal the firing head to the projection 14 and prevent ingress of well fluids into the bore 15.

The firing head has an axial bore 19 of reduced diameter communicating with the bottom of the bore 15. Another bore 20 of still further reduced diameter extends axially downwardly from the bore 19 to communicate with a recess 21 extending axially upwardly from the bottom of the firing head.

An electrical contact member 22 is insulatedly supported by the projection 14 at its lower end and is electrically connected by insulated conductors (not shown) extending upwardly through the assembly to the wire of the conductor cable. An insulating sleeve 23, of resilient material such as rubber, is inserted in the bore 19. The sleeve frictionally supports a metallic spring 24 that makes contact at its upper end with the contact member 22 and is electrically connected at its lower end to the terminal wire 25 of an electric blasting cap 26. The other terminal wire 27 of the blasting cap is grounded to the assembly by having its free end looped under the bottom of the insulating sleeve 23 and pressed into contact with the wall of the bore 19. It will be noted that the blasting cap is in part supported in the assembly by the walls of the bore 20.

The recess 21 of the firing head has internal threads 28 at its lower end which mate with the external threads 29 provided on the cylindrical boss 30 of the cutter head 10. An O-ring 31 seals the boss within the recess 21 of the firing head to prevent intrusion of well fluids.

Referring to FIGS. 2 and 3, the cutter head 10 has a top wall 32 and an annular cylindrical side wall 33. Preferably, the top wall, the side wall, and the upstanding boss 30 are machined from a single piece of steel to provide an integral housing component for the cutter head. The bottom of the housing is closed by a plug 34 which may be machined from aluminum and which provides a bottom wall for the housing of the cutter head. The plug has a cylindrical portion 35 inserted in the lower end of the side wall section 33 and a flanged portion 36 abutting the bottom of the side wall section. The plug is securely retained in the assembled position shown by means of screws 37—37 threaded into the bottom of the side wall section 33 and engaging the shoulders 38 of the holes 39 formed in the flange of the plug.

A shaped explosive charge cartridge 40 is mounted within the chamber 41 of the cutter head. The cartridge includes identical lower and upper end plates 42 and 43 which are circular in horizontal cross-section. The outer edges of the end plates are beveled as shown at 44 to provide a narrow rim 45. Each end plate is of substantially uniform thickness from its beveled edge to a zone approximately half-way in to the center of the disc. Each end plate has an inwardly-projecting cylindrical portion or boss 46 providing a thickened central section for the end plate. Each end plate has an axial fuse bore 47 counterbored from the outer face to provide an enlarged axial recess 48.

The cartridge 40 includes an annular booster charge element 49 sandwiched between the inner faces of the central bosses 46 of the end plates. The booster charge element may be formed of compressed granular cyclonite or other suitable booster material. The booster element has a central hole 50 of the same diameter as the axial bores 47 in the end plates, the central hole being axially aligned with the bores to form a vertical passage through the cartridge. The end of a detonating fuse may extend

through the passage as shown in FIG. 1 wherein the detonating fuse, such as a Primacord fuse, is indicated by the reference numeral 51.

Referring again to FIG. 2, it is seen that the outside diameter of the booster element 49 is the same as the outside diameter of the end plate boxes 46. It is also seen that the two end plates 42 and 43 with the booster element sandwiched therebetween form a spool-shaped container for the annular lower and upper lined main shaped explosive charge elements designated 52 and 53, respectively. The lower and upper shaped charge elements 52 and 53 are identical to each other. Each such element has a main explosive charge 54, of compressed waxed RDX for example. The outer peripheral face 55 of each main explosive charge element is lined with an inert annular liner section 56. The liner sections 56 are of truncated conical form and abut each other at their inner peripheries, flaring outwardly from each other to provide an annular cavity of V-shaped vertical cross-section.

The cartridge 40 may be fabricated and assembled along the following lines. Waxed granular cyclonite is compressed in a suitable die into one of the conical liner sections 56 to form a lined pellet of the shape indicated in the drawings. The lined main charge pellet thus formed is cemented to one of the end plates such as 42 along the surfaces 57 and 58. A booster charge element 49 is placed on and cemented to the cylindrical portion 46 of the end plate along the upper surface 59. A second lined main charge pellet with an end plate cemented thereto is inverted over the lower element and booster charge and is cemented along the contacting surfaces. The cartridge, thus formed and assembled, provides a unitary explosive component that may be readily inserted in the housing of the cutter.

The housing is counterbored upwardly from the bottom, the counterbore having a diameter equal to that of the cartridge 40. A shoulder 60 is thus formed on the side wall of the housing against which the upper beveled rim of the cartridge is seated. The parts are so dimensioned that the upper surface of the cylindrical portion 35 of the plug 34 retains the cartridge in the position indicated in FIGS. 1 and 2.

With reference to FIG. 1, it will be seen that the side wall section of the housing is provided with an annular groove 61 opposite the annular lined cavity of the cartridge 40. The groove is symmetrical about a horizontal plane passing medially through the cartridge 40. The upper half of the groove is defined by a short horizontal face 62 intersecting a downwardly and outwardly sloping face 63 which in turn intersects a vertical cylindrical face 64 defining a thin wall section 65 that faces the vertex of the lined cavity of the shaped charge. The bottom half of the groove is a mirror image of the upper half.

It will be seen that the outer rims of the liner sections 56 abut the side wall of the housing immediately above and below the edges of the groove 61. Such contact of the liner with the side wall of the housing improves the performance of the cutting jet over a jet formed by a device in which the liner is not laterally supported around the rims.

A fuse tube 66 of aluminum or the like extends between the cartridge 40 and the top wall 32 of the housing, the lower end of the tube being received in the recess 48 of the plate 43 and the upper end of the tube being received in a recess 67 formed in the top wall of the housing. The cylindrical boss 30 of the cutter head is provided with an axial bore 68 through which a part of the explosive train extends.

The top of the detonating fuse 51 is crimped into the bottom of a fuse booster 69, as shown in FIG. 1. The upper end of the fuse booster projects above the top of the cylindrical boss 30 into contact with the bottom of the electric blasting cap 26, the top of the fuse booster being wrapped with friction tape 70 to hold the booster in place.

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In assembling the apparatus, the fuse tube 66 is first inserted in the cutter head and the cartridge 40 is then inserted into the head through the open bottom. The plug 34 is then positioned and secured in place by means of the screws 37. An O-ring 71 is employed to seal the plug to the side wall section of the cutter head. This is completed the assembly of the cutter head. So much of the apparatus is usually assembled in the charge manufacturing plant. It will be noted that the cutter head assembly in this condition has no blasting cap or other sensitive means for detonating the explosive component of the cutter head; hence, the assembly is relatively safe and may be shipped and handled with a minimum of hazard.

In the field and preparatory to use of the apparatus in a well, the firing head assembly 11 is secured to the adapter 12 by the screws 16. The firing head is equipped with the blasting cap 26 and rigged for firing. A suitable length of detonating cord 51 is provided with a fuse booster 69 and inserted in the cutter head as shown in FIG. 1, the top of the fuse booster being taped in place as indicated at 70. Thereafter, the cutter head is threaded into the firing head and the apparatus is ready to be lowered into the tubing of an oil well for severing the tubing.

The apparatus is lowered in the well and located with the cartridge 40 opposite the site where the tubing is to be severed. The firing circuit is energized from the surface of the earth to explode the blasting cap 26. The blasting cap fires the fuse booster 69 which, in turn, detonates the fuse 51. When the explosion wave in the fuse reaches the annular booster element 49, the latter is detonated. The explosion wave travels radially outwardly through the booster 49 to detonate the main charge elements 52 and 53 in a symmetrical manner. The explosion wave travels outwardly in the main charge and attacks the liner elements 56 to provide a horizontal planar cutting jet traveling radially outwardly in the plane of the vertex of the lined shaped charge cavity. The planar cutting jet impinges upon the thin section 65 of the side wall of the cutter head and severs the bottom of the cutter head from the top along a circular cut that usually takes out the entire thin section 65 between the upper inclined groove face 63 and the lower inclined groove face 72. The cutting jet has enough residual energy to continue outwardly to cut the surrounding tubing opposite the groove 61. It will be understood that the cutter head fits within the tubing with only enough clearance to permit the tool to be run into the tubing without becoming lodged therein.

When the cutter is fired, the lower severed section of the housing, including the side wall section below the thin web 65 and the plug 34, falls with the severed section of the tubing to the bottom of the well and may later be removed if desired. The upper section of the housing 10 above the thin web 65 remains substantially intact and it, together with the tool parts thereabove including the firing head, is withdrawn from the well. The upper section of the housing may be unscrewed from the firing head and discarded and the firing head may be reloaded and equipped with a fresh cutter head for another cutting operation.

With the cutter apparatus of the present invention, as shown in FIGS. 1 to 3, tubing is severed without producing any objectionable flare in the end of the tubing above the cut. Thus, the tubing may be easily pulled from the well with no tendency to become lodged due to a flared bottom. The lower section of tubing that is severed from the upper section is generally found to have an upper end that is slightly flared; however, it may ordinarily be retrieved from the well without difficulty using conventional fishing tools.

It will be seen that the shaped charge cartridge 40 is located a substantial distance below the top wall of the housing to leave a substantially unobstructed space in the housing above the shaped charge. This space serves

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as an expansion chamber into which the upwardly moving parasitic products of the explosion of the shaped charge may expand and to a large extent dissipate their energy. Such energy, being absorbed within the upper section of the housing, is prevented from acting on the tubing being severed to bulge or flare the bottom of the tubing above the cut. By the expression "parasitic products of explosion" is meant those products of the explosion that do not directly enter the cutting jet.

The material and thickness of the housing walls above the groove 61 are selected in relation to the explosive forces involved, to withstand such forces and to remain intact when the charge is fired. The housing walls above the groove are sufficiently strong to also contain the explosive forces produced by the detonating fuse 51 extending axially through the chamber.

The thin wall section 65 is strong enough to withstand well pressure at the deepest location at which the tool is expected to be used; however, it is purposely kept as thin as possible so that only a minimum of energy is taken away from the jet as the latter cuts through the thin wall section. Thus, the jet retains the largest possible quantity of energy for the useful work of cutting the tubing.

The downwardly and outwardly sloping upper face 63 of the groove 61 has been found beneficial in minimizing flaring of the tubing above the cut. It is thought that the downward slope of the face 63 directs some of the parasitic products of explosion downwardly and away from the tubing above the cut.

The groove 61 provides an annular stand-off space in which the planar cutting jet may properly form before reaching the thin wall section 65.

The embodiment of the invention shown in FIGS. 1 to 3 is especially proportioned for use in tubing of 3" to 3 1/4" I.D. and is shown substantially to scale. The O.D. of the cutter head is 2 13/16". The I.D. of the housing above the cartridge 40 is 1 15/16" and the I.D. of the counterbored portion of the housing at the lower end thereof is 2 1/2". The height of the expansion chamber within the housing and above the cartridge 40 is 2 1/4". The width of the groove 61 at the inner wall of the housing is 7/16" and the thickness of the thin wall section 65 is 1/16". The height of the thin wall section is 3/16". The inclined groove faces 63 and 72 are disposed at approximately 30° to the horizontal; however, this angle may vary within practical limits from approximately 20° to approximately 60°. Of course, other sizes of tubing cutters may be made to cut larger or smaller tubing.

In FIGS. 4 and 5 there is shown another form of the invention in many respects similar to that shown in FIGS. 1 to 3. The cutter head of FIGS. 4 and 5 is identical to that shown in FIGS. 1 to 3 from the level of the bottom of the cartridge up. In the cutter head shown in FIGS. 4 and 5, the housing side wall portion 73 is extended for a substantial distance below the bottom of the cartridge 40' and is provided with a bottom closure plug 34' to form a second expansion chamber 74 between the cartridge and the plug. The expansion chamber 74 is of substantially the same size as the expansion chamber above the cartridge 40'.

The cartridge 40' is supported against the shoulder 60' and opposite the groove 61' by support means including a length of aluminum tubing 75, the top end of which is received in the recess 48' of the cartridge and the lower end of which rests in a cup 76 brazed to a spider 77 having radial leaf-spring legs that engage the top of the plug 34' to resiliently urge the tube and cartridge 40' into the illustrated positions.

The fuse booster 69' and detonating fuse 51' are similar to the corresponding components shown in FIGS. 1 to 3. However, the fuse 51' may extend down through the cartridge 40' and through the lower tube 75 to the bottom thereof. The fuse portion below the cartridge

serves upon detonation to destroy the tube 75, whereby less large debris is produced.

In use, the cutter head of FIGS. 4 and 5 is connected to a firing head such as the firing head 11 of FIG. 1 and to the other necessary equipment for lowering the cutter head into a well. The assembled tool is fired from the surface of the earth as described with reference to FIGS. 1 to 3. The formation of the horizontal planar cutting jet takes place as described hereinbefore. The jet cuts through the thin wall section 65' to sever the tubing surrounding the cutter head in a manner analogous to that described hereinbefore.

With the cutter head of FIGS. 4 and 5, having expansion chambers within the housing both above and below the cartridge, the vertical parasitic products of the explosion of the cartridge 40' and the products of explosion of the fuse 51' are absorbed and shielded from the tubing being severed to a greater extent than with a cutter head having only a single expansion chamber above the cartridge. Thus, significantly less damage is done to the portions of the tubing above and below the cut. The flaring of the lower severed section of tubing immediately below the cut is less pronounced than with the device of FIGS. 1 to 3, and the flaring of the upper section of the tubing is inconsequential.

I claim:

1. A device for severing pipe in an oil well bore and the like comprising:

- (a) a short cylindrical, non-frangible, pressure-resistant housing including a hollow body portion and a separate end plug sealingly closing the lower end of said body,
- (b) said body portion having a thick annular side wall and a thick top wall integral therewith,
- (c) said top wall having a central, upstanding cylindrical boss integral therewith,
- (d) said boss providing an axial opening therethrough adapted to receive a detonating fuse therein,
- (e) the lower section of said side wall having a counterbore therein terminating a substantial distance below said top wall and providing a downwardly-facing shoulder,
- (f) said side wall providing a horizontal annular groove opening inwardly of said housing and having a thin section bounding the outer periphery of the groove,
- (g) said groove being located subjacent and close to said shoulder in the counterbored portion of said body,
- (h) a generally cylindrical, shaped explosive charge cartridge slidably received in said counterbore with the upper edge of the cartridge seated against said shoulder and the lower edge of said cartridge abutting the wall of said counterbore below said groove,
- (i) said cartridge having a main charge of explosive material having an outwardly-opening, annular, lined cavity facing said thin section and adapted upon being fired to produce a radially expanding planar cutting jet adapted to cleanly sever said side wall at said thin section,
- (j) said cartridge providing an axial opening therethrough adapted to receive a portion of a detonating fuse,
- (k) said housing and said cartridge defining therebetween a substantially unobstructed space above said cartridge providing an expansion chamber for the parasitic products of said cartridge resulting from detonation thereof,
- (l) the walls of said body above said groove being of sufficient thickness and strength to remain intact and to be substantially undistorted when said cartridge is fired,
- (m) a rigid, fuse-receiving tube connecting the axial opening in said boss with the axial opening in said cartridge, said tube extending axially through said expansion chamber above said cartridge, and

(n) means retaining the upper edge of said cartridge firmly seated against the shoulder in the counterbored portion of said body.

2. A device for severing pipe in an oil well bore and the like comprising:

- (a) a short cylindrical, non-frangible, pressure-resistant housing including a hollow body portion and a separate end plug sealingly closing the lower end of said body,
  - (b) said body portion having a thick annular side wall and a thick top wall integral therewith,
  - (c) said top wall having a central, upstanding cylindrical boss integral therewith,
  - (d) said boss providing an axial opening therethrough adapted to receive a detonating fuse therein,
  - (e) the lower section of said side wall having a counterbore therein terminating a substantial distance below said top wall and providing a downwardly-facing shoulder,
  - (f) said side wall providing a horizontal annular groove opening inwardly of said housing and having a thin section bounding the outer periphery of the groove,
  - (g) said groove being located subjacent and close to said shoulder in the counterbored portion of said body,
  - (h) a generally cylindrical, shaped explosive charge cartridge slidably received in said counterbore with the upper edge of the cartridge seated against said shoulder and the lower edge of said cartridge abutting the wall of said counterbore below said groove,
  - (i) said cartridge having a main charge of explosive material having an outwardly-opening, annular, lined cavity facing said thin section and adapted upon being fired to produce a radially expanding planar cutting jet adapted to cleanly sever said side wall at said thin section,
  - (j) said cartridge providing an axial opening therethrough adapted to receive a portion of a detonating fuse,
  - (k) said housing and said cartridge defining therebetween a substantially unobstructed space above said cartridge providing an expansion chamber for the parasitic products of said cartridge resulting from detonation thereof,
  - (l) the walls of said body above said groove being of sufficient thickness and strength to remain intact and to be substantially undistorted when said cartridge is fired,
  - (m) a rigid, fuse-receiving tube connecting the axial opening in said boss with the axial opening in said cartridge, said tube extending axially through said expansion chamber above said cartridge, and
  - (n) the upper surface of said end plug abutting the lower surface of said cartridge to retain the cartridge firmly seated against the shoulder in the counterbored portion of said body.
3. A device for severing pipe in an oil well bore and the like comprising:
- (a) a short cylindrical, non-frangible, pressure-resistant housing including a hollow body portion and a separate end plug sealingly closing the lower end of said body,
  - (b) said body portion having a thick annular side wall and a thick top wall integral therewith,
  - (c) said top wall having a central, upstanding cylindrical boss integral therewith,
  - (d) said boss providing an axial opening therethrough adapted to receive a detonating fuse therein,
  - (e) the lower section of said side wall having a counterbore therein terminating a substantial distance below said top wall and providing a downwardly-facing shoulder,
  - (f) said side wall providing a horizontal annular groove opening inwardly of said housing and having a thin section bounding the outer periphery of the groove,

- (g) said groove being located subjacent and close to said shoulder in the counterbored portion of said body,
- (h) a generally cylindrical, shaped explosive charge cartridge slidably received in said counterbore with the upper edge of the cartridge seated against said shoulder and the lower edge of said cartridge abutting the wall of said counterbore below said groove, 5
- (i) said cartridge having a main charge of explosive material having an outwardly-opening, annular, lined cavity facing said thin section and adapted upon being fired to produce a radially expanding planar cutting jet adapted to cleanly sever said side wall at said thin section, 10
- (j) said cartridge providing an axial opening there-through adapted to receive a portion of a detonating fuse, 15
- (k) said housing and said cartridge defining substantially unobstructed spaces above and below said cartridge for the parasitic products resulting from detonation thereof, 20
- (l) the walls of said body above said groove being of sufficient thickness and strength to remain intact and to be substantially undistorted when said cartridge is fired, 25
- (m) a rigid, fuse-receiving tube connecting the axial opening in said boss with the axial opening in said cartridge, said tube extending axially through said expansion chamber above said cartridge, and
- (n) support means extending across the expansion chamber below said cartridge engaging said end plug and said cartridge to retain the upper edge of the cartridge firmly seated against the shoulder in the counterbored portion of said body. 30
4. A device for severing pipe in an oil well bore and the like comprising: 35
- (a) a short cylindrical, non-frangible, pressure-resistant housing including a hollow body portion and a separate end plug sealingly closing the lower end of said body, 40
- (b) said body portion having a thick annular side wall and a thick top wall integral therewith,
- (c) said top wall having a central, upstanding cylindrical boss integral therewith,
- (d) said boss providing an axial opening therethrough adapted to receive a detonating fuse therein, 45
- (e) the lower section of said side wall having a counterbore therein terminating a substantial distance below said top wall and providing a downwardly-facing shoulder,
- (f) said side wall providing a horizontal annular groove 50

- opening inwardly of said housing and having a thin section bounding the outer periphery of the groove,
- (g) said groove being located subjacent and close to said shoulder in the counterbored portion of said body,
- (h) a generally cylindrical, shaped explosive charge cartridge slidably received in said counterbore with the upper edge of the cartridge seated against said shoulder and the lower edge of said cartridge abutting the wall of said counterbore below said groove,
- (i) said cartridge having a main charge of explosive material having an outwardly-opening, annular, lined cavity facing said thin section and adapted upon being fired to produce a radially expanding planar cutting jet adapted to cleanly sever said side wall at said thin section,
- (j) said cartridge providing an axial opening there-through adapted to receive a portion of a detonating fuse,
- (k) said housing and said cartridge defining therebetween a substantially unobstructed space above said cartridge providing an expansion chamber for the parasitic products of said cartridge resulting from detonation thereof,
- (l) the walls of said body above said groove being of sufficient thickness and strength to remain intact and to be substantially undistorted when said cartridge is fired,
- (m) a rigid, fuse-receiving tube connecting the axial opening in said boss with the axial opening in said cartridge, said tube extending axially through said expansion chamber above said cartridge, and
- (n) means including a spring acting against said end plug retaining the upper edge of said cartridge firmly seated against the shoulder in the counterbored portion of said body.

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